Supporting Information

Regioselective oxidative C–H heptafluoroisopropylation of heteroarenes with heptafluoroisopropyl silver

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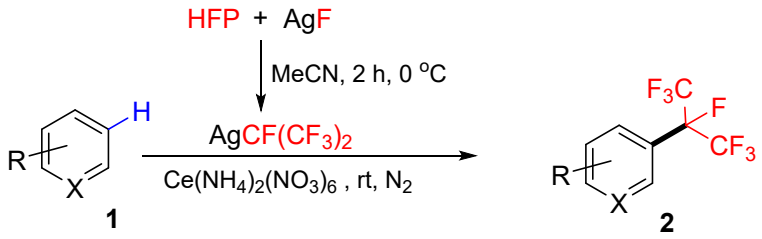
1. General Information

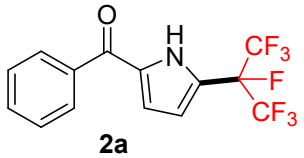
^{1}H NMR (TMS as the internal standard), ^{13}C NMR and ^{19}F NMR spectra ($CFCl_3$ as the outside standard and low field is positive) were recorded on a 400 MHz spectrometer. Chemical shifts (δ) are reported in ppm, and coupling constants (*J*) are in Hertz (Hz). The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet. High-resolution mass spectra (HRMS) were obtained on a GC-TOF mass spectrometer. Unless otherwise noted, all reagents were obtained commercially and used without further purification.

2. General Procedures for Heptafluoroisopropylation of Heteroarenes



In a nitrogen-filled glove box, an oven-dried reaction tube with Teflon-coated stirrer bar was charged with silver fluoride (152.4 mg, 1.2 mmol) and was brought under an atmosphere of dry nitrogen. To this vessel, anhydrous acetonitrile (6.0 mL) and hexafluoropropylene (balloon, 1 atm) were added, and the mixture was stirred at ice-water bath in the dark until silver fluoride precipitate dissolved completely. Then this solution was added to another oven-dried vessel, which was filled with $Ce(NH_4)_2(NO_3)_6$ (657.6 mg, 1.2 mmol) and heteroarene (0.6 mmol). The reaction mixture was stirred at ambient temperature for 12 hours. The crude mixture was filtered through a pad of Celite, and the pad was washed with EtOAc. The filtrate was concentrated in vacuo and purified by flash column chromatography over silica gel to give pure product.

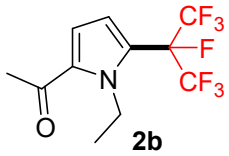
(5-(Perfluoropropan-2-yl)-1*H*-pyrrol-2-yl)(phenyl)methanone (2a)



The product mixture was purified by silica gel column chromatography (PE / EA = 8:1) to afford **2a** (189.3 mg, 93%) as a white solid, mp 118-120 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.31 (s, 1H), 7.93 (d, *J* = 7.3 Hz, 2H), 7.61 (t, *J* = 7.4 Hz, 1H), 7.51 (t, *J* = 7.6 Hz, 2H), 6.94 – 6.89 (m, 1H), 6.65 – 6.59 (m, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ

-76.45 (d, J = 9.1 Hz, 6F), -180.59 – -180.77 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 185.0, 137.3, 133.1, 132.6, 129.1, 128.5, 122.1 (d, J = 22.1 Hz), 120.0 (qd, J = 288.2, 27.5 Hz), 118.7, 112.0, 90.8 – 87.4 (m). **MS** (**EI**): m/z 339 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{14}H_8F_7NO$: 339.0489; Found: 339.0491.

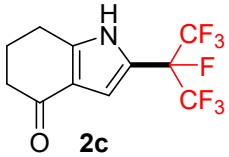
1-(1-Ethyl-5-(perfluoropropan-2-yl)-1*H*-pyrrol-2-yl)ethan-1-one (2b)



2b

The product mixture was purified by silica gel column chromatography (PE / EA = 10:1) to afford **2b** (144.8 mg, 79%) as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.99 (dd, J = 4.4, 1.4 Hz, 1H), 6.49 (dd, J = 2.3, 1.1 Hz, 1H), 4.55 (d, J = 7.5 Hz, 2H), 2.49 (s, 3H), 1.33 (t, J = 6.9 Hz, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.48 (d, J = 6.1 Hz, 6F), -182.96 – -183.19 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 188.9, 133.4, 122.1 (d, J = 17.5 Hz), 120.4 (qd, J = 288.9, 28.7 Hz), 119.5, 111.9 – 111.6 (m), 93.1 – 89.7 (m), 43.5 (d, J = 11.3 Hz), 28.5, 17.2 (d, J = 2.5 Hz). **MS** (**EI**): m/z 305 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{11}H_{10}F_7NO$: 305.0645; Found: 305.0643.

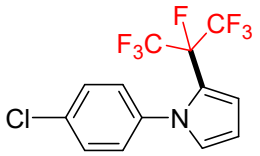
2-(Perfluoropropan-2-yl)-1,5,6,7-tetrahydro-4*H*-indol-4-one (2c)



2c

The product mixture was purified by silica gel column chromatography (PE / EA = 2:1) to afford **2c** (145.3 mg, 80%) as a white solid, mp 165-166 °C. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 12.40 (s, 1H), 6.66 (s, 1H), 2.82 (t, J = 6.1 Hz, 2H), 2.37 (t, J = 6.0 Hz, 2H), 2.05 (p, J = 6.3 Hz, 2H). **^{19}F NMR** (376 MHz, DMSO-d_6) δ -75.80 (d, J = 9.9 Hz, 6F), -175.42 – -175.61 (m, 1F). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 192.8, 146.9, 120.4, 119.9 (qd, J = 287.8, 28.7 Hz), 114.8 (d, J = 22.3 Hz), 107.3, 90.6 – 87.1 (m), 37.5, 23.2, 21.9. **MS** (**EI**): m/z 303 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{11}H_8F_7NO$: 303.0489; Found: 303.0486.

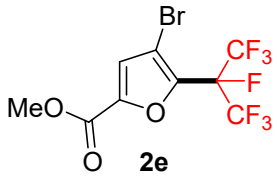
1-(4-Chlorophenyl)-2-(perfluoropropan-2-yl)-1*H*-pyrrole (2d)



2d

The product mixture was purified by silica gel column chromatography (PE) to afford **2d** (154.4 mg,74%) as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.38 (d, *J* = 8.7 Hz, 2H), 7.25 (dd, *J* = 8.7, 1.5 Hz, 2H), 6.81 – 6.77 (m, 1H), 6.67 – 6.62 (m, 1H), 6.36 – 6.31 (m, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -76.41 (d, *J* = 9.1 Hz, 6F), -178.70 – -178.89 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 139.2 (d, *J* = 3.1 Hz), 134.7, 128.9, 128.87, 128.86, 120.4 (qd, *J* = 288.2, 28.4 Hz), 116.7 (d, *J* = 18.0 Hz), 113.7 – 113.5 (m), 109.4, 92.8 – 89.2 (m). **MS** (**EI**): m/z 345 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{13}H_7ClF_7N$: 345.0150; Found: 345.0156.

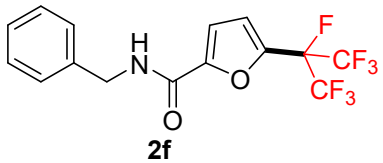
Methyl 4-bromo-5-(perfluoropropan-2-yl)furan-2-carboxylate (2e)



2e

The product mixture was purified by silica gel column chromatography (PE / EA = 10:1) to afford **2e** (158.1 mg, 71%) as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.25 (s, 1H), 3.93 (s, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.19 (d, *J* = 8.9 Hz, 6F), -184.48 – -184.64 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.27, 146.75, 138.44 (d, *J* = 29.5 Hz), 122.31 (d, *J* = 1.5 Hz), 119.6 (qd, *J* = 290.2, 27.0 Hz), 105.05, 91.11 – 87.58 (m), 52.81. **MS** (**EI**): m/z 372 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_9H_4BrF_7O_3$: 371.9227; Found: 371.9231.

***N*-benzyl-5-(perfluoropropan-2-yl)furan-2-carboxamide (2f)**

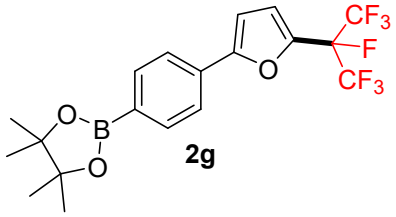


2f

The product mixture was purified by silica gel column chromatography (PE / EA = 5:1) to afford **2f** (204.1 mg, 92%) as a white solid, mp 102-105 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.40 – 7.27 (m, 5H), 7.21 (dd, *J* = 3.7, 1.5 Hz, 1H), 6.90 (d, *J* = 3.6 Hz, 2H), 4.62 (d, *J* = 6.0 Hz, 2H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.63 (d, *J* = 9.5 Hz, 6F), -

178.24 – -178.42 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.1, 150.6, 140.2 (d, *J* = 26.2 Hz), 137.7, 128.9, 128.0, 127.9, 119.8 (qd, *J* = 289.0, 27.7 Hz), 115.9, 115.1, 89.7 – 86.2 (m), 43.4. **MS** (**EI**): m/z 369 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{15}H_{10}F_7NO_2$: 369.0594; Found: 369.0595.

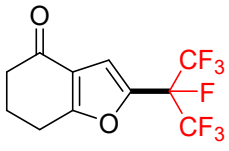
4,4,5,5-Tetramethyl-2-(4-(5-(perfluoropropan-2-yl)furan-2-yl)phenyl)-1,3,2-dioxaborolane (2g)



2g

The product mixture was purified by silica gel column chromatography (PE / EA = 20:1) to afford **2g** (196.8 mg, 75%) as a white solid, mp 49-51 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.0 Hz, 2H), 7.68 (d, *J* = 8.1 Hz, 2H), 6.91 (d, *J* = 3.0 Hz, 1H), 6.79 (d, *J* = 3.4 Hz, 1H), 1.36 (s, 12H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.33 (d, *J* = 9.9 Hz, 6F), -174.69 – -174.97 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.3 (d, *J* = 1.8 Hz), 138.7 (d, *J* = 26.7 Hz), 135.5, 131.7, 123.6, 120.2 (qd, *J* = 288.7, 28.2 Hz), 116.2, 106.7, 90.1 – 86.6 (m), 84.2, 25.0. **MS** (**EI**): m/z 438 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{19}H_{18}{}^{10}BF_7O_3$: 437.1268; Found: 437.1263.

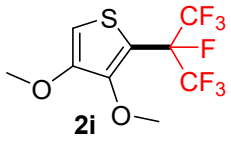
2-(Perfluoropropan-2-yl)-6,7-dihydrobenzofuran-4(5*H*)-one (2h)



2h

The product mixture was purified by silica gel column chromatography (PE / EA = 8:1) to afford **2h** (166.7 mg, 91%) as a yellow oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.09 (s, 1H), 2.95 (t, *J* = 6.3 Hz, 2H), 2.53 (t, *J* = 6.2 Hz, 2H), 2.28 – 2.17 (m, 2H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.58 (d, *J* = 9.5 Hz, 6F), -176.94 – -177.13 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 193.4, 169.3, 139.7 (d, *J* = 26.7 Hz), 122.0, 119.9 (qd, *J* = 289.3, 28.2 Hz), 111.1, 89.7 – 86.3 (m), 37.6, 23.4, 22.3. **MS** (**EI**): m/z 304 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{11}H_7F_7O_2$: 304.0329; Found: 304.0321.

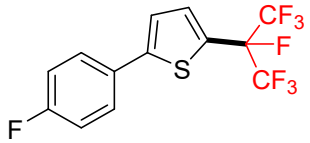
3,4-Dimethoxy-2-(perfluoropropan-2-yl)thiophene (2i)



2i

The product mixture was purified by silica gel column chromatography (PE) to afford **2i** (163.1 mg, 87%) as a yellow oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.40 (s, 1H), 3.87 (s, 3H), 3.85 (s, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.99 (d, *J* = 7.6 Hz, 6F), -172.60 – -172.74 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 151.0 (d, *J* = 1.4 Hz), 147.4 (d, *J* = 5.3 Hz), 109.7 (d, *J* = 24.6 Hz), 120.4 (qd, *J* = 288.9, 27.9 Hz), 99.1 (d, *J* = 2.8 Hz), 93.3 – 89.9 (m), 60.4, 57.5. **MS** (**EI**): m/z 312 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_9H_7F_7O_2S$: 312.0049; Found: 312.0052.

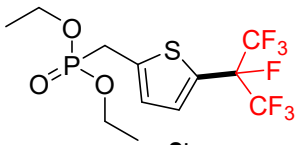
2-(4-Fluorophenyl)-5-(perfluoropropan-2-yl)thiophene (2j)



2j

The product mixture was purified by silica gel column chromatography (PE / EA = 20:1) to afford **2j** (180.8 mg, 87%) as a white solid, mp 41-42 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.57 (dd, *J* = 8.6, 5.2 Hz, 2H), 7.34 (d, *J* = 3.8 Hz, 1H), 7.24 – 7.20 (m, 1H), 7.11 (t, *J* = 8.5 Hz, 2H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -76.79 (d, *J* = 8.5 Hz, 6F), -112.61 – -112.71 (m, 1F), -171.09 – -171.26 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.2 (d, *J* = 249.0 Hz), 147.3, 129.9 (d, *J* = 6.4 Hz), 129.3 (d, *J* = 3.4 Hz), 128.1 (d, *J* = 8.2 Hz), 126.2 (d, *J* = 23.6 Hz), 123.4, 120.4 (qd, *J* = 288.7, 28.0 Hz), 116.3 (d, *J* = 21.9 Hz), 92.9 – 89.4 (m). **MS** (**EI**): m/z 346 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{13}H_6F_8S$: 346.0057; Found: 346.0060.

Diethyl ((5-(perfluoropropan-2-yl)thiophen-2-yl)methyl)phosphonate (2k)

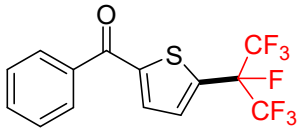


2k

The product mixture was purified by silica gel column chromatography (PE / EA = 1:1) to afford **2k** (176.6 mg, 73%) as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.20 (d, *J* = 3.6 Hz, 1H), 7.03 – 6.98 (m, 1H), 4.14 – 4.02 (m, 4H), 3.34 (d, *J* = 21.0 Hz, 2H),

1.26 (t, J = 7.1 Hz, 6H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -76.87 (d, J = 8.5 Hz, 6F), -171.21 – -171.38 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 137.4 (d, J = 9.7 Hz), 129.2 – 128.8 (m), 127.9 (d, J = 8.3 Hz), 126.3 (dd, J = 23.6, 4.1 Hz), 120.2 (qd, J = 288.1, 27.8 Hz), 92.8 – 89.2 (m), 62.8 (d, J = 6.8 Hz), 28.2 (d, J = 144.1 Hz), 16.4 (d, J = 5.9 Hz). **MS** (**EI**): m/z 402 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{12}H_{14}F_7O_3PS$: 402.0284; Found: 402.0282.

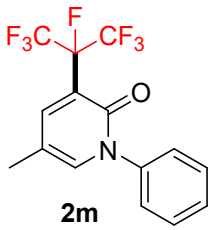
(5-(Perfluoropropan-2-yl)thiophen-2-yl)(phenyl)methanone (2l)



2l

The product mixture was purified by silica gel column chromatography (PE / EA = 20:1) to afford **2l** (126.9 mg, 59%) as a white solid, mp 90-91 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.88 (d, J = 7.3 Hz, 2H), 7.67 – 7.60 (m, 2H), 7.56 – 7.50 (m, 2H), 7.41 (d, J = 3.7 Hz, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -76.52 (d, J = 8.3 Hz, 6F), -172.22 – -172.40 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 187.6, 146.6, 137.1, 135.1 (d, J = 23.5 Hz), 133.8, 133.2, 129.4, 129.1 (d, J = 6.1 Hz), 128.8, 120.0 (qd, J = 288.6, 27.5 Hz), 92.9 – 89.3 (m). **MS** (**EI**): m/z 356 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{14}H_7F_7OS$: 356.0100; Found: 356.0107.

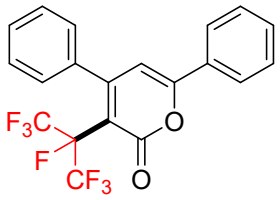
5-Methyl-3-(perfluoropropan-2-yl)-1-phenylpyridin-2(1*H*)-one (2m)



2m

The product mixture was purified by silica gel column chromatography (PE / EA = 8:1) to afford **2m** (108.7 mg, 51%) as a white solid, mp 85-86 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.71 (dd, J = 2.5, 1.3 Hz, 1H), 7.52 – 7.46 (m, 2H), 7.45 – 7.40 (m, 1H), 7.39 – 7.33 (m, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -73.84 (d, J = 4.5 Hz, 6F), -174.02 (s, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.7 (d, J = 6.4 Hz), 143.8 (d, J = 17.7 Hz), 140.2, 139.1, 129.6, 129.0, 126.7, 120.7 (qd, J = 289.2, 27.4 Hz), 119.1 (d, J = 21.6 Hz), 113.9 (d, J = 1.8 Hz), 94.2 – 90.7 (m), 17.2. **MS** (**EI**): m/z 353 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{15}H_{10}F_7NO$: 353.0645; Found: 353.0648.

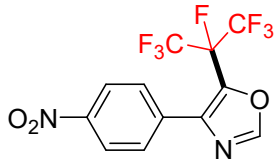
3-(Perfluoropropan-2-yl)-4,6-diphenyl-2*H*-pyran-2-one (2n)



2n

The product mixture was purified by silica gel column chromatography (PE / EA = 8:1) to afford **2n** (209.9 mg, 84%) as a white solid, mp 130-131 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 7.3 Hz, 2H), 7.56 – 7.40 (m, 6H), 7.25 – 7.19 (m, 2H), 6.57 (s, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -72.98 (d, *J* = 4.2 Hz, 6F), -168.08 – -168.20 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.2 (d, *J* = 3.2 Hz), 160.4, 158.1 (d, *J* = 8.3 Hz), 138.4 (d, *J* = 5.7 Hz), 132.3, 129.9, 129.3, 128.6, 128.2, 126.3, 125.7 (d, *J* = 4.9 Hz), 120.6 (qd, *J* = 289.8, 27.5 Hz), 109.0 (d, *J* = 20.0 Hz), 106.6 (d, *J* = 2.1 Hz), 96.0 – 92.2 (m). **MS** (**EI**): m/z 416 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{20}H_{11}F_7O_2$: 416.0642; Found: 416.0647.

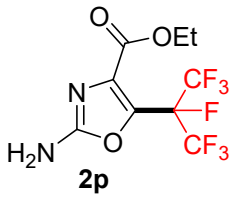
4-(4-Nitrophenyl)-5-(perfluoropropan-2-yl)oxazole (2o)



2o

The product mixture was purified by silica gel column chromatography (PE / EA = 5:1) to afford **2o** (174.6 mg, 81%) as a white solid, mp 98-100 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.29 (d, *J* = 8.9 Hz, 2H), 8.15 (d, *J* = 1.6 Hz, 1H), 7.82 (dd, *J* = 9.0, 2.1 Hz, 2H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.60 (d, *J* = 8.9 Hz, 6F), -182.44 – -182.64 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 152.4, 148.5, 141.9, 135.6, 132.9 (d, *J* = 35.5 Hz), 130.2 (d, *J* = 5.2 Hz), 123.7, 119.8 (qd, *J* = 290.0, 26.9 Hz), 91.3 – 87.7 (m). **MS** (**EI**): m/z 358 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{12}H_5F_7N_2O_3$: 358.0183; Found: 358.0182.

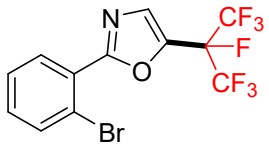
Ethyl 2-amino-5-(perfluoropropan-2-yl)oxazole-4-carboxylate (2p)



2p

The product mixture was purified by silica gel column chromatography (PE / EA = 1:1) to afford **2p** (148.1 mg, 76%) as a white solid, mp 84-85 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 6.07 (s, 2H), 4.35 (q, *J* = 7.2 Hz, 2H), 1.35 (t, *J* = 7.1 Hz, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.40 (d, *J* = 9.1 Hz, 6F), -179.82 – -180.02 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.7, 159.9, 119.9 (qd, *J* = 290.3, 27.8 Hz), 135.5, 131.7 (d, *J* = 35.3 Hz), 90.1 – 86.5 (m), 62.1, 14.1. **MS** (**EI**): m/z 324 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_9H_7F_7N_2O_3$: 324.0339; Found: 324.0343.

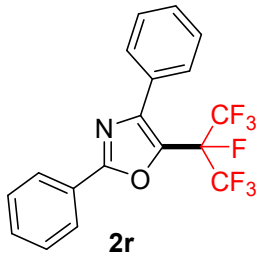
2-(2-Bromophenyl)-5-(perfluoropropan-2-yl)oxazole (2q)



2q

The product mixture was purified by silica gel column chromatography (PE / EA = 20:1) to afford **2q** (183.9 mg, 78%) as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.96 (d, *J* = 7.8 Hz, 1H), 7.73 (d, *J* = 8.0 Hz, 1H), 7.65 (d, *J* = 2.1 Hz, 1H), 7.43 (t, *J* = 7.6 Hz, 1H), 7.35 (t, *J* = 7.2 Hz, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.43 (d, *J* = 9.8 Hz, 6F), -175.94 – -176.13 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.1, 137.8 (d, *J* = 27.4 Hz), 134.9, 132.5, 131.8, 131.7 – 131.6 (m), 127.7, 127.1, 121.6, 119.9 (qd, *J* = 289.3, 28.1 Hz), 89.5 – 86.0 (m). **MS** (**EI**): m/z 391 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{12}H_5BrF_7NO$: 390.9437; Found: 390.9438.

5-(Perfluoropropan-2-yl)-2,4-diphenyloxazole (2r)

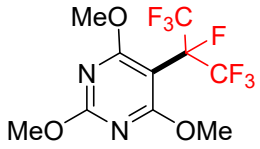


2r

The product mixture was purified by silica gel column chromatography (PE / EA = 20:1) to afford **2r** (208.4 mg, 89%) as a white solid, mp 91-92 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.18 – 8.12 (m, 2H), 7.77 – 7.71 (m, 2H), 7.59 – 7.45 (m, 6H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.59 (d, *J* = 9.1 Hz, 6F), -182.21 – -182.40 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.8, 145.5, 131.8, 130.5 (d, *J* = 34.9 Hz), 130.1, 129.6, 129.2 (d, *J* = 4.3 Hz), 129.1, 128.5, 127.1, 126.1, 120.2 (qd, *J* = 290.5, 27.6 Hz), 91.3 – 87.8 (m).

MS (**EI**): m/z 389 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{18}H_{10}F_7NO$: 389.0645; Found: 389.0643.

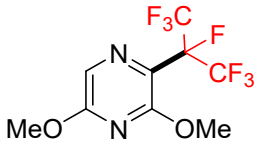
2,4,6-Trimethoxy-5-(perfluoropropan-2-yl)pyrimidine (2s)



2s

The product mixture was purified by silica gel column chromatography (PE / EA = 20:1) to afford **2s** (71.6 mg, 35%) as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 4.00 (s, 3H), 3.98 (s, 6H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -74.90 (d, J = 4.8 Hz, 6F), -175.65 – -175.75 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 165.0, 121.2 (qd, J = 289.1, 28.2 Hz), 94.5 – 90.8 (m), 85.9 (d, J = 23.1 Hz), 55.2, 54.9. **MS** (**EI**): m/z 338 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{10}H_9F_7N_2O_3$: 338.0496; Found: 338.0501

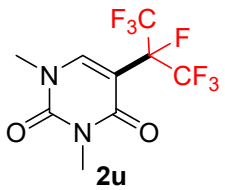
3,5-Dimethoxy-2-(perfluoropropan-2-yl)pyrazine (2t)



2t

The product mixture was purified by silica gel column chromatography (PE / EA = 10:1) to afford **2t** (120.3 mg, 65%) as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85 (s, 1H), 4.02 (s, 3H), 4.01 (s, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -74.39 (d, J = 7.1 Hz, 6F), -182.46 – -182.61 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.2, 158.2 (d, J = 2.3 Hz), 124.5 (d, J = 2.3 Hz), 120.9 (qd, J = 289.8, 27.8 Hz), 120.1 (d, J = 25.0 Hz), 93.5 – 90.0 (m), 54.2, 54.2. **MS** (**EI**): m/z 308 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_9H_7F_7N_2O_2$: 308.0390; Found: 308.0394.

1,3-Dimethyl-5-(perfluoropropan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2u)

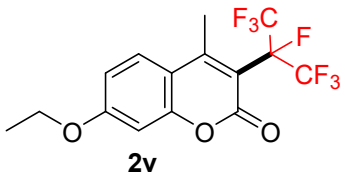


2u

The product mixture was purified by silica gel column chromatography (PE / EA = 5:1) to afford **2u** (76.5 mg, 41%) as a white solid, mp 93-95 °C. **^{1}H NMR** (400 MHz, $CDCl_3$)

δ 7.59 (s, 1H), 3.50 (s, 3H), 3.35 (s, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -74.80 (d, *J* = 4.9 Hz, 6F), -177.54 – -177.65 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.8 (d, *J* = 6.4 Hz), 150.8, 144.8 (d, *J* = 22.0 Hz), 120.3 (qd, *J* = 289.0, 27.1 Hz), 101.5 (d, *J* = 20.3 Hz), 93.1 – 89.6 (m), 38.1, 28.3. **MS** (**EI**): m/z 308 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_9H_7F_7N_2O_2$: 308.0390; Found: 308.0391.

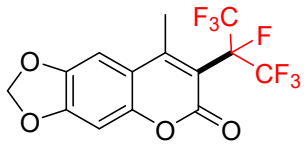
7-Ethoxy-4-methyl-3-(perfluoropropan-2-yl)-2*H*-chromen-2-one (2v)



2v

The product mixture was purified by silica gel column chromatography (PE / EA = 10:1) to afford **2v** (125.9 mg, 56%) as a white solid, mp 105-106 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 9.1 Hz, 1H), 6.90 (dd, *J* = 9.0, 2.4 Hz, 1H), 6.77 (d, *J* = 2.4 Hz, 1H), 4.11 (q, *J* = 7.0 Hz, 2H), 2.66 (d, *J* = 5.8 Hz, 3H), 1.46 (t, *J* = 7.0 Hz, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -72.89 (d, *J* = 3.1 Hz, 6F), -167.34 – -167.44 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.7, 157.9, 157.6 (d, *J* = 8.1 Hz), 154.9, 127.0, 121.0 (qd, *J* = 290.5, 27.7 Hz), 113.9, 113.4, 110.1 (d, *J* = 21.4 Hz), 100.7, 96.6 – 93.1 (m), 64.6, 16.6 (d, *J* = 20.2 Hz), 14.6. **MS** (**EI**): m/z 372 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{15}H_{11}F_7O_3$: 372.0591; Found: 372.0592.

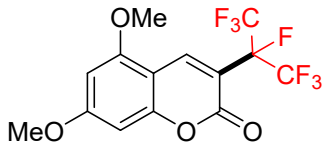
8-Methyl-7-(perfluoropropan-2-yl)-6*H*-[1,3]dioxolo[4,5-*g*]chromen-6-one (2w)



2w

The product mixture was purified by silica gel column chromatography (PE / EA = 5:1) to afford **2w** (136.8 mg, 61%) as a white solid, mp 152-153 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.17 (s, 1H), 6.79 (s, 1H), 6.12 (s, 2H), 2.62 (d, *J* = 5.4 Hz, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -72.81 (d, *J* = 3.1 Hz, 6F), -167.10 – -167.20 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.7, 157.4 (d, *J* = 7.9 Hz), 152.8, 150.6, 145.8, 121.0 (qd, *J* = 289.8, 28.1 Hz), 114.1, 114.0, 110.6 (d, *J* = 21.2 Hz), 103.0, 97.9, 96.5 – 93.0 (m), 17.1 (d, *J* = 20.5 Hz). **MS** (**EI**): m/z 372 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{14}H_7F_7O_4$: 372.0227; Found: 372.0225.

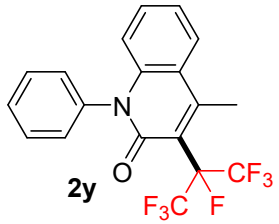
5,7-Dimethoxy-3-(perfluoropropan-2-yl)-2*H*-chromen-2-one (2x)



2x

The product mixture was purified by silica gel column chromatography (PE / EA = 10:1) to afford **2x** (144.1 mg, 64%) as a white solid, mp 180-181 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.42 (s, 1H), 6.43 (d, *J* = 1.8 Hz, 1H), 6.31 (d, *J* = 1.9 Hz, 1H), 3.93 (s, 3H), 3.88 (s, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -74.25 (d, *J* = 5.2 Hz, 6F), -175.35 – -175.49 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.2, 158.1, 157.6, 156.7, 140.9 (d, *J* = 17.0 Hz), 120.5 (qd, *J* = 289.4, 27.6 Hz), 109.3 (d, *J* = 22.6 Hz), 103.0 (d, *J* = 2.4 Hz), 95.4, 92.6, 93.3 – 89.9 (m), 56.3, 56.2. **MS** (**EI**): m/z 374 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{14}H_9F_7O_4$: 374.0384; Found: 374.0390.

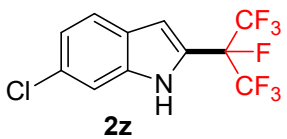
4-Methyl-3-(perfluoropropan-2-yl)-1-phenylquinolin-2(1*H*)-one (2y)



2y

The product mixture was purified by silica gel column chromatography (PE / EA = 8:1) to afford **2y** (126.5 mg, 52%) as a white solid, mp 177-178 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 8.3 Hz, 1H), 7.59 (t, *J* = 7.6 Hz, 2H), 7.51 (t, *J* = 7.4 Hz, 1H), 7.41 (t, *J* = 7.7 Hz, 1H), 7.32 – 7.22 (m, 3H), 6.69 (d, *J* = 8.4 Hz, 1H), 2.81 (d, *J* = 6.0 Hz, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -72.11 (d *J* = 1.8 Hz, 6F), -165.44 – -165.53 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.0 (d, *J* = 7.5 Hz), 152.9, 140.8, 137.0, 132.0, 130.5, 129.3, 128.9, 126.1, 122.9, 121.3 (qd, *J* = 289.9, 28.4 Hz), 121.1, 119.1 (d, *J* = 20.9 Hz), 116.4, 97.4 – 93.9 (m), 16.9 (d, *J* = 21.1 Hz). **MS** (**EI**): m/z 403 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{19}H_{12}F_7NO$: 403.0802; Found: 403.0803.

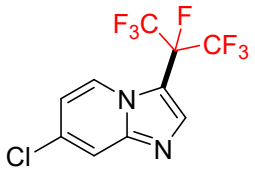
6-Chloro-2-(perfluoropropan-2-yl)-1*H*-indole (2z)



2z

The product mixture was purified by silica gel column chromatography (PE / EA = 50:1) to afford **2z** (117.2 mg, 61%) as a white solid, mp 95-96 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.44 (s, 1H), 7.59 (d, *J* = 8.5 Hz, 1H), 7.46 (s, 1H), 7.19 (dd, *J* = 8.5, 1.6 Hz, 1H), 6.89 (s, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -76.30 (d, *J* = 9.1 Hz, 6F), -180.36 – -180.54 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 136.7, 130.7, 125.9, 122.8, 122.4 (d, *J* = 22.0 Hz), 122.3, 120.3 (qd, *J* = 288.0, 27.4 Hz), 111.6, 105.7 – 105.5 (m), 91.3 – 87.8 (m). **MS** (**EI**): m/z 319 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{11}H_5ClF_7N$: 318.9993; Found: 318.9996.

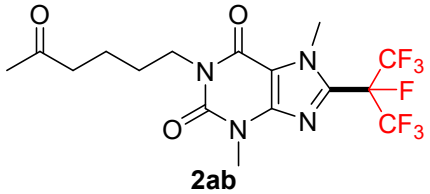
7-Chloro-3-(perfluoropropan-2-yl)imidazo[1,2-*a*]pyridine (2aa)



2aa

The product mixture was purified by silica gel column chromatography (PE / EA = 10:1) to afford **2aa** (131.1 mg, 68%) as a white solid, mp 78-80 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.28 (d, *J* = 7.5 Hz, 1H), 7.90 (s, 1H), 7.73 (d, *J* = 1.5 Hz, 1H), 6.95 (dd, *J* = 7.5, 1.6 Hz, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.14 (d, *J* = 10.5 Hz, 6F), -181.64 – -181.84 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 148.3, 137.1, 133.8 (d, *J* = 1.5 Hz), 126.8 (d, *J* = 12.3 Hz), 120.7 (qd, *J* = 289.8, 29.0 Hz), 117.5, 115.9, 110.0 (d, *J* = 23.6 Hz), 92.5 – 88.7 (m). **MS** (**EI**): m/z 320 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{10}H_4ClF_7N_2$: 319.9946; Found: 319.9943.

3,7-Dimethyl-1-(5-oxohexyl)-8-(perfluoropropan-2-yl)-3,7-dihydro-1*H*-purine-2,6-dione (2ab)

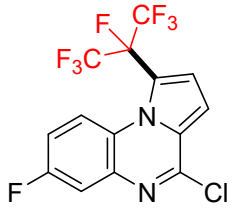


2ab

Using NFSI as oxidant. The product mixture was purified by silica gel column chromatography (PE / EA = 1:1) to afford **2ab** (125.8 mg, 47%) as a white solid, mp 85-86 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 4.18 (d, *J* = 4.0 Hz, 3H), 3.99 (t, *J* = 6.6 Hz, 2H), 3.53 (s, 3H), 2.48 (t, *J* = 6.7 Hz, 2H), 2.12 (s, 3H), 1.67 – 1.59 (m, 4H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -74.53 (d, *J* = 7.8 Hz, 6F), -184.60 – -184.76 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 208.7, 155.3, 151.1, 147.3, 136.1 (d, *J* = 22.7 Hz), 119.7 (qd, *J* =

289.8, 27.0 Hz), 110.0, 92.3 – 88.8 (m), 43.2, 41.2, 34.2 (d, *J* = 11.0 Hz), 30.1, 29.9, 27.5, 21.0. **MS** (**EI**): m/z 446 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{16}H_{17}F_7N_4O_3$: 446.1183; Found: 446.1178.

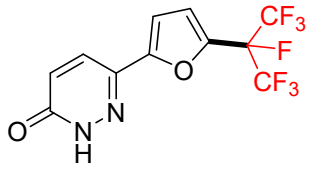
4-Chloro-7-fluoro-1-(perfluoropropan-2-yl)pyrrolo[1,2-*a*]quinoxaline (2ac)



2ac

The product mixture was purified by silica gel column chromatography (PE / EA = 50:1) to afford **2ac** (188.9 mg, 81%) as a white solid, mp 99-101 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.25 – 8.18 (m, 1H), 7.61 (dd, *J* = 8.6, 3.0 Hz, 1H), 7.35 – 7.26 (m, 2H), 7.23 (dd, *J* = 4.8, 1.5 Hz, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -72.66 (d, *J* = 9.3 Hz, 6F), -114.41 – -114.50 (m, 1F), -162.41 – -162.61 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.3 (dd, *J* = 248.4, 2.1 Hz), 146.5, 138.1 (d, *J* = 11.6 Hz), 129.1, 124.9 (d, *J* = 2.8 Hz), 120.8 (qd, *J* = 291.8, 29.2 Hz), 120.1 (dd, *J* = 30.3, 8.8 Hz), 119.6 – 119.3 (m), 117.4 (d, *J* = 20.7 Hz), 116.1 (dd, *J* = 23.6, 3.3 Hz), 115.5 (d, *J* = 22.8 Hz), 109.9, 93.3 – 89.8 (m). **MS** (**EI**): m/z 388 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{14}H_5ClF_8N_2$: 388.0008; Found: 388.0012.

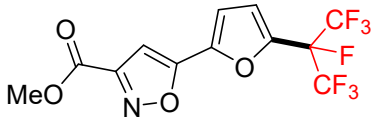
6-(5-(Perfluoropropan-2-yl)furan-2-yl)pyridazin-3(2*H*)-one (2ad)



2ad

The product mixture was purified by silica gel column chromatography (PE / EA = 1:1) to afford **2ad** (168.9 mg, 85%) as a white solid, mp 167-167 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 12.46 (s, 1H), 7.75 (d, *J* = 9.9 Hz, 1H), 7.10 (d, *J* = 9.9 Hz, 1H), 7.01 (dd, *J* = 3.6, 1.0 Hz, 1H), 6.95 (d, *J* = 3.5 Hz, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.41 (d, *J* = 9.6 Hz, 6F), -176.30 – -176.51 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.6, 152.2 (d, *J* = 1.7 Hz), 139.9 (d, *J* = 27.0 Hz), 137.8, 130.7, 130.3, 120.0 (qd, *J* = 288.8, 27.5 Hz), 116.5, 109.2, 89.9 – 86.3 (m). **MS** (**EI**): m/z 330 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{11}H_5F_7N_2O_2$: 330.0234; Found: 330.0231.

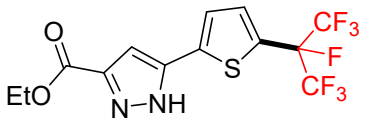
Methyl 5-(5-(perfluoropropan-2-yl)furan-2-yl)isoxazole-3-carboxylate (2ae)



2ae

The product mixture was purified by silica gel column chromatography (PE / EA = 10:1) to afford **2ae** (193.4 mg, 89%) as a white solid, mp 74-75 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.05 (d, *J* = 3.6 Hz, 1H), 6.95 (d, *J* = 3.6 Hz, 1H), 6.94 (s, 1H), 3.97 (s, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.69 (d, *J* = 9.5 Hz, 6F), -177.82 – -178.01 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.7, 159.8, 156.7, 145.2, 141.2 (d, *J* = 27.4 Hz), 119.8 (qd, *J* = 289.0, 27.6 Hz), 116.0, 111.9, 101.5, 89.9 – 86.4 (m), 53.1. **MS** (**EI**): m/z 361 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{12}H_6F_7NO_4$: 361.0180; Found: 361.0178.

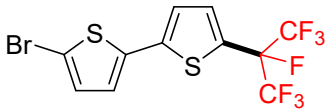
Ethyl 5-(5-(perfluoropropan-2-yl)thiophen-2-yl)-1*H*-pyrazole-3-carboxylate (2af)



2af, 71%

The product mixture was purified by silica gel column chromatography (PE / EA = 2:1) to afford **2af** (166.8 mg, 71%) as a white solid, mp 139-140 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 11.79 (s, 1H), 7.40 – 7.35 (m, 1H), 7.33 (d, *J* = 4.0 Hz, 1H), 7.06 (s, 1H), 4.43 (q, *J* = 7.1 Hz, 2H), 1.41 (t, *J* = 7.1 Hz, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -76.71 (d, *J* = 8.5 Hz, 6F), -171.36 – -171.52 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.5, 146.2, 139.1, 136.4, 129.5 (d, *J* = 6.4 Hz), 126.7 (d, *J* = 23.6 Hz), 124.5, 120.3 (qd, *J* = 288.4, 27.8 Hz), 106.1, 92.9 – 89.4 (m), 62.0, 14.3. **MS** (**EI**): m/z 390 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{13}H_9F_7N_2O_2S$: 390.0267; Found: 390.0274.

5-Bromo-5'-(perfluoropropan-2-yl)-2,2'-bithiophene (2ag)

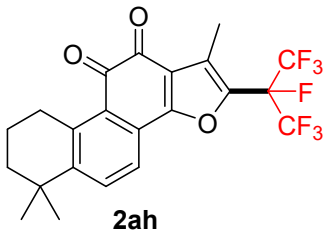


2ag

The product mixture was purified by silica gel column chromatography (PE / EA = 10:1) to afford **2ag** (211.6 mg, 85%) as a white solid, mp 36-37 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.26 (d, *J* = 3.7 Hz, 1H), 7.11 – 7.07 (m, 1H), 7.00 (d, *J* = 3.9 Hz, 1H), 6.97 (d, *J* = 3.9 Hz, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -76.71 (d, *J* = 8.5 Hz, 6F), -171.18 – -171.35 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 140.3, 136.9, 131.0, 129.7

(d, J = 6.2 Hz), 126.0 (d, J = 23.8 Hz), 125.4, 124.0, 120.2 (qd, J = 288.5, 27.8 Hz), 113.0, 92.7 – 89.3 (m). **MS** (**EI**): m/z 412 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{11}H_4BrF_7S_2$: 411.8821; Found: 411.8816.

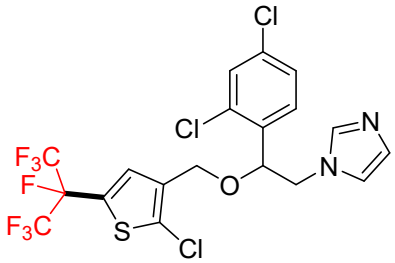
1,6,6-Trimethyl-2-(perfluoropropan-2-yl)-6,7,8,9-tetrahydrophenanthro[1,2-*b*]furan-10,11-dione (2ah)



2ah

The product mixture was purified by silica gel column chromatography (PE / EA = 20:1) to afford **2ah** (150.5 mg, 54%) as an orange red solid, mp 152-154 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.67 (d, J = 8.1 Hz, 1H), 7.56 (d, J = 8.1 Hz, 1H), 3.15 (t, J = 6.3 Hz, 2H), 2.42 (d, J = 2.3 Hz, 3H), 1.83 – 1.72 (m, 2H), 1.67 – 1.60 (m, 2H), 1.29 (s, 6H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.88 (d, J = 8.8 Hz, 6F), -184.42 – -184.60 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 182.4, 175.2, 162.3, 151.9, 145.2, 136.1 (d, J = 31.3 Hz), 133.9, 126.9, 126.7, 126.0, 120.9, 120.2 (qd, J = 289.7, 27.1 Hz), 120.1 (d, J = 1.1 Hz), 91.6 – 88.1 (m), 37.8, 35.0, 31.9, 30.0, 19.1, 8.7 (d, J = 5.6 Hz). **MS** (**EI**): m/z 462 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{22}H_{17}F_7O_3$: 462.1060; Found: 462.1056.

1-(2-((2-Chloro-5-(perfluoropropan-2-yl)thiophen-3-yl)methoxy)-2-(2,4-dichlorophenyl)ethyl)-1*H*-imidazole (2ai)

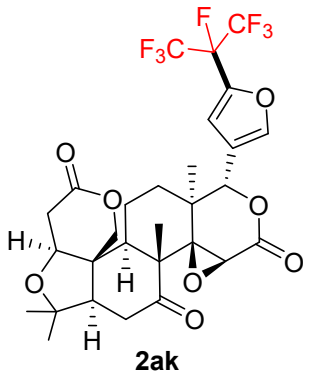


2ai

The product mixture was purified by silica gel column chromatography (DCM / EA = 1:1) to afford **2ai** (253.8 mg, 76%) as an off-white solid, mp 65-66 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.43 – 7.39 (m, 2H), 7.27 – 7.25 (m, 2H), 7.06 (s, 1H), 7.00 (s, 1H), 6.86 (s, 1H), 4.95 (dd, J = 7.7, 2.8 Hz, 1H), 4.37 (d, J = 12.1 Hz, 1H), 4.24 (d, J = 12.1 Hz, 1H), 4.16 (dd, J = 14.6, 2.8 Hz, 1H), 4.00 (dd, J = 14.5, 7.7 Hz, 1H). **^{19}F NMR** (376

MHz, $CDCl_3$) δ -76.71 (d, *J* = 8.5 Hz, 6F), -172.59 – -172.76 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 137.9, 135.2, 135.1, 133.6, 133.3, 132.4 (d, *J* = 2.0 Hz), 129.8, 129.4, 129.3 (d, *J* = 6.9 Hz), 128.4, 128.0, 124.8 (d, *J* = 24.3 Hz), 119.9 (qd, *J* = 288.6, 27.5 Hz), 119.7, 92.3 – 89.0 (m), 77.6, 64.1, 51.4. **MS** (**EI**): m/z 554 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{19}H_{12}Cl_3F_7N_2OS$: 553.9619; Found: 553.9615.

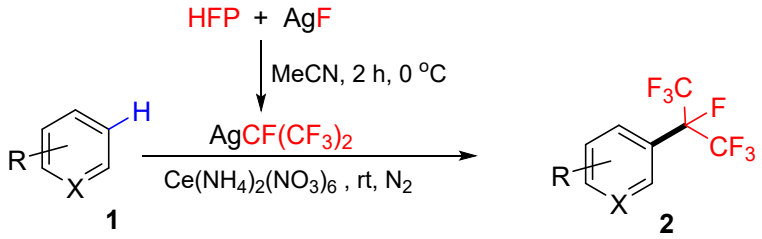
(4aS,6aR,8aR,8bR,9aS,12S,12aS,14aR,14bR)-6,6,8a,12a-tetramethyl-12-(5-(perfluoropropan-2-yl)furan-3-yl)decahydro-1*H*,3*H*-oxireno[2,3-*d*]pyrano[4',3':3,3a]isobenzofuro[5,4-*f*]isochromene-3,8,10(6*H*,9a*H*)-trione (2ak)



2ak

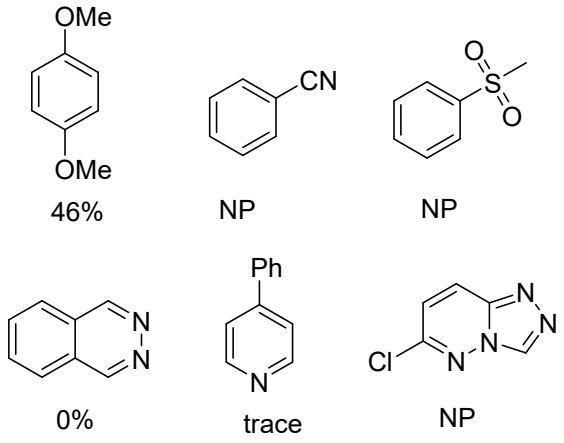
The product mixture was purified by silica gel column chromatography (DCM / EA = 1:1) to afford **2ak** (275.6 mg, 72%) as a white solid, mp 255-257 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.55 (s, 1H), 6.74 (s, 1H), 5.44 (s, 1H), 4.71 (d, *J* = 13.1 Hz, 1H), 4.42 (d, *J* = 13.1 Hz, 1H), 4.01 (s, 1H), 3.97 (s, 1H), 2.89 – 2.77 (m, 2H), 2.64 (d, *J* = 16.3 Hz, 1H), 2.52 (d, *J* = 11.3 Hz, 1H), 2.42 – 2.34 (m, 1H), 2.26 – 2.19 (m, 1H), 1.94 – 1.83 (m, 1H), 1.82 – 1.72 (m, 2H), 1.49 – 1.39 (m, 1H), 1.20 (s, 3H), 1.09 (s, 3H), 1.08 (s, 3H), 1.01 (s, 3H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -75.71 (d, *J* = 9.1 Hz, 6F), -177.13 – -177.33 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 206.4, 169.5, 166.4, 144.0, 139.9 (d, *J* = 27.4 Hz), 121.8, 119.7 (qd, *J* = 288.8, 27.9 Hz), 113.7, 89.6 – 86.1 (m), 80.2, 79.0, 65.7, 65.3, 60.2, 53.8, 51.2, 47.9, 45.9, 37.9, 36.3, 35.6, 30.6, 30.0, 21.3, 20.4, 18.6, 17.5. **MS** (**ESI**): m/z 661 ($[M+Na]^+$); **HRMS**(**ESI**): m/z ($[M+Na]^+$) Calcd for $C_{29}H_{29}F_7O_8Na$: 661.1643; Found: 661.1657.

