SUPPORTING INFORMATION

Exploring F/CF_3 substituted oxocarbenium ions for the diastereoselective assembly of highly substituted tetrahydrofurans

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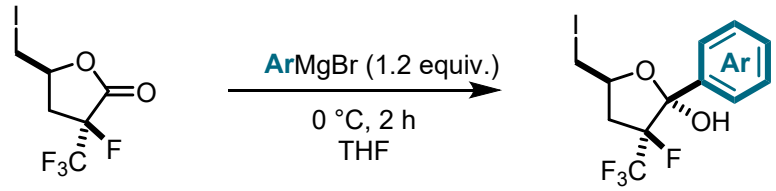
1. General Informations

Chromatography: Flash chromatographies were carried out using Merck 9385 Kieselgel 60 silica gel under air atmosphere or using puriFlash® columns (30 µm) on a CombiFlash® apparatus from Teledyne. Thin layer chromatographies were carried out on Merck Kieselgel 60 F254 0.2 mm plates. Visualization was accomplished using ultraviolet light (254 nm) and chemical staining with a solution of phosphomolybdic acid in EtOH as appropriated.

Data Collection: ^{1}H, ^{13}C and ^{19}F NMR spectra were recorded at 400 MHz or 500 MHz for ^{1}H, 100 MHz or 126 MHz for ^{13}C and 376 MHz or 471 MHz for ^{19}F on Bruker Avance Nandbay 400 MHz or Avance Neo Avance III 1BAY 500 MHz spectrometers at 298 ± 3 K using $CDCl_3$ as solvent unless otherwise stated. Chemical shifts (δ) are quoted in parts per million (ppm) relative to residual solvent ($CHCl_3$: δH = 7.26 ppm for ^{1}H and $CDCl_3$: δC = 77.16 ppm for ^{13}C) or external standards (C_6F_6 for ^{19}F). Coupling constants (*J*) are quoted to the nearest 0.1 Hz. The following abbreviations are used to indicate the multiplicity of the signals: s = singlet; d = doublet; t = triplet; q = quartet; m = multiplet; br = broad; and associated combinations, e.g. dd = doublet of doublets. DEPT 135 and 2-dimensional experiments (COSY, HSQC, HMBC and NOESY) were used to support assignments when appropriated. High resolution mass spectra (HRMS) were recorded on a Bruker Q-TOF Impact HD apparatus using a positive electrospray (ESI) ionization source. Melting points (M.p.) were recorded using a Büchi Melting Point B-545 apparatus.

2. Synthesis of products

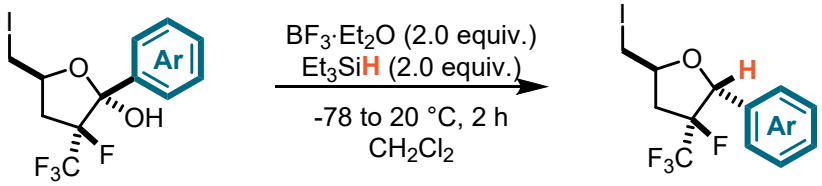
General procedure for the Grignard reagent addition:



2, d.r. > 20:1 **3a-f**

A dry flask under argon atmosphere equipped with a magnetic stirrer was charged with lactone **2** (1.0 equiv.) and THF (1 M). The solution was cooled to 0 °C, the Grignard reagent (1.2 equiv.) was added dropwise and the reaction was allowed to stir for 2 h at 0 °C. The reaction was quench with a saturated NH_4Cl aqueous solution and extracted three times with CH_2Cl_2. The organic layers were gathered, dried over Na_2SO_4, filtered and the solvent removed under reduced pressure. Purification by flash column chromatography (SiO_2, PE/EtOAc) afforded the desired product.

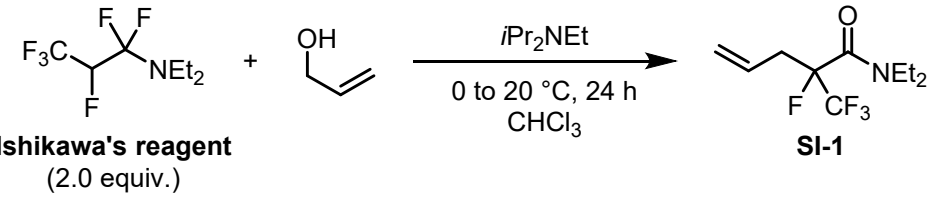
General procedure for the reduction:



3a-f **4a-f**

A dry flask under argon atmosphere equipped with a magnetic stirrer was charged with hemiacetal **3** (1.0 equiv.) and CH_2Cl_2 (0.2 M). The solution was cooled to -78 °C and Et_3SiH (2.0 equiv.), then $BF_3{\cdot}Et_2O$ (2.0 equiv.) were successively added. The cooling bath was removed and the reaction mixture was stirred for 2 h. The reaction was quench with a saturated $NaHCO_3$ aqueous solution and vigorously stirred for 2 minutes. The layers were separated and the aqueous layer was extracted three times with CH_2Cl_2. The organic layers were gathered, dried over Na_2SO_4, filtered and the solvent removed under reduced pressure. Purification by flash column chromatography (SiO_2, PE/EtOAc) afforded the desired product.

(SI-1) *N*,*N*-Diethyl-2-fluoro-2-(trifluoromethyl)pent-4-enamide[1]



Ishikawa's reagent (2.0 equiv.)

SI-1

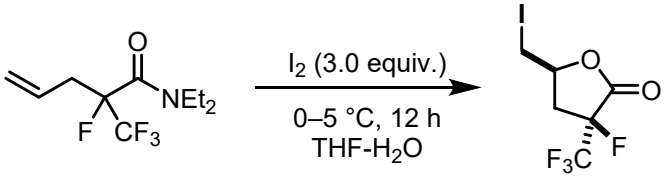
In a dry Schlenk tube under argon atmosphere equipped with magnetic stirrer was condensed perfluoropropene (approx. 2.1 mL, 20.0 mmol, 2.0 equiv.) at -78 °C. A solution of diethylamine (2.07 mL, 20.0 mmol, 2.0 equiv.) in $CHCl_3$ (10 mL, 2 M) was added slowly. After the addition, the tube was sealed, and this Ishikawa's reagent[2] solution was allowed to reach room temperature over 1 h. A separate dry Schlenk tube under argon atmosphere was charged with allyl alcohol (0.68 mL, 10.0 mmol, 1 equiv.), $CHCl_3$ (10 mL, 1 M) and ethyldiisopropylamine (3.48 mL, 20.0 mmol, 2 equiv.). The Ishikawa's reagent solution was added slowly to the alcohol solution at 0 °C and the reaction mixture was stirred for 24 h time at 20 °C. The reaction mixture was poured to a saturated $NaHCO_3$ aqueous solution, stirred for 5 min and extracted three times with CH_2Cl_2. The organic layers were gathered, dried over Na_2SO_4, filtered and the solvent removed under reduced pressure. Purification (PE/EtOAc, 100:0 to 9:1) afforded the desired product as a colorless oil (2.28 g, 9.45 mmol, 95% yield). The collected data of the product are in agreement with those reported in the literature.[1]

Rf = 0.70 (PE/EtOAc, 9:1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 5.72 (ddt, *J* = 17.2, 10.1, 7.2 Hz, 1H), 5.26 (dd, *J* = 23.4, 6.1 Hz, 2H), 3.62 – 3.49 (m, 1H), 3.38 (q, *J* = 7.1 Hz, 3H), 3.36 – 3.30 (m, 1H), 3.13 (ddd, $^3J_{H,F}$ = 35.7, *J* = 14.3, 6.9 Hz, 1H), 2.68 (td, *J* = 14.3, 7.4 Hz, 1H), 1.18 (t, *J* = 7.0 Hz, 3H), 1.14 (t, *J* = 7.1 Hz, 3H).

^{19}F{^{1}H} NMR (376 MHz, $CDCl_3$) δ -77.4 (d, *J* = 6.9 Hz), -172.7 (q, *J* = 6.7 Hz).

(2) *trans*-3-Fluoro-5-(iodomethyl)-3-(trifluoromethyl)dihydrofuran-2(3H)-one



SI-1

2, d.r. >20:1

A flask equipped with a magnetic stirrer was charged with alkene-amide derivative **SI-1** (830 mg, 3.44 mmol, 1.0 equiv.) and THF-H_2O (20 mL, 1:1 v/v, 0.17 M). The solution was cooled to 0 °C and iodine (2.62 g, 10.32 mmol, 3.0 equiv.) was added in one portion. The reaction mixture was vigorously stirred for 12 h at 0-5 °C. The reaction was quenched with $Na_2S_2O_3$ and extracted three times with CH_2Cl_2. The organic layers were gathered, dried over Na_2SO_4, filtered and the solvent removed under reduced pressure. Purification (PE/EtOAc, 100:0 to 90:10) afforded the desired product as a colorless oil (875 mg, 2.81 mmol, 82% yield, d.r. >20:1). Crude d.r. >20:1. The collected data of the product are in agreement with those reported in the literature.[1]

Rf = 0.30 (PE/EtOAc, 9:1).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 4.61 (qdd, *J* = 7.3, 4.2, 2.1 Hz, 1H), 3.50 (dd, *J* = 10.6, 4.3 Hz, 1H), 3.35 (ddd, *J* = 10.6, 8.0, 0.9 Hz, 1H), 3.09 (ddd, *J* = 15.1, 10.7, 6.7 Hz, 1H), 2.53 (dddq, *J* = 25.4, 15.2, 7.5, 1.3 Hz, 1H).

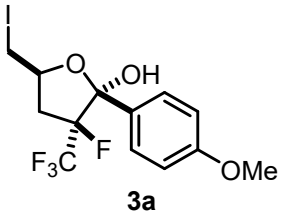
^{13}C{^{1}H} NMR (101 MHz, Chloroform-*d*) δ 164.6 (d, *J* = 23.4 Hz), 121.1 (dd, *J* = 283.4, 31.1 Hz), 91.3 (dq, *J* = 205.5, 35.7 Hz), 75.3 (d, *J* = 4.3 Hz), 35.8 (d, *J* = 20.6 Hz), 5.1.

^{19}F NMR (376 MHz, Chloroform-*d*) δ -79.9 (dd, *J* = 12.4, 4.5 Hz), -169.3 – -169.5 (m).

IR (neat) νmax (cm^{-1}): 3029, 2964, 1795, 1331, 1296, 1205, 1171, 1139, 1083, 999, 751.

HRMS (EI) Calcd. for $C_6H_5F_4IO_2$ $[M]^+$ = 311.9265, found = 311.9256.

(3a) *trans,cis*-3-Fluoro-5-(iodomethyl)-2-(4-methoxyphenyl)-3-(trifluoromethyl)tetrahydrofuran-2-ol



3a

Following the **general procedure for the Grignard reagent addition** using **2** (312.0 mg, 1.00 mmol, 1.0 equiv.), THF (1.0 mL) and 4-methoxyphenylmagnesium bromide in solution in THF (1.2 mL, 1.2 mmol, 1.2 equiv., 1.0 M). Purification (PE/EtOAc, 100:0 to 85:15) afforded the desired product as a white solid (302 mg, 0.72 mmol, 72% yield, d.r. > 20:1). Crude d.r. > 20:1.

Rf = 0.20 (PE/EtOAc, 85:15).

M.p. = 131-132 °C (EtOAc).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.55 (d, *J* = 8.4 Hz, 2H), 6.94 – 6.87 (m, 2H), 4.43 (dddt, *J* = 9.5, 7.2, 5.5, 2.3 Hz, 1H), 3.83 (s, 3H), 3.44 (dd, *J* = 10.0, 5.3 Hz, 1H), 3.36 (dd, *J* = 10.1, 7.6 Hz, 1H), 3.25 (d, *J* = 4.3 Hz, 1H), 2.95 (ddd, *J* = 35.9, 14.8, 8.5 Hz, 1H), 2.31 (dddd, *J* = 26.9, 14.9, 4.4, 1.0 Hz, 1H).

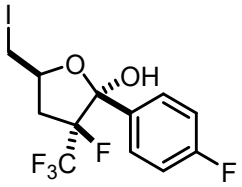
^{13}C{^{1}H} NMR (126 MHz, Chloroform-*d*) δ 160.7, 129.3, 128.0, 122.1 (qd, *J* = 282.8, 29.8 Hz), 113.4, 106.6 (d, *J* = 28.5 Hz), 98.9 (dq, *J* = 194.0, 31.2 Hz), 75.3, 55.4, 37.3 (d, *J* = 20.9 Hz), 7.7.

^{19}F{^{1}H} NMR (471 MHz, Chloroform-*d*) δ -74.4 (d, *J* = 7.0 Hz), -160.9 (dddd, *J* = 34.5, 27.1, 12.3, 6.6 Hz).

IR (neat) νmax (cm^{-1}): 3377, 2973, 2949, 1613, 1516, 1258, 1185, 1164, 1129, 1089, 1020, 984, 839, 677.

HRMS (EI) Calcd. for $C_{13}H_{13}F_4IO_3$ $[M]^+$ = 419.9840, found = 419.9813.

(3b) *trans,cis*-3-Fluoro-2-(4-fluorophenyl)-5-(iodomethyl)-3-(trifluoromethyl)tetrahydrofuran-2-ol



3b

Following the **general procedure for the Grignard reagent addition** using **2** (312.0 mg, 1.00 mmol, 1.0 equiv.), THF (1.0 mL) and 4-fluorophenylmagnesium bromide in solution in THF (1.5 mL, 1.2 mmol, 1.2 equiv., 0.8 M). Purification (PE/EtOAc, 100:0 to 90:10) afforded the desired product as a white solid (359 mg, 0.88 mmol, 88% yield, d.r. > 20:1). Crude d.r. > 20:1.

Rf = 0.30 (PE/EtOAc, 9:1).

M.p. = 108-109 °C (EtOAc).

^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.62 (dd, *J* = 8.6, 5.3 Hz, 2H), 7.12 – 7.03 (m, 2H), 4.57 – 4.48 (m, 1H), 3.46 (dd, *J* = 10.2, 5.5 Hz, 1H), 3.39 (dd, *J* = 10.2, 7.2 Hz, 1H), 3.10 (d, *J* = 4.3 Hz, 1H), 2.98 (ddd, *J* = 35.5, 14.9, 8.5 Hz, 1H), 2.34 (dddd, *J* = 27.0, 14.9, 4.3, 1.0 Hz, 1H).

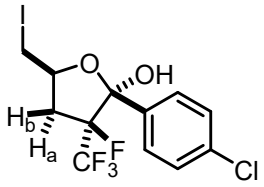
$^{13}C\{^1H\}$ NMR (101 MHz, Chloroform-*d*) δ 163.8 (d, *J* = 249.1 Hz), 131.8 (d, *J* = 3.0 Hz), 130.0 (d, *J* = 8.4 Hz), 122.1 (qd, *J* = 282.5, 29.6 Hz), 115.1 (d, *J* = 21.7 Hz), 106.3 (d, *J* = 28.4 Hz), 99.1 (dq, *J* = 194.8, 31.5 Hz), 75.7, 37.3 (d, *J* = 20.7 Hz), 7.3.

$^{19}F\{^1H\}$ NMR (376 MHz, Chloroform-*d*) δ -74.4 (d, *J* = 6.7 Hz), -111.8 , -160.8 (q, *J* = 7.0 Hz).

IR (neat) νmax (cm^{-1}): 3400, 2964, 2960, 1604, 1510, 1204, 1187, 1128, 1081, 1028, 989, 835, 811, 733.

HRMS (EI) Calcd. for $C_{12}H_{10}F_5IO_2$ $[M]^+$ = 407.9640, found = 407.9618.

(3c) *trans,cis*-2-(4-Chlorophenyl)-3-fluoro-5-(iodomethyl)-3-(trifluoromethyl)tetrahydrofuran-2-ol



3c

Following the **general procedure for the Grignard reagent addition** using **2** (281.0 mg, 0.90 mmol, 1.0 equiv.), THF (0.9 mL) and 4-chlorophenylmagnesium bromide in solution in 2-MeTHF (1.1 mL, 1.1 mmol, 1.2 equiv., 1 M). Purification (PE/EtOAc, 100:0 to 95:5) afforded the desired product as a white solid (247 mg, 0.58 mmol, 65% yield, d.r. > 20:1). Crude d.r. > 20:1.

Rf = 0.50 (PE/EtOAc, 9:1).

M.p. = 130-131 °C (EtOAc).

^1H NMR (500 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.5 Hz, 2H), 7.40 – 7.33 (m, 2H), 4.57 (ddddd, *J* = 8.8, 7.2, 5.8, 4.4, 1.7 Hz, 1H), 3.46 (dd, *J* = 10.2, 5.5 Hz, 1H), 3.40 (dd, *J* = 10.1, 7.2 Hz, 1H), 3.04 (brs, 1H), 2.99 (ddd, *J* = 35.5, 15.0, 8.6 Hz, 1H), 2.35 (ddd, *J* = 27.1, 14.9, 4.1 Hz, 1H).

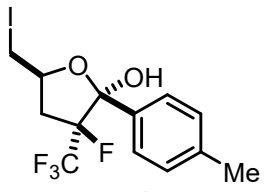
$^{13}C\{^1H\}$ NMR (126 MHz, $CDCl_3$) δ 136.1, 134.4, 129.4, 128.3, 122.0 (qd, *J* = 282.4, 29.5 Hz), 106.2 (d, *J* = 28.5 Hz), 99.1 (dq, *J* = 195.0, 31.4 Hz), 75.8, 37.2 (d, *J* = 20.5 Hz), 7.4.

^{19}F NMR (471 MHz, $CDCl_3$) δ -74.4 (d, *J* = 6.9 Hz), -160.9 – -161.1 (m).

IR (neat) νmax (cm^{-1}): 3441, 2945, 1495, 1438, 1294, 1204, 1163, 1092, 1004, 988, 832, 729, 672.

HRMS (EI) Calcd. for $C_{12}H_{10}ClF_4IO_2$ $[M]^+$ = 423.9345, found = 423.9341.

(3d) *trans,cis*-3-Fluoro-5-(iodomethyl)-2-(*p*-tolyl)-3-(trifluoromethyl)tetrahydrofuran-2-ol



3d

Following the **general procedure for the Grignard reagent addition** using **2** (312.0 mg, 1.00 mmol, 1.0 equiv.), THF (1.0 mL) and *p*-tolylmagnesium bromide in solution in Et_2O (2.4 mL, 1.2 mmol, 1.2 equiv., 0.5 M). Purification (PE/EtOAc, 100:0 to 95:5) afforded the desired product as a white solid (306 mg, 0.76 mmol, 76% yield, d.r. > 20:1). Crude d.r. > 20:1.

Rf = 0.50 (PE/EtOAc, 9:1).

M.p. = 152-153 °C (EtOAc).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.52 (d, *J* = 8.1 Hz, 2H), 7.21 (d, *J* = 8.0 Hz, 2H), 4.60 – 4.37 (m, 1H), 3.52 – 3.43 (m, 1H), 3.43 – 3.34 (m, 1H), 3.18 – 2.90 (m, 2H), 2.38 (s, 3H), 2.36 – 2.27 (m, 1H).

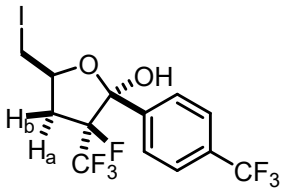
^{13}C{^{1}H} NMR (126 MHz, Chloroform-*d*) δ 139.9, 133.0, 128.8, 127.8, 122.1 (qd, *J* = 282.9, 29.6 Hz), 106.6 (d, *J* = 28.5 Hz), 99.1 (dq, *J* = 194.1, 31.6 Hz), 75.5, 37.3 (d, *J* = 20.6 Hz), 21.4, 7.6.

^{19}F NMR (471 MHz, Chloroform-*d*) δ -74.4 (d, *J* = 7.4 Hz), -161.0 (ddt, *J* = 33.1, 27.0, 6.2 Hz).

IR (neat) νmax (cm^{-1}): 3380, 3033, 2945, 1416, 1280, 1202, 1190, 1174, 1129, 1089, 1020, 914, 810, 732.

HRMS (EI) Calcd. for $C_{13}H_{13}F_4IO_2$ $[M]^+$ = 403.9891, found = 403.9887.

(3e) *trans,cis*-3-Fluoro-5-(iodomethyl)-3-(trifluoromethyl)-2-(4-(trifluoromethyl)phenyl)tetrahydrofuran-2-ol



3e

Following the **general procedure for the Grignard reagent addition** using **2** (281.0 mg, 0.90 mmol, 1.0 equiv.), THF (0.9 mL) and 4-trifluorophenylmagnesium bromide in solution in Et_2O (2.2 mL, 1.1 mmol, 1.2 equiv., 0.5 M). Purification (PE/EtOAc, 100:0 to 95:5) afforded the desired product as a white solid (285 mg, 0.62 mmol, 69% yield, d.r. > 20:1). Crude d.r. > 20:1.

Rf = 0.50 (PE/EtOAc, 9:1).

M.p. = 113-114 °C (EtOAc).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.78 (d, *J* = 8.2 Hz, 2H), 7.66 (d, *J* = 8.3 Hz, 2H), 4.65 – 4.58 (m, 1H), 3.49 (dd, *J* = 10.2, 5.6 Hz, 1H), 3.43 (dd, *J* = 10.2, 7.1 Hz, 1H), 3.05 (d, *J* = 7.9 Hz, 1H), 3.02 (ddd, *J* = 35.3, 14.9, 8.5 Hz, 1H), 2.38 (ddd, *J* = 27.2, 14.9, 4.3 Hz, 1H).

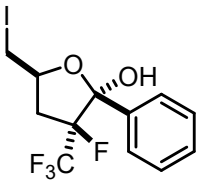
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$) δ 139.7, 132.0 (q, *J* = 32.7 Hz,), 128.6, 125.0 (q, *J* = 3.7 Hz), 124.0 (q, *J* = 272.0 Hz), 121.9 (qd, *J* = 282.6, 29.7 Hz), 106.0 (d, *J* = 28.6 Hz), 99.3 (dq, *J* = 195.7, 31.6 Hz), 76.1, 37.3 (d, *J* = 20.7 Hz), 7.2.

^{19}F NMR (471 MHz, $CDCl_3$) δ -62.8, -74.4 (d, *J* = 6.8 Hz), -160.9 – -161.2 (m).

IR (neat) νmax (cm^{-1}): 3405, 2950, 1328, 1182, 1161, 1121, 1069, 1014, 989, 838, 734.

HRMS (EI) Calcd. for $C_{13}H_{10}F_7IO_2$ $[M]^+$ = 457.9608, found = 457.9609.

(3f) *trans,cis*-3-Fluoro-5-(iodomethyl)-2-phenyl-3-(trifluoromethyl)tetrahydrofuran-2-ol



3f

Following the **general procedure for the Grignard reagent addition** using **2** (281.0 mg, 0.90 mmol, 1.0 equiv.), THF (0.9 mL) and phenylmagnesium bromide in solution in THF (1.1 mL, 1.1 mmol, 1.2 equiv., 1 M). Purification (PE/EtOAc, 100:0 to 97:3) afforded the desired product as a white solid (275 mg, 0.71 mmol, 78% yield, d.r. > 20:1). Crude d.r. > 20:1.

Rf = 0.50 (PE/EtOAc, 9:1).

M.p. = 114-115 °C (EtOAc).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.67 – 7.62 (m, 2H), 7.46 – 7.37 (m, 3H), 4.55 – 4.48 (m, 1H), 3.47 (dd, *J* = 10.1, 5.4 Hz, 2H), 3.40 (dd, *J* = 10.0, 7.5 Hz, 1H), 3.13 (d, *J* = 4.3 Hz, 1H), 2.98 (ddd, *J* = 35.5, 14.8, 8.5 Hz, 1H), 2.34 (dddd, *J* = 27.0, 14.9, 4.3, 1.0 Hz, 1H).

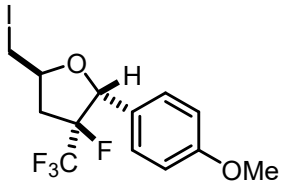
^{13}C{^{1}H} NMR (126 MHz, Chloroform-*d*) δ 135.9, 129.9, 128.1, 127.9, 122.1 (qd, *J* = 282.6, 29.7 Hz), 106.5 (d, *J* = 28.8 Hz), 99.1 (dq, *J* = 194.9, 31.3 Hz), 75.6, 37.3 (d, *J* = 20.9 Hz), 7.6.

^{19}F NMR (471 MHz, Chloroform-*d*) δ -74.4 (d, *J* = 6.9 Hz), -161.0 – -161.3 (m).

IR (neat) νmax (cm^{-1}): 3380, 3036, 2943, 1356, 1284, 1189, 1131, 1100, 1024, 988, 909, 767, 701.

HRMS (EI) Calcd. for $C_{12}H_{11}F_4IO_2$ [M]$^+$ = 389.9734, found = 389.9719.

(4a) *trans-cis*-3-Fluoro-5-(iodomethyl)-2-(4-methoxyphenyl)-3-(trifluoromethyl)tetrahydrofuran



4a

Following the **general procedure for the reduction** using **3a** (42.0 mg, 0.10 mmol, 1.0 equiv.), CH_2Cl_2 (0.5 mL), Et_3SiH (32 µL, 0.20 mmol, 2.0 equiv.) and $BF_3{\cdot}Et_2O$ (25 µL, 0.20 mmol, 2.0 equiv.). Purification (PE/EtOAc, 100:0 to 95:5) afforded the desired product as a colorless oil (32.3 mg, 0.08 mmol, 80% yield, d.r. > 20:1). Crude d.r. = 18:1.

Rf = 0.50 (PE/EtOAc, 9:1).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.21 (d, *J* = 8.7 Hz, 2H), 6.90 – 6.85 (m, 2H), 5.41 (d, *J* = 21.5 Hz, 1H), 4.81 (tdd, *J* = 8.6, 5.2, 3.3 Hz, 1H), 3.81 (s, 3H), 3.45 (dd, *J* = 9.9, 5.3 Hz, 1H), 3.39 (ddd, *J* = 9.7, 9.2, 0.7 Hz, 1H), 2.77 (ddd, *J* = 30.1, 14.9, 8.4 Hz, 1H), 2.57 (ddd, *J* = 21.6, 14.9, 3.3 Hz, 1H).

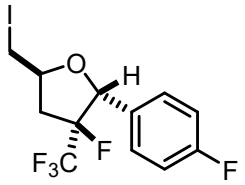
^{13}C{^{1}H} NMR (126 MHz, Chloroform-*d*) δ 160.1, 128.2, 126.9 (d, *J* = 7.3 Hz), 122.2 (qd, *J* = 282.5, 31.5 Hz), 111.8, 101.8 (dq, *J* = 193.1, 31.2 Hz), 86.1 (d, *J* = 28.4 Hz), 78.7, 55.4, 36.6 (d, *J* = 20.3 Hz), 8.7.

^{19}F NMR (471 MHz, Chloroform-*d*) δ -75.7 (d, *J* = 7.1 Hz), -157.6 (dtq, *J* = 28.4, 21.1, 7.3 Hz).

IR (neat) νmax (cm^{-1}): 3042, 3015, 2965, 2923, 2839, 1612, 1251, 1177, 1149, 1135, 1018, 836, 802, 736.

HRMS (EI) Calcd. for $C_{13}H_{13}F_4IO_2$ $[M]^+$ = 403.9891, found = 403.9884.

(4b) *trans,cis*-3-Fluoro-2-(4-fluorophenyl)-5-(iodomethyl)-3-(trifluoromethyl)tetrahydrofuran



4b

Following the **general procedure for the reduction** using **3b** (20.4 mg, 0.05 mmol, 1.0 equiv.), CH_2Cl_2 (0.25 mL), Et_3SiH (20 µL, 0.10 mmol, 2.0 equiv.) and $BF_3{\cdot}Et_2O$ (15 µL, 0.10 mmol, 2.0 equiv.). Purification (PE/EtOAc, 100:0 to 98:2) afforded the desired product as a colorless oil (18.1 mg, 0.046 mmol, 92% yield, d.r. > 20:1). Crude d.r. > 20:1.

Rf = 0.50 (PE/EtOAc, 9:1).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.29 (dd, *J* = 8.6, 5.4 Hz, 2H), 7.11 – 7.02 (m, 2H), 5.43 (d, *J* = 21.1 Hz, 1H), 4.79 (tdd, *J* = 8.7, 5.3, 3.7 Hz, 1H), 3.46 (dd, *J* = 10.0, 5.3 Hz, 1H), 3.40 (ddd, *J* = 9.8, 8.8, 0.7 Hz, 1H), 2.78 (ddd, *J* = 27.5, 14.9, 8.2 Hz, 1H), 2.59 (ddd, *J* = 21.6, 14.9, 3.7 Hz, 1H).

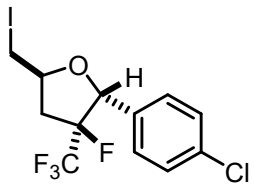
^{13}C{^{1}H} NMR (126 MHz, Chloroform-*d*) δ 163.1 (d, *J* = 247.3 Hz), 130.6 (dd, *J* = 6.5, 3.2 Hz), 128.7 (d, *J* = 8.3 Hz), 122.1 (qd, *J* = 283.0, 31.4 Hz), 115.5 (d, *J* = 22.0 Hz), 101.6 (dq, *J* = 194.0, 31.6 Hz), 85.4 (d, *J* = 28.5 Hz), 78.6, 36.9 (d, *J* = 20.2 Hz), 8.4.

^{19}F NMR (471 MHz, Chloroform-*d*) δ -75.9 (d, *J* = 7.2 Hz), -112.7 (ddd, *J* = 13.8, 8.7, 5.3 Hz), -158.8 (dtq, *J* = 28.3, 21.4, 7.1 Hz).

IR (neat) νmax (cm^{-1}): 2951, 2923, 1608, 1512, 1226, 1180, 1148, 1134, 1069, 1015, 837, 806, 733.

HRMS (EI) Calcd. for $C_{12}H_{10}F_5IO$ $[M]^+$ = 391.9691, found = 391.9692.

(4c) *trans-cis*-2-(4-Chlorophenyl)-3-fluoro-5-(iodomethyl)-3-(trifluoromethyl)tetrahydrofuran



4c

Following the **general procedure for the reduction** using **3c** (42.4 mg, 0.10 mmol, 1.0 equiv.), CH_2Cl_2 (0.5 mL), Et_3SiH (32 µL, 0.20 mmol, 2.0 equiv.) and $BF_3{\cdot}Et_2O$ (25 µL, 0.20 mmol, 2.0 equiv.). Purification (PE/EtOAc, 100:0 to 96:4) afforded the desired product as a colorless oil (37.6 mg, 0.09 mmol, 92% yield, d.r. > 20:1). Crude d.r. > 20:1.

Rf = 0.60 (PE/EtOAc, 9:1).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.36 – 7.32 (m, 2H), 7.25 (d, *J* = 8.7 Hz, 2H), 5.41 (d, *J* = 20.9 Hz, 1H), 4.78 (tdd, *J* = 8.8, 5.3, 3.9 Hz, 1H), 3.45 (dd, *J* = 9.9, 5.3 Hz, 1H), 3.40 (ddd, *J* = 8.8, 8.6, 0.7 Hz, 1H), 2.77 (ddd, *J* = 27.2, 14.9, 8.2 Hz, 1H), 2.59 (ddd, *J* = 21.7, 14.9, 3.8 Hz, 1H).

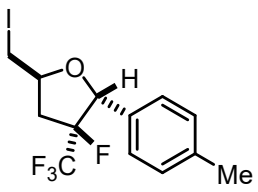
^{13}C{^{1}H} NMR (126 MHz, Chloroform-*d*) δ 134.9, 133.3 (d, *J* = 6.2 Hz), 128.7, 128.3, 122.1 (qd, *J* = 282.8, 31.6 Hz), 101.6 (dq, *J* = 194.7, 31.3 Hz), 85.3 (d, *J* = 28.4 Hz), 78.7, 37.0 (d, *J* = 20.2 Hz), 8.4 (d, *J* = 1.5 Hz).

^{19}F NMR (471 MHz, Chloroform-*d*) δ -75.8 (d, *J* = 7.4 Hz), -159.0 (tdd, *J* = 28.6, 14.3, 7.5 Hz).

IR (neat) νmax (cm^{-1}): 2961, 1719, 1705, 1594, 1490, 1403, 1268, 1173, 1092, 1015, 832, 759.

HRMS (EI) Calcd. for $C_{12}H_{10}ClF_4IO$ $[M]^+$ = 407.9395, found = 407.9373.

(4d) *trans-cis*-3-Fluoro-5-(iodomethyl)-2-(*p*-tolyl)-3-(trifluoromethyl)tetrahydrofuran



4d

Following the **general procedure for the reduction** using **3d** (40.4 mg, 0.10 mmol, 1.0 equiv.), CH_2Cl_2 (0.5 mL), Et_3SiH (32 µL, 0.20 mmol, 2.0 equiv.) and $BF_3{\cdot}Et_2O$ (25 µL, 0.20 mmol, 2.0 equiv.). Purification (PE/EtOAc, 100:0 to 98:2) afforded the desired product as a colorless oil (36.4 mg, 0.09 mmol, 94% yield, d.r. > 20:1). Crude d.r. > 20:1.

Rf = 0.65 (PE/EtOAc, 9:1).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.21 – 7.14 (m, 4H), 5.42 (d, *J* = 21.4 Hz, 1H), 4.82 (tdd, *J* = 8.7, 5.2, 3.4 Hz, 1H), 3.46 (dd, *J* = 9.8, 5.3 Hz, 1H), 3.39 (ddd, *J* = 9.2, 9.1, 0.7 Hz, 1H), 2.77 (ddd, *J* = 30.4, 14.9, 8.4 Hz, 1H), 2.58 (ddd, *J* = 21.7, 14.9, 3.4 Hz, 1H), 2.35 (s, 3H).

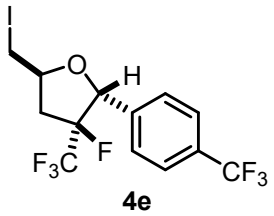
^{13}C{^{1}H} NMR (126 MHz, Chloroform-*d*) δ 138.9, 132.0 (d, *J* = 6.7 Hz), 129.2, 126.8, 122.1 (qd, *J* = 282.5, 31.3 Hz), 101.9 (dq, *J* = 193.0, 31.2 Hz), 86.3 (d, *J* = 27.6 Hz), 78.8, 36.6 (d, *J* = 20.2 Hz), 21.4, 8.7 (d, *J* = 2.5 Hz).

^{19}F NMR (471 MHz, Chloroform-*d*) δ -75.6 (d, *J* = 7.3 Hz), -157.5 (dtq, *J* = 29.2, 21.9, 7.0 Hz).

IR (neat) νmax (cm^{-1}): 3035, 2952, 2926, 1704, 1612, 1270, 1178, 1125, 1019, 821, 754.

HRMS (EI) Calcd. for $C_{13}H_{13}F_4IO$ $[M]^+$ = 387.9942, found = 387.9946.

(4e) *trans-cis*-3-Fluoro-5-(iodomethyl)-3-(trifluoromethyl)-2-(4-(trifluoromethyl)phenyl)tetrahydrofuran



4e

Following the **general procedure for the reduction** using **3e** (45.8 mg, 0.10 mmol, 1.0 equiv.), CH_2Cl_2 (0.5 mL), Et_3SiH (32 µL, 0.20 mmol, 2.0 equiv.) and $BF_3{\cdot}Et_2O$ (25 µL, 0.20 mmol, 2.0 equiv.). Purification (PE/EtOAc, 100:0 to 96:4) afforded the desired product as a colorless oil (33.8 mg, 0.08 mmol, 77% yield (97% BRSM), d.r. > 20:1). Crude d.r. > 20:1.

Or:

Following the **general procedure for the reduction** with slight modifications using **3e** (183.2 mg, 0.40 mmol, 1.0 equiv.), CH_2Cl_2 (2 mL), Et_3SiH (192 µL, 1.20 mmol, 3.0 equiv.) and $BF_3{\cdot}Et_2O$ (150 µL, 1.20 mmol, 3.0 equiv.), the reaction was stirred for 14 h. Purification

(PE/EtOAc, 100:0 to 95:5) afforded the desired product as a colorless oil (161.6 mg, 0.37 mmol, 92% yield, d.r. > 20:1).

Rf = 0.70 (PE/EtOAc, 9:1).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.63 (d, *J* = 8.2 Hz, 2H), 7.45 (d, *J* = 8.1 Hz, 2H), 5.49 (d, *J* = 20.6 Hz, 1H), 4.79 (tdd, *J* = 8.6, 5.2, 4.2 Hz, 1H), 3.47 (dd, *J* = 10.1, 5.3 Hz, 1H), 3.42 (ddd, *J* = 8.6, 8.5, 0.8 Hz, 1H), 2.80 (ddd, *J* = 25.4, 14.9, 8.2 Hz, 1H), 2.62 (ddd, *J* = 21.7, 14.9, 4.2 Hz, 1H).

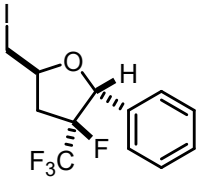
^{13}C{^{1}H} NMR (126 MHz, Chloroform-*d*) δ 138.7 (d, *J* = 5.7 Hz), 131.2 (q, *J* = 32.3 Hz), 127.3, 125.5 (q, *J* = 4.0 Hz), 124.0 (q, *J* = 272.3 Hz), 122.1 (qd, *J* = 282.9, 31.8 Hz), 101.6 (dq, *J* = 194.9, 31.9 Hz), 85.0 (d, *J* = 28.6 Hz), 78.6 (d, *J* = 1.6 Hz), 37.2 (d, *J* = 20.2 Hz), 8.3.

^{19}F NMR (471 MHz, Chloroform-*d*) δ -62.7, -75.9 (d, *J* = 7.9 Hz), -159.7 – -159.9 (m).

IR (neat) νmax (cm^{-1}): 2945, 1719, 1413, 1325, 1270, 1167, 1126, 1067, 1018, 863, 844, 775, 705.

HRMS (EI) Calcd. for $C_{13}H_{10}F_7IO$ $[M]^+$ = 441.9659, found = 441.9621.

(4f) *trans-cis*-3-Fluoro-5-(iodomethyl)-2-phenyl-3-(trifluoromethyl)tetrahydrofuran



4f

Following the **general procedure for the reduction** using **3f** (39.0 mg, 0.10 mmol, 1.0 equiv.), CH_2Cl_2 (0.5 mL), Et_3SiH (32 µL, 0.20 mmol, 2.0 equiv.) and $BF_3{\cdot}Et_2O$ (25 µL, 0.20 mmol, 2.0 equiv.). Purification (PE/EtOAc, 100:0 to 98:2) afforded the desired product as a colorless oil (33.8 mg, 0.09 mmol, 90% yield, d.r. > 20:1). Crude d.r. > 20:1.

Rf = 0.40 (PE).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.39 – 7.32 (m, 3H), 7.32 – 7.29 (m, 2H), 5.46 (d, *J* = 21.3 Hz, 1H), 4.83 (tdd, *J* = 8.8, 5.2, 3.5 Hz, 1H), 3.47 (dd, *J* = 9.9, 5.2 Hz, 1H), 3.40 (ddd, *J* = 9.9, 9.0, 0.7 Hz, 1H), 2.79 (ddd, *J* = 29.4, 14.9, 8.4 Hz, 1H), 2.59 (ddd, *J* = 21.4, 14.8, 3.2 Hz, 1H).

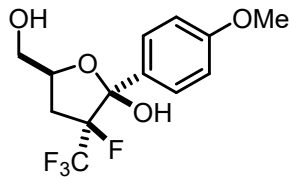
$^{13}C\{^1H\}$ NMR (126 MHz, Chloroform-*d*) δ 134.9 (d, *J* = 6.5 Hz), 129.0, 128.5, 126.9, 122.1 (qd, *J* = 283.0, 31.3 Hz), 101.9 (dq, *J* = 193.1, 31.3 Hz), 86.2 (d, *J* = 28.3 Hz), 78.8, 36.7 (d, *J* = 20.2 Hz), 8.6.

^{19}F NMR (471 MHz, Chloroform-*d*) δ -75.7 (d, *J* = 7.3 Hz), -157.9 (dtq, *J* = 28.9, 21.9, 7.5 Hz).

IR (neat) νmax (cm^{-1}): 3036, 2921, 1456, 1364, 1268, 1181, 1148, 1135, 1018, 748, 734, 698.

HRMS (EI) Calcd. for $C_{12}H_{11}F_4IO$ $[M]^+$ = 373.9785, found = 373.9790.

(6a) *trans-cis*-3-Fluoro-5-(hydroxymethyl)-2-(4-methoxyphenyl)-3-(trifluoromethyl)tetrahydrofuran-2-ol



6a

Following a reported procedure[3], a dry flask under argon atmosphere equipped with a magnetic stirrer was charged with **3a** (84.0 mg, 0.20 mmol, 1.0 equiv.), DMF (2 mL), $CsCO_2CF_3$ (73.8 mg, 0.30 mmol, 1.5 equiv.) and was heated to 90 °C for 2 h. The reaction was cooled down to 20 °C, Et_2NH (0.06 mL, 0.60 mmol, 3.0 equiv.) was added and the reaction was stirred for 3 h at 20 °C. H_2O was added, and the aqueous layer was extracted three times with EtOAc. The organic layers were gathered, washed three times with H_2O, dried over Na_2SO_4, filtered and the solvent removed under reduced pressure. Purification by flash column chromatography (SiO_2, PE/EtOAc, 100:0 to 98:2) afforded the desired product as a colorless oil (23.0 mg, 0.074 mmol, 37% yield).

Rf = 0.30 (PE/EtOAc, 9:1).

^1H NMR (500 MHz, Chloroform-*d*) δ 7.49 (d, *J* = 8.8 Hz, 2H), 6.95 – 6.88 (m, 2H), 4.98 (ddd, *J* = 5.0, 3.5, 1.1 Hz, 1H), 4.02 (d, *J* = 6.6 Hz, 1H), 3.94 (ddd, *J* = 6.6, 3.6, 2.6 Hz, 1H), 3.82 (s, 3H), 2.55 (dddd, *J* = 18.3, 14.1, 5.5, 2.5 Hz, 1H), 2.11 (dd, *J* = 21.7, 14.1 Hz, 1H).

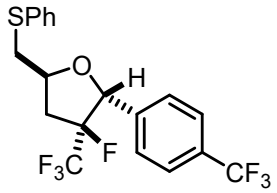
$^{13}C\{^1H\}$ NMR (126 MHz, Chloroform-*d*) δ 160.6, 127.6, 123.2, 122.1 (qd, *J* = 282.4, 32.4 Hz), 113.6, 106.4 (d, *J* = 20.1 Hz), 99.2 (dq, *J* = 208.7, 30.9 Hz), 75.9 (d, *J* = 1.8 Hz), 70.5, 55.4, 37.3 (d, *J* = 23.9 Hz).

^{19}F NMR (471 MHz, Chloroform-*d*) δ -78.8 (d, *J* = 8.4 Hz), -177.5 – -177.7 (m).

IR (neat) νmax (cm^{-1}): 3009, 2964, 2915, 2845, 1617, 1519, 1254, 1179, 1063, 1033, 1002, 834.

HRMS (EI) Calcd. for $C_{13}H_{14}F_4O_4$ $[M]^+$ = 310.0823, found = 310.0826.

(5e) *trans-cis*-3-Fluoro-5-((phenylthio)methyl)-3-(trifluoromethyl)-2-(4-(trifluoromethyl)phenyl)tetrahydrofuran



5e

A dry flask under argon atmosphere was charged with **4e** (44.2 mg, 0.10 mmol, 1.0 equiv.), PhSH (21 µL, 0.20 mmol, 2.0 equiv.), $NaHCO_3$ (25.2 mg, 0.30 mmol, 3.0 equiv.), DMF (0.1 mL) and was heated to 80 °C for 24 h. The reaction was then allowed to cool to room temperature and was diluted with EtOAc. H_2O was added and the aqueous layer was extracted three times with EtOAc. The organic layers were gathered, washed three times with H_2O, dried over Na_2SO_4, filtered and the solvent removed under reduced pressure. Purification by flash column chromatography (SiO_2, PE/EtOAc, 100:0 to 96:4) afforded the desired product as a colorless oil (38.5 mg, 0.091 mmol, 91% yield).

Rf = 0.60 (PE/EtOAc, 9:1).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.60 (d, *J* = 8.2 Hz, 2H), 7.46 – 7.40 (m, 4H), 7.37 – 7.29 (m, 2H), 7.27 – 7.21 (m, 1H), 5.41 (d, *J* = 21.3 Hz, 1H), 4.70 (tdd, *J* = 8.6, 5.5, 3.6 Hz, 1H), 3.41 (dd, *J* = 13.7, 5.5 Hz, 1H), 3.16 (dd, *J* = 13.7, 8.4 Hz, 1H), 2.73 (ddd, *J* = 27.2, 14.9, 8.3 Hz, 1H), 2.58 (ddd, *J* = 22.3, 14.9, 3.7 Hz, 1H).

^{13}C{^{1}H} NMR (126 MHz, Chloroform-*d*) δ 139.0 (d, *J* = 6.1 Hz), 134.8, 131.1 (q, *J* = 32.6 Hz), 130.2, 129.4, 127.4, 127.0, 125.4 (q, *J* = 3.7 Hz), 124.0 (q, *J* = 272.2 Hz), 122.1 (qd, *J* = 282.8, 31.7 Hz), 101.9 (dq, *J* = 194.3, 31.4 Hz), 84.8 (d, *J* = 29.1 Hz), 77.5, 38.5, 36.2 (d, *J* = 20.1 Hz).

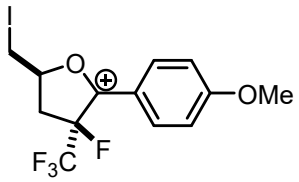
^{19}F NMR (471 MHz, Chloroform-*d*) δ -62.7, -75.8 (d, *J* = 7.8 Hz), -158.7 (dtq, *J* = 29.2, 22.2, 7.5 Hz).

IR (neat) νmax (cm^{-1}): 3069, 2927, 1624, 1585, 1421, 1325, 1165, 1123, 1068, 1019, 844, 738, 691.

HRMS (EI) Calcd. for $C_{19}H_{15}F_7OS$ $[M]^+$ = 424.0726, found = 424.0731.

3. *In situ* VT NMR observation of cationic species in superacid

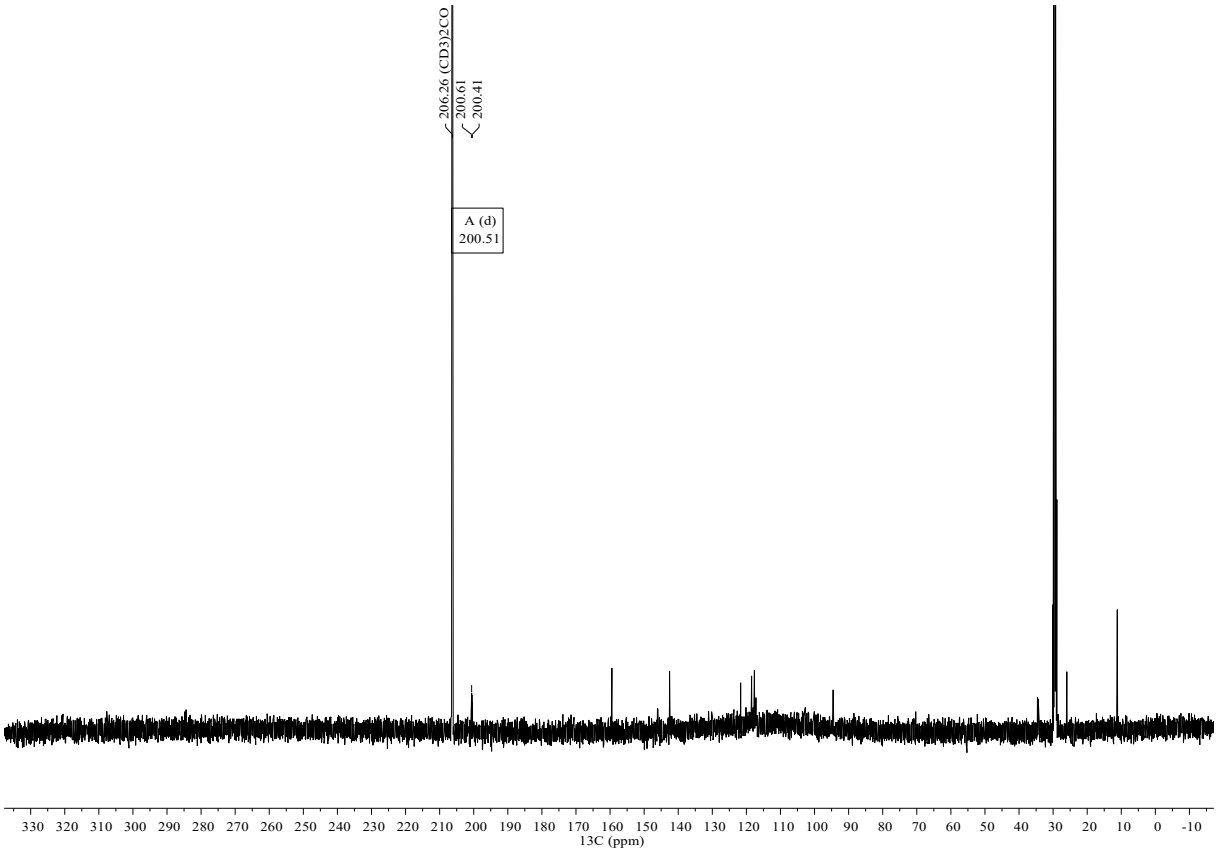
(A1) 3-Fluoro-5-(iodomethyl)-2-(4-methoxyphenyl)-3-(trifluoromethyl)tetrahydrofuran-2-ylium



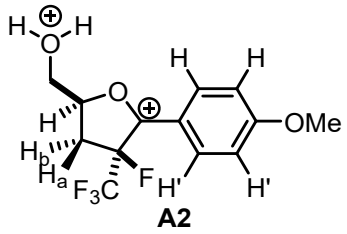
A1

A PTFE tube equipped with a magnetic stirrer was charged with **3a** (42.0 mg, 0.10 mmol, 1.0 equiv.), was cooled to -50 °C and a solution of HF/SbF_5 (1:1 v/v, 1.0 mL) was added. The obtained solution was added into a precooled PTFE NMR insert and was then subjected to VT NMR experiments using acetone-d_6 as external standard.

