Supporting information

Reaction of β-alkoxyvinyl polyfluoroalkylketones with ethyl isocyanoacetate and its use for the synthesis of new polyfluoroalkyl pyrroles and pyrrolidines

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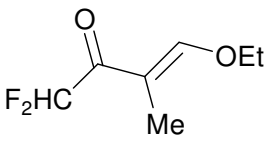
General

Melting points are uncorrected. NMR spectra were recorded on spectrometers from Bruker at 300 MHz (Avance II and DRX) and 400 MHz (Avance II) and from Agilent at 500 MHz (VNMRS) and 600 MHz (DD2) at 25 °C. TMS (for ^{1}H and ^{13}C NMR) and CCl_3F (for ^{19}F NMR) were used as internal standards. IR spectra were recorded on Bruker Vertex 70. Mass spectra (ESI-MS) were measured on a MicroTof Bruker Daltonics.The progress of reactions was monitored by TLC-plates (silica gel 60 F_{254}, Merck). Column chromatography was carried out on silica gel 60 (Merck, particle size 0.040–0.063). Elemental analyses are correct within the limits of ± 0.3% for C, H, N.

All starting materials were of the highest commercial quality and were used without further purification. Starting enones **1a** [1]**, 1b,d,e** [2], **1c** [3], **1f** [4], **1k,l** [5], **1m,n** [6], **1o** [7] were synthesized by the described procedures.

1. Synthesis of enones 1g-j.



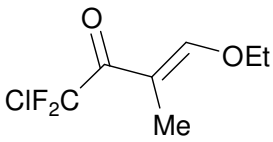
(*E*)-4-Ethoxy-1,1-difluoro-3-methyl-but-3-en-2-one (1g). A solution of difluoroacetic acid chloride (22.9 g, 0.2 mol) in anhyd CH_2Cl_2 (40 mL) was added to a mixture of 1-ethoxy-propene (mixture of *cis/trans*-isomers) (15.5 g, 0.18 mol) and pyridine (14.2 g, 0.18 mol) in CH_2Cl_2 (200 mL) under stirring and cooling to –10 °C. The reaction mixture was then stirred for 20 h at r.t., then H_2O (200 mL) was added, the H_2O phase was extracted with CH_2Cl_2 (3×100 mL). The combined organic layers were dried over anhyd Na_2SO_4 and the solvent was evaporated. The residue was distilled under reduced pressure (95-97 °C, 20 mm Hg) giving enone **1g** as light yellow liquid. Yield: 20.6 g (63%).

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.37 (3H, t, *J* = 7.2 Hz, CH_3), 1.73 (3H, s, CH_3), 4.17 (2H, q, *J* = 7.2 Hz, CH_2O), 5.97 (1H, t, *J* = 54.5 Hz, CHF_2), 7.59 (1H, s, CH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 7.8, 15.3, 71.2, 111.9 (t, *J* = 254.3 Hz), 113.1, 163.4 (t, *J* = 6.2 Hz), 187.5 (t, *J* = 24.4 Hz) ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –118.98 (d, *J* = 54.5 Hz, CHF_2) ppm.

ESI-MS (*m/z*): calcd. for $C_7H_{10}F_2NaO_2$ (187.0541). Found 187.0538.



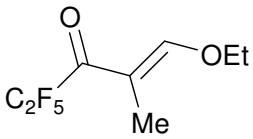
***(E)*-1-Chloro-4-ethoxy-1,1-difluoro-3-methyl-but-3-en-2-one (1h)** was obtained by the same procedure as compound **1g** from chlorodifluoroacetic acid chloride (29.8 g, 0.2 mol) and purified by distillation under reduced pressure (94-96 °C, 20 mm Hg) giving enone **1h** as light yellow liquid. Yield: 31.0 g (78%).

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.40 (3H, t, *J* = 7.2 Hz, CH_3), 1.82 (3H, s, CH_3), 4.21 (2H, q, *J* = 7.2 Hz, CH_2O), 7.66 (1H, s, CH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 8.6, 15.4, 71.5, 110.4, 113.1, 120.7 (t, *J* = 305.6 Hz), 164.1 (t, *J* = 5.5 Hz), 181.5 (t, *J* = 27.5 Hz) ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$), δ = –68.65 (s, CF_2Cl) ppm.

ESI-MS (*m/z*): calcd. for $C_7H_9ClF_2NaO_2$ (221.0151). Found 221.0153.



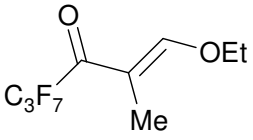
(*E*)-1-Ethoxy-4,4,5,5,5-pentafluoro-2-methyl-pent-1-en-3-one (1i) was obtained by the same procedure as compound **1g** from perfluoropropionic acid chloride (36.5 g, 0.2 mol) and purified by distillation under reduced pressure (96-98 °C, 20 mm Hg) giving enone **1i** as low yellow liquid. Yield: 32.0 g (69%).