3. Screening Results for Incompatible Arenes and Heteroarenes

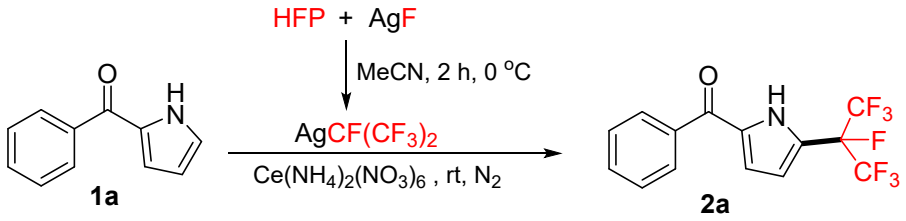


In a nitrogen-filled glove box, an oven-dried reaction tube with Teflon-coated stirrer bar was charged with silver fluoride (50.8 mg, 0.4 mmol) and was brought under an atmosphere of dry nitrogen. To this vessel, anhydrous acetonitrile (2.0 mL) and hexafluoropropylene (balloon, 1 atm) were added, and the mixture was stirred at ice-water bath in the dark until silver fluoride precipitate dissolved completely. Then this solution was added to another oven-dried vessel, which was filled with $Ce(NH_4)_2(NO_3)_6$ (219.2 mg, 0.4 mmol) and heteroarene (0.2 mmol). After stirred at room temperature for 12 hours, trifluoromethoxybenzene was added as an internal standard. Yields were determined by ^{19}F NMR spectroscopy.

Table S1. Screening Results for Incompatible (Hetero)arenes



4. Oxidative Heptafluoroisopropylation of 1a on a 1.0 mmol Scale

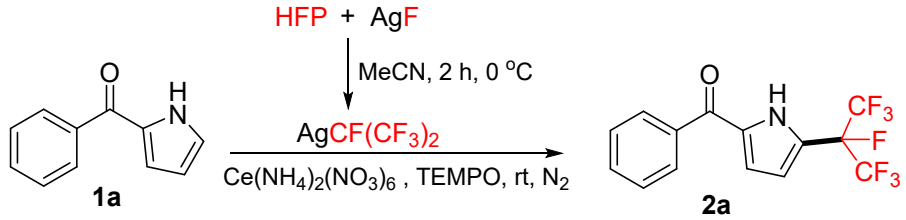


In a nitrogen-filled glove box, an oven-dried reaction tube with Teflon-coated stirrer bar was charged with silver fluoride (254.0 mg, 2.0 mmol) and was brought under an atmosphere of dry nitrogen. To this vessel, anhydrous acetonitrile (10.0 mL) and

hexafluoropropylene (balloon, 1 atm) were added, and the mixture was stirred at ice-water bath in the dark until silver fluoride precipitate dissolved completely. Then this solution was added to another oven-dried vessel, which was filled with $Ce(NH_4)_2(NO_3)_6$ (1096.4 mg, 2.0 mmol) and phenyl(1H-pyrrol-2-yl)methanone (171.2 mg, 1.0 mmol). The reaction mixture was stirred at ambient temperature for 12 hours. The crude mixture was filtered through a pad of Celite, and the pad was washed with EtOAc. The filtrate was concentrated in vacuo and purified by flash column chromatography over silica gel (elution with PE / EA = 8:1) to give **2a** (308.9 mg, 91%) as a white solid.

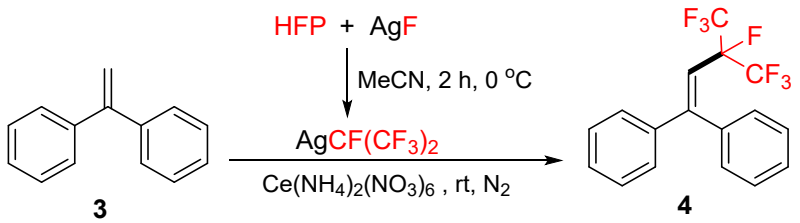
5. Mechanistic Experiments

Heptafluoroisopropylation of Alkene 1a in the presence of TEMPO



In a nitrogen-filled glove box, an oven-dried reaction tube with Teflon-coated stirrer bar was charged with silver fluoride (50.8 mg, 0.4 mmol) and was brought under an atmosphere of dry nitrogen. To this vessel, anhydrous acetonitrile (2.0 mL) and hexafluoropropylene (balloon, 1 atm) were added, and the mixture was stirred at ice-water bath in the dark until silver fluoride precipitate dissolved completely. Then this solution was added to another oven-dried vessel, which filling with $Ce(NH_4)_2(NO_3)_6$ (219.2 mg, 0.4 mmol) and phenyl(1H-pyrrol-2-yl)methanone (34.2 mg, 0.2 mmol). and TEMPO (62.4 mg, 0.4 mmol). After stirred at room temperature for 12 hours, trifluoromethoxybenzene was added as an internal standard. ^{19}F NMR analysis of this reaction mixture showed that **2a** was not fromed.

Heptafluoroisopropylation of 1,1-Diphenylethylene (3)



In a nitrogen-filled glove box, an oven-dried reaction tube with Teflon-coated stirrer bar was charged with silver fluoride (152.4 mg, 1.2 mmol) and was brought under an atmosphere of dry nitrogen. To this vessel, anhydrous acetonitrile (6.0 mL) and hexafluoropropylene (balloon, 1 atm) were added, and the mixture was stirred at ice-water bath in the dark until silver fluoride

precipitate dissolved completely. Then this solution was added to another oven-dried vessel, which was filled with $Ce(NH_4)_2(NO_3)_6$ (657.6 mg, 1.2 mmol). In the end, 1,1-Diphenylethylene (108.1 mg, 0.6 mmol) was added. The reaction mixture was stirred at ambient temperature for 12 hours. The crude mixture was filtered through a pad of Celite, and the pad was washed with EtOAc. The filtrate was concentrated in vacuo and purified by flash column chromatography over silica gel (elution with PE) to afford **4** (190.6 mg, 91%) as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.47 – 7.44 (m, 3H), 7.43 – 7.37 (m, 3H), 7.37 – 7.30 (m, 4H), 6.09 (d, J = 26.4 Hz, 1H). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -76.88 (d, J = 7.7 Hz, 6F), -184.15 – -184.36 (m, 1F). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 153.4, 141.3, 137.9 (d, J = 2.7 Hz), 129.3, 128.8 (d, J = 3.3 Hz), 128.7, 128.1, 127.9, 127.8, 120.7 (qd, J = 288.8, 28.0 Hz), 110.1 (d, J = 13.7 Hz), 93.8 – 90.2 (m). **MS** (**EI**): m/z 348 M^+; **HRMS** (**EI-TOF**): m/z M^+ Calcd for $C_{17}H_{11}F_7$: 348.0743; Found: 348.0748.

6. X-ray structural data

X-ray structural data for 2a

Crystals suitable for X-Ray analysis was obtained via vapor diffusion (DCM/hexane) at room temperature.

The crystal structure has been deposited at the Cambridge Crystallographic Date Center and allocated the deposition numbers CCDC 2142015. This data can be obtained free of charge from the Cambridge Crystallographic Date Center via www.ccdc.cam.ac.uk/data_request/cif

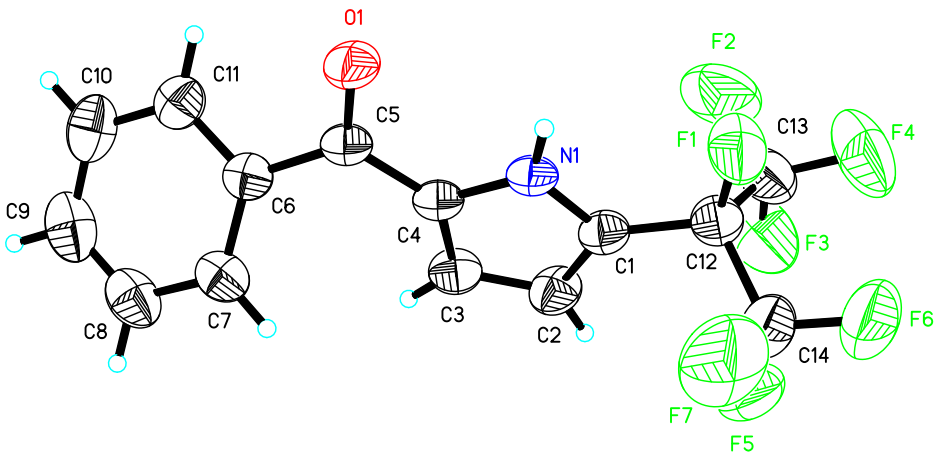


Figure S1. ORTEP drawing of the X-ray crystallographic structure of compound 2a. The thermal ellipsoids are shown at the 30% probability level.

Table S2. Crystal data and structure refinement for **2a**.

Identification code	mo_d8v21842_0m	
Empirical formula	C14 H8 F7 N O	
Formula weight	339.21	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 21/c	
Unit cell dimensions	a = 13.1368(5) Å	a= 90°.
	b = 7.7148(3) Å	b= 111.4880(10)°.
	c = 15.2040(6) Å	g = 90°.
Volume	1433.79(10) $Å^3$	
Z	4	
Density (calculated)	1.571 Mg/m^3	
Absorption coefficient	0.161 mm^{-1}	
F(000)	680	
Crystal size	0.200 x 0.150 x 0.100 mm^3	
Theta range for data collection	2.748 to 25.999°.	
Index ranges	-16<=h<=15, -9<=k<=9, -18<=l<=18	
Reflections collected	20585	
Independent reflections	2799 [R(int) = 0.0665]	
Completeness to theta = 25.242°	99.4 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7456 and 0.5292	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2799 / 0 / 209	
Goodness-of-fit on F^2	1.051	
Final R indices [I>2sigma(I)]	R1 = 0.0703, wR2 = 0.2044	
R indices (all data)	R1 = 0.0915, wR2 = 0.2310	
Extinction coefficient	0.056(14)	

Largest diff. peak and hole	0.329 and -0.209 e.Å^{-3}

X-ray structural data for 2o

Crystals suitable for X-Ray analysis was obtained via vapor diffusion (DCM/hexane) at room temperature.

The crystal structure has been deposited at the Cambridge Crystallographic Date Center and allocated the deposition numbers CCDC 2142017. This data can be obtained free of charge from the Cambridge Crystallographic Date Center via www.ccdc.cam.ac.uk/data_request/cif

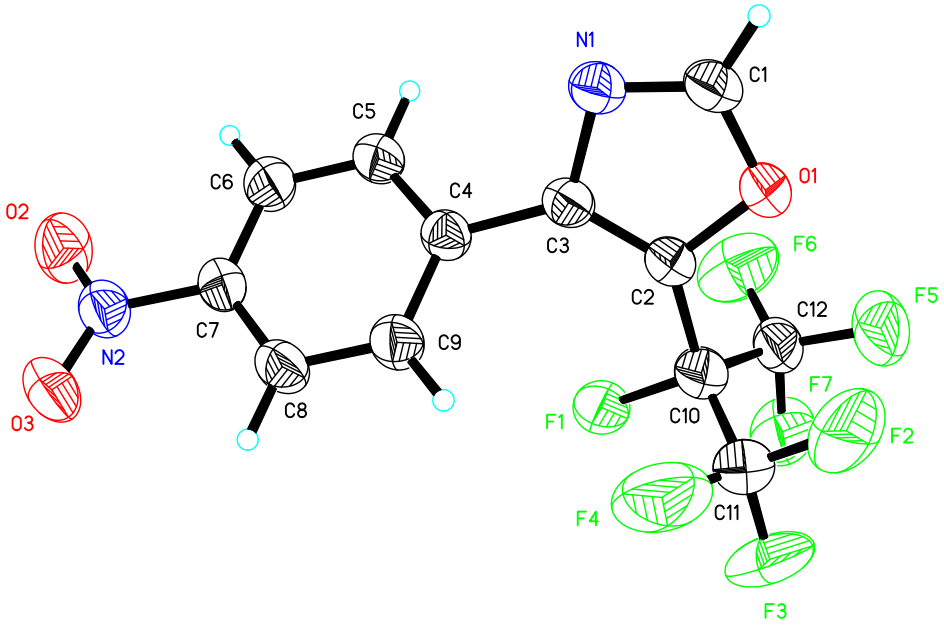


Figure S2. ORTEP drawing of the X-ray crystallographic structure of compound 2o. The thermal ellipsoids are shown at the 30% probability level.

Table S3. Crystal data and structure refinement for 2o.

Identification code	mo_d8v21846_0m	
Empirical formula	C12 H5 F7 N2 O3	
Formula weight	358.18	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 21/c	
Unit cell dimensions	a = 14.5625(6) Å	a= 90°.
	b = 6.7748(3) Å	b= 115.6730(10)°.
	c = 15.5762(6) Å	g = 90°.
Volume	1385.01(10) $Å^3$	
Z	4	
Density (calculated)	1.718 Mg/m^3	
Absorption coefficient	0.184 mm^{-1}	
F(000)	712	
Crystal size	0.200 x 0.150 x 0.120 mm^3	
Theta range for data collection	2.632 to 24.999°.	
Index ranges	-17<=h<=16, -8<=k<=8, -18<=l<=18	
Reflections collected	18273	
Independent reflections	2412 [R(int) = 0.0464]	
Completeness to theta = 25.242°	96.1 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7456 and 0.5960	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2412 / 137 / 299	
Goodness-of-fit on F^2	1.026	
Final R indices [I>2sigma(I)]	R1 = 0.0495, wR2 = 0.1301	
R indices (all data)	R1 = 0.0616, wR2 = 0.1436	
Extinction coefficient	0.041(10)	

Largest diff. peak and hole	0.221 and -0.174 e.Å^{-3}

X-ray structural data for 2u

Crystals suitable for X-Ray analysis was obtained via vapor diffusion (DCM/hexane) at room temperature.

The crystal structure has been deposited at the Cambridge Crystallographic Date Center and allocated the deposition numbers CCDC 2142018. This data can be obtained free of charge from the Cambridge Crystallographic Date Center via www.ccdc.cam.ac.uk/data_request/cif

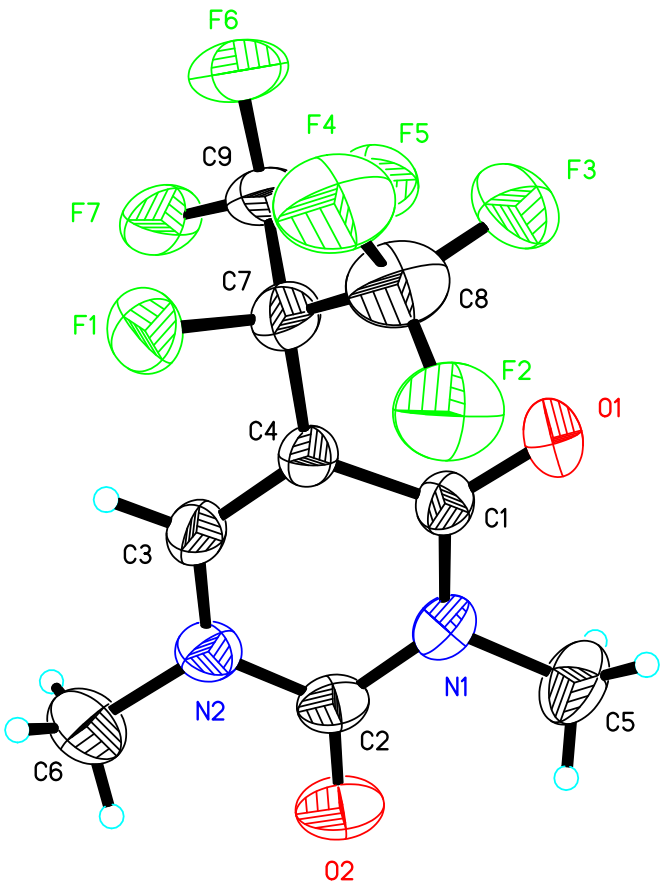


Figure S3. ORTEP drawing of the X-ray crystallographic structure of compound 2u. The thermal ellipsoids are shown at the 30% probability level.

Table S4. Crystal data and structure refinement for **2u**.

Identification code	d8v21857	
Empirical formula	C9 H7 F7 N2 O2	
Formula weight	308.17	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	C c	
Unit cell dimensions	a = 13.3881(15) Å	a= 90°.
	b = 13.9966(16) Å	b= 111.114(4)°.
	c = 7.0375(8) Å	g = 90°.
Volume	1230.2(2) $Å^3$	
Z	4	
Density (calculated)	1.664 Mg/m^3	
Absorption coefficient	0.186 mm^{-1}	
F(000)	616	
Crystal size	0.200 x 0.160 x 0.120 mm^3	
Theta range for data collection	4.374 to 25.969°.	
Index ranges	-15<=h<=16, -17<=k<=17, -8<=l<=8	
Reflections collected	8963	
Independent reflections	2287 [R(int) = 0.0374]	
Completeness to theta = 25.242°	97.9 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7456 and 0.6347	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2287 / 92 / 264	
Goodness-of-fit on F^2	1.052	
Final R indices [I>2sigma(I)]	R1 = 0.0489, wR2 = 0.1305	
R indices (all data)	R1 = 0.0585, wR2 = 0.1412	
Absolute structure parameter	-0.5(3)	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.161 and -0.126 $e.Å^{-3}$	

X-ray structural data for 2v

Crystals suitable for X-Ray analysis was obtained via vapor diffusion (DCM/hexane) at room temperature.

The crystal structure has been deposited at the Cambridge Crystallographic Date Center and allocated the deposition numbers CCDC 2142021. This data can be obtained free of charge from the Cambridge Crystallographic Date Center via www.ccdc.cam.ac.uk/data_request/cif

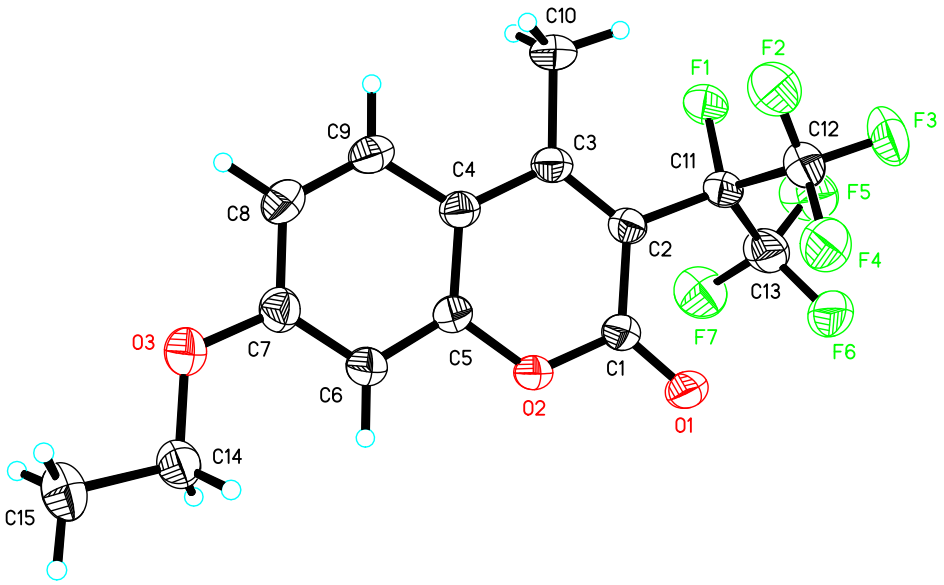


Figure S4. ORTEP drawing of the X-ray crystallographic structure of compound 2v. The thermal ellipsoids are shown at the 30% probability level.

Table S5. Crystal data and structure refinement for 2v.

Identification code	mo_d8v21841_0m	
Empirical formula	C15 H11 F7 O3	
Formula weight	372.24	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P -1	
Unit cell dimensions	a = 7.6131(4) Å	a= 101.045(2)°.
	b = 8.0077(4) Å	b= 94.103(2)°.
	c = 14.8609(7) Å	g = 118.1070(10)°.
Volume	770.51(7) $Å^3$	
Z	2	
Density (calculated)	1.604 Mg/m^3	
Absorption coefficient	0.165 mm^{-1}	
F(000)	376	
Crystal size	0.200 x 0.160 x 0.130 mm^3	
Theta range for data collection	2.843 to 25.995°.	
Index ranges	-9<=h<=9, -9<=k<=9, -18<=l<=18	
Reflections collected	15172	
Independent reflections	2988 [R(int) = 0.0408]	
Completeness to theta = 25.242°	98.7 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7456 and 0.6121	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2988 / 0 / 229	
Goodness-of-fit on F^2	1.049	
Final R indices [I>2sigma(I)]	R1 = 0.0413, wR2 = 0.1122	
R indices (all data)	R1 = 0.0505, wR2 = 0.1213	
Extinction coefficient	0.047(16)	
Largest diff. peak and hole	0.211 and -0.165 $e.Å^{-3}$	

X-ray structural data for 2ad

Crystals suitable for X-Ray analysis was obtained via vapor diffusion (DCM/hexane) at room temperature.

The crystal structure has been deposited at the Cambridge Crystallographic Date Center and allocated the deposition numbers CCDC 2142019. This data can be obtained free of charge from the Cambridge Crystallographic Date Center via www.ccdc.cam.ac.uk/data_request/cif

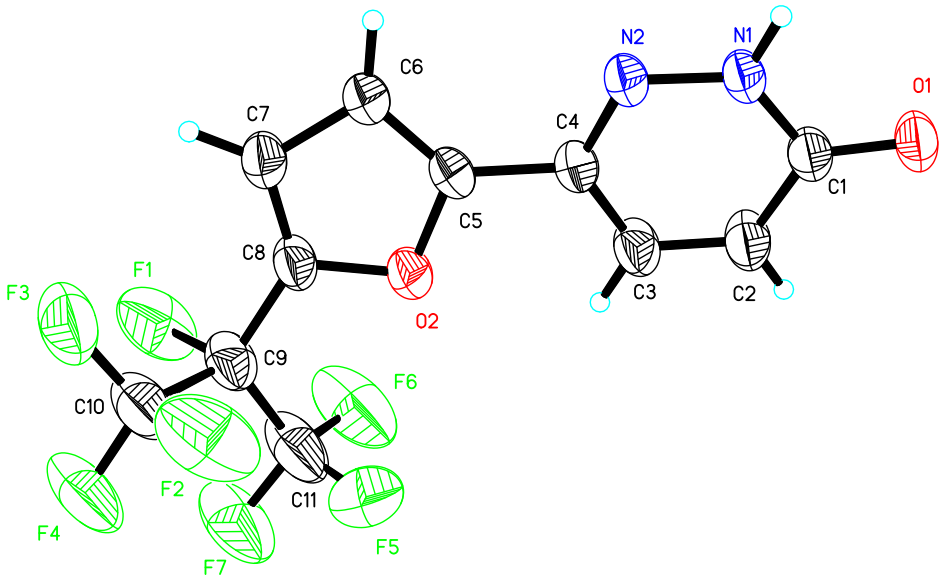


Figure S5. ORTEP drawing of the X-ray crystallographic structure of compound 2ad. The thermal ellipsoids are shown at the 30% probability level.

Table S6. Crystal data and structure refinement for **2ad**.

Identification code	mo_d8v21856_0m	
Empirical formula	C11 H5 F7 N2 O2	
Formula weight	330.17	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P -1	
Unit cell dimensions	a = 5.8411(4) Å	a= 93.549(2)°.
	b = 7.4893(6) Å	b= 99.686(2)°.
	c = 15.3251(11) Å	g = 103.603(2)°.
Volume	638.70(8) $Å^3$	
Z	2	
Density (calculated)	1.717 Mg/m^3	
Absorption coefficient	0.186 mm^{-1}	
F(000)	328	
Crystal size	0.200 x 0.150 x 0.070 mm^3	
Theta range for data collection	2.712 to 24.998°.	
Index ranges	-6<=h<=6, -8<=k<=8, -18<=l<=18	
Reflections collected	8513	
Independent reflections	2226 [R(int) = 0.0340]	
Completeness to theta = 25.242°	97.3 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7456 and 0.6369	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2226 / 2 / 199	
Goodness-of-fit on F^2	1.065	
Final R indices [I>2sigma(I)]	R1 = 0.0803, wR2 = 0.2404	
R indices (all data)	R1 = 0.0932, wR2 = 0.2593	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.523 and -0.285 $e.Å^{-3}$	

X-ray structural data for 2ae

Crystals suitable for X-Ray analysis was obtained via vapor diffusion (DCM/hexane) at room temperature.

The crystal structure has been deposited at the Cambridge Crystallographic Date Center and allocated the deposition numbers CCDC 2142020. This data can be obtained free of charge from the Cambridge Crystallographic Date Center via www.ccdc.cam.ac.uk/data_request/cif

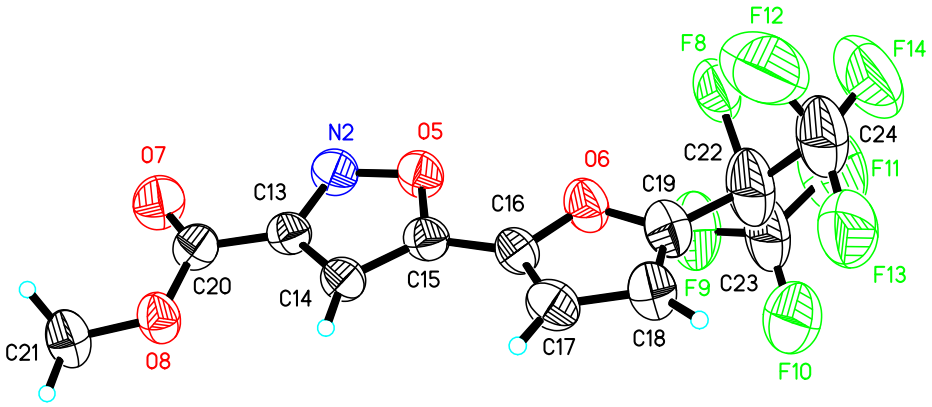


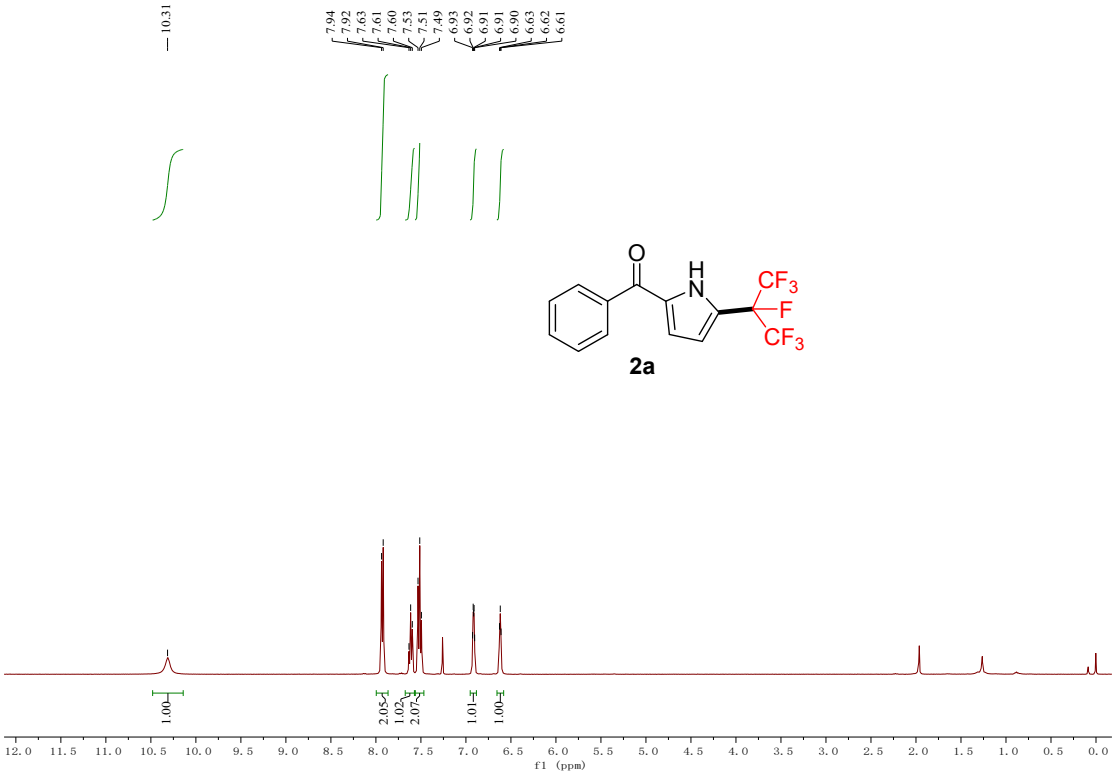
Figure S6. ORTEP drawing of the X-ray crystallographic structure of compound 2ae. The thermal ellipsoids are shown at the 30% probability level.

Table S7. Crystal data and structure refinement for **2ae**.

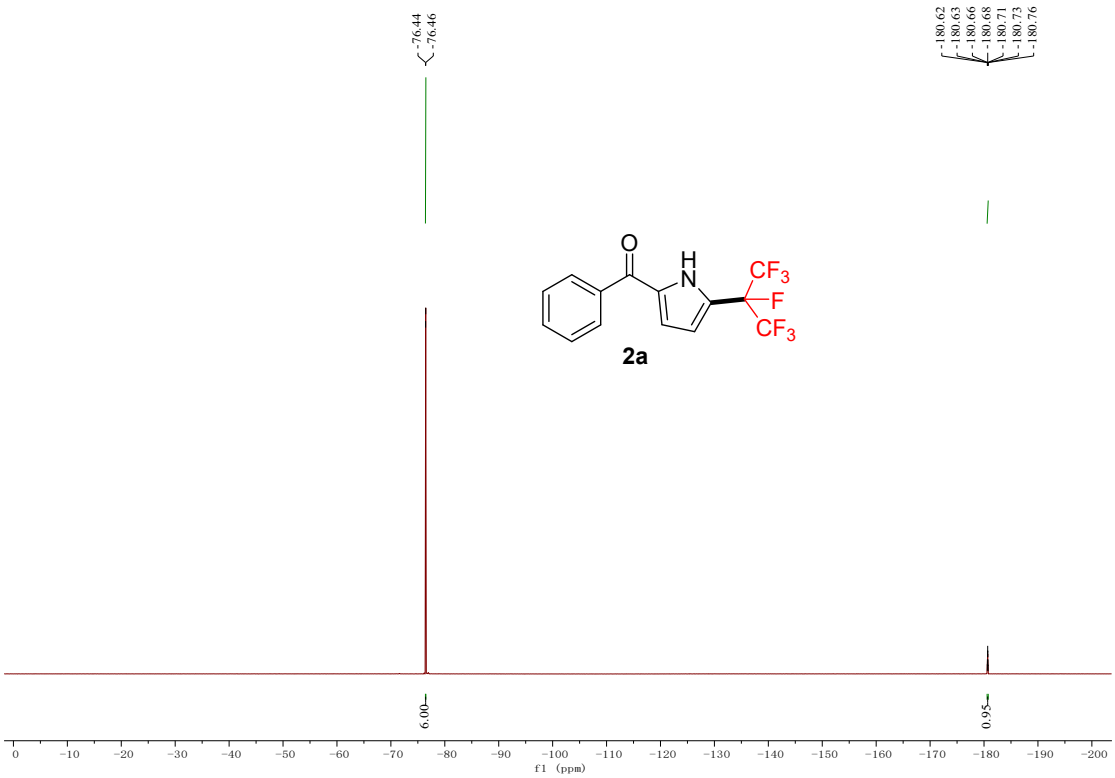
Identification code	d8v21845	
Empirical formula	C12 H6 F7 N O4	
Formula weight	361.18	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P -1	
Unit cell dimensions	a = 7.0659(7) Å	α= 94.470(3)°.
	b = 11.0627(11) Å	β= 99.704(3)°.
	c = 18.7151(18) Å	γ = 90.033(3)°.
Volume	1437.5(2) $Å^3$	
Z	4	
Density (calculated)	1.669 Mg/m^3	
Absorption coefficient	0.181 mm^{-1}	
F(000)	720	
Crystal size	0.200 x 0.160 x 0.070 mm^3	
Theta range for data collection	1.847 to 24.999°.	
Index ranges	-8<=h<=8, -13<=k<=12, -22<=l<=22	
Reflections collected	18644	
Independent reflections	5053 [R(int) = 0.0631]	
Completeness to theta = 25.242°	96.8 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7456 and 0.4198	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	5053 / 280 / 597	
Goodness-of-fit on F^2	1.250	
Final R indices [I>2sigma(I)]	R1 = 0.1077, wR2 = 0.2993	
R indices (all data)	R1 = 0.1425, wR2 = 0.3479	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.550 and -0.424 $e.Å^{-3}$	

7. Copies of ^{1}H NMR, ^{19}F NMR and ^{13}C NMR Spectra of Products

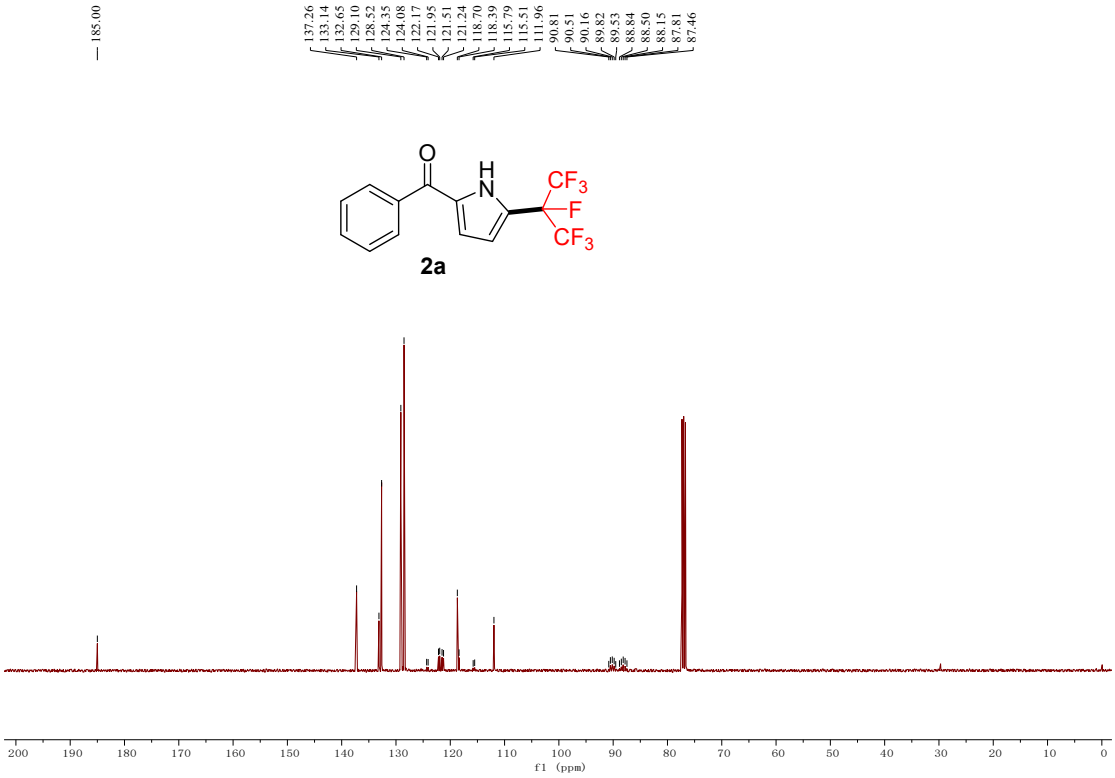
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



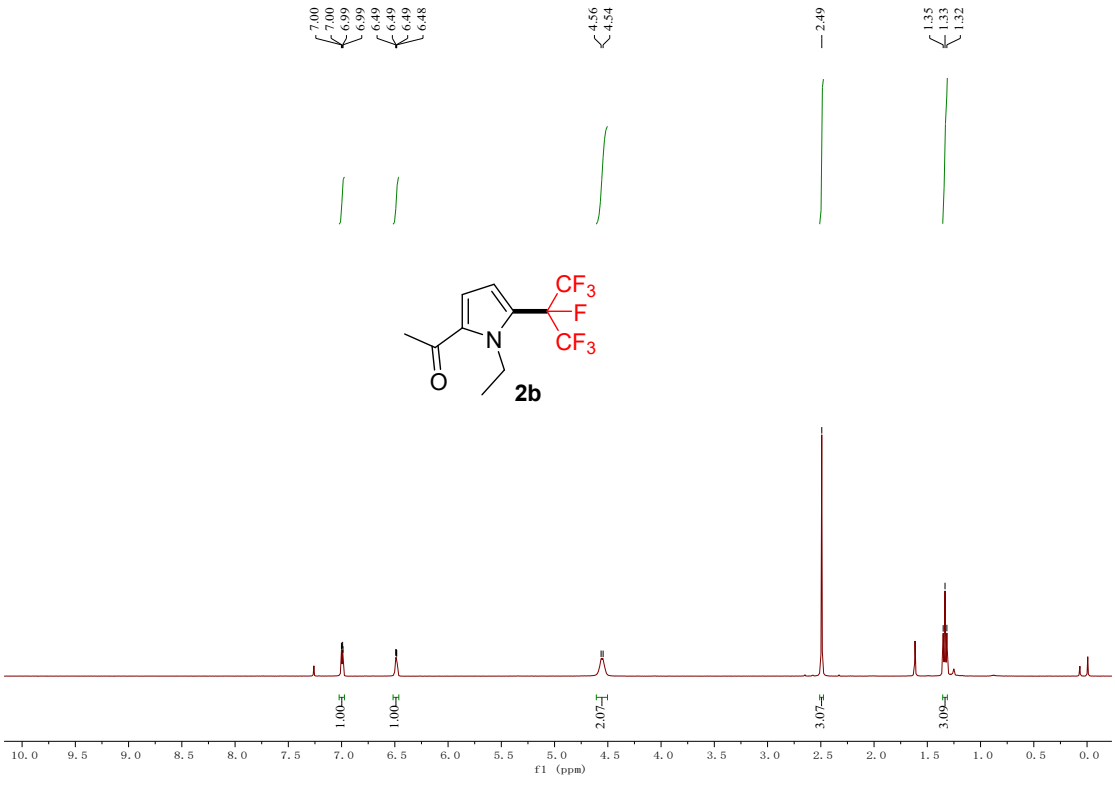
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



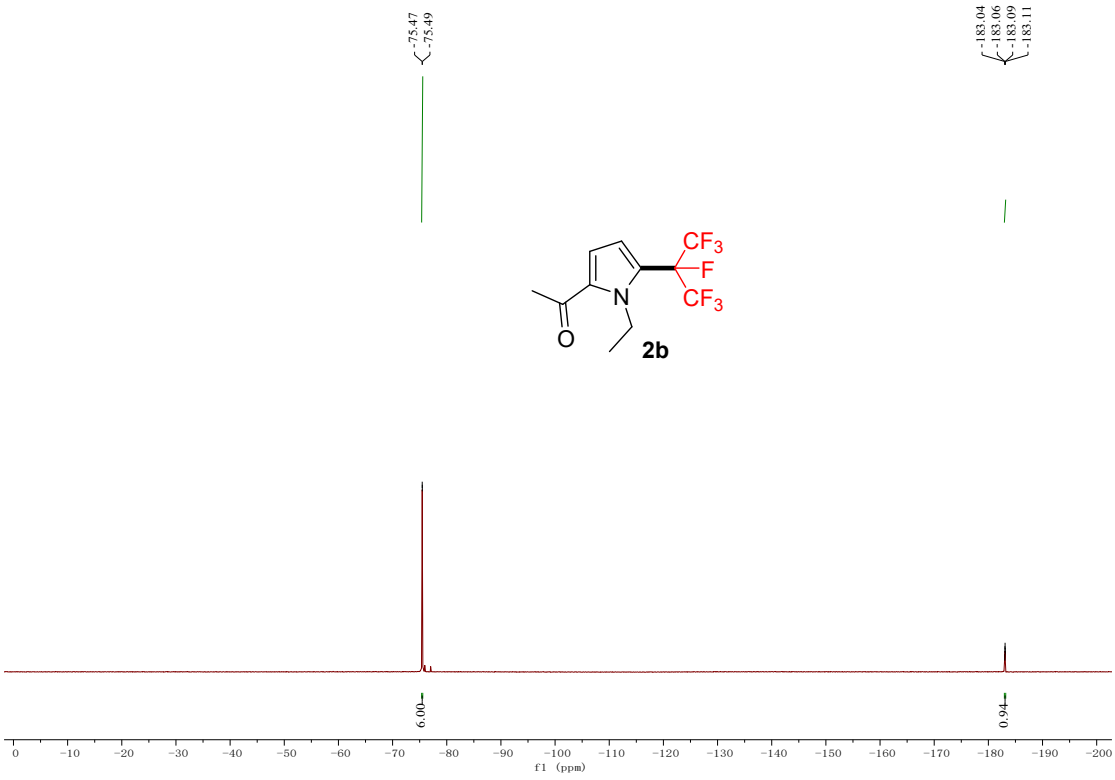
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



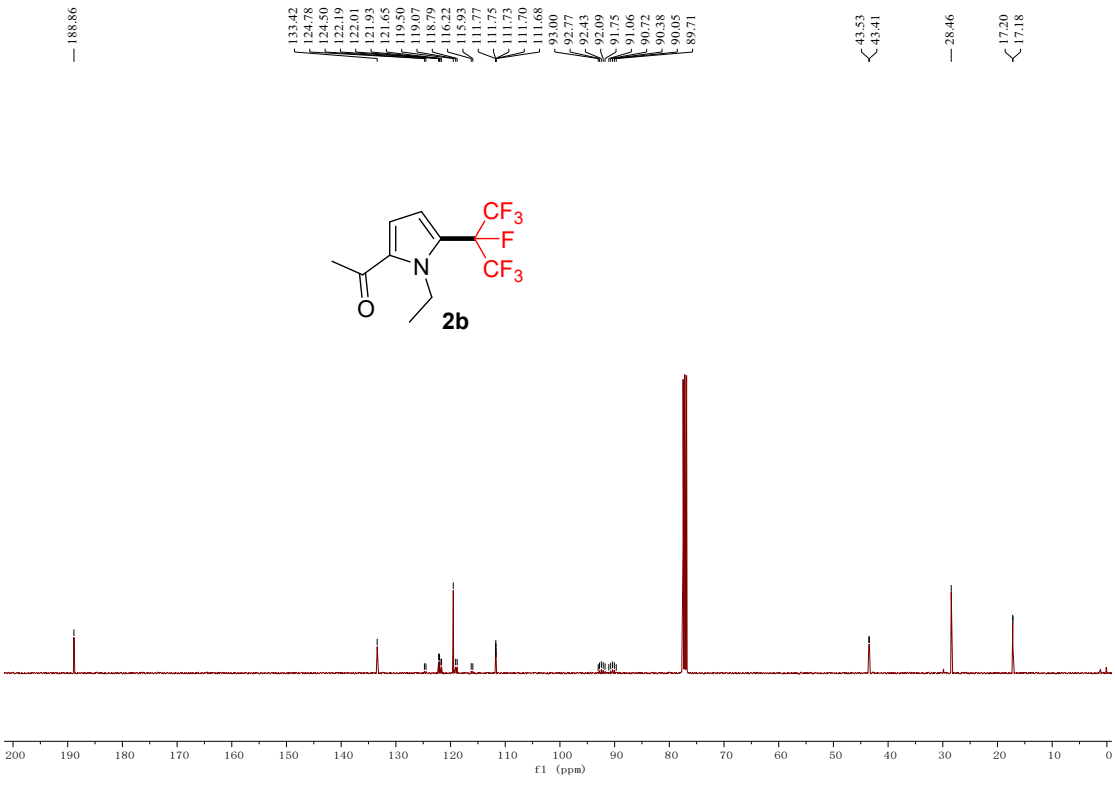
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



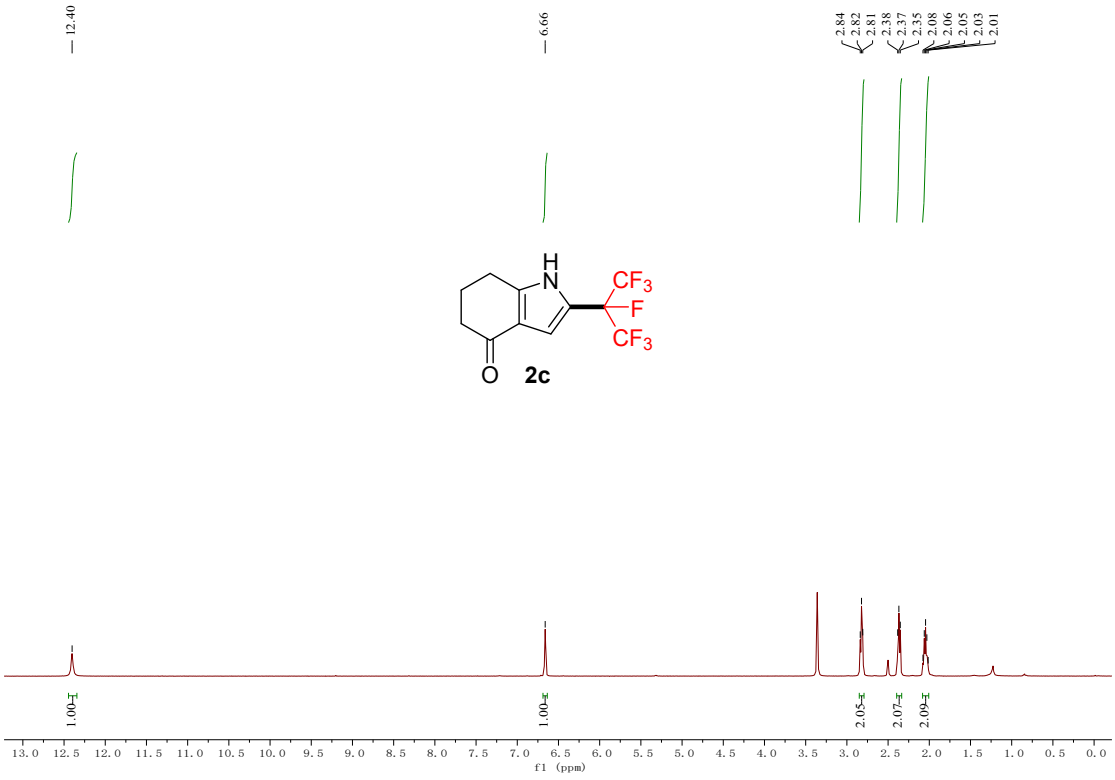
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