Low-resolution NMR spectra was obtained, nevertheless allowing to detect the diagnostic furanosyl cation signal at δ = 200.5 (d, J = 20.3 Hz) in the ^{13}C NMR spectrum (-20 °C).



(A2) 3-Fluoro-5-(hydroxymethyl)-2-(4-methoxyphenyl)-3-(trifluoromethyl)tetrahydrofuran-2-ylium



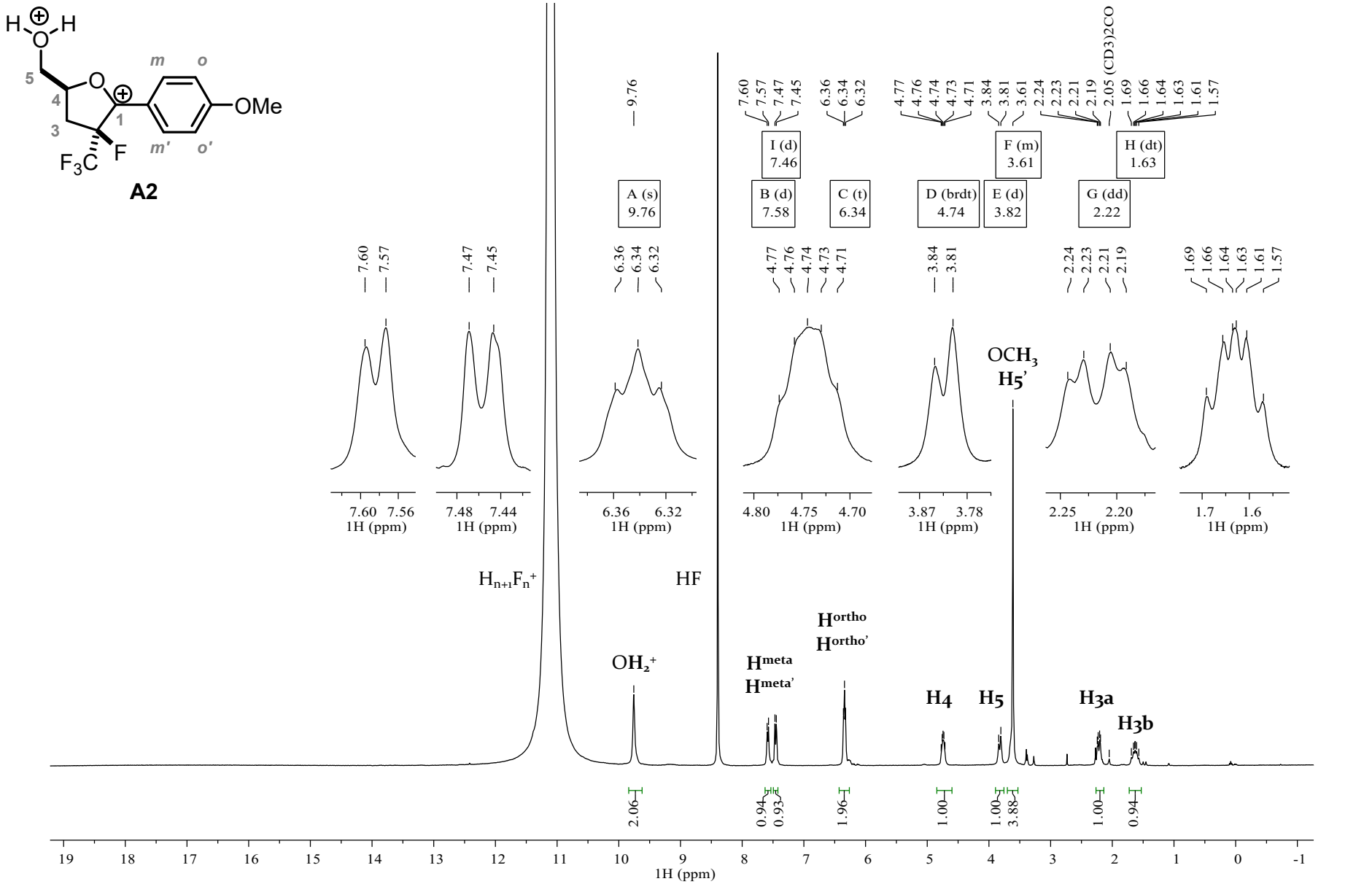
A2

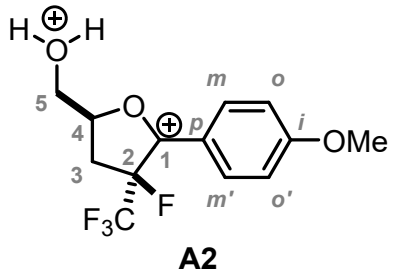
A PTFE tube equipped with a magnetic stirrer was charged with **6a** (18.0 mg, 0.06 mmol, 1.0 equiv.), was cooled to -50 °C and a solution of HF/SbF_5 (1:1 v/v, 0.5 mL) was added. The obtained solution was added into a precooled PTFE NMR insert and was then subjected to VT NMR experiments using acetone-d_6 as external standard.

^{1}H NMR (400 MHz, 223 K, Acetone-d_6) δ 9.76 (s, 2H, $^+O\underline{\mathbf{H}}_2$), 7.58 (d, J = 8.9 Hz, 1H, $\mathbf{H^{meta}}$), 7.46 (d, J = 9.0 Hz, 1H, $\mathbf{H^{meta'}}$), 6.34 (t, J = 7.1 Hz, 2H, $\mathbf{H^{ortho}}$ + $\mathbf{H^{ortho'}}$), 4.74 (brdt, J = 12.5, 6.6 Hz, 1H, **H4**), 3.82 (d, J = 13.9 Hz, 1H, **H5**), 3.72 – 3.50 (m, 4H, $OC\underline{\mathbf{H}}_3$ + **H5'**), 2.22 (dd, J = 15.1, 5.7 Hz, 1H, **H3a**), 1.63 (dt, J = 23.1, 14.0 Hz, 1H, **H3b**).

$^{13}C\{^1H\}$ NMR (101 MHz, Acetone-d_6) δ 201.5 (d, *J* = 19.5 Hz, **C1**), 162.2 (**CAr^{ipso}**), 145.3 (d, *J* = 9.2 Hz, **CAr^{meta}**), 141.7 (**CAr$^{meta'}$**), 121.6 (**CAr^{para}**), 117.3 (**CAr^{ortho}**), 116.4 (**CAr$^{ortho'}$**), 100.1 (dq, *J* = 225.0, 36.0 Hz, **C2**), 94.4 (**C4**), 69.9 (O**C**H_3), 68.2 (**C5**), 28.7 – 28.5 (m, **C3**). The CF_3 signal was not observed.

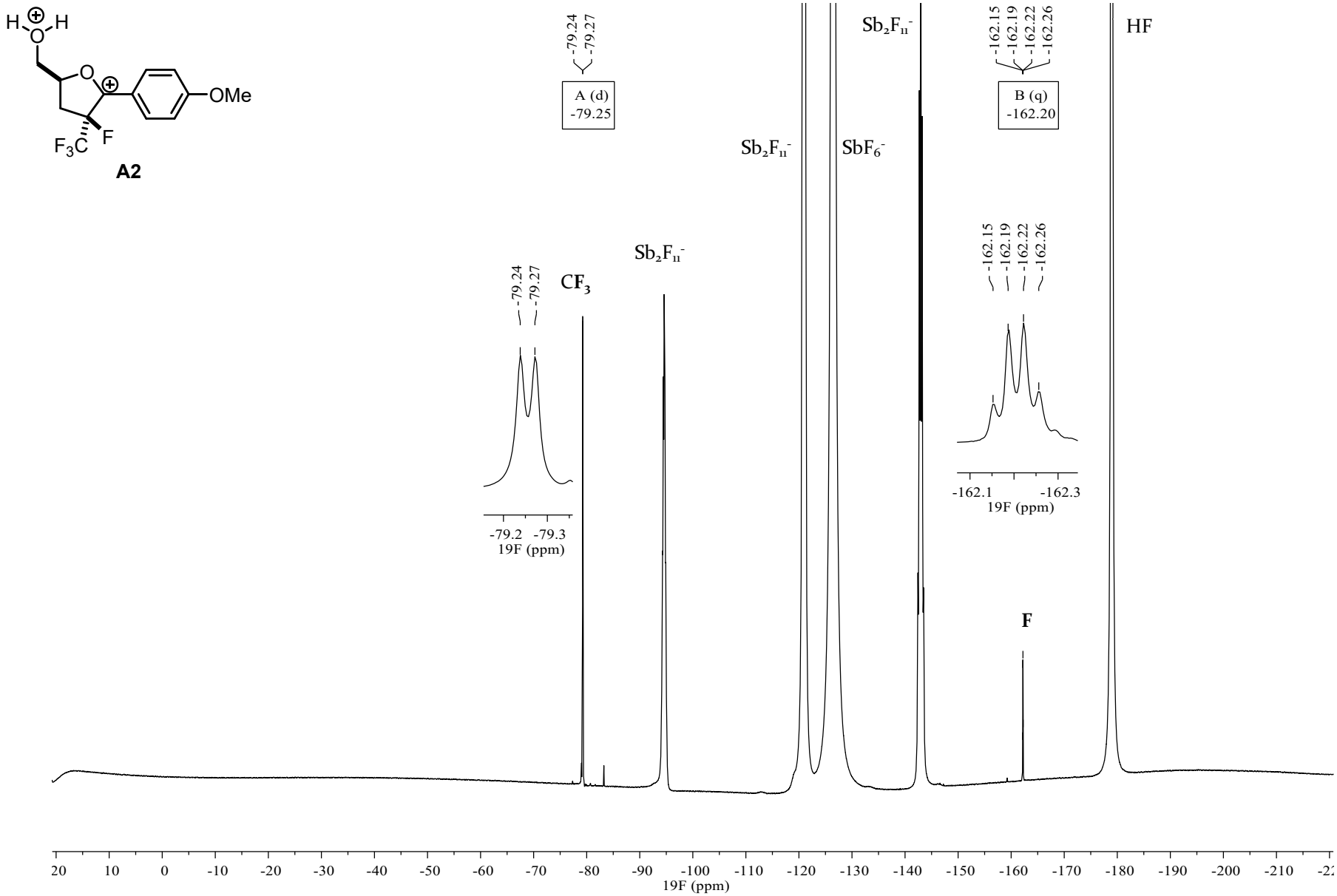
$^{19}F\{^1H\}$ NMR (376 MHz, Acetone-d_6) δ -79.3 (d, *J* = 12.6 Hz, C**F**$_3$), -162.2 (q, *J* = 13.0 Hz, C**F**).

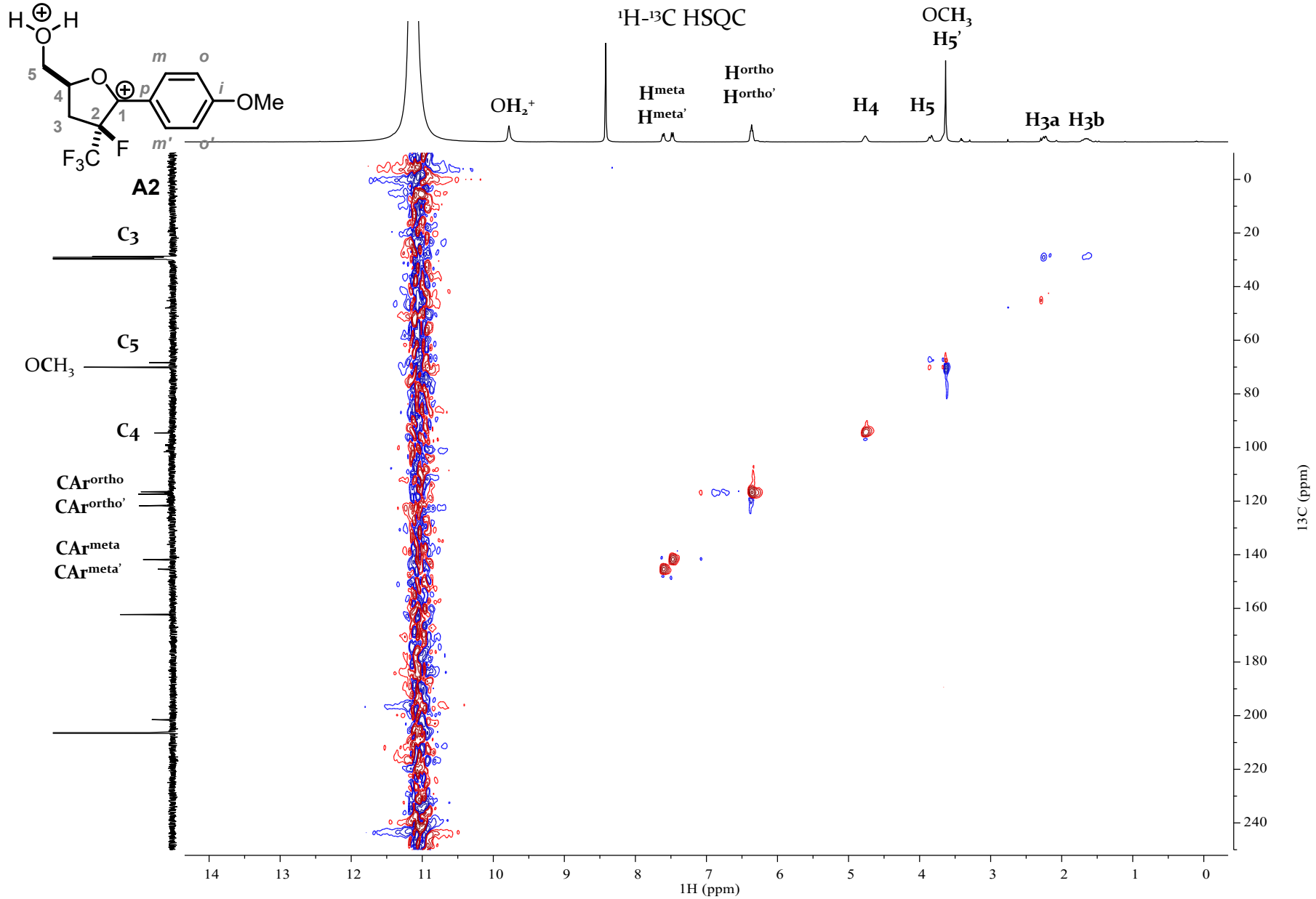

A2
A (s) 9.76
B (d) 7.58
C (t) 6.34
D (brdt) 4.74
E (d) 3.82
F (m) 3.61
G (dd) 2.22
H (dt) 1.63
I (d) 7.46
(CD3)2CO
$H_{n+1}F_n^+$
HF
OH_2^+
H^{meta}
$H^{meta'}$
H^{ortho}
$H^{ortho'}$
H4
H5
OCH_3
H5'
H3a
H3b
1H (ppm)

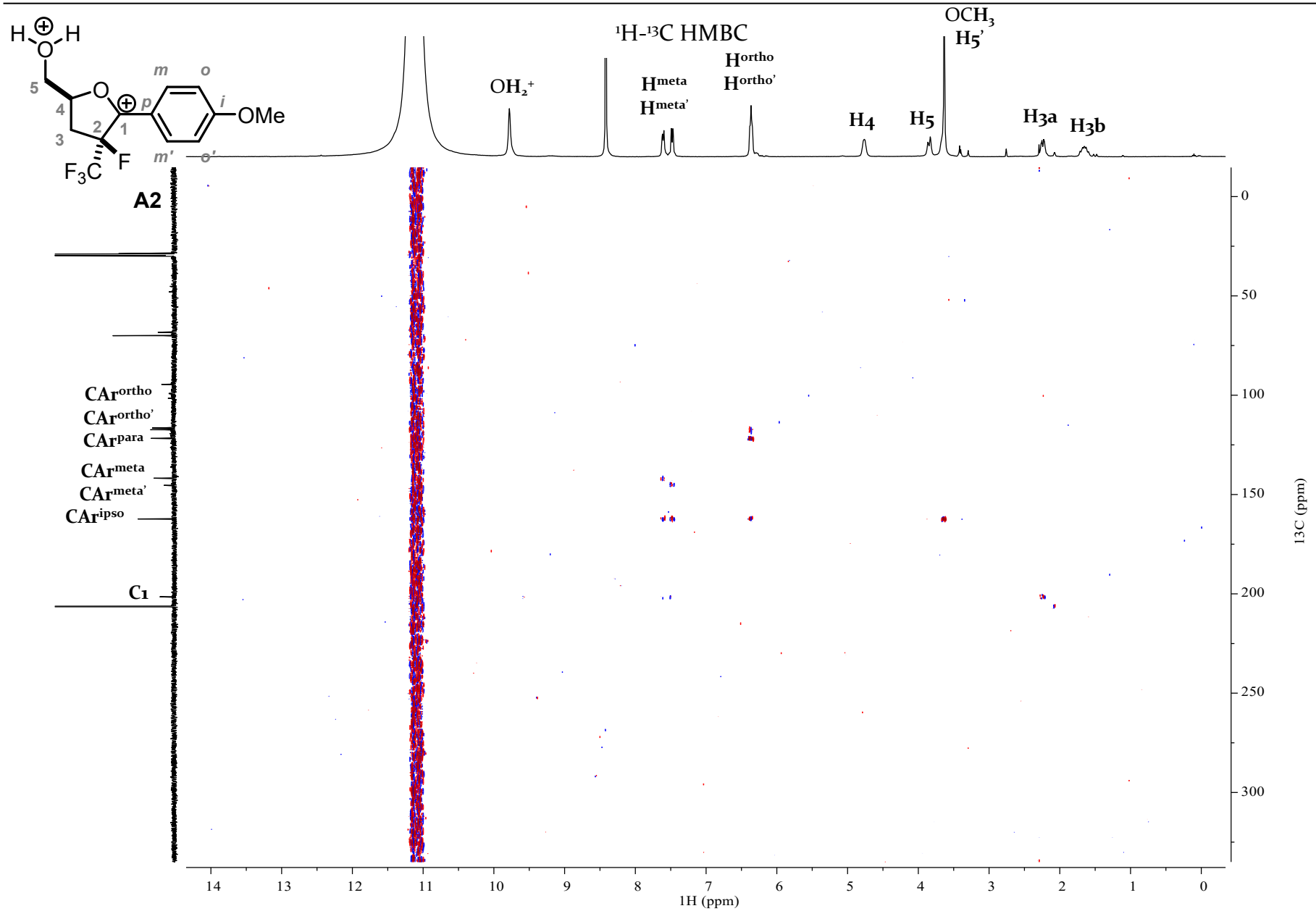

H
O
H
5
4
3
2
1
O
p
m
o
i
OMe
m'
o'
F
F3C

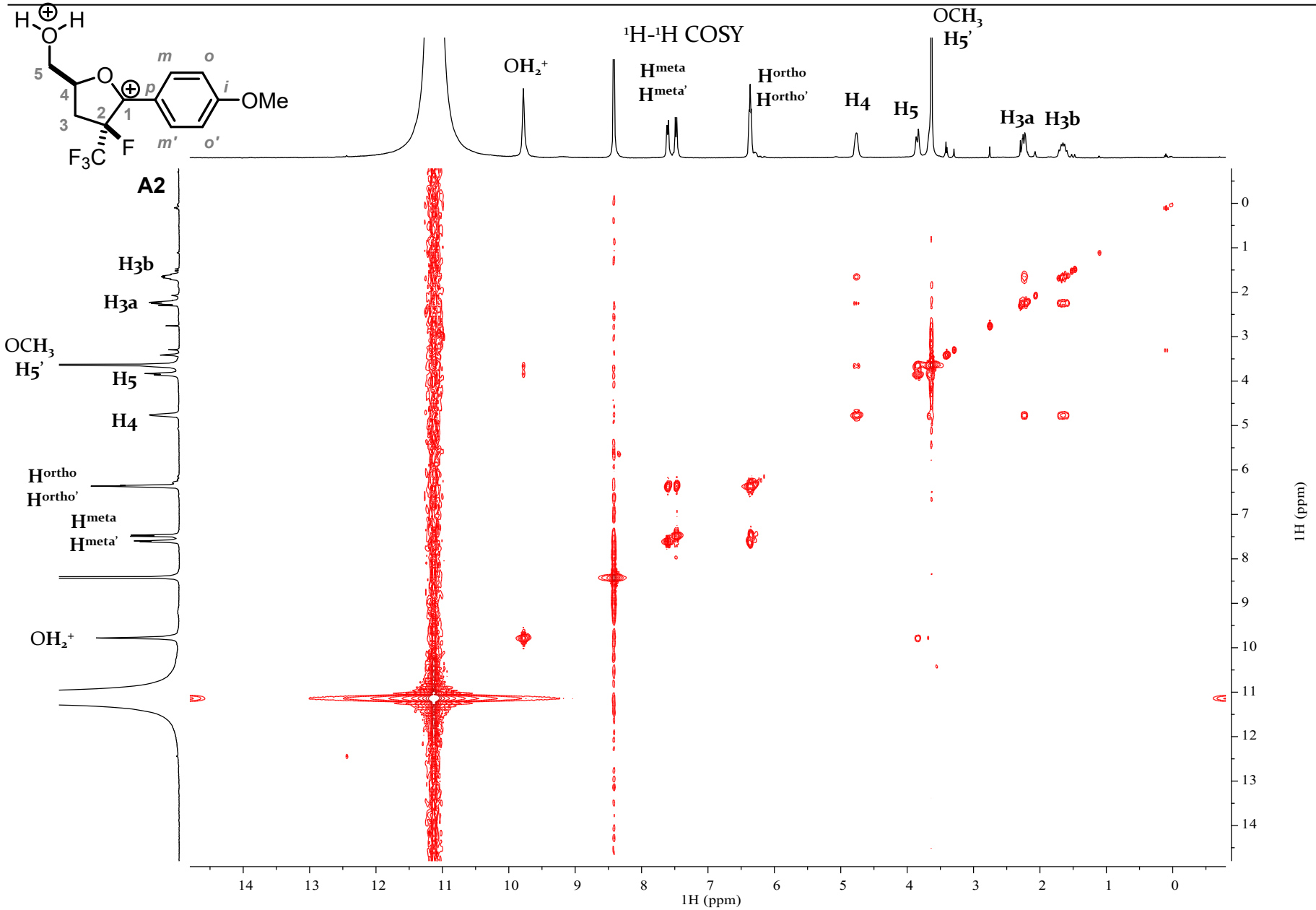
A2

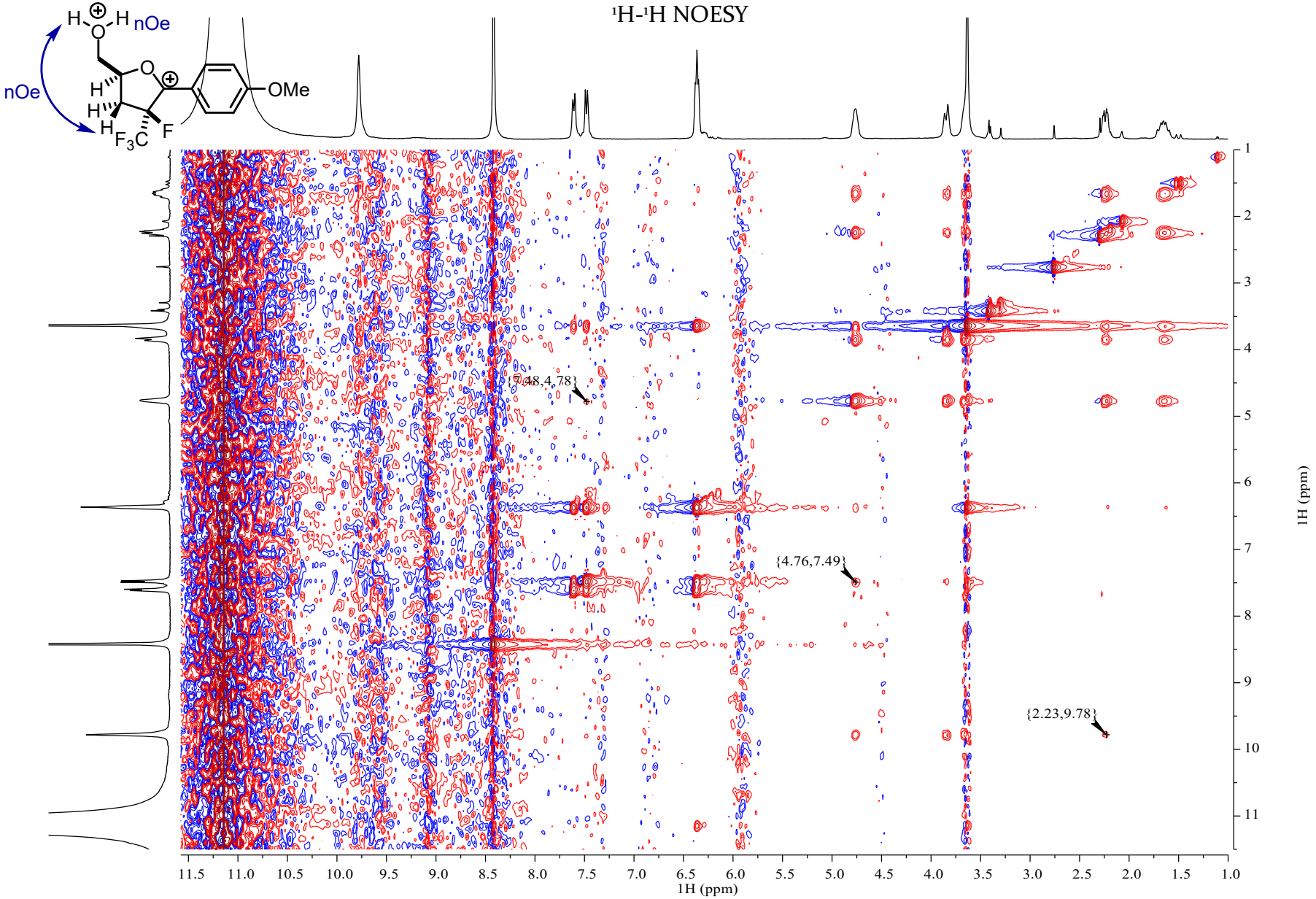
206.26 (CD3)2CO
201.55
201.36
162.16
145.33
145.24
141.65
121.59
117.25
116.37
101.44
101.07
99.19
98.85
94.40
69.91
68.18
28.60
A (d)
201.45
B (d)
145.28
C (dd)
100.14
D (m)
28.60
OCH3
CArpara
CAripso
CArmeta
CArmeta'
CArortho
CArortho'
C1
C2
C4
C5
C3
330 320 310 300 290 280 270 260 250 240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
13C (ppm)


A2
A (d)
-79.25
B (q)
-162.20
-79.24
-79.27
-162.15
-162.19
-162.22
-162.26
CF3
Sb2F11-
SbF6-
HF
F
-79.2 -79.3
19F (ppm)
-162.1 -162.3
19F (ppm)
19F (ppm)

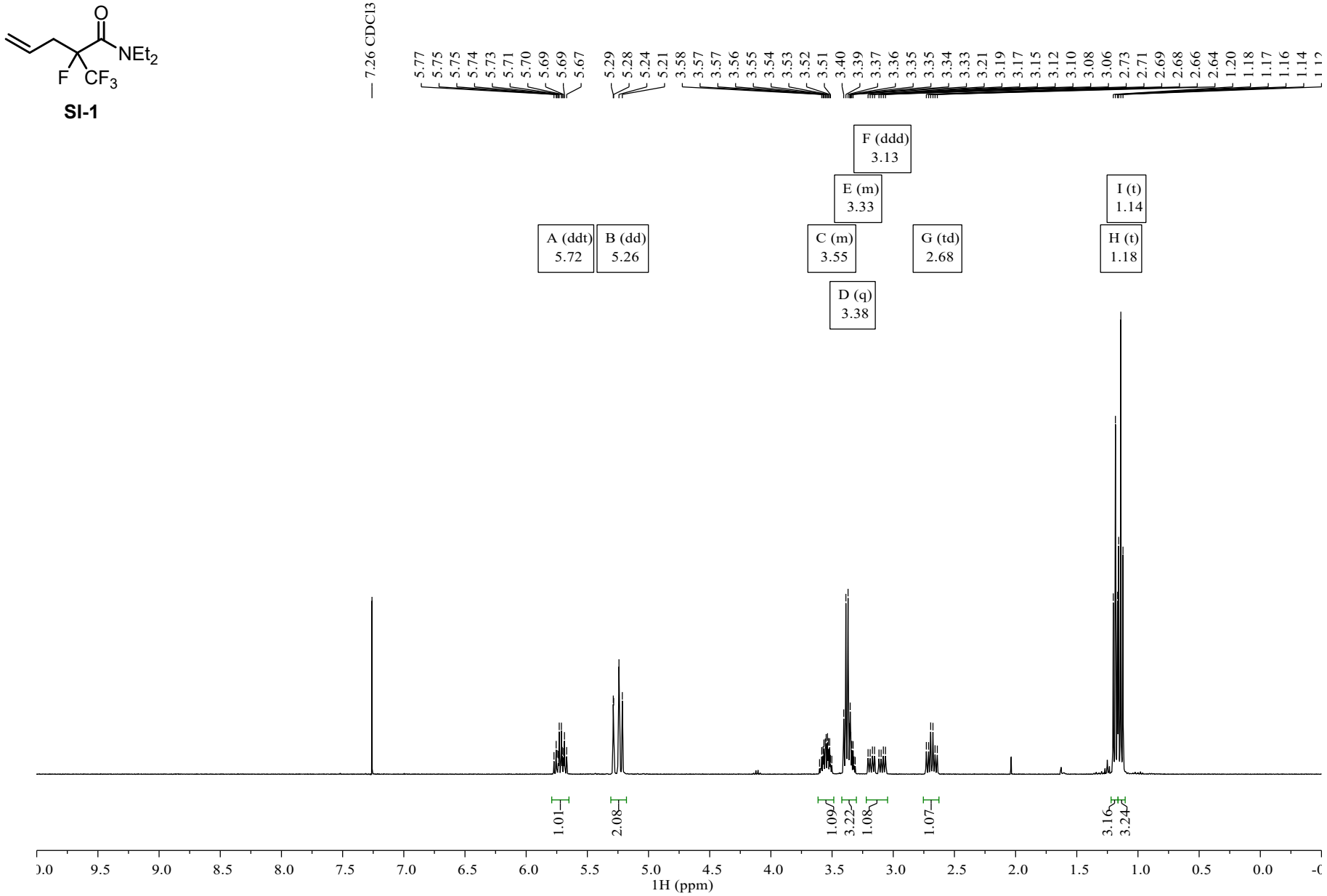

^{1}H-^{13}C HSQC
OCH$_3$
H5'
OH$_2^+$
H^{meta}
H$^{meta'}$
H^{ortho}
H$^{ortho'}$
H4
H5
H3a H3b
A2
C3
C5
OCH$_3$
C4
CAr^{ortho}
CAr$^{ortho'}$
CAr^{meta}
CAr$^{meta'}$
1H (ppm)
13C (ppm)

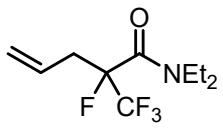

^{1}H-^{13}C HMBC
OH_2^+
H^{meta}
$H^{meta'}$
H^{ortho}
$H^{ortho'}$
H4
H5
OCH_3
H5'
H3a
H3b
A2
CAr^{ortho}
$CAr^{ortho'}$
CAr^{para}
CAr^{meta}
$CAr^{meta'}$
CAr^{ipso}
C1
1H (ppm)
13C (ppm)


A2
¹H-¹H COSY
OCH₃
H5'
OH₂⁺
Hmeta
Hmeta'
Hortho
Hortho'
H4
H5
H3a
H3b
OMe
F
F3C
m
o
p
i
m'
o'
1H (ppm)


nOe
nOe
OMe
F
^{1}H-^{1}H NOESY
{7.48,4.78}
{4.76,7.49}
{2.23,9.78}
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0
1H (ppm)
1 2 3 4 5 6 7 8 9 10 11
1H (ppm)

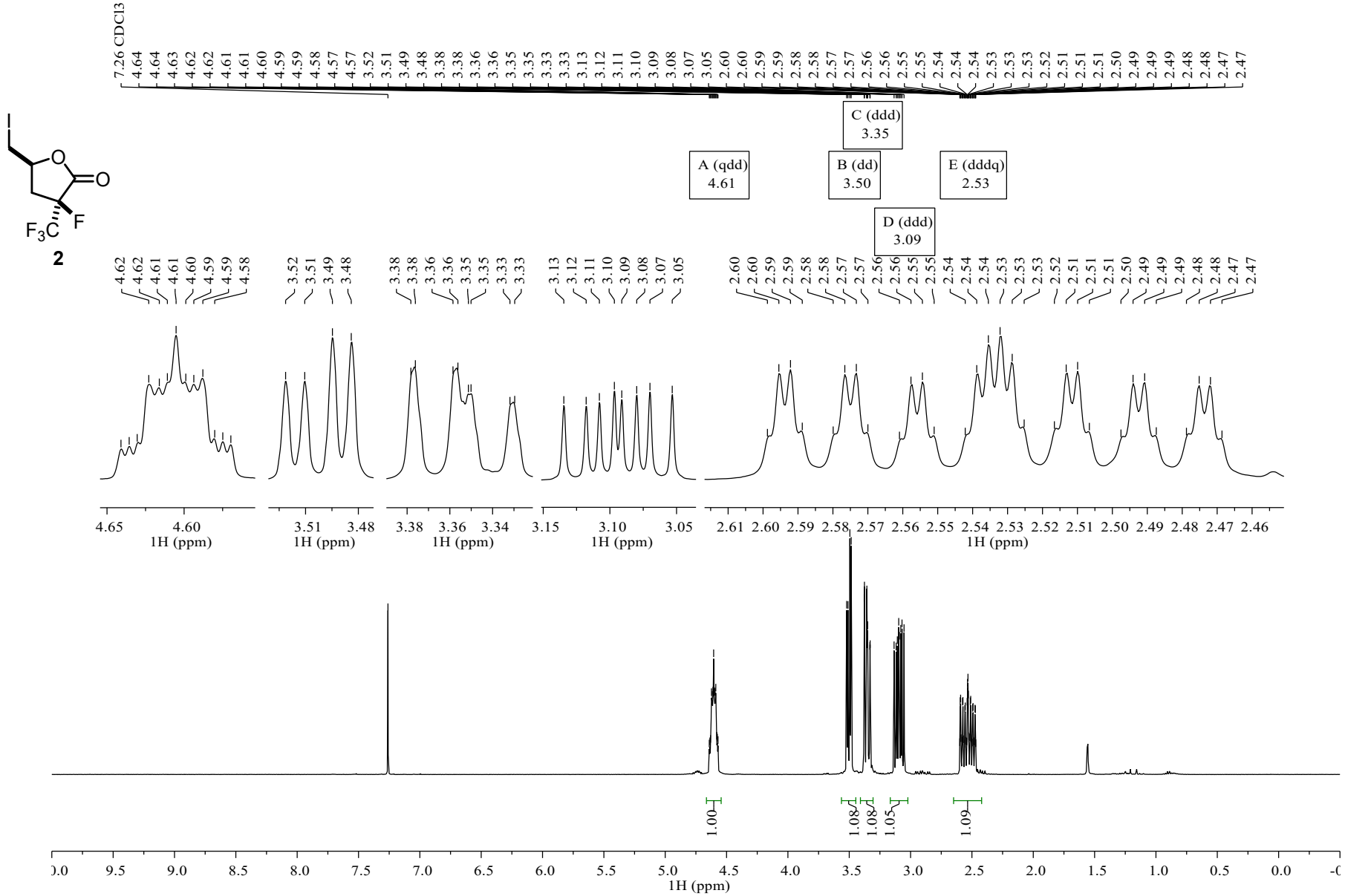
4. NMR spectra


O
NEt2
F CF3
SI-1
7.26 CDCl3
A (ddt) 5.72
B (dd) 5.26
C (m) 3.55
D (q) 3.38
E (m) 3.33
F (ddd) 3.13
G (td) 2.68
H (t) 1.18
I (t) 1.14
1.01
2.08
1.09
3.22
1.08
1.07
3.16
3.24
1H (ppm)

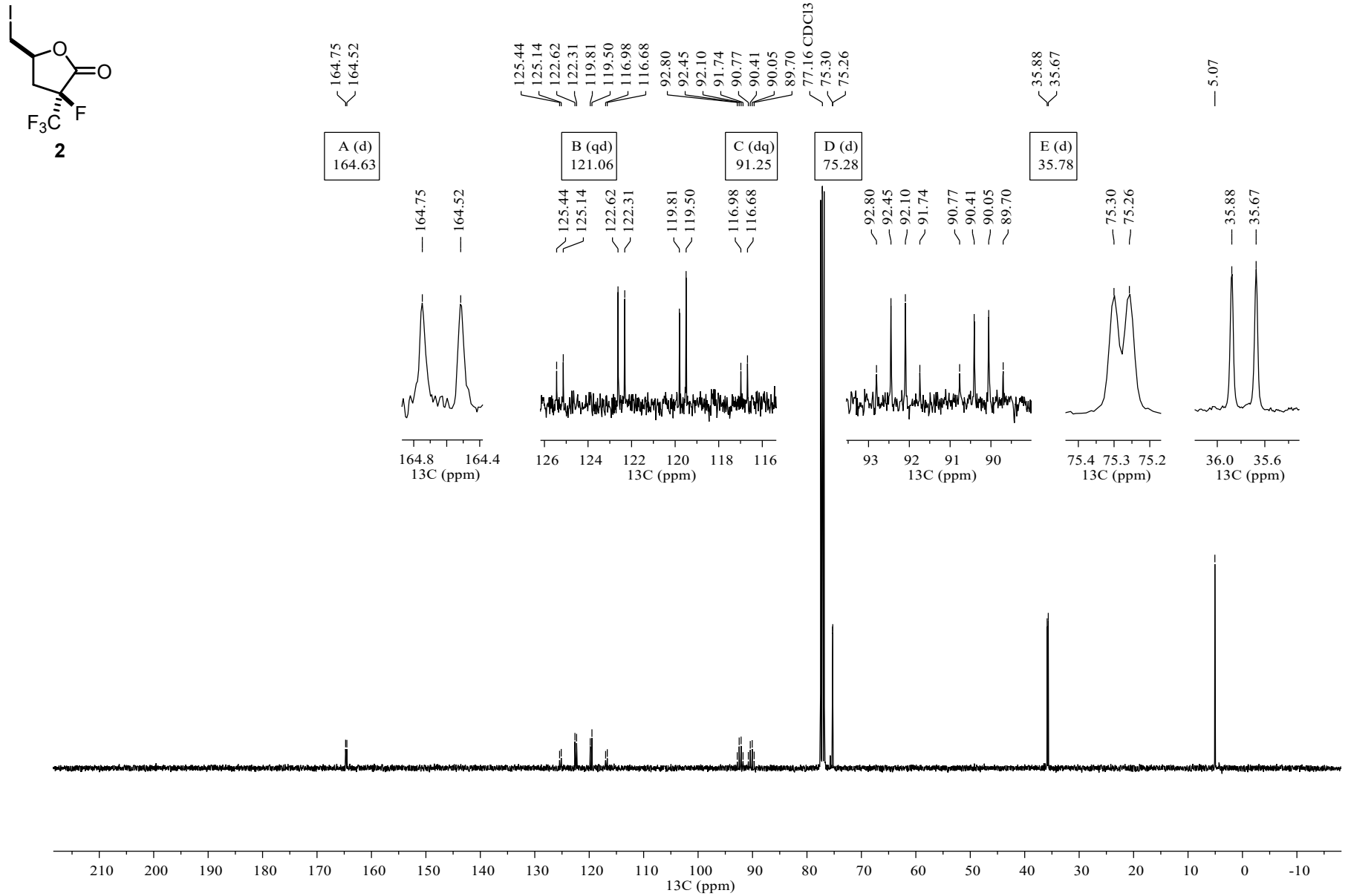

O
NEt2
F
CF3

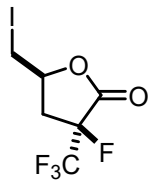
SI-1

-77.41
-77.43
A (d)
-77.42
-172.66
-172.67
-172.69
-172.71
B (q)
-172.68
-77.40
-77.50
19F (ppm)
-172.64
-172.72
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)


7.26 CDCl3
A (qdd) 4.61
B (dd) 3.50
C (ddd) 3.35
D (ddd) 3.09
E (dddq) 2.53
1H (ppm)
1.00
1.08
1.08
1.05
1.09

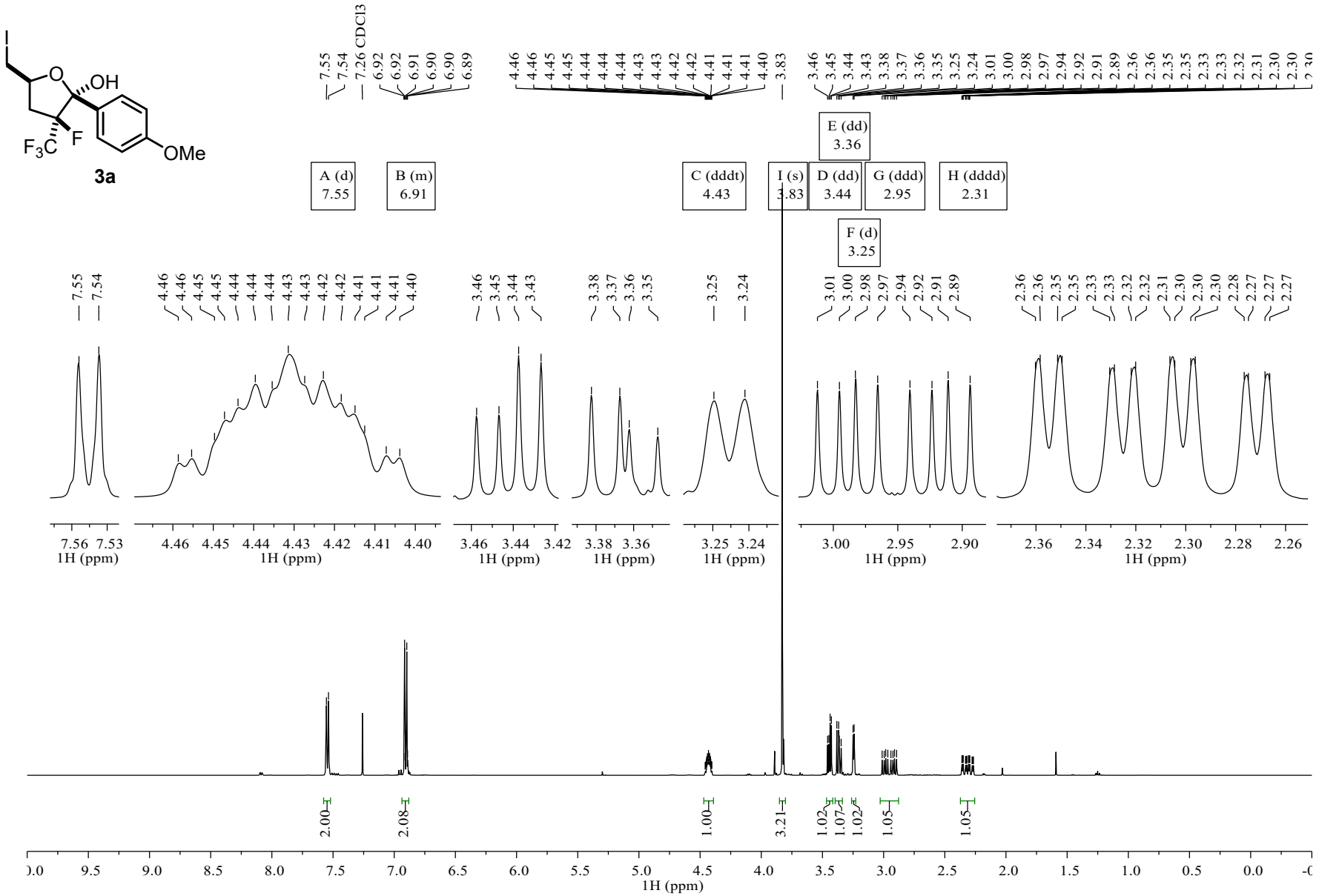
2

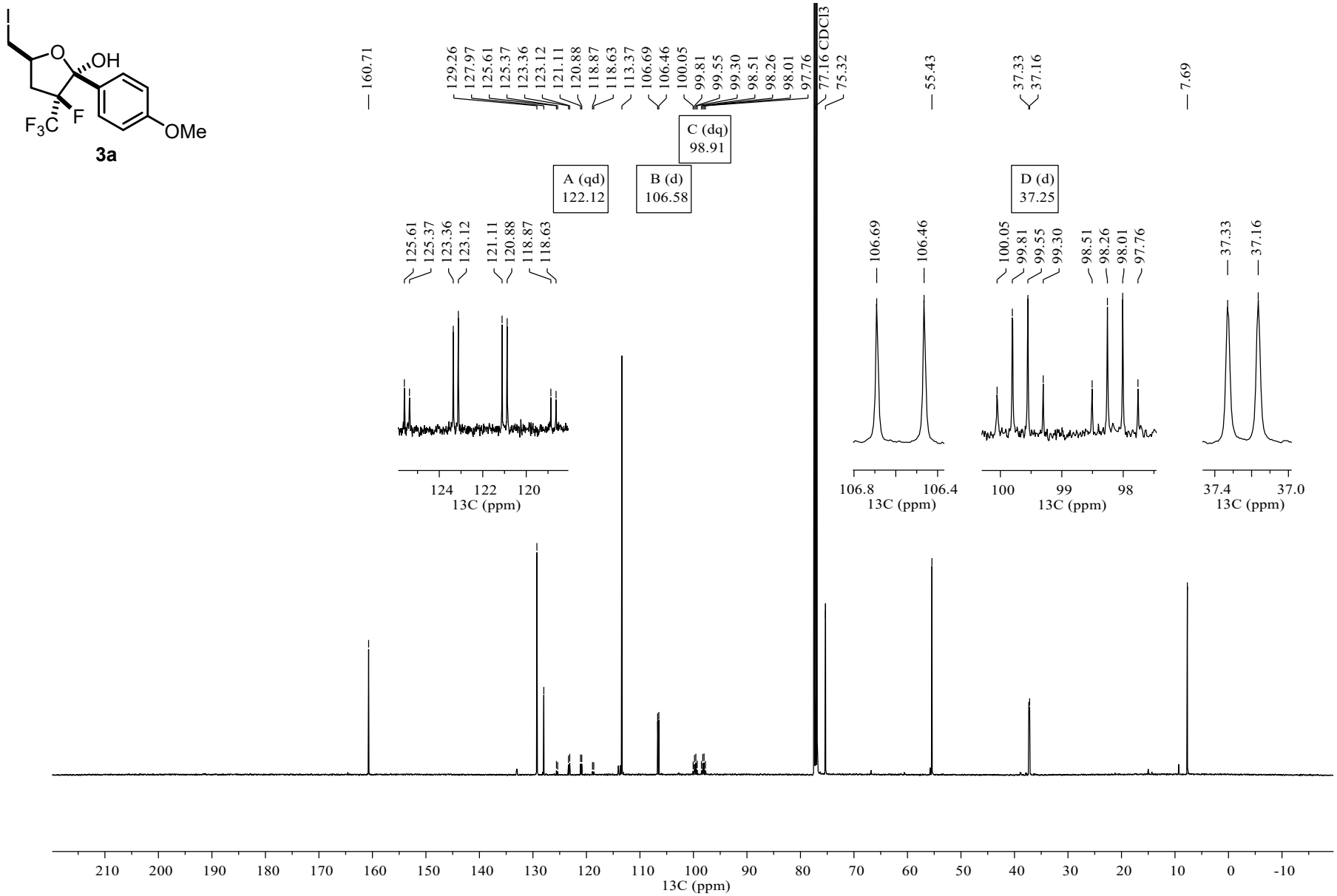

2
164.75
164.52
125.44
125.14
122.62
122.31
119.81
119.50
116.98
116.68
92.80
92.45
92.10
91.74
90.77
90.41
90.05
89.70
77.16 CDCl3
75.30
75.26
35.88
35.67
5.07
A (d)
164.63
B (qd)
121.06
C (dq)
91.25
D (d)
75.28
E (d)
35.78
13C (ppm)