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.37 (3H, t, *J* = 7.2 Hz, CH_3), 1.77 (3H, s, CH_3), 4.20 (2H, q, *J* = 7.2 Hz, CH_2O), 7.63 (1H, s, CH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 8.0, 15.1, 71.6, 108.9 (tq, J_1 = 268.5 Hz, J_2 = 37.1 Hz), 113.6, 118.1 (qt, = 287.1 Hz, J_2 = 35.0 Hz), 164.6 (t, *J* = 8.5 Hz), 182.0 (t, *J* = 25.4 Hz) ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$), δ = –82.45 (3F, s, CF_3), –113.88 (2F, s, CF_2) ppm.

ESI-MS (*m/z*): calcd. for $C_8H_9F_5NaO_2$ (255.0415). Found 255.0417.



(*E*)-1-Ethoxy-4,4,5,5,6,6,6-heptafluoro-2-methyl-hex-1-en-3-one (1j) was obtained by the same procedure as compound **1g** from perfluorobutyric acid chloride (46.5 g, 0.2 mol) and purified by distillation under reduced pressure (98-100 °C, 20 mm Hg) giving enone **1j** as light yellow liquid. Yield: 32.7 g (58%).

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.38 (3H, t, *J* = 7.2 Hz, CH_3), 1.79 (3H, s, CH_3), 4.20 (2H, q, *J* = 7.2 Hz, CH_2O), 7.61 (1H, s, CH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 8.4, 15.1, 71.6, 108.5 (tq, J_1 = 267.0 Hz, J_2 = 37.5 Hz), 110.8 (tt, J_1 = 268.4 Hz, J_2 = 30.7 Hz), 114.4, 117.6 (qt, = 288.4 Hz, J_2 = 33.8 Hz), 164.8 (t, *J* = 8.5 Hz), 181.6 (t, *J* = 24.2 Hz) ppm.

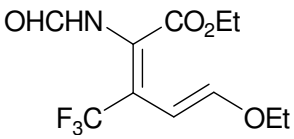
^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –80.72 (3F, t, *J* = 9.5 Hz, CF_3), –112.2 (2F, q, *J* = 9.5 Hz, CF_2), –126.28 (2F, s, CF_2) ppm.

ESI-MS (*m/z*): calcd. for $C_9H_9F_7NaO_2$ (305.0383). Found 305.0379.

2. Reaction of enones 1a-n with ethyl isocyanoacetate.

General procedure

Ethyl isocyanoacetate (1.13 g, 10 mmol) in 10 mL of anhyd THF was added dropwise via syringe to a solution of *t*-BuOK (1.12 g, 10 mmol) in 10 mL of anhydrous THF at –78 °C. After the addition was complete, the solution was stirred for further 30 min at –78 °C. Then a solution of the corresponding enone **1a-o** (8 mmol) in THF was added dropwise via syringe. The mixture was stirred at –78 °C for 1 h, then warmed to r.t. within 1–2 h. Aqueous HCl (1 N, 10 mL) was added and the mixture was stirred for 30 min. The THF layer was separated, the aqueous layer was extracted with CH_2Cl_2 (3×50 mL), and the organic layers were combined, dried over anhyd Na_2SO_4, filtered and concentrated under reduced pressure. The products were separated and purified by column chromatography of the reaction mixture using appropriate eluent.



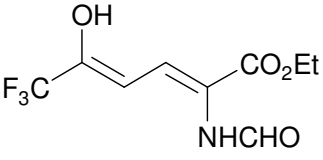
Ethyl (2*Z*,4*E*)-5-ethoxy-2-formamido-3-(trifluoromethyl)-penta-2,4-dienoate (4a) was obtained from enone **1a** (1.34g, 8 mmol) and purified by column chromatography (EtOAc/c-Hex, 1:2, R_f = 0.36) giving compound **4a** as light yellow oil. Yield: 0.25g (11%).

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.29 (3H, t, *J* = 7.1 Hz, CH_3), 1.31 (3H, t, *J* = 7.1 Hz, CH_3), 3.84 (2H, q, *J* = 7.1 Hz, OCH_2), 4.30 (2H, q, *J* = 7.1 Hz, OCH_2), 5.46 (1H, d, *J* = 12.7 Hz, CH), 6.65 (1H, d, J = 12.7 Hz, CH), 7.71 (1H, s, NH), 8.17 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 13.7, 14.5, 62.2, 66.1, 95.7, 117.4 (q, *J* = 29.9 Hz), 123.4 (q, *J* = 276.6 Hz), 127.3, 153.0, 158.8, 164.1 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –60.58 (s, CF_3) ppm.