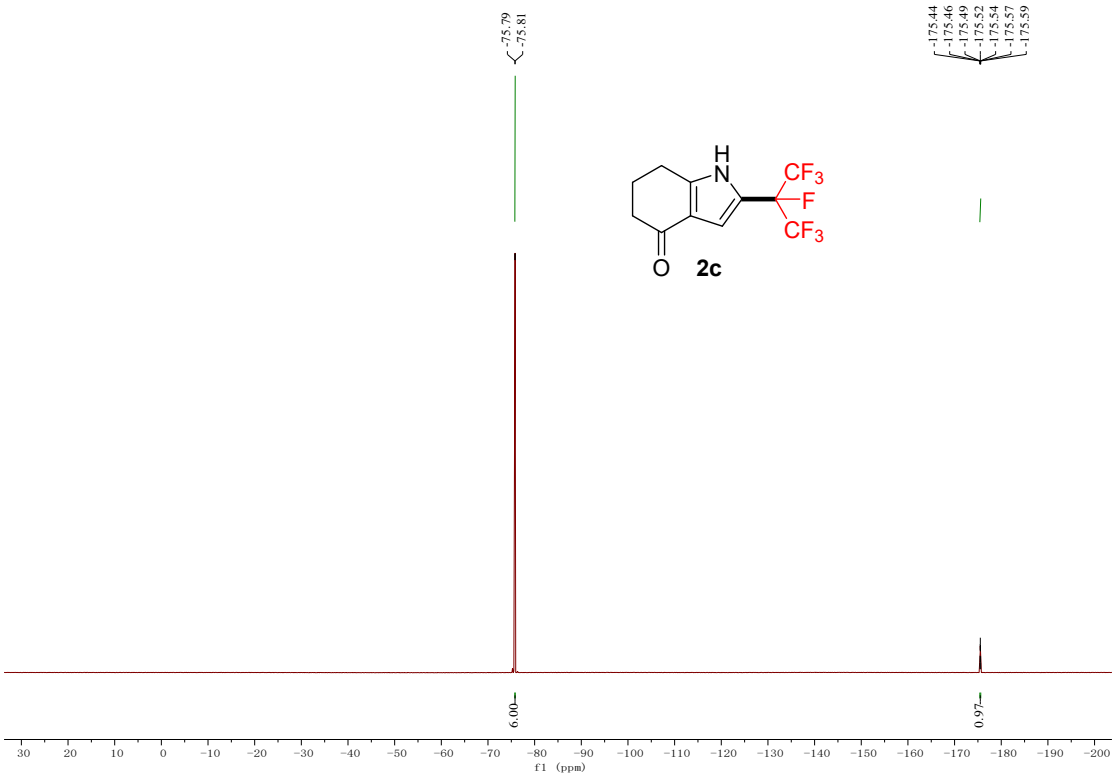
*^{13}C NMR (*101MHz, *$CDCl_3$)*



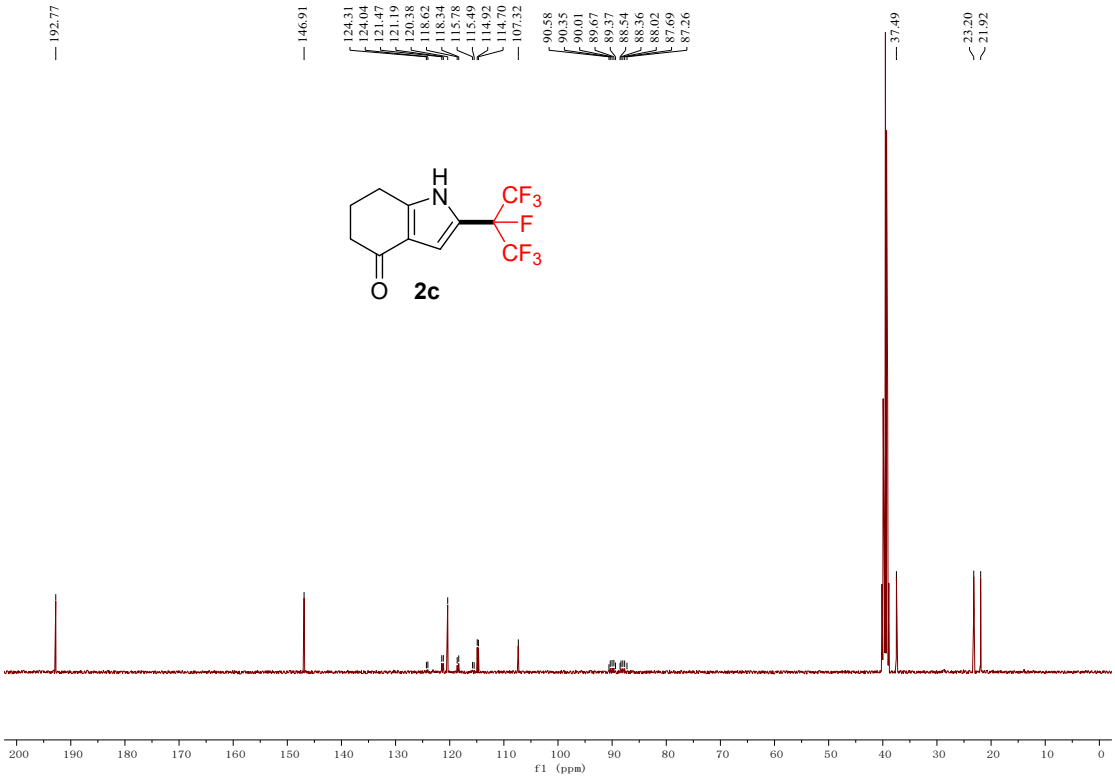
*[1]H NMR (*400 MHz, DMSO-d_6*)*



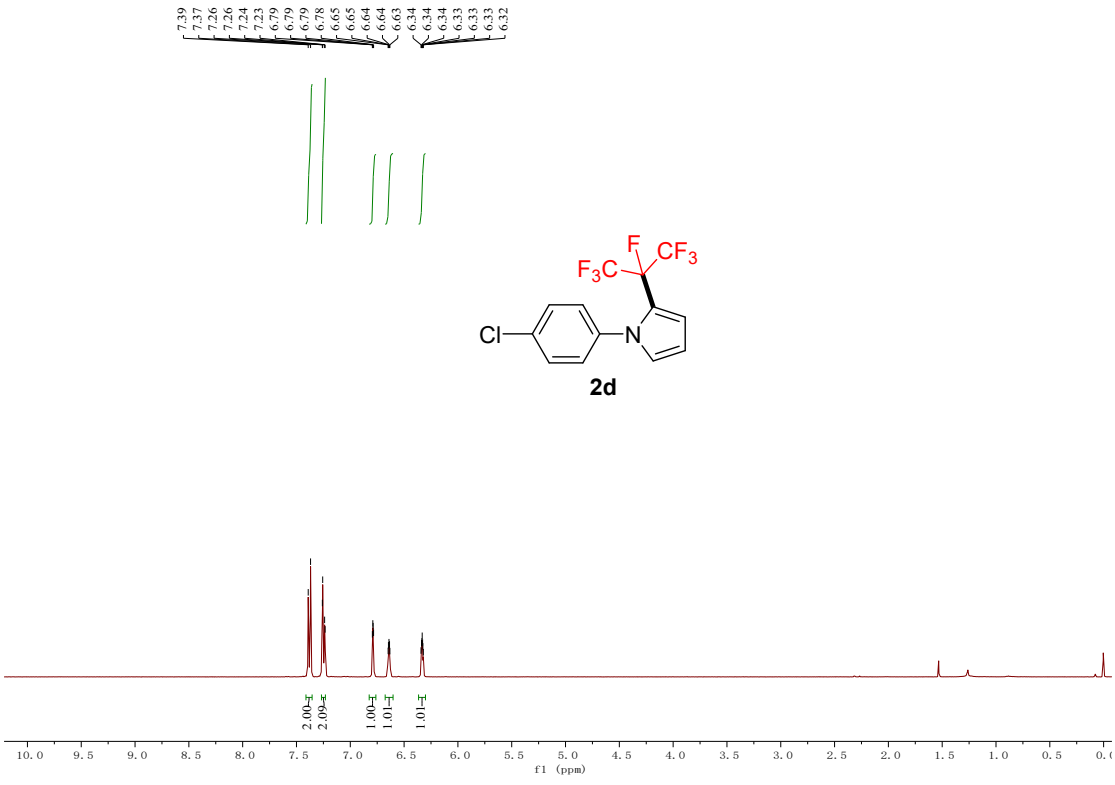
*[19]F NMR (*376 MHz, DMSO-d_6*)*



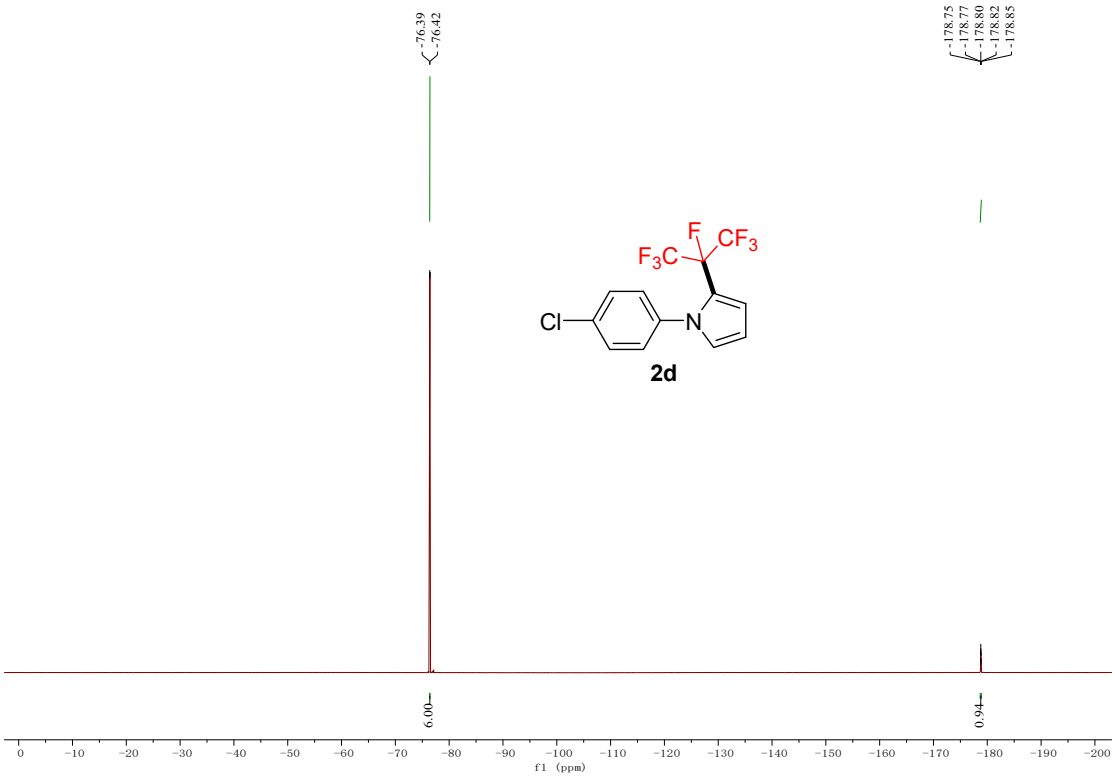
*^{13}C NMR (*101MHz, DMSO-d_6*)*



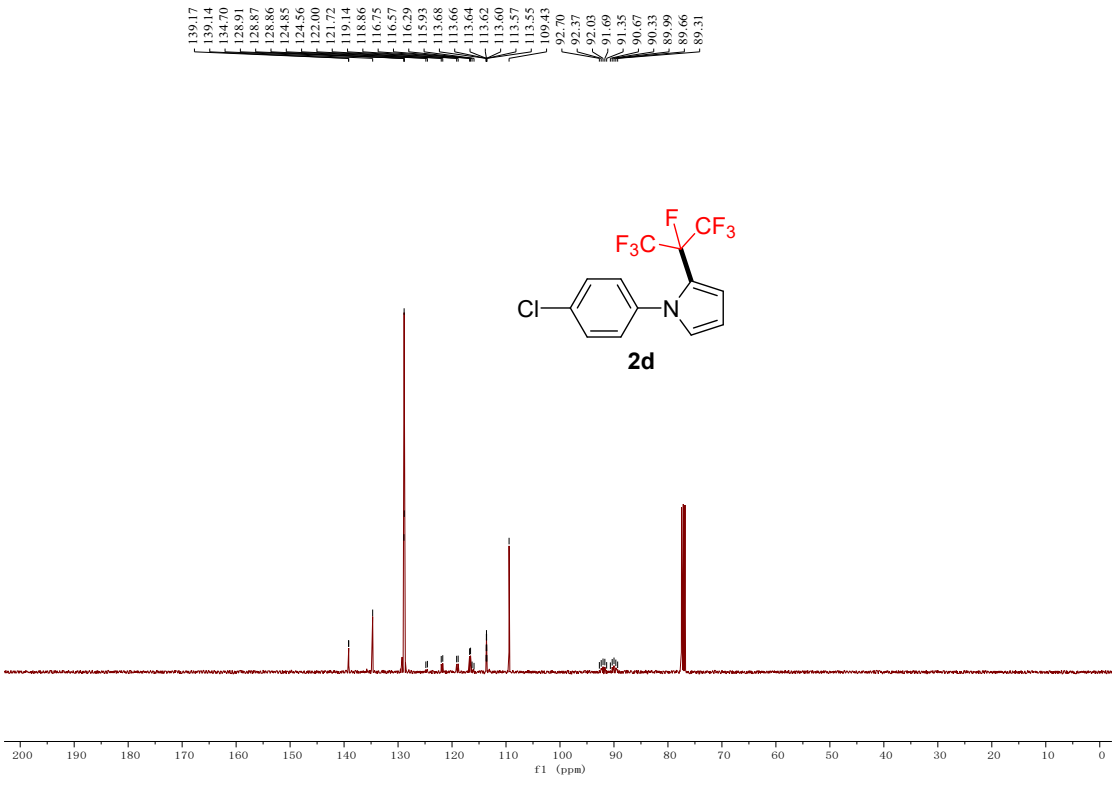
*^{1}H NMR (*400 MHz, *$CDCl_3$*)*



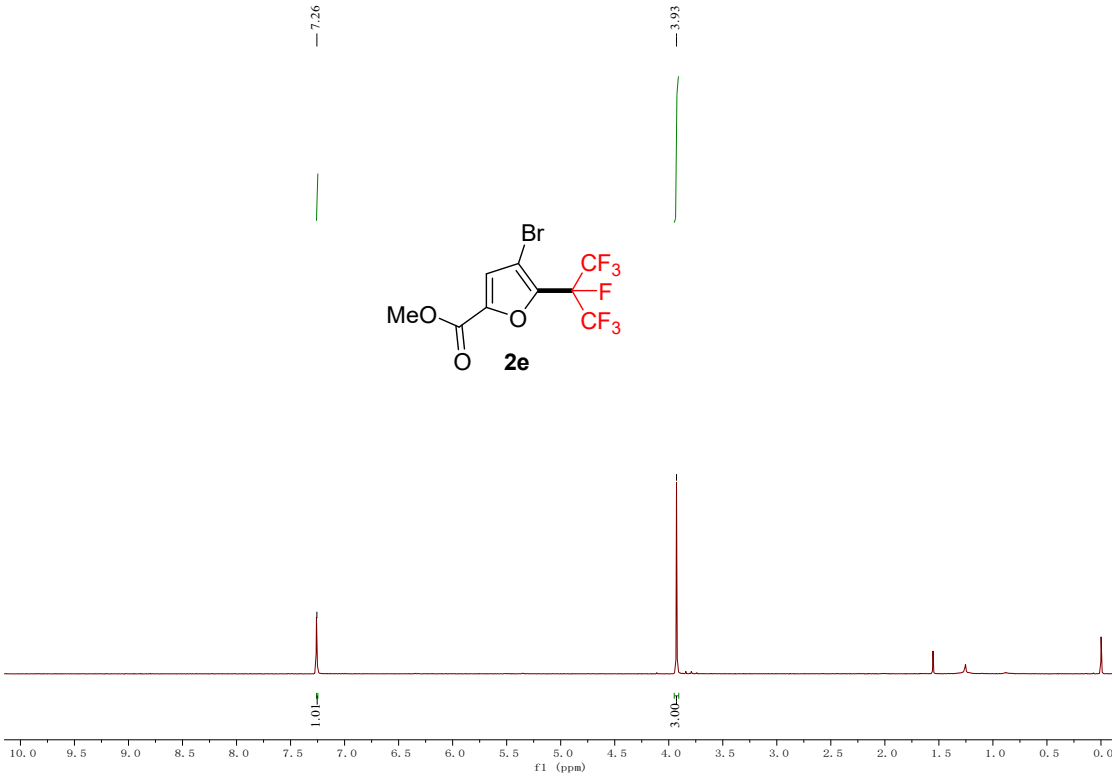
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



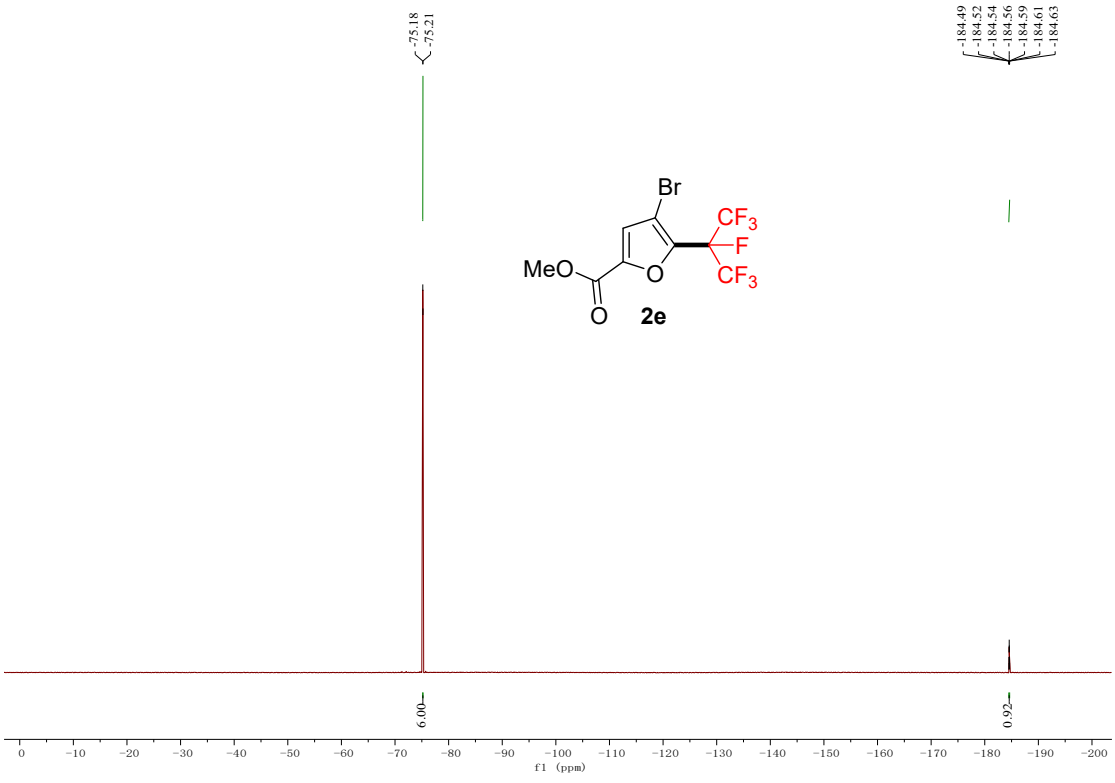
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



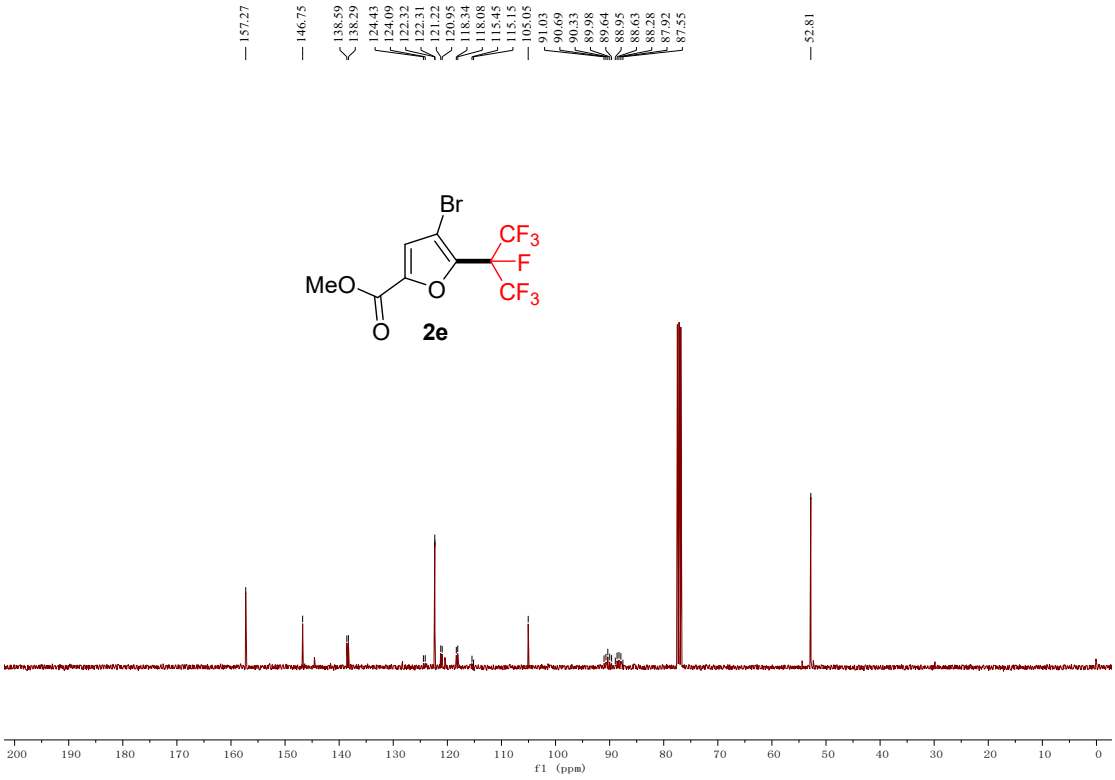
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



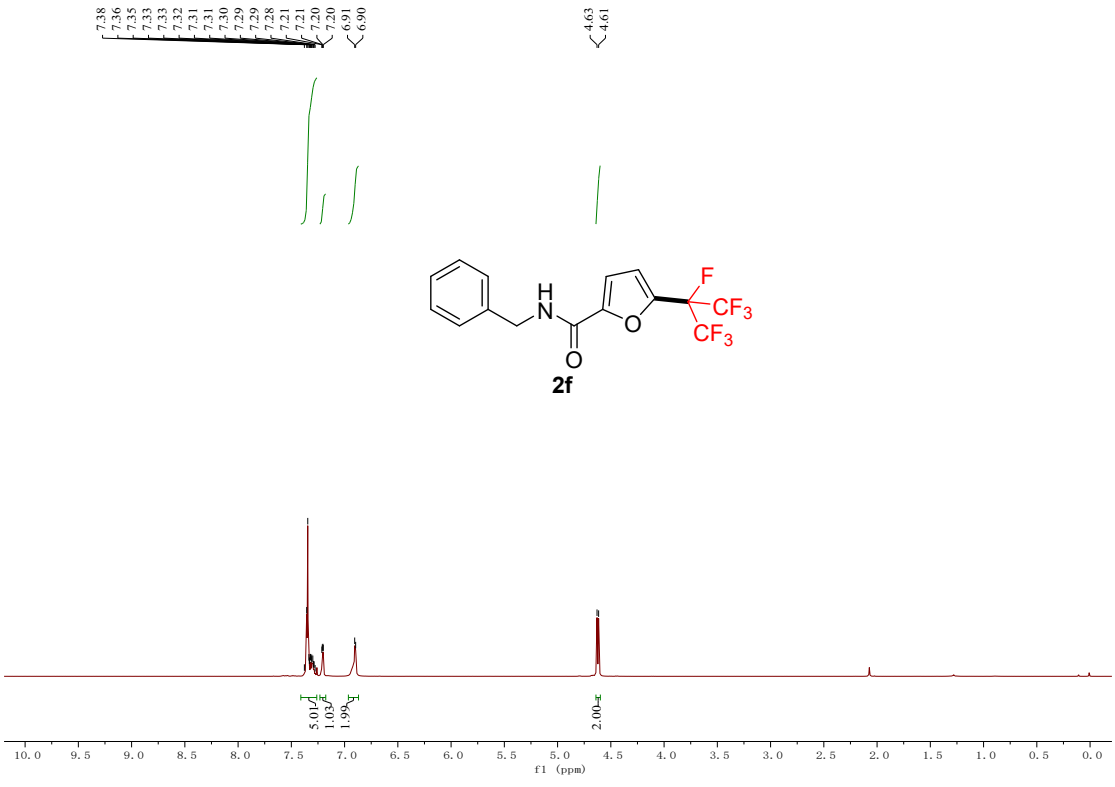
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



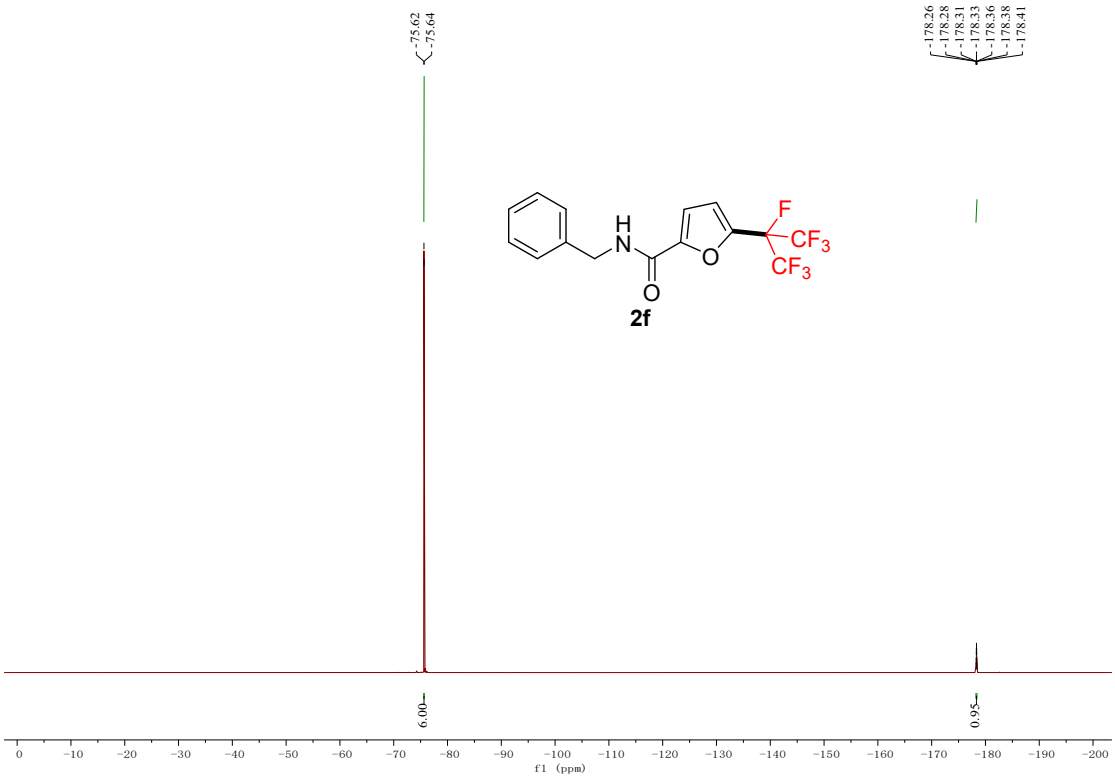
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



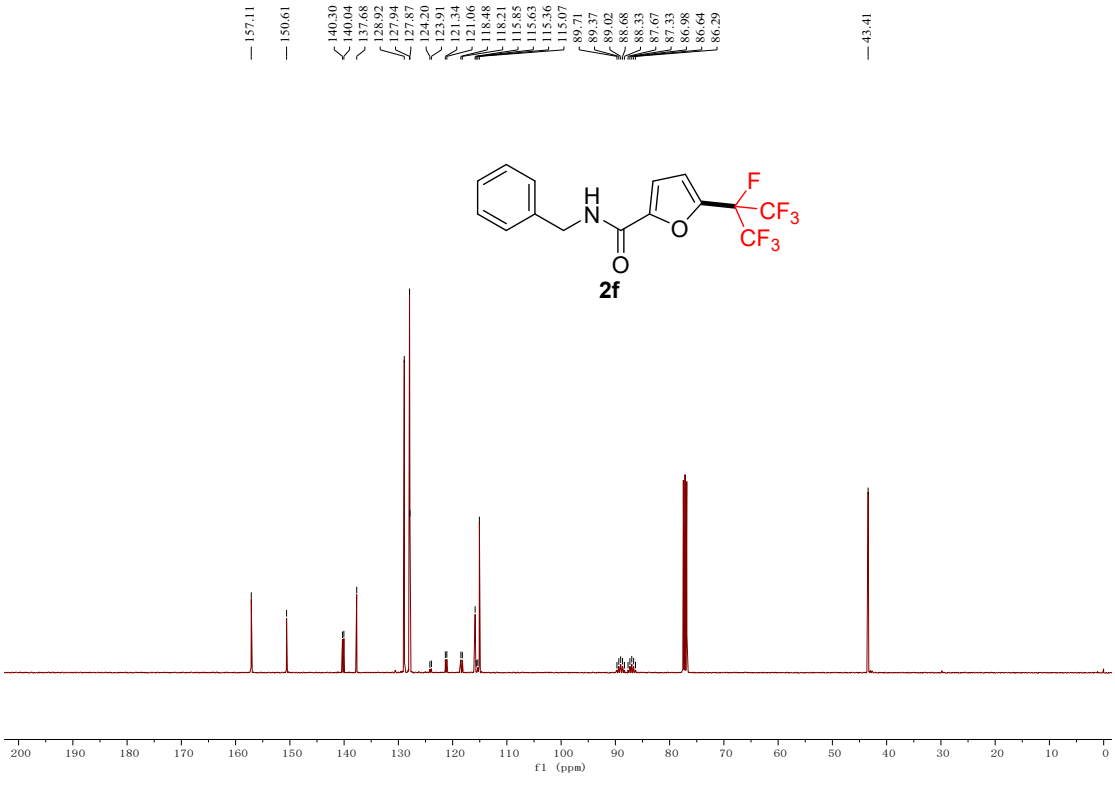
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



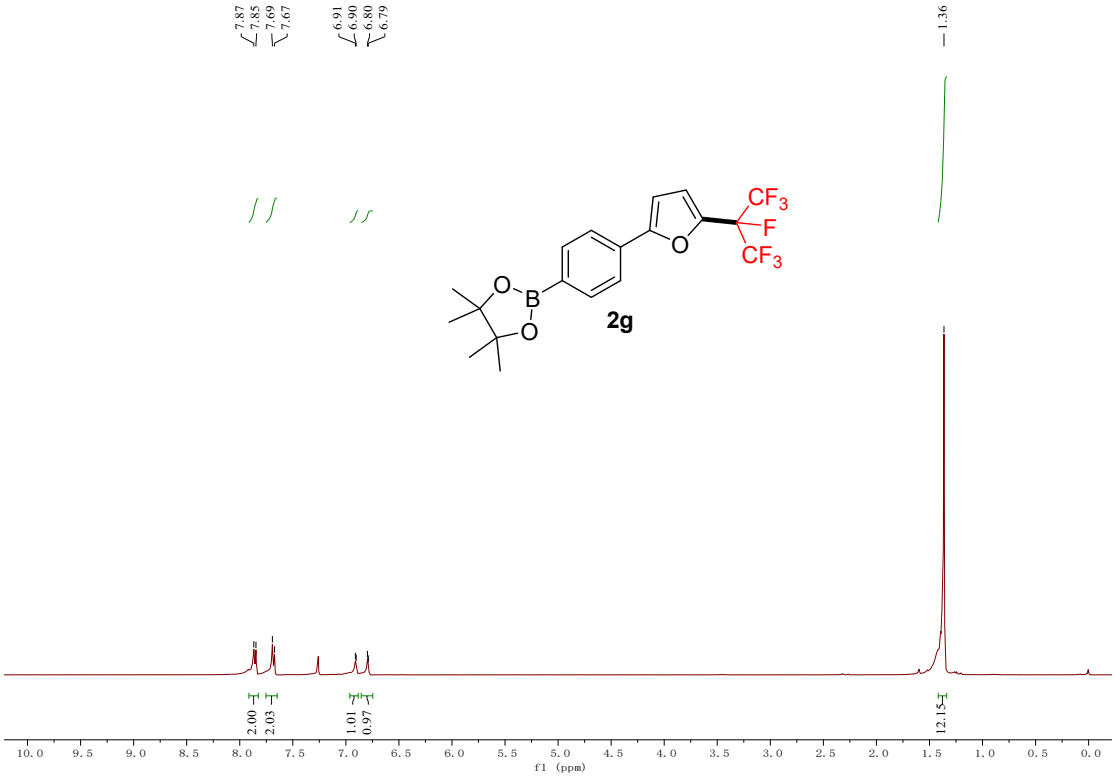
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



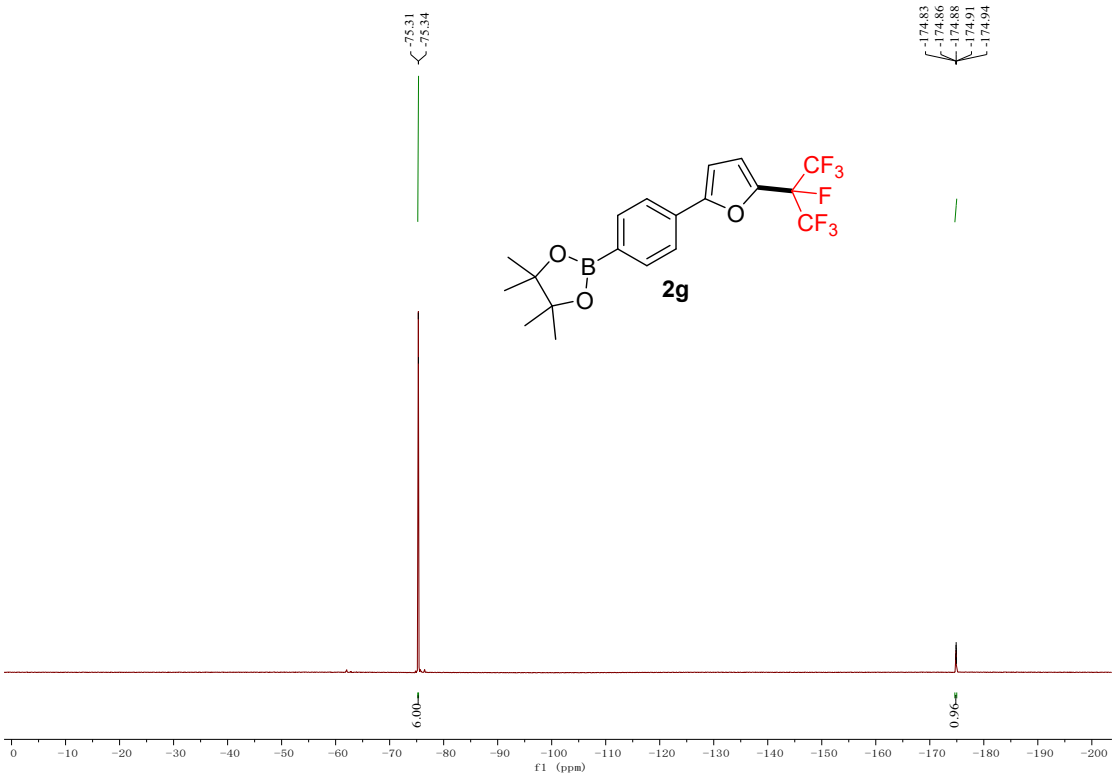
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



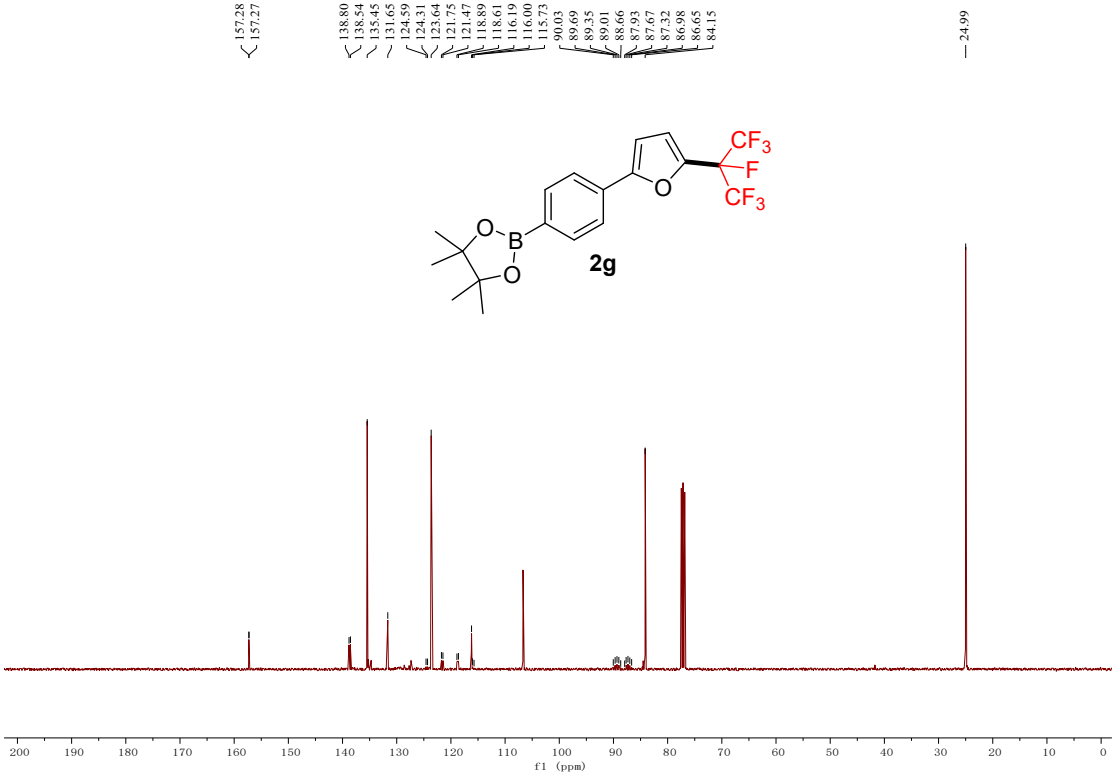
*[1]H NMR (*400 MHz, *$CDCl_3$)*



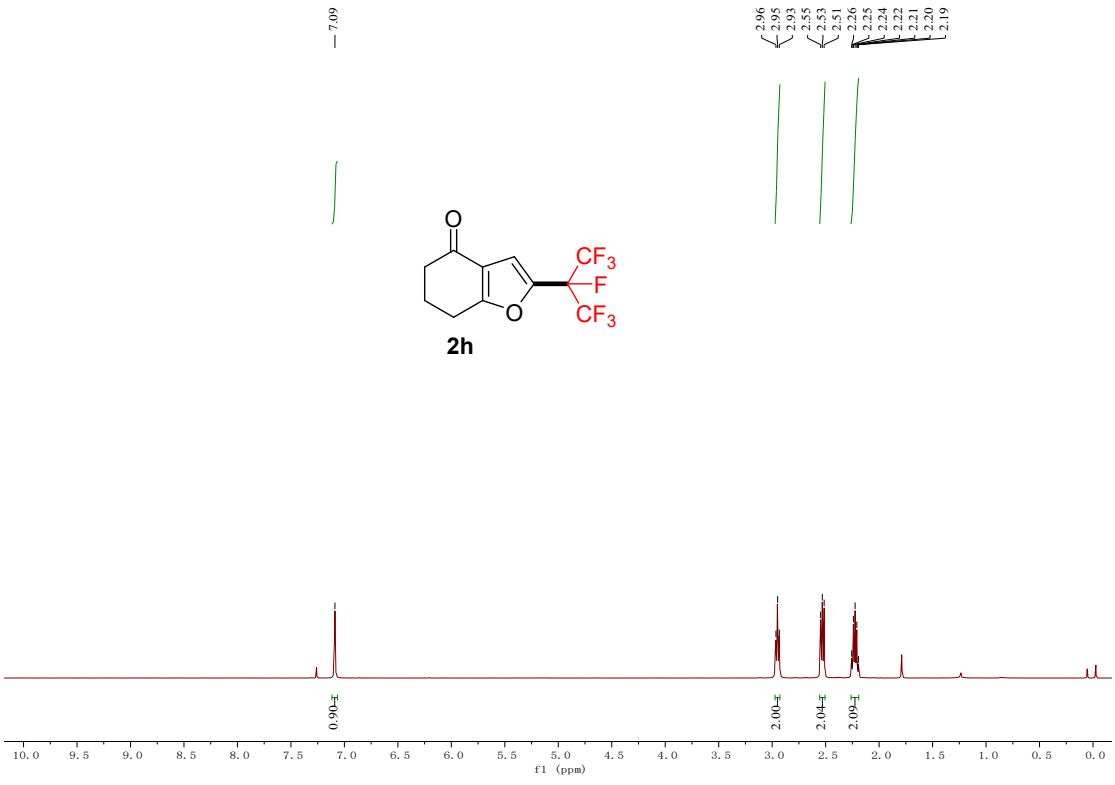
*[19]F NMR (*376 MHz, *$CDCl_3$)*



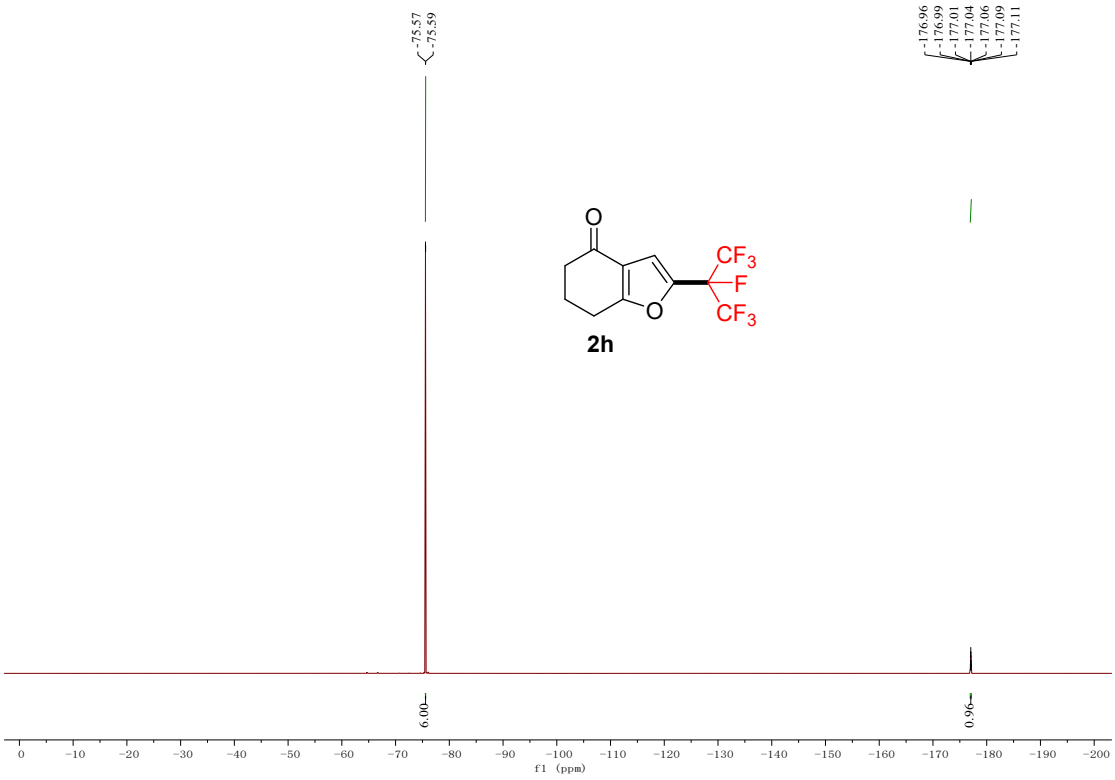
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



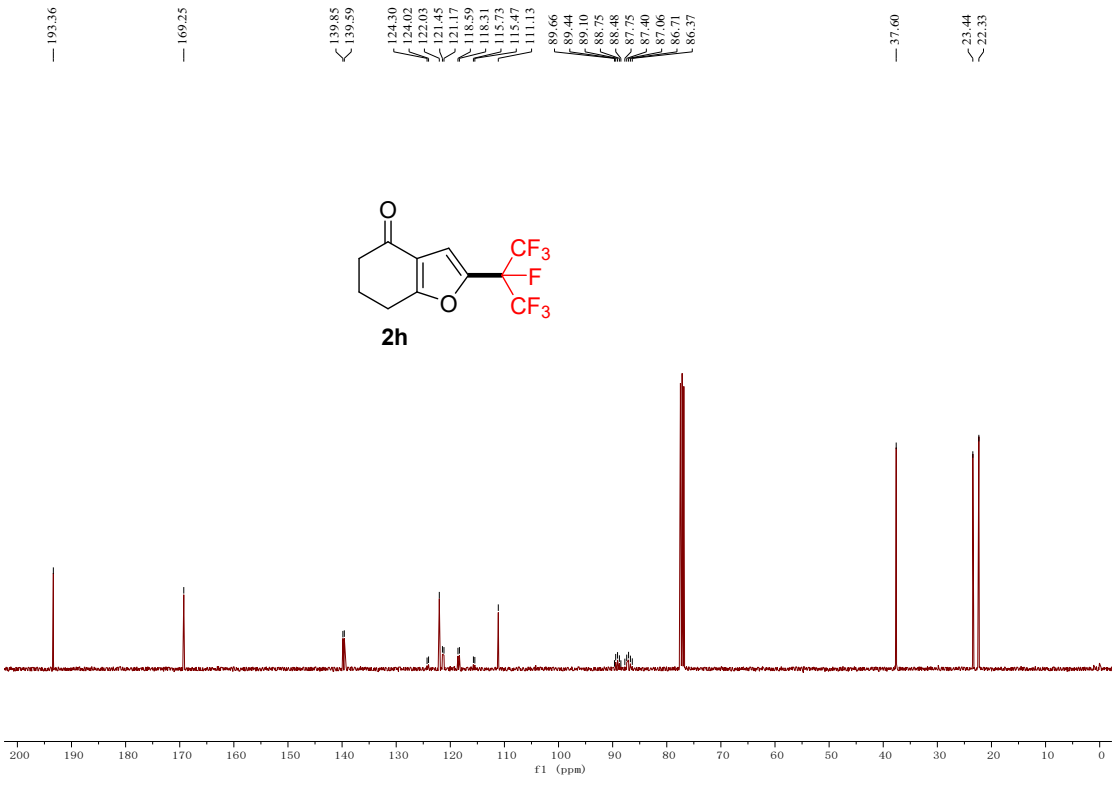
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