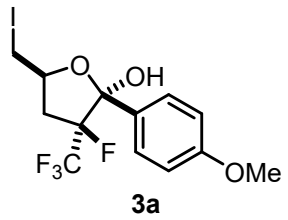

I
O
O
F3C
F

2

-79.91
-79.92
-79.94
-79.95
A (dd)
-79.93
-169.35
-169.38
-169.42
-169.45
-169.48
-169.50
B (m)
-169.43
-79.92 -79.98
19F (ppm)
19F (ppm)


3a
A (d) 7.55
B (m) 6.91
C (dddt) 4.43
I (s) 3.83
D (dd) 3.44
E (dd) 3.36
G (ddd) 2.95
H (dddd) 2.31
F (d) 3.25
7.26 CDCl3
1H (ppm)

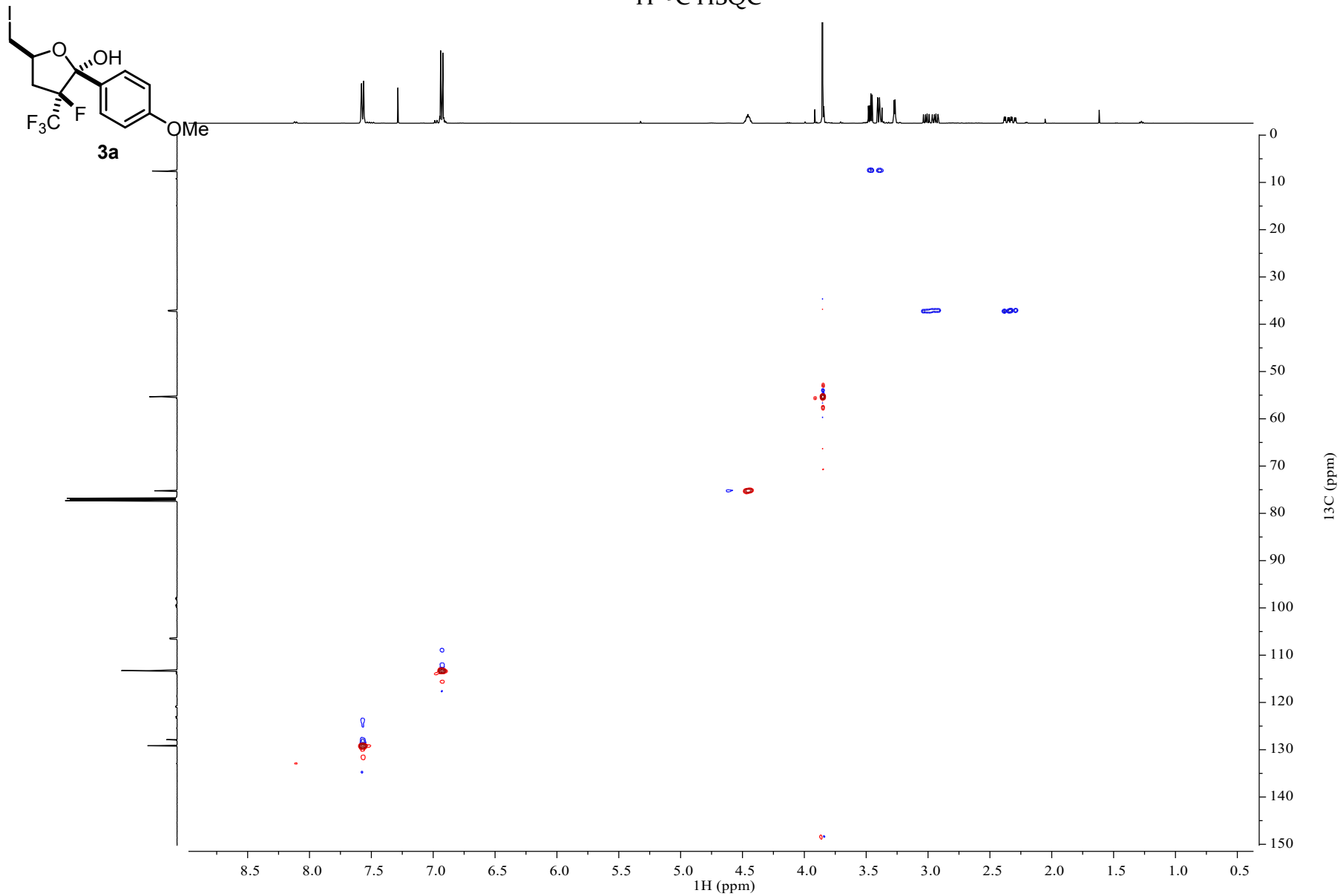

3a
160.71
129.26
127.97
125.61
125.37
123.36
123.12
121.11
120.88
118.87
118.63
113.37
106.69
106.46
100.05
99.81
99.55
99.30
98.51
98.26
98.01
97.76
77.16 CDCl3
75.32
55.43
37.33
37.16
7.69
A (qd)
122.12
B (d)
106.58
C (dq)
98.91
D (d)
37.25
13C (ppm)

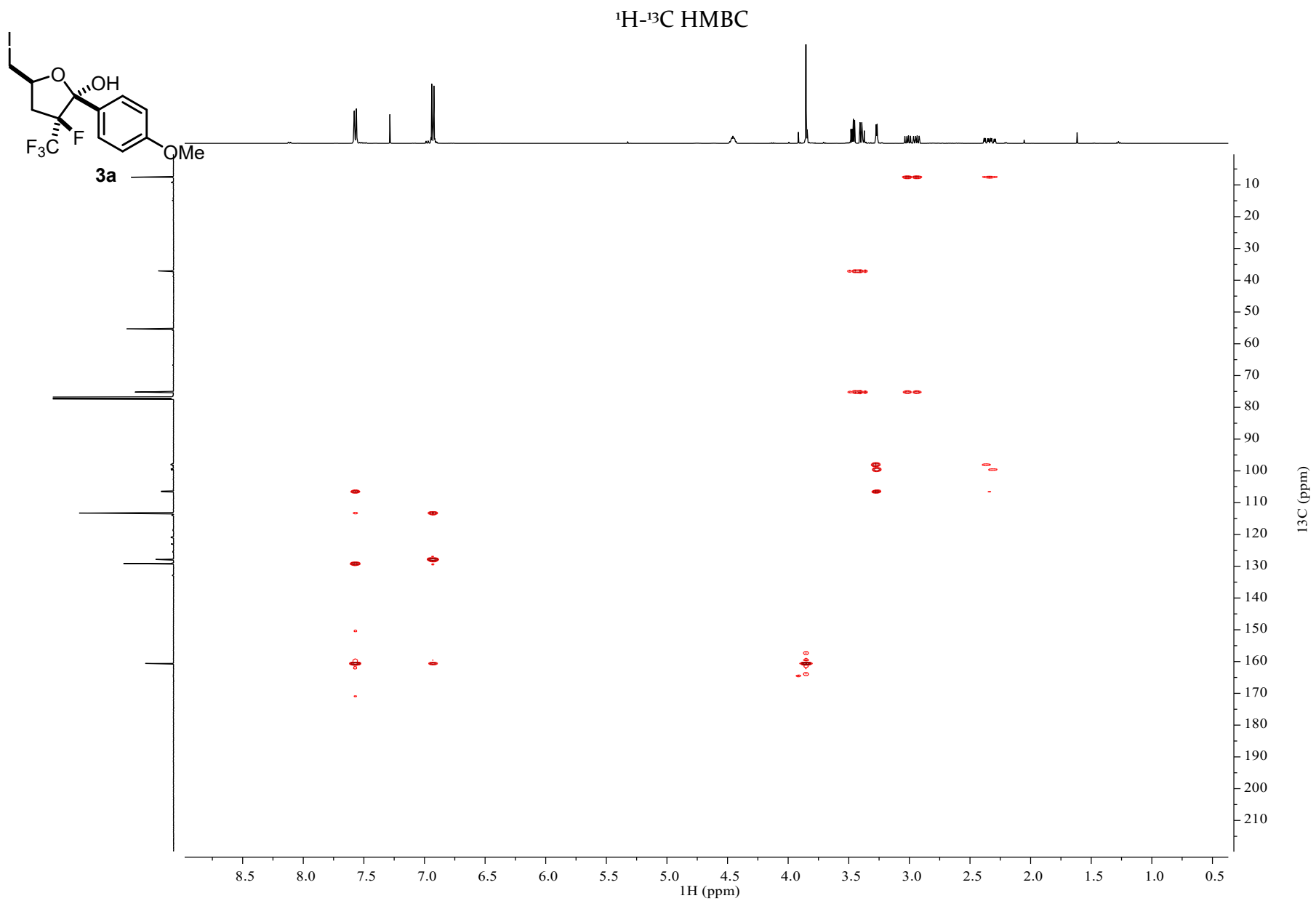

I
O
OH
F3C
F
OMe

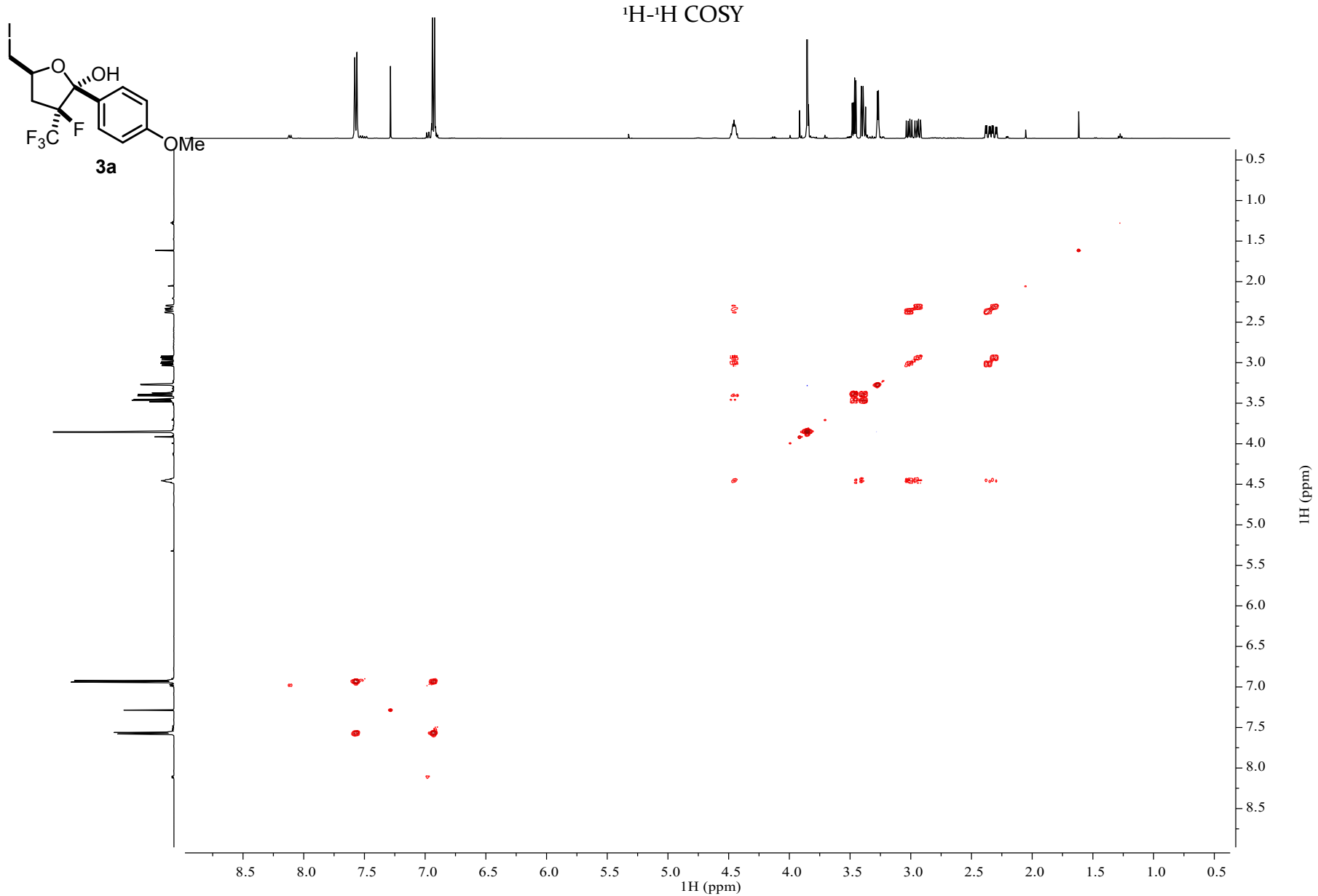
3a

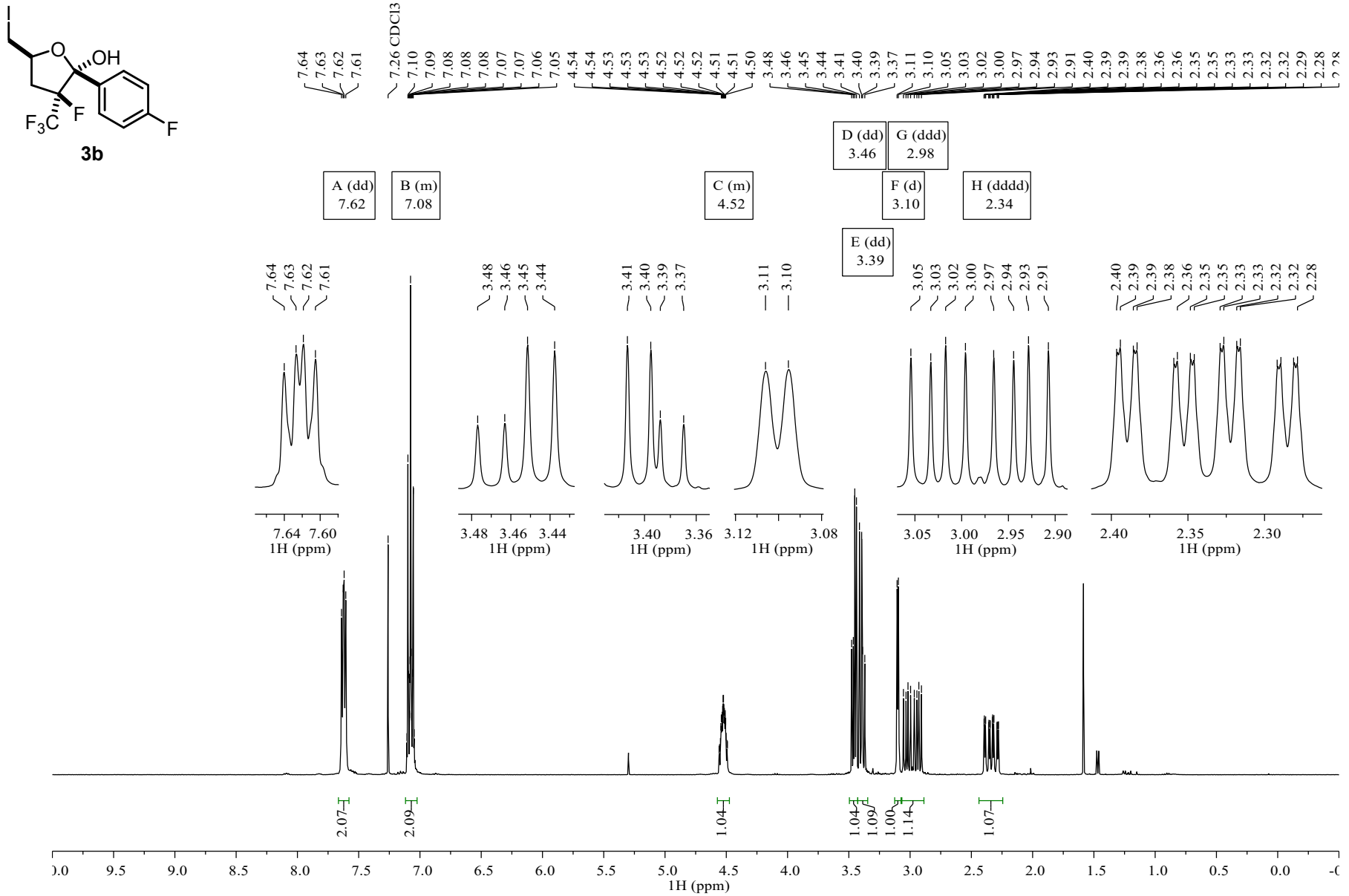
-74.39
-74.41
A (d)
-74.40
-160.82
-160.84
-160.85
-160.86
-160.88
-160.90
-160.91
-160.92
-160.94
-160.96
-160.97
-160.98
-161.00
-161.01
B (dddd)
-160.91
-74.40 -74.43
19F (ppm)
-160.80 -160.85 -160.90 -160.95 -161.00
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)

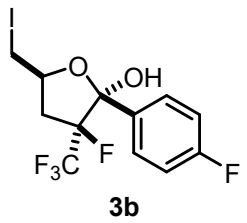
^{1}H-^{13}C HSQC


I
O
OH
F
F3C
OMe
3a
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
13C (ppm)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)


^{1}H-^{13}C HMBC
OH
O
F
F_3C
OMe
3a
1H (ppm)
13C (ppm)

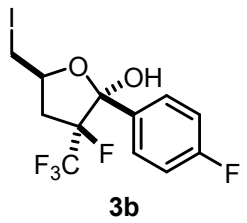

^{1}H-^{1}H COSY
I
O
OH
F
F_3C
OMe
3a
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
1H (ppm)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)


3b
A (dd) 7.62
B (m) 7.08
C (m) 4.52
D (dd) 3.46
E (dd) 3.39
F (d) 3.10
G (ddd) 2.98
H (ddddd) 2.34
7.26 CDCl3
1H (ppm)
2.07
2.09
1.04
1.04
1.09
1.00
1.14
1.07


O
OH
F3C
F
F

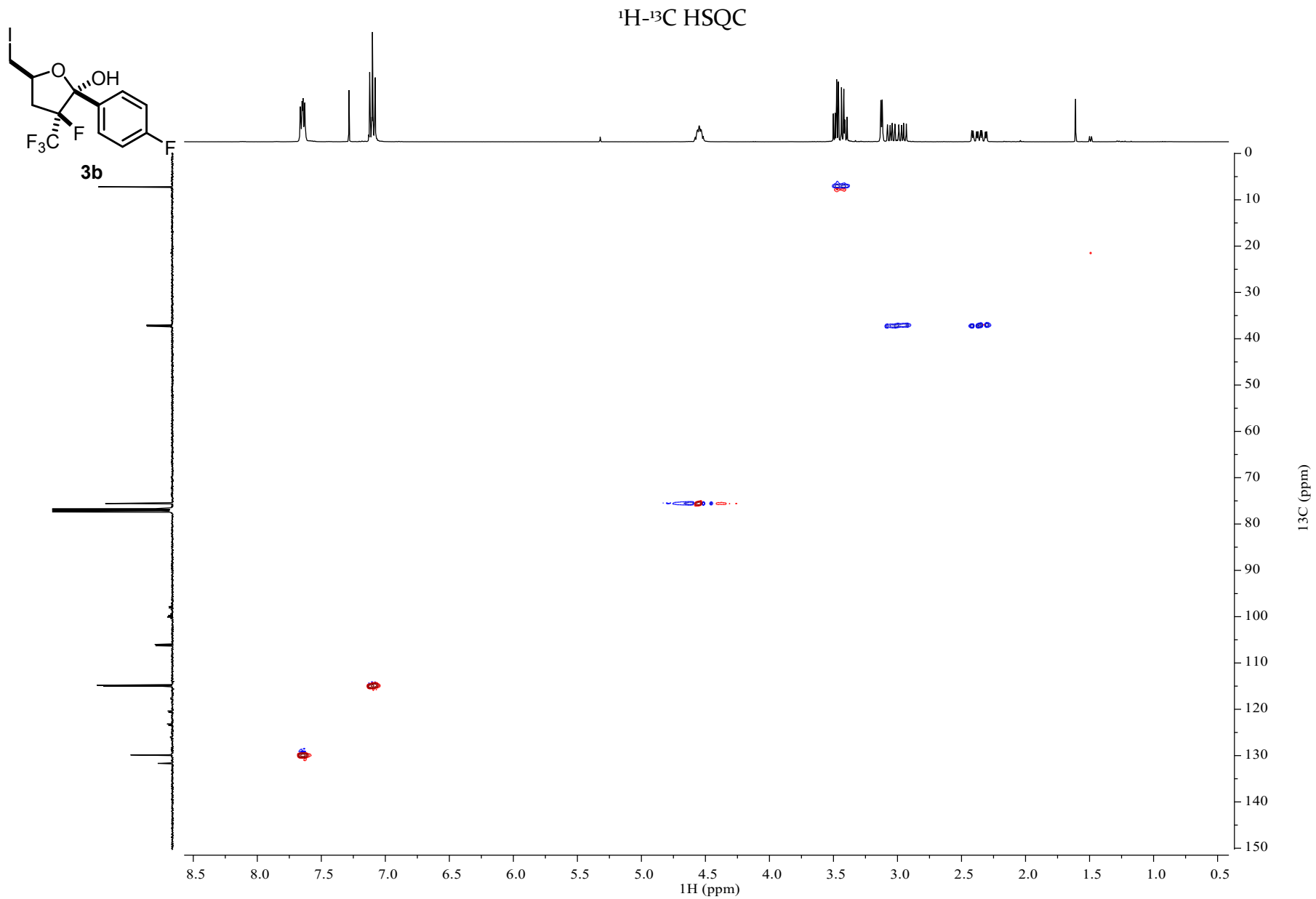
3b

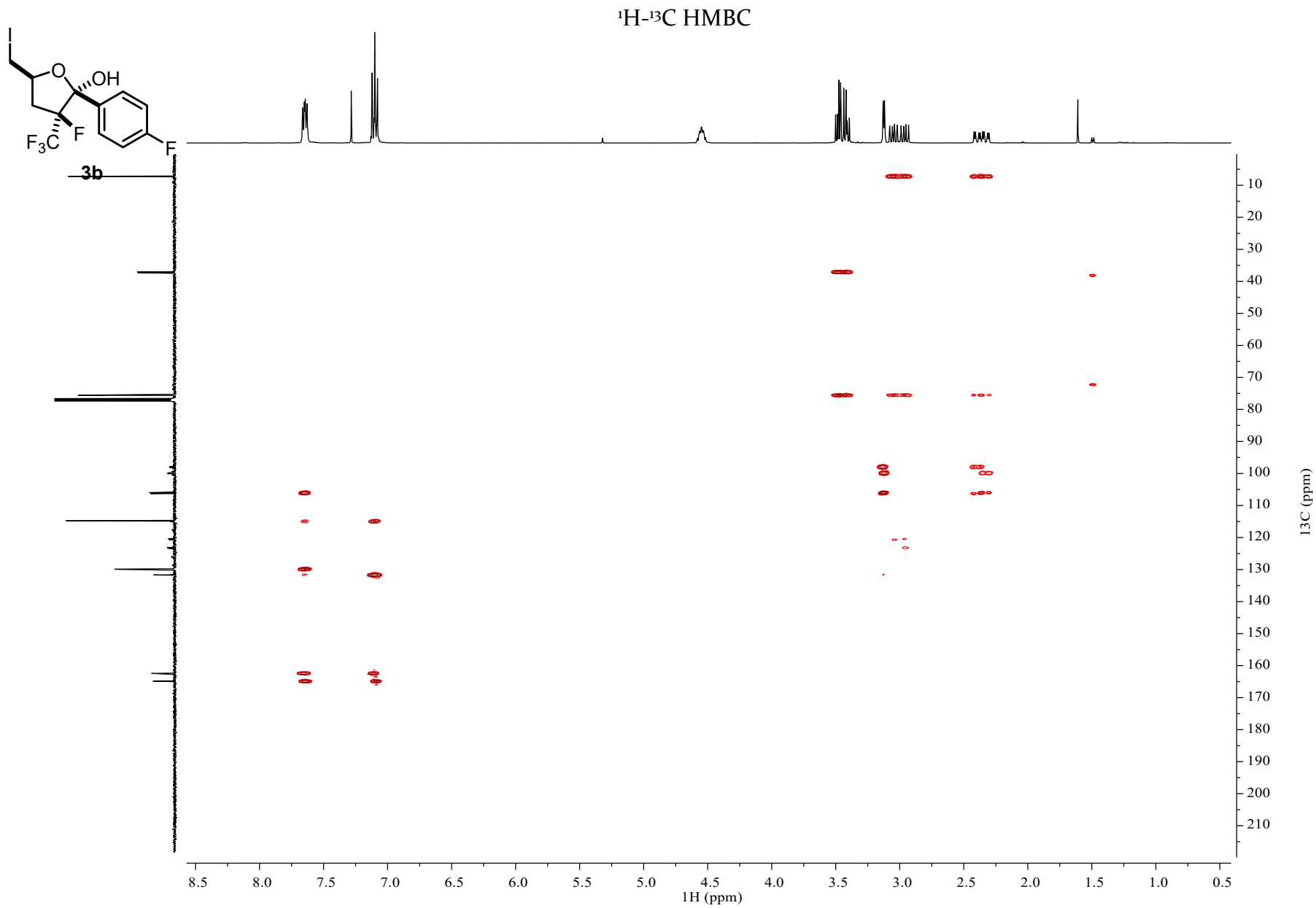
165.04
162.57
131.85
131.82
130.07
129.99
126.41
126.12
123.61
123.31
120.80
120.51
117.99
117.70
115.15
114.94
106.41
106.13
100.51
100.20
99.89
99.57
98.57
98.26
97.95
97.63
77.16 CDCl3
75.70
37.39
37.19
7.34
A (d) 163.80
B (d) 131.84
C (d) 130.03
D (qd) 122.06
E (d) 115.05
F (d) 106.27
G (dq) 99.07
H (d) 37.29
13C (ppm)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

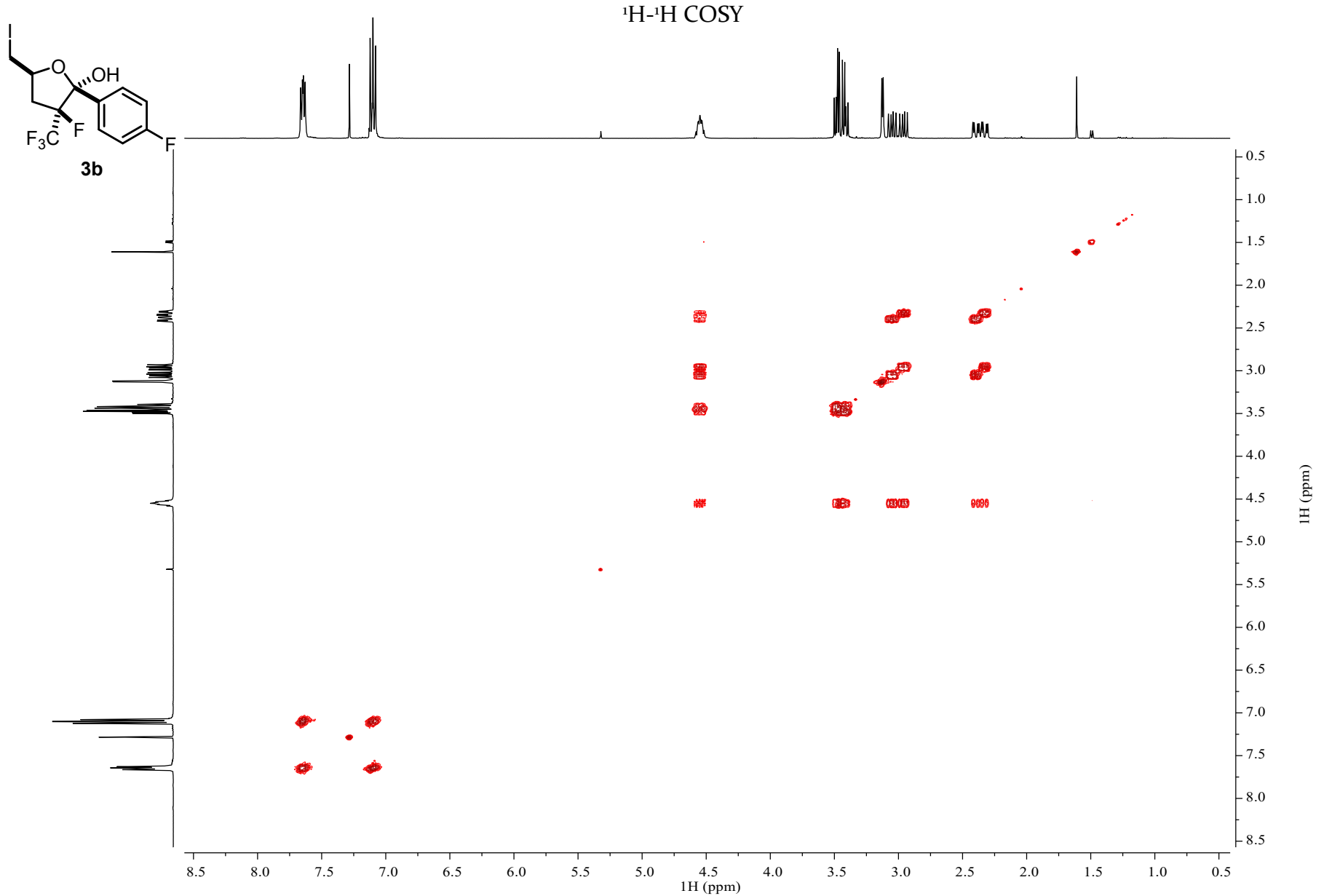

I
O
OH
F
F3C
F

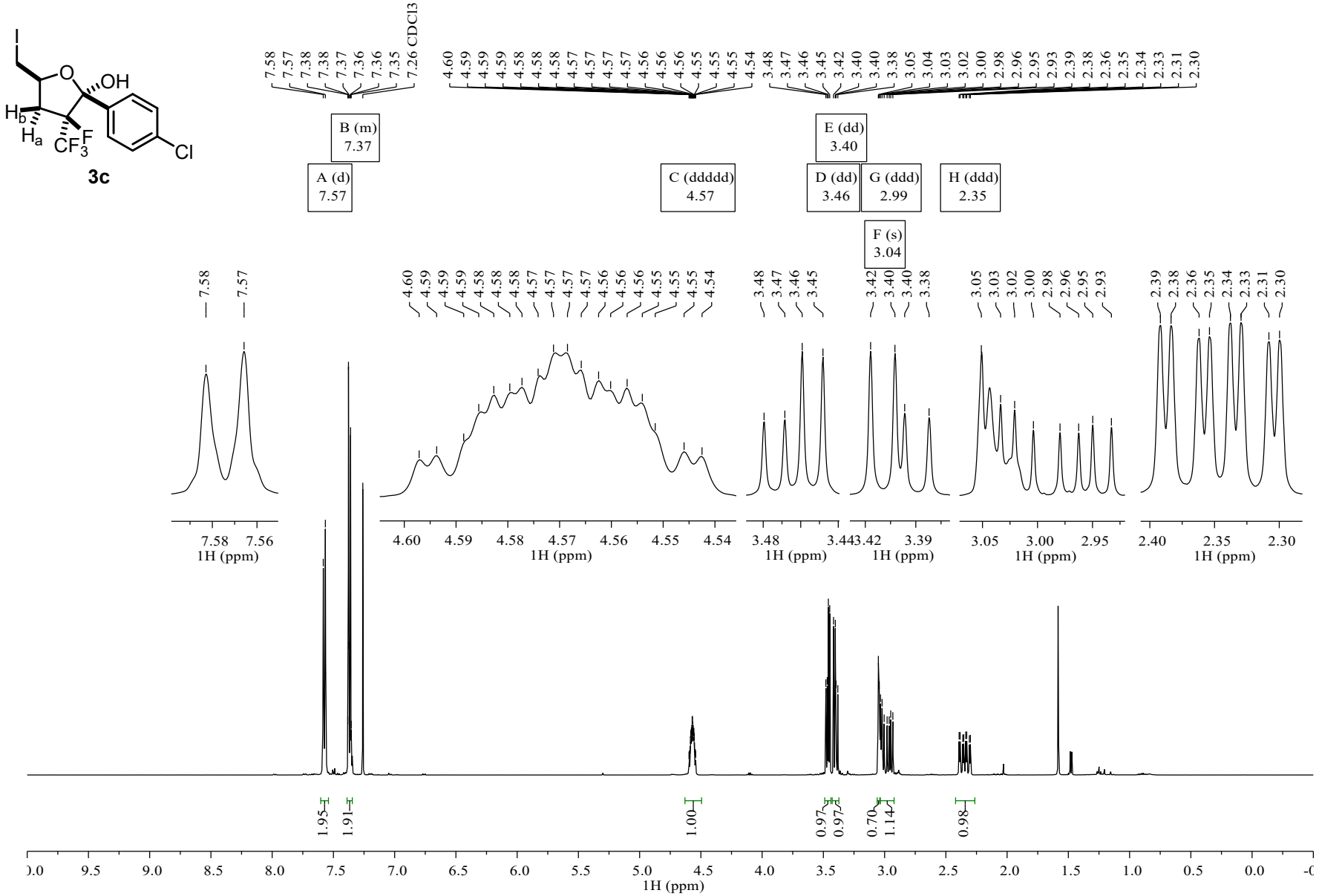
3b

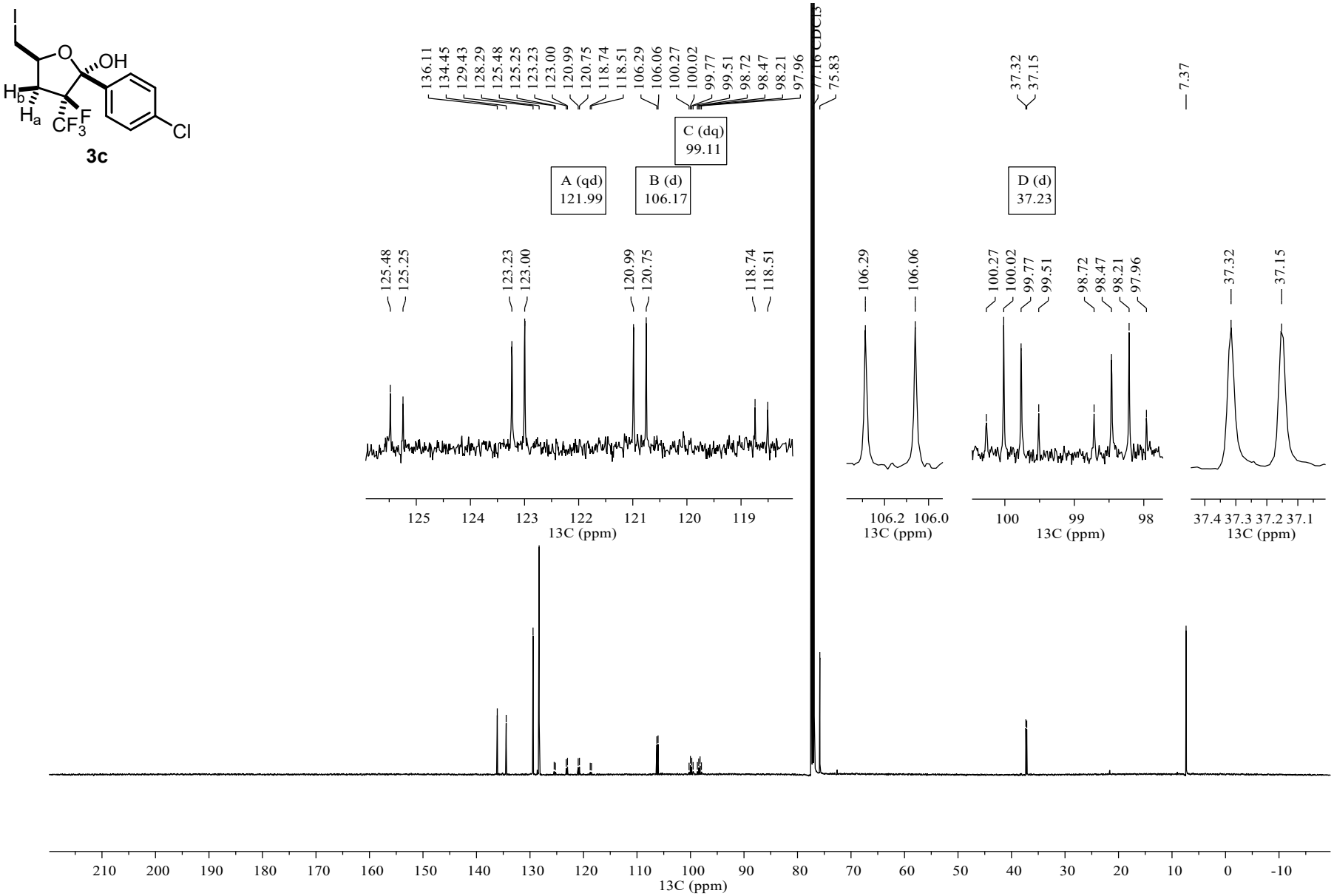
-74.40
-74.42
-111.84
-160.81
-160.83
-160.85
-160.87
A (d)
-74.41
B (s)
-111.84
C (q)
-160.84
-74.40
-74.42
-74.40
-74.44
19F (ppm)
-160.81
-160.83
-160.85
-160.87
-160.80
-160.90
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)

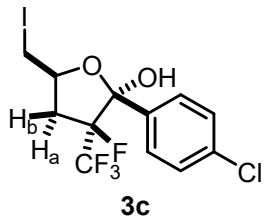

^{1}H-^{13}C HSQC
3b
1H (ppm)
13C (ppm)


¹H-¹³C HMBC
OH
F
F3C
F
3b
1H (ppm)
13C (ppm)


^{1}H-^{1}H COSY
I
O
OH
F
F_3C
F
3b
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)
1H (ppm)


3c
A (d) 7.57
B (m) 7.37
C (ddddd) 4.57
D (dd) 3.46
E (dd) 3.40
F (s) 3.04
G (ddd) 2.99
H (ddd) 2.35
CDCl3
1H (ppm)

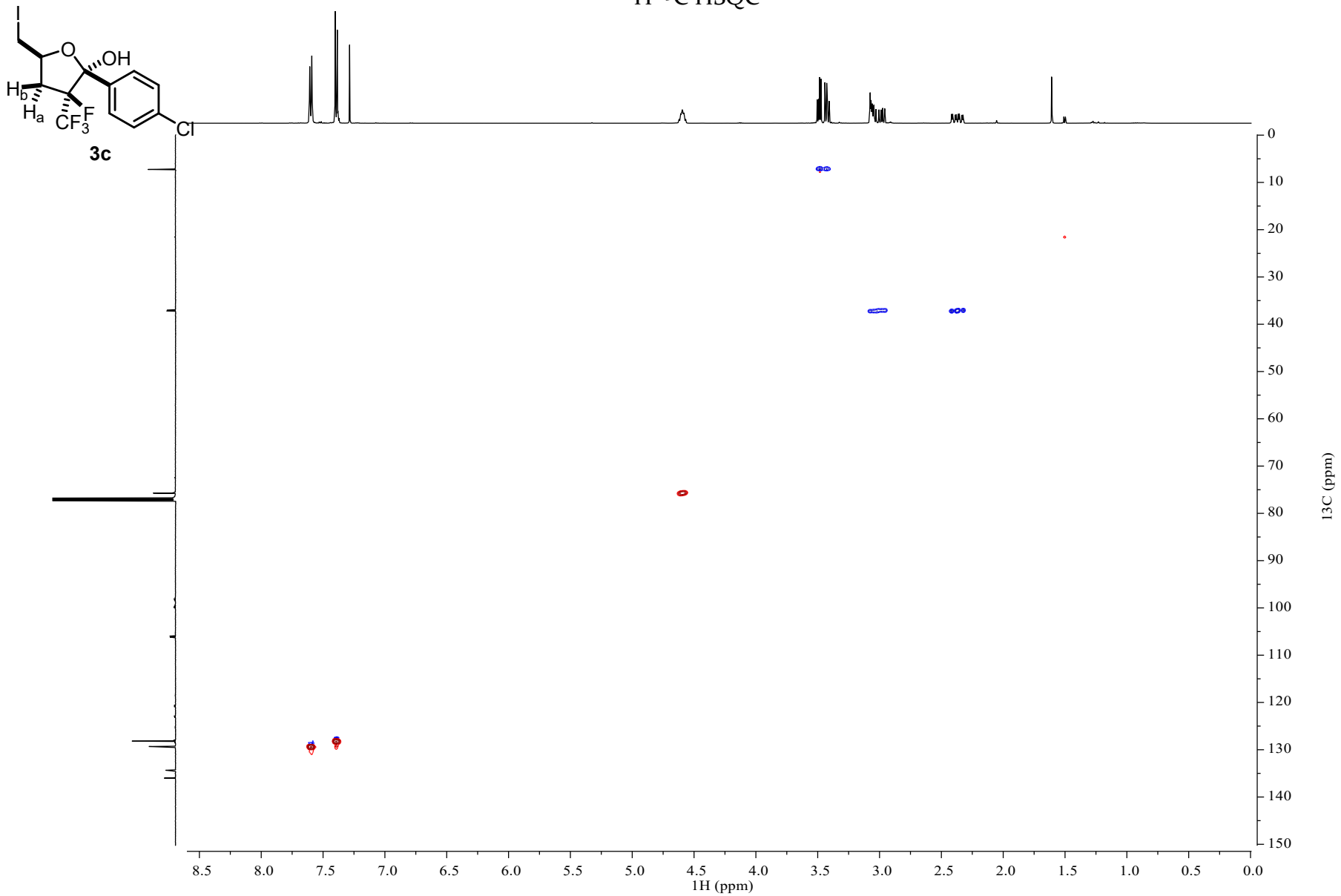

3c
136.11
134.45
129.43
128.29
125.48
125.25
123.23
123.00
120.99
120.75
118.74
118.51
106.29
106.06
100.27
100.02
99.77
99.51
98.72
98.47
98.21
97.96
77.16 CDCl3
75.83
37.32
37.15
7.37
A (qd)
121.99
B (d)
106.17
C (dq)
99.11
D (d)
37.23
13C (ppm)