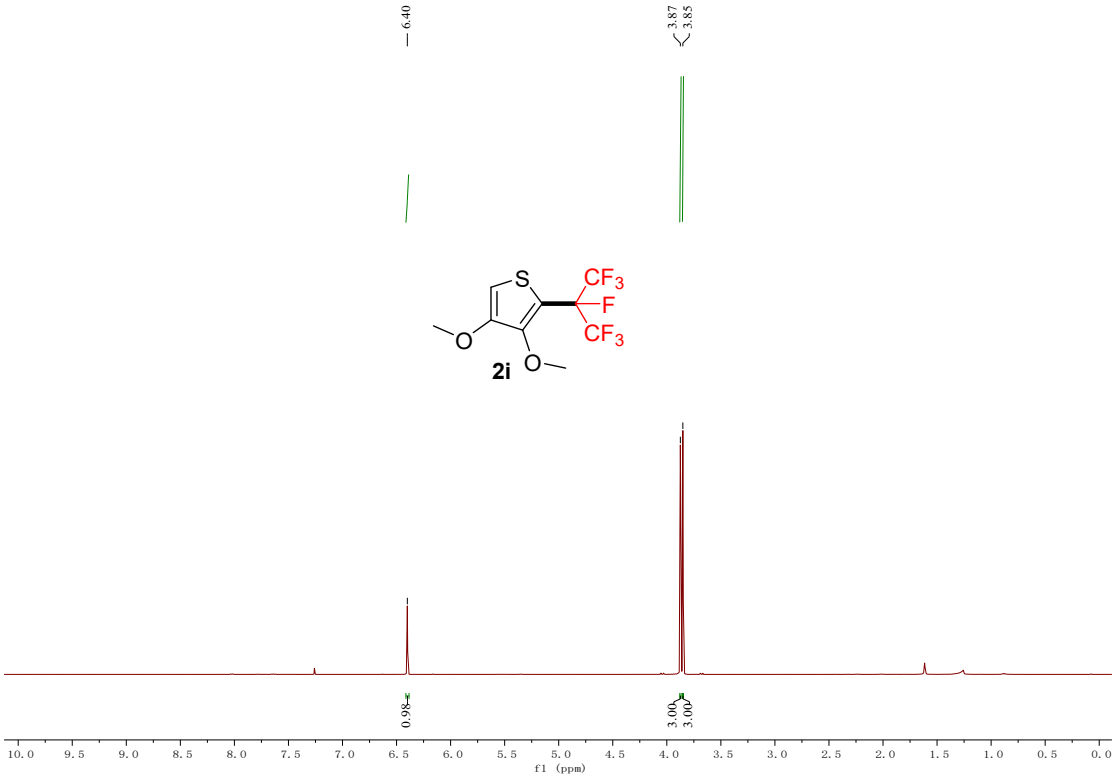
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



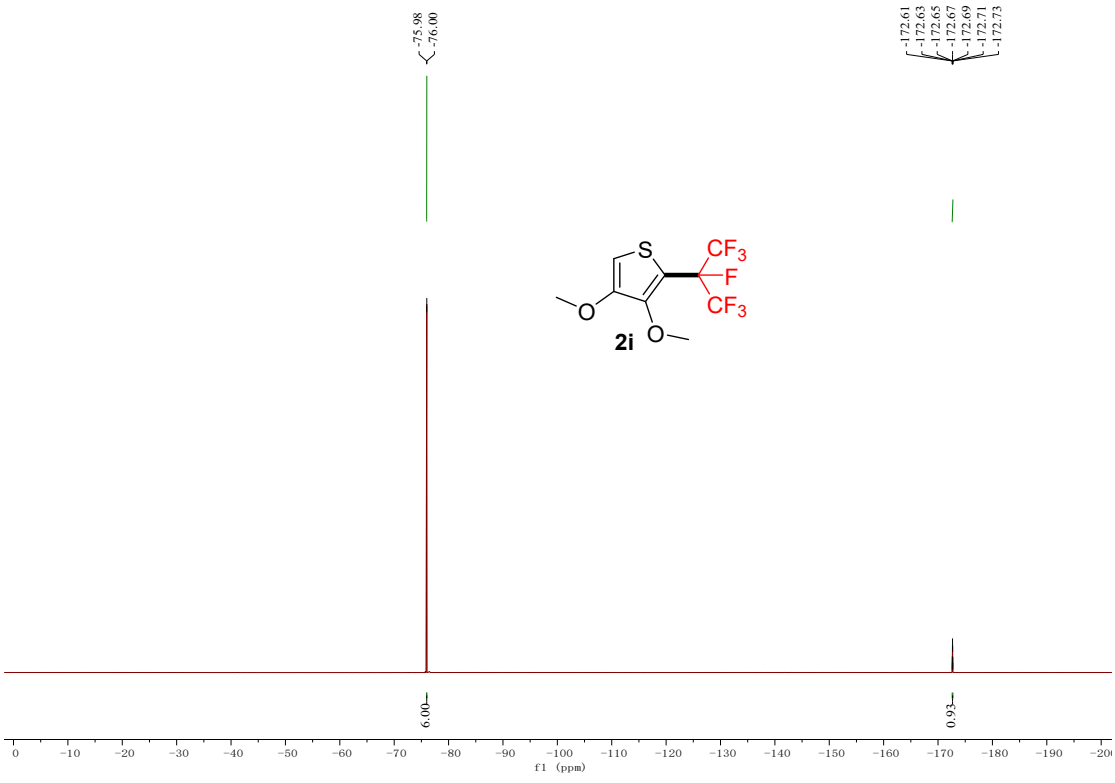
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



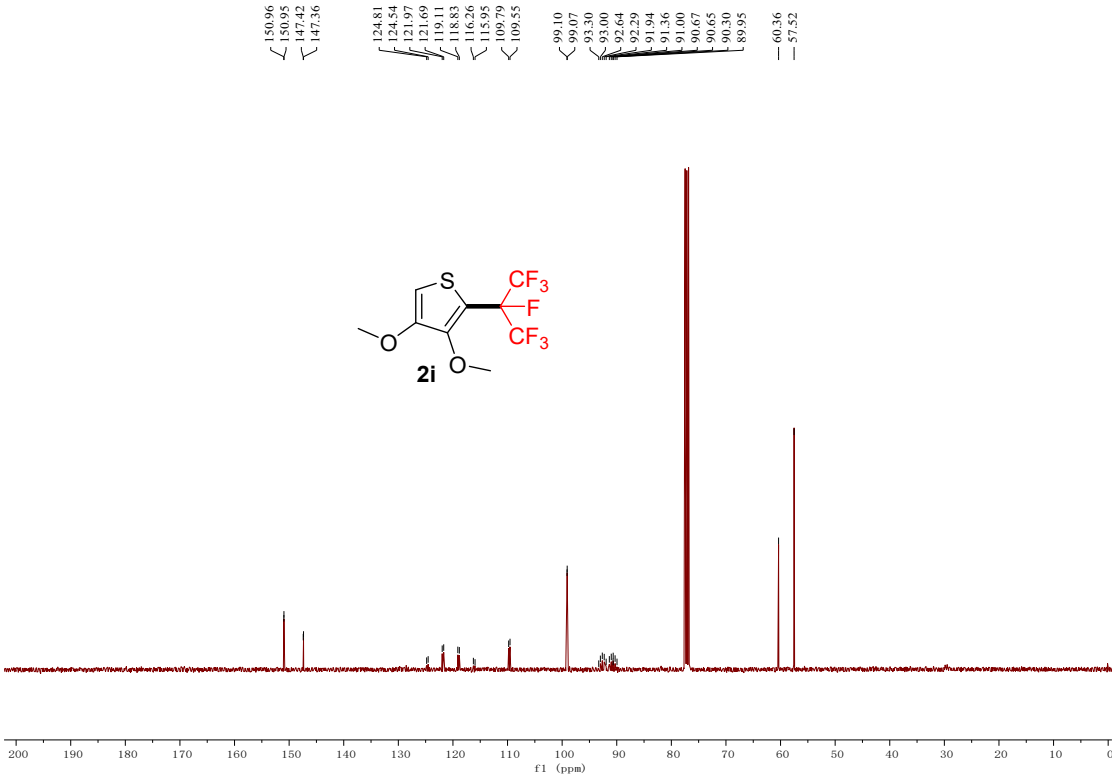
*[1]H NMR (*400 MHz, *$CDCl_3$)*



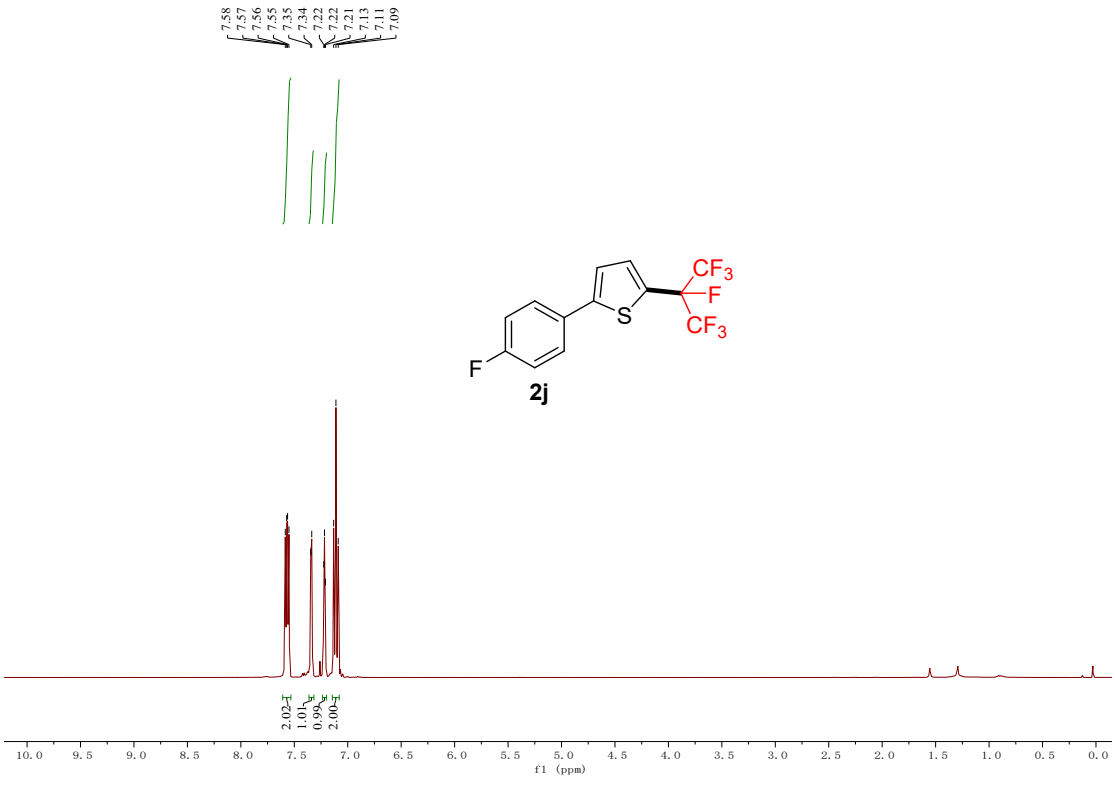
*[19]F NMR (*376 MHz, *$CDCl_3$)*



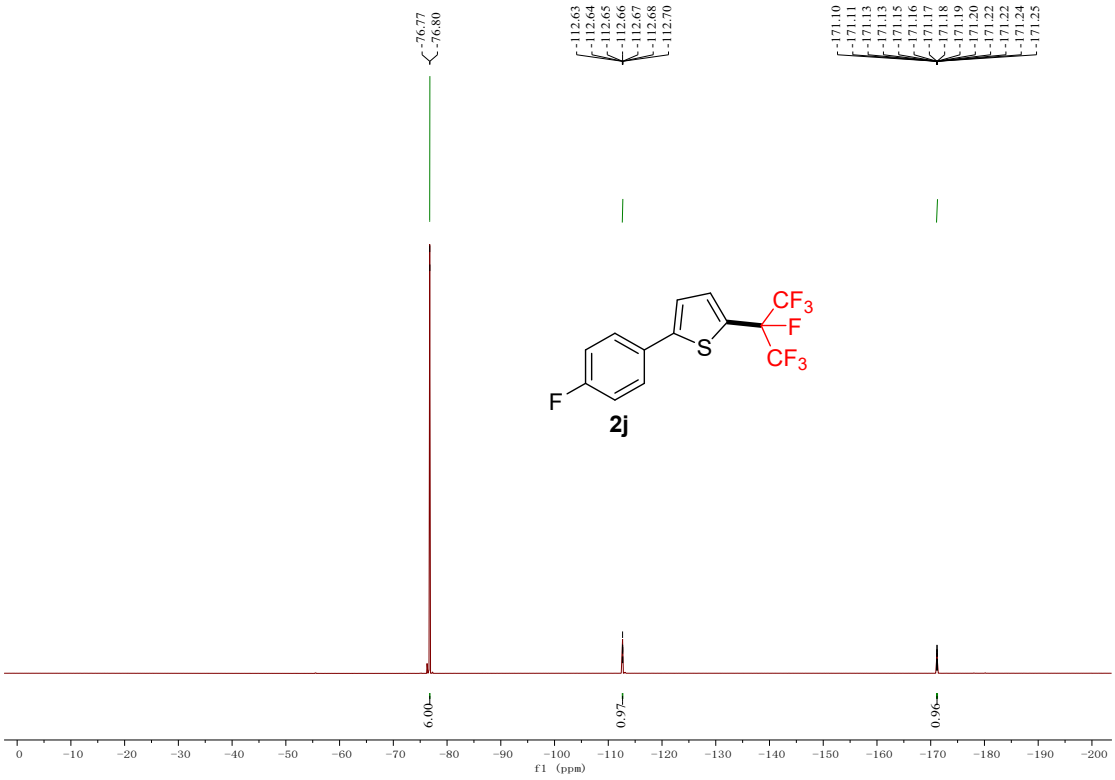
*[13]C NMR (*101 MHz, *$CDCl_3$)*



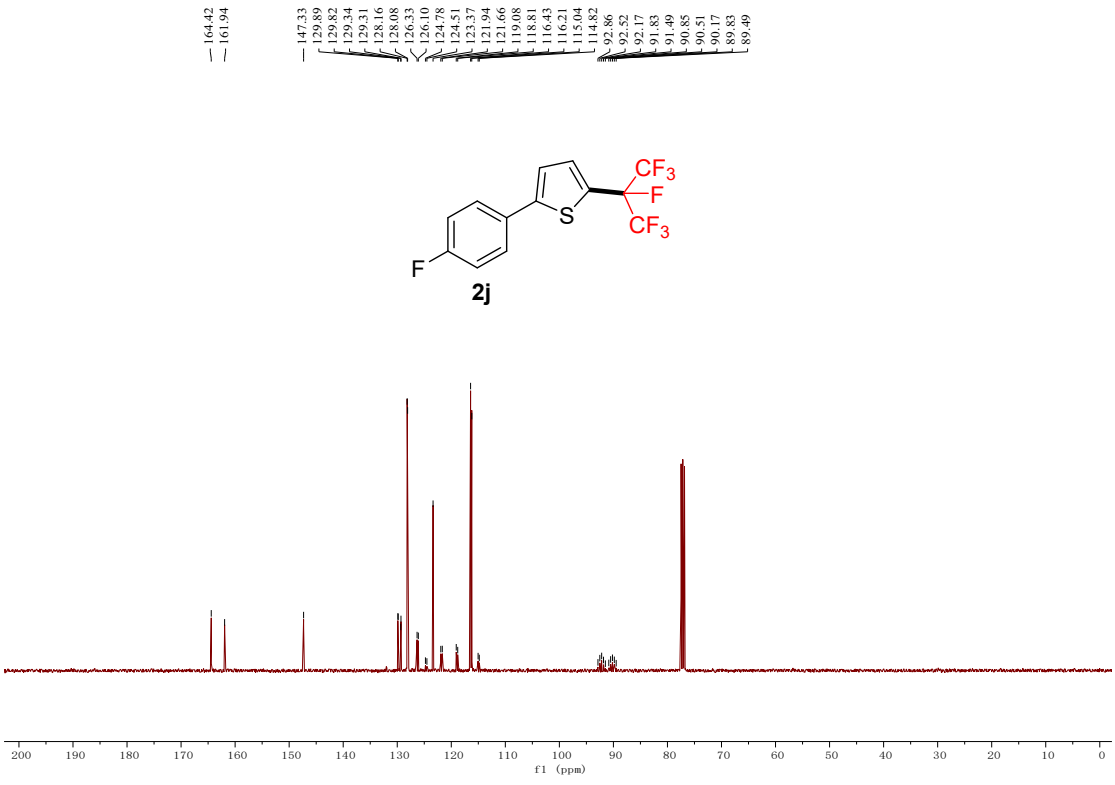
*[1]H NMR (*400 MHz, *$CDCl_3$)*



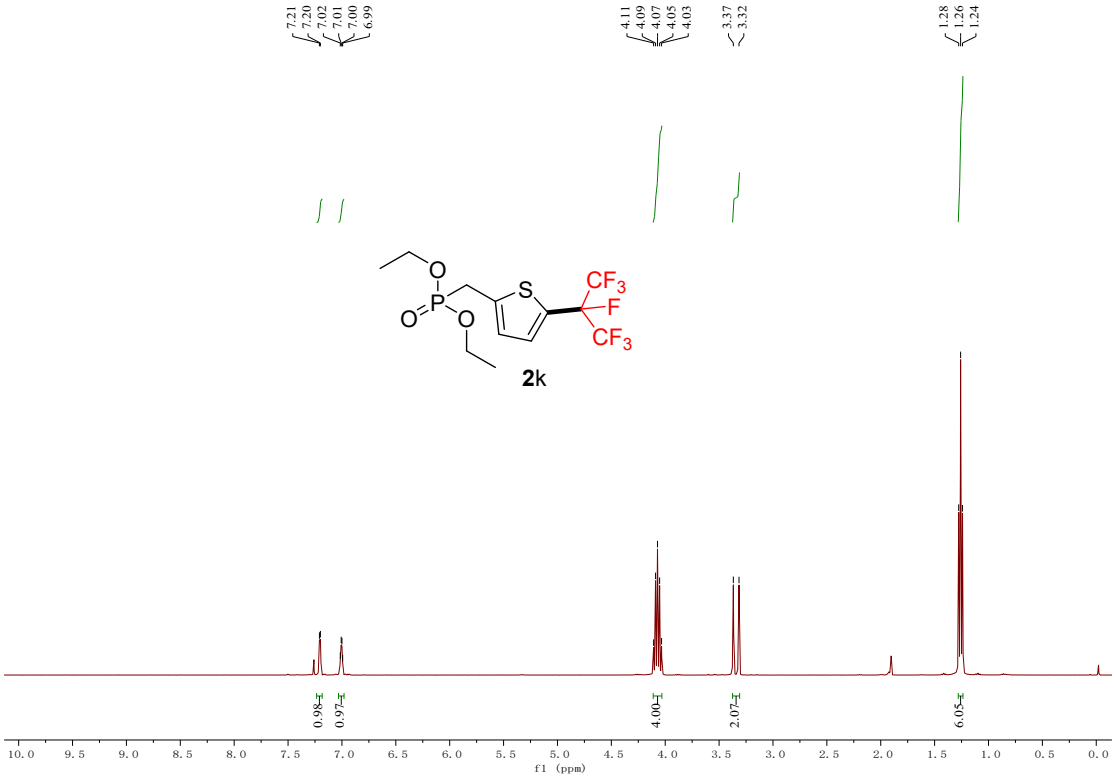
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



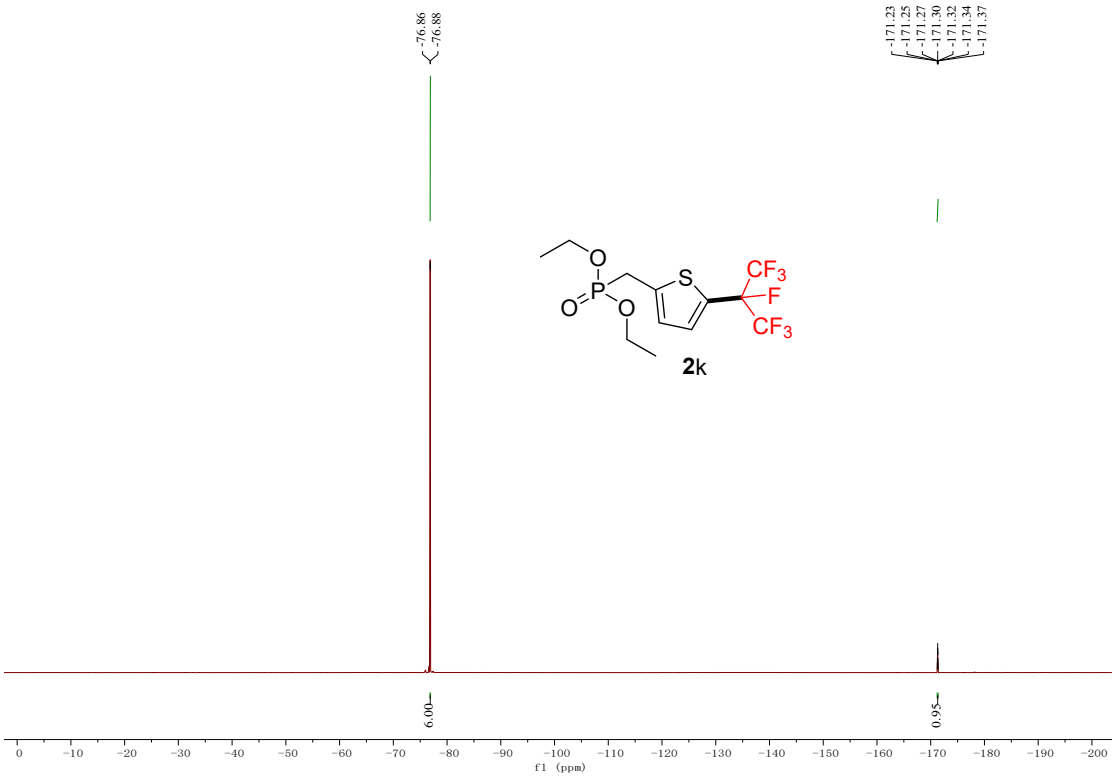
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



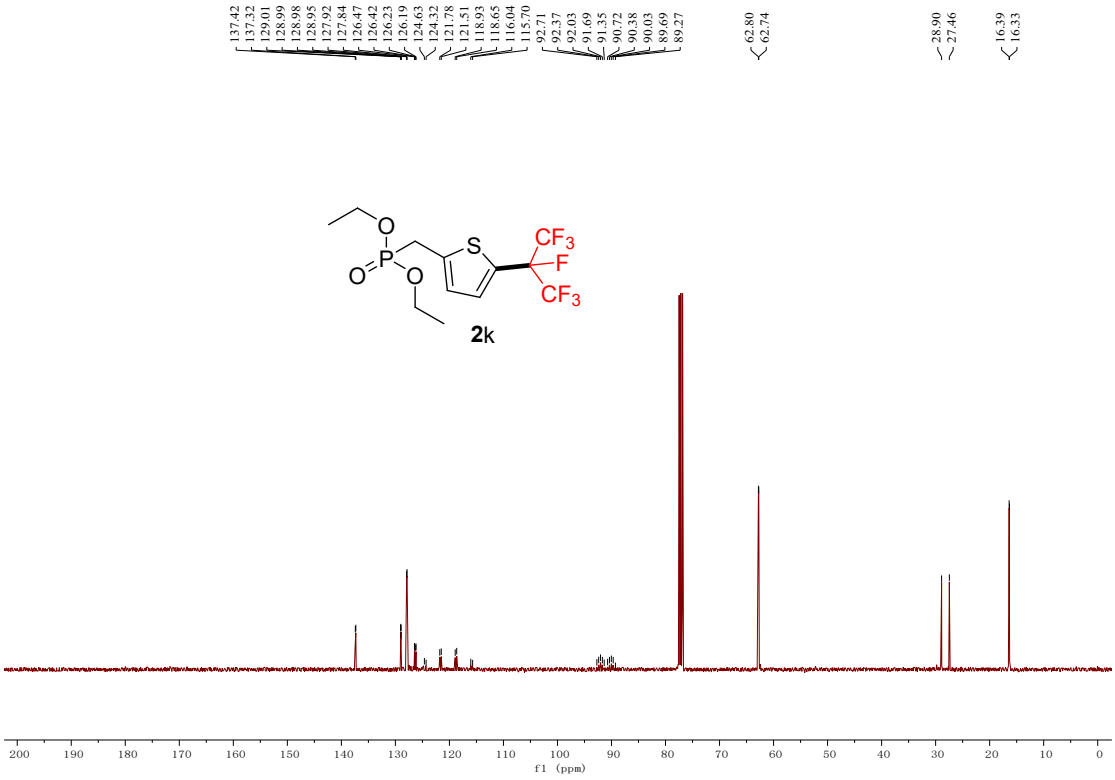
*[1]H NMR (*400 MHz, *$CDCl_3$)*



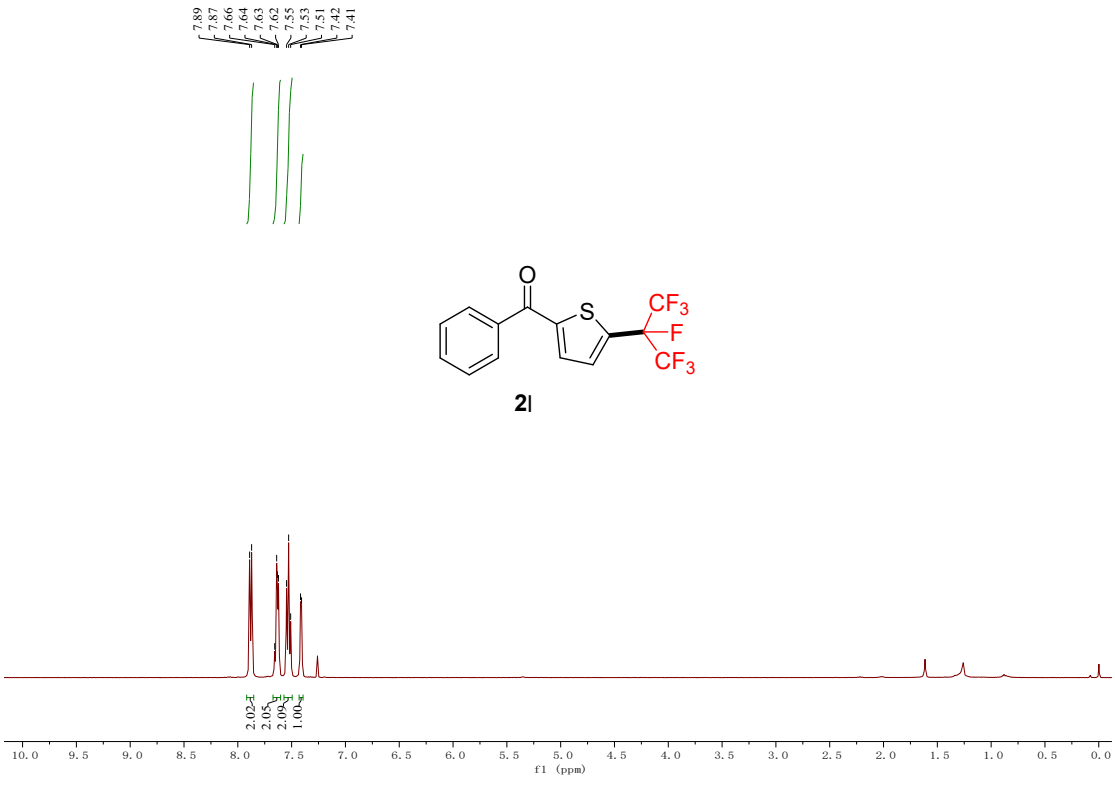
*[19]F NMR (*376 MHz, *$CDCl_3$)*



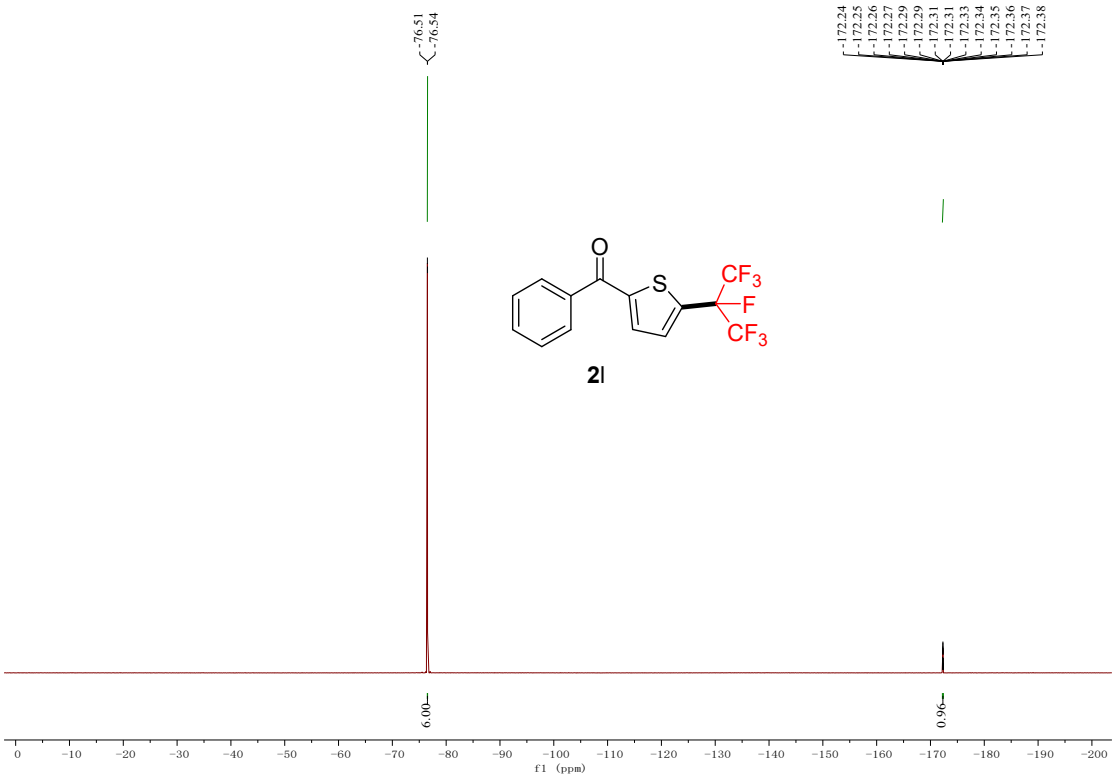
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



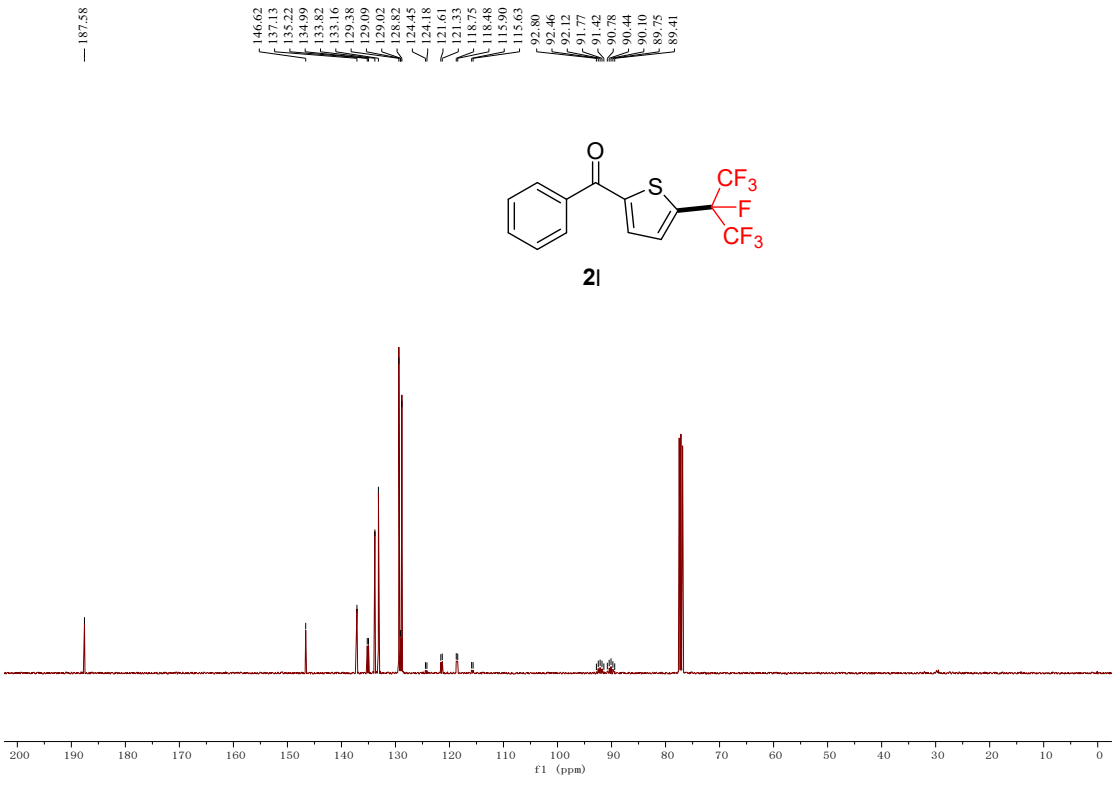
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



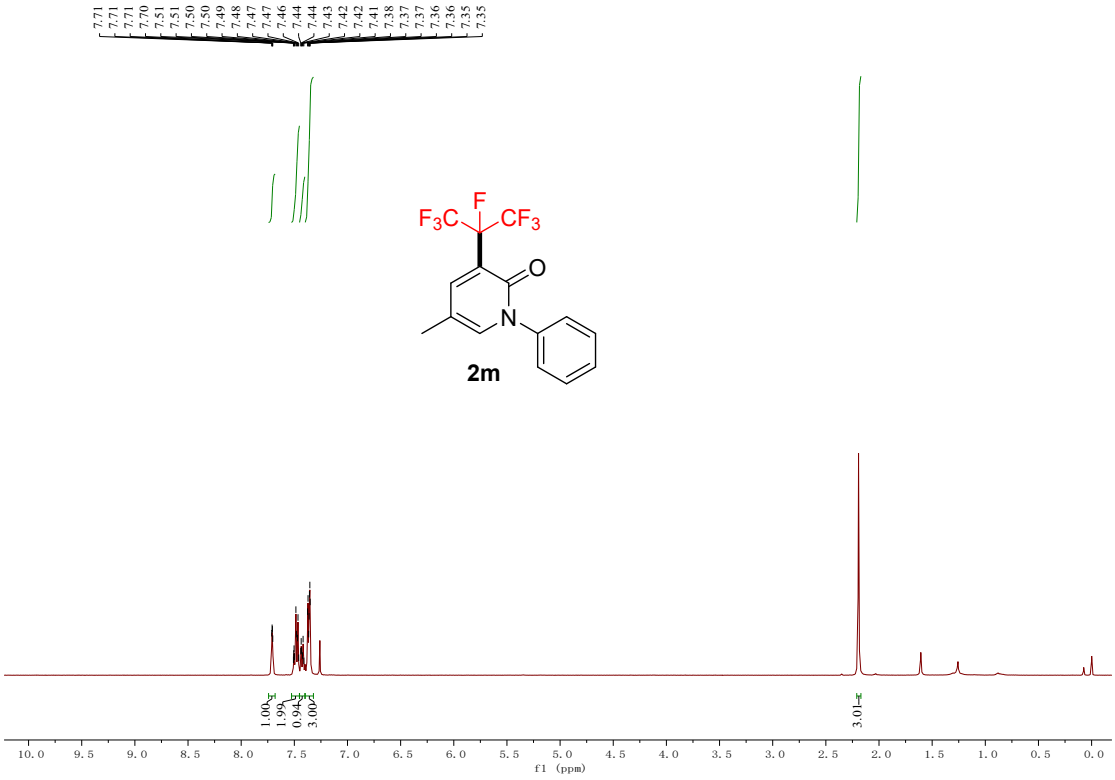
*[19]F NMR (*376 MHz, *$CDCl_3$)*



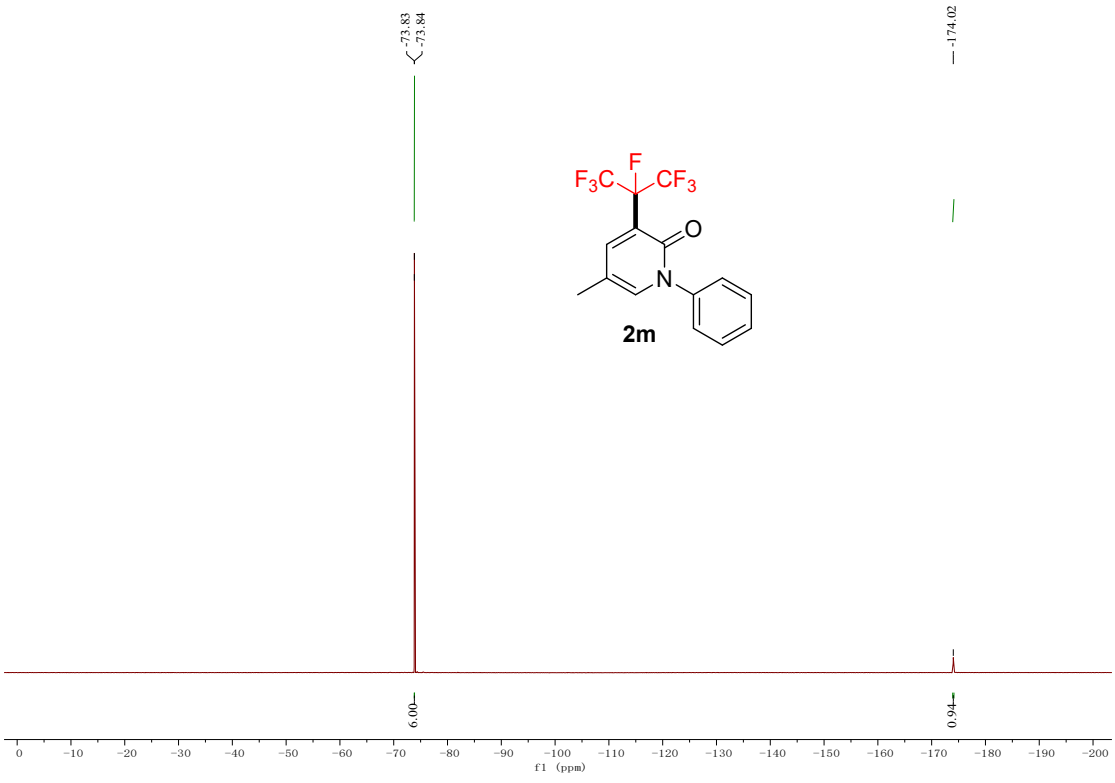
*[13]C NMR (*101 MHz, *$CDCl_3$)*



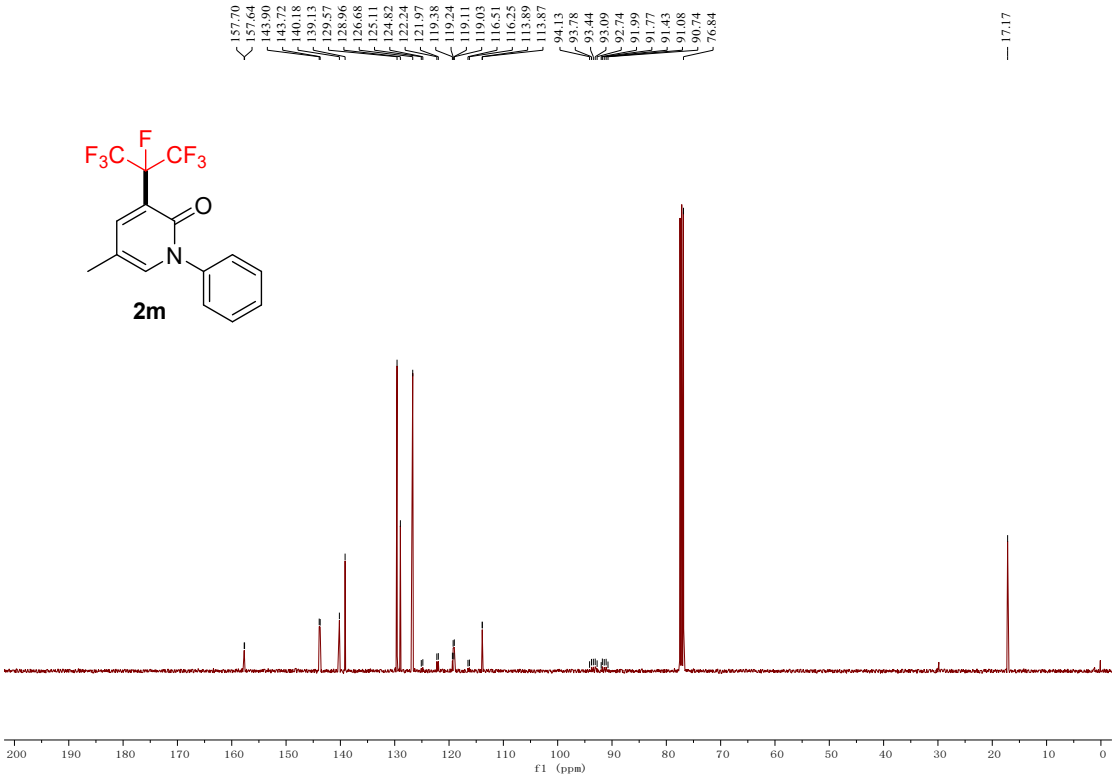
*[1]H NMR (*400 MHz, *$CDCl_3$)*



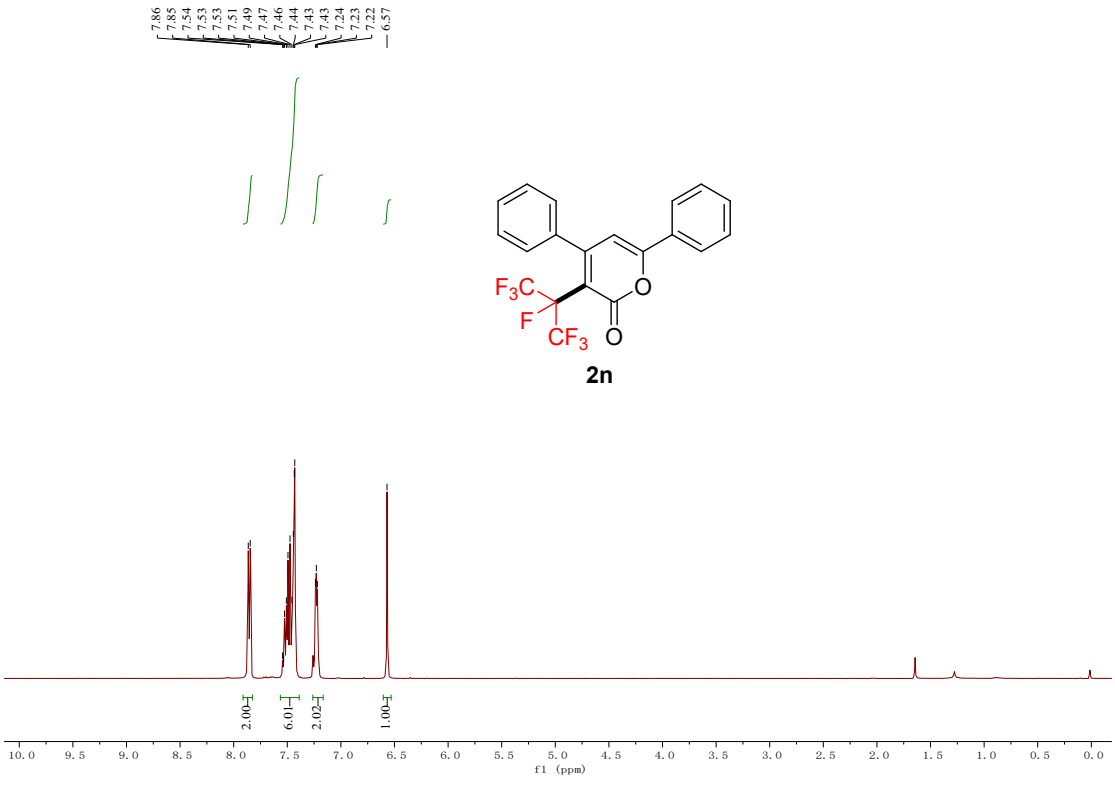
*[19]F NMR (*376 MHz, *$CDCl_3$)*



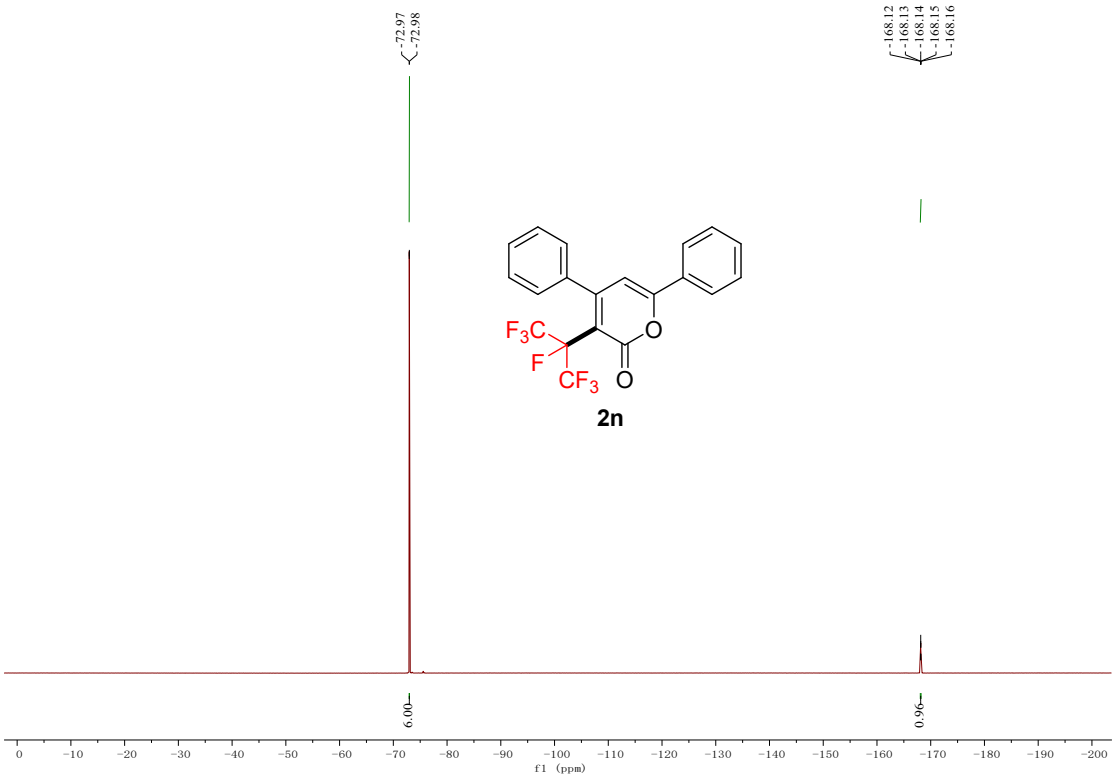
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



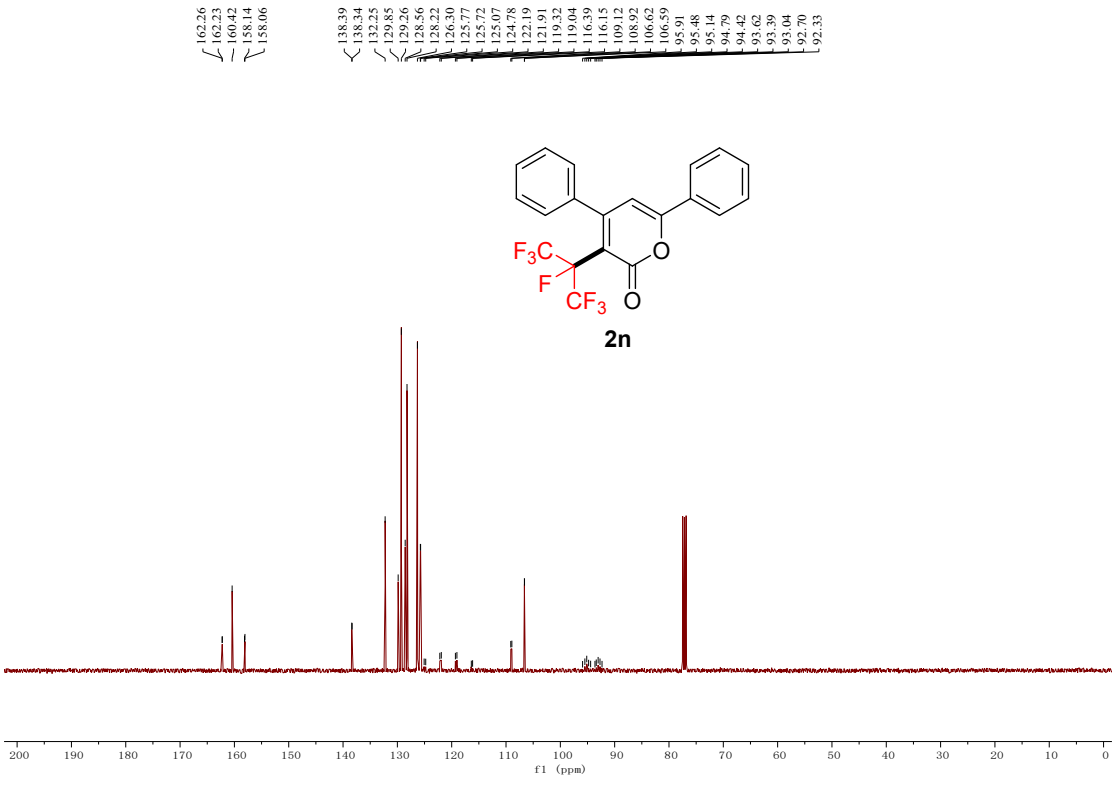
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



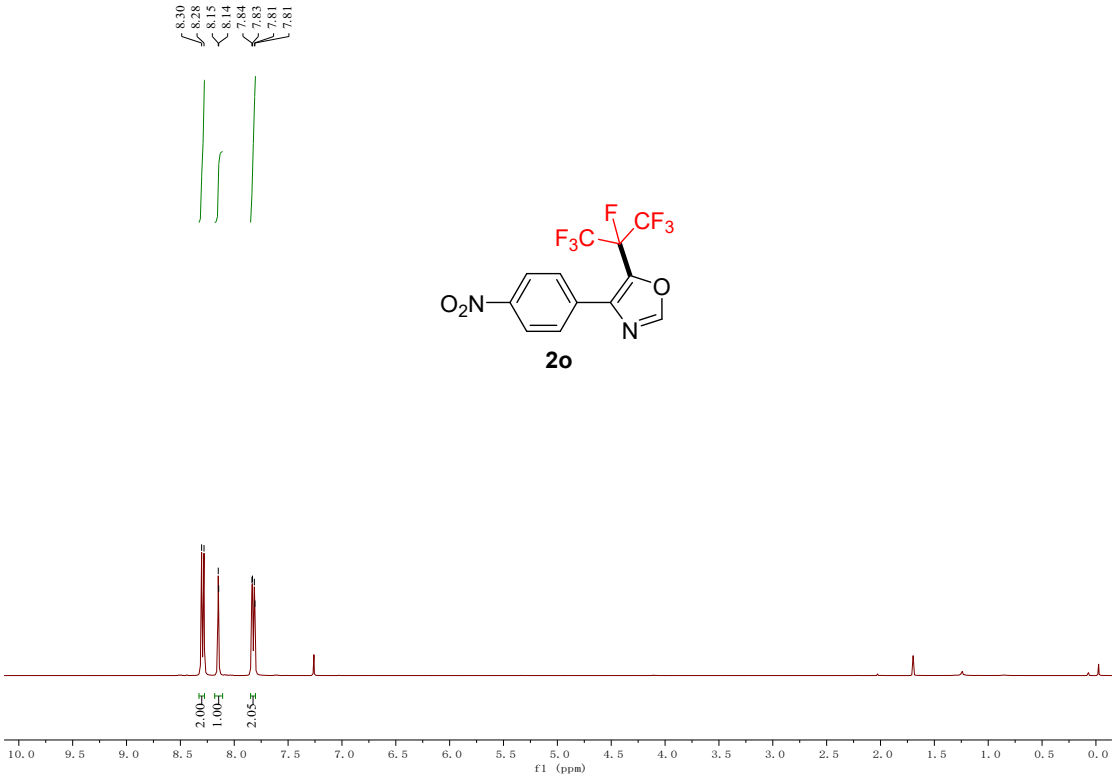
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



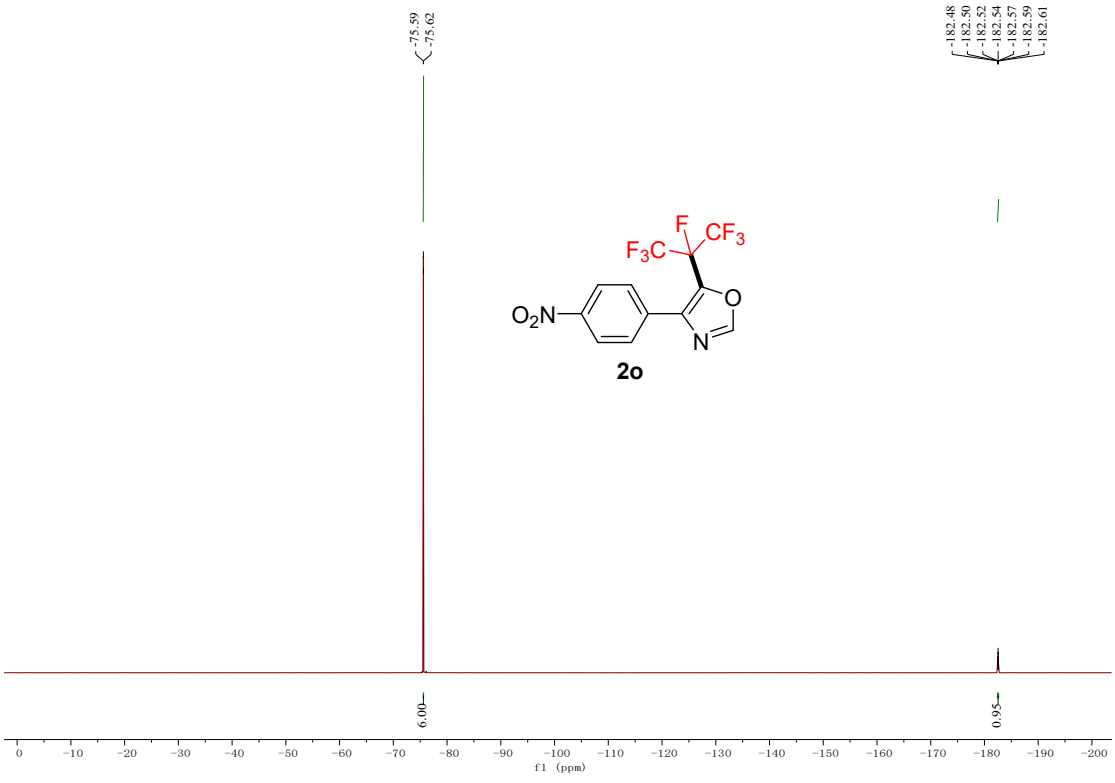
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



*[1]H NMR (*400 MHz, *$CDCl_3$)*



*[19]F NMR (*376 MHz, *$CDCl_3$)*



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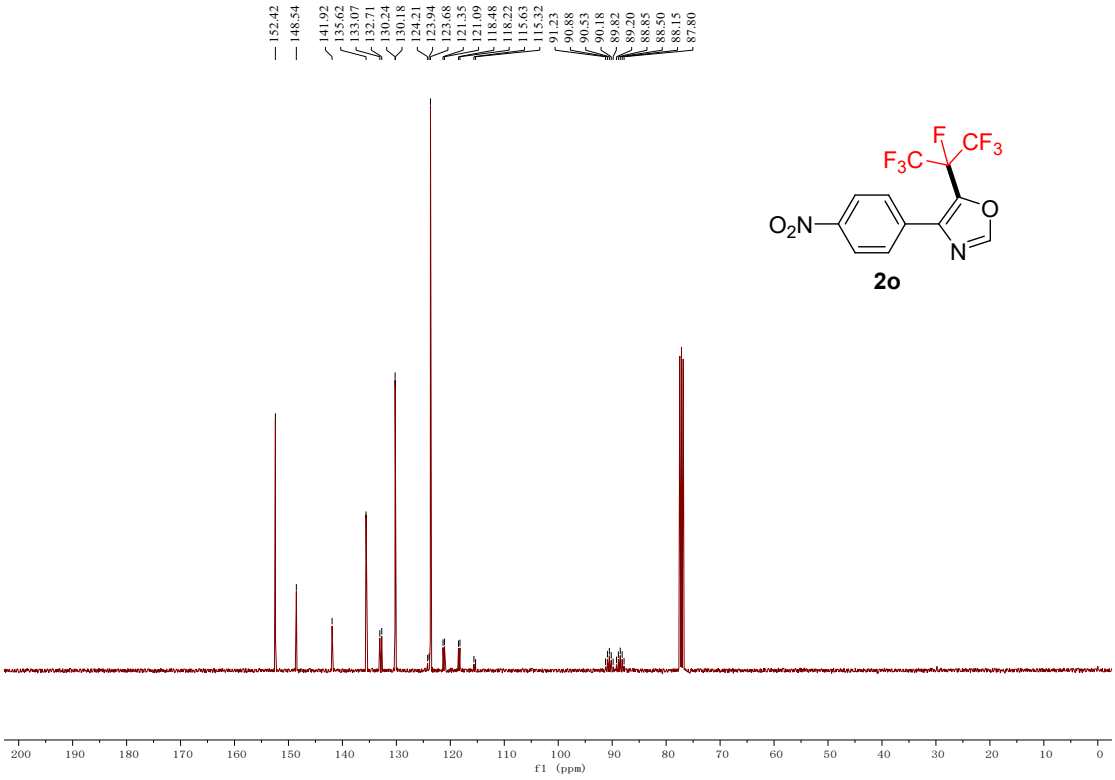

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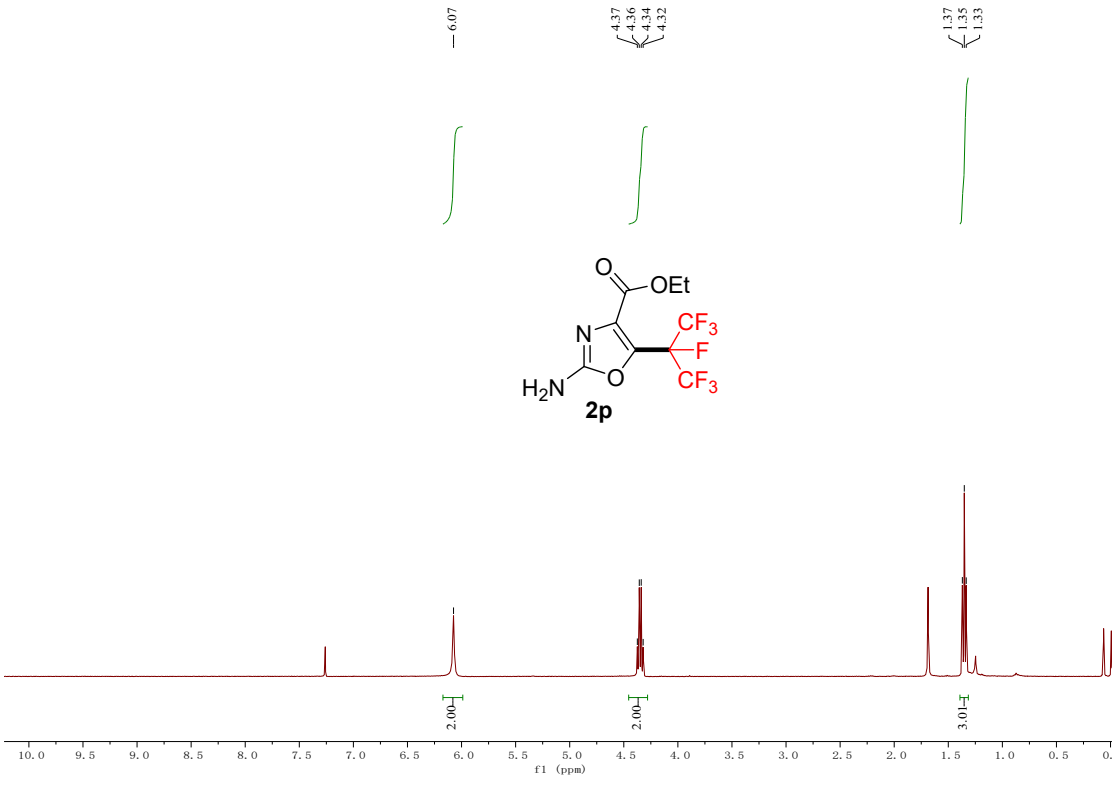

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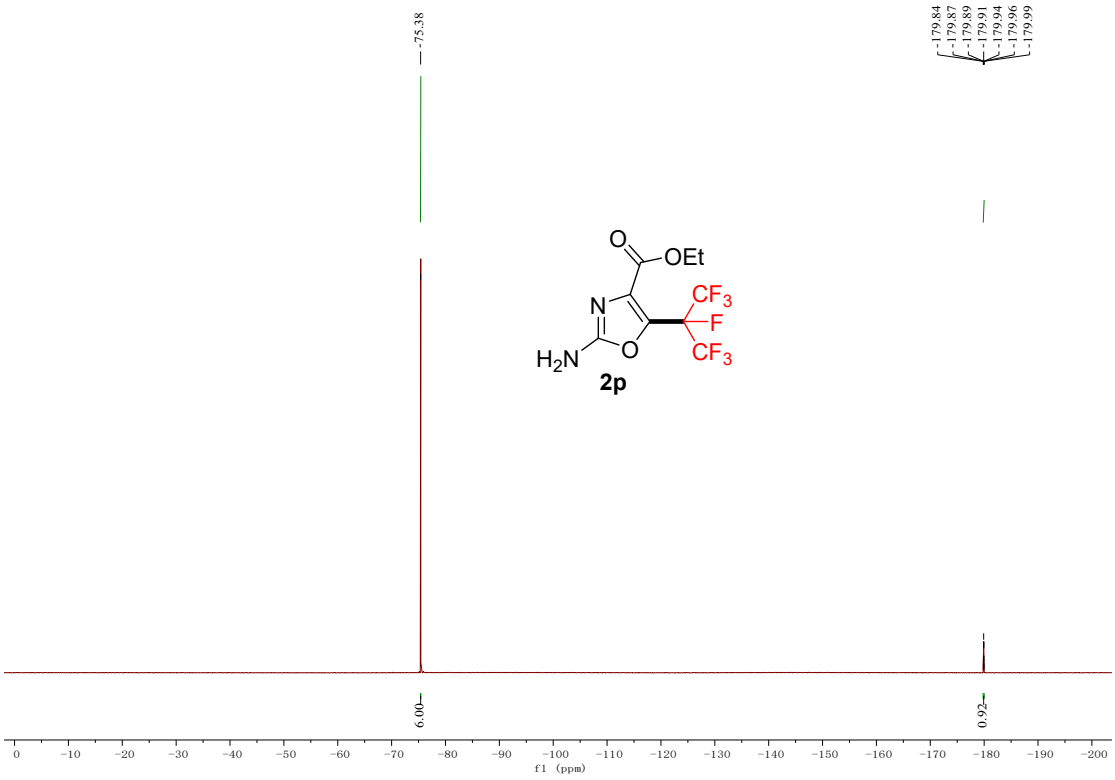

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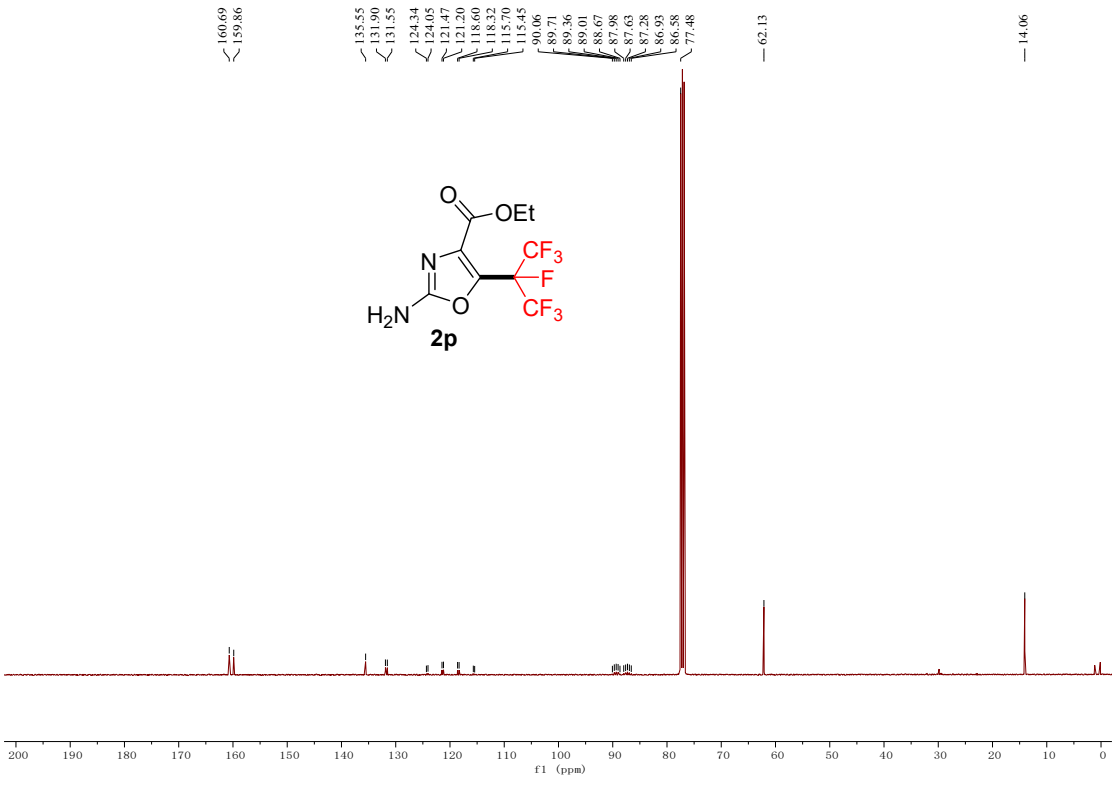

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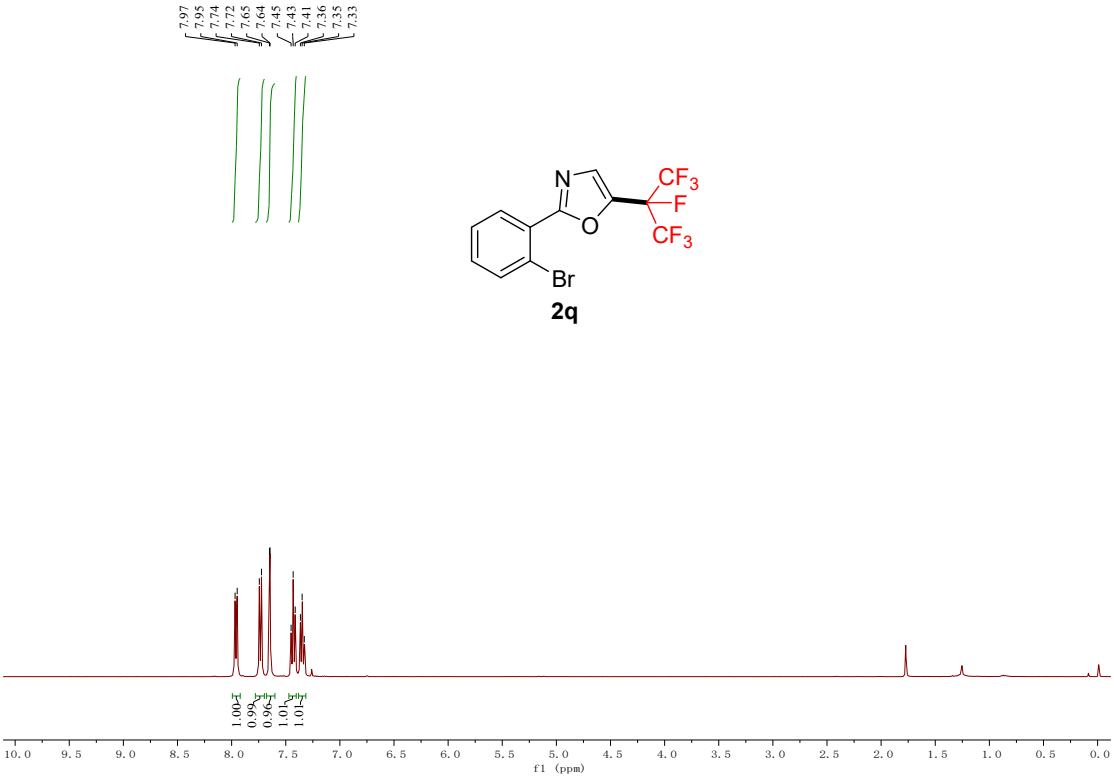

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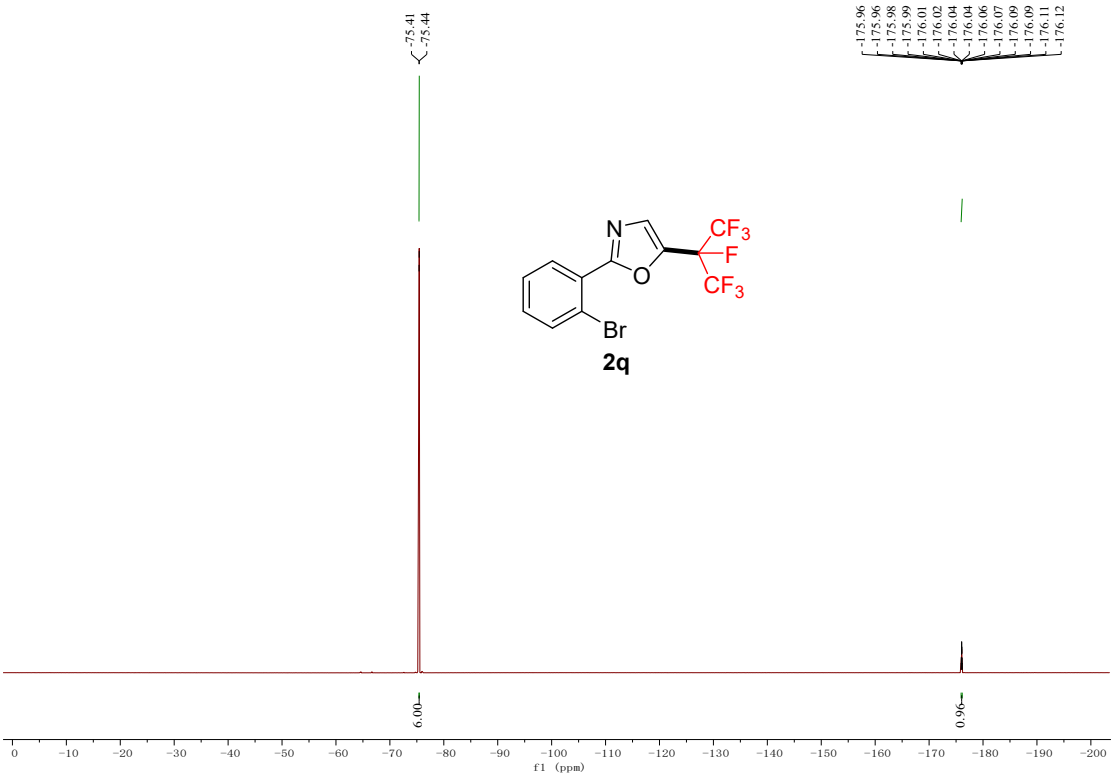
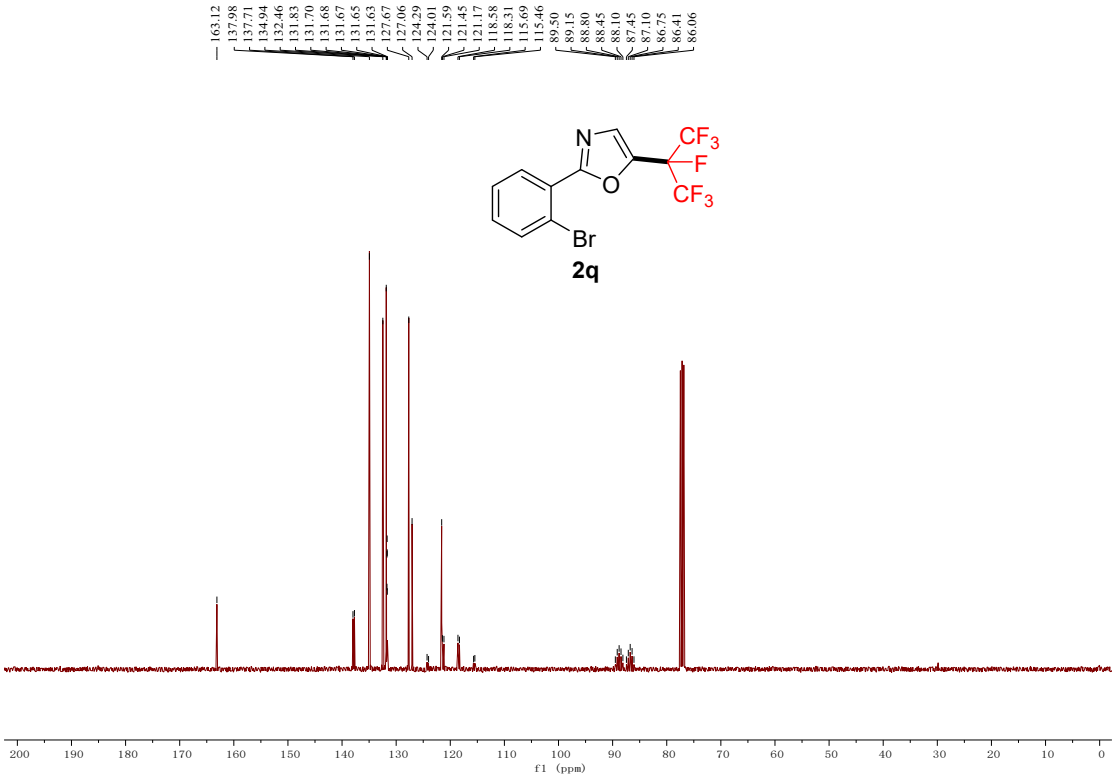


*^{13}C NMR (*101 MHz, *$CDCl_3$)*



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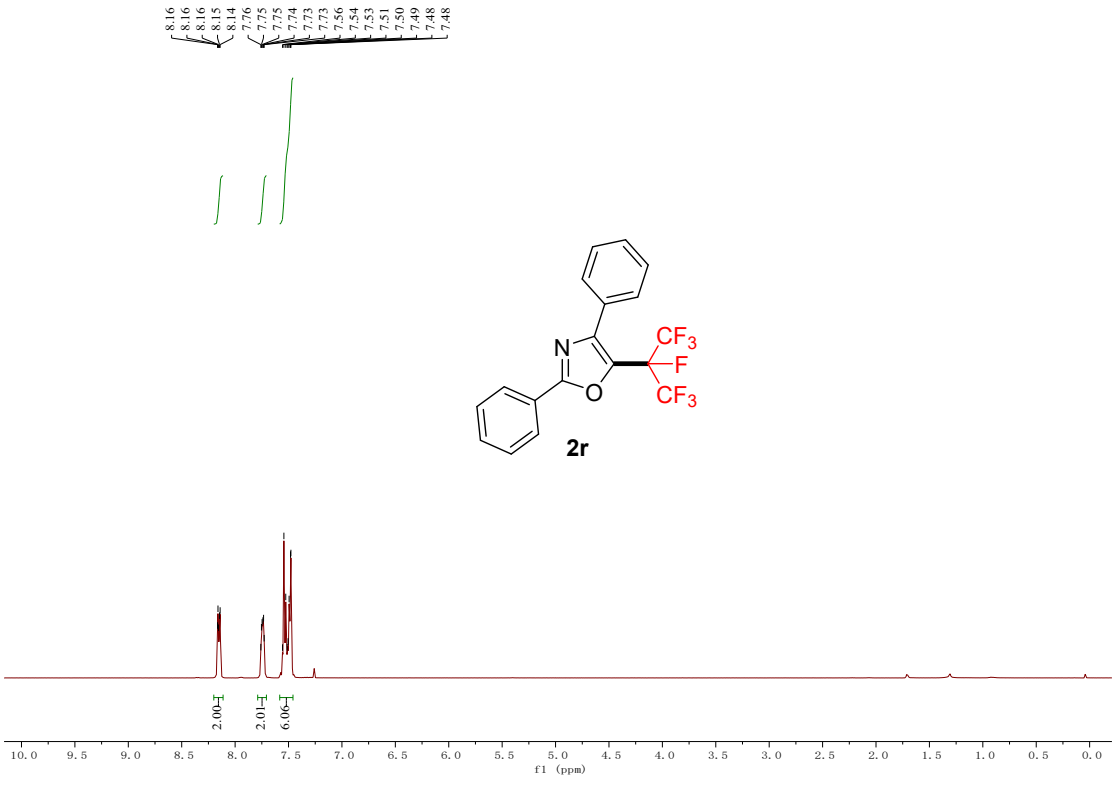
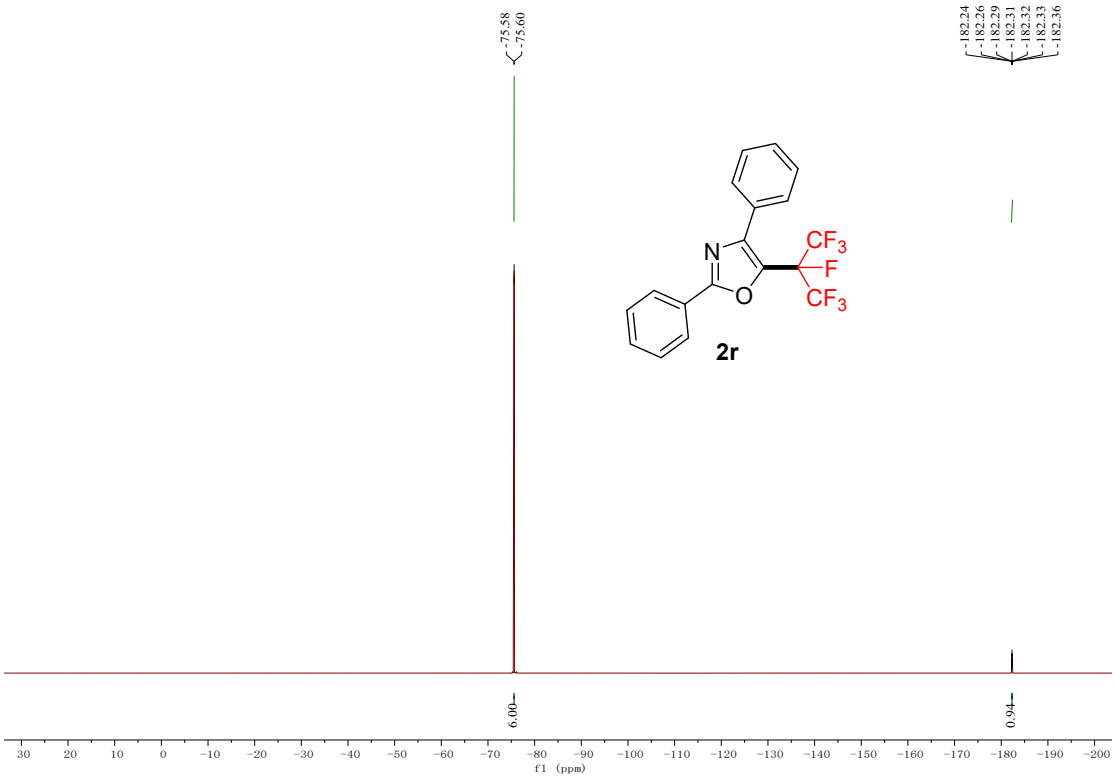


*^{19}F NMR (*376 MHz, *$CDCl_3$)*



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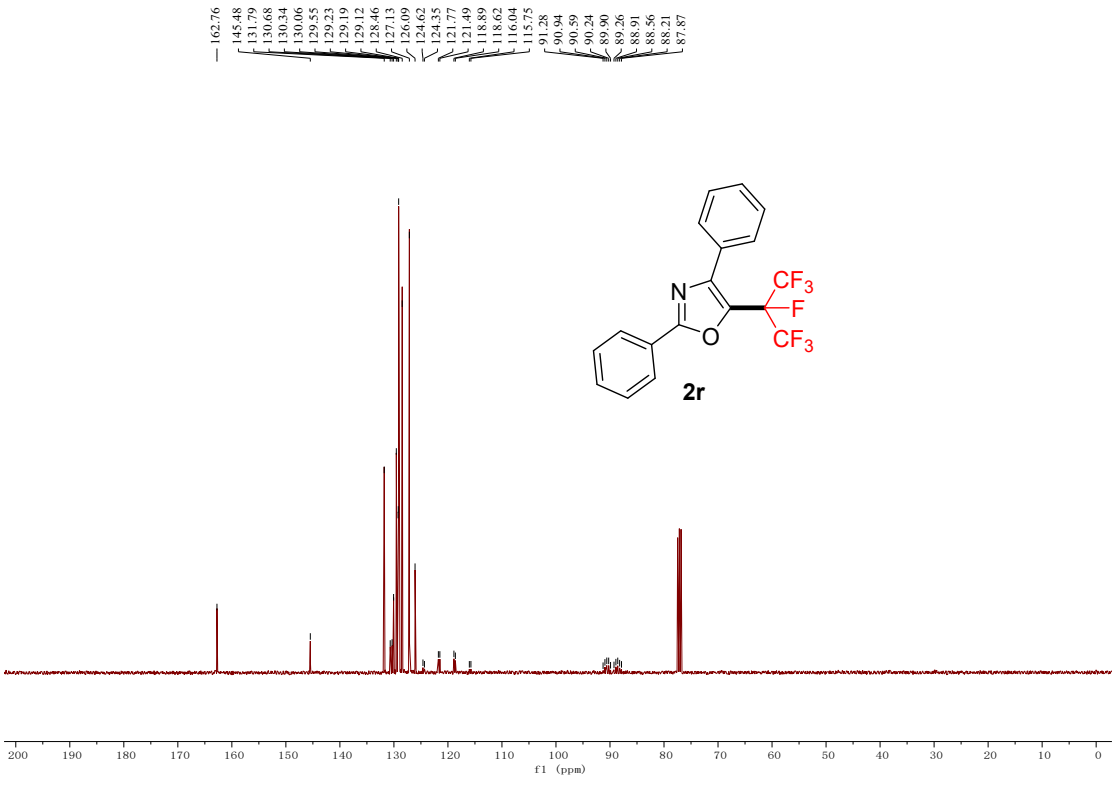

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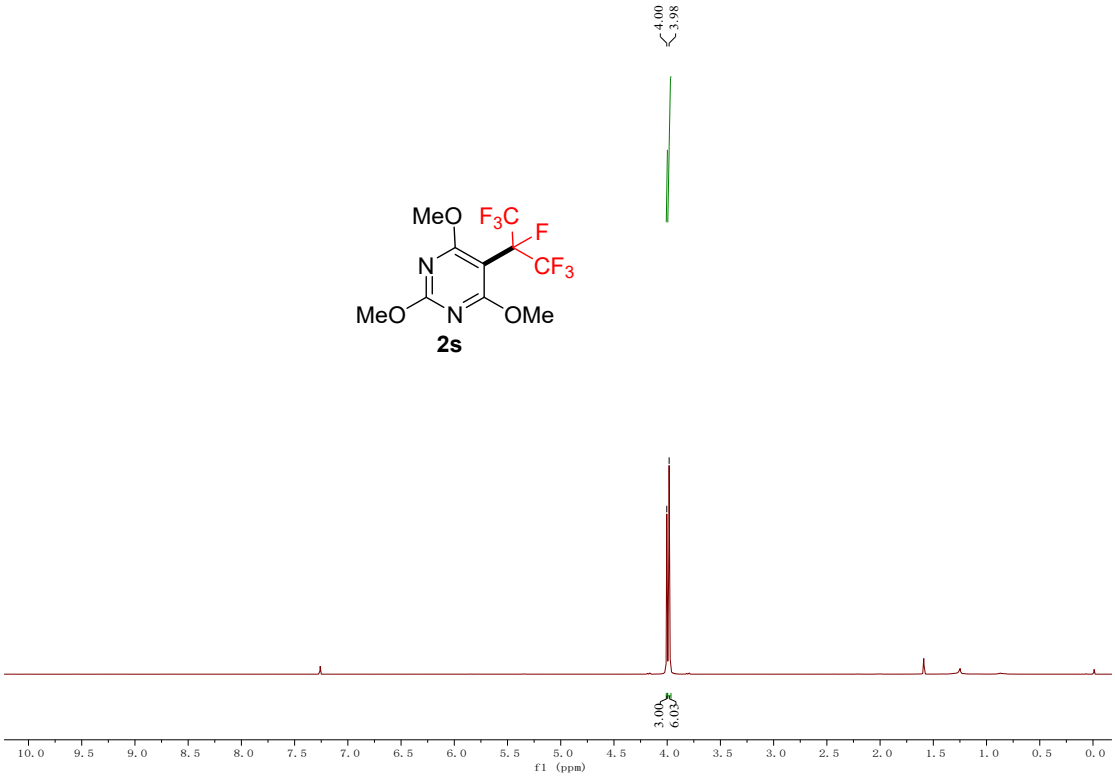

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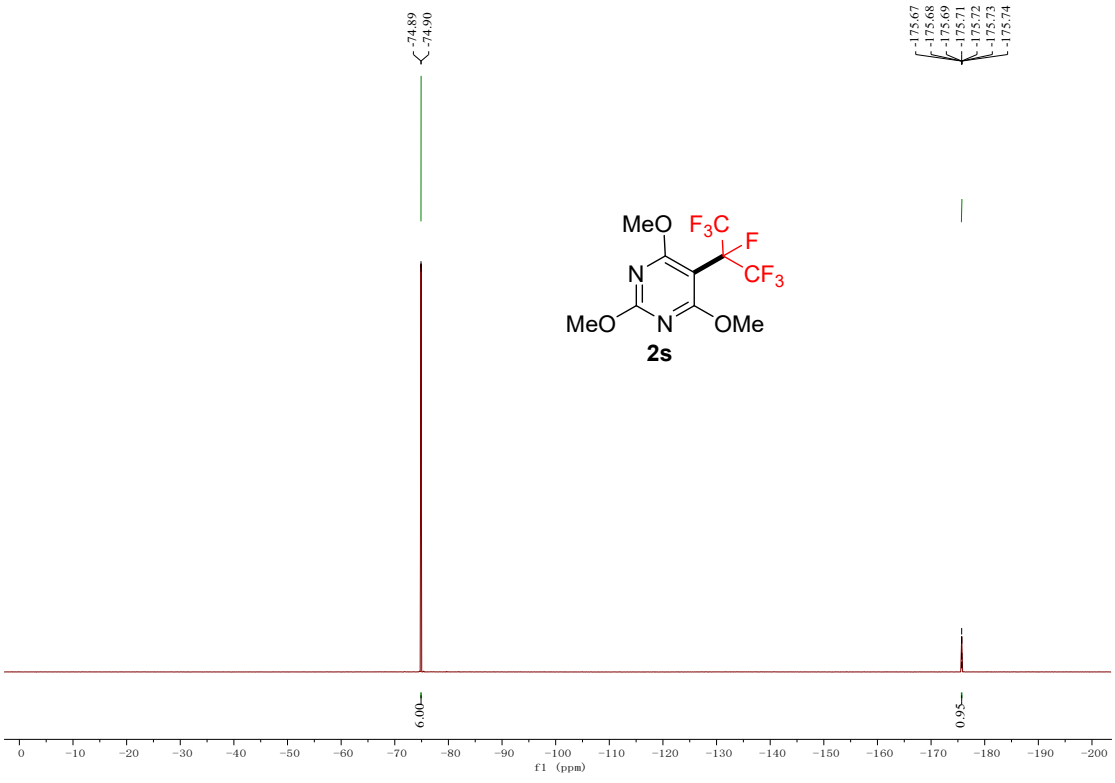

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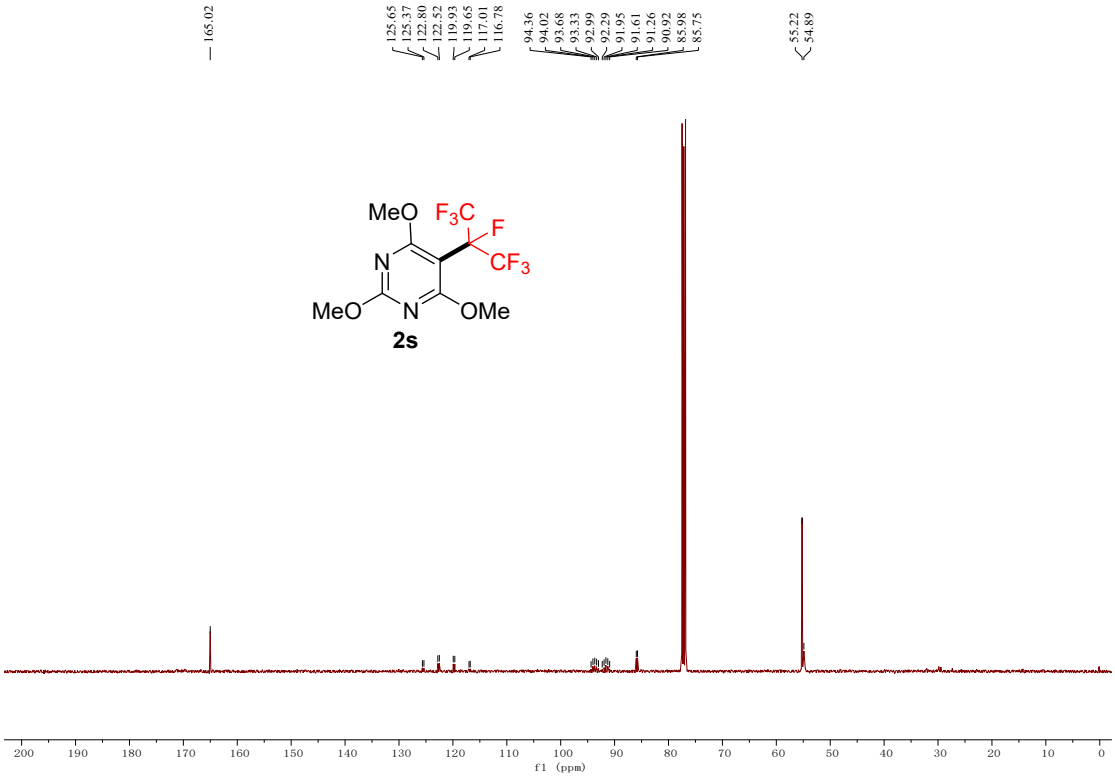

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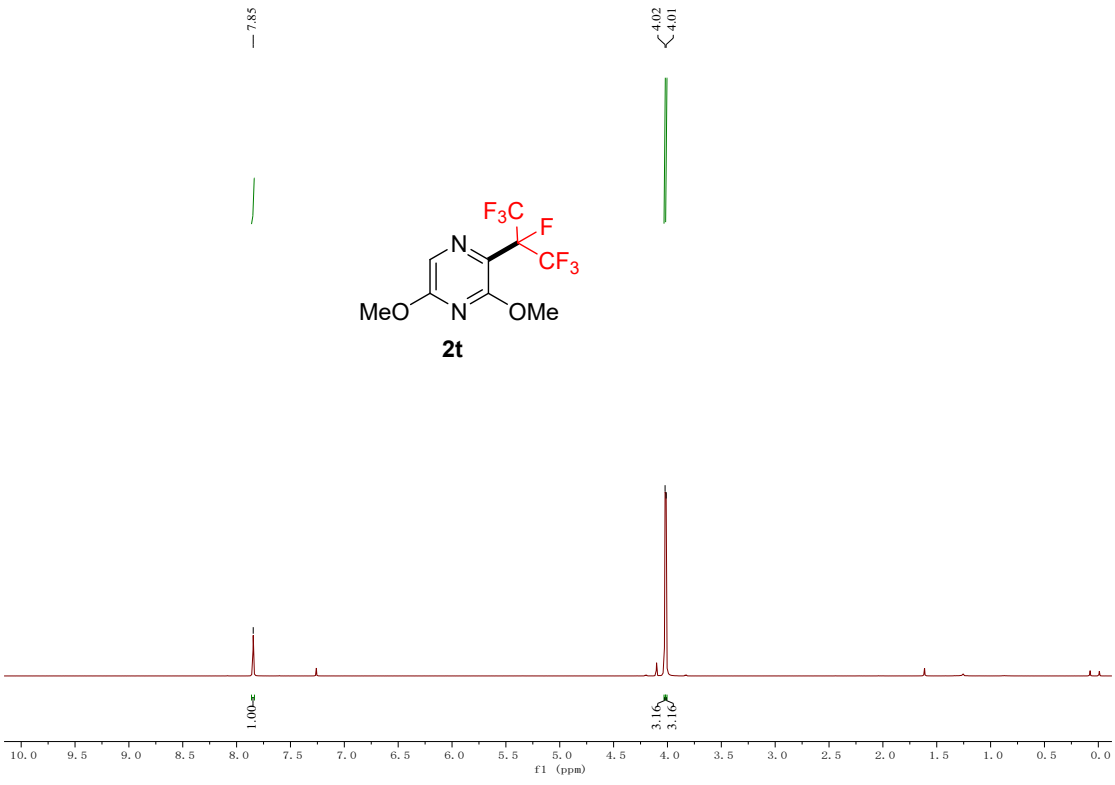