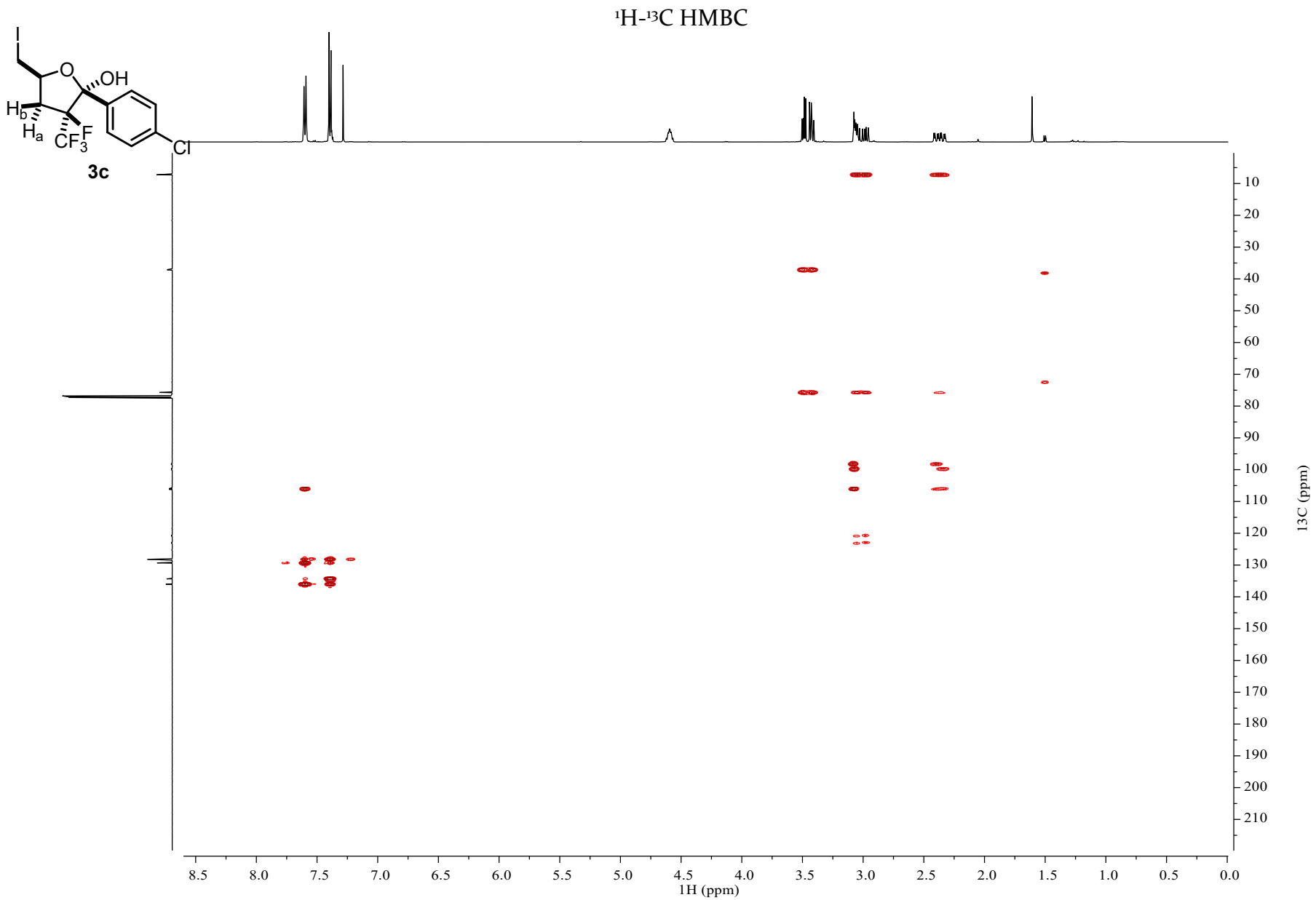

I
O
OH
Hb
Ha
CF3
F
Cl

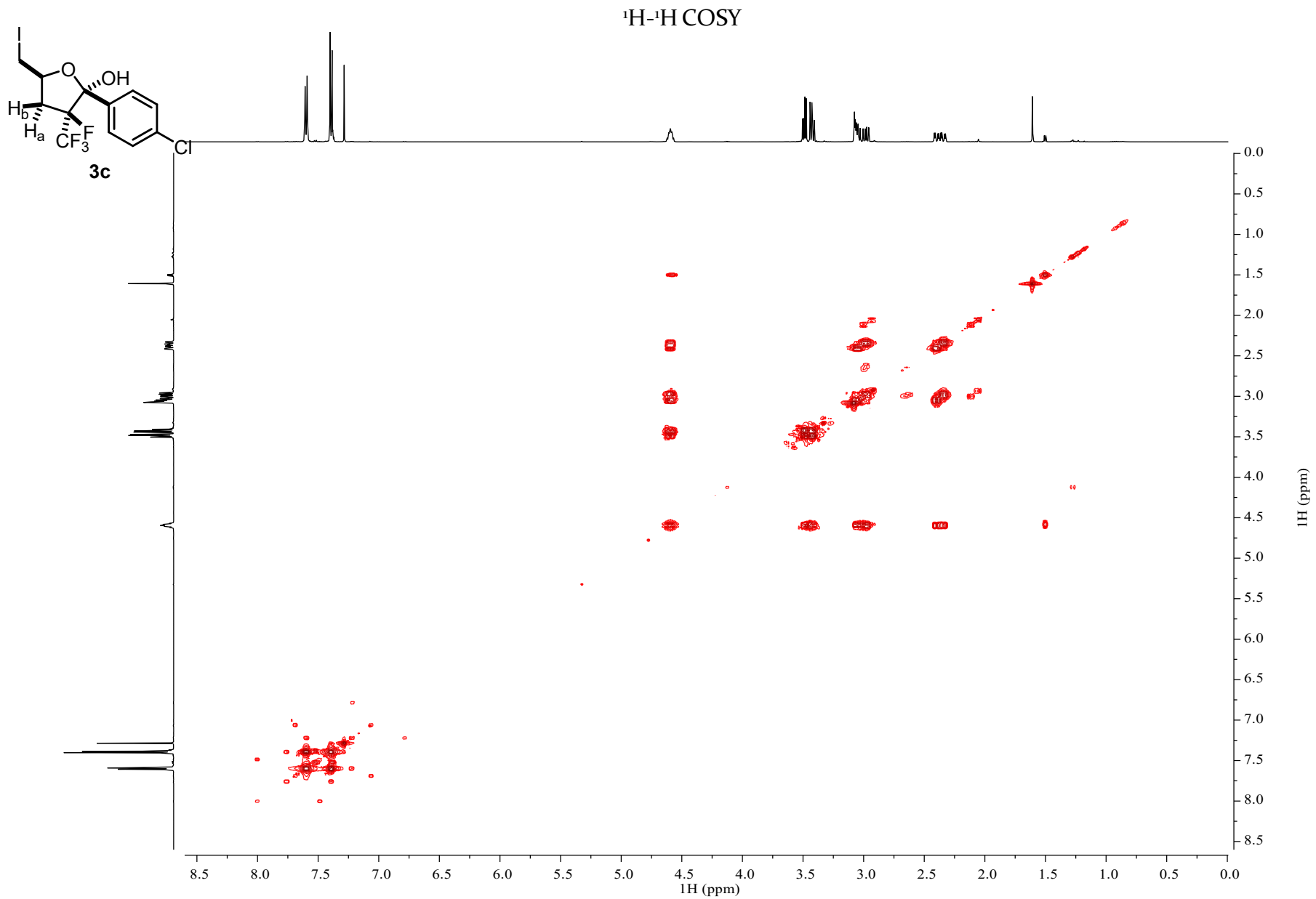
3c

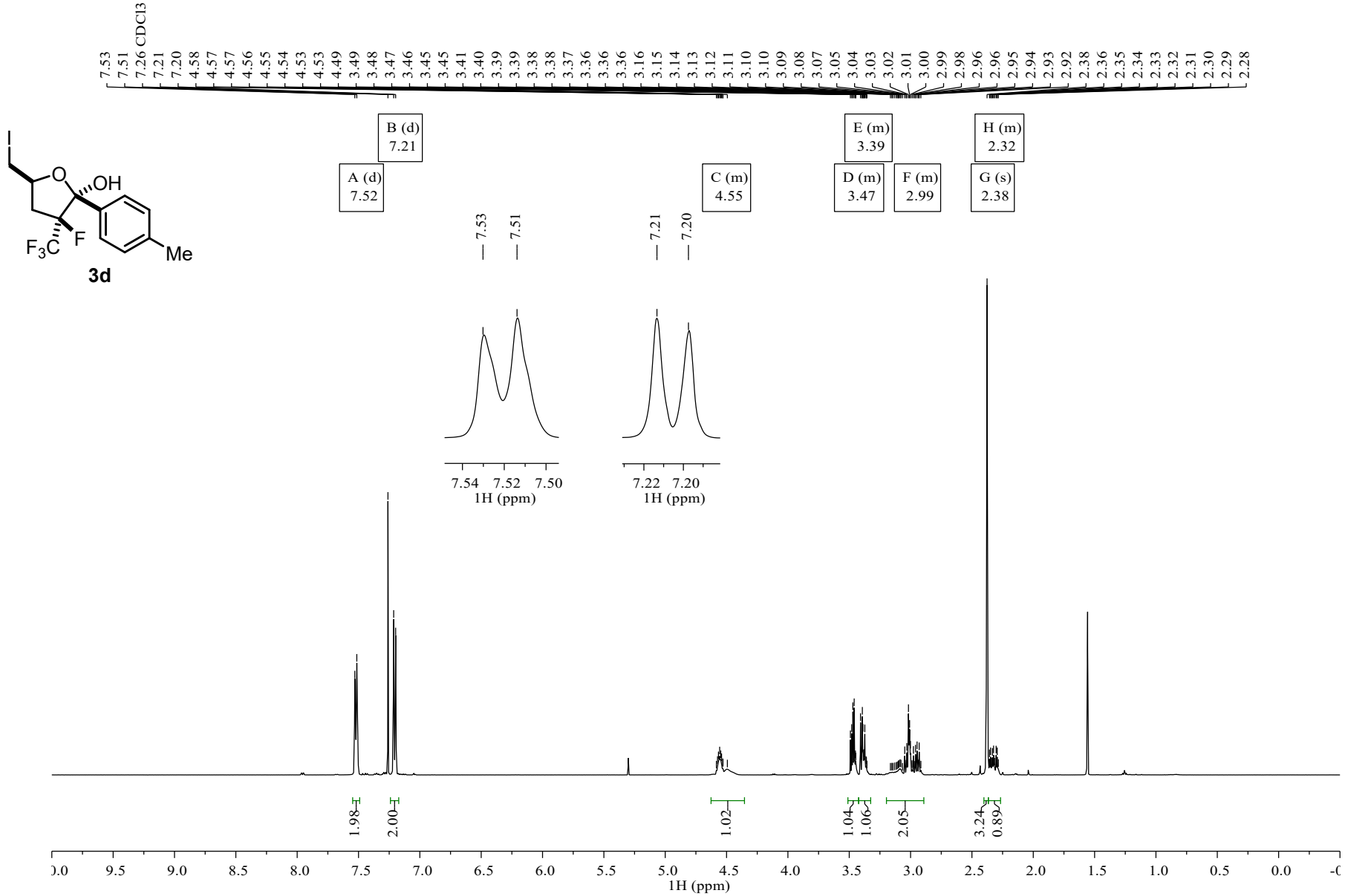
-74.38
-74.39
A (d)
-74.39
-160.90
-160.91
-160.92
-160.93
-160.95
-160.97
-160.98
-160.99
-161.01
-161.03
-161.04
-161.05
-161.07
B (m)
-160.98
-74.38-74.40
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)

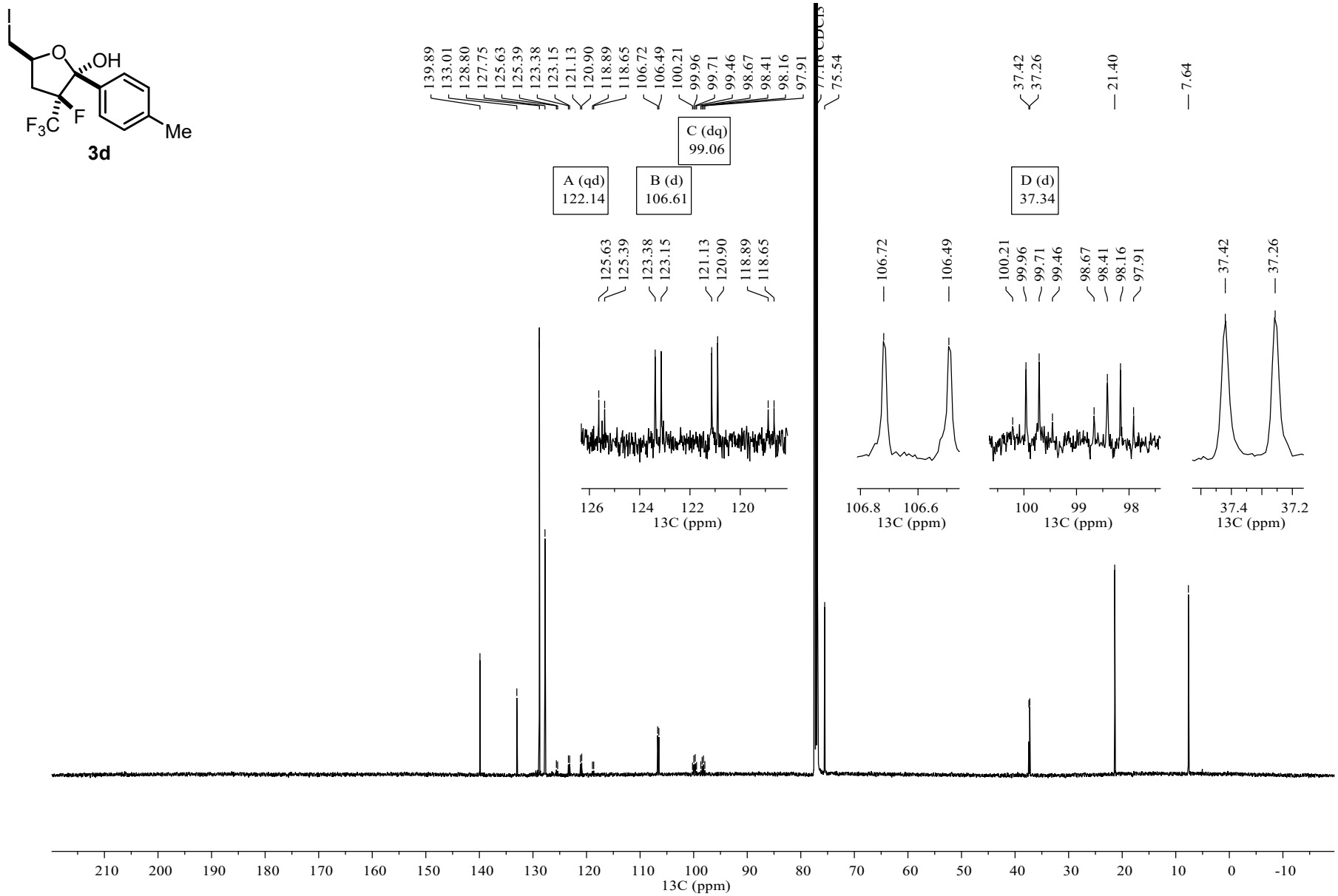
^{1}H-^{13}C HSQC

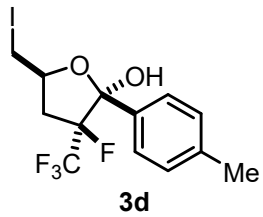

I
O
OH
Hb
Ha
CF3
F
Cl
3c
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
13C (ppm)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)


¹H-¹³C HMBC
I
O
OH
Hb
Ha
CF3
F
Cl
3c
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
13C (ppm)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)

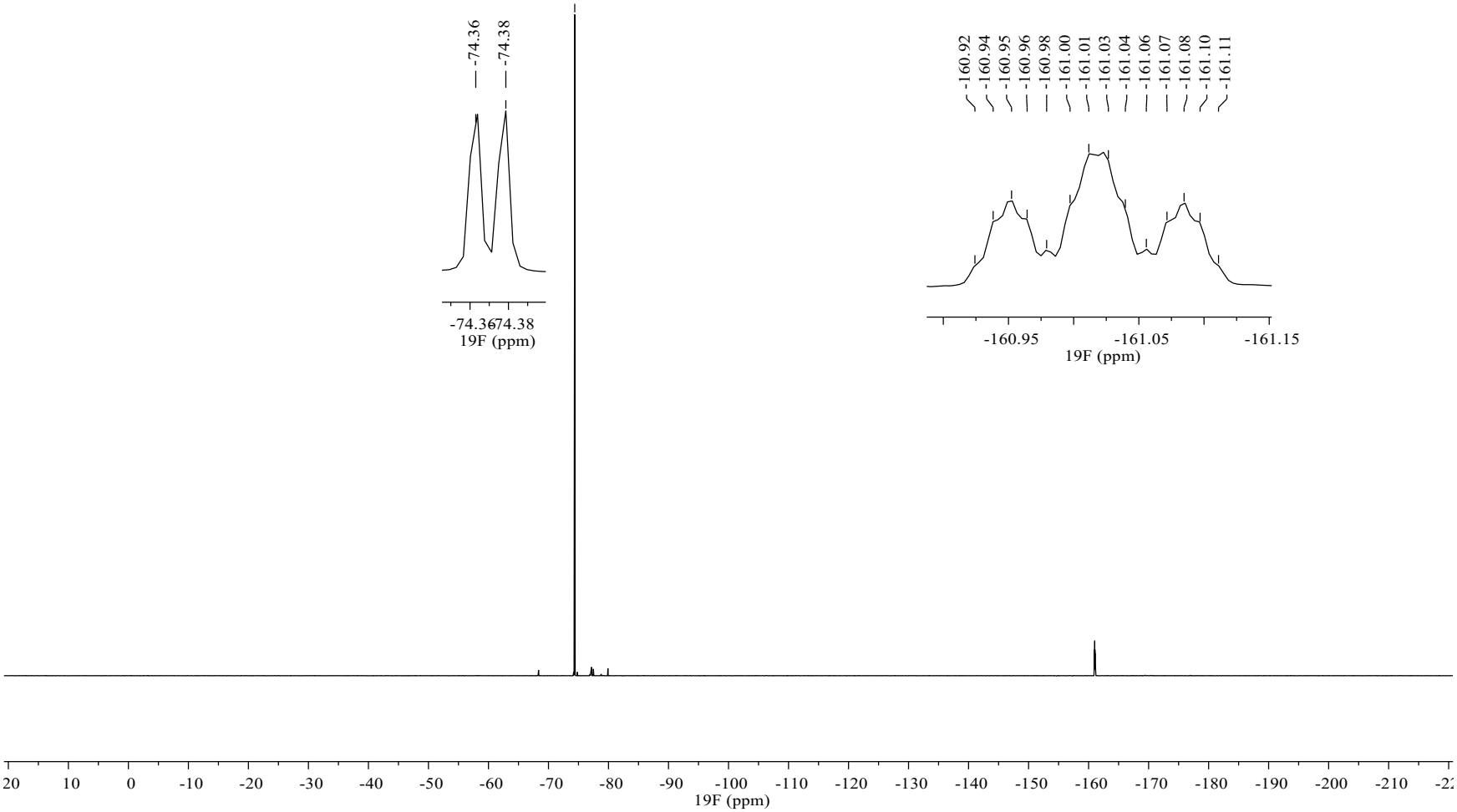

^{1}H-^{1}H COSY
I
O
OH
H_b
H_a
CF_3
F
Cl
3c
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)

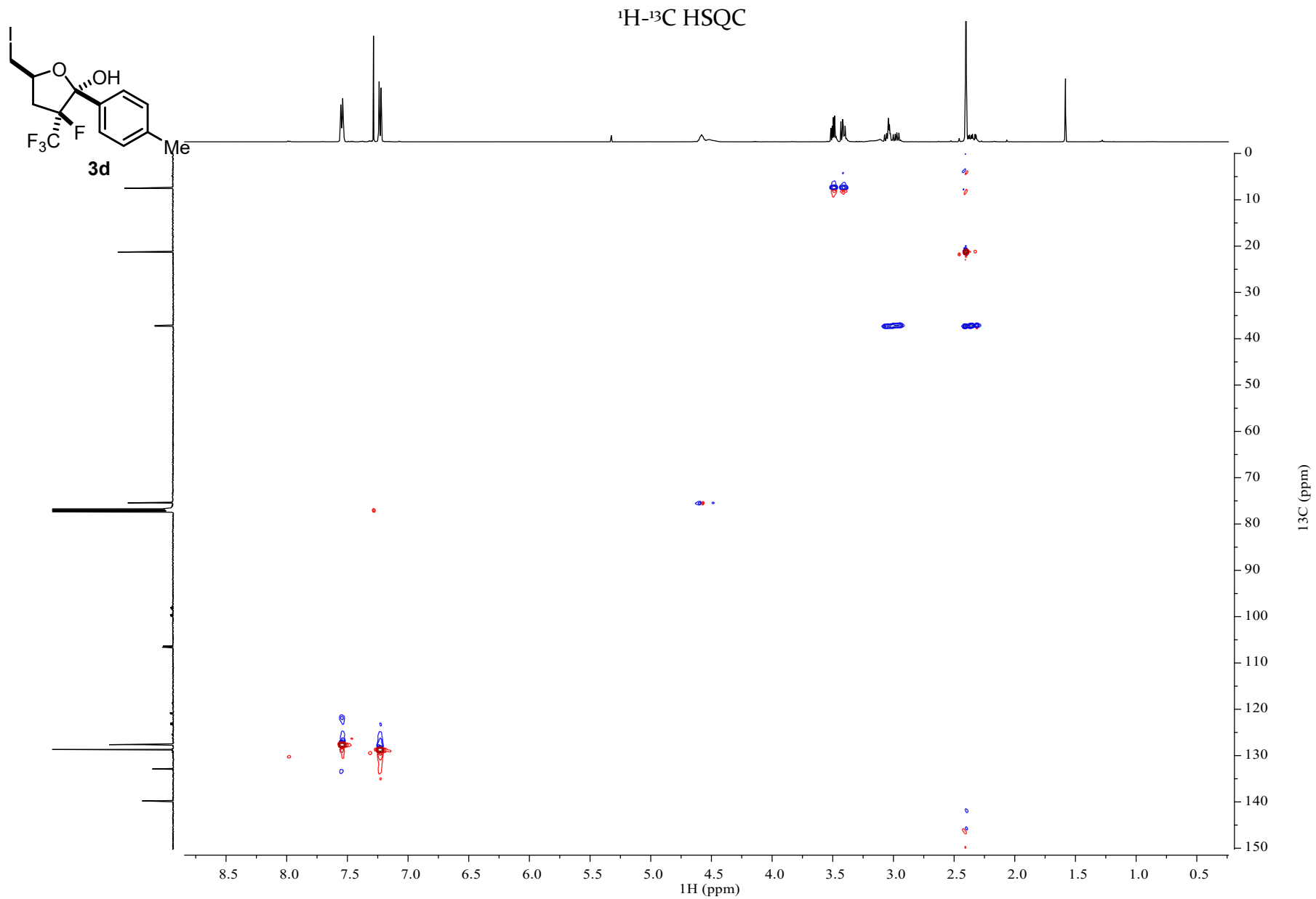

7.53 7.51 7.26 CDCl3 7.21 7.20 4.58 4.57 4.57 4.56 4.55 4.54 4.53 4.53 4.49 3.49 3.48 3.47 3.46 3.45 3.45 3.41 3.40 3.39 3.39 3.38 3.38 3.37 3.36 3.36 3.36 3.16 3.15 3.14 3.13 3.12 3.11 3.10 3.10 3.09 3.08 3.07 3.05 3.04 3.03 3.02 3.01 3.00 2.99 2.98 2.96 2.96 2.95 2.94 2.93 2.92 2.38 2.36 2.35 2.34 2.33 2.32 2.31 2.30 2.29 2.28
A (d) 7.52
B (d) 7.21
C (m) 4.55
D (m) 3.47
E (m) 3.39
F (m) 2.99
G (s) 2.38
H (m) 2.32
3d
7.54 7.52 7.50
1H (ppm)
7.22 7.20
1H (ppm)
1.98 2.00 1.02 1.04 1.06 2.05 3.24 0.89
1H (ppm)

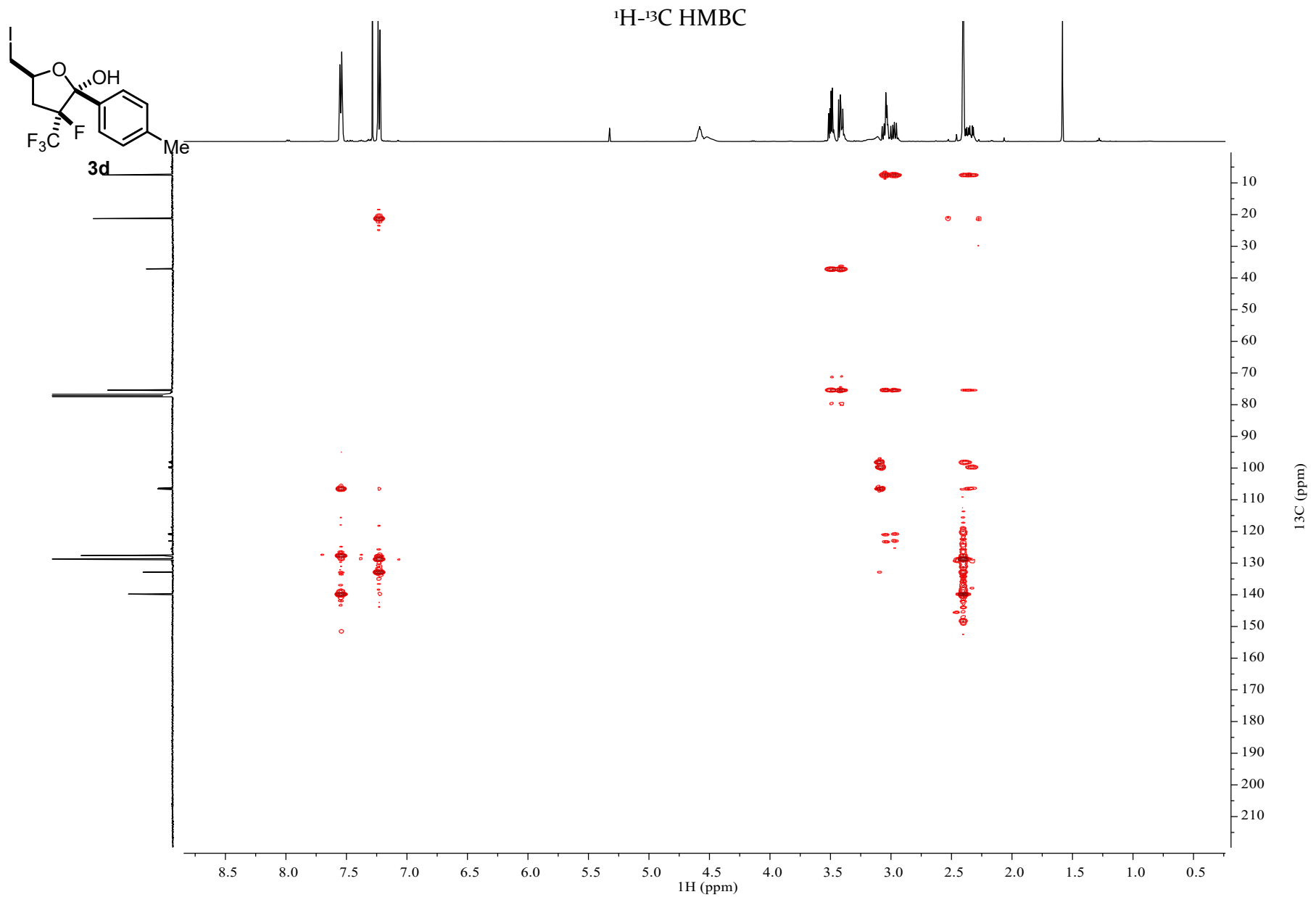

I
O
OH
F3C
F
Me
3d
139.89
133.01
128.80
127.75
125.63
125.39
123.38
123.15
121.13
120.90
118.89
118.65
106.72
106.49
100.21
99.96
99.71
99.46
98.67
98.41
98.16
97.91
77.16 CDCl3
75.54
37.42
37.26
21.40
7.64
C (dq)
99.06
A (qd)
122.14
B (d)
106.61
D (d)
37.34
13C (ppm)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

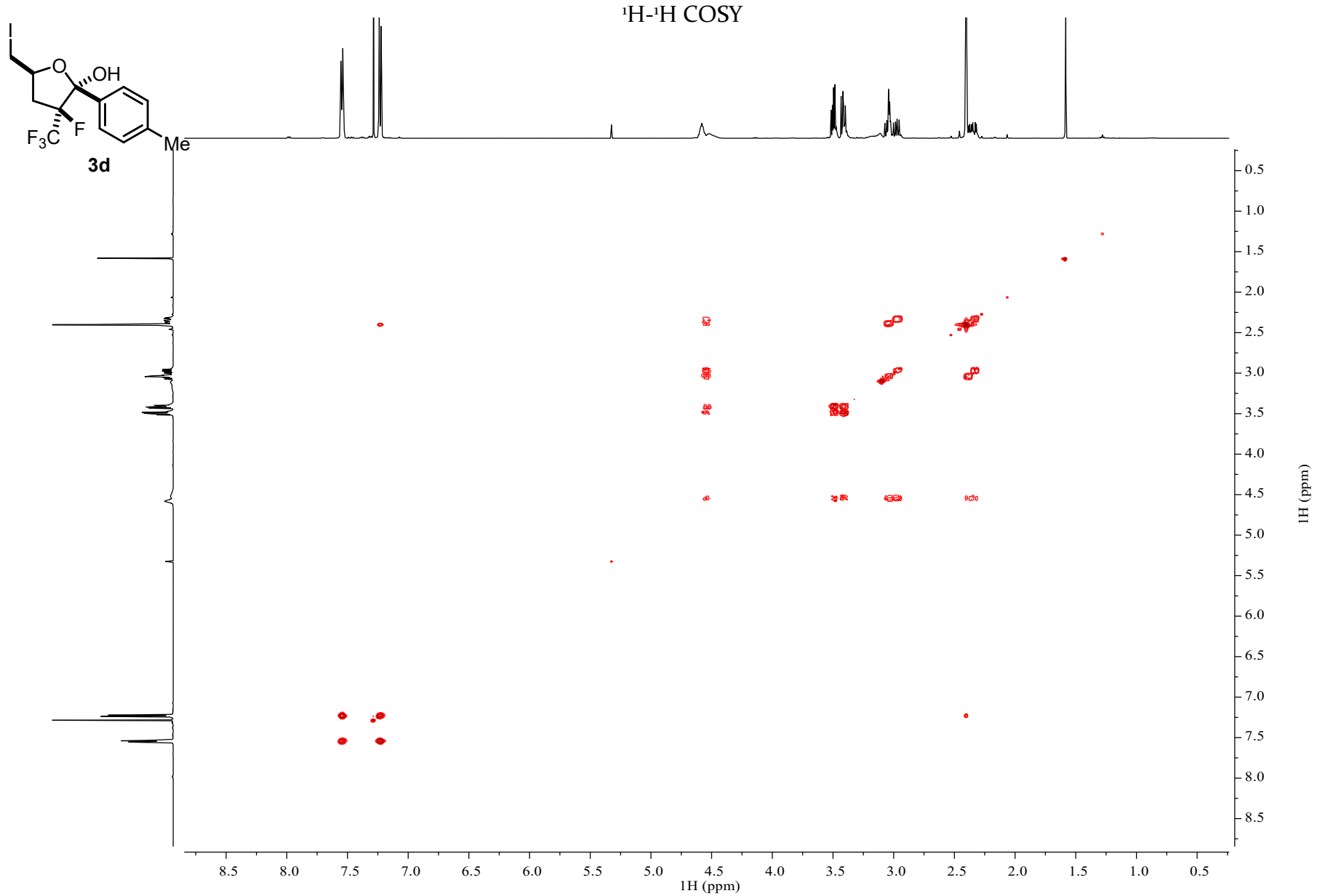

I
O
OH
F3C
F
Me

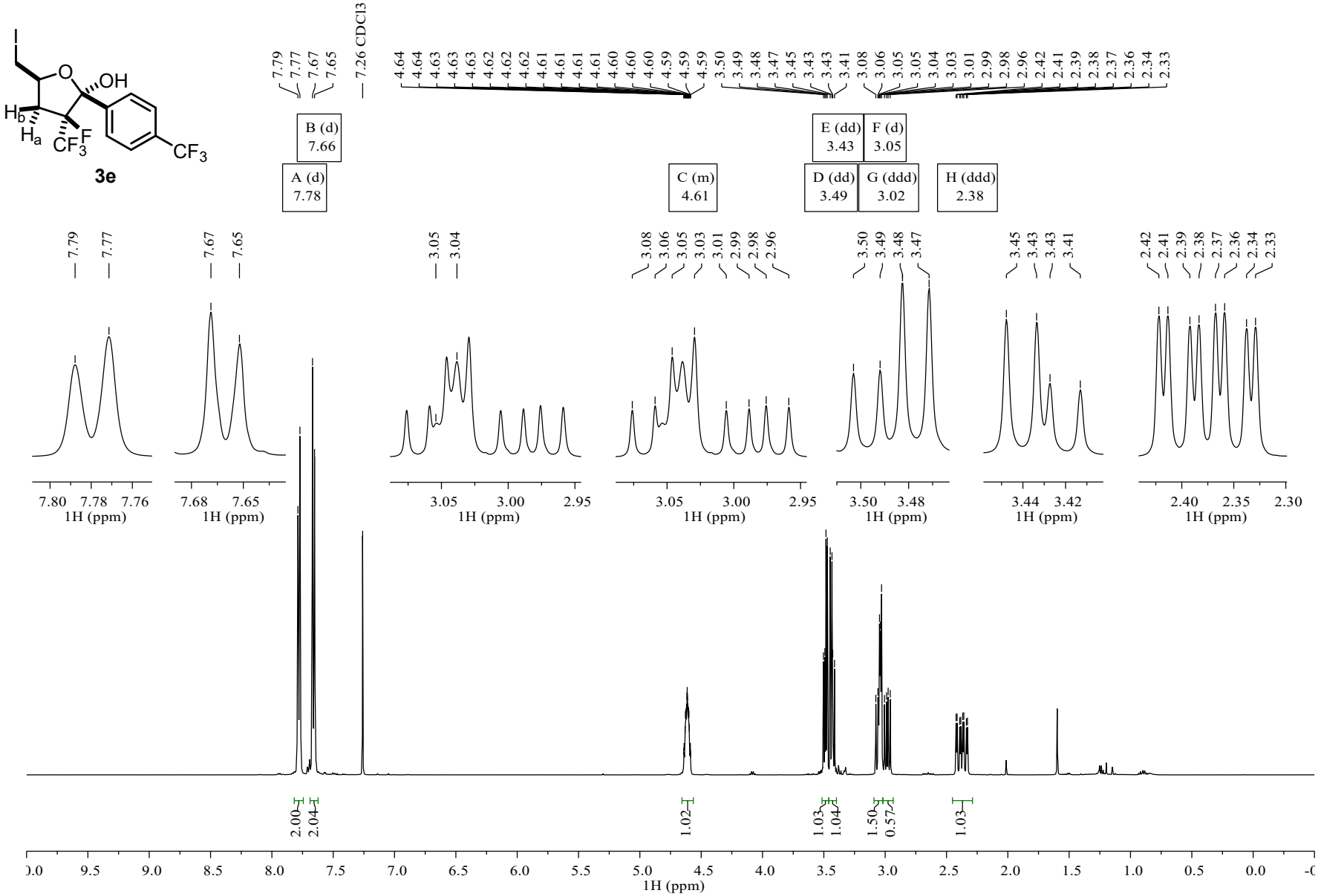
3d

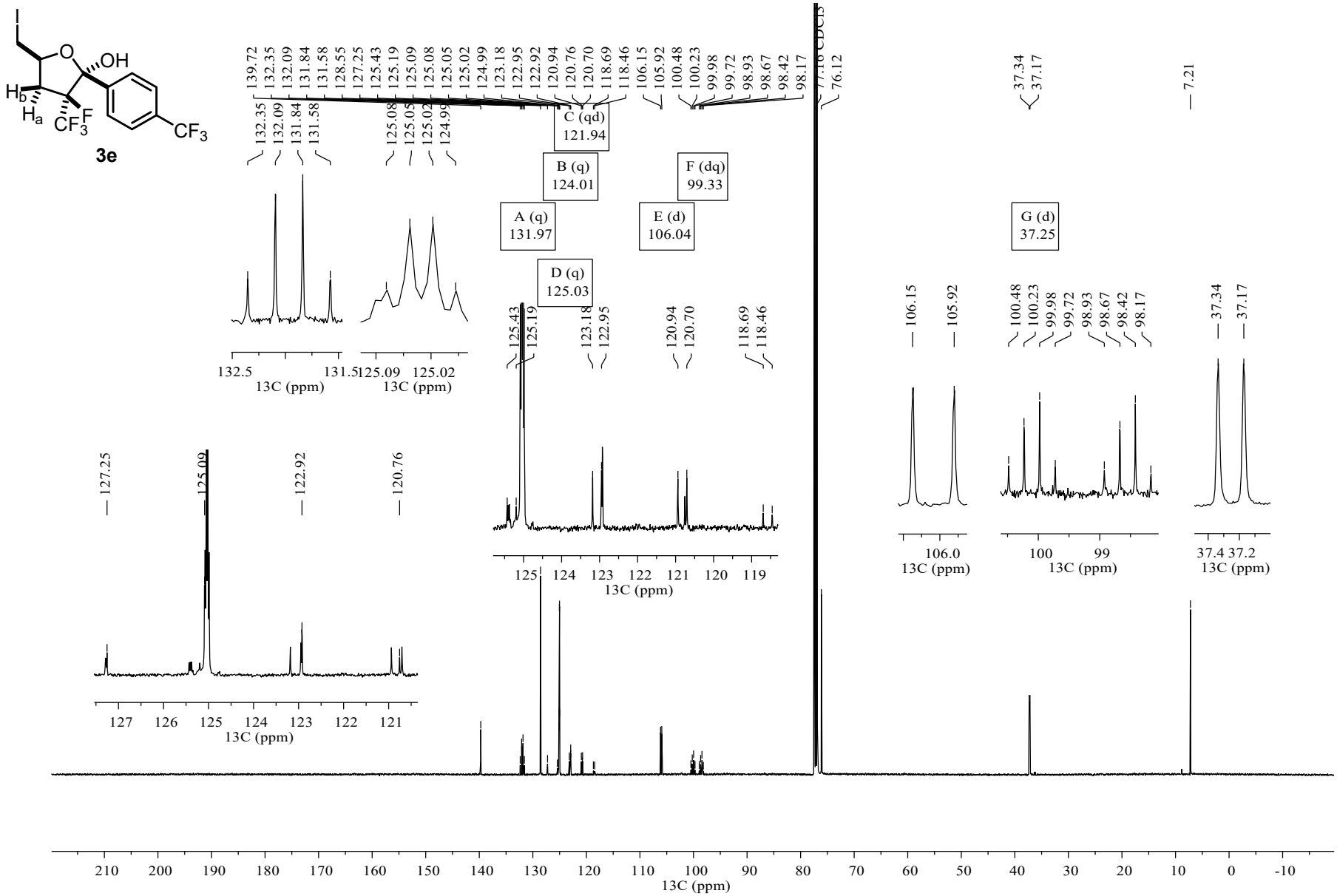

-74.36
-74.38
A (d)
-74.37
-160.92
-160.94
-160.95
-160.96
-160.98
-161.00
-161.01
-161.03
-161.04
-161.06
-161.07
-161.08
-161.10
-161.11
B (ddt)
-161.02
-74.36674.38
19F (ppm)
-160.95
-161.05
-161.15
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)

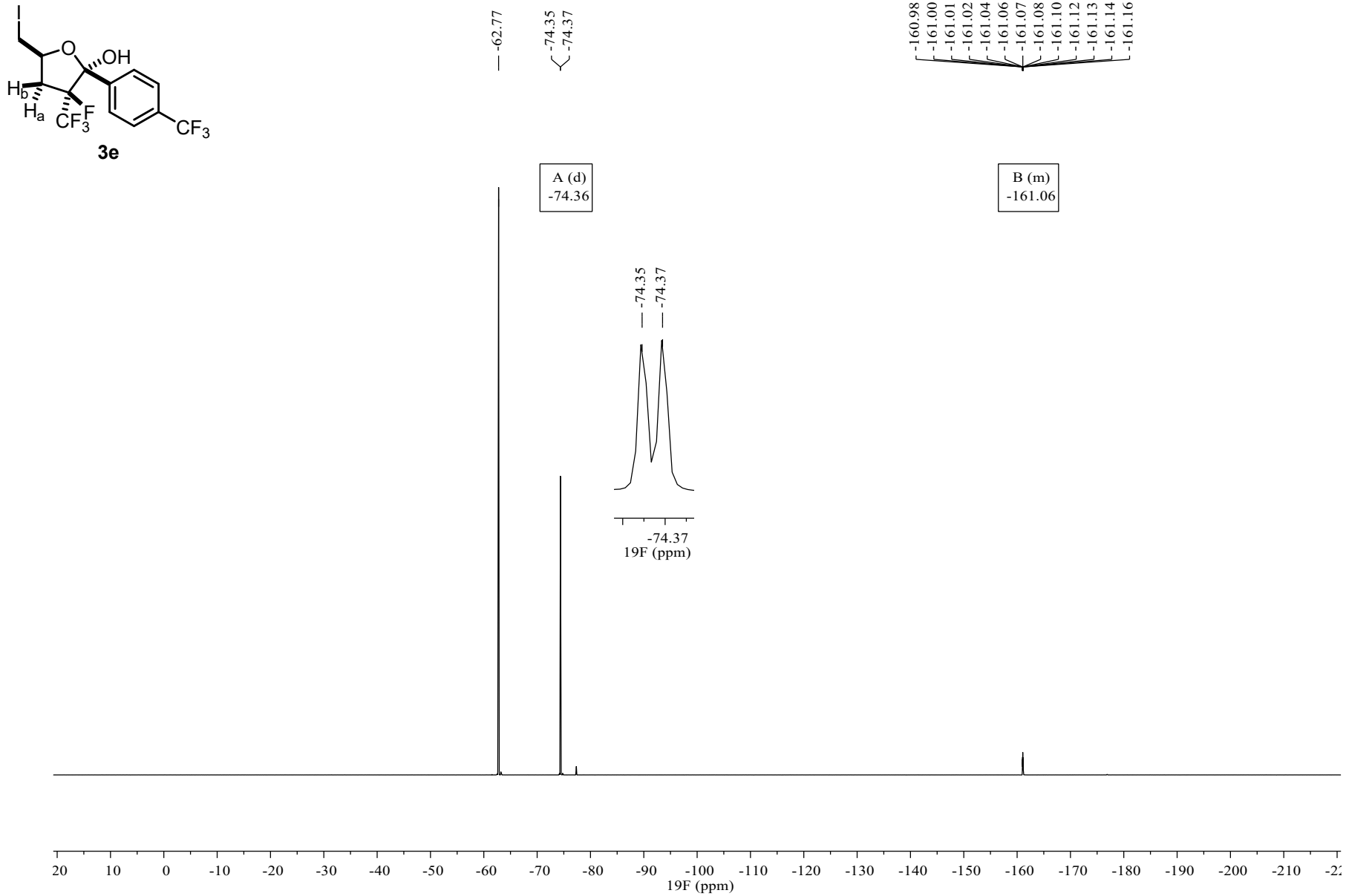

^{1}H-^{13}C HSQC
I
O
OH
F
F_3C
Me
3d
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
13C (ppm)

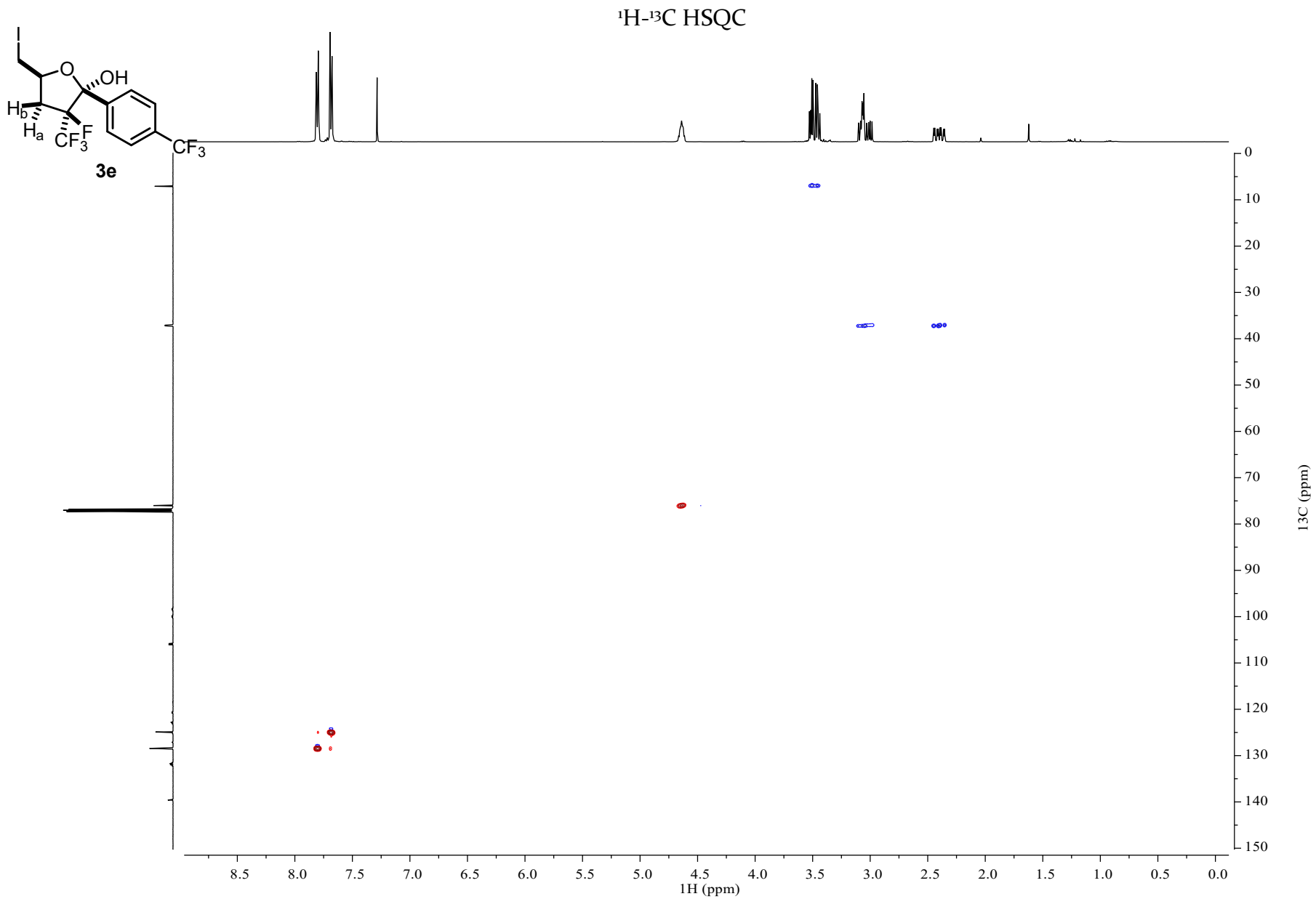

¹H-¹³C HMBC
I
O
OH
F
F3C
Me
3d
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
13C (ppm)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)

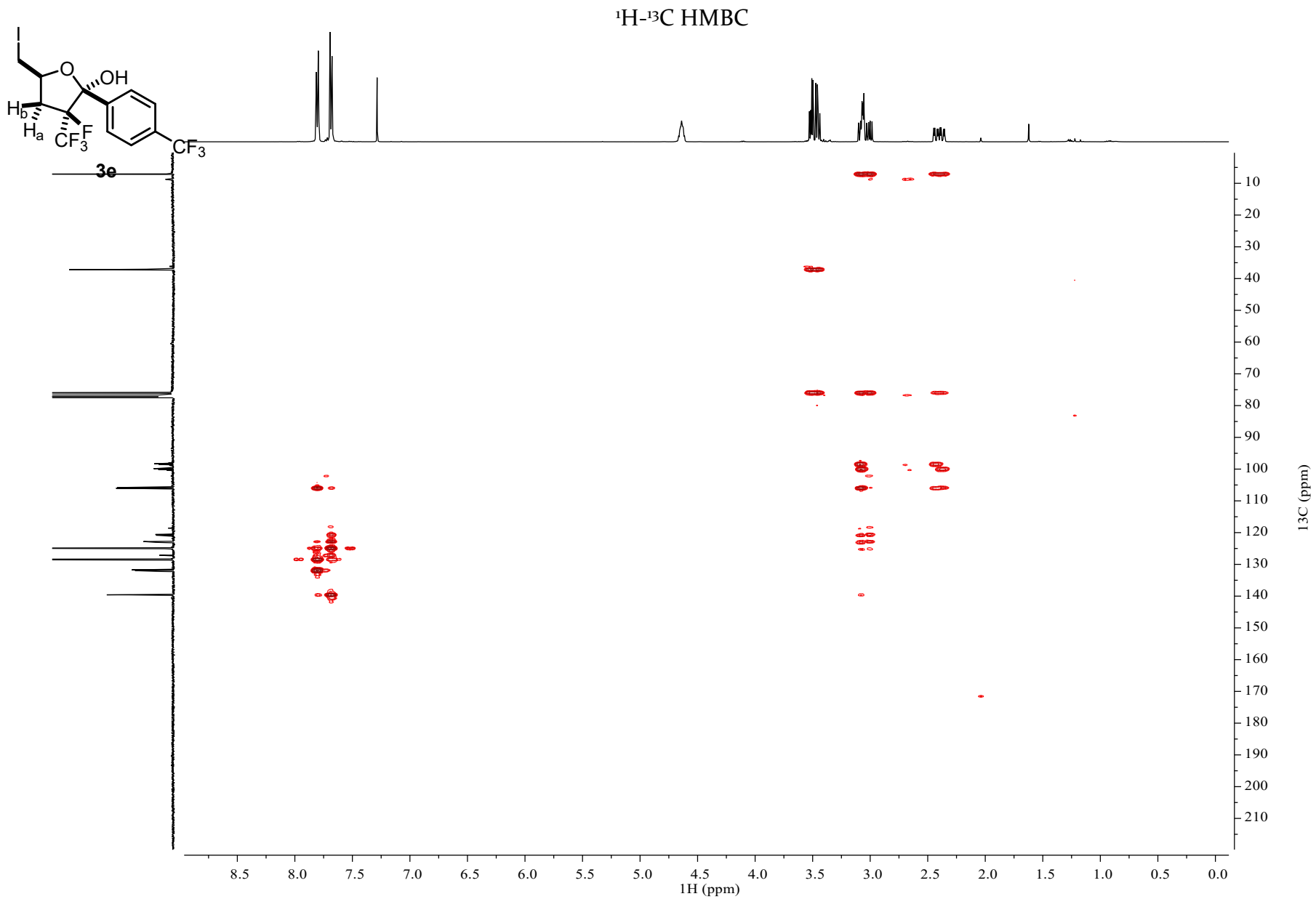

^{1}H-^{1}H COSY
I
O
OH
F$_3$C
F
Me
3d
1H (ppm)
1H (ppm)

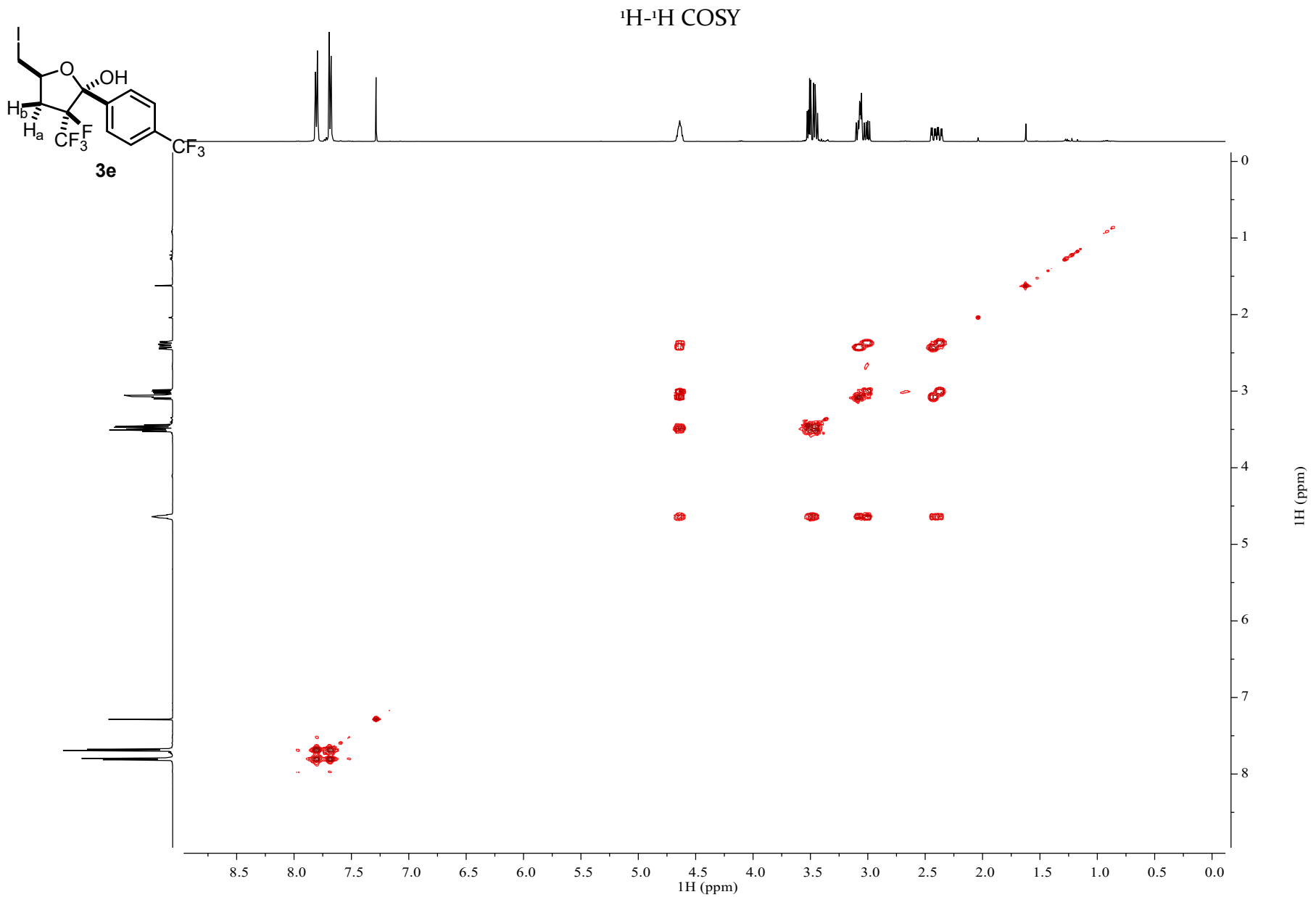

3e
7.26 CDCl3
A (d) 7.78
B (d) 7.66
C (m) 4.61
D (dd) 3.49
E (dd) 3.43
F (d) 3.05
G (ddd) 3.02
H (ddd) 2.38
1H (ppm)