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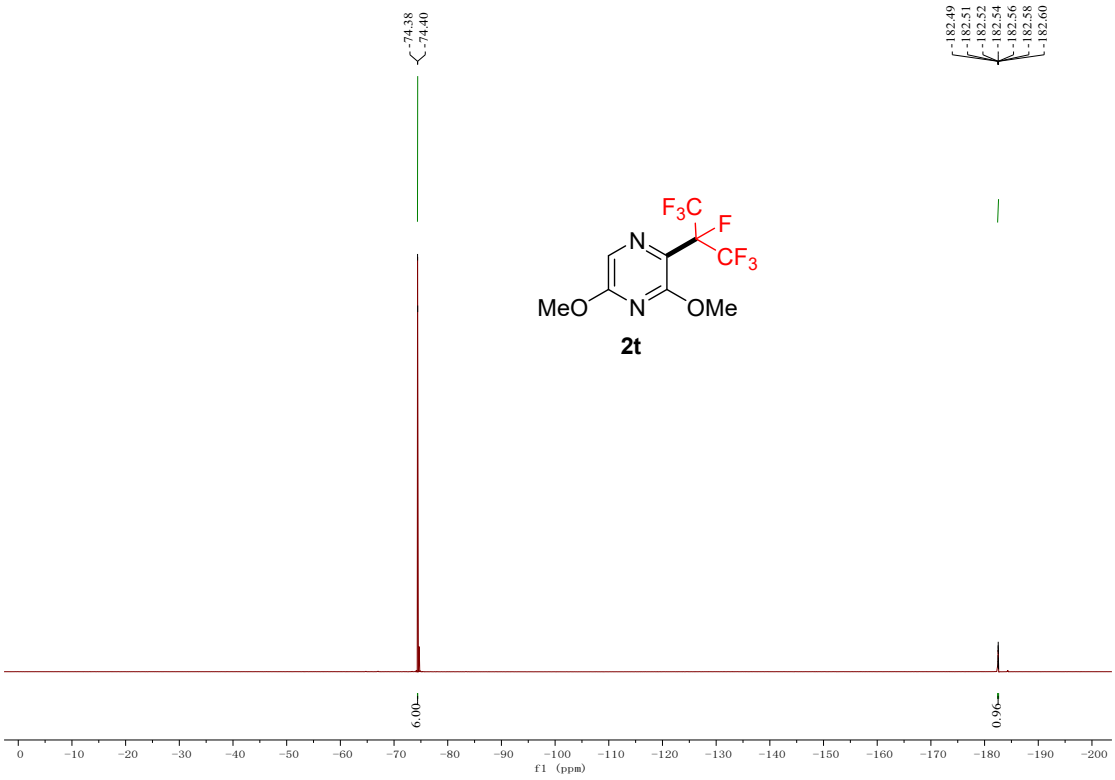

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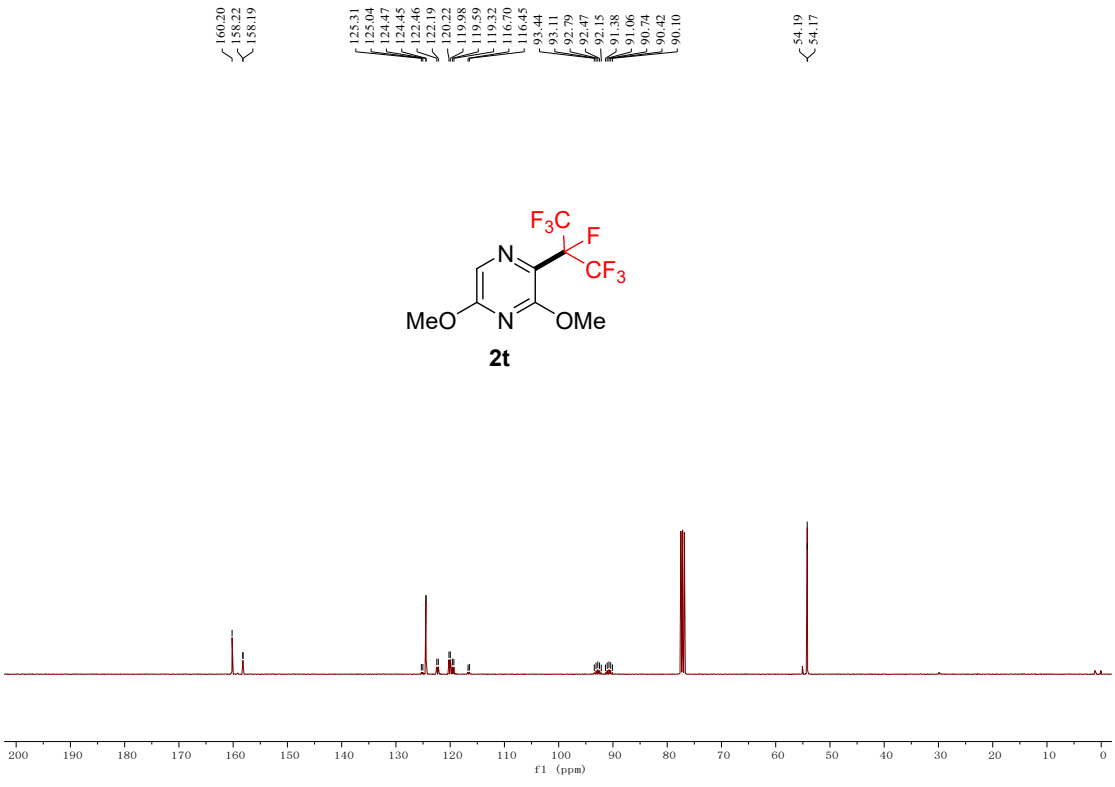

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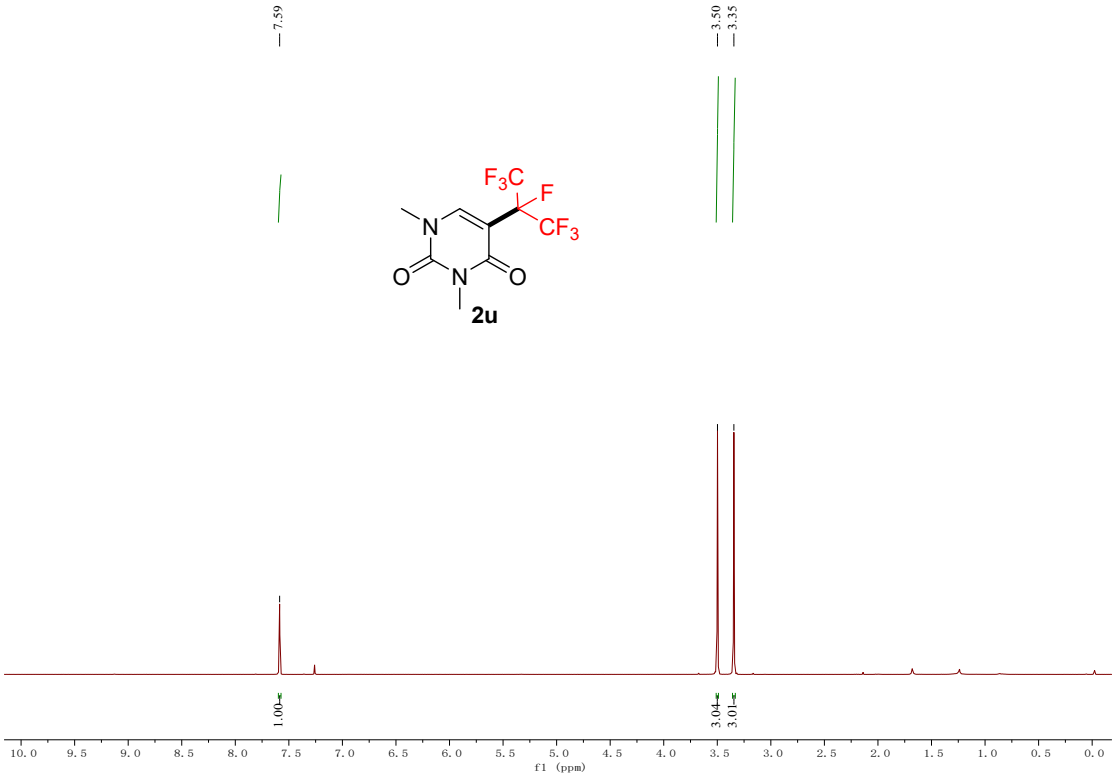

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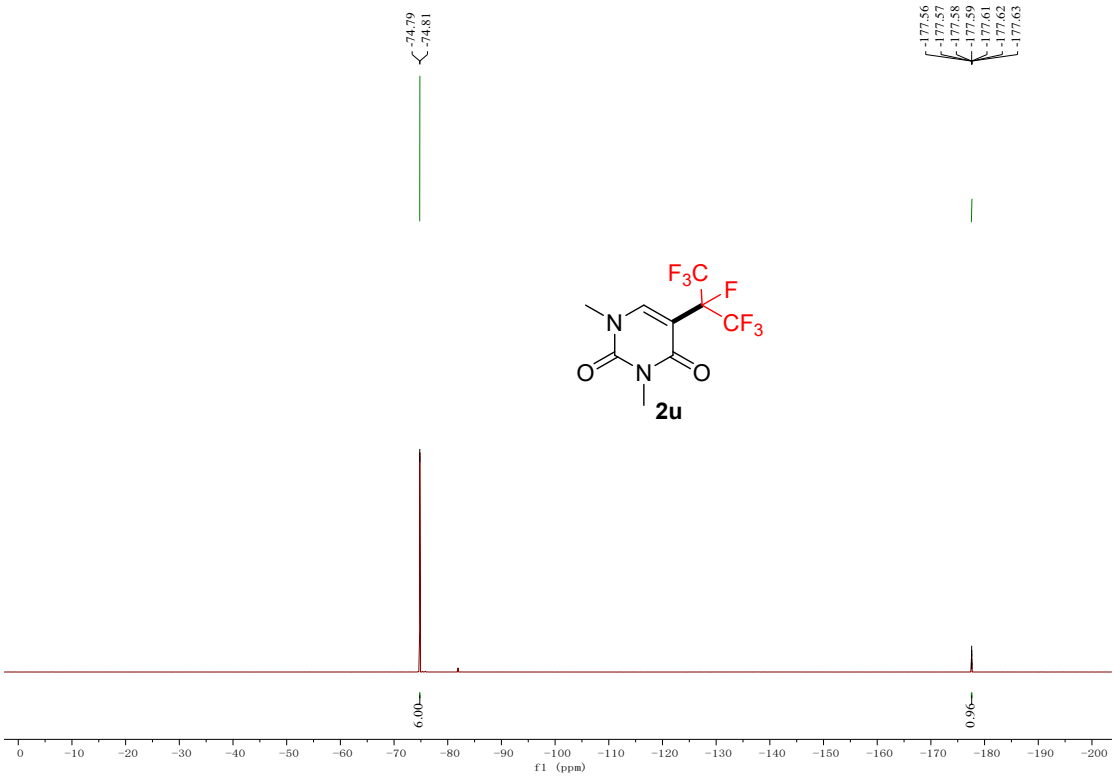

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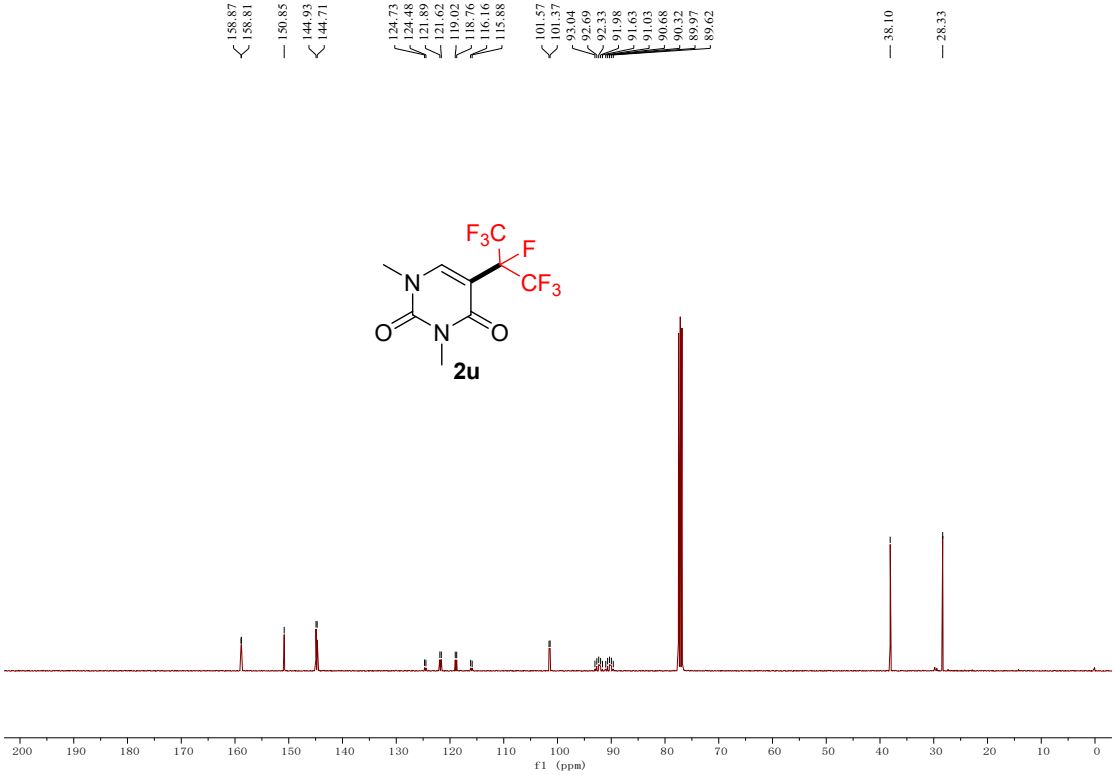

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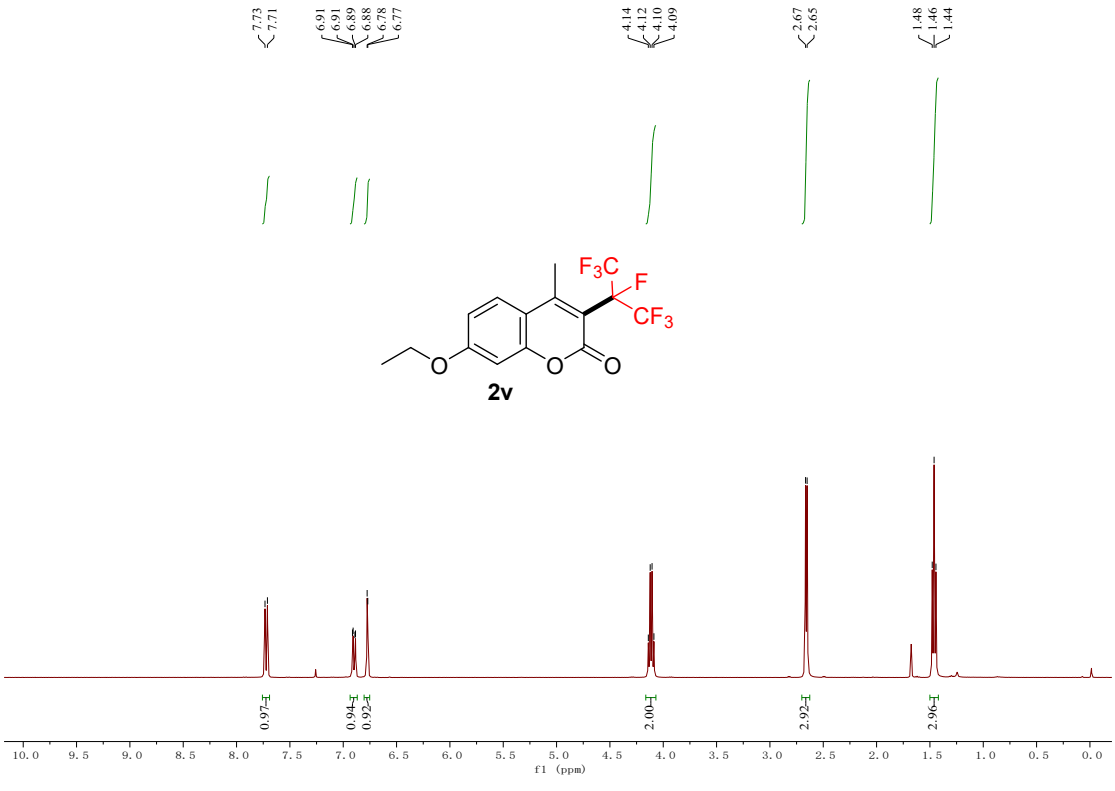

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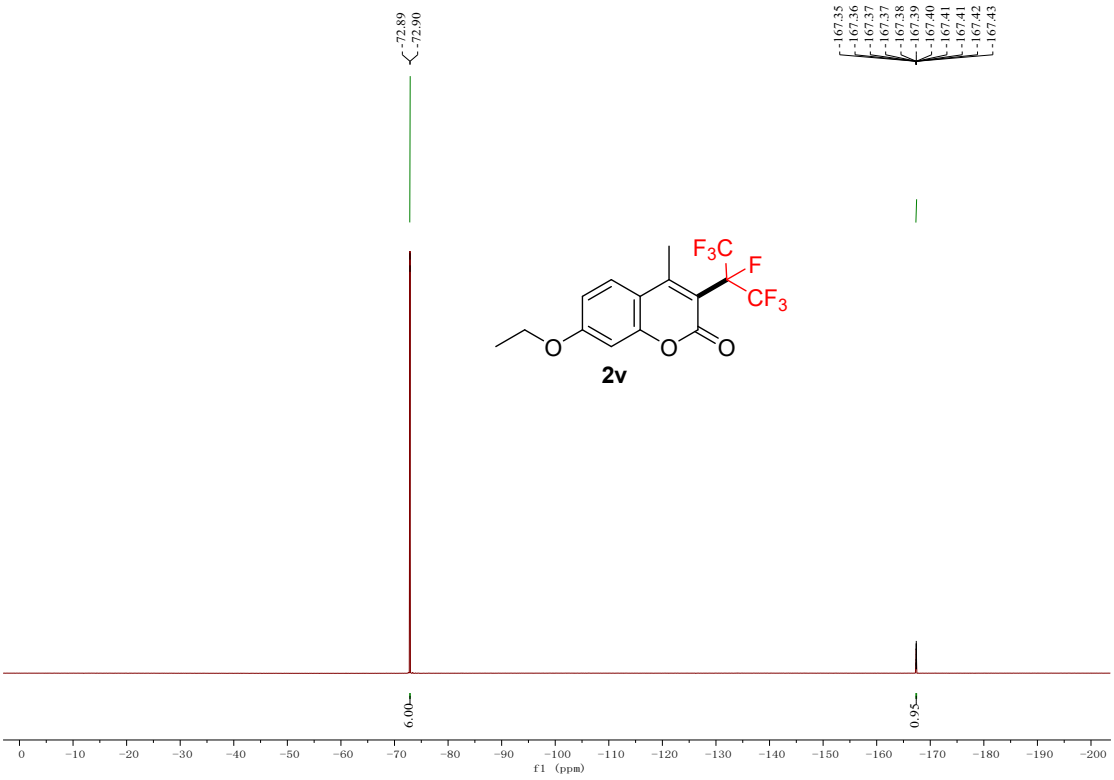

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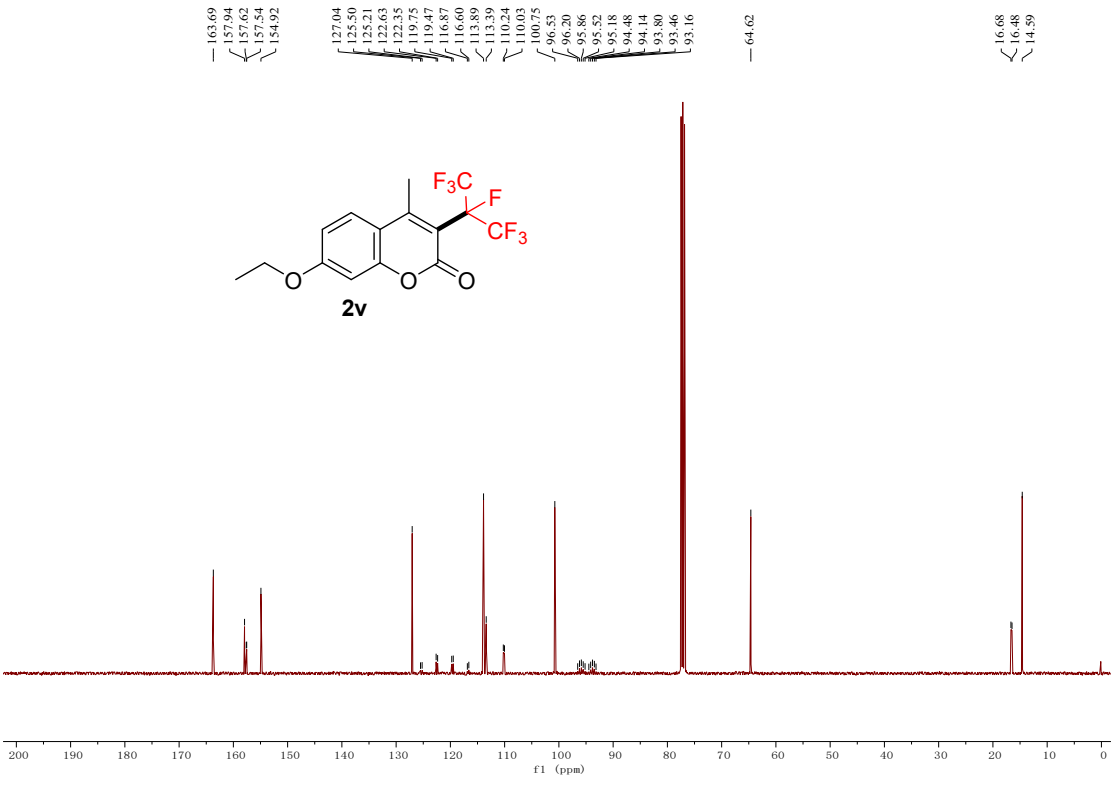
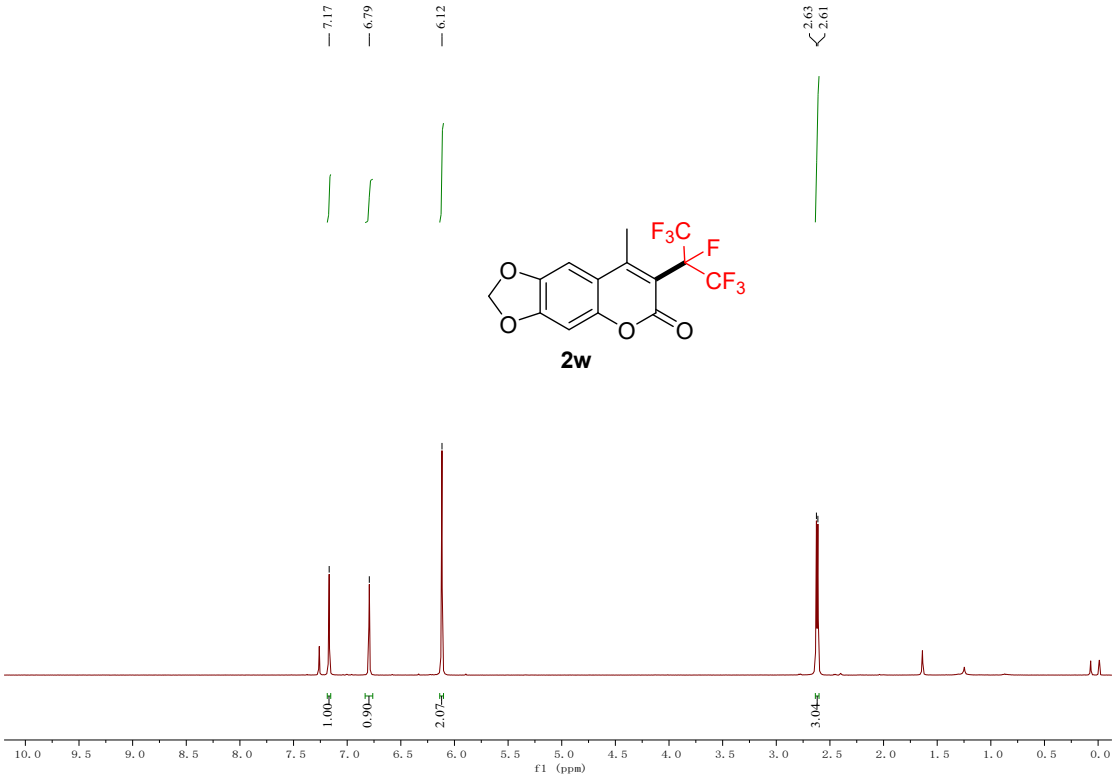


*[1]H NMR (*400 MHz, *$CDCl_3$)*



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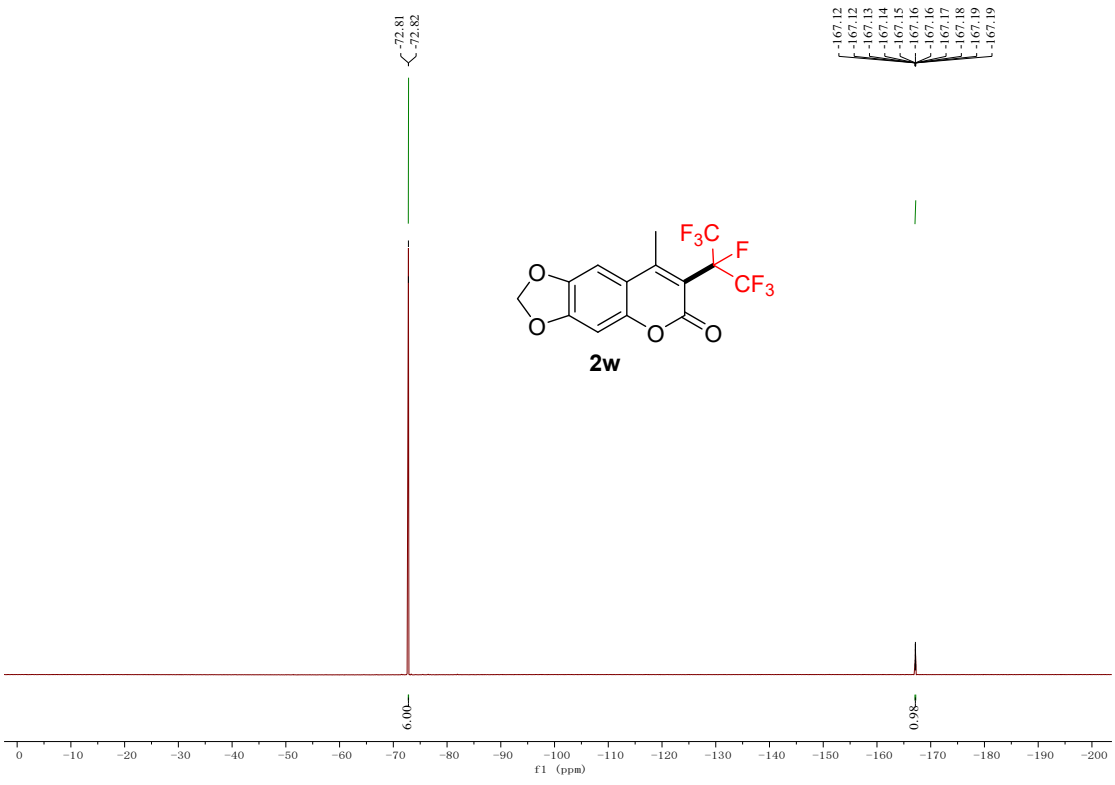

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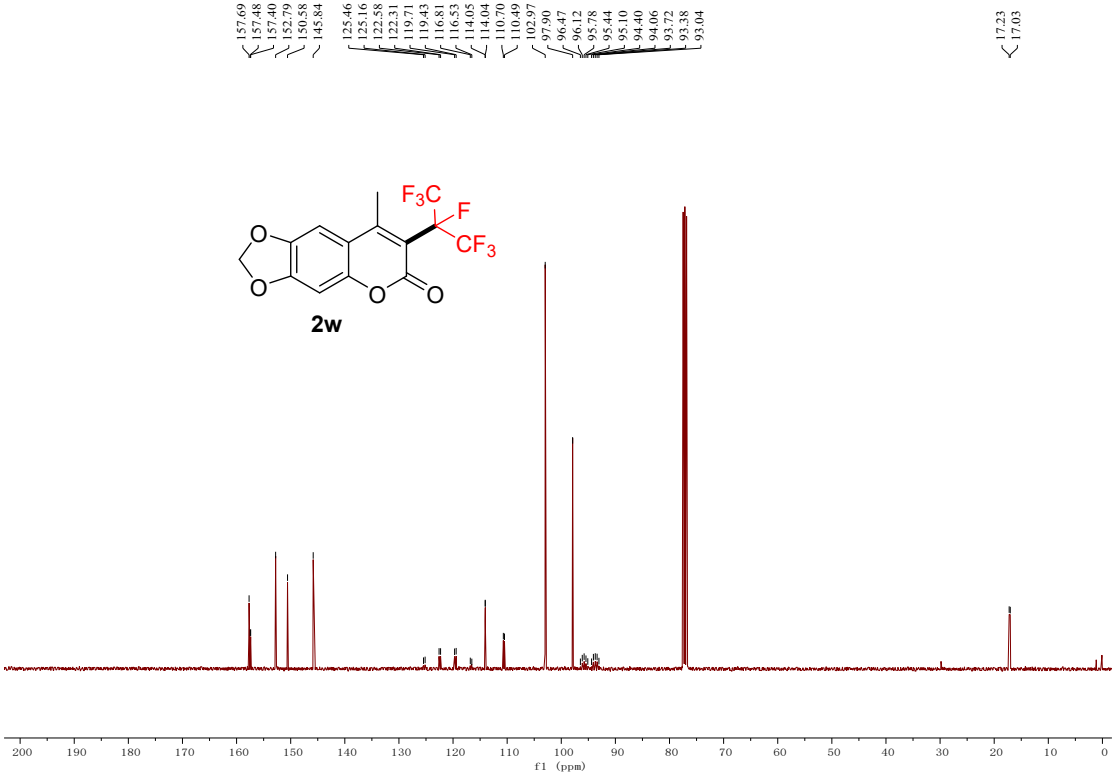

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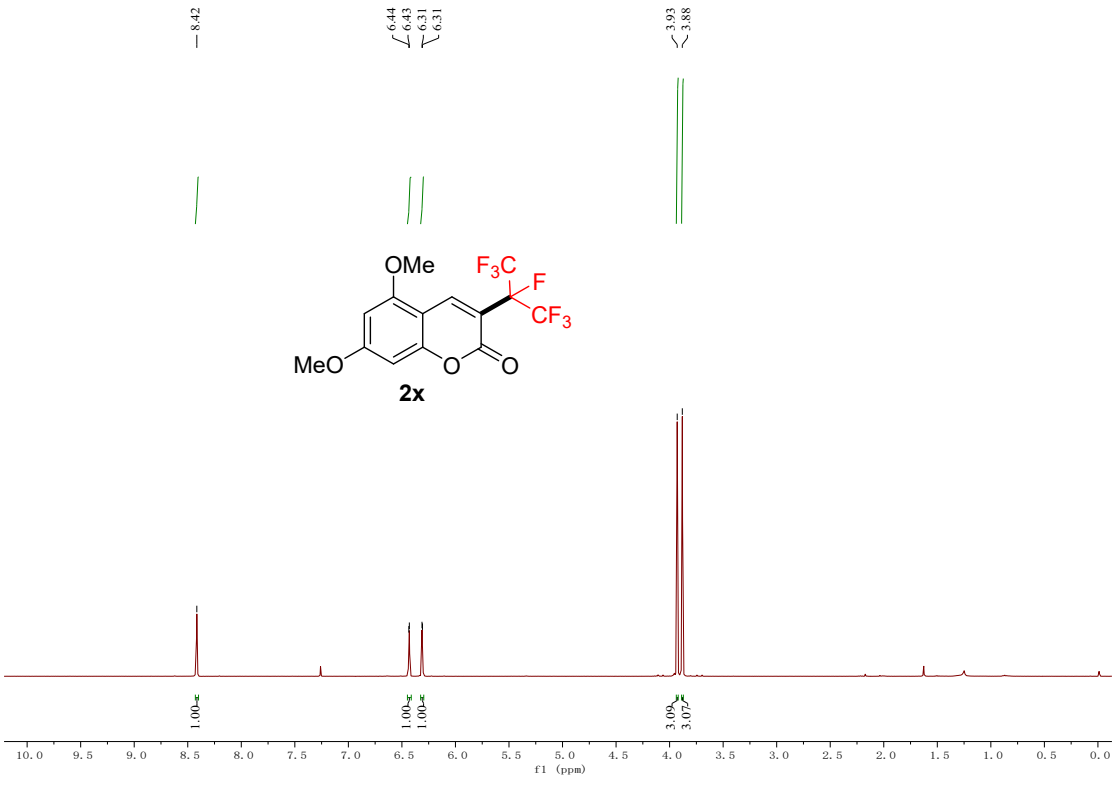

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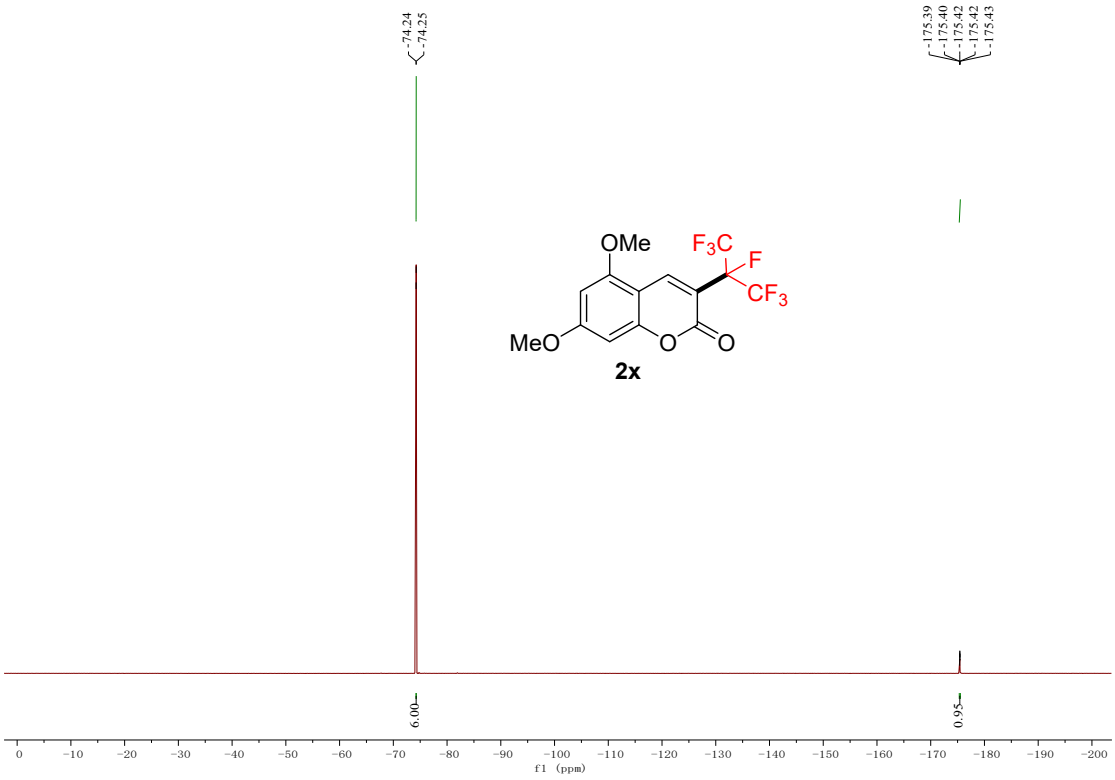

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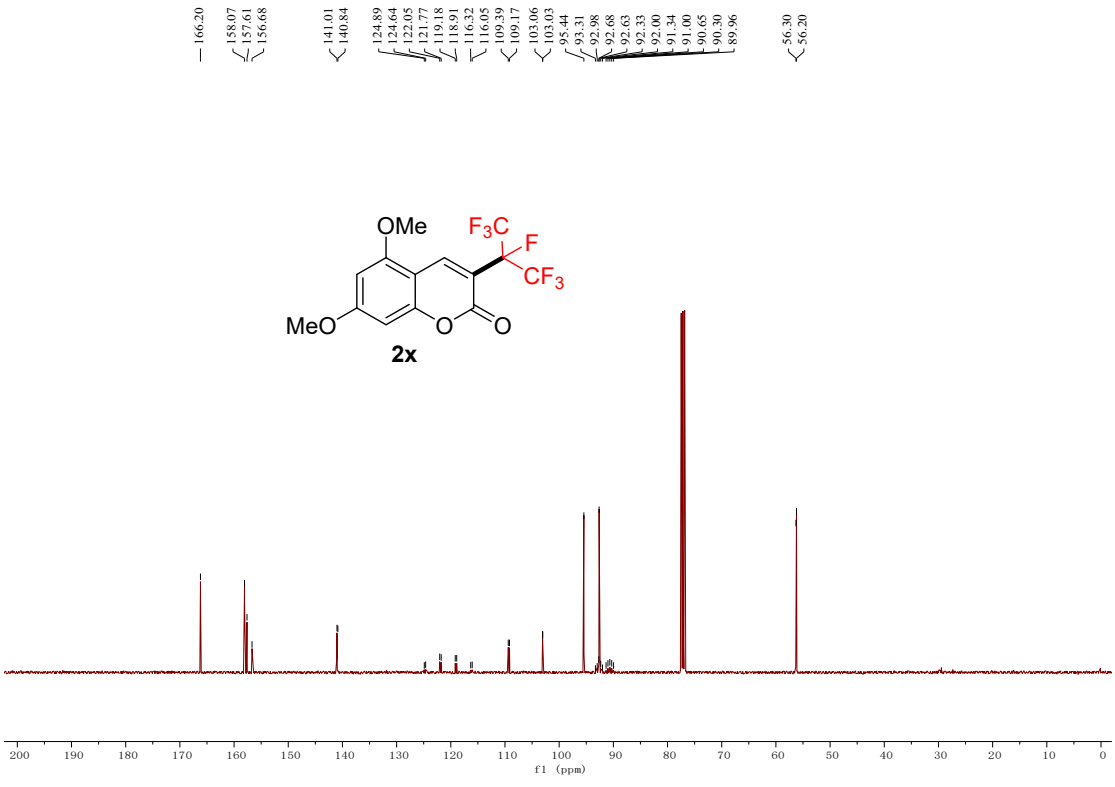

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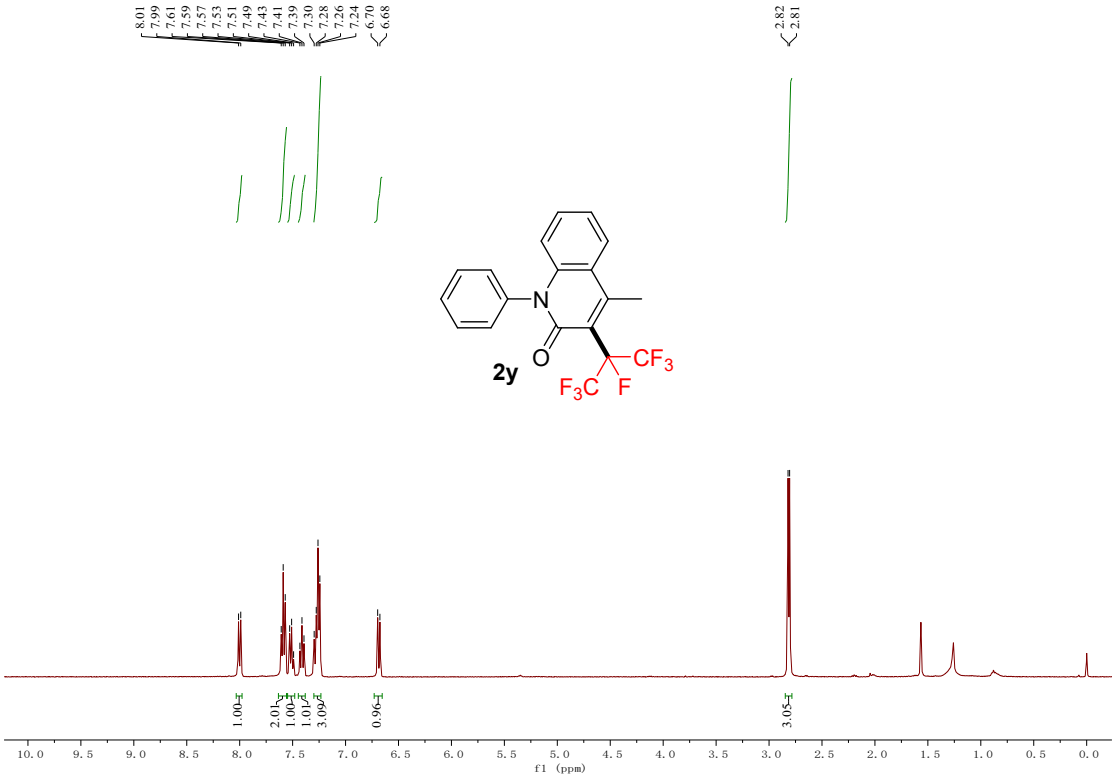

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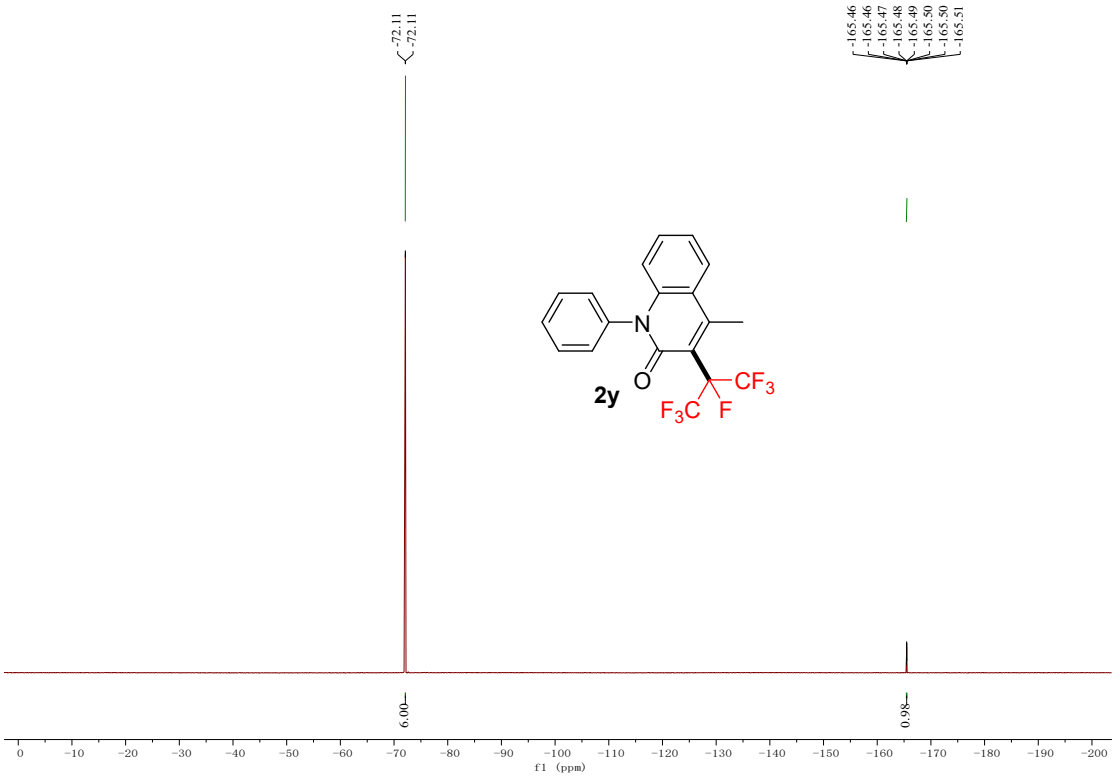

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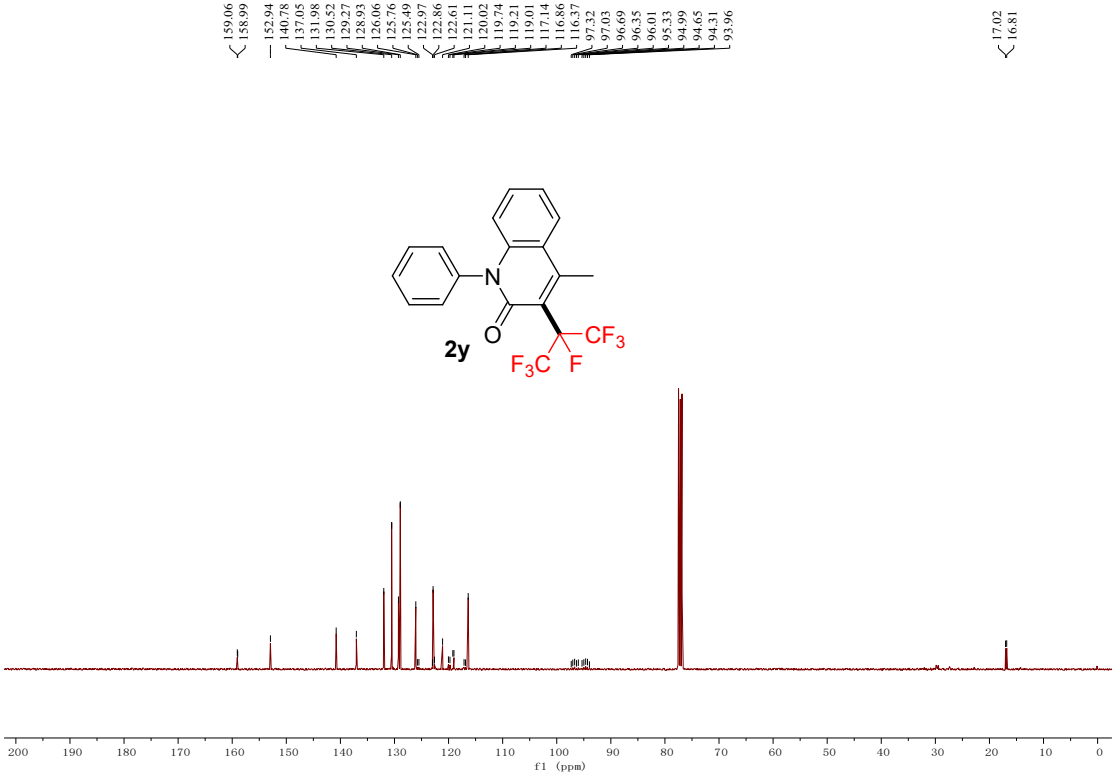

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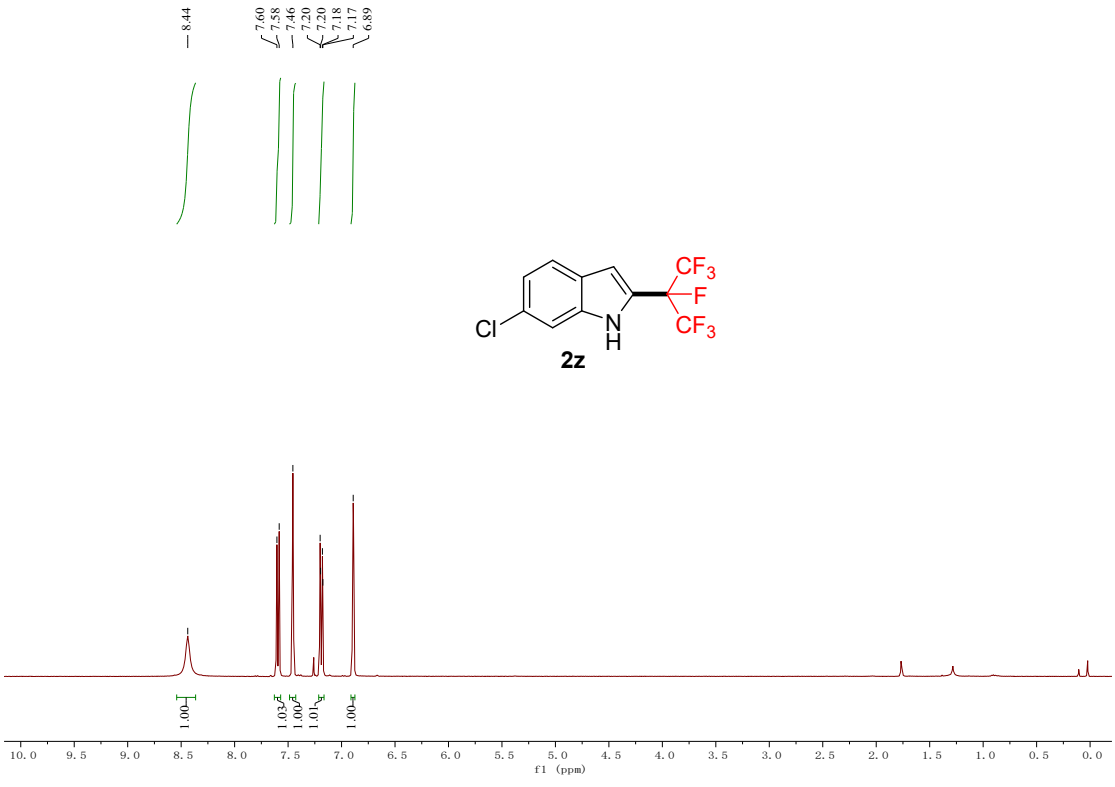

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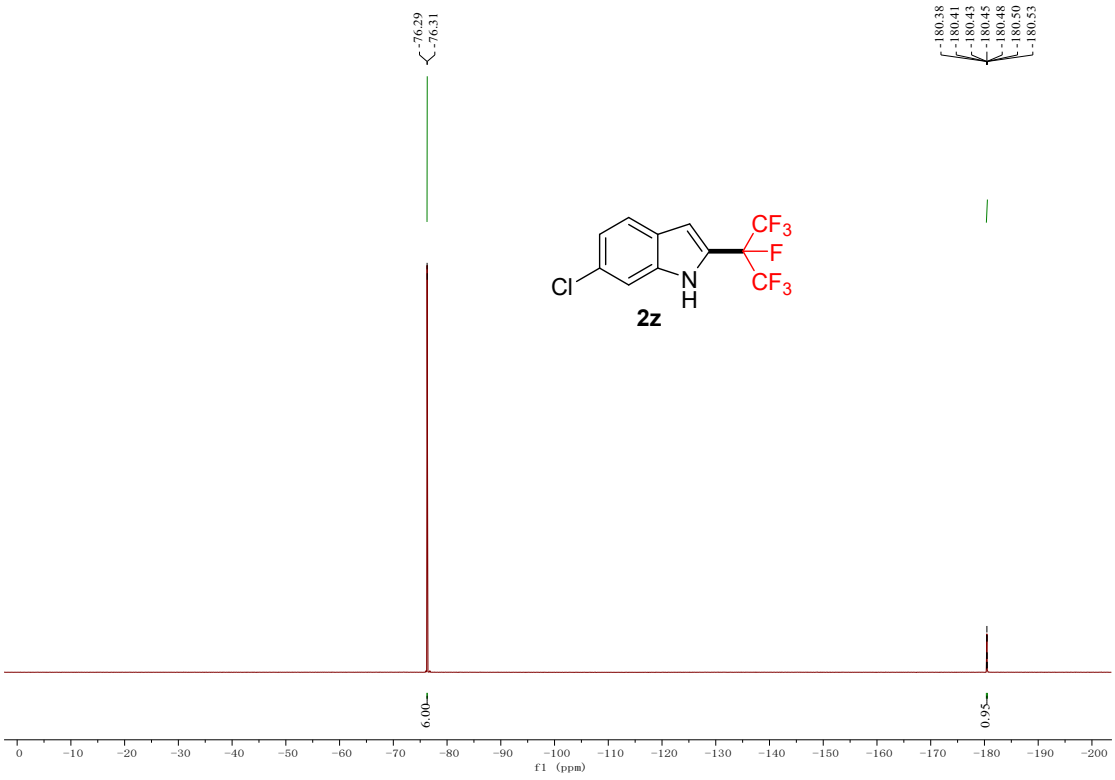

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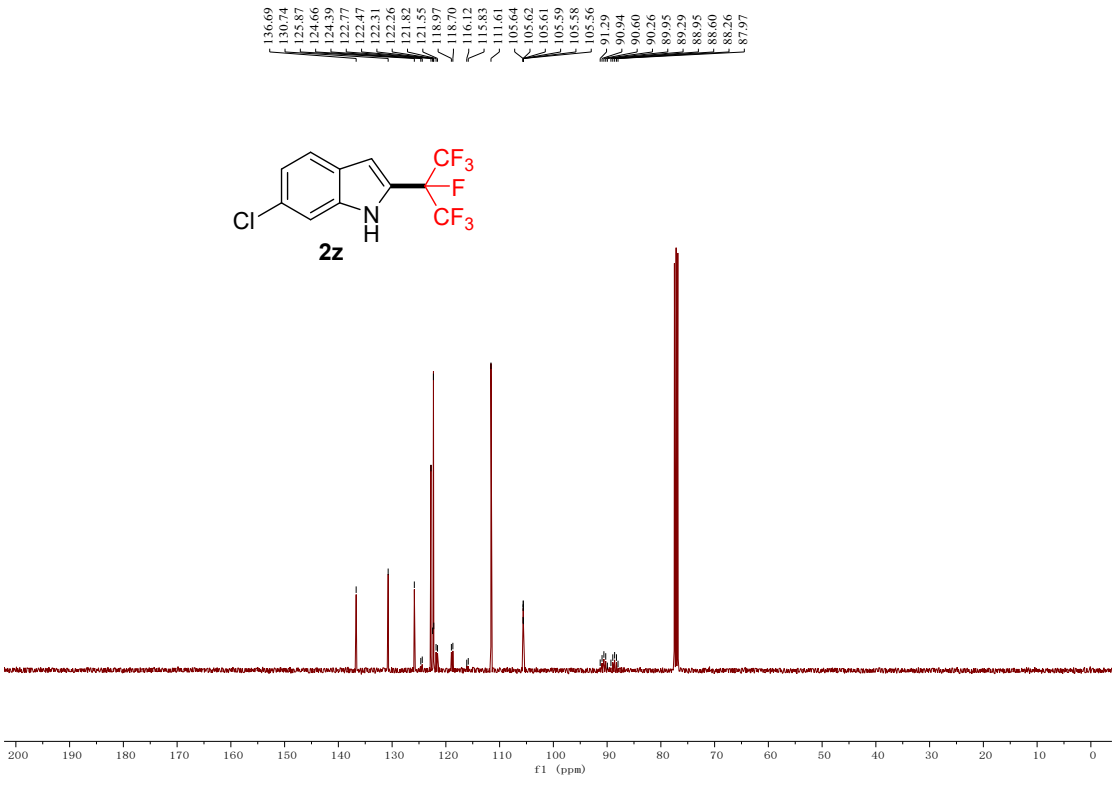

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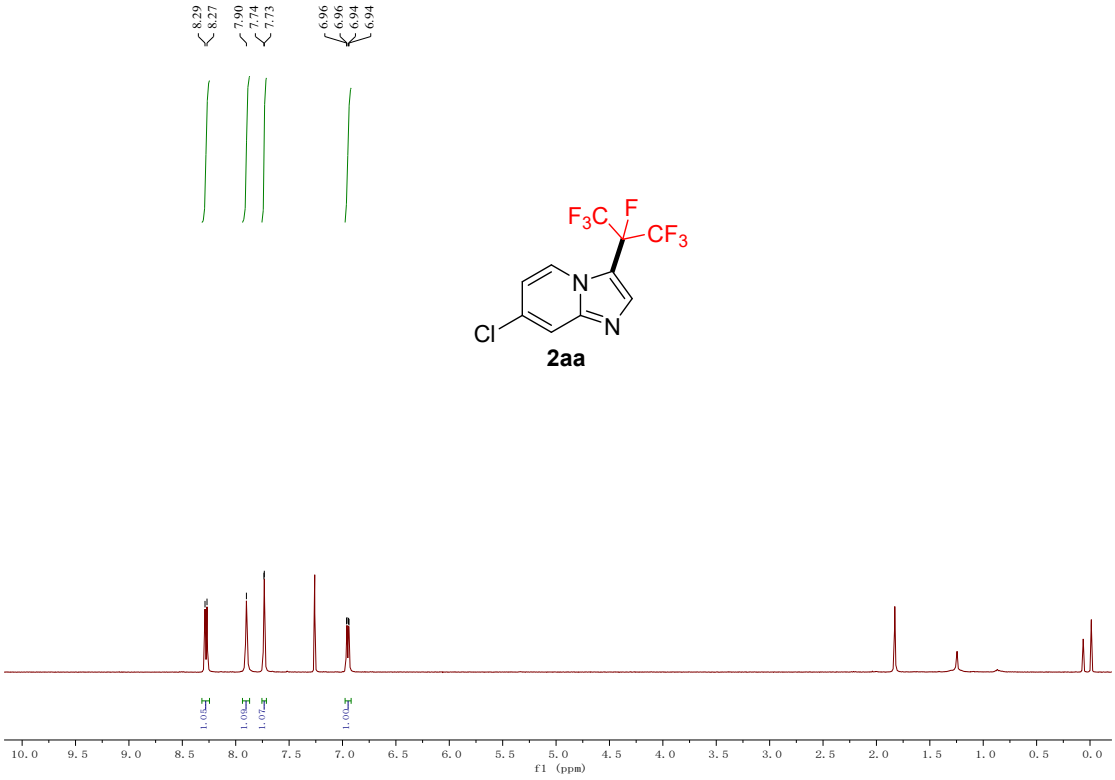

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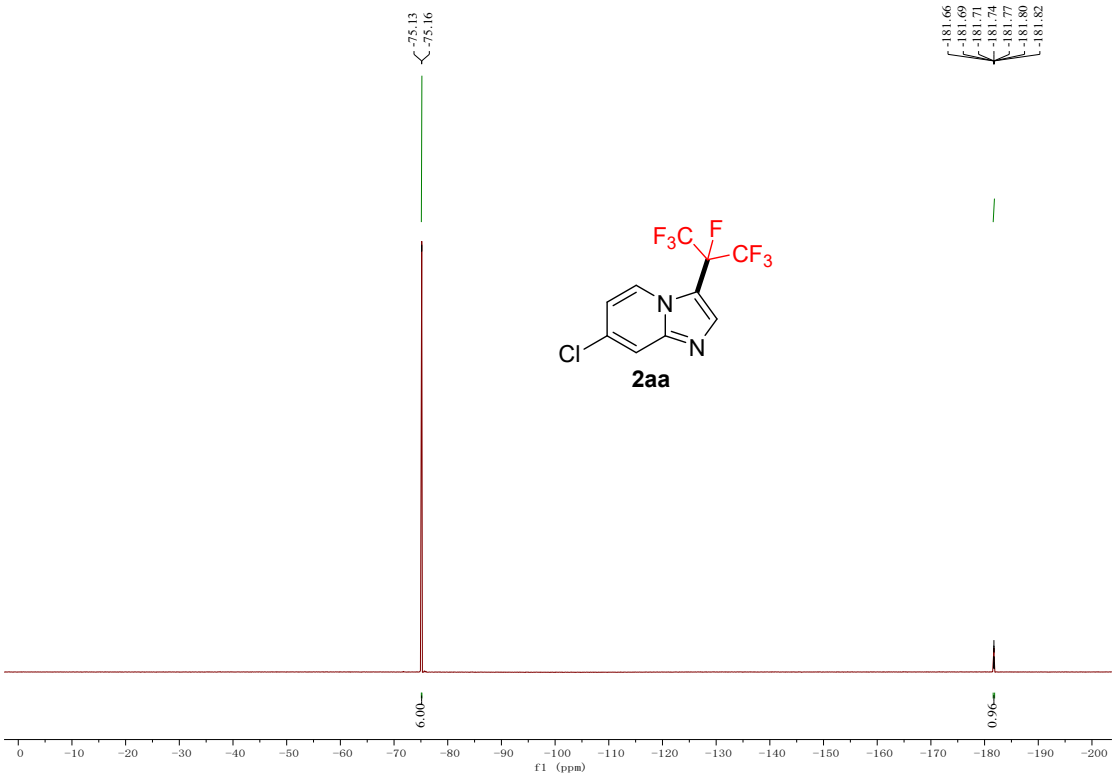

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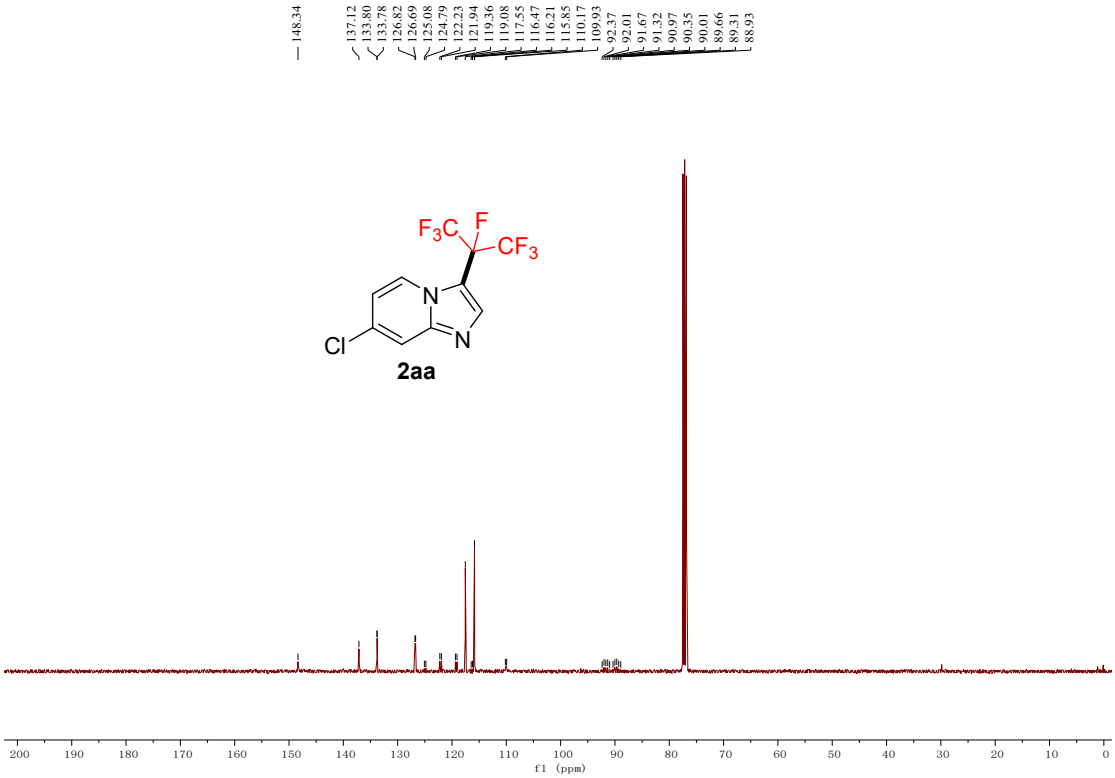

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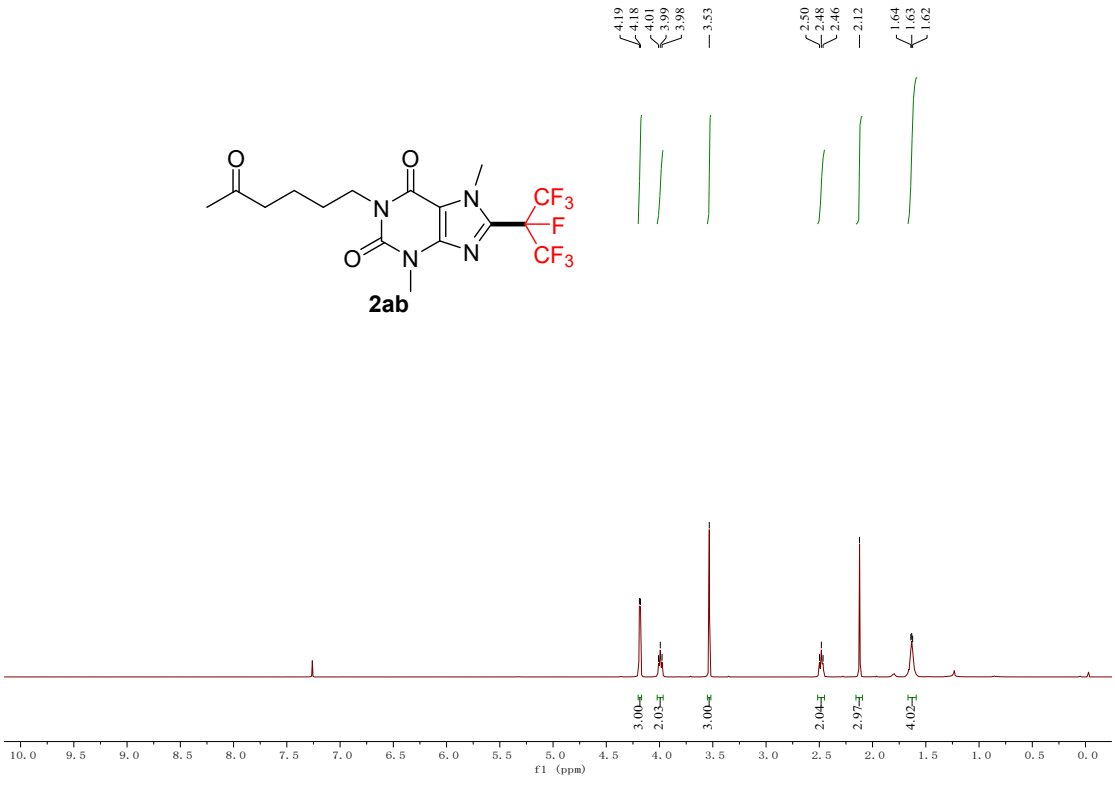

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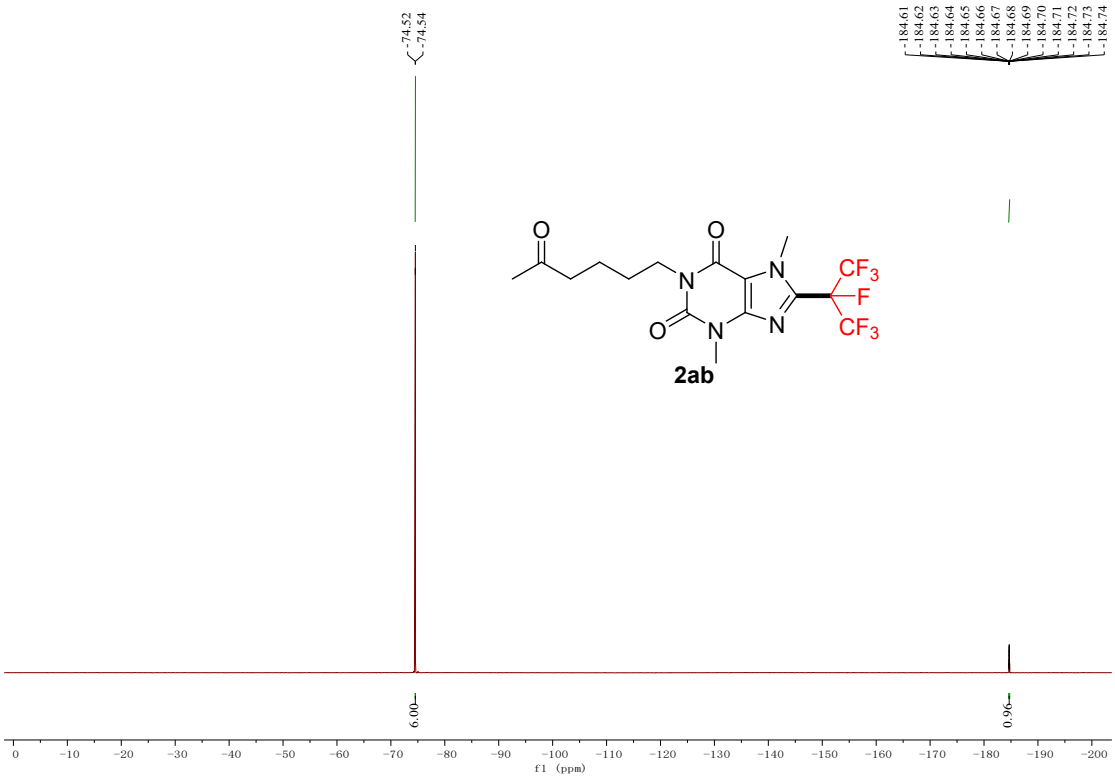

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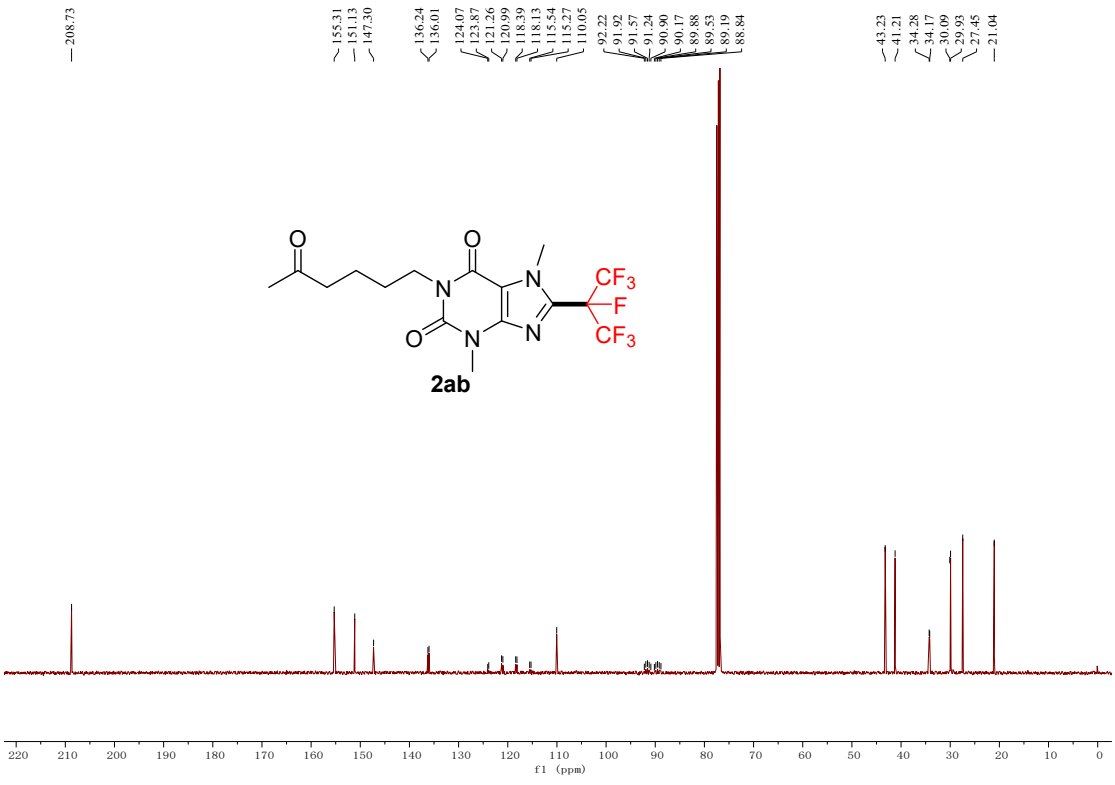

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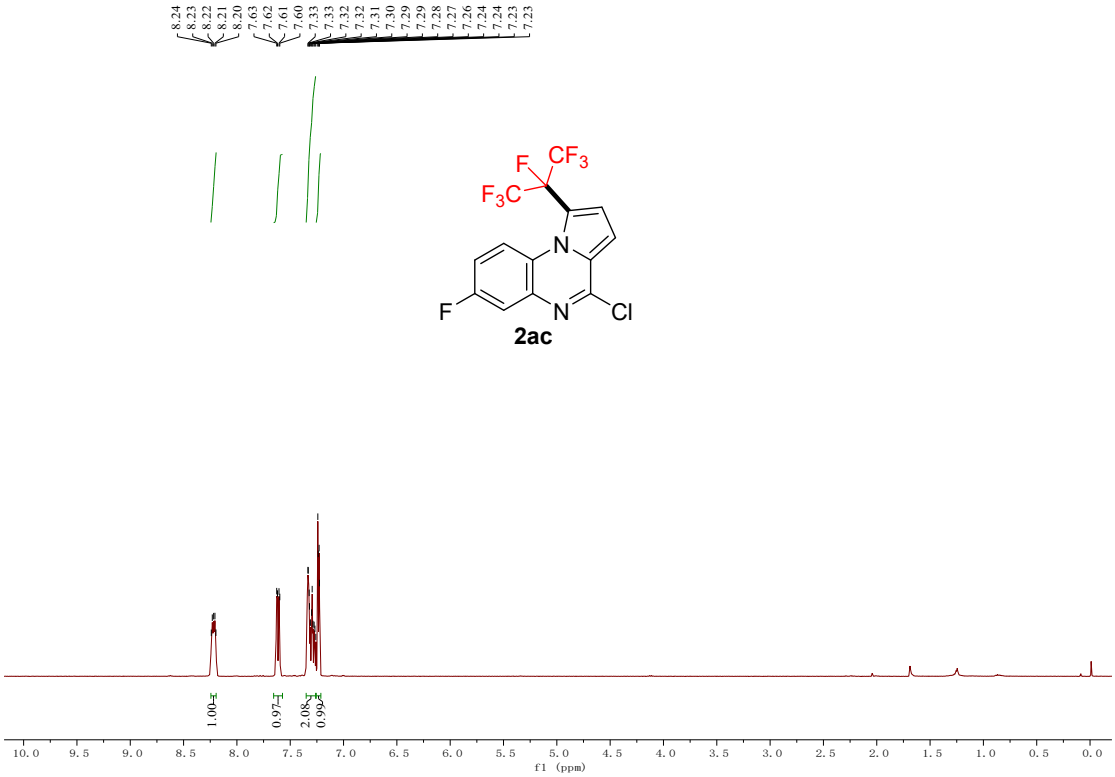

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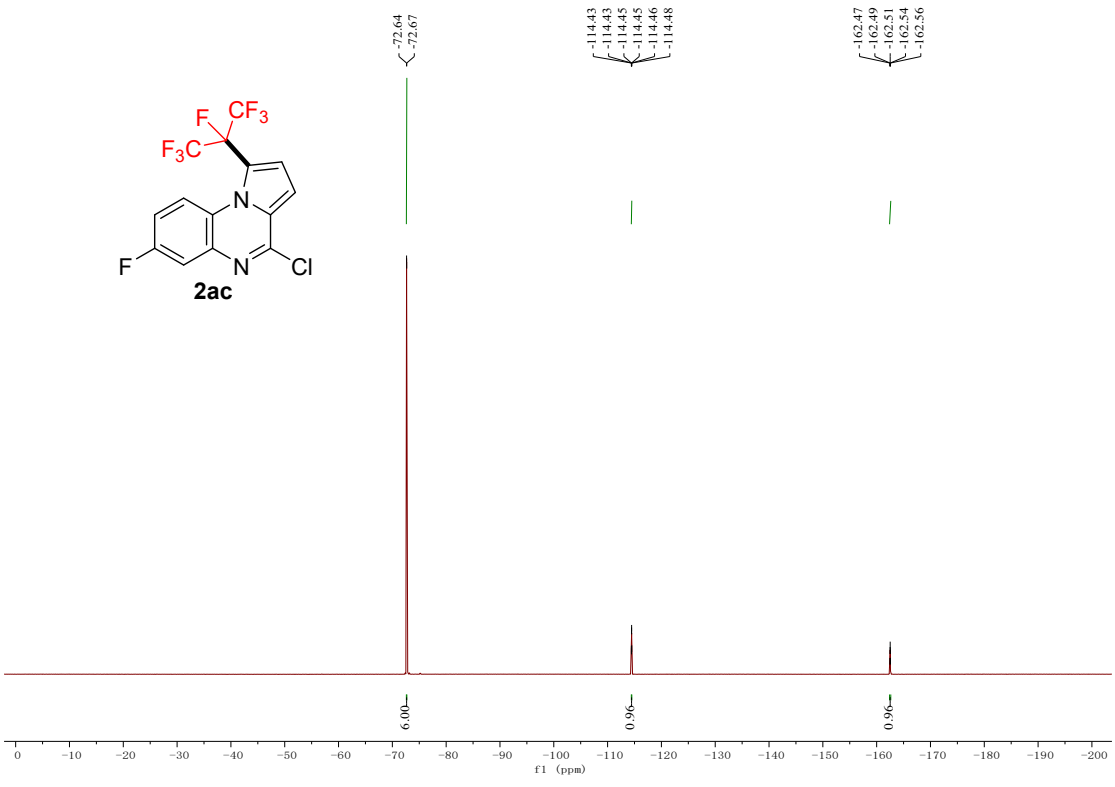

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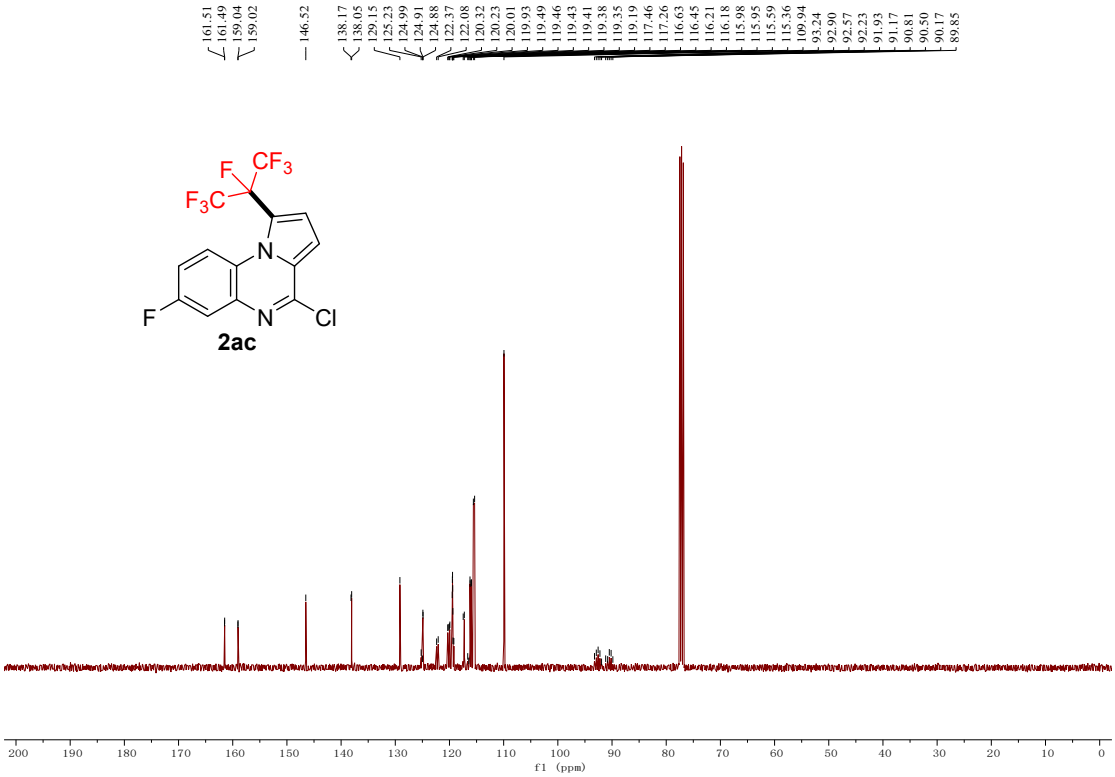
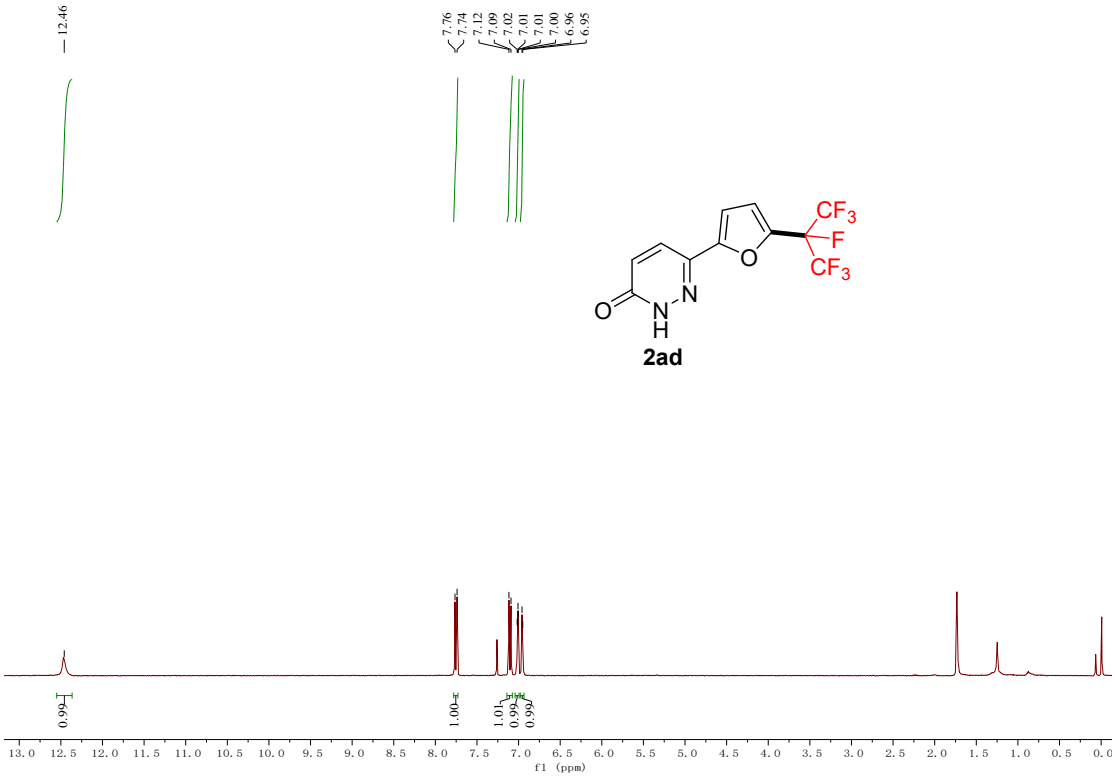
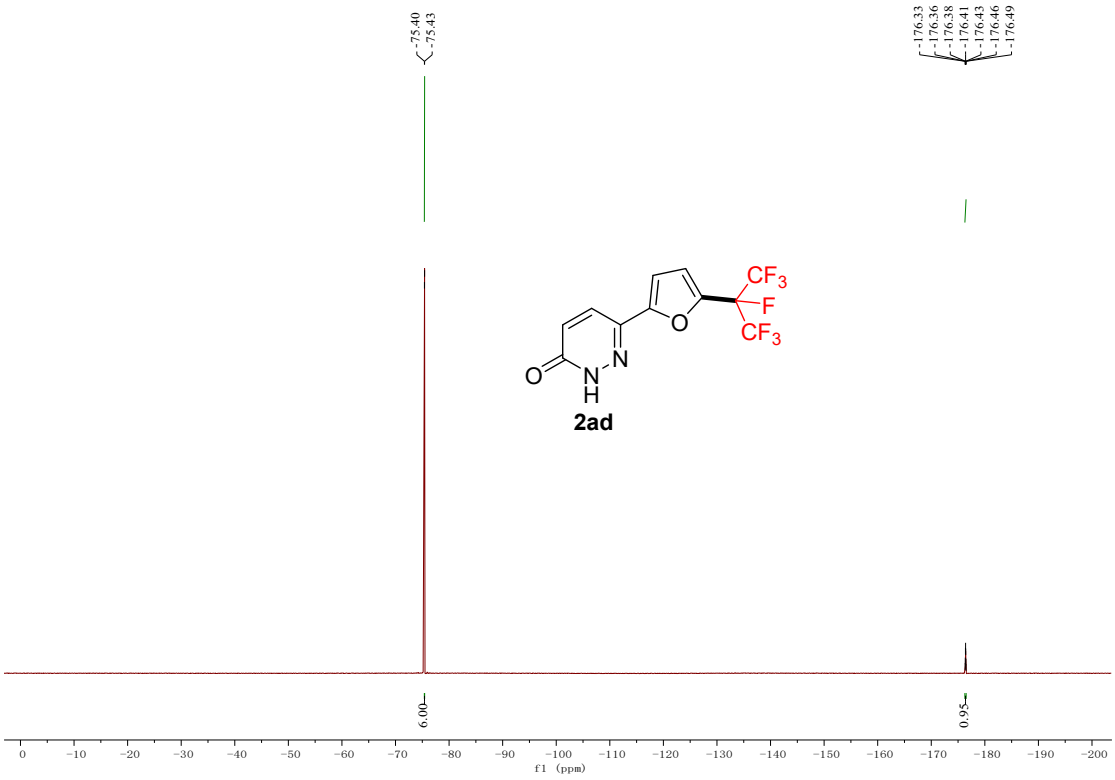


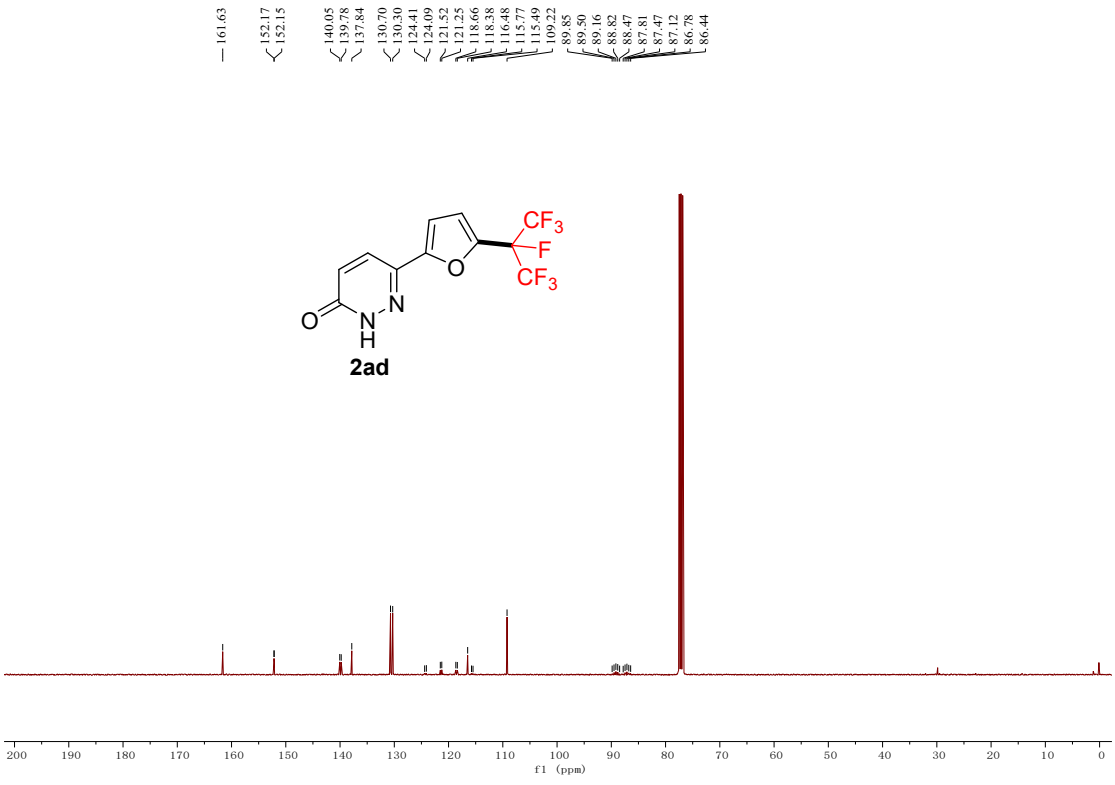
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



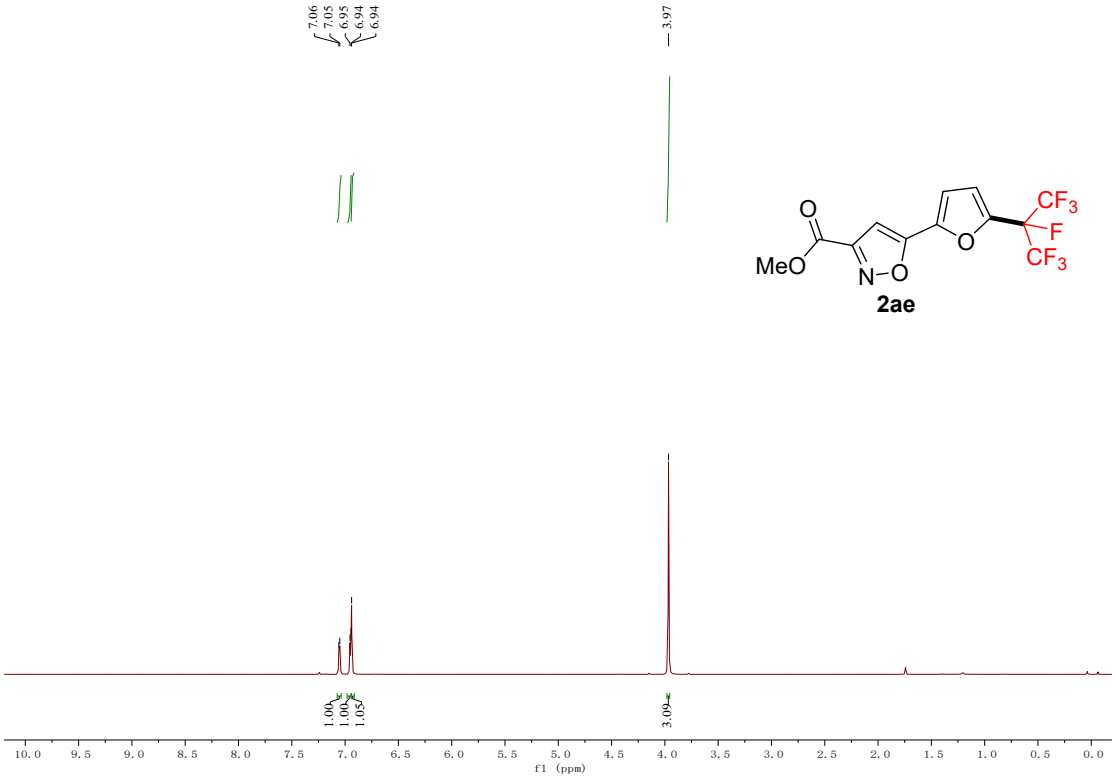
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



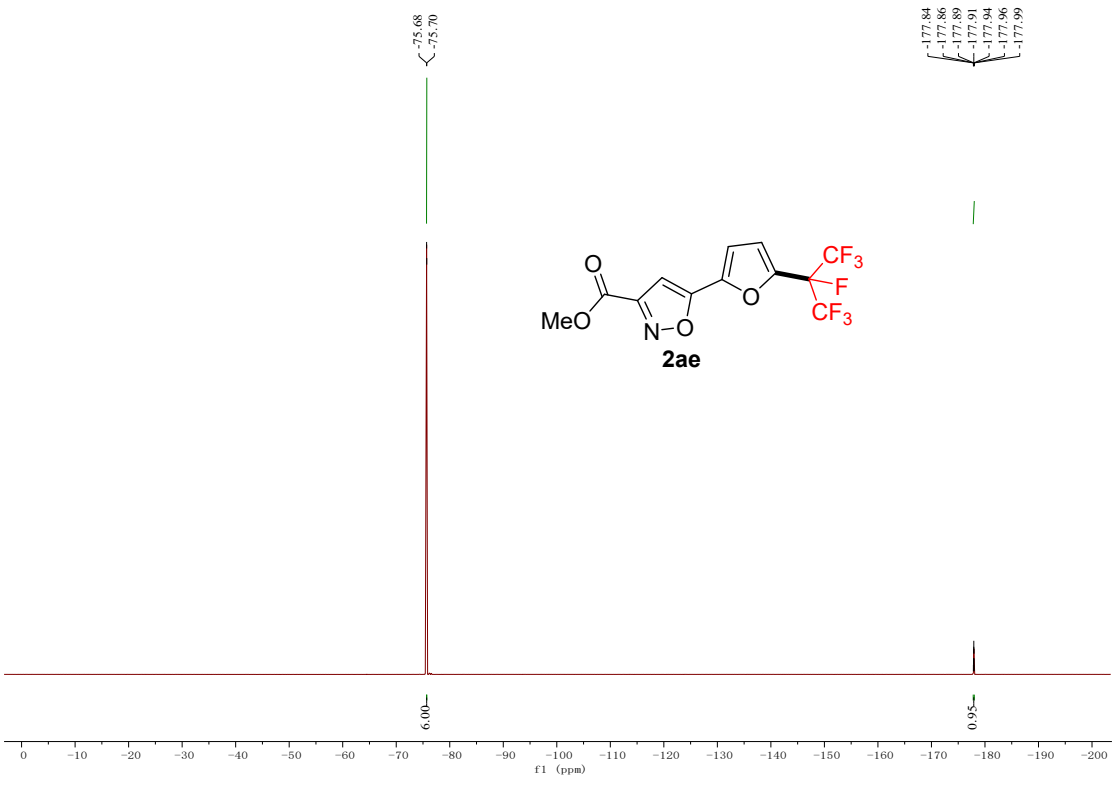
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



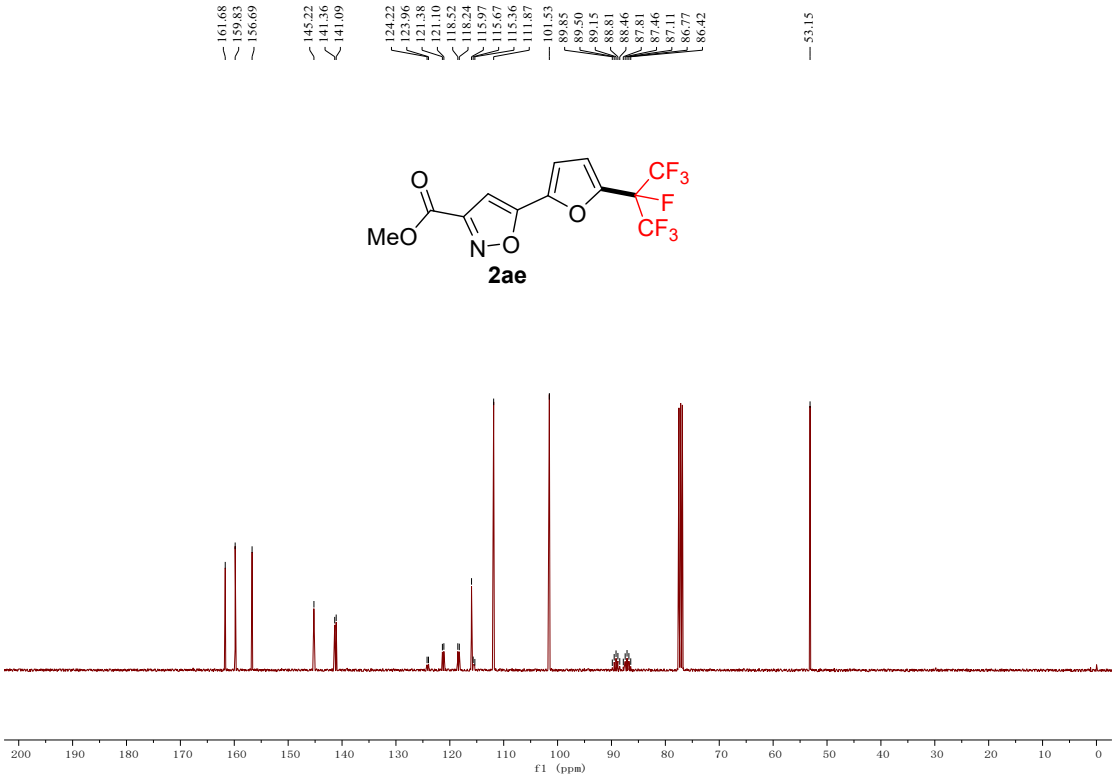
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