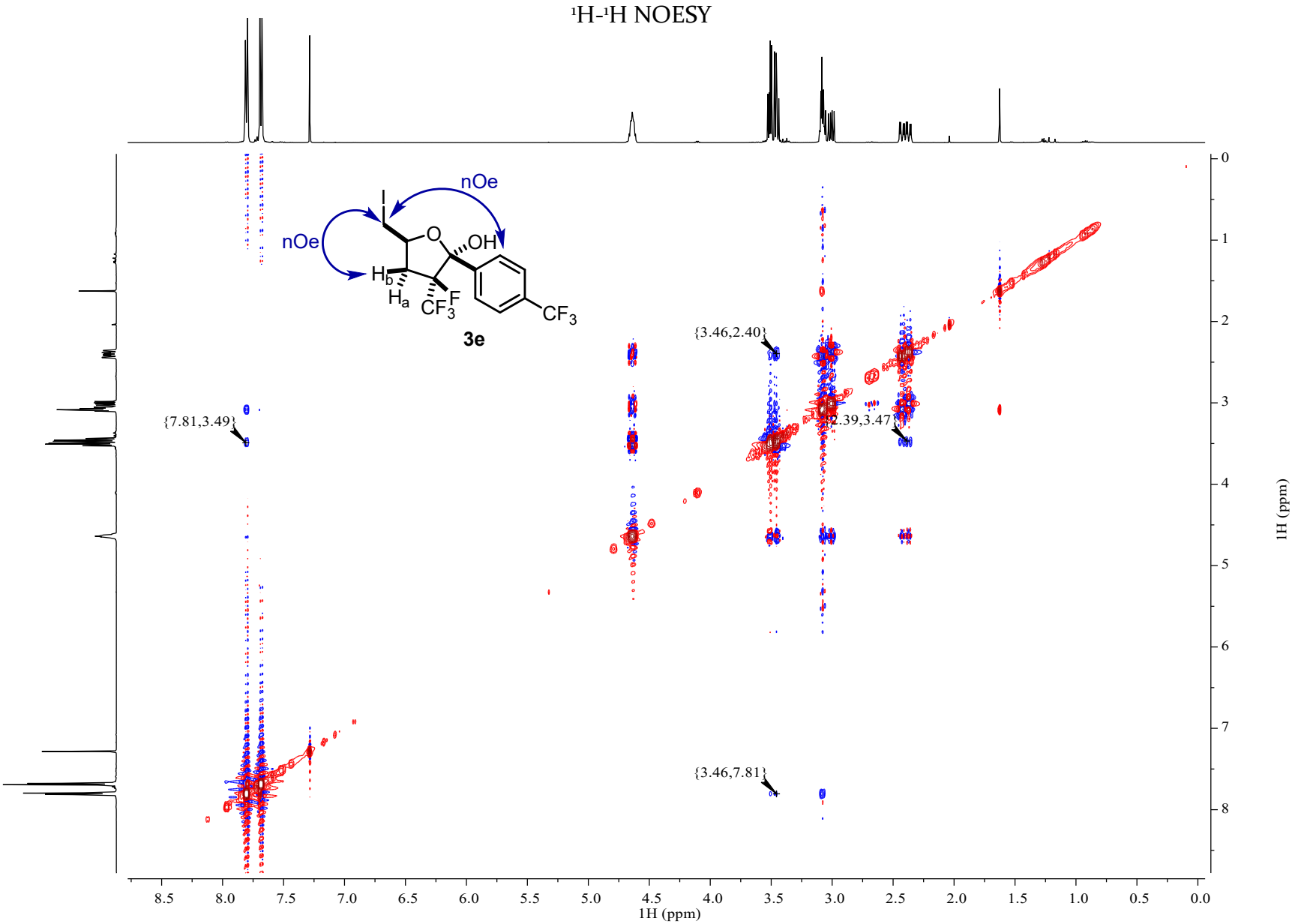

3e
C (qd) 121.94
B (q) 124.01
A (q) 131.97
F (dq) 99.33
E (d) 106.04
D (q) 125.03
G (d) 37.25
13C (ppm)

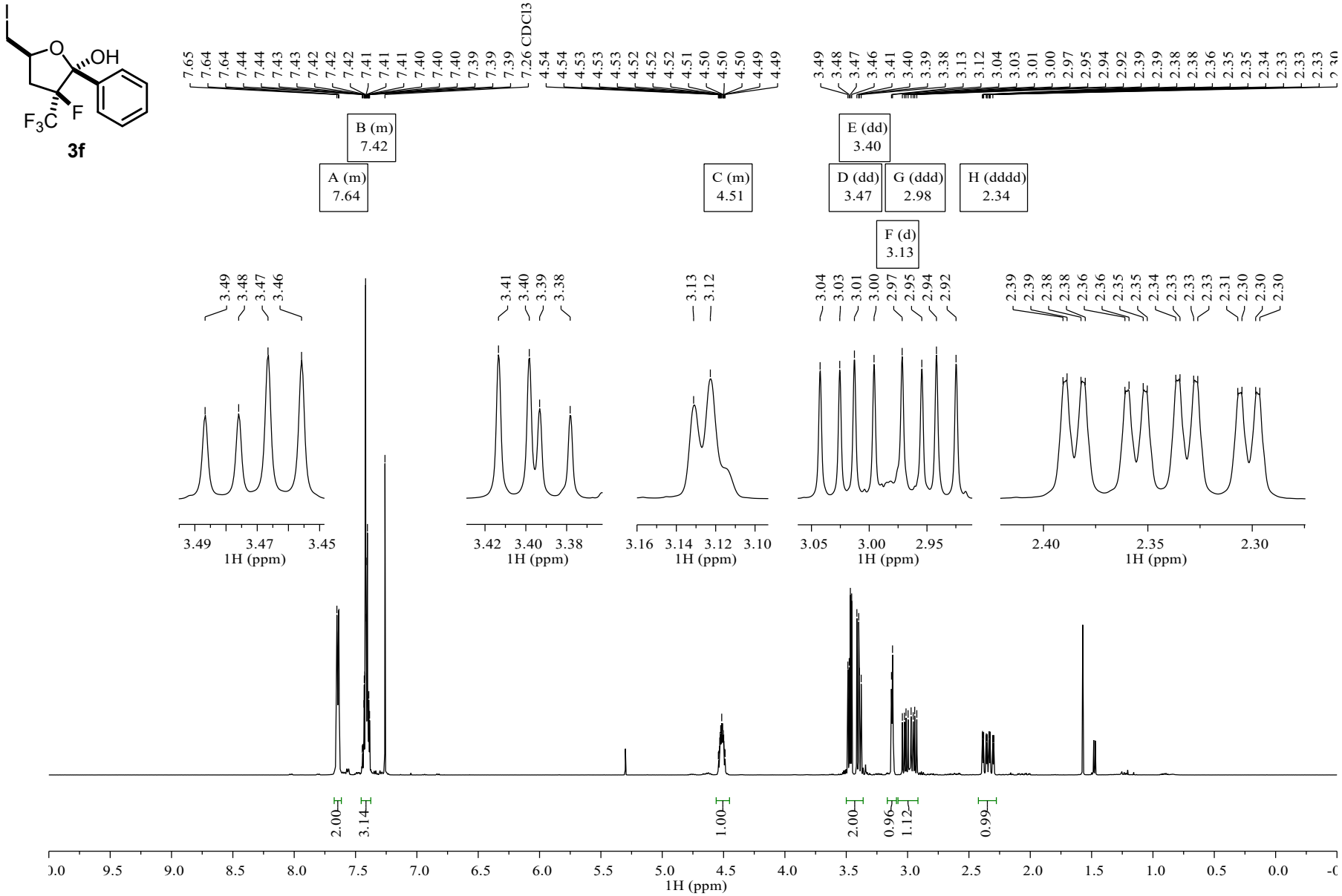

I
O
OH
Hb
Ha
CF3
F
CF3
3e
-62.77
-74.35
-74.37
-160.98
-161.00
-161.01
-161.02
-161.04
-161.06
-161.07
-161.08
-161.10
-161.12
-161.13
-161.14
-161.16
A (d)
-74.36
B (m)
-161.06
-74.35
-74.37
-74.37
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)

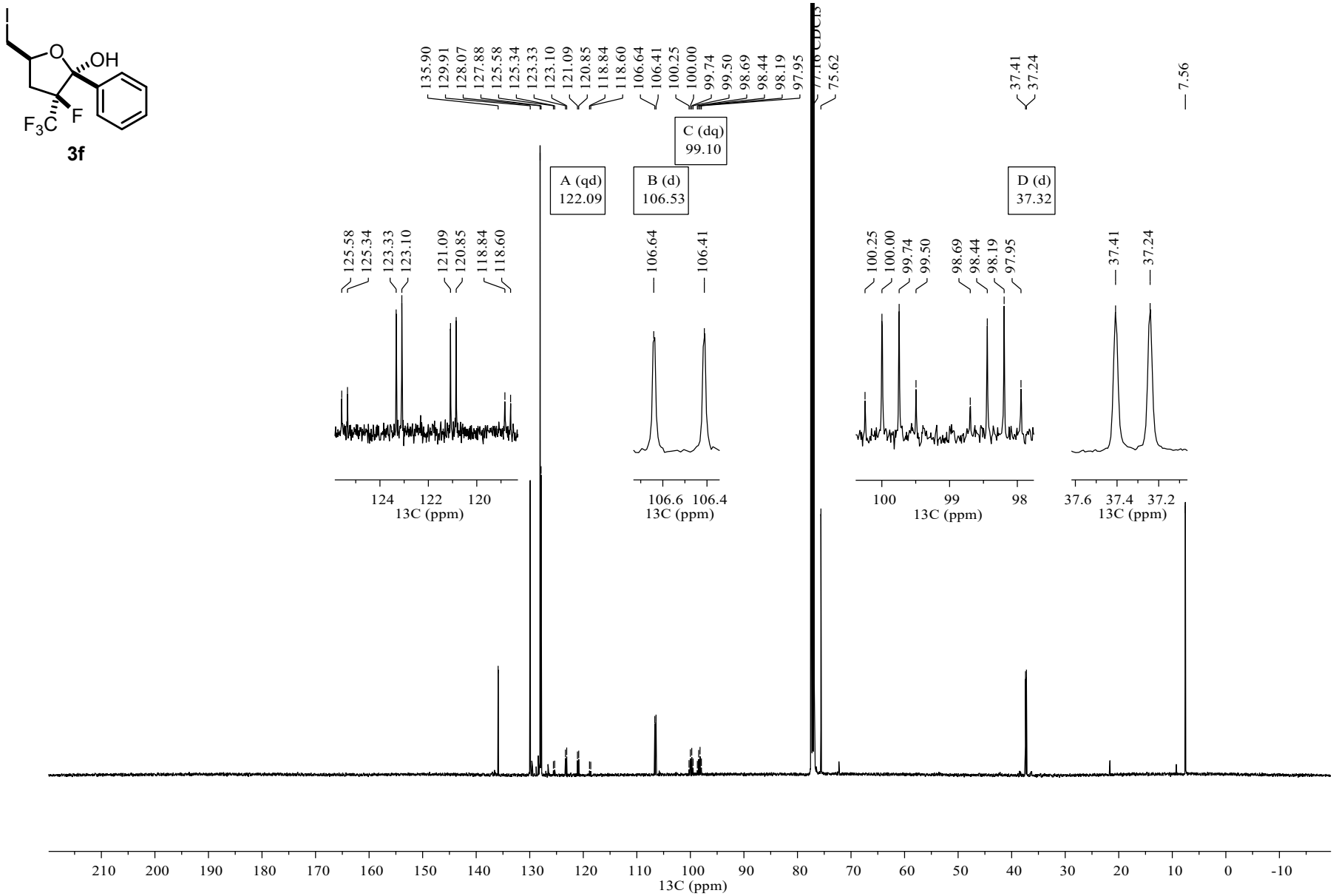

^{1}H-^{13}C HSQC
I
O
OH
H_b
H_a
CF_3
F
CF_3
3e
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
13C (ppm)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)

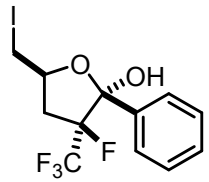

¹H-¹³C HMBC
3e
OH
Hb
Ha
CF3
F
CF3
13C (ppm)
1H (ppm)


^{1}H-^{1}H COSY
I
O
OH
H_b
H_a
CF_3
F
CF_3
3e
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)
0
1
2
3
4
5
6
7
8
1H (ppm)


¹H-¹H NOESY
nOe
nOe
OH
O
Hb
Ha
CF3
F
CF3
3e
{7.81,3.49}
{3.46,2.40}
{2.39,3.47}
{3.46,7.81}
1H (ppm)
1H (ppm)

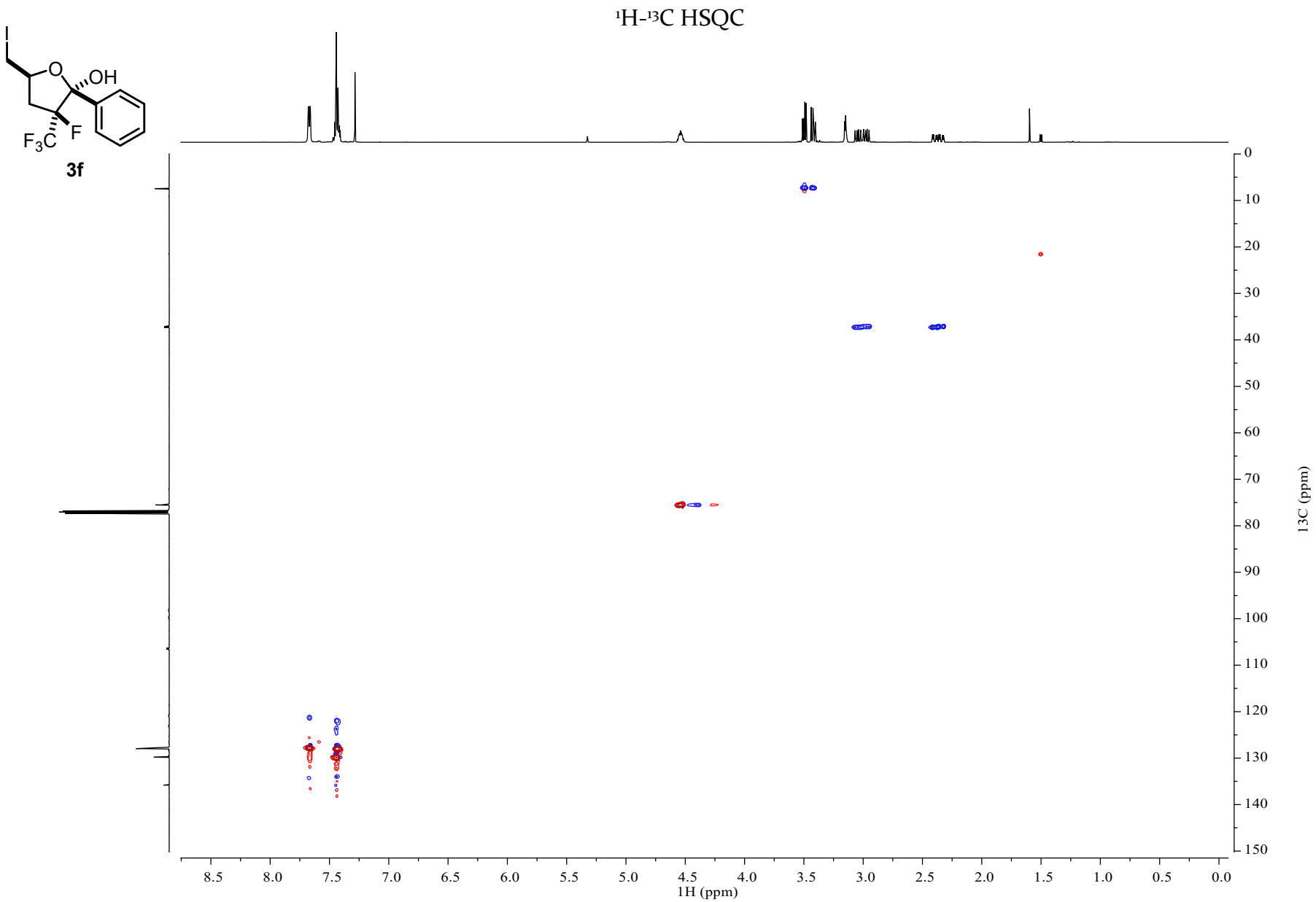

3f
B (m) 7.42
A (m) 7.64
C (m) 4.51
E (dd) 3.40
D (dd) 3.47
G (ddd) 2.98
H (dddd) 2.34
F (d) 3.13
CDCl3
1H (ppm)
2.00
3.14
1.00
2.00
0.96
1.12
0.99

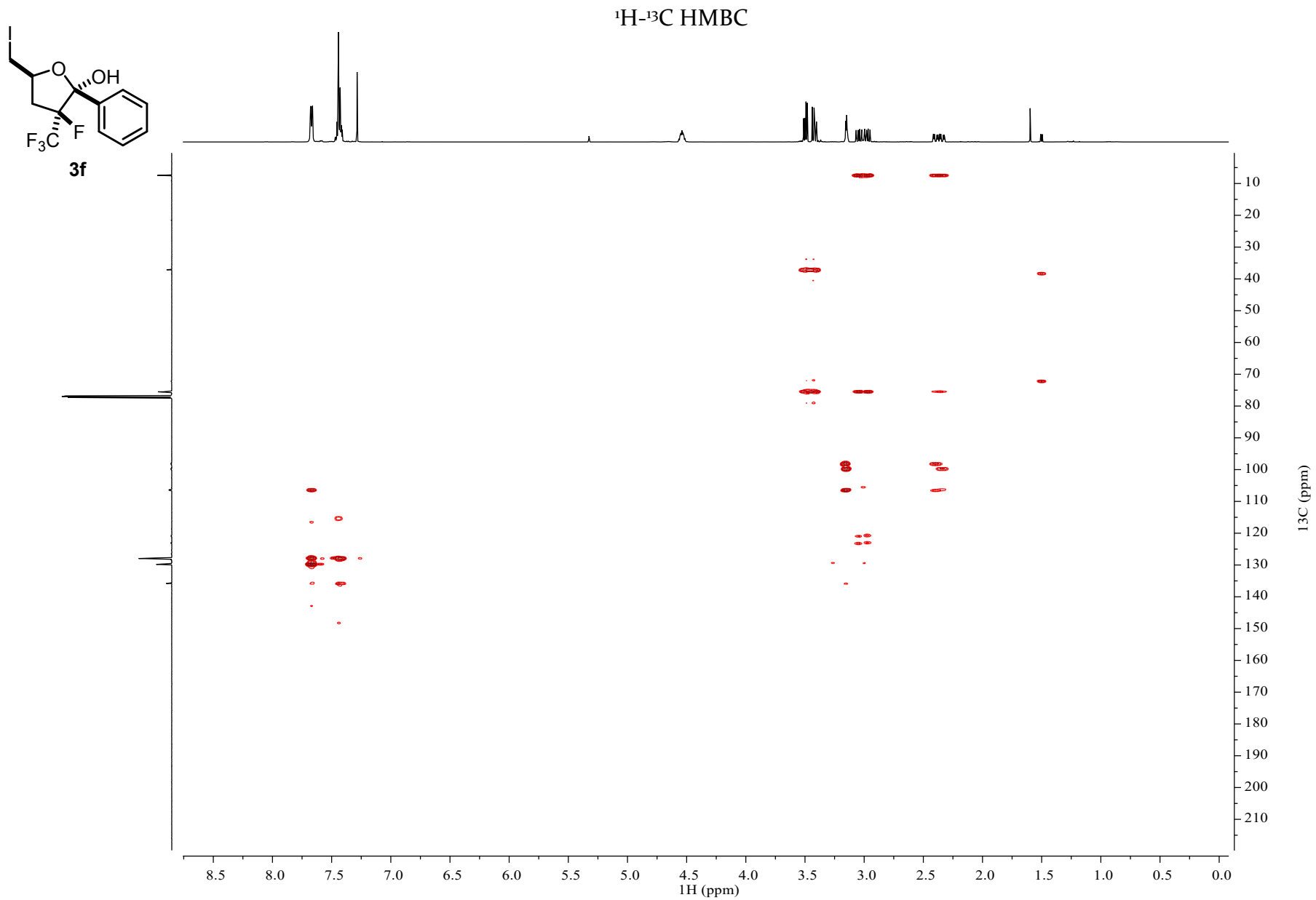

3f
135.90
129.91
128.07
127.88
125.58
125.34
123.33
123.10
121.09
120.85
118.84
118.60
106.64
106.41
100.25
100.00
99.74
99.50
98.69
98.44
98.19
97.95
77.16 CDCl3
75.62
37.41
37.24
7.56
A (qd)
122.09
B (d)
106.53
C (dq)
99.10
D (d)
37.32
13C (ppm)

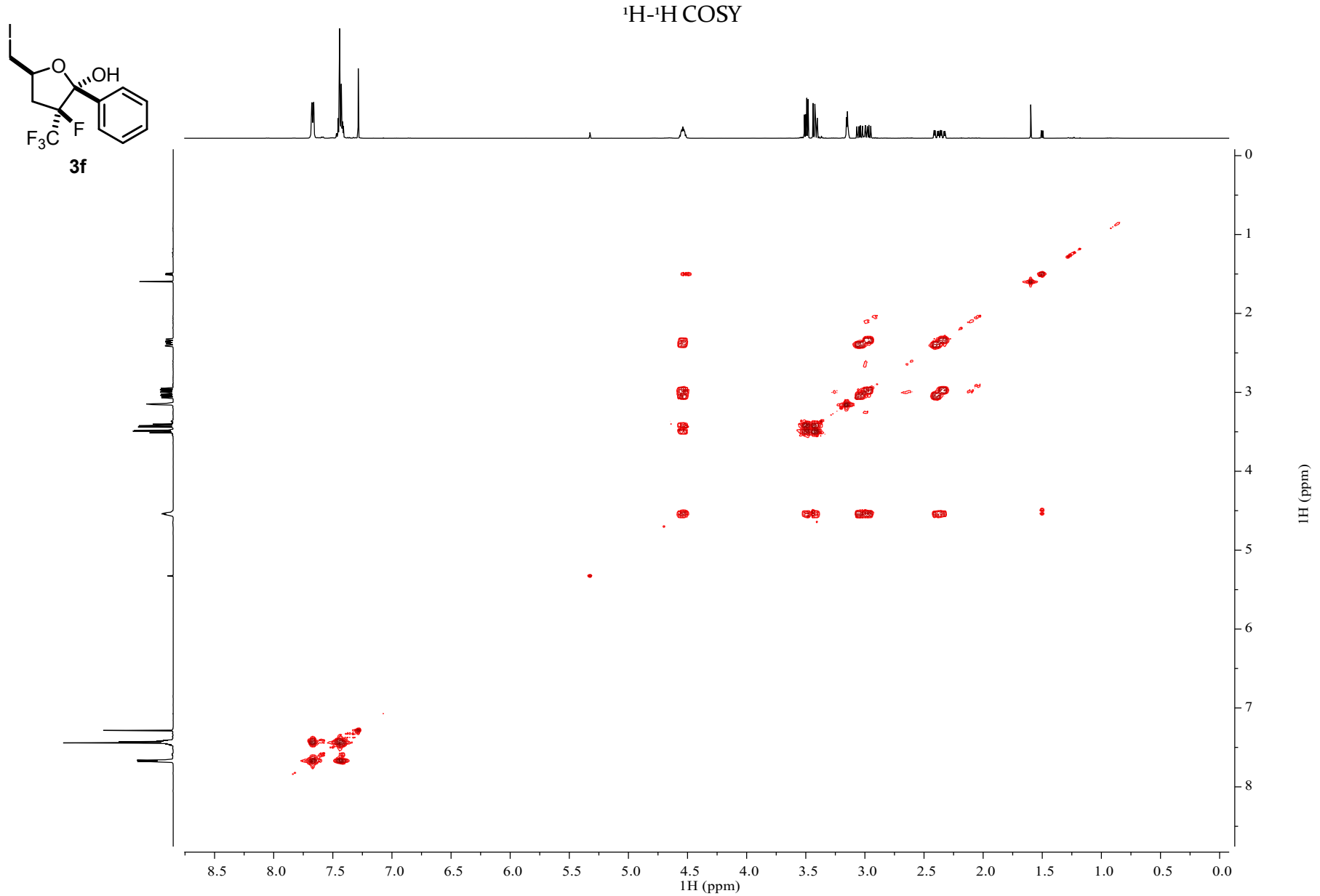

I
O
OH
F3C
F

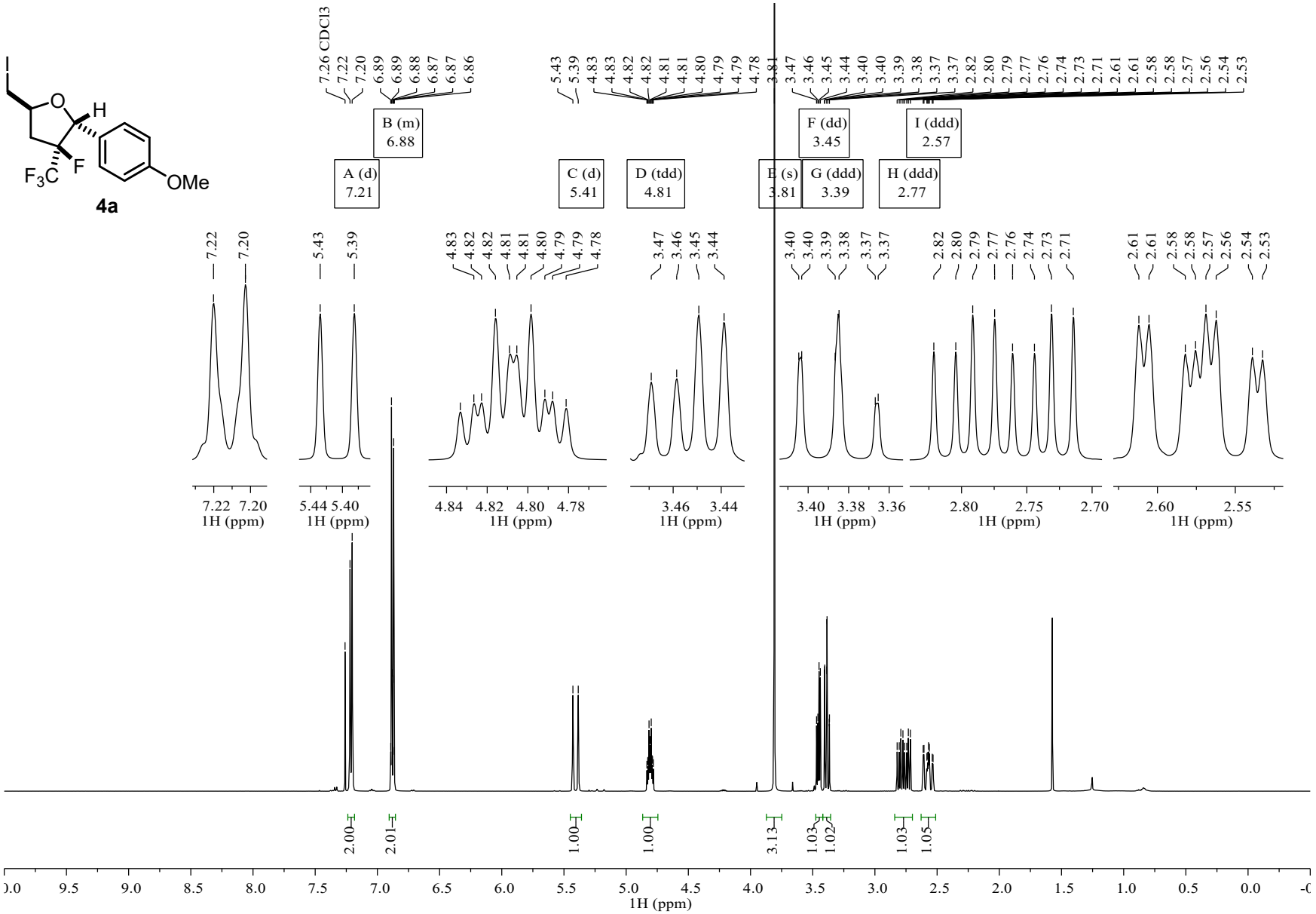
3f

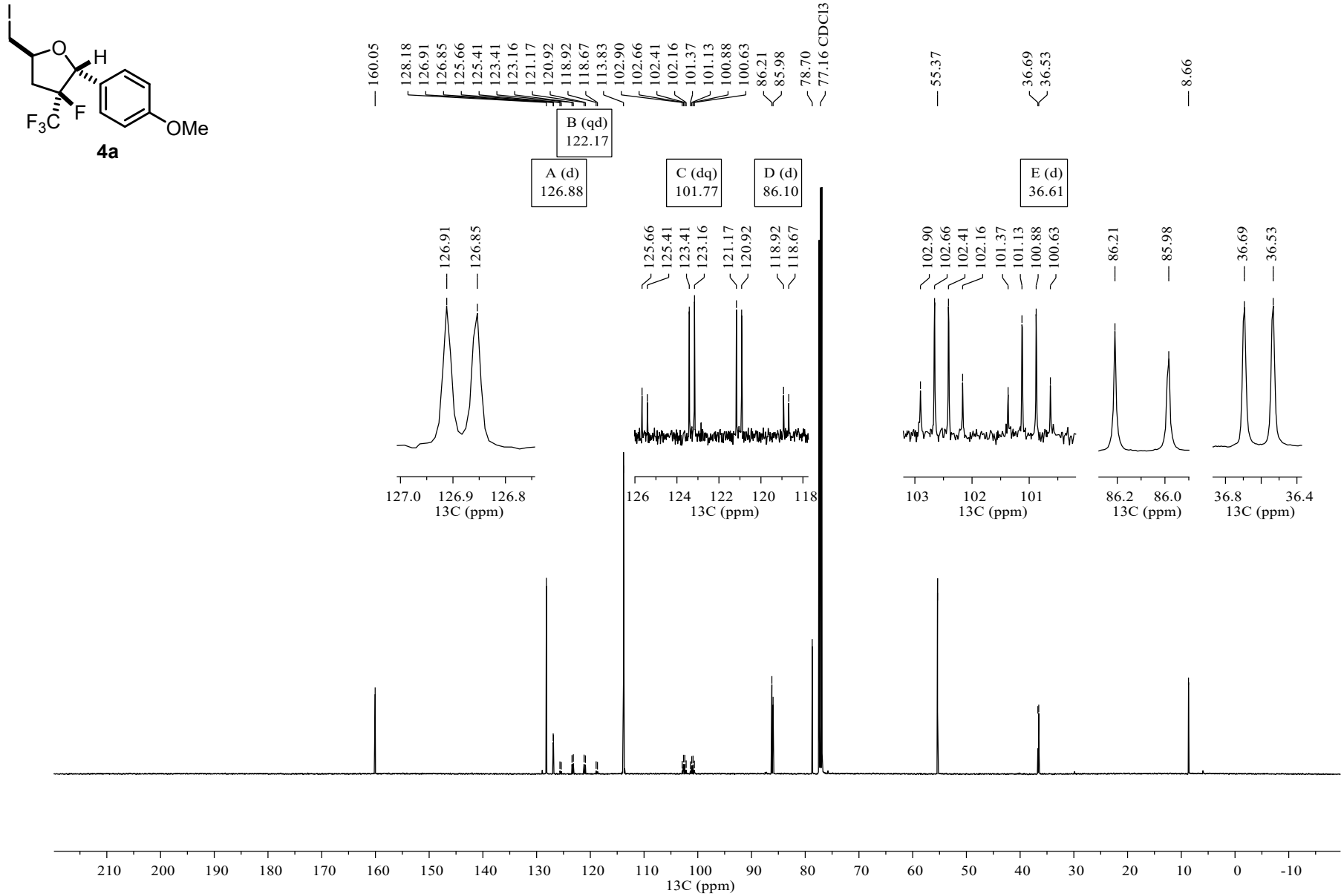
-74.34
-74.36
A (d)
-74.35
-161.06
-161.07
-161.08
-161.10
-161.12
-161.13
-161.14
-161.18
-161.19
-161.20
-161.21
B (m)
-161.13
-74.34
-74.36
-74.34 -74.37
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)

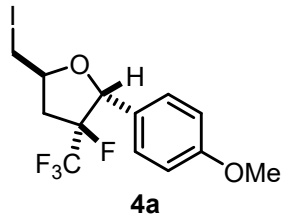

^{1}H-^{13}C HSQC
OH
F
F_3C
3f
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
13C (ppm)


^{1}H-^{13}C HMBC
OH
F
F_3C
3f
1H (ppm)
13C (ppm)


^{1}H-^{1}H COSY
OH
F
F_3C
3f
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)
0
1
2
3
4
5
6
7
8
1H (ppm)

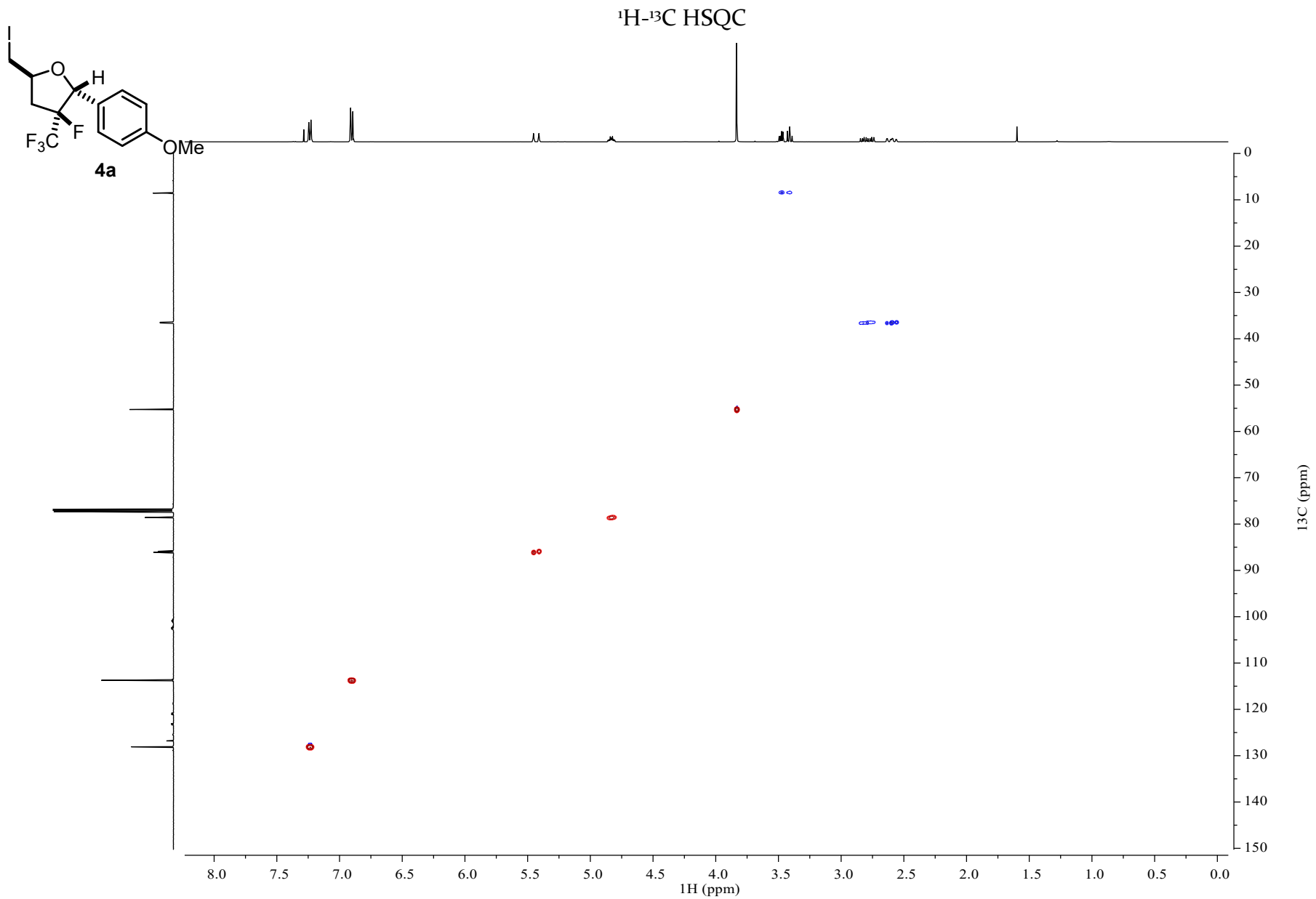

4a
A (d) 7.21
B (m) 6.88
C (d) 5.41
D (tdd) 4.81
E (s) 3.81
F (dd) 3.45
G (ddd) 3.39
H (ddd) 2.77
I (ddd) 2.57
1H (ppm)

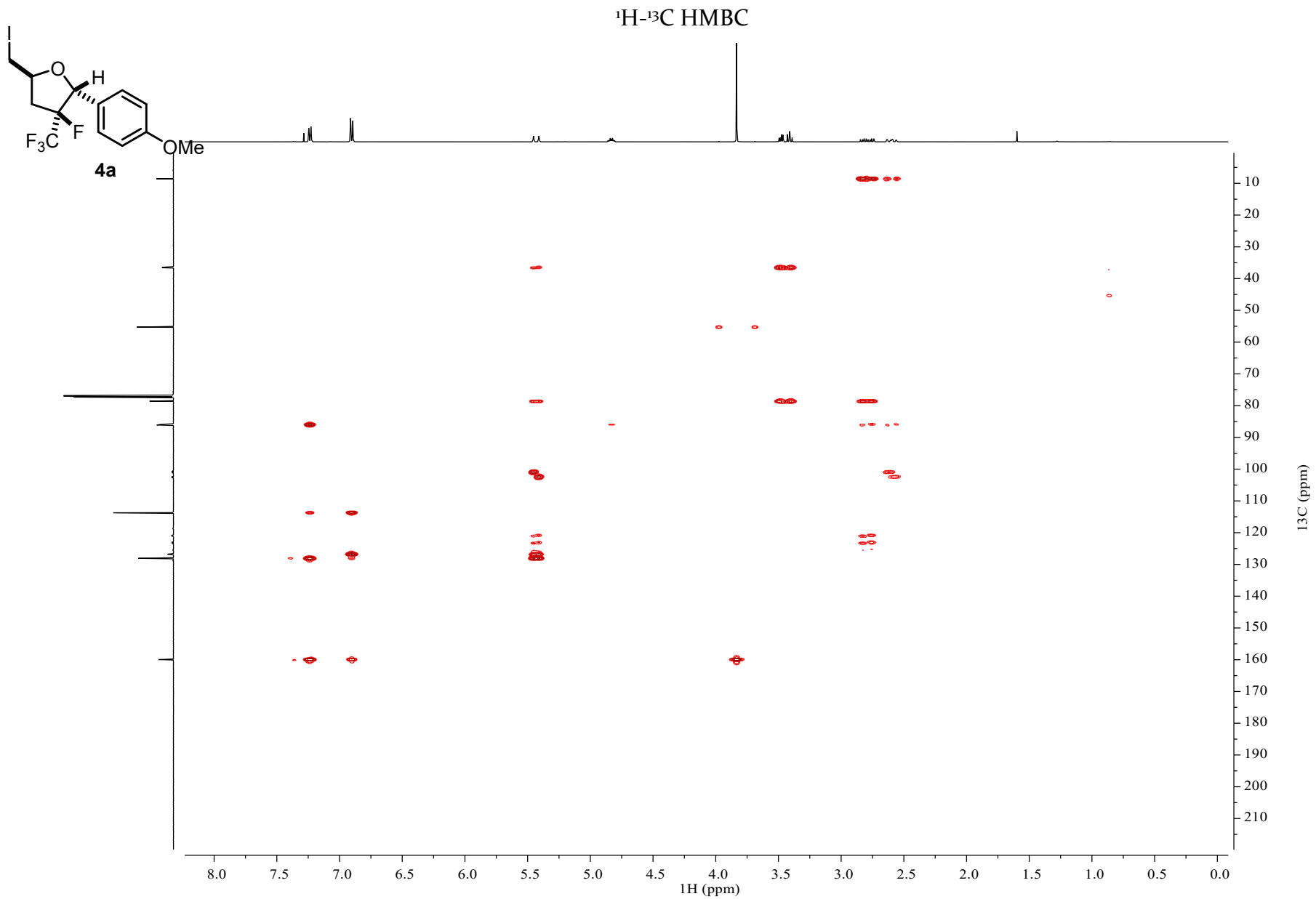

4a
160.05
128.18
126.91
126.85
125.66
125.41
123.41
123.16
121.17
120.92
118.92
118.67
113.83
102.90
102.66
102.41
102.16
101.37
101.13
100.88
100.63
86.21
85.98
78.70
77.16 CDCl3
55.37
36.69
36.53
8.66
A (d) 126.88
B (qd) 122.17
C (dq) 101.77
D (d) 86.10
E (d) 36.61
13C (ppm)


I
O
H
F
F3C
OMe

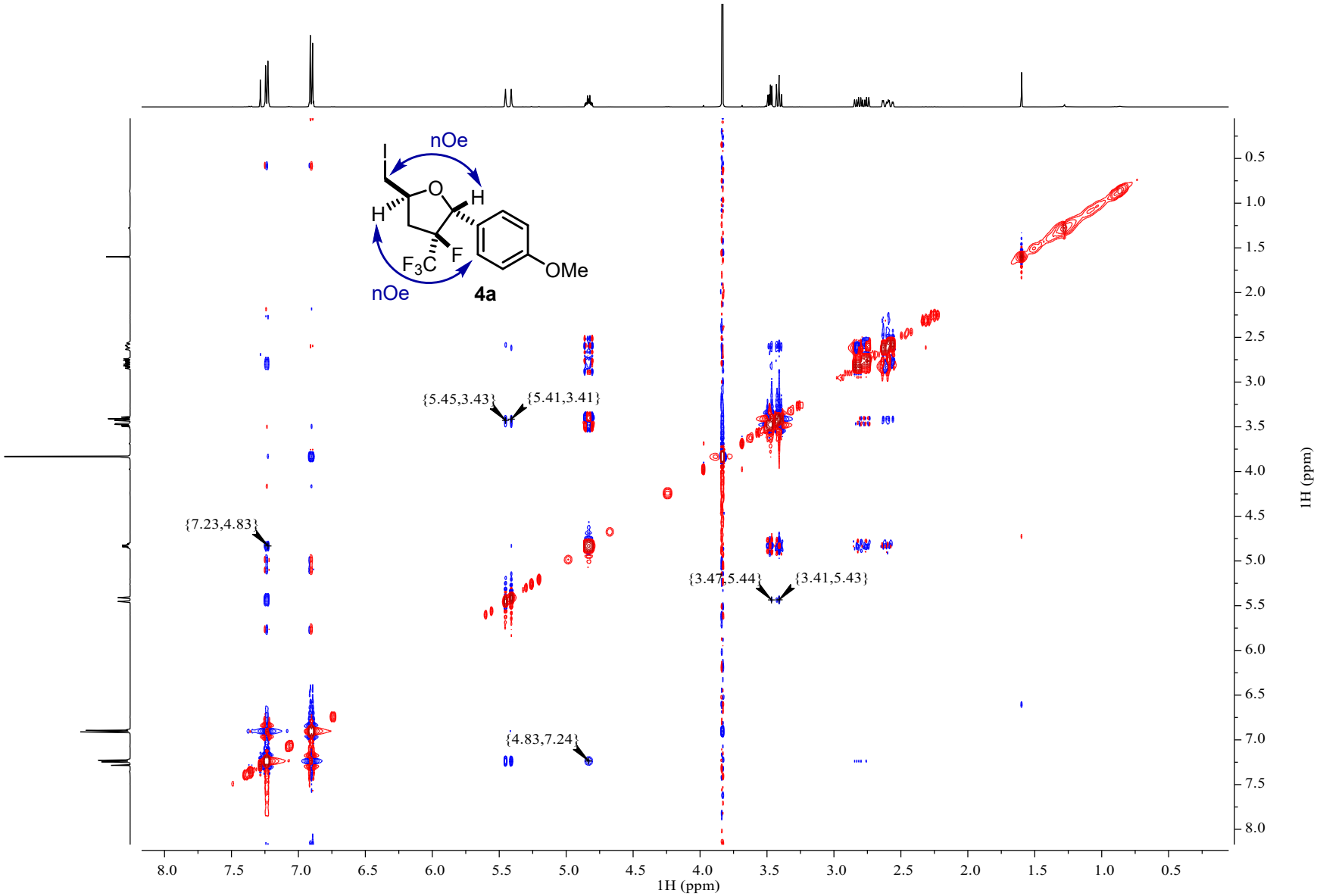
4a

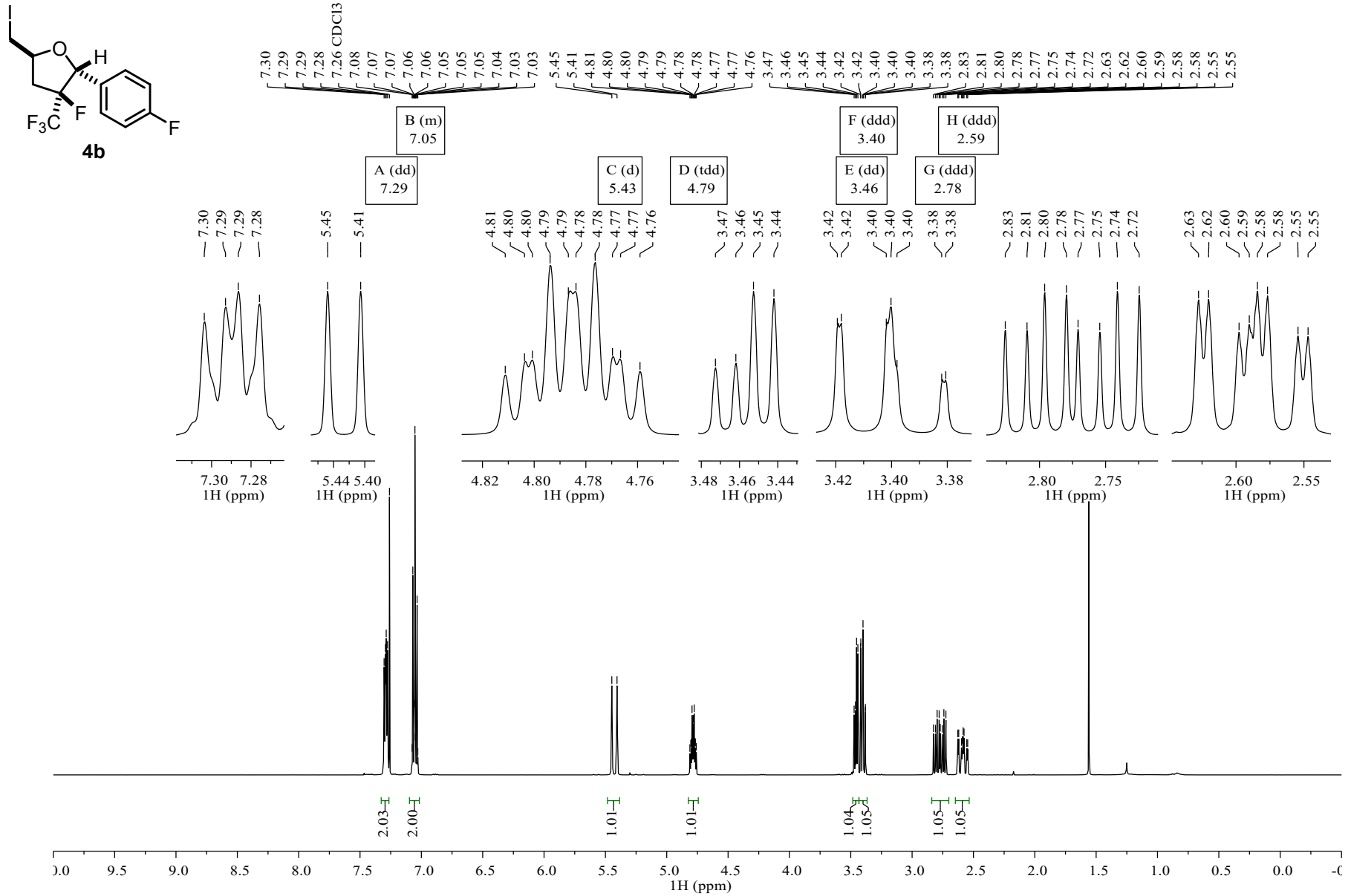
-75.71
-75.72
A (d)
-75.72
-157.45
-157.47
-157.48
-157.50
-157.51
-157.53
-157.54
-157.56
-157.57
-157.59
-157.61
-157.62
-157.64
-157.65
B (dtq)
-157.55
-75.68 -75.72
19F (ppm)
-157.45 -157.50 -157.55 -157.60 -157.65
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)