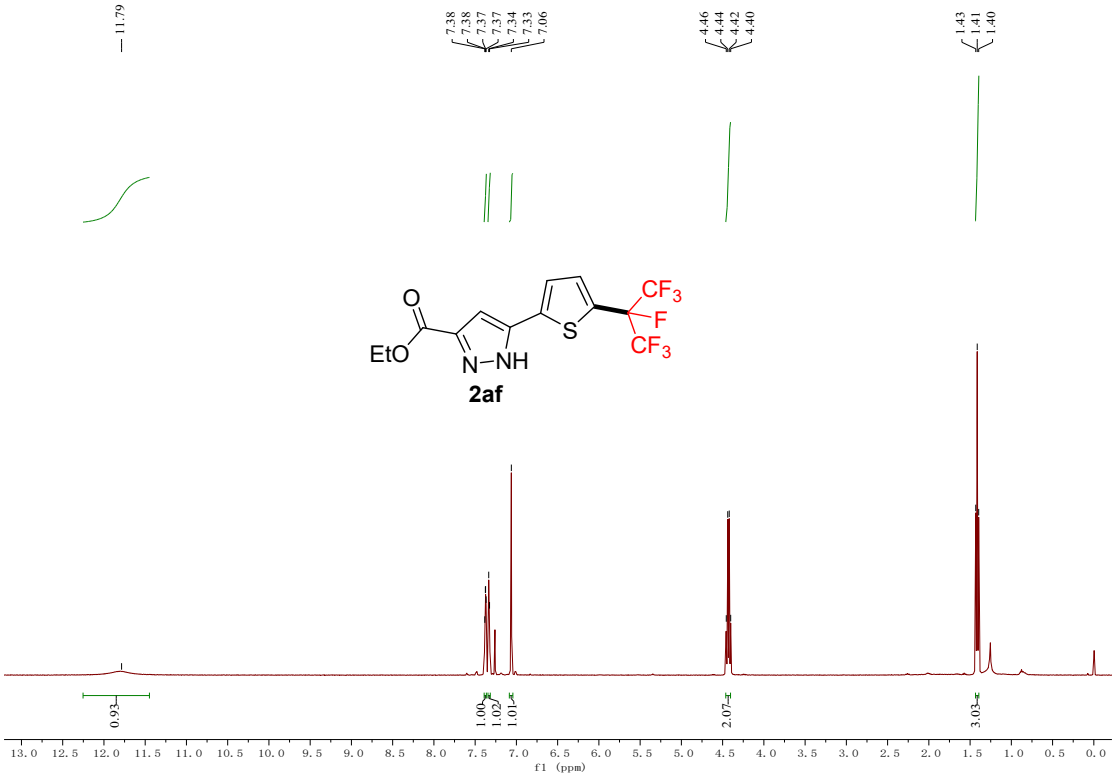
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



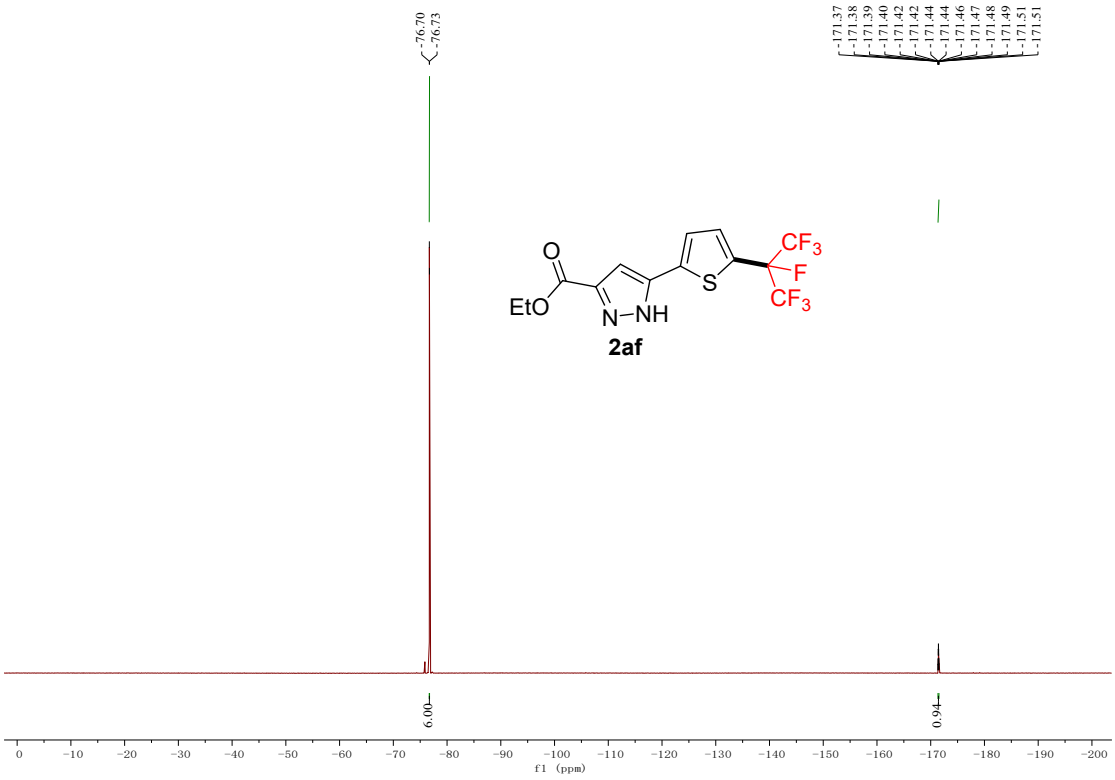
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



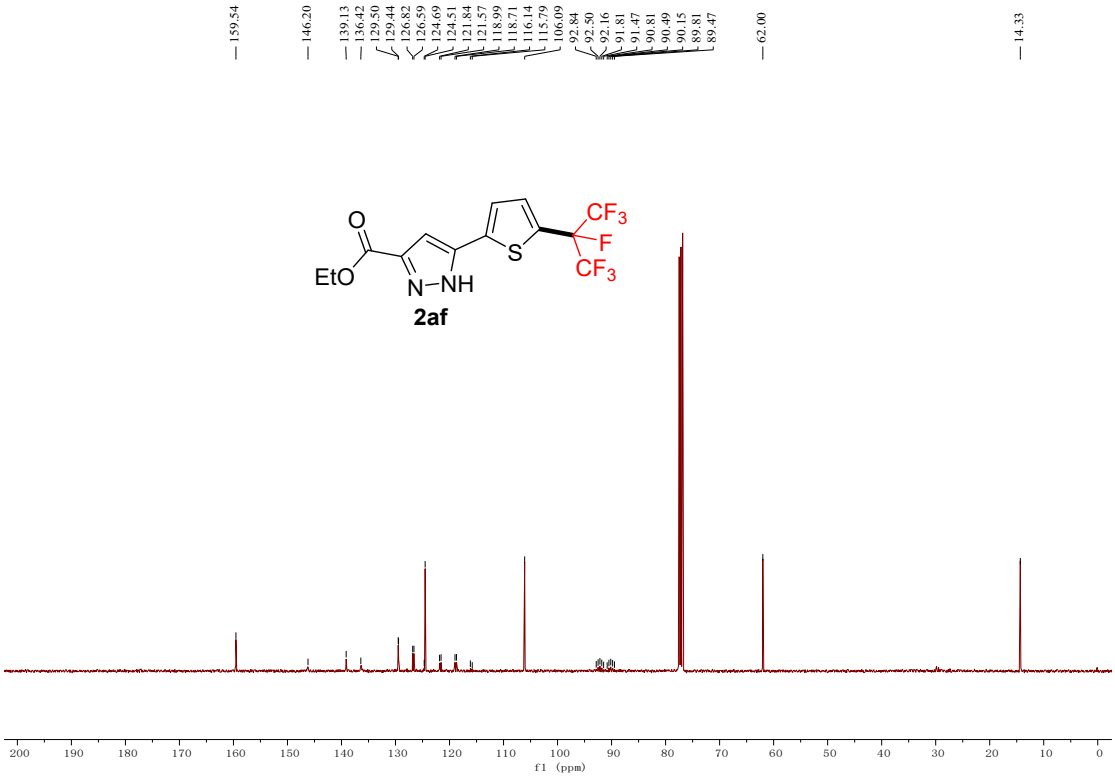
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



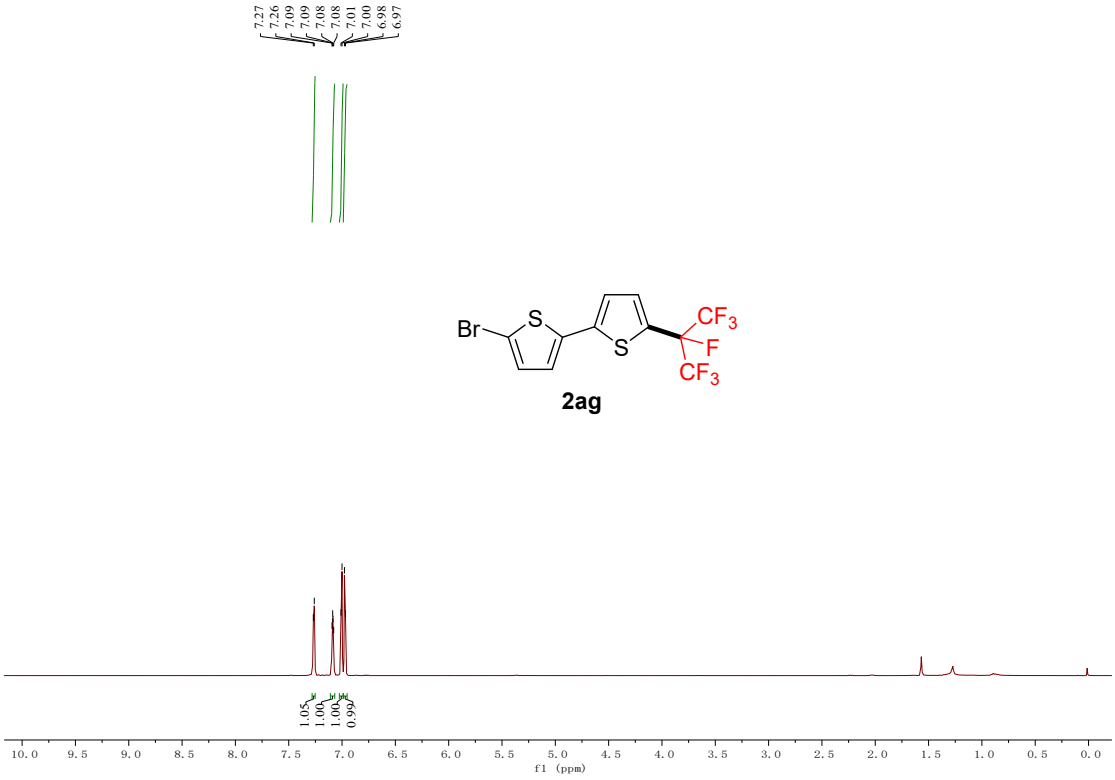
*[19]F NMR (*376 MHz, *$CDCl_3$)*



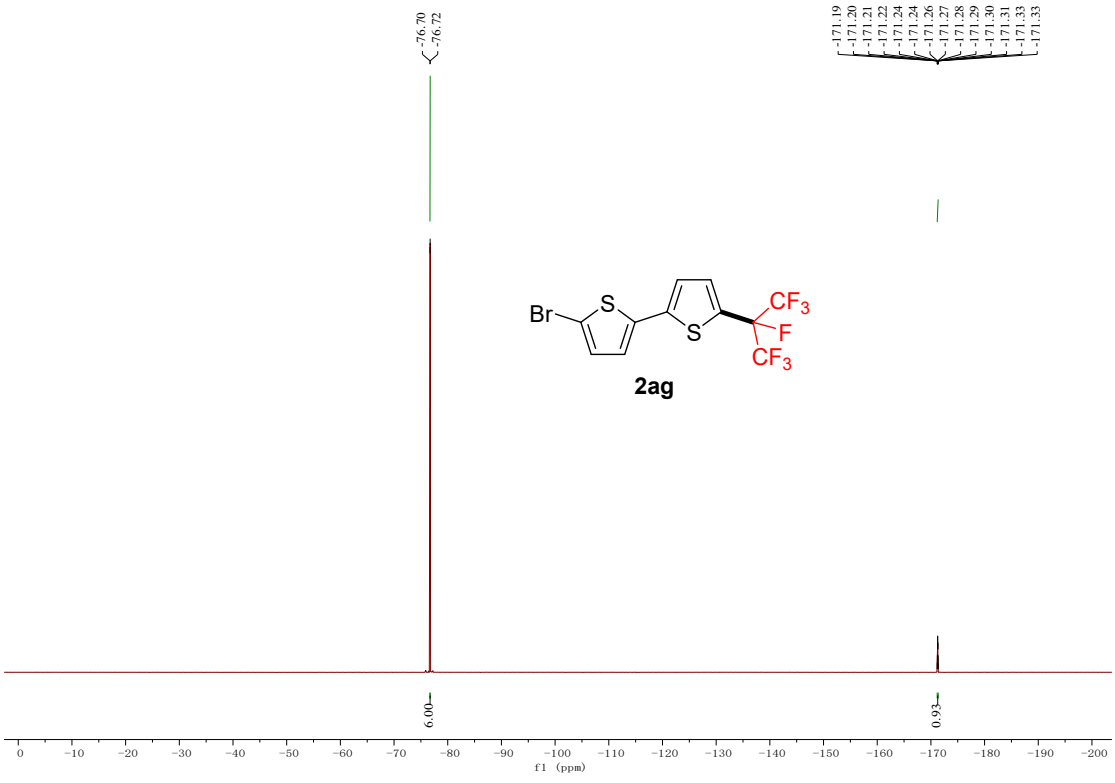
*[13]C NMR (*101 MHz, *$CDCl_3$)*



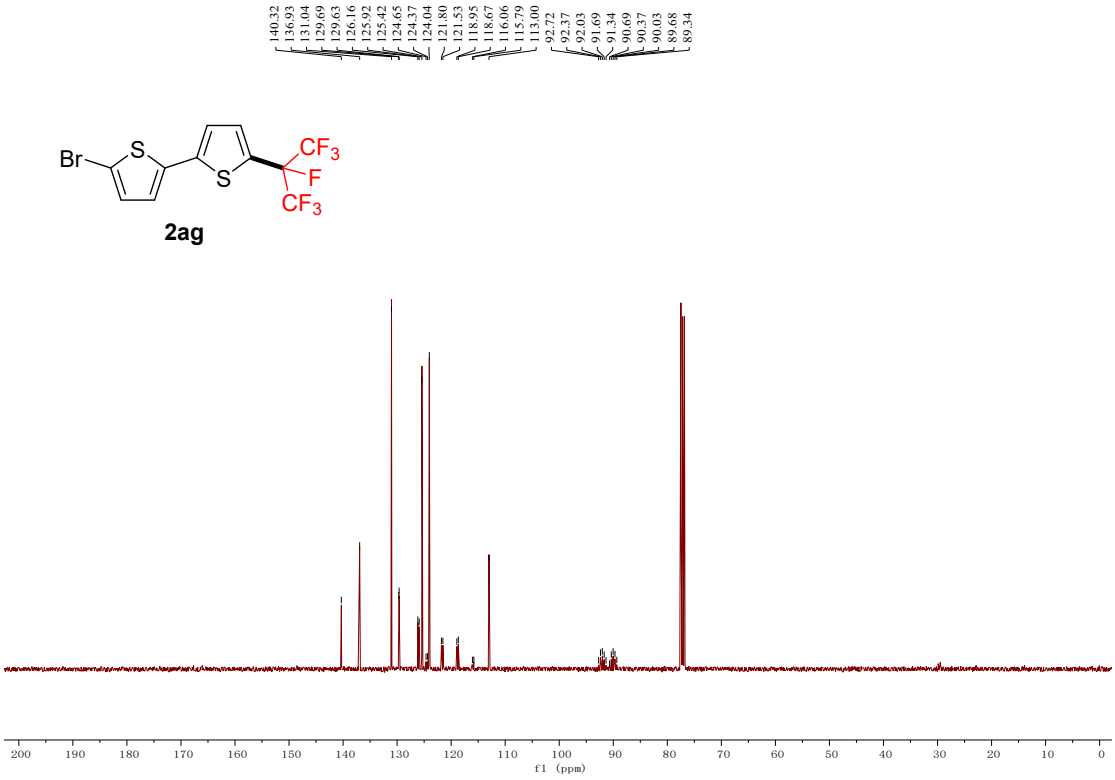
*[1]H NMR (*400 MHz, *$CDCl_3$)*



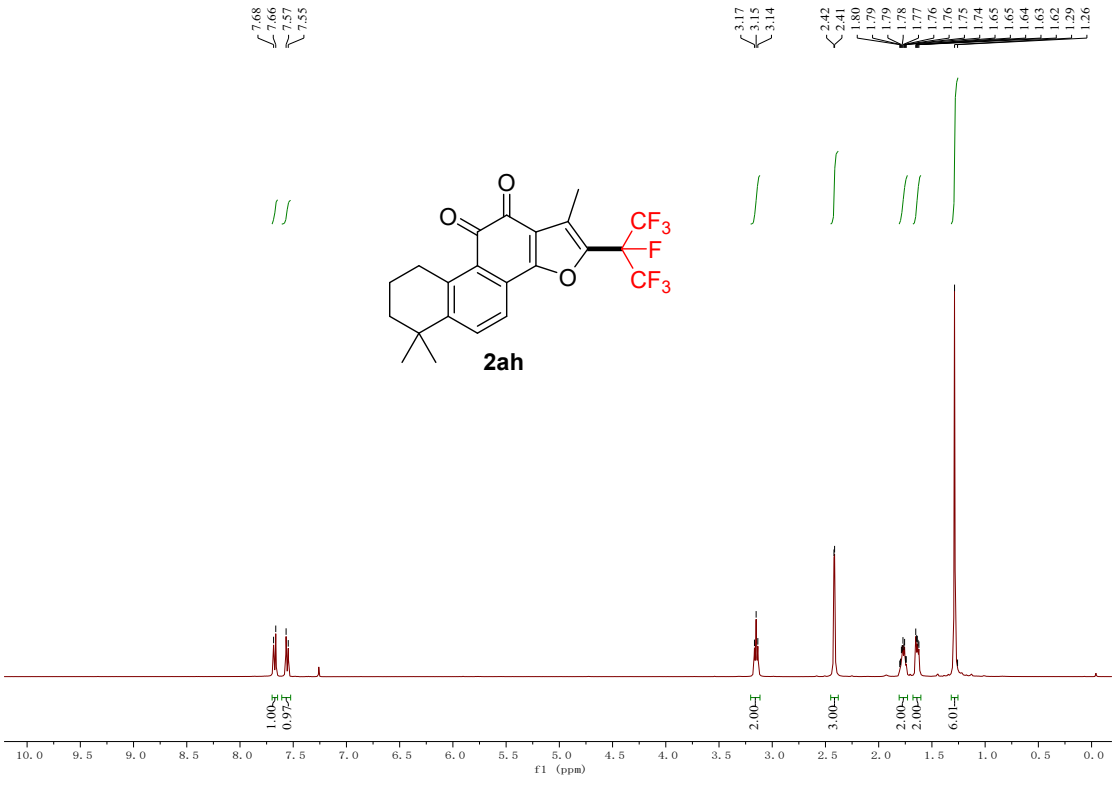
*[19]F NMR (*376 MHz, *$CDCl_3$)*



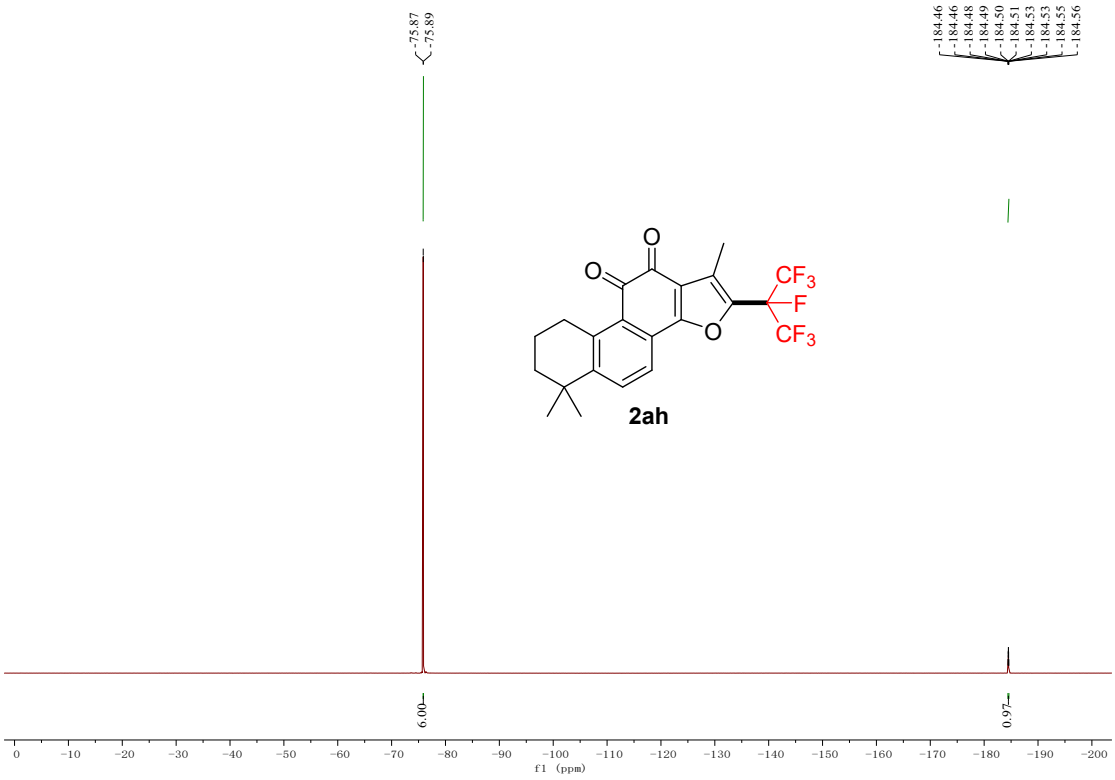
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



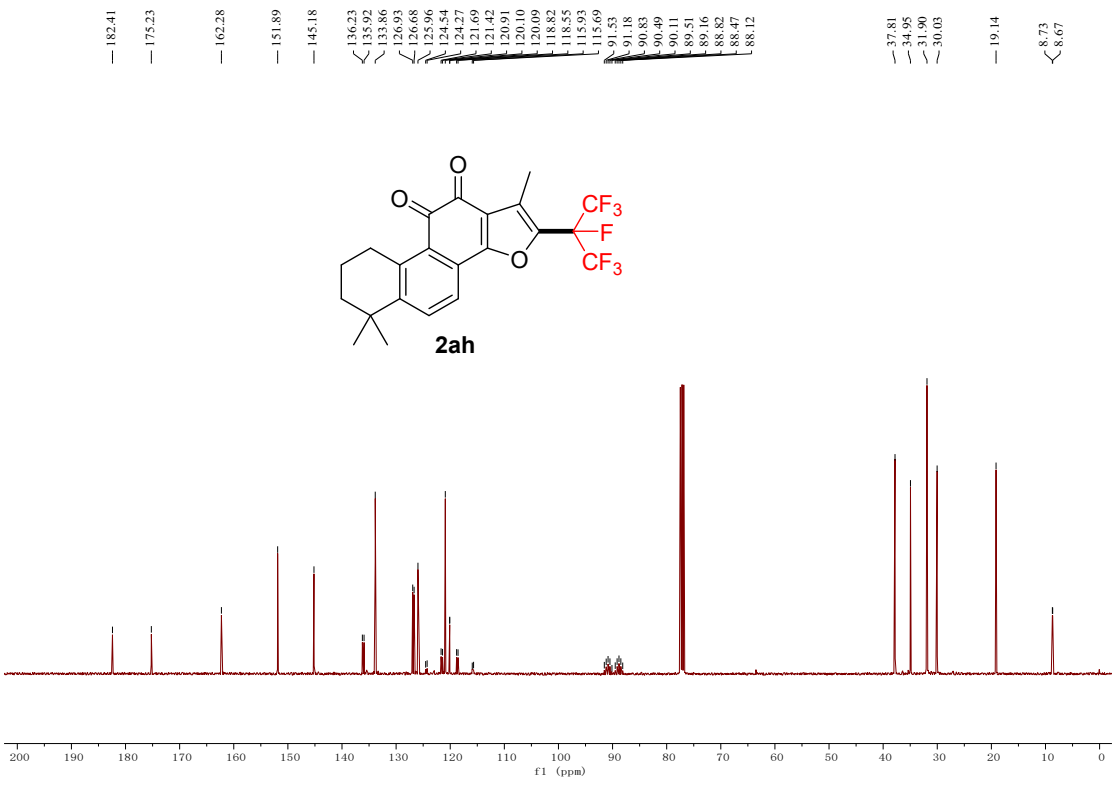
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



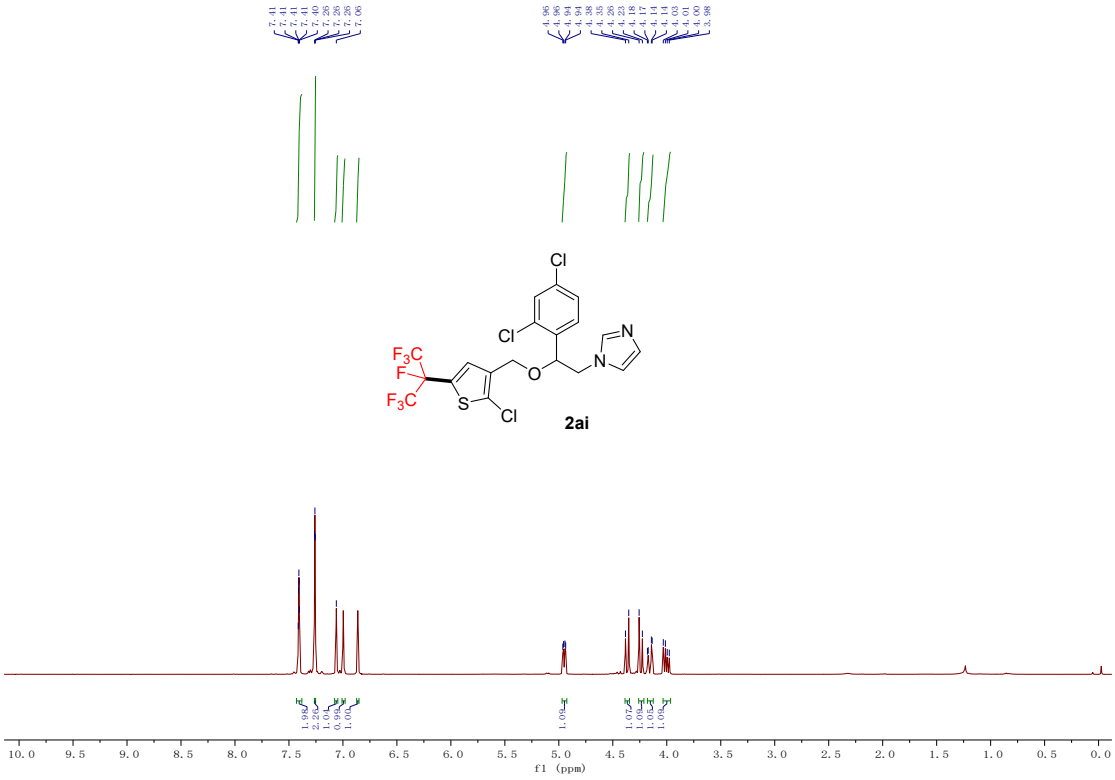
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



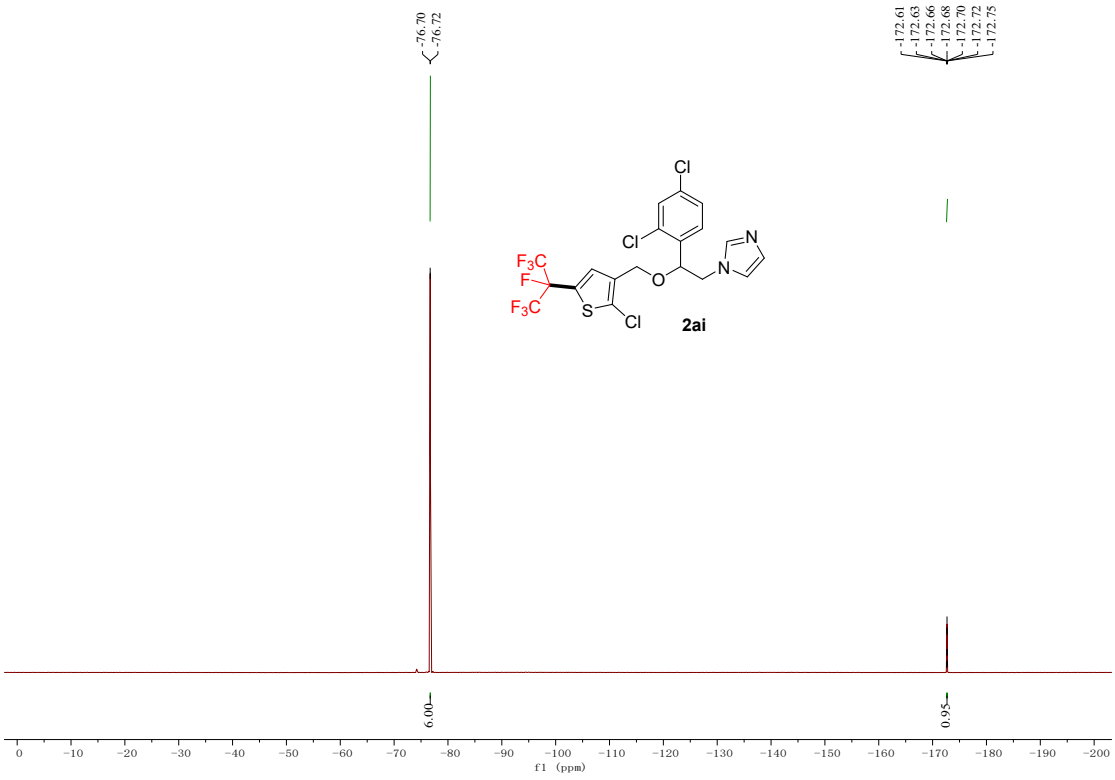
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



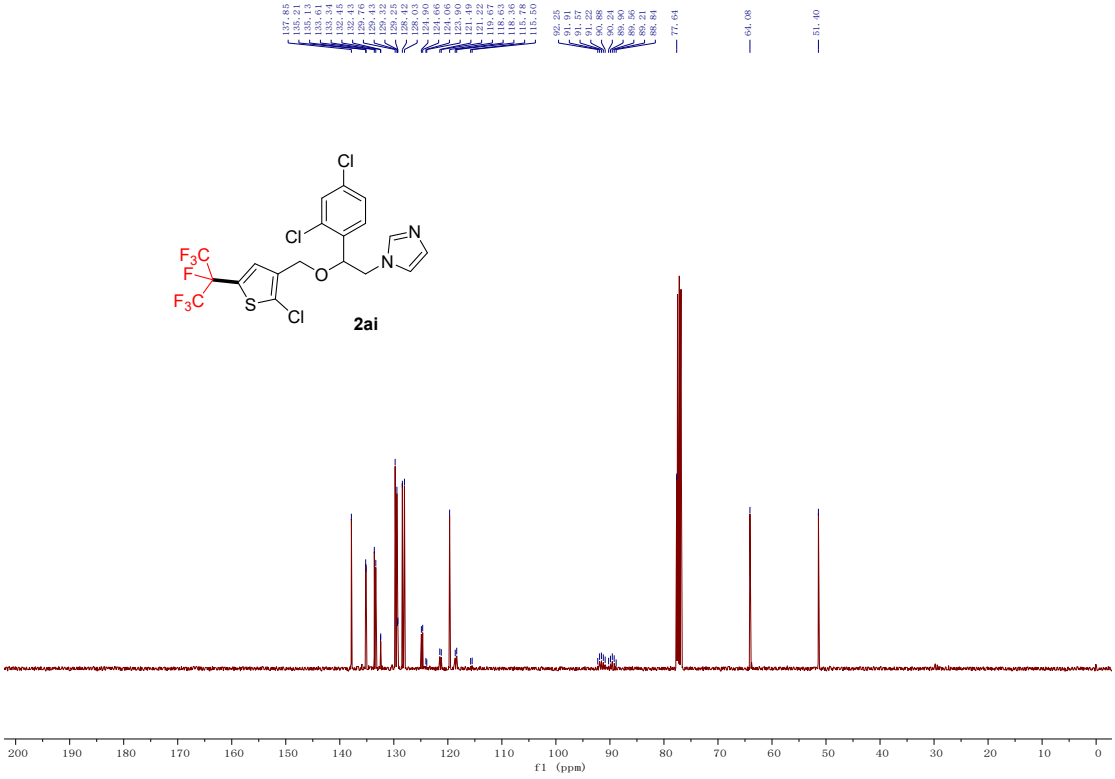
*[1]H NMR (*400 MHz, *$CDCl_3$))*



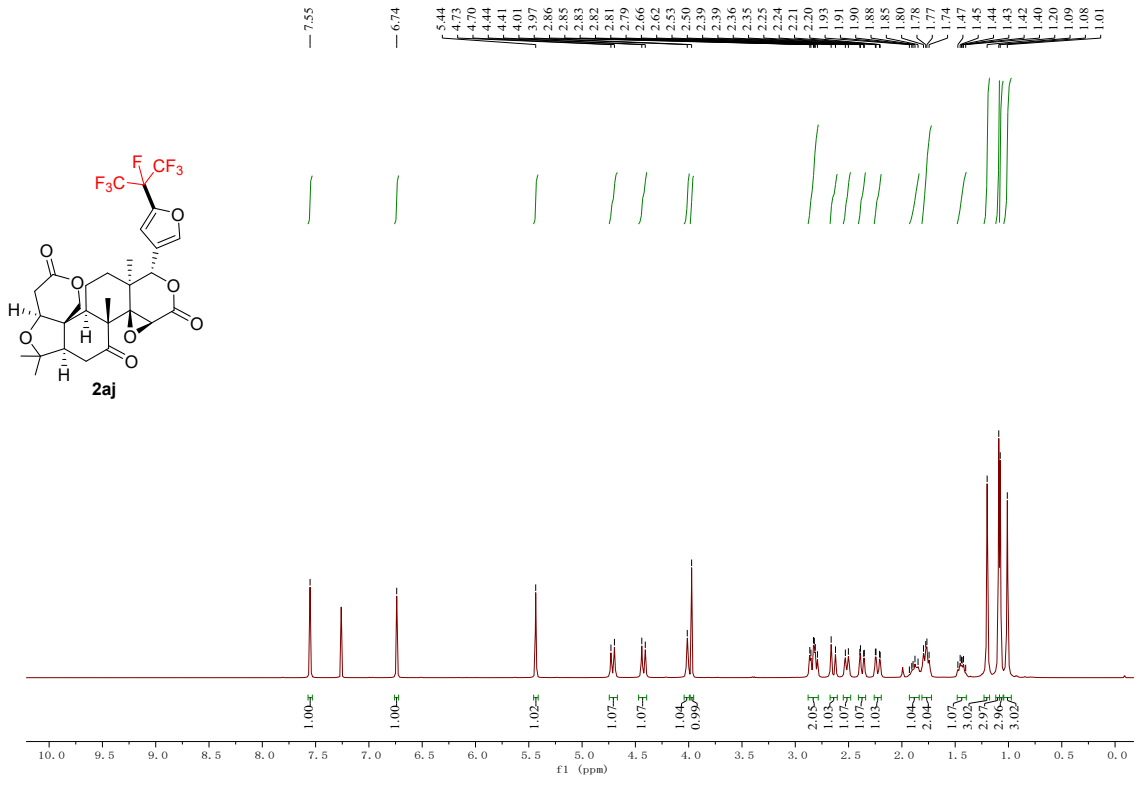
*[19]F NMR (*376 MHz, *$CDCl_3$)*



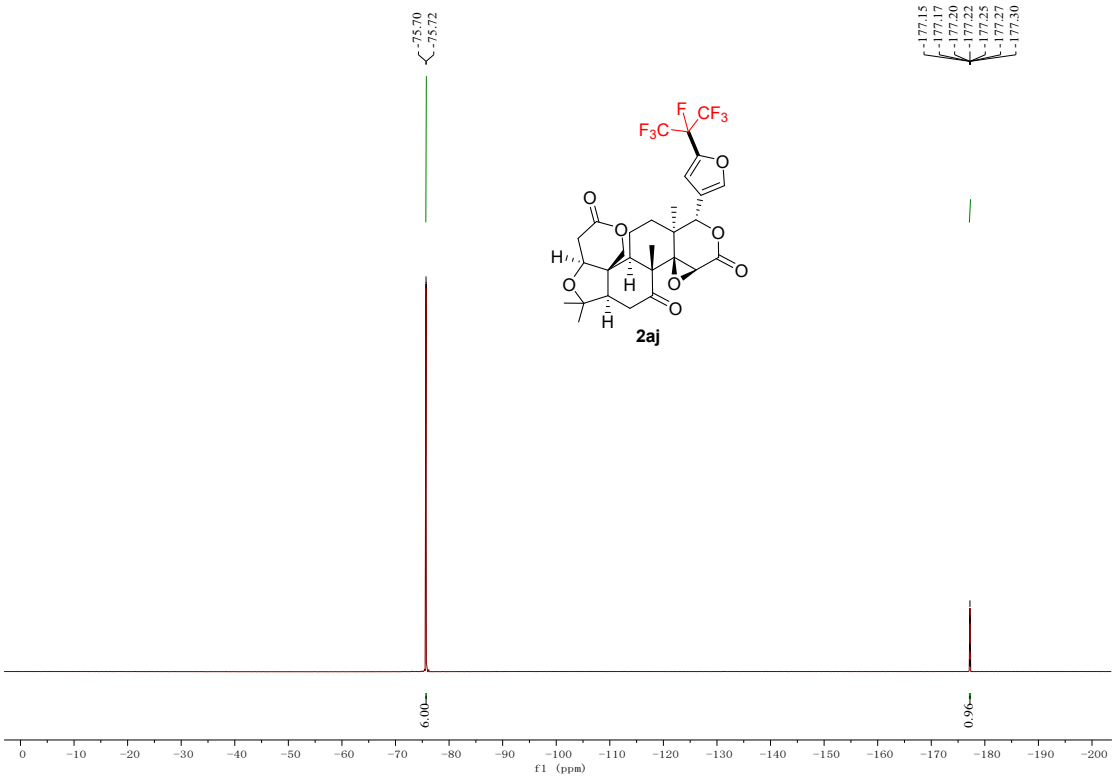
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



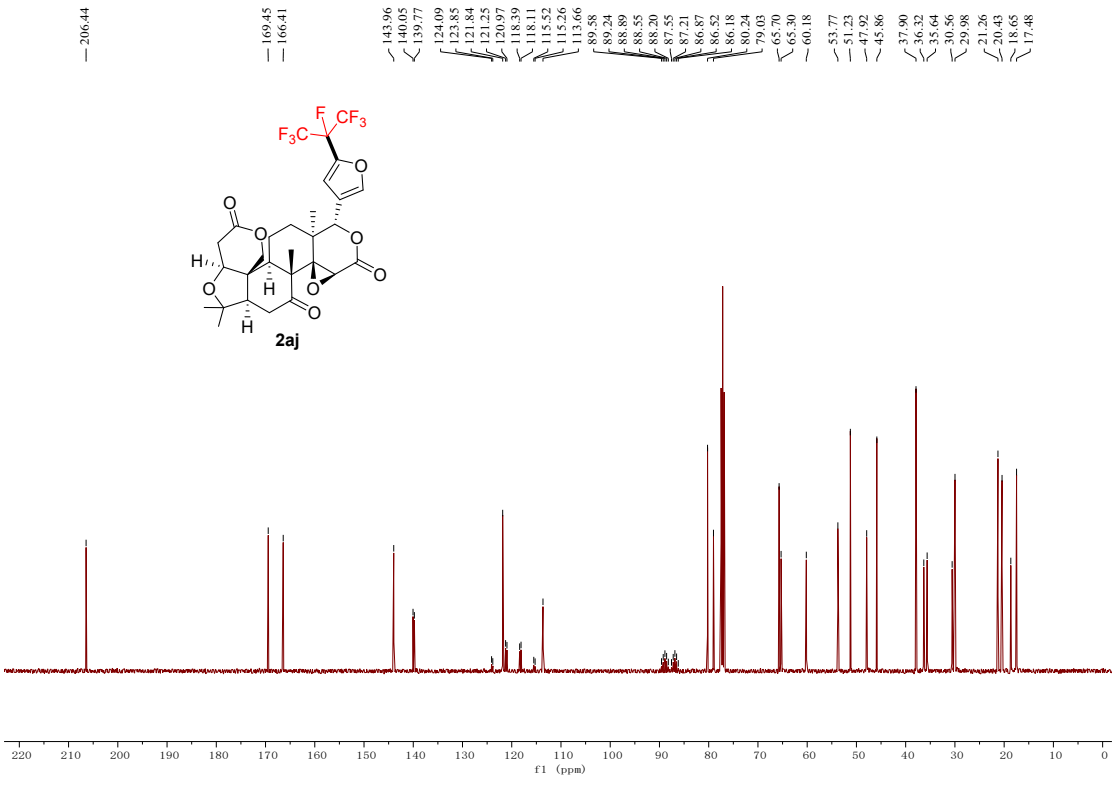
*^{1}H NMR (*400 MHz, *$CDCl_3$)*



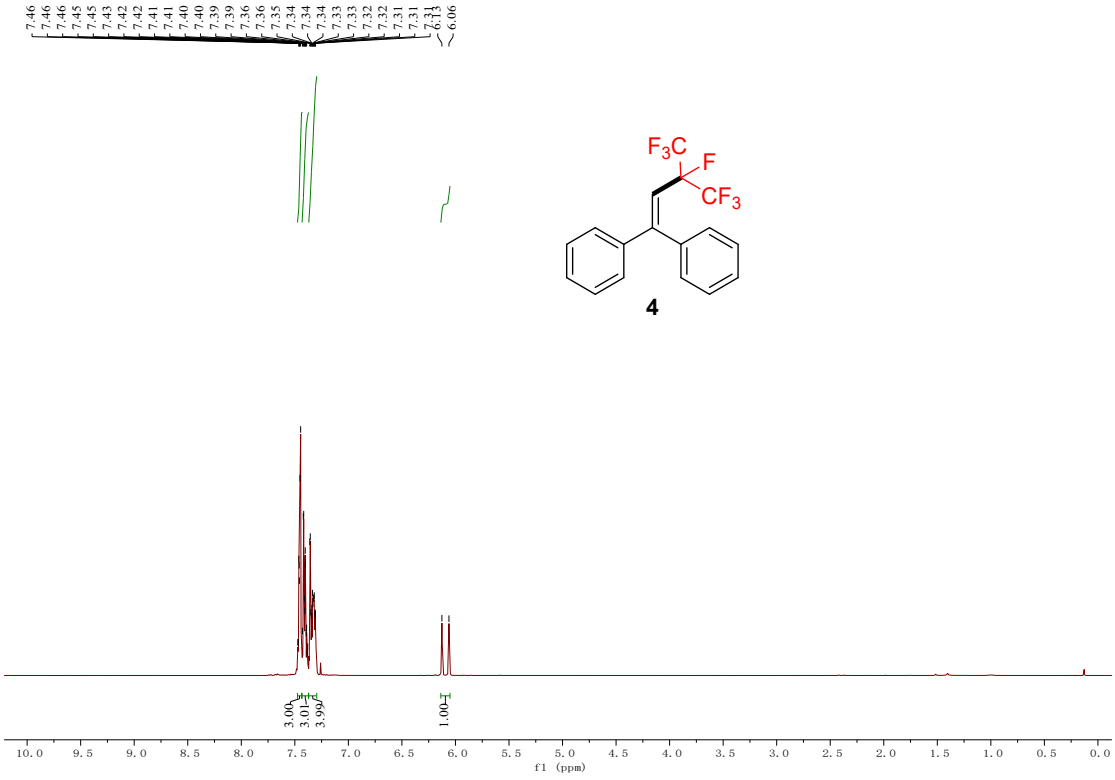
*^{19}F NMR (*376 MHz, *$CDCl_3$)*



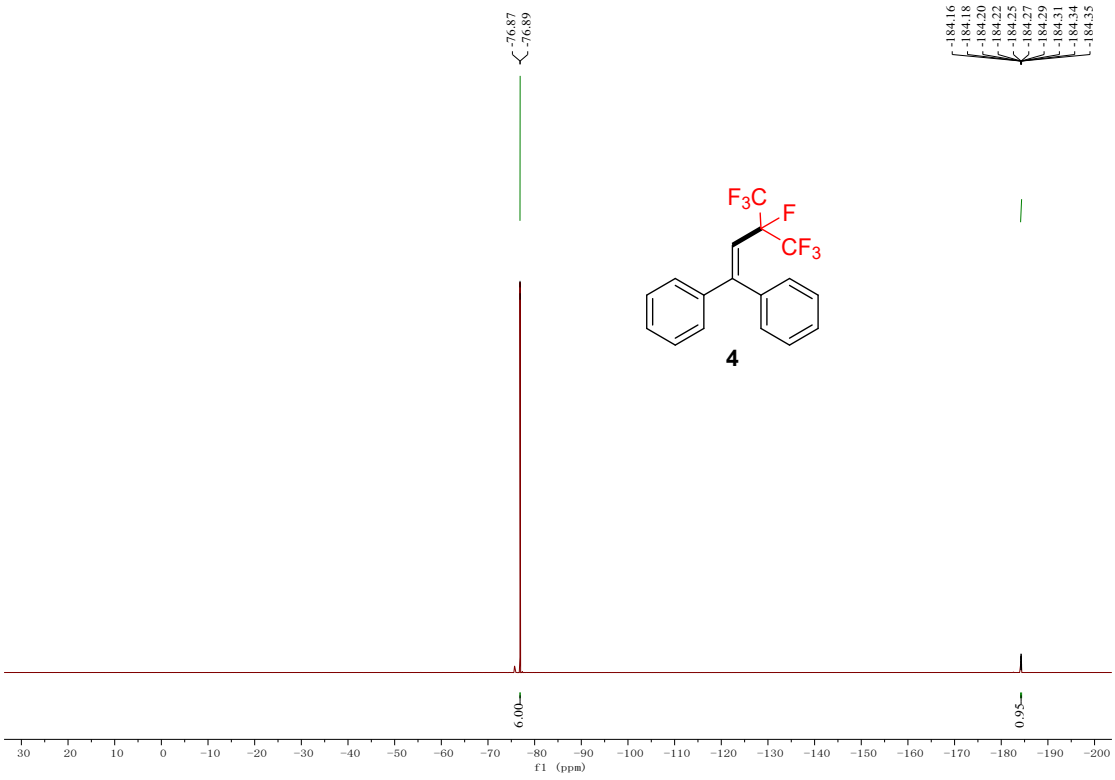
*^{13}C NMR (*101 MHz, *$CDCl_3$)*



*[1]H NMR (*400 MHz, *CDCl3)*



*[19]F NMR (*376 MHz, *CDCl3)*



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