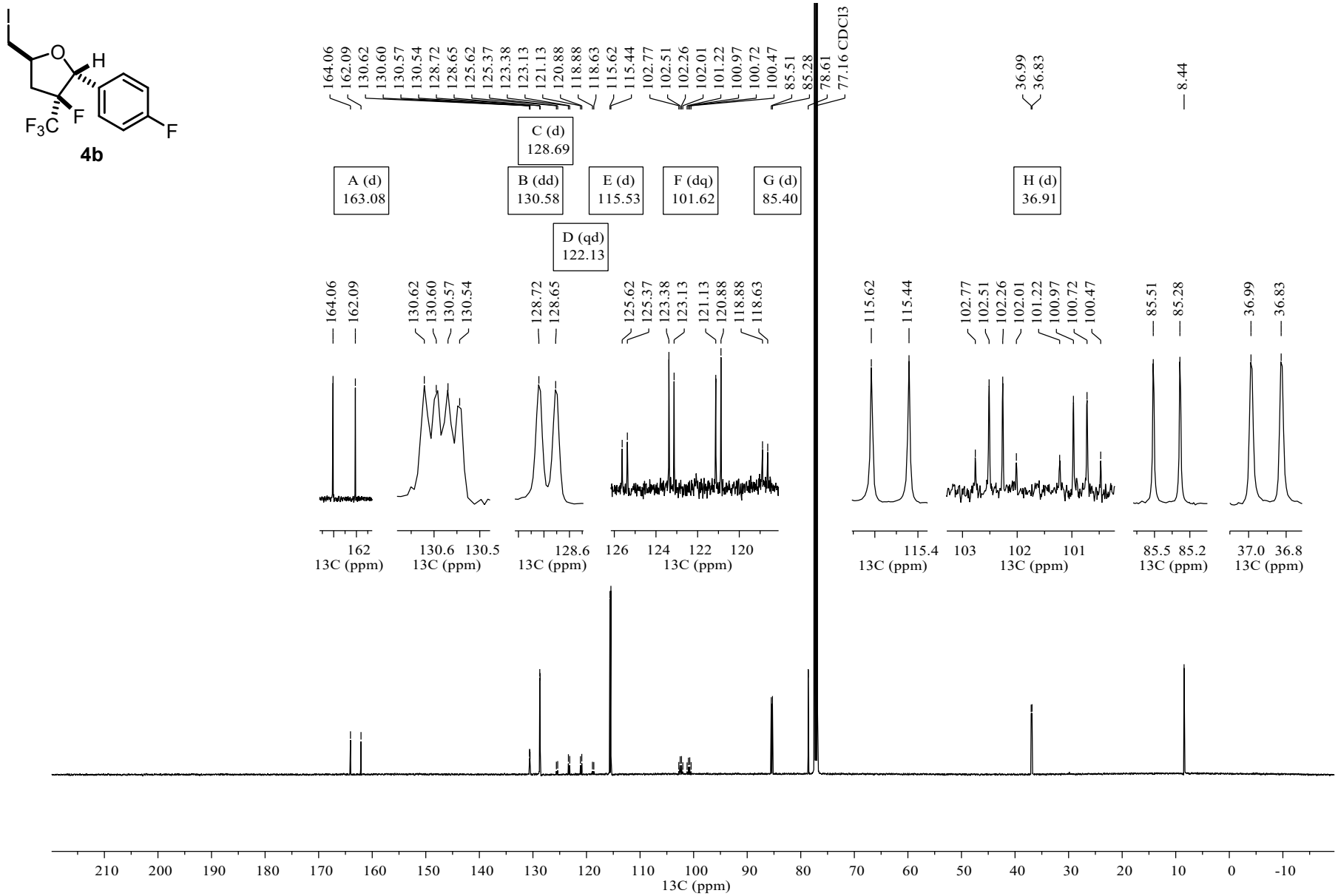

^{1}H-^{13}C HSQC
I
O
H
F
F_3C
OMe
4a
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
13C (ppm)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)

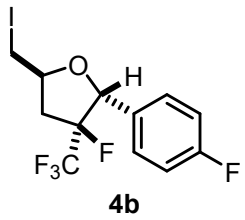

¹H-¹³C HMBC
I
O
H
F
F3C
OMe
4a
13C (ppm)
1H (ppm)

^{1}H-^{1}H NOESY


nOe
nOe
4a
{5.45,3.43}
{5.41,3.41}
{7.23,4.83}
{3.47,5.44}
{3.41,5.43}
{4.83,7.24}
1H (ppm)
1H (ppm)

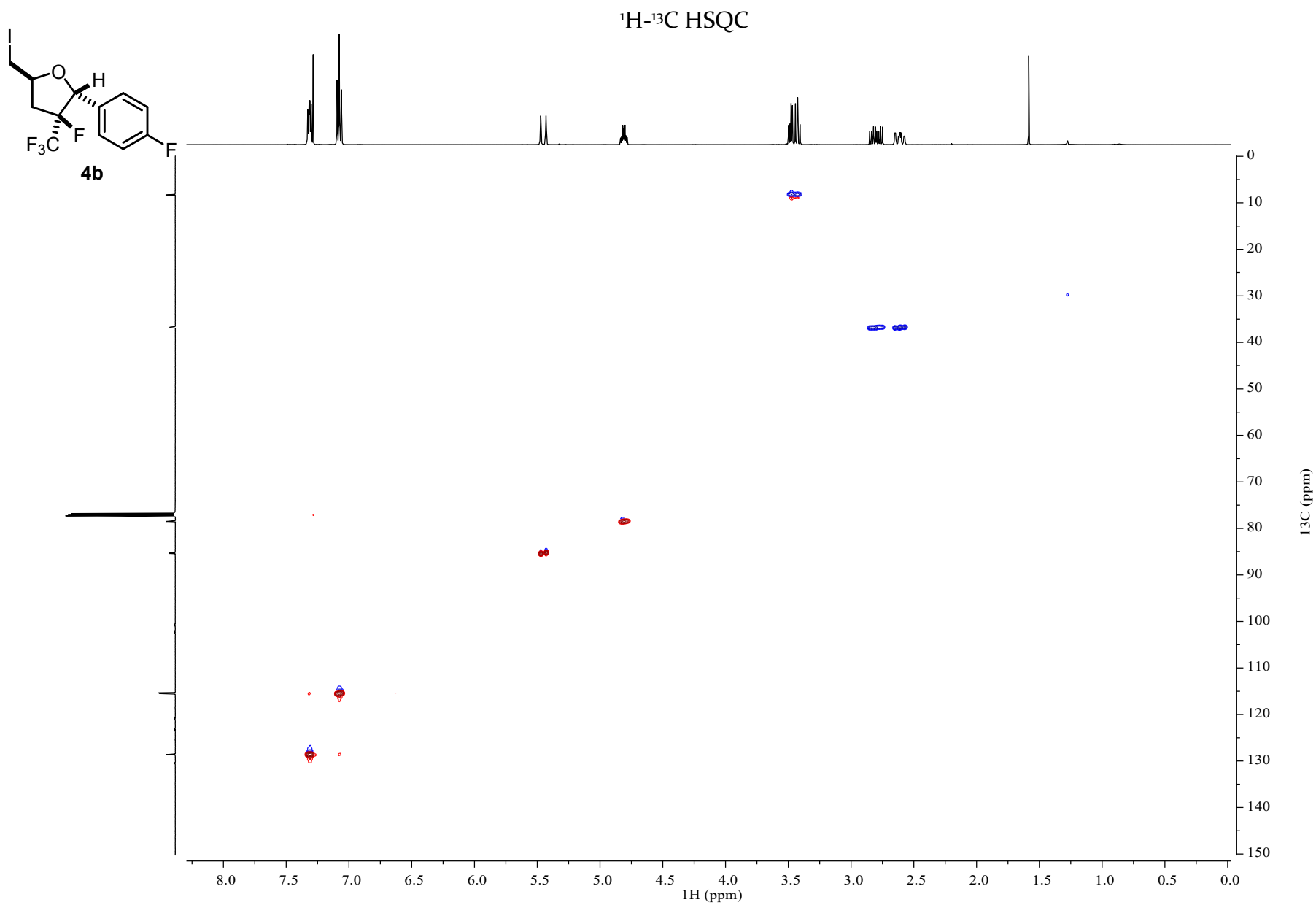

4b
CDCl3
B (m) 7.05
A (dd) 7.29
C (d) 5.43
D (tdd) 4.79
F (ddd) 3.40
E (dd) 3.46
G (ddd) 2.78
H (ddd) 2.59
1H (ppm)

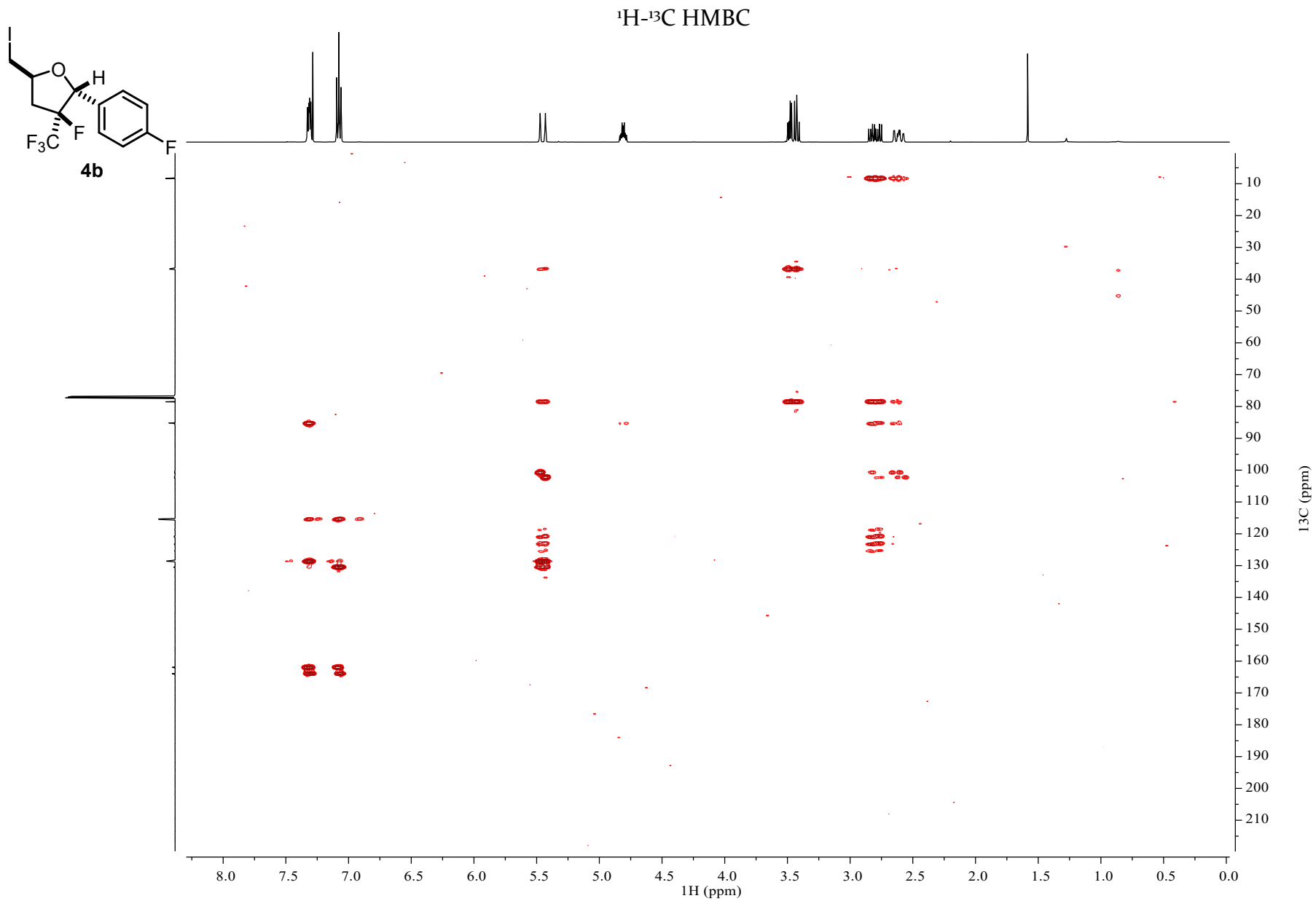

4b
164.06
162.09
130.62
130.60
130.57
130.54
128.72
128.65
125.62
125.37
123.38
123.13
121.13
120.88
118.88
118.63
115.62
115.44
102.77
102.51
102.26
102.01
101.22
100.97
100.72
100.47
85.51
85.28
78.61
77.16 CDCl3
36.99
36.83
8.44
A (d) 163.08
B (dd) 130.58
C (d) 128.69
D (qd) 122.13
E (d) 115.53
F (dq) 101.62
G (d) 85.40
H (d) 36.91
13C (ppm)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

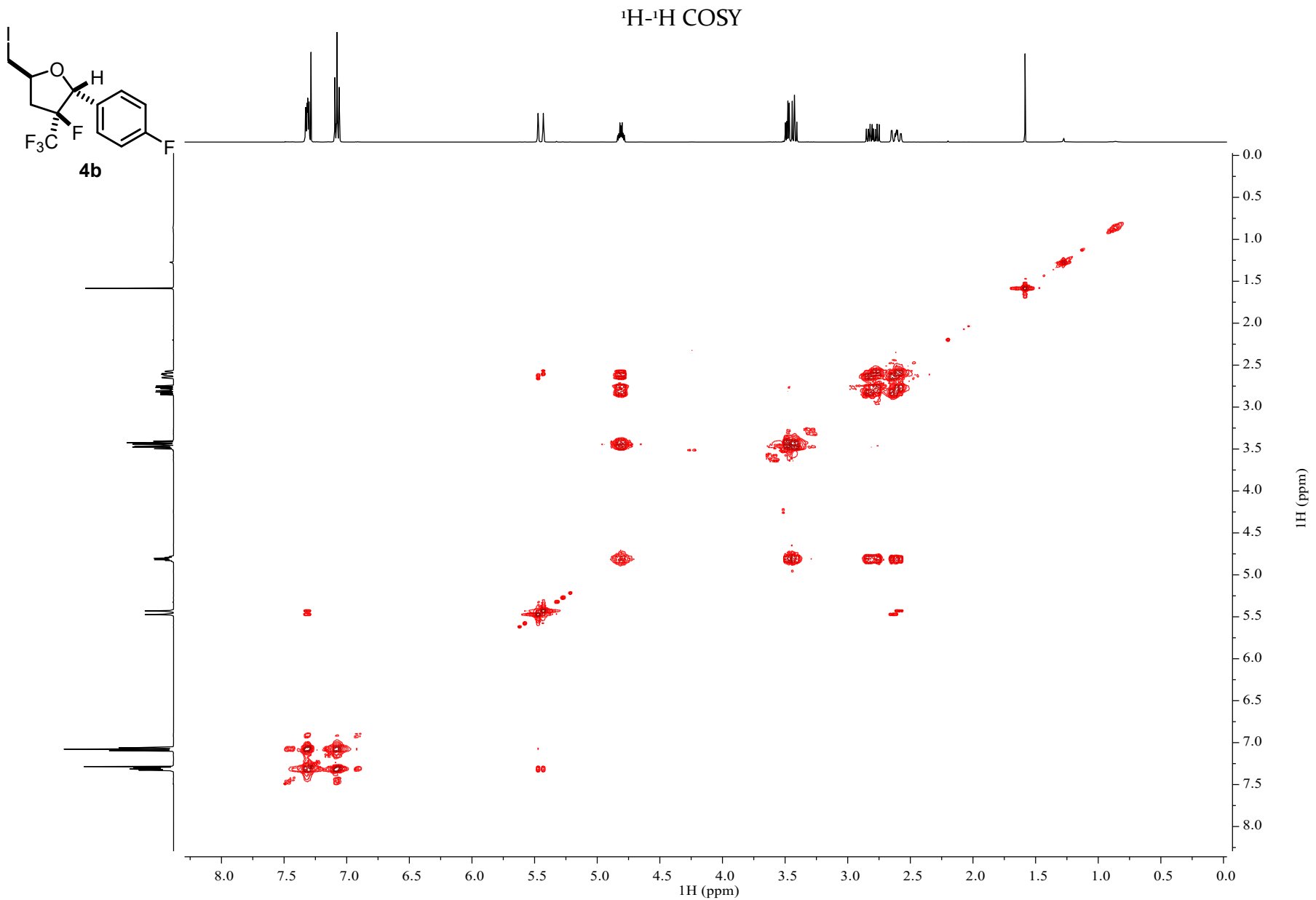

I
O
H
F
F3C
F

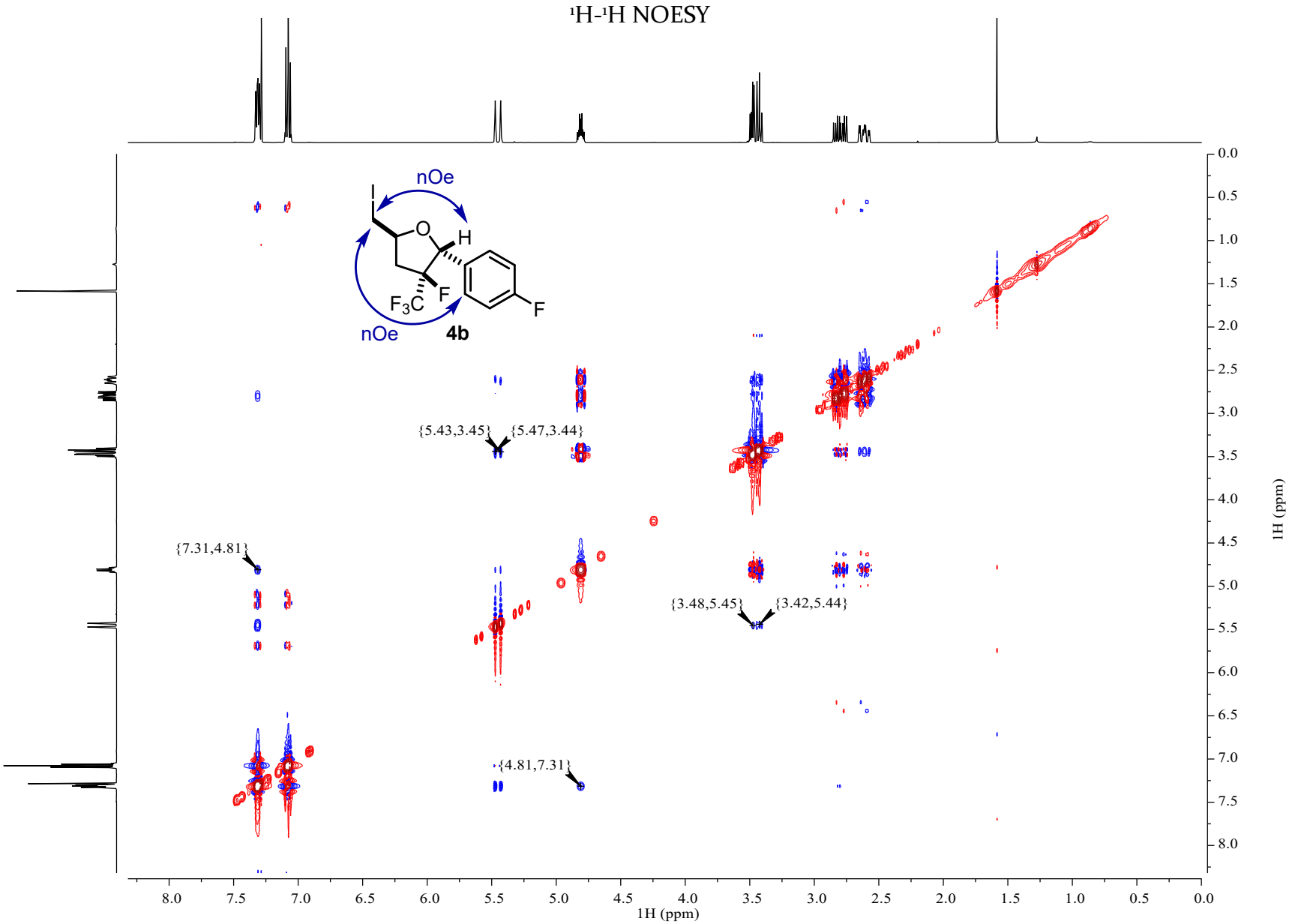
4b

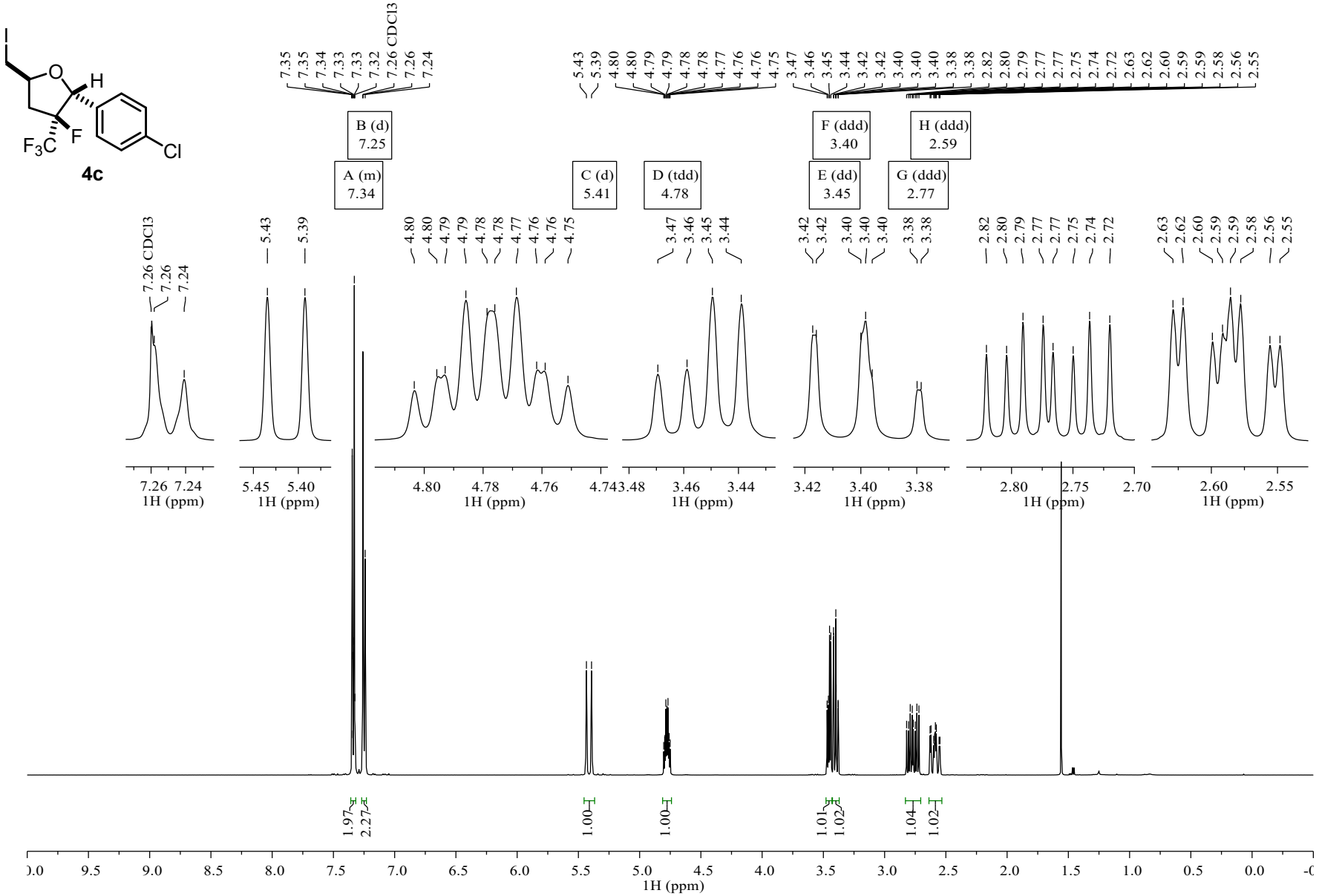
-75.84
-75.86
A (d)
-75.85
-112.67
-112.69
-112.69
-112.70
-112.71
-112.72
-112.73
B (ddd)
-112.70
-158.70
-158.71
-158.73
-158.74
-158.76
-158.77
-158.79
-158.80
-158.82
-158.83
-158.85
-158.86
-158.88
-158.89
C (dtq)
-158.80
-75.80
-75.90
19F (ppm)
-112.70
-112.75
19F (ppm)
-158.70
-158.75
-158.80
-158.85
-158.90
19F (ppm)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
19F (ppm)

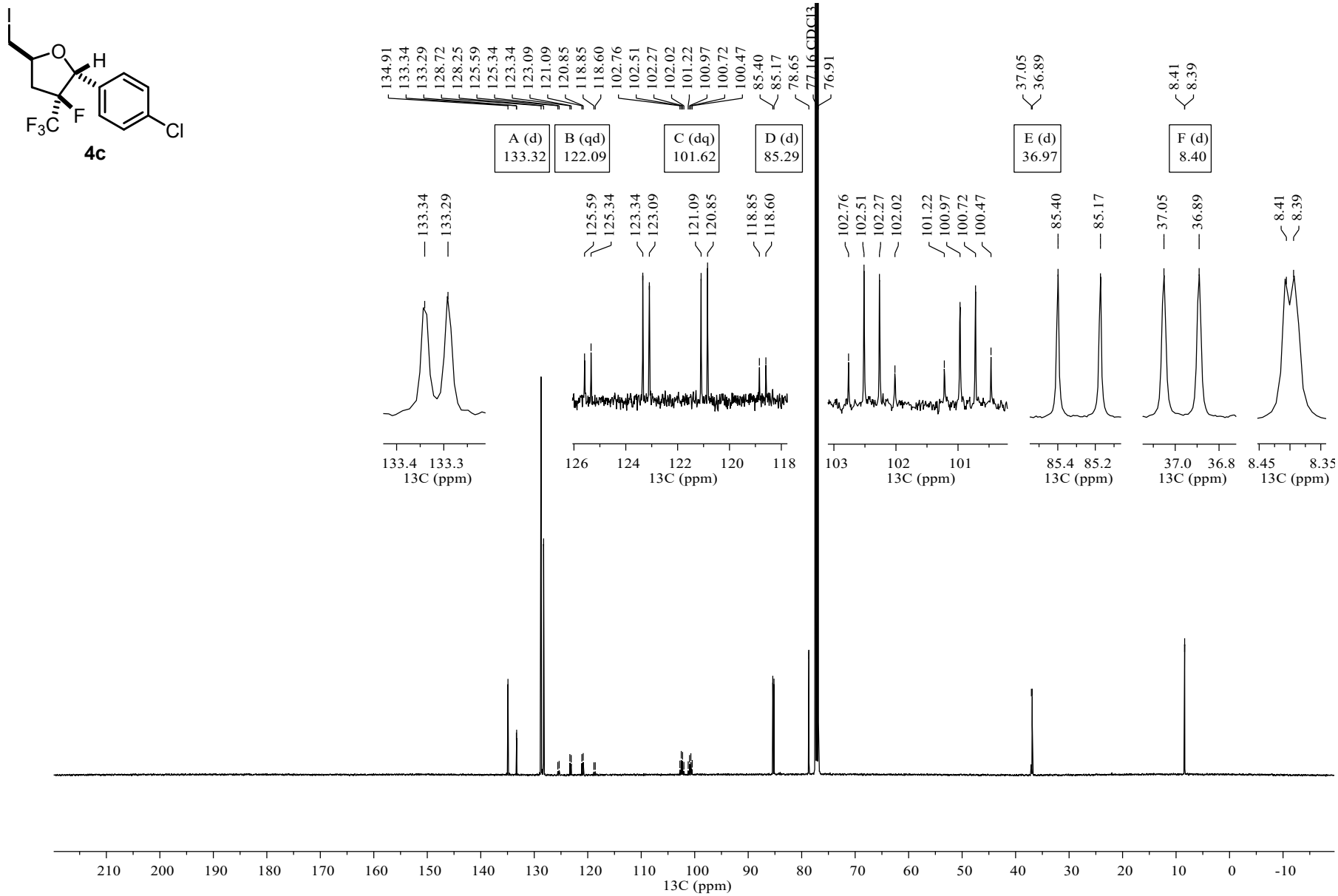

^{1}H-^{13}C HSQC
4b
1H (ppm)
13C (ppm)

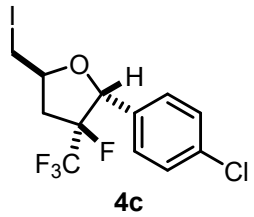

^{1}H-^{13}C HMBC
4b
1H (ppm)
13C (ppm)


¹H-¹H COSY
4b
1H (ppm)
1H (ppm)


¹H-¹H NOESY
nOe
nOe
4b
{5.43,3.45}
{5.47,3.44}
{7.31,4.81}
{3.48,5.45}
{3.42,5.44}
{4.81,7.31}
1H (ppm)
1H (ppm)


4c
A (m) 7.34
B (d) 7.25
C (d) 5.41
D (tdd) 4.78
E (dd) 3.45
F (ddd) 3.40
G (ddd) 2.77
H (ddd) 2.59
7.26 CDCl3
1H (ppm)

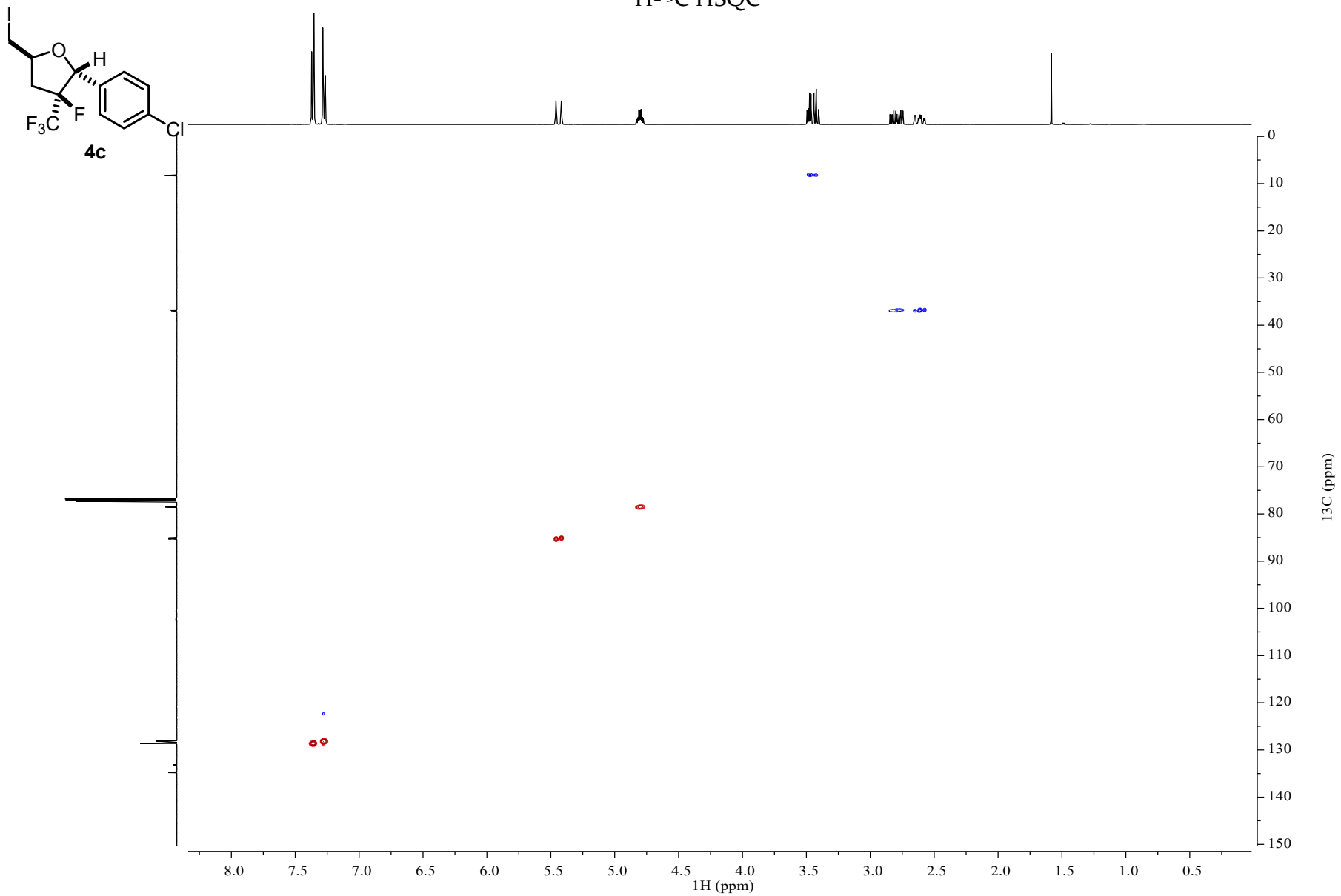

4c
134.91
133.34
133.29
128.72
128.25
125.59
125.34
123.34
123.09
121.09
120.85
118.85
118.60
102.76
102.51
102.27
102.02
101.22
100.97
100.72
100.47
85.40
85.17
78.65
77.16 CDCl3
76.91
37.05
36.89
8.41
8.39
A (d) 133.32
B (qd) 122.09
C (dq) 101.62
D (d) 85.29
E (d) 36.97
F (d) 8.40
13C (ppm)

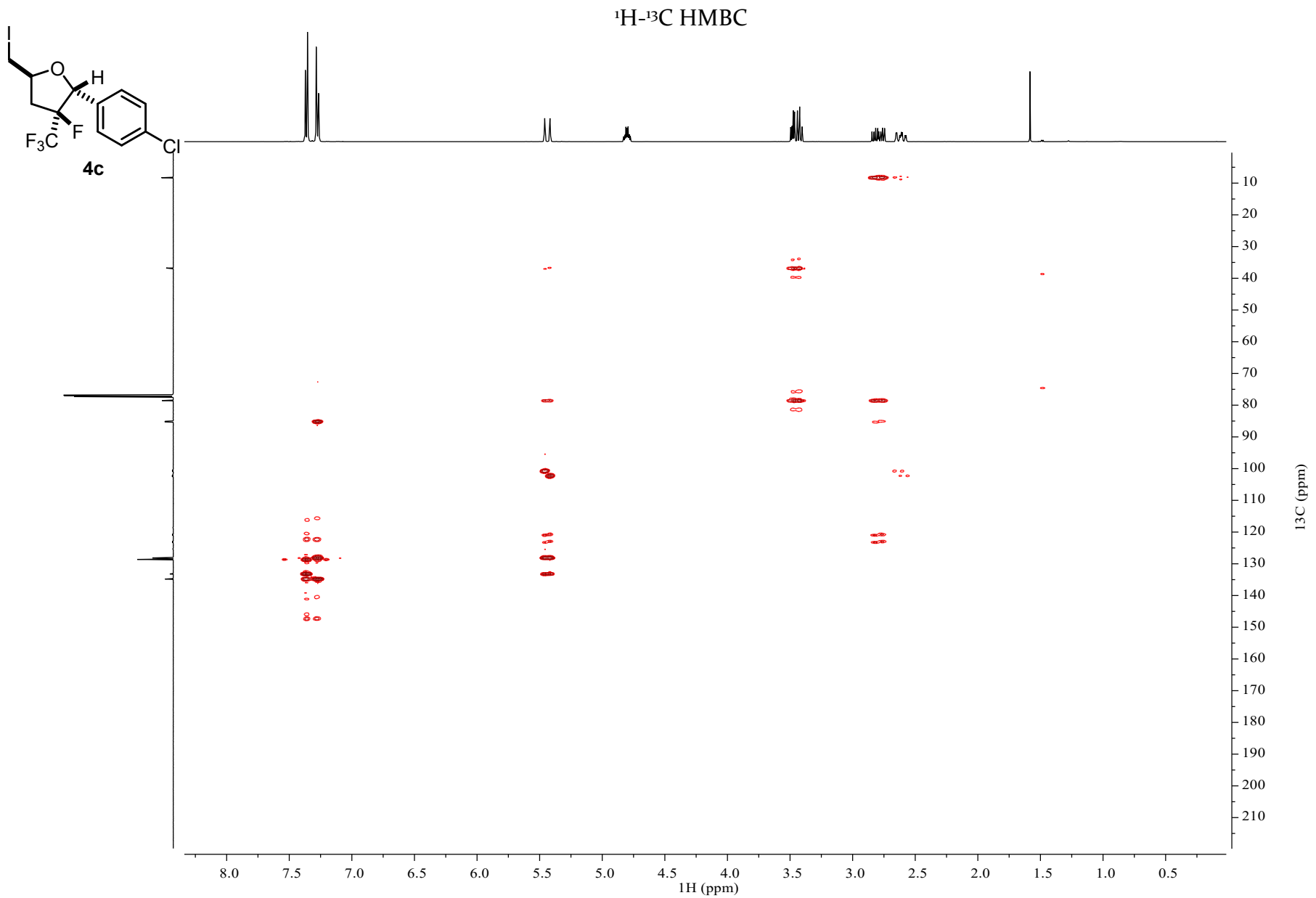

I
O
H
F
F3C
Cl

4c

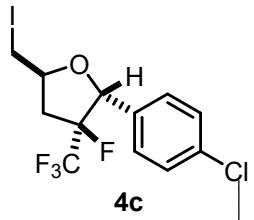
-75.78
-75.80
A (d)
-75.79
-158.85
-158.87
-158.88
-158.90
-158.91
-158.93
-158.94
-158.96
-158.97
-158.99
-159.00
-159.02
-159.03
-159.05
B (tdd)
-158.95
-75.76 -75.80
19F (ppm)
-158.85 -158.90 -158.95 -159.00 -159.05
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)

^{1}H-^{13}C HSQC


I
O
H
F
F3C
Cl
4c
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
13C (ppm)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)

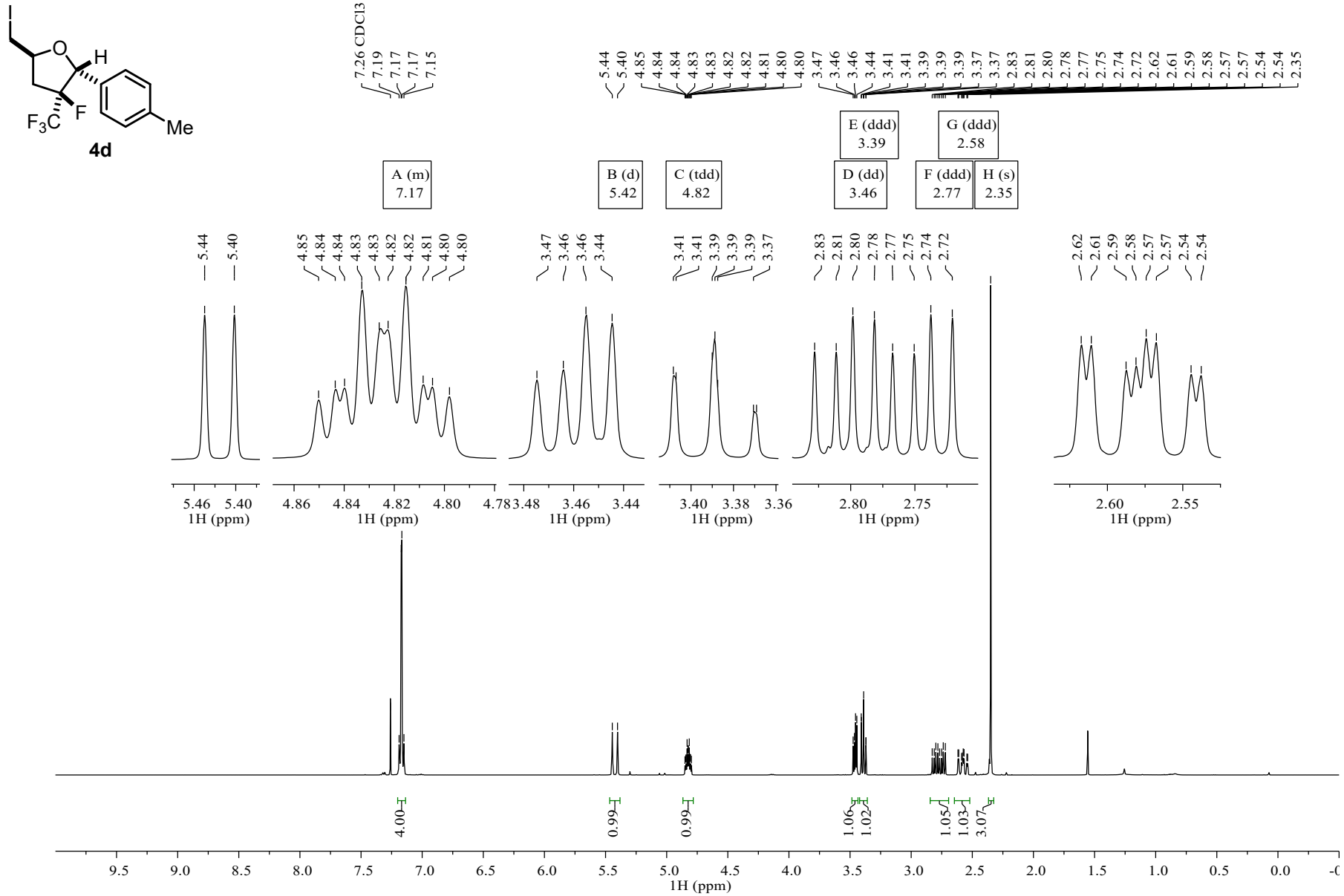

¹H-¹³C HMBC
4c
1H (ppm)
13C (ppm)

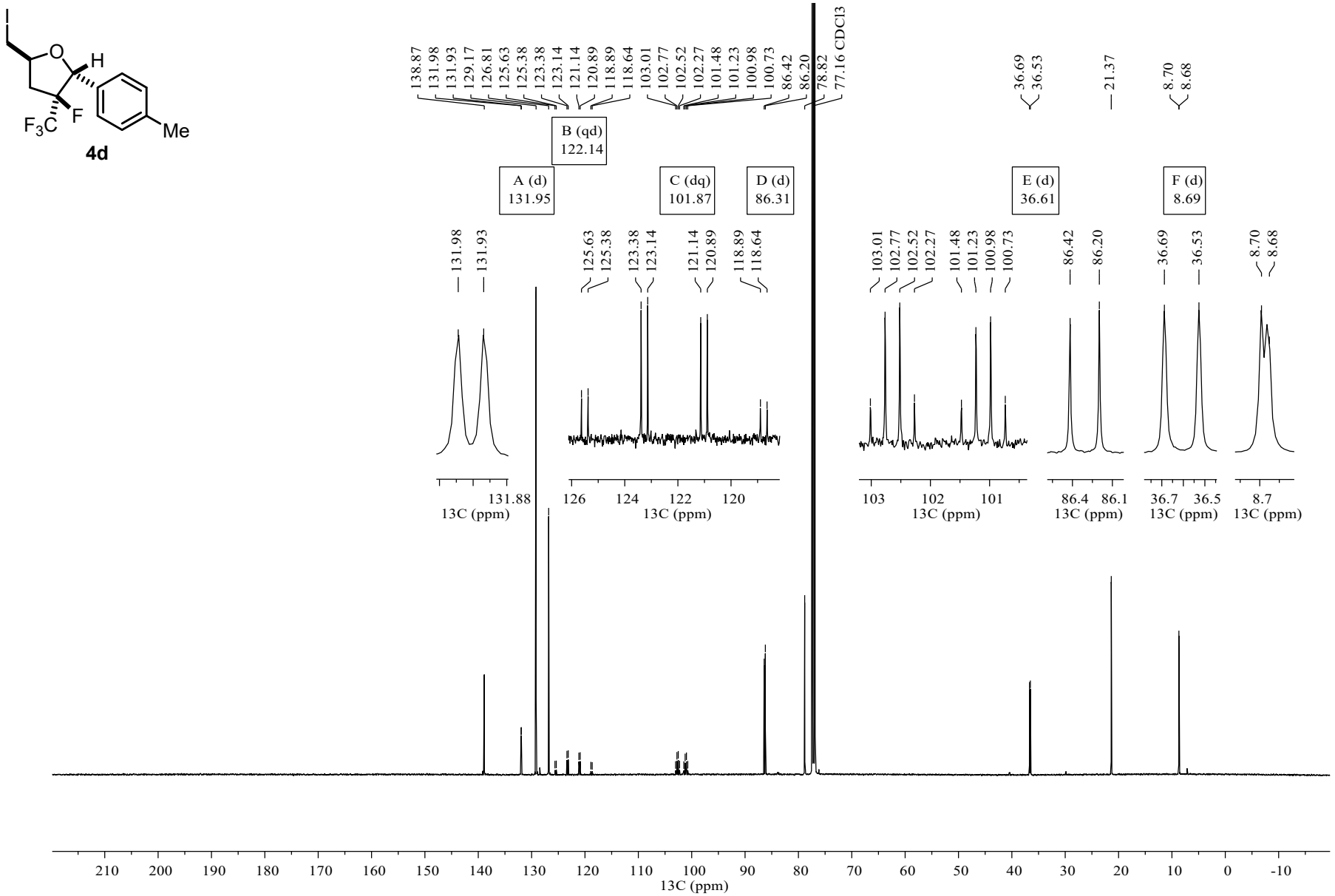
^{1}H-^{1}H COSY

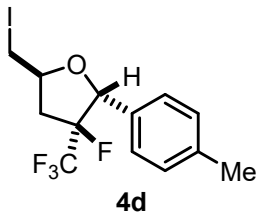

I
O
H
F
F3C
Cl

4c

0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
1H (ppm)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)


4d
7.26 CDCl3
A (m) 7.17
B (d) 5.42
C (tdd) 4.82
D (dd) 3.46
E (ddd) 3.39
F (ddd) 2.77
G (ddd) 2.58
H (s) 2.35
1H (ppm)

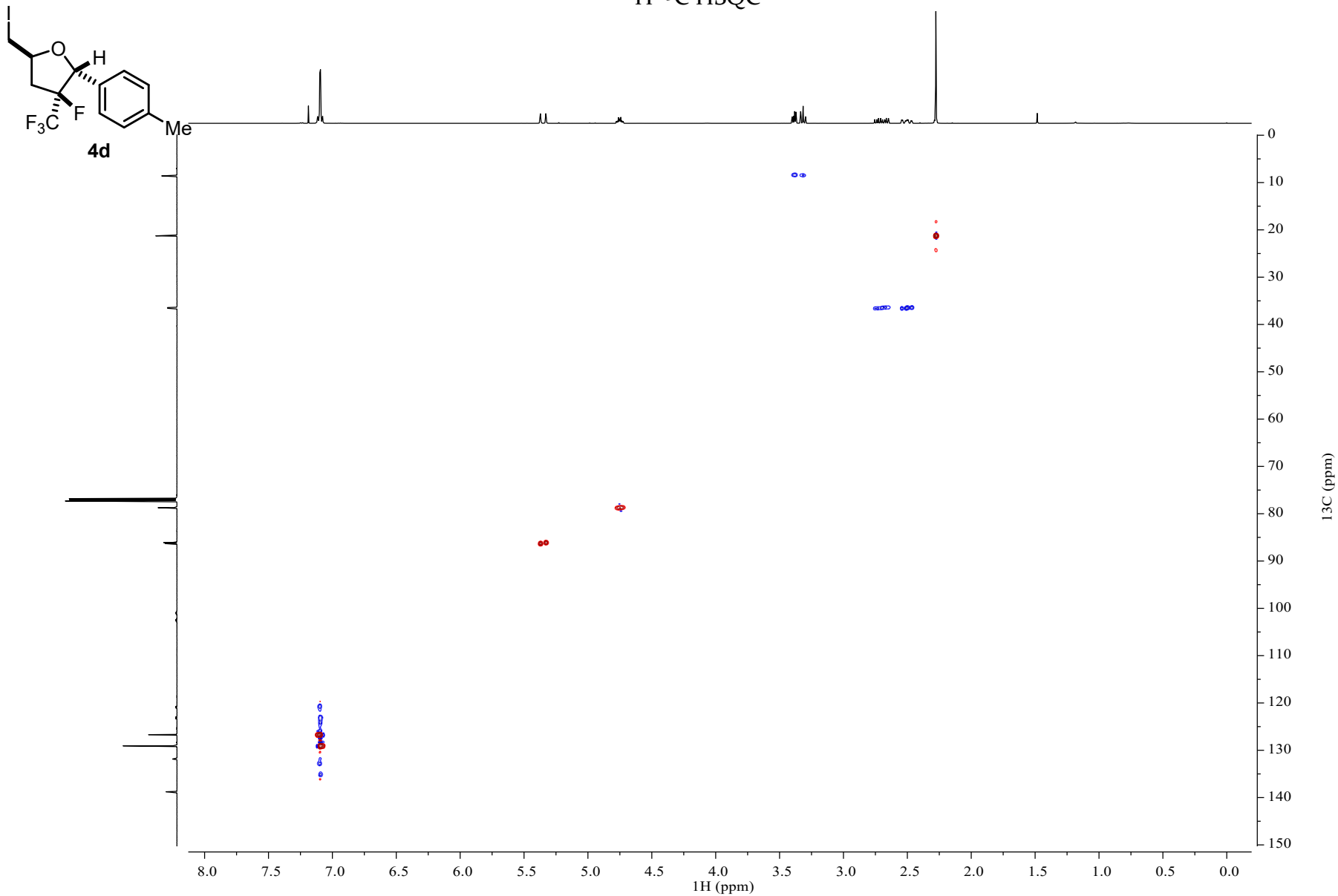

4d
138.87
131.98
131.93
129.17
126.81
125.63
125.38
123.38
123.14
121.14
120.89
118.89
118.64
103.01
102.77
102.52
102.27
101.48
101.23
100.98
100.73
86.42
86.20
78.82
77.16 CDCl3
36.69
36.53
21.37
8.70
8.68
B (qd)
122.14
A (d)
131.95
C (dq)
101.87
D (d)
86.31
E (d)
36.61
F (d)
8.69
13C (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

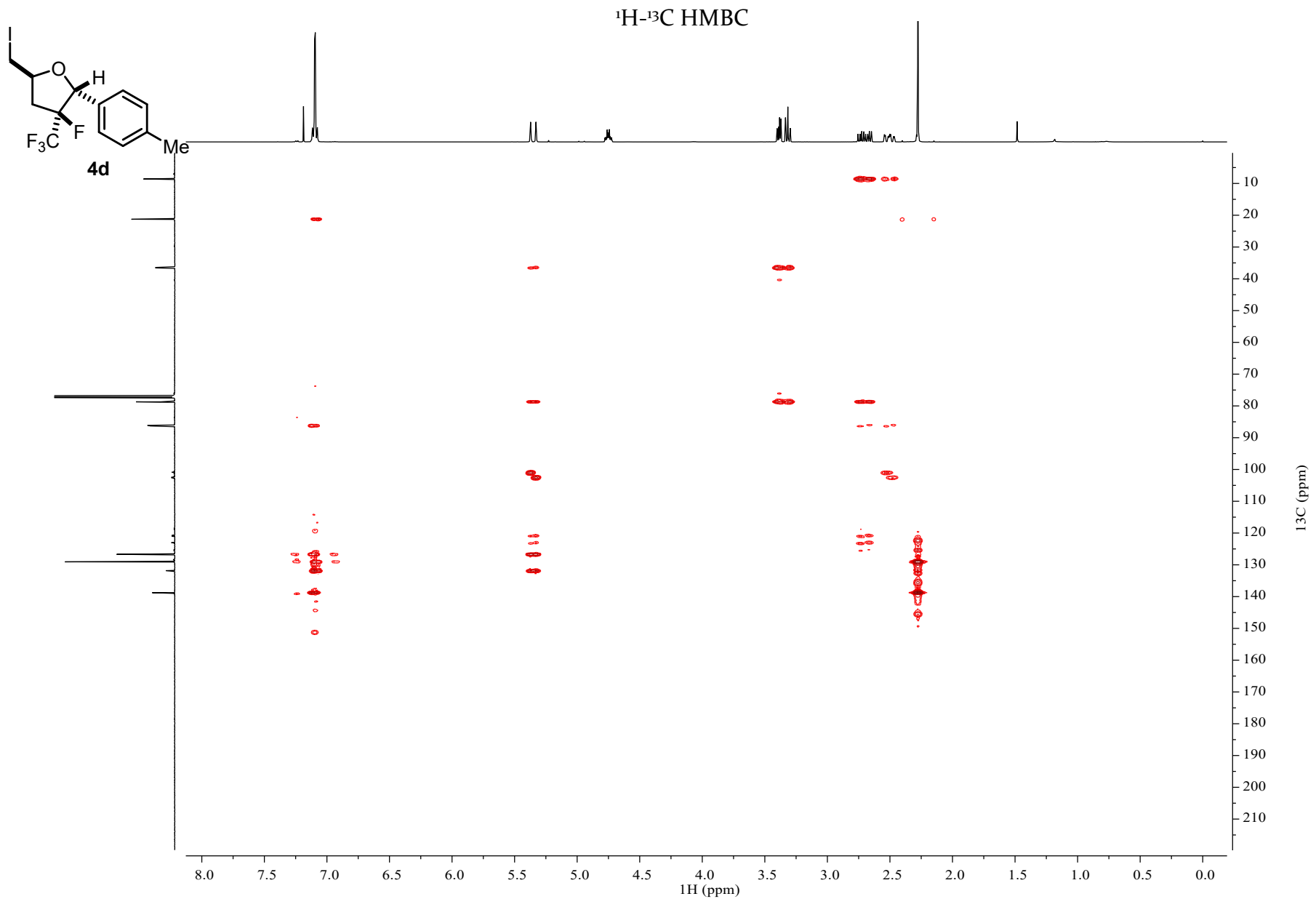

I
O
H
F
F3C
Me

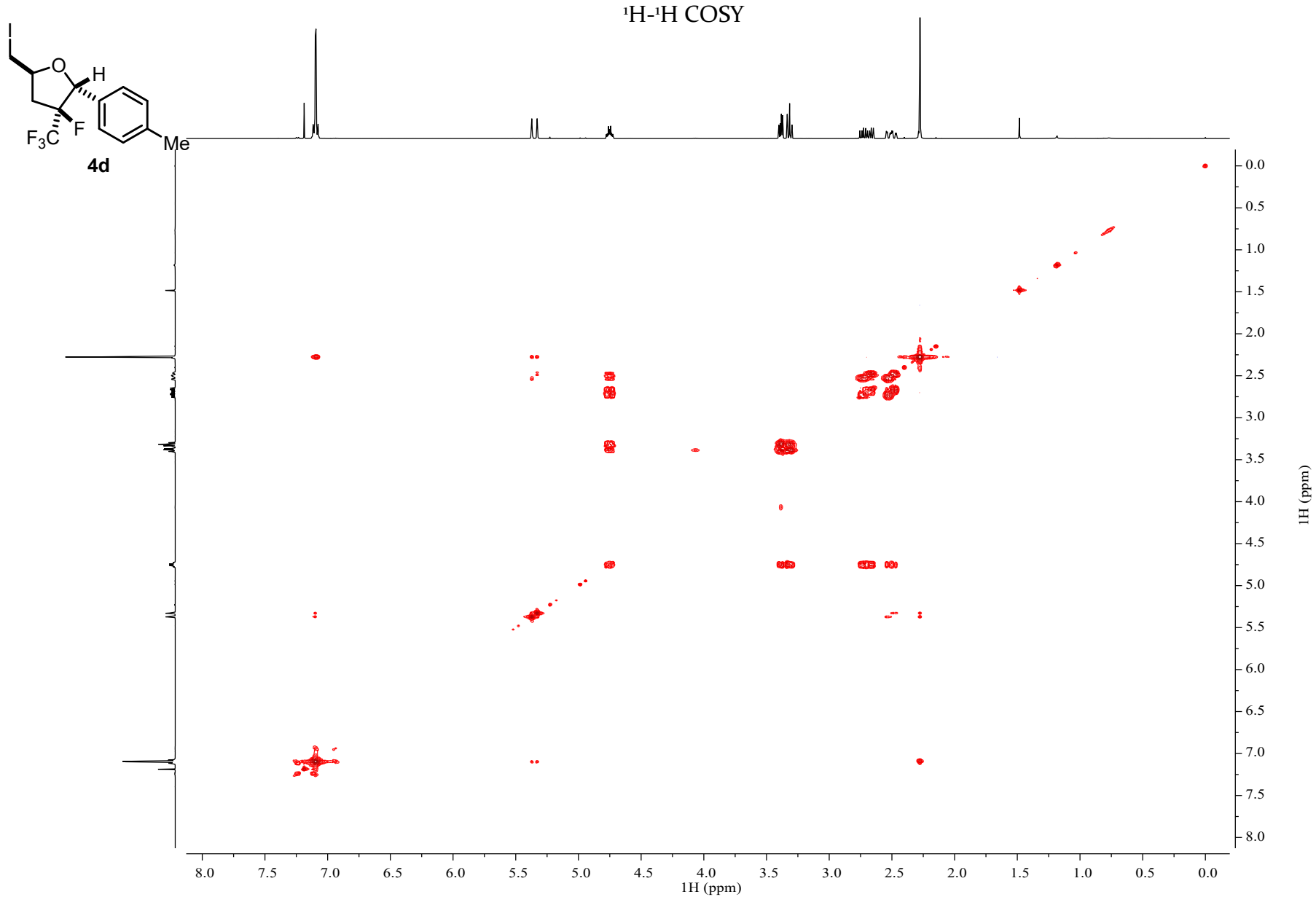
4d

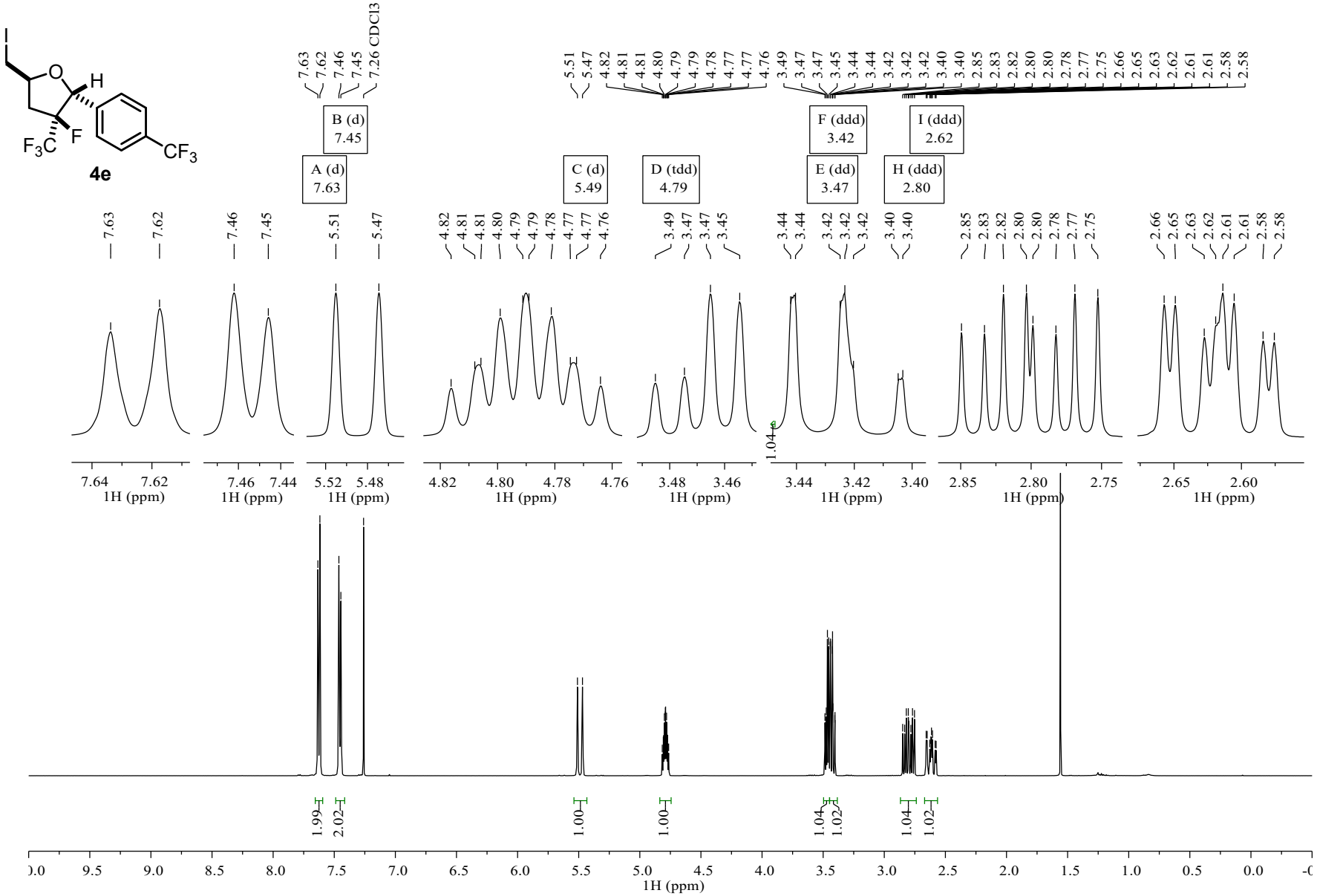
-75.62
-75.64
A (d)
-75.63
-157.37
-157.39
-157.40
-157.42
-157.43
-157.45
-157.47
-157.48
-157.50
-157.51
-157.53
-157.54
-157.56
-157.57
B (dtq)
-157.47
-75.60
-75.65
19F (ppm)
-157.40
-157.50
-157.60
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)

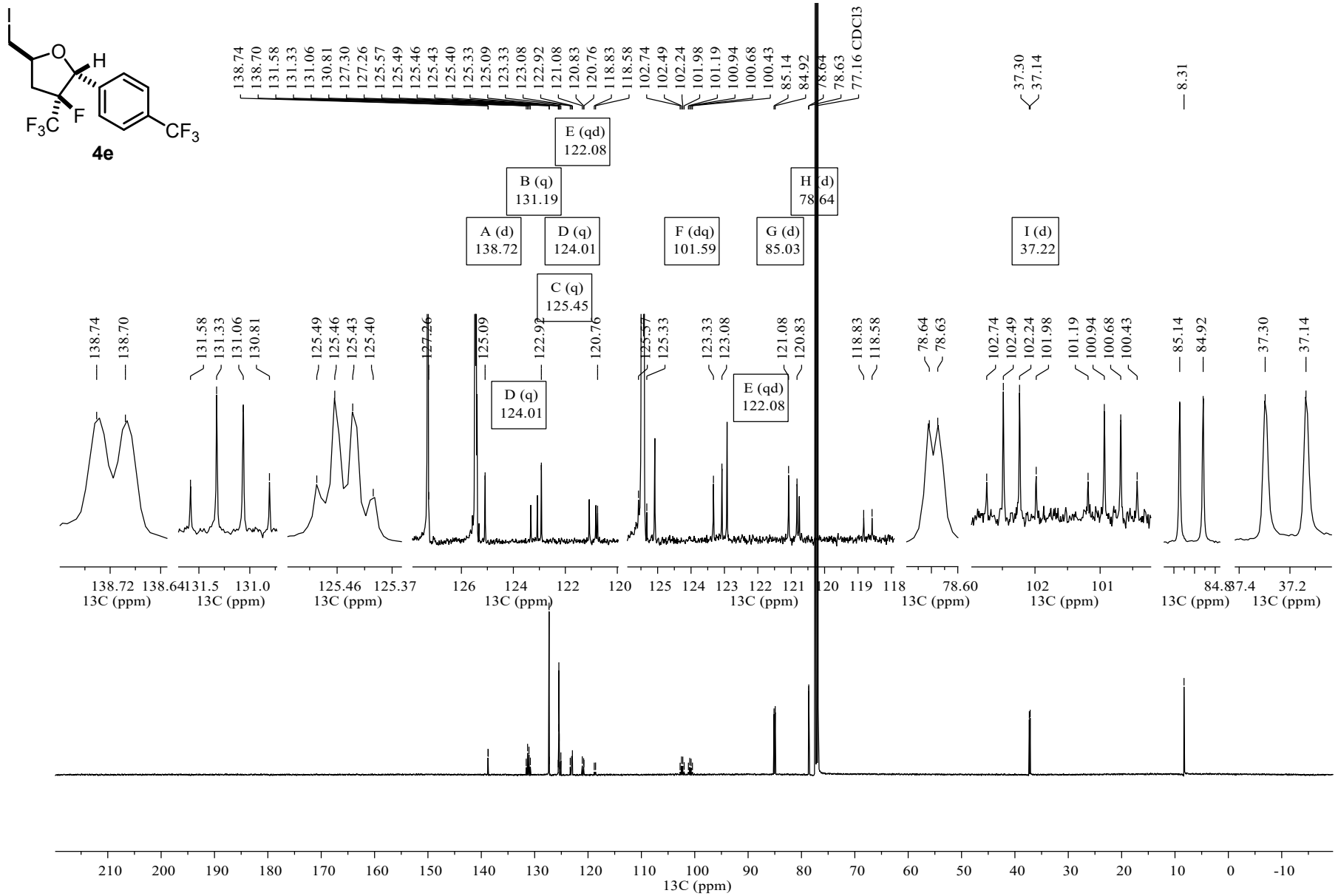
^{1}H-^{13}C HSQC

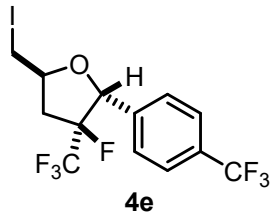

I
O
H
F
F3C
Me
4d
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
13C (ppm)


¹H-¹³C HMBC
4d
Me
F
H
O
F3C
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
13C (ppm)


¹H-¹H COSY
O
H
F
F3C
Me
4d
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)
1H (ppm)


4e
7.63
7.62
7.46
7.45
7.26 CDCl3
5.51
5.47
4.82
4.81
4.81
4.80
4.79
4.79
4.78
4.77
4.77
4.76
3.49
3.47
3.47
3.45
3.44
3.44
3.42
3.42
3.42
3.40
3.40
2.85
2.83
2.82
2.80
2.80
2.78
2.77
2.75
2.66
2.65
2.63
2.62
2.61
2.61
2.58
2.58
A (d) 7.63
B (d) 7.45
C (d) 5.49
D (tdd) 4.79
E (dd) 3.47
F (ddd) 3.42
H (ddd) 2.80
I (ddd) 2.62
1.04
1.99
2.02
1.00
1.00
1.04
1.02
1.04
1.02
1H (ppm)

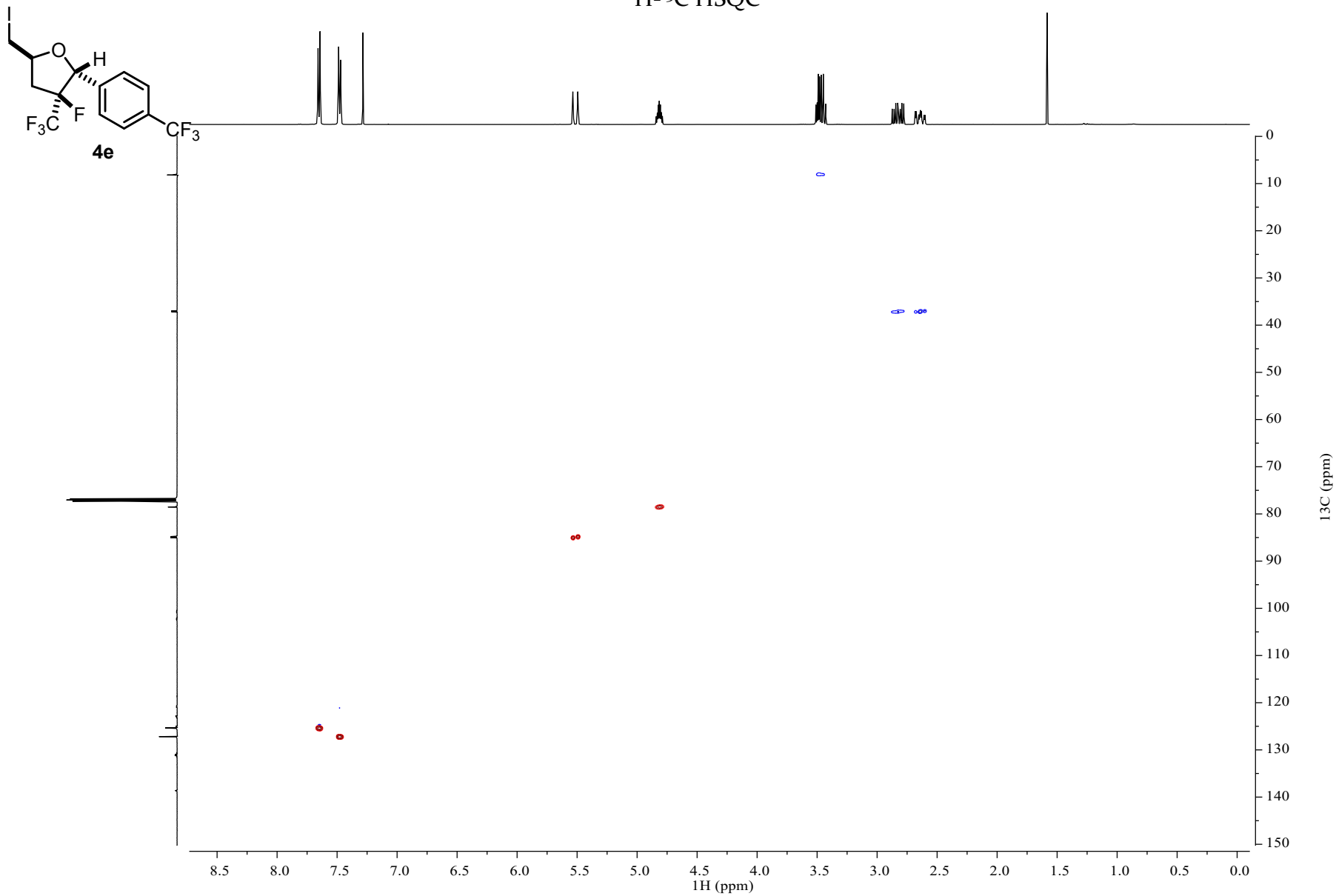

4e
138.74
138.70
131.58
131.33
131.06
130.81
127.30
127.26
125.57
125.49
125.46
125.43
125.40
125.33
125.09
123.33
123.08
122.92
121.08
120.83
120.76
118.83
118.58
102.74
102.49
102.24
101.98
101.19
100.94
100.68
100.43
85.14
84.92
78.64
78.63
77.16 CDCl3
37.30
37.14
8.31
E (qd)
122.08
B (q)
131.19
H (d)
78.64
A (d)
138.72
D (q)
124.01
F (dq)
101.59
G (d)
85.03
I (d)
37.22
C (q)
125.45
13C (ppm)

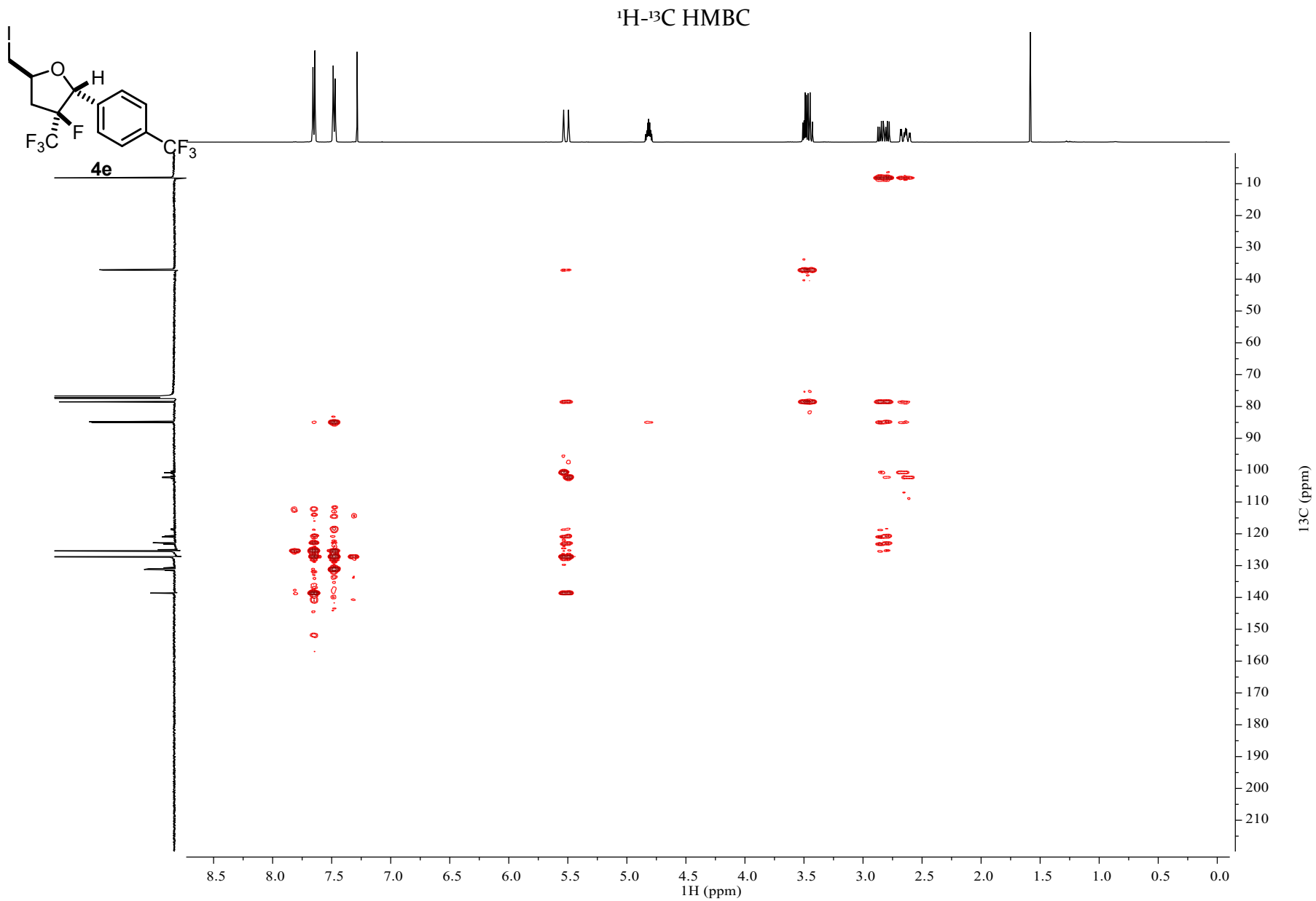

I
O
H
F
F3C
CF3

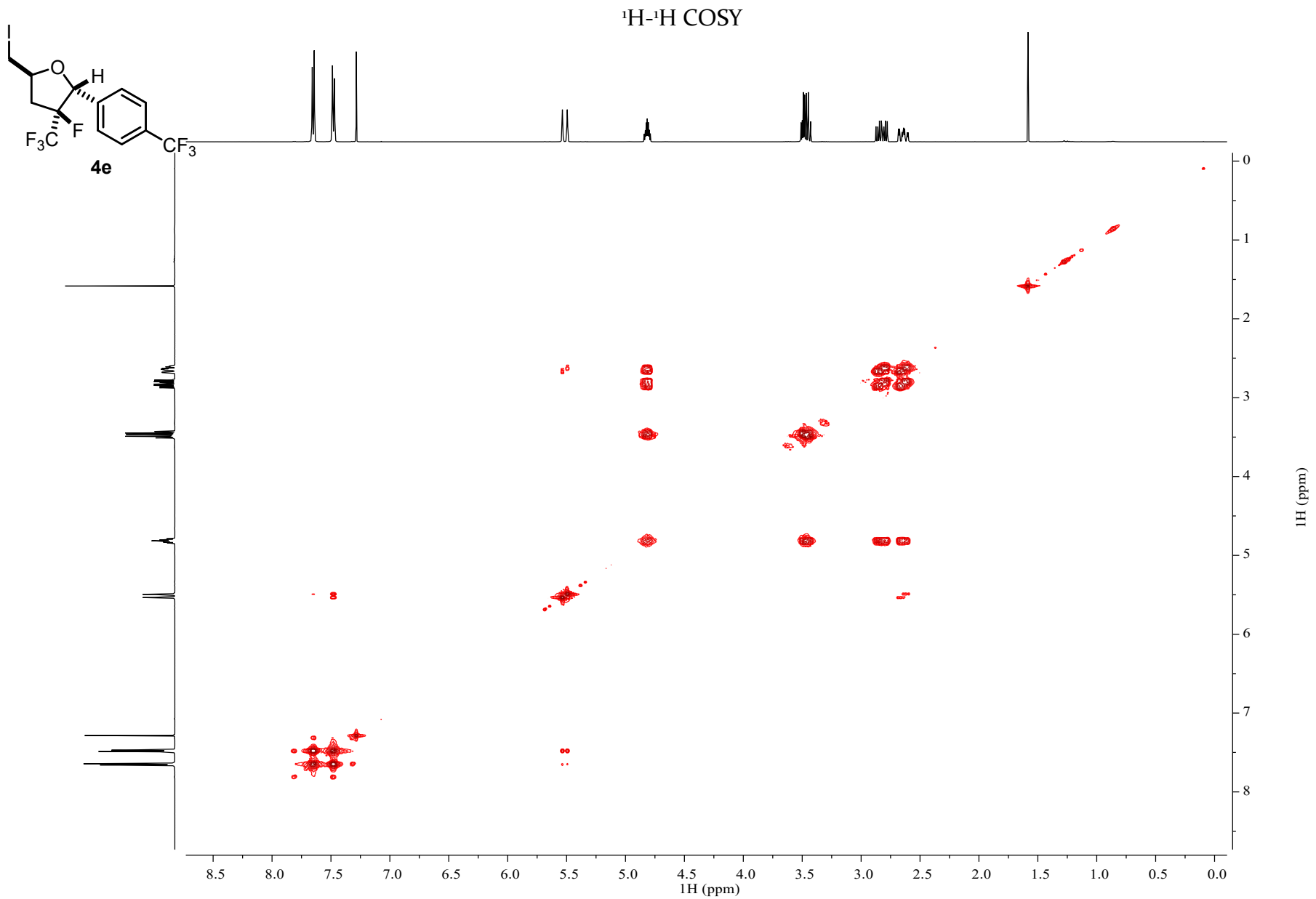
4e

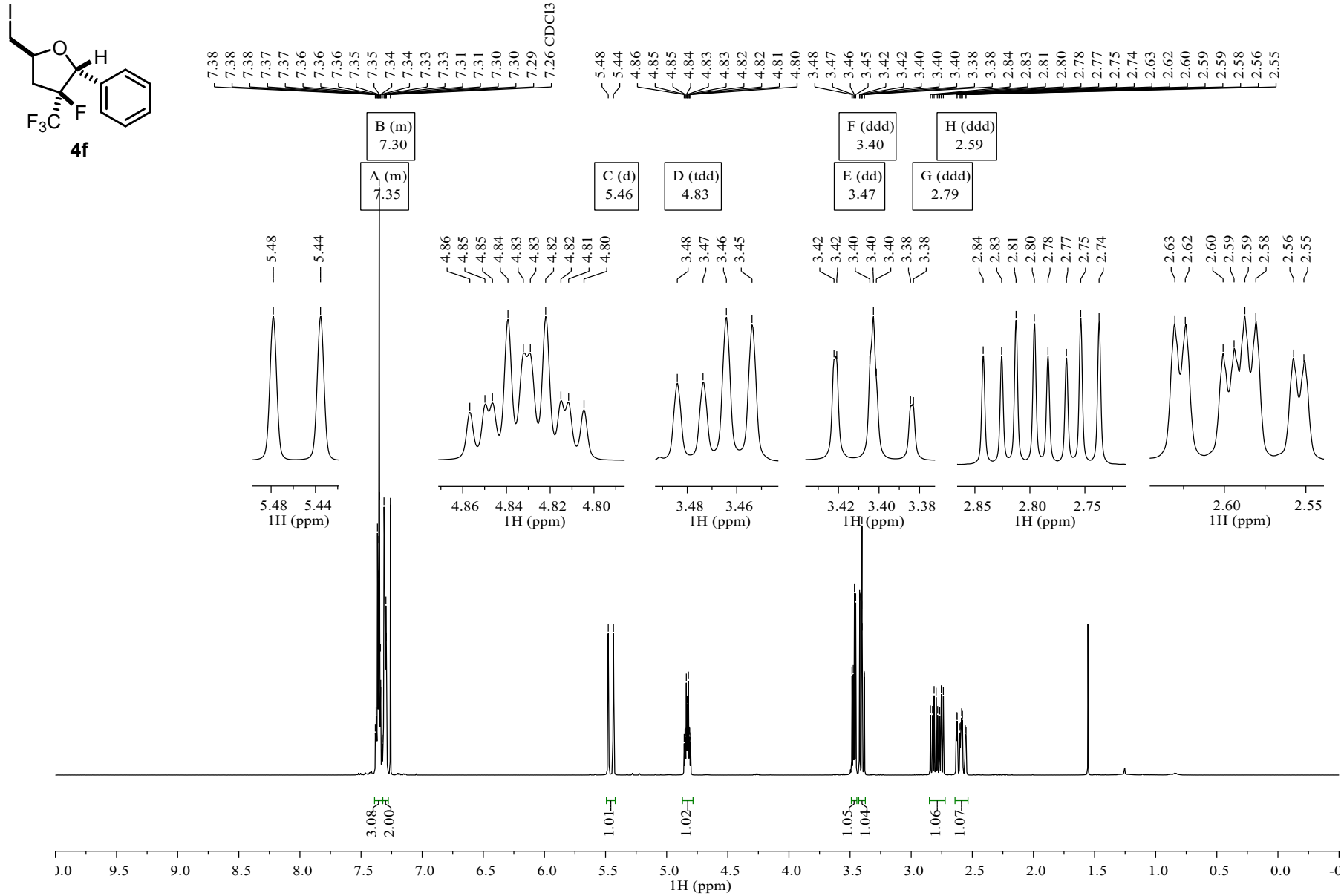
-62.69
-75.86
-75.88
-159.66
-159.68
-159.69
-159.71
-159.72
-159.74
-159.75
-159.77
-159.78
-159.78
-159.79
-159.81
-159.82
-159.84
-159.85
A (d)
-75.87
B (m)
-159.76
-75.86
-75.88
-75.86
-75.88
19F (ppm)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
19F (ppm)

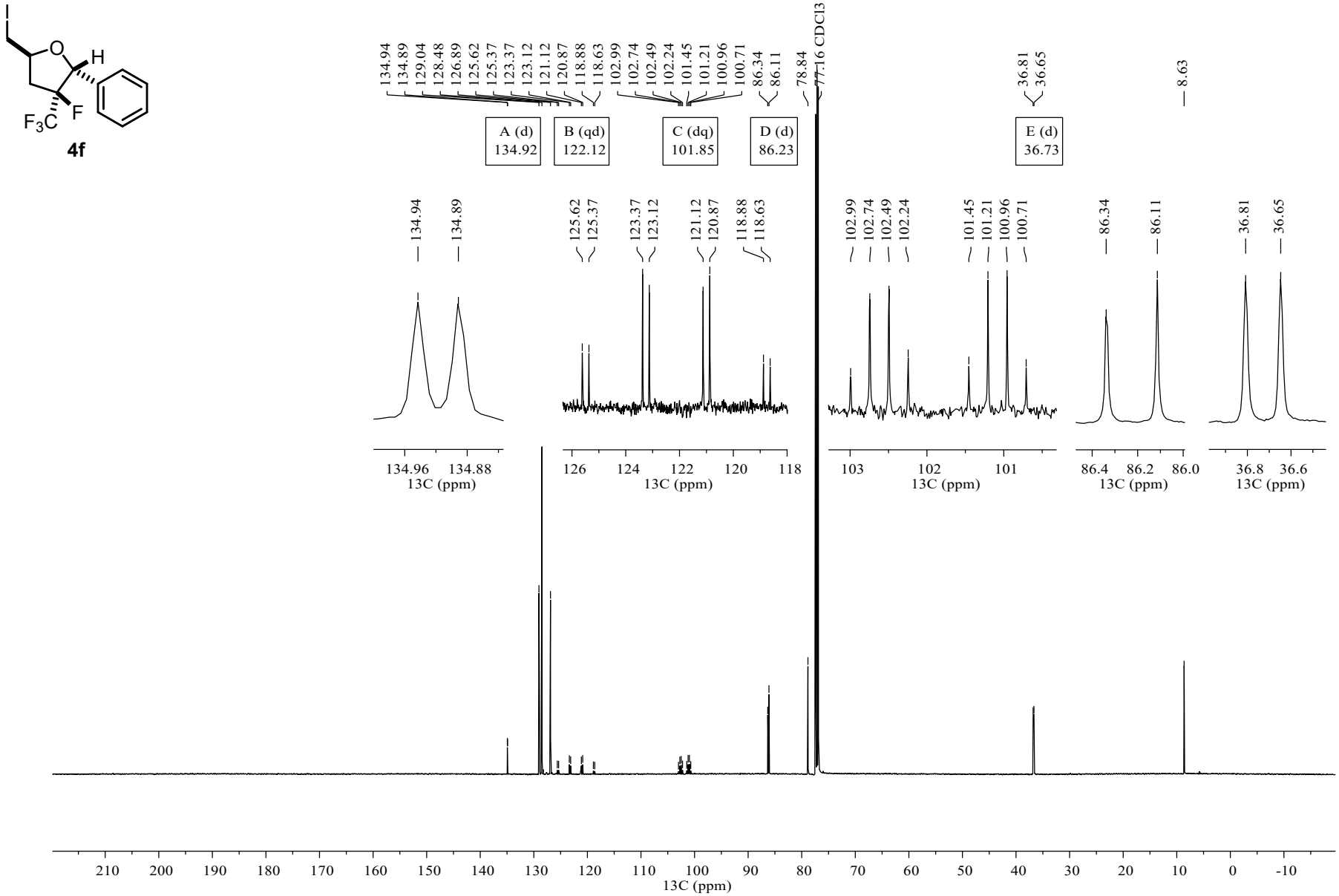
^{1}H-^{13}C HSQC

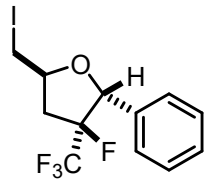

I
O
H
F
F3C
CF3
4e
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
13C (ppm)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)


¹H-¹³C HMBC
4e
1H (ppm)
13C (ppm)


^{1}H-^{1}H COSY
4e
1H (ppm)
1H (ppm)


4f
B (m) 7.30
A (m) 7.35
C (d) 5.46
D (tdd) 4.83
F (ddd) 3.40
E (dd) 3.47
H (ddd) 2.59
G (ddd) 2.79
CDCl3
1H (ppm)

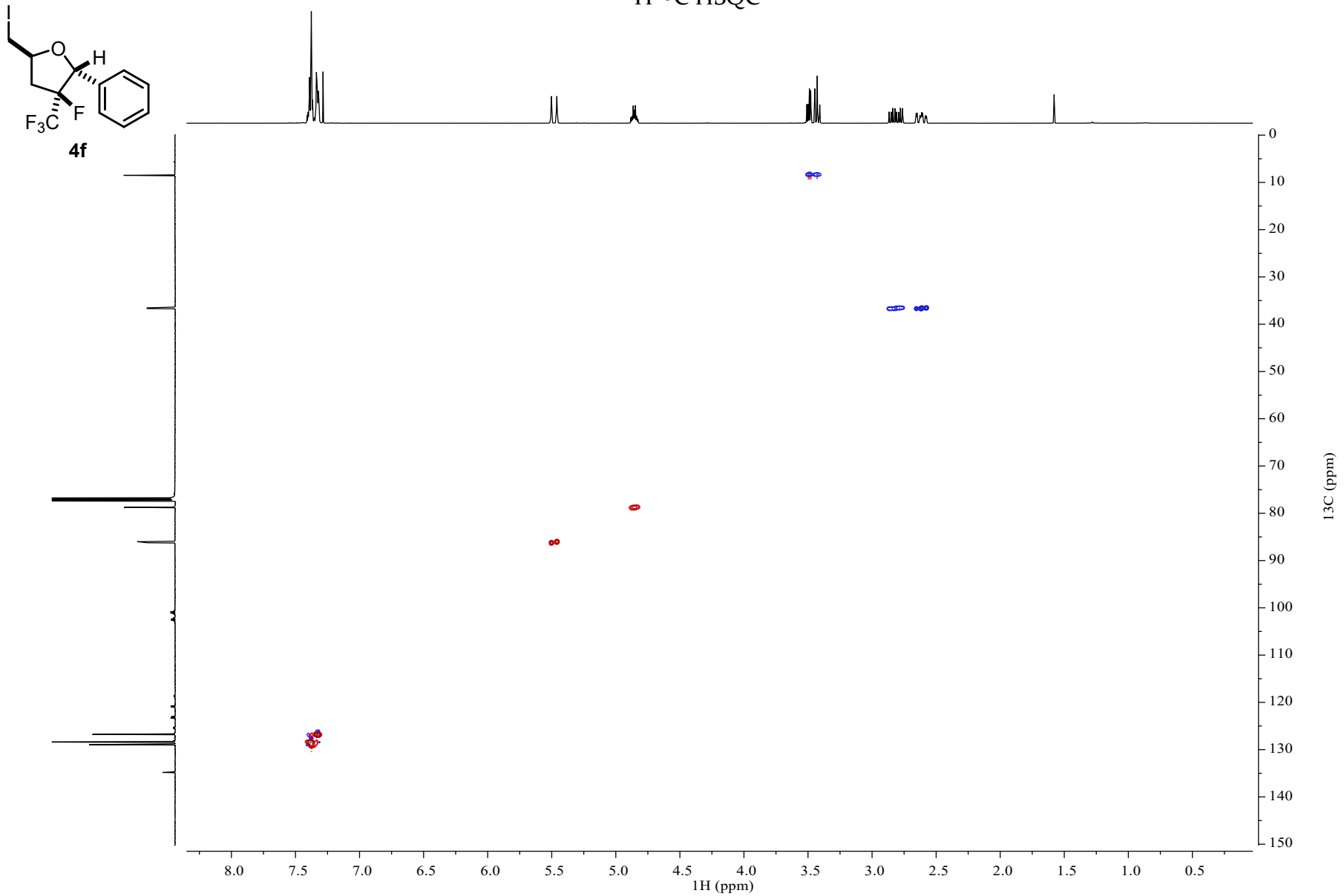

4f
134.94
134.89
129.04
128.48
126.89
125.62
125.37
123.37
123.12
121.12
120.87
118.88
118.63
102.99
102.74
102.49
102.24
101.45
101.21
100.96
100.71
86.34
86.11
78.84
77.16 CDCl3
36.81
36.65
8.63
A (d) 134.92
B (qd) 122.12
C (dq) 101.85
D (d) 86.23
E (d) 36.73
134.96 134.88 13C (ppm)
126 124 122 120 118 13C (ppm)
103 102 101 13C (ppm)
86.4 86.2 86.0 13C (ppm)
36.8 36.6 13C (ppm)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
13C (ppm)

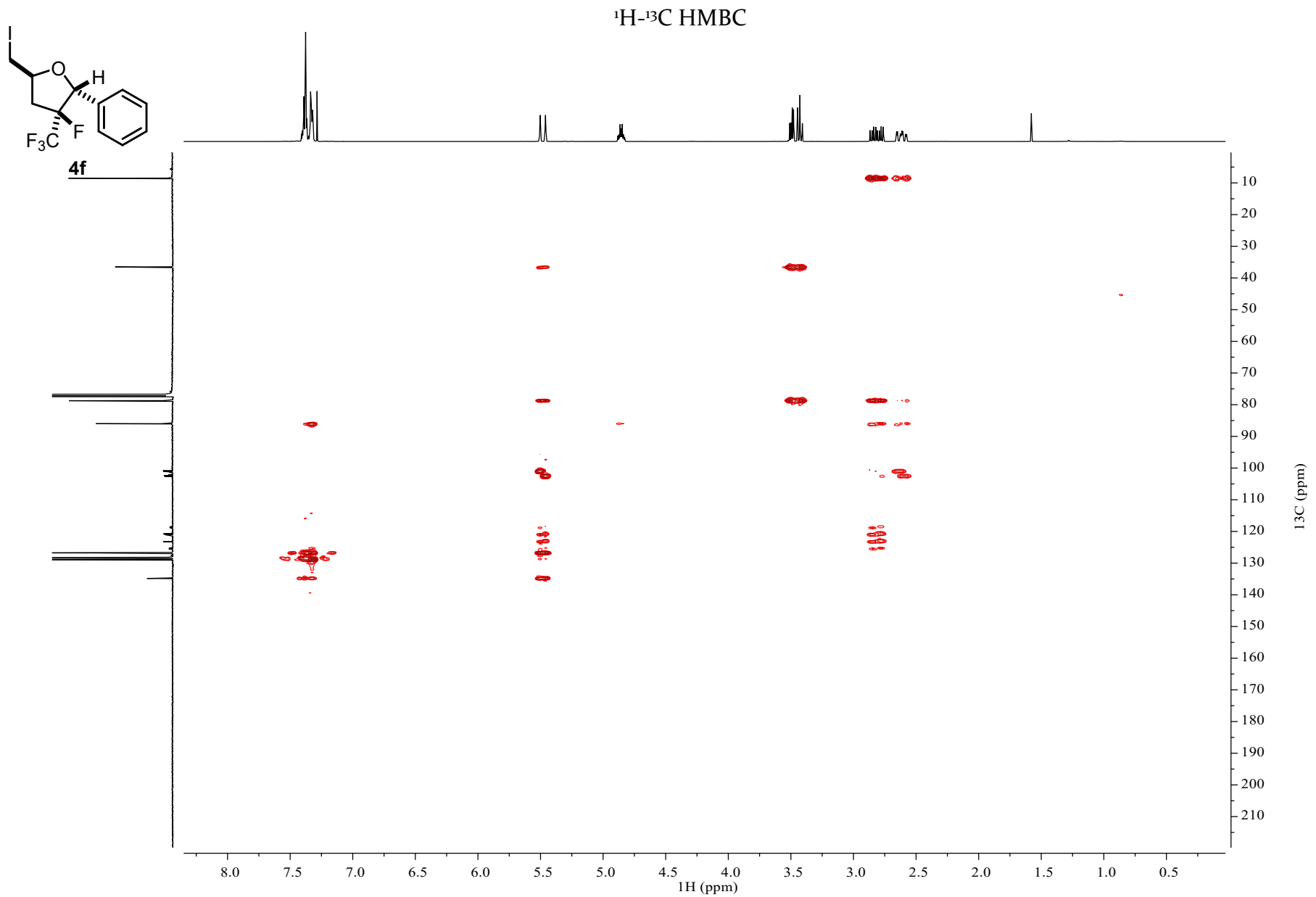

I
O
H
F
F3C

4f

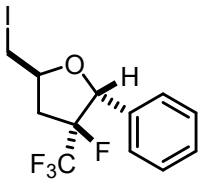
-75.70
-75.71
A (d)
-75.71
-157.82
-157.83
-157.85
-157.86
-157.88
-157.90
-157.91
-157.93
-157.94
-157.96
-157.97
-157.99
-158.00
-158.02
B (dtq)
-157.92
-75.68
-75.72
19F (ppm)
-157.80
-157.85
-157.90
-157.95
-158.00
19F (ppm)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
19F (ppm)

^{1}H-^{13}C HSQC


I
O
H
F
F3C
4f
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
13C (ppm)

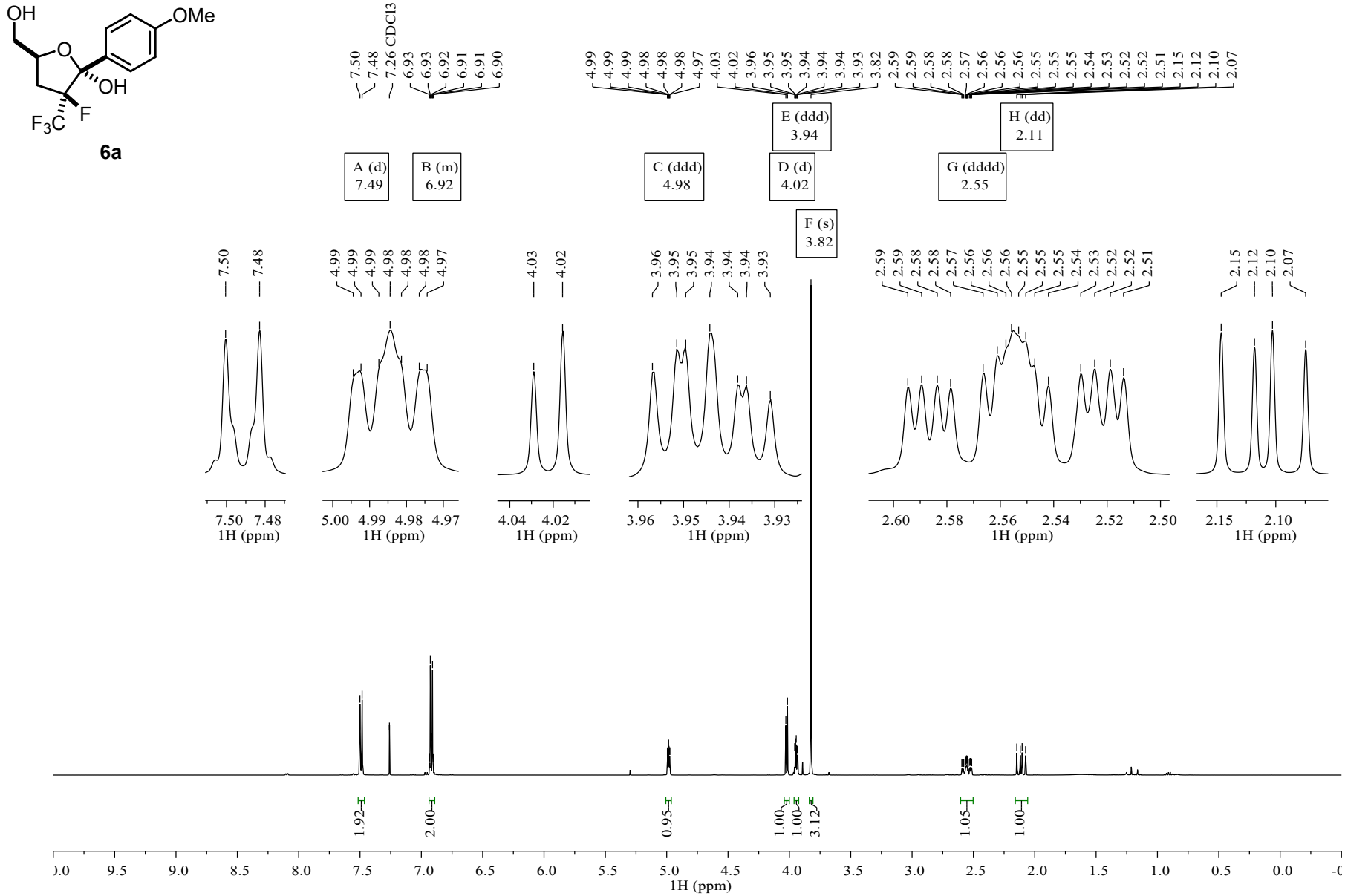

¹H-¹³C HMBC
4f
O
H
F
F3C
1H (ppm)
13C (ppm)

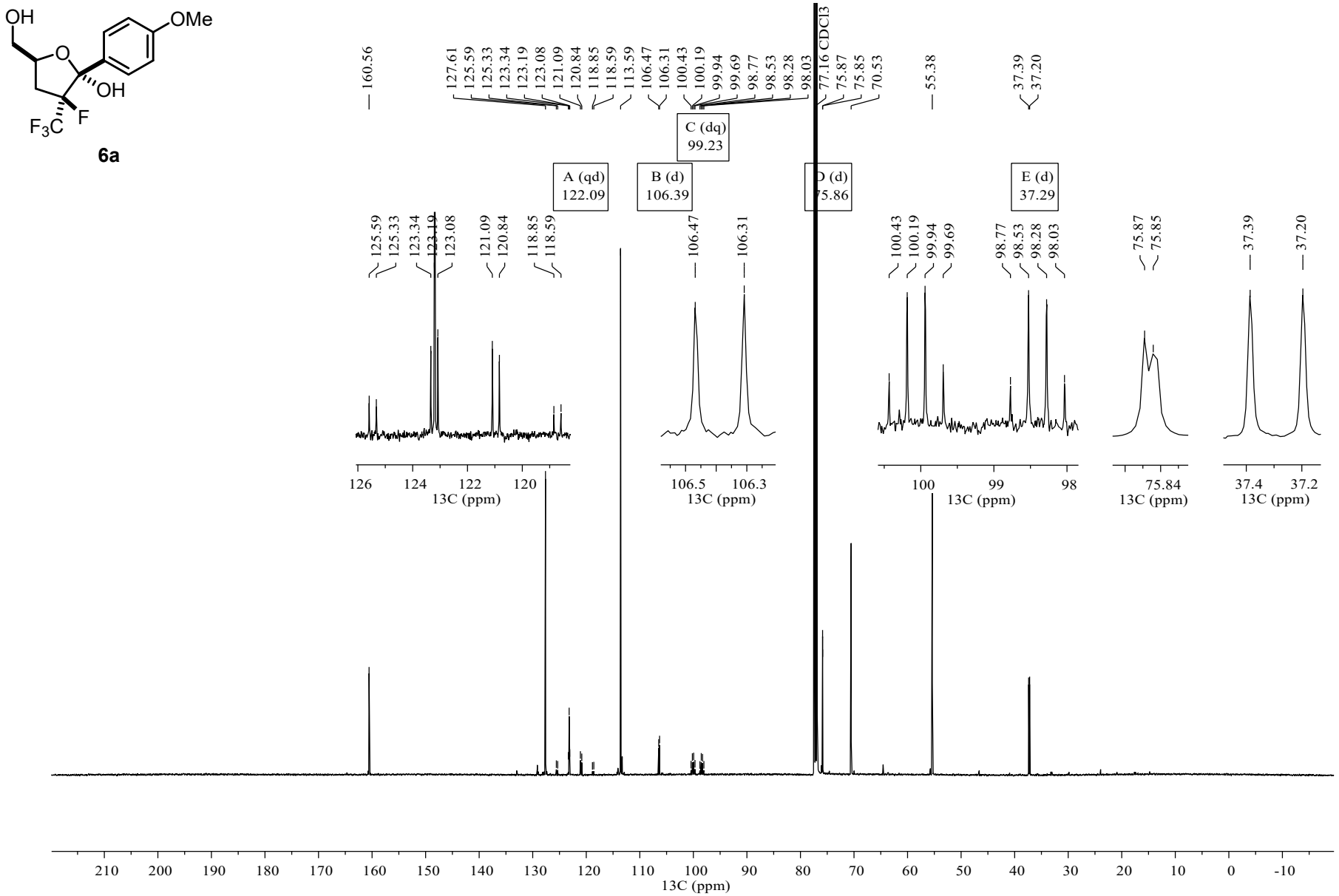
^{1}H-^{1}H COSY

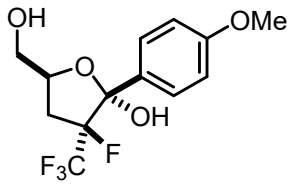

I
O
H
F
F3C

4f

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1H (ppm)
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
1H (ppm)

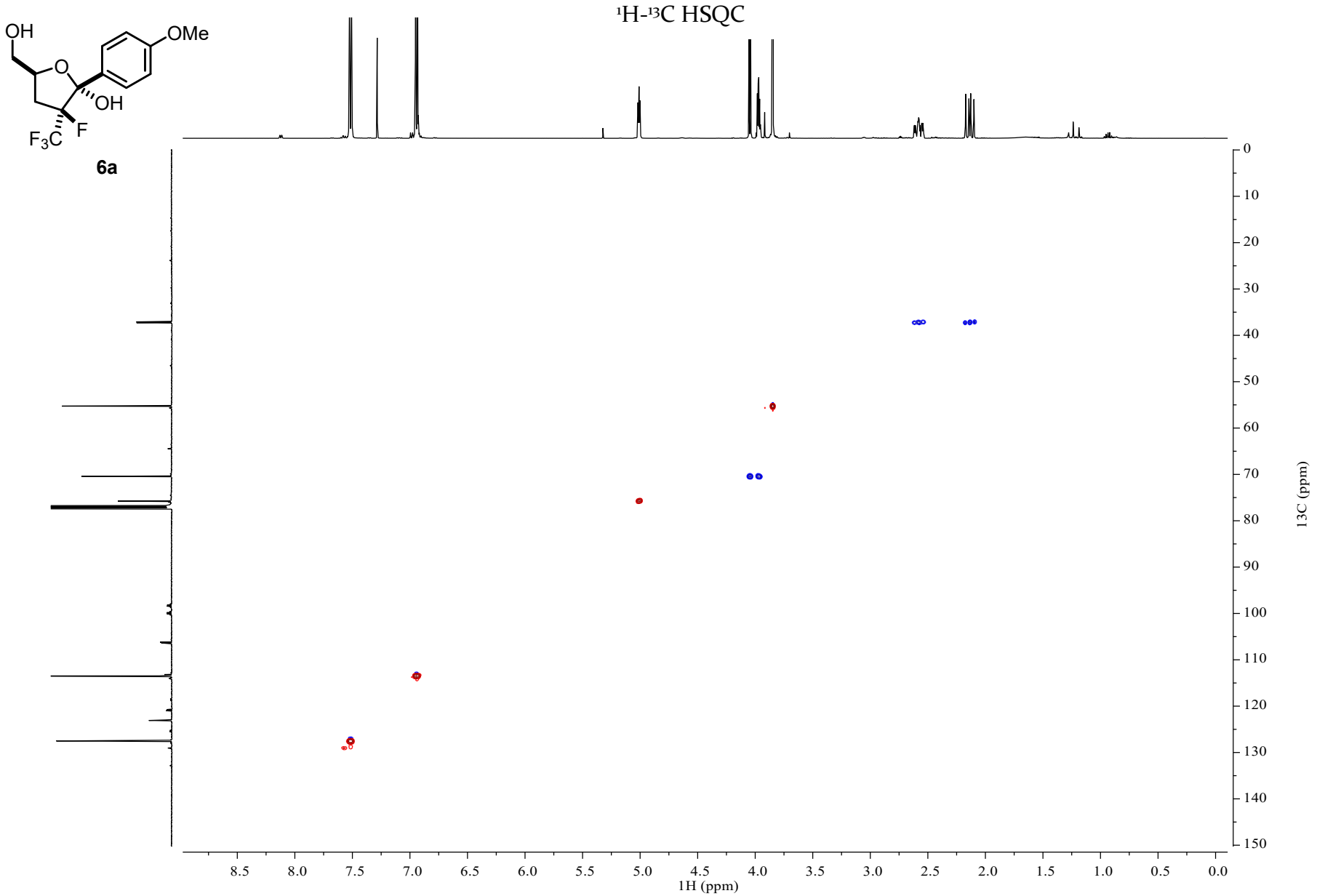

OH
OMe
O
OH
F3C
F
6a
7.50
7.48
7.26 CDCl3
6.93
6.92
6.91
6.91
6.90
4.99
4.99
4.99
4.98
4.98
4.97
4.03
4.02
3.96
3.95
3.95
3.94
3.94
3.94
3.93
3.82
2.59
2.59
2.58
2.58
2.57
2.56
2.56
2.56
2.55
2.55
2.55
2.54
2.53
2.52
2.52
2.51
2.15
2.12
2.10
2.07
A (d) 7.49
B (m) 6.92
C (ddd) 4.98
D (d) 4.02
E (ddd) 3.94
F (s) 3.82
G (dddd) 2.55
H (dd) 2.11
1H (ppm)
1.92
2.00
0.95
1.00
1.00
3.12
1.05
1.00

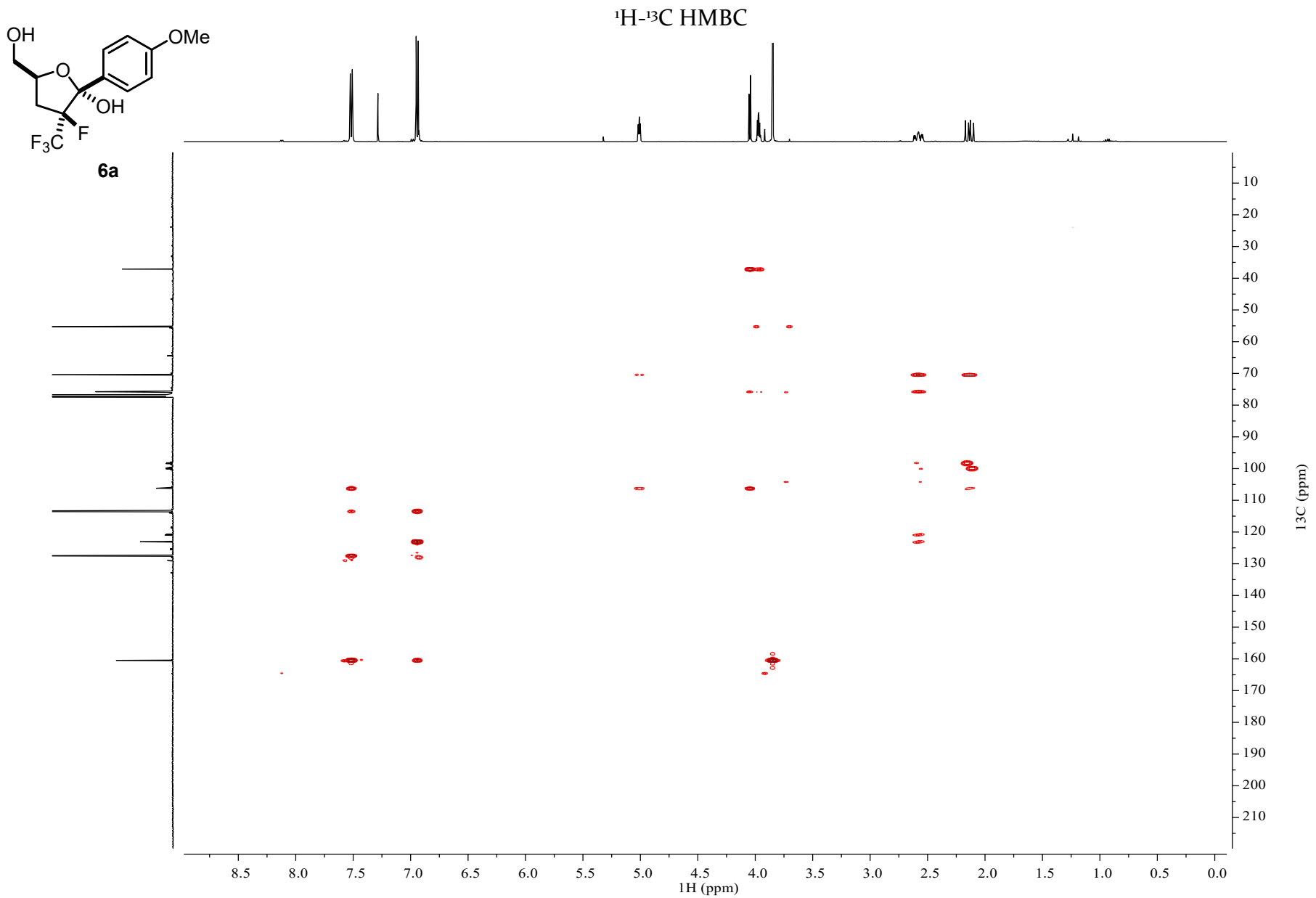

OH
OMe
O
OH
F3C
F
6a
160.56
127.61
125.59
125.33
123.34
123.19
123.08
121.09
120.84
118.85
118.59
113.59
106.47
106.31
100.43
100.19
99.94
99.69
98.77
98.53
98.28
98.03
77.16 CDCl3
75.87
75.85
70.53
55.38
37.39
37.20
C (dq)
99.23
A (qd)
122.09
B (d)
106.39
D (d)
75.86
E (d)
37.29
13C (ppm)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10

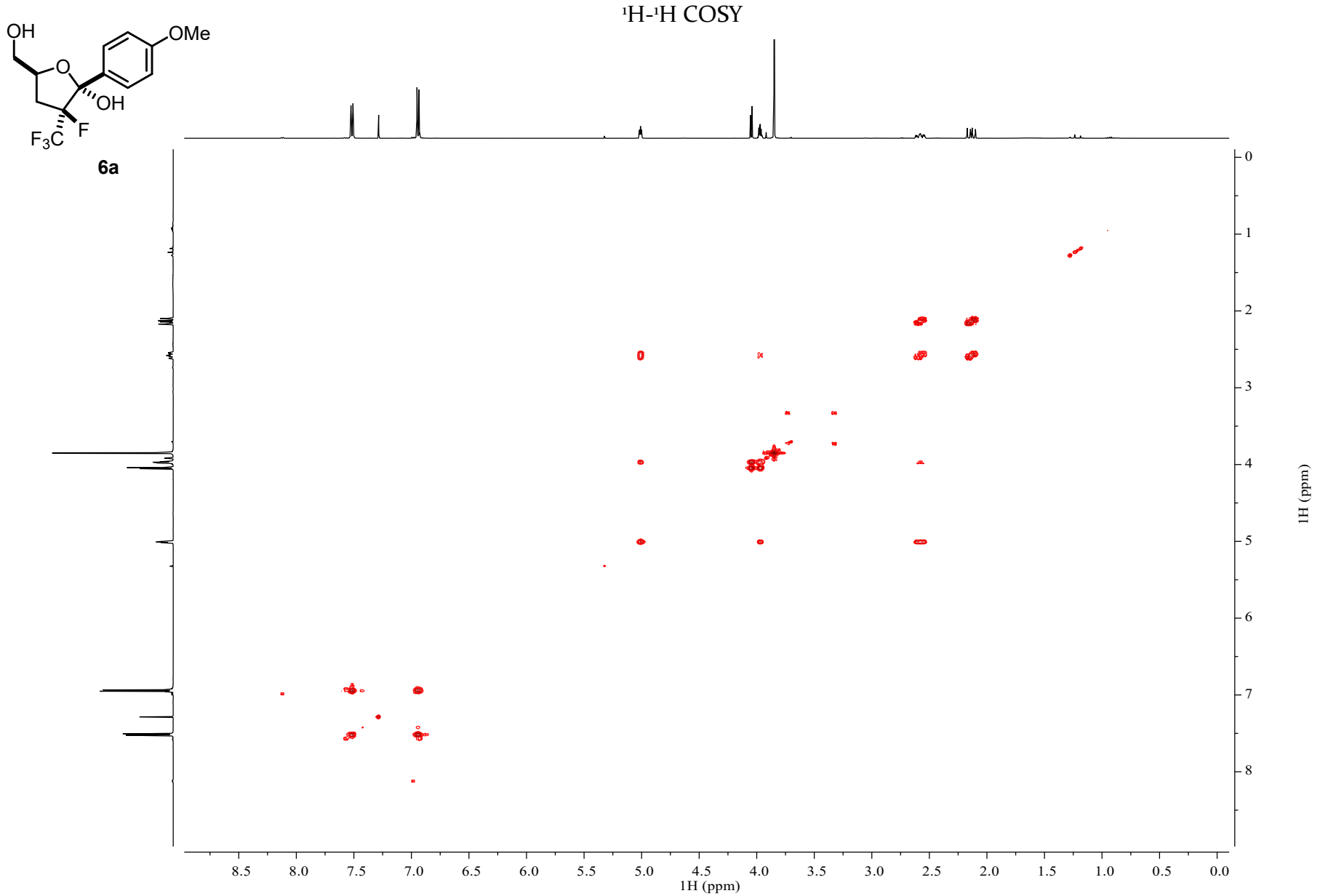

OH
OMe
O
OH
F
F3C

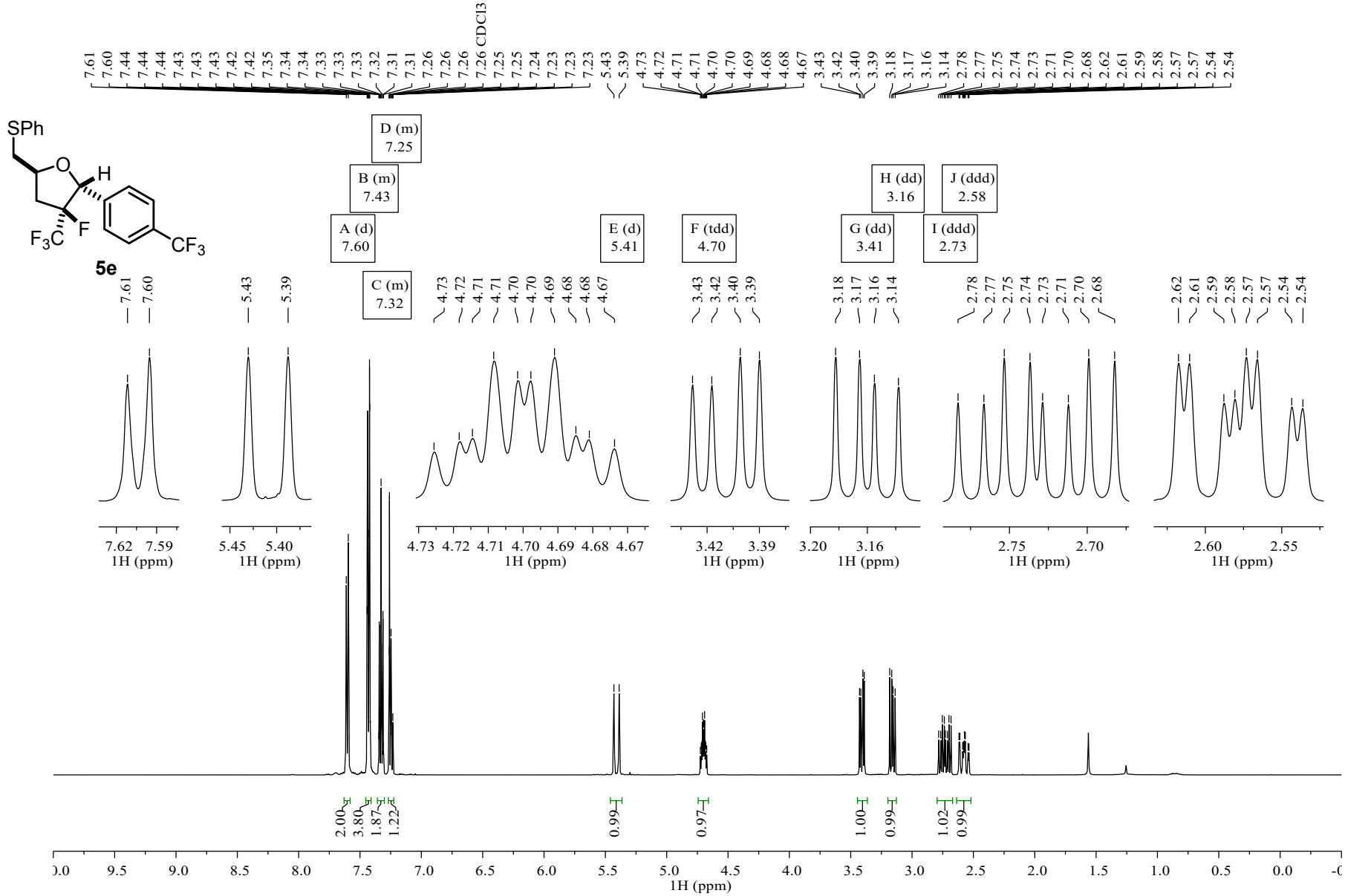
6a

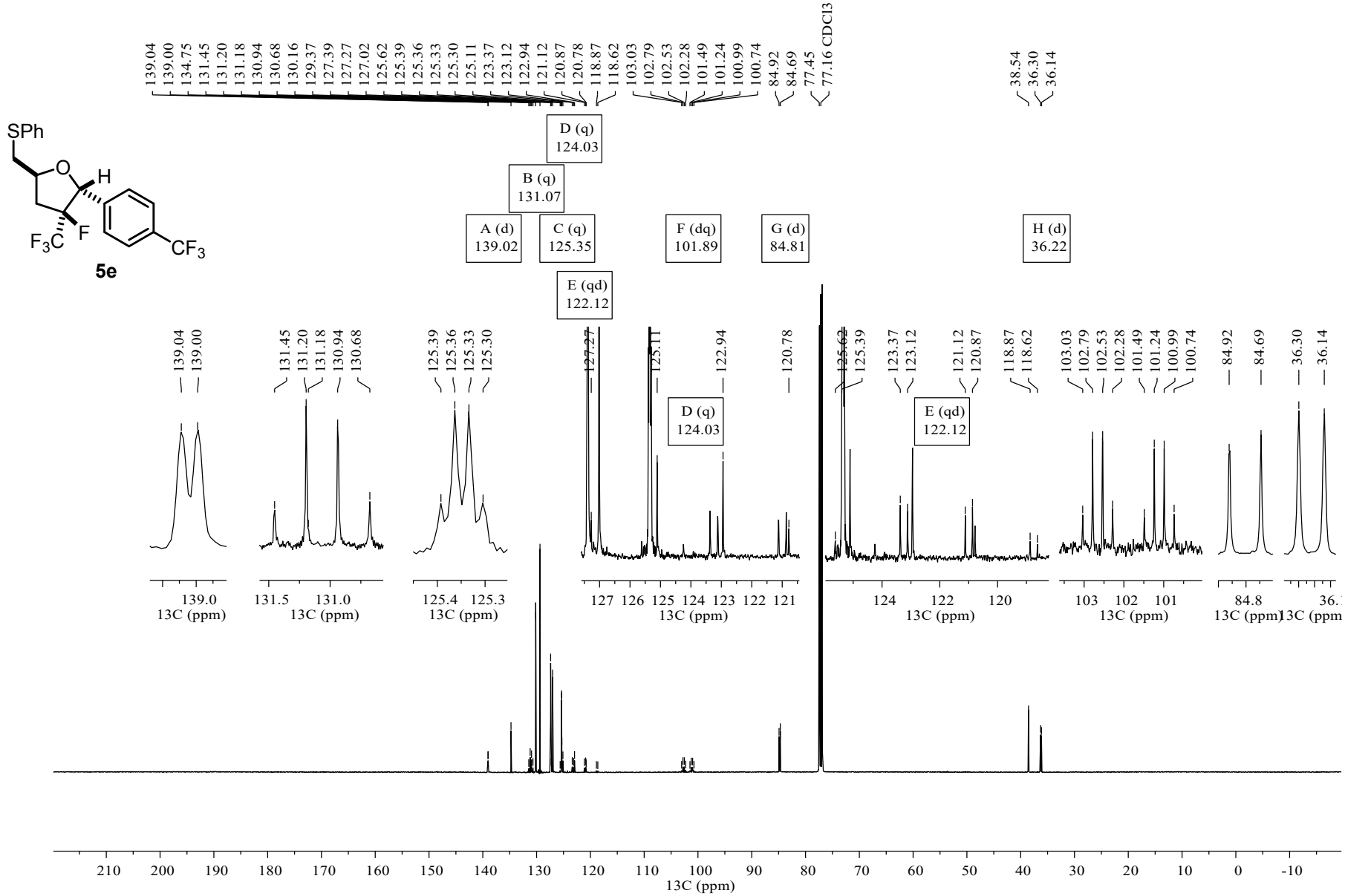
-78.82
-78.84
A (d)
-78.83
-177.52
-177.54
-177.56
-177.58
-177.59
-177.60
-177.61
-177.63
-177.64
-177.66
B (m)
-177.59
-78.82
-78.84
-78.82
-78.86
19F (ppm)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
19F (ppm)

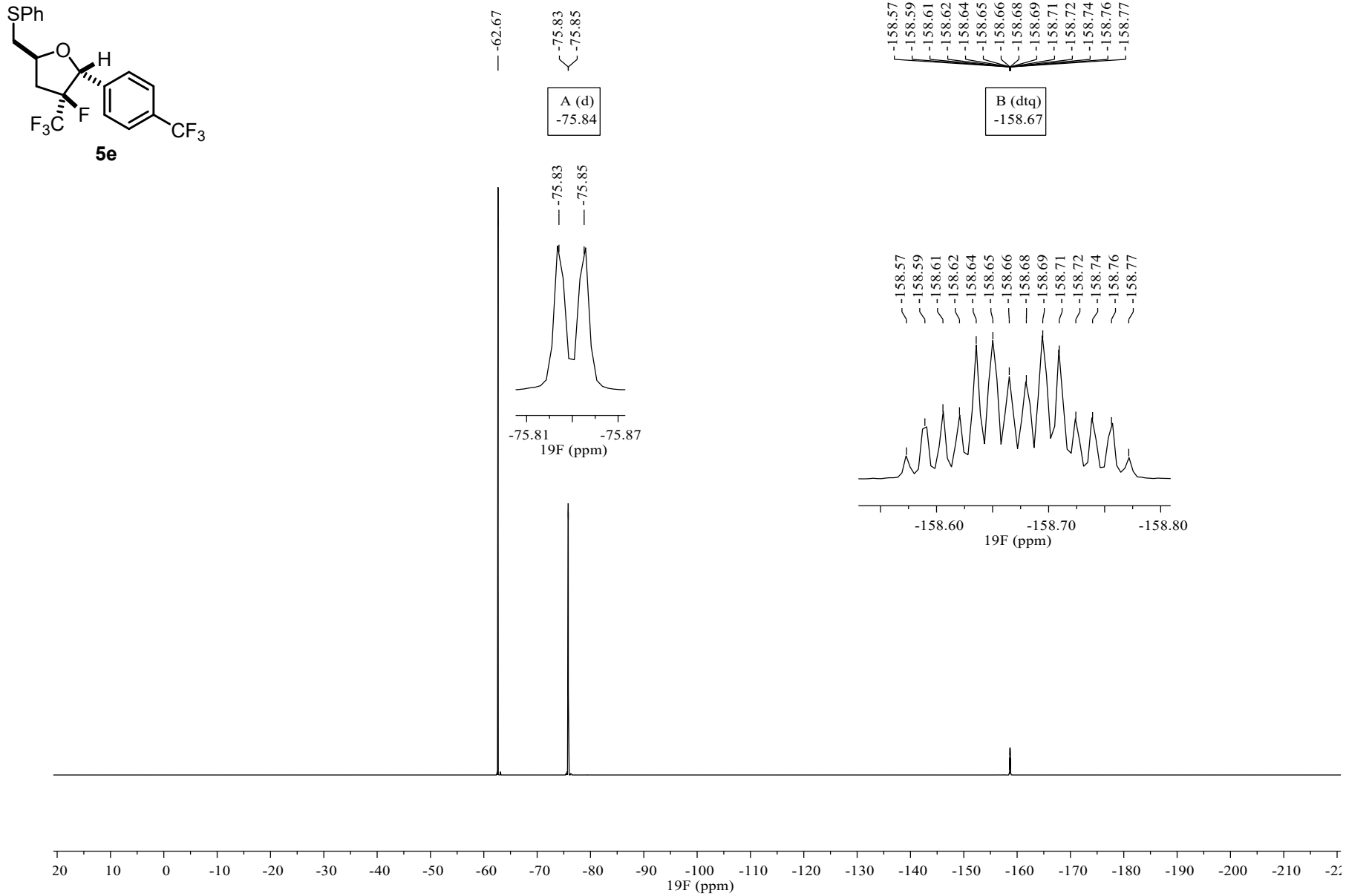

OH
OMe
O
OH
F
F3C
6a
1H-13C HSQC
1H (ppm)
13C (ppm)

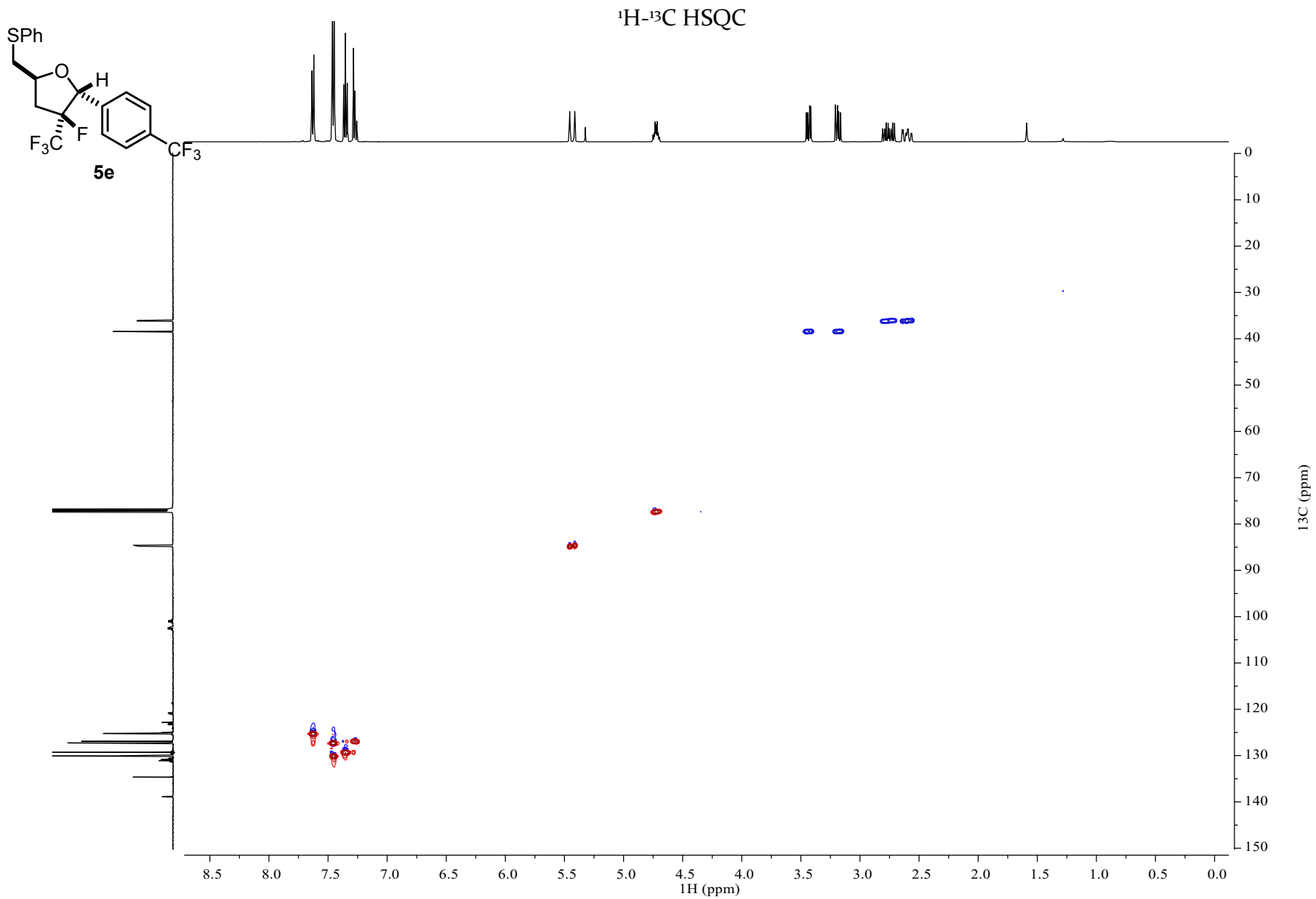

^{1}H-^{13}C HMBC
OH
OMe
O
OH
F_3C
F
6a
13C (ppm)
1H (ppm)

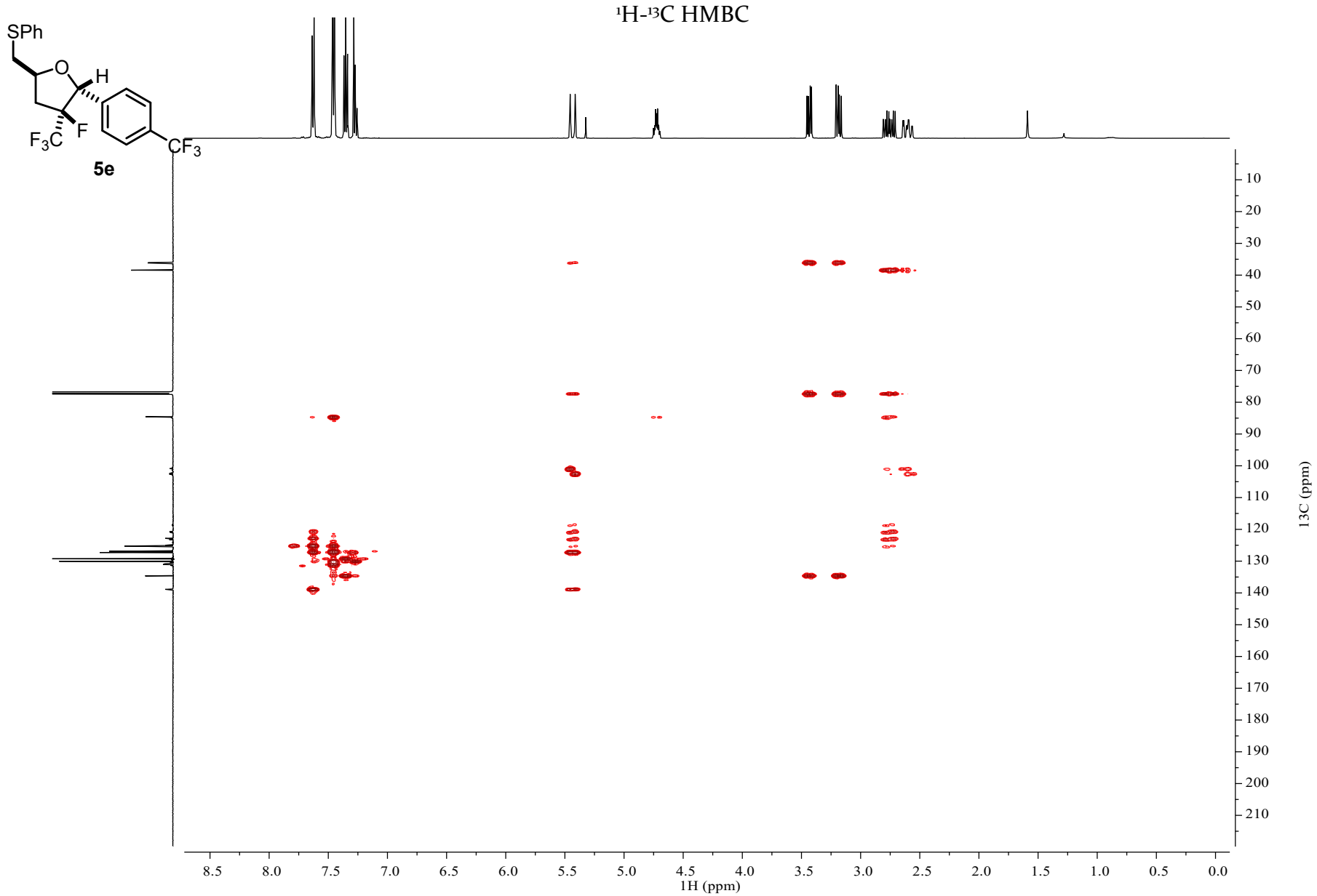

^{1}H-^{1}H COSY
OH
OMe
O
OH
F_3C
F
6a
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)
0
1
2
3
4
5
6
7
8
1H (ppm)

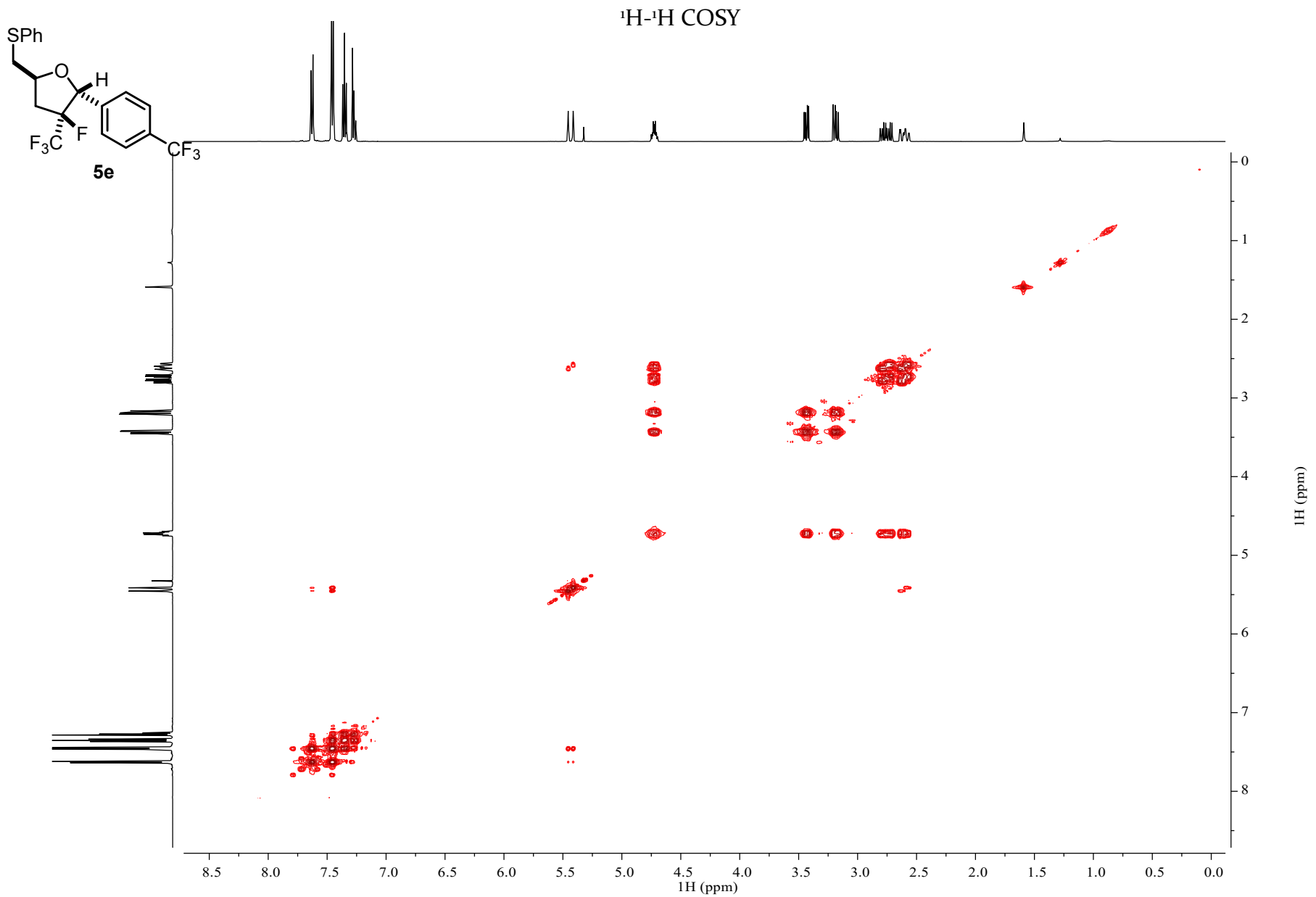

SPh
O
H
F
F3C
CF3
5e
CDCl3
D (m) 7.25
B (m) 7.43
A (d) 7.60
C (m) 7.32
E (d) 5.41
F (tdd) 4.70
H (dd) 3.16
J (ddd) 2.58
G (dd) 3.41
I (ddd) 2.73
1H (ppm)
2.00
3.80
1.87
1.22
0.99
0.97
1.00
0.99
1.02
0.99


SPh
O
H
F3C
F
CF3
5e
139.04
139.00
134.75
131.45
131.20
131.18
130.94
130.68
130.16
129.37
127.39
127.27
127.02
125.62
125.39
125.36
125.33
125.30
125.11
123.37
123.12
122.94
121.12
120.87
120.78
118.87
118.62
103.03
102.79
102.53
102.28
101.49
101.24
100.99
100.74
84.92
84.69
77.45
77.16 CDCl3
38.54
36.30
36.14
D (q)
124.03
B (q)
131.07
A (d)
139.02
C (q)
125.35
F (dq)
101.89
G (d)
84.81
H (d)
36.22
E (qd)
122.12
13C (ppm)


SPh
O
H
F
F3C
CF3
5e
-62.67
-75.83
-75.85
A (d)
-75.84
-158.57
-158.59
-158.61
-158.62
-158.64
-158.65
-158.66
-158.68
-158.69
-158.71
-158.72
-158.74
-158.76
-158.77
B (dtq)
-158.67
-75.81
-75.87
19F (ppm)
-158.60
-158.70
-158.80
19F (ppm)
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
19F (ppm)

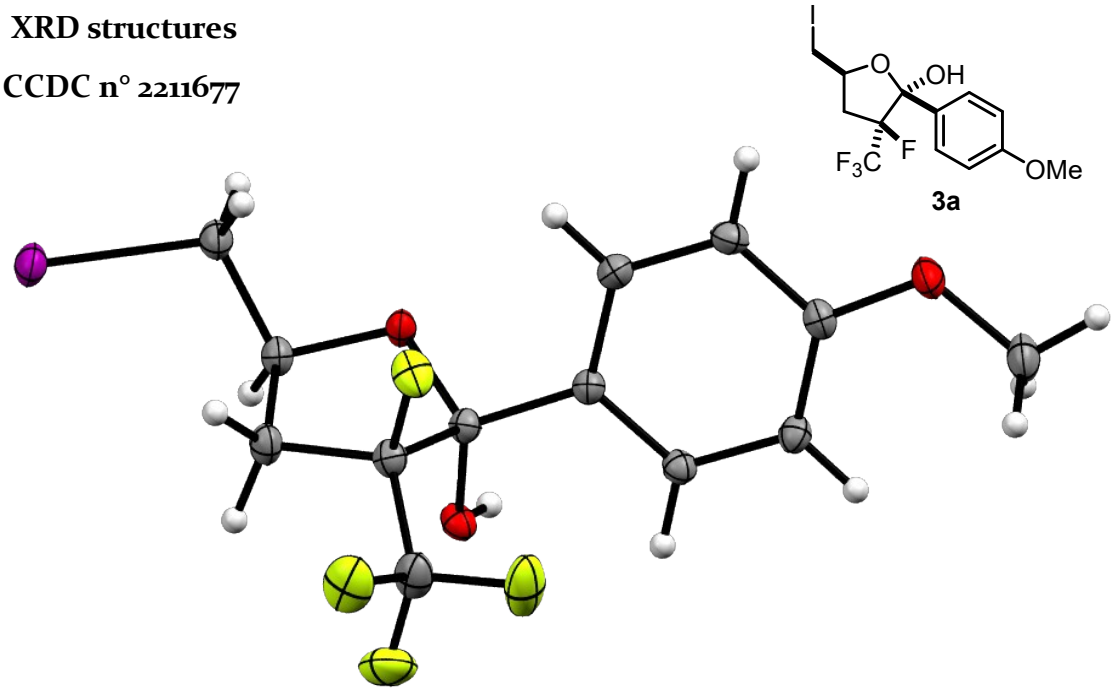

^{1}H-^{13}C HSQC
SPh
O
H
F
F_3C
CF_3
5e
1H (ppm)
13C (ppm)


^{1}H-^{13}C HMBC
SPh
O
H
F
F_3C
CF_3
5e
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
13C (ppm)


^{1}H-^{1}H COSY
SPh
O
H
F
F_3C
CF_3
5e
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1H (ppm)
0
1
2
3
4
5
6
7
8
1H (ppm)

5. XRD structures

3a, CCDC n° 2211677



Empirical formula	$C_{13}H_{13}F_4IO_3$	
Formula weight	420.13 g.mol^{-1}	
Temperature	120(2) K	
Wavelength	0.71073 Å	
Crystal system, Space group	Triclinic, *P*-1	
Unit cell dimensions	a = 10.1192(3) Å	α = 88.7920(10)°
	b = 12.0673(3) Å	β = 77.9670(10)°
	c = 13.3266(4) Å	γ = 67.5800(10)°
Volume	1468.20(7) Å^3	
Z, Density (calculated)	4, 1.901 Mg/m^3	
Absorption coefficient	2.232 mm^{-1}	
F(000)	816	
Crystal size	0.080 x 0.060 x 0.050 mm^3	
Theta range for data collection	2.230 to 31.041°.	
Limiting indices	-14<=h<=12, -17<=k<=17, -19<=l<=19	
Reflections collected	104291	
Independent reflections	9399 [R(int) = 0.0315]	
Completeness to theta = 25.242°	99.9 %	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	9399 / 0 / 389	
Goodness-of-fit on F^2	1.098	
Final R indices [I>2sigma(I)]	R1 = 0.0216, wR2 = 0.0426	
R indices (all data)	R1 = 0.0269, wR2 = 0.0454	
Largest diff. peak and hole	0.452 and -0.828 e.Å^{-3}	

6. References

1. K.-I. Ogu, M. Akazome and K. Ogura, *J. Fluorine Chem.*, 2003, **124**, 69-80.
2. A. Takaoka, H. Iwakiri and N. Ishikawa, *Bull. Chem. Soc. Jpn.*, 1979, **52**, 3377-3380.
3. A. G. Myers, M. Siu and F. Ren, *J. Am. Chem. Soc.*, 2002, **124**, 4230-4232.