ESI-MS (*m/z*): calcd. for $C_{11}H_{14}F_3NNaO_4$ (304.0767). Found 304.0768.



Ethyl (2*Z*,4*Z*)-6,6,6-trifluoro-2-formamido-5-hydroxy-hexa-2,4-dienoate (5a) was obtained from enone **1a** (1.34 g, 8 mmol) and was purified by column chromatography

(EtOAc/c-Hex, 1:2, R_f = 0.36) giving compound **5a** as light yellow oil. Yield: 1.54 g (76%).

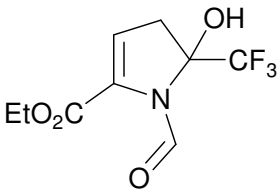
^{1}H NMR (500 MHz, DMSO-d_6): δ = 1.23 (3H, t, *J* = 6.9 Hz, CH_3), 4.17 (2H, q, *J* = 6.9 Hz, OCH_2), 5.85 (1H, d, *J* = 12.6 Hz, CH), 7.28 (1H, d, *J* = 12.6 Hz, CH), 8.14 (1H, s, CHO), 9.71 (1H, s, NH), 11.55 (1H, br. s, OH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.5, 61.3, 100.6, 120.9 (q, *J* = 270.5 Hz), 123.4, 126.0, 144.7 (q, *J* = 31.7 Hz), 160.5, 164.3 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$), δ = –70.74 (s, CF_3) ppm.

Anal. calcd. for: $C_9H_{10}F_3NO_4$ (253.17): C, 42.70; H, 3.98; N, 5.53. Found C, 42.93; H, 3.82; N, 5.55.

ESI-MS (*m/z*): calcd. for $C_9H_{10}F_3NNaO_4$ (276.0454). Found 276.0455.



Ethyl 1-formyl-5-hydroxy-5-(trifluoromethyl)-4,5-dihydro-1H-pyrrole-2-carboxylate (8a) was found to be tautomer of **5a** which is the major compound in $CDCl_3$ solution (see **Table 1**).

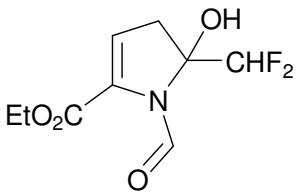
IR ($CHCl_3$): ν = 1726, 1183, 1242, 1286, 1314, 1334, 1636, 1666, 1727 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.35 (3H, t, *J* = 7.2 Hz, CH_3), 2.96 (1H, d, *J* = 20.0 Hz, H_a of CH_2), 3.14 (dd, J_1 = 20.0 Hz, J_2 = 3.4 Hz, H_b of CH_2), 4.31 (2H, q, *J* = 7.2 Hz, CH_2O), 6.25 (1H, s, CH), 6.46 (1H, br.s, OH), 9.30 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.0, 38.6, 62.1, 93.3 (q, *J* = 33.6 Hz), 121.4, 127.2 (q, J = 283.4 Hz), 133.1, 159.2, 164.1 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = – 84.48 (s, CF_3) ppm.

ESI-MS (*m/z*): calcd. for $C_9H_{10}F_3NNaO_4$ (276.0454). Found 276.0455.



Ethyl 5-(difluoromethyl)-1-formyl-5-hydroxy-4,5-dihydro-1H-pyrrole-2-carboxylate (8b) was obtained from enone **1b** 1.20 g (8 mmol)and was purified by column chromatography (EtOAc/Hex, 1:1, R_f = 0.44) giving compound **8b** as light yellow oil. Yield: 1.35 g (72%).

IR ($CHCl_3$) ν = 1087, 1185, 1241, 1322, 1633, 1653, 1725, 3026, 3473 cm^{-1}.

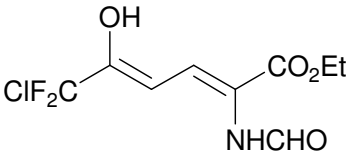
^1H NMR (500 MHz, $CDCl_3$): δ = 1.35 (3H, t, *J* = 7.2 Hz, CH_3), 2.72 (1H, dt, J_1 = 20.1 Hz, J_2 = 3.1 Hz, Ha of CH_2), 3.21 (1H, dd, J_1 = 3.0 Hz, J_2 = 20.1 Hz, H_b of CH_2), 4.30 (2H, q, J = 7.2 Hz, OCH_2), 5.21 (1H, br. s, OH), 6.25 (1H, t, *J* = 3.0 Hz, CH), 9.36 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.1, 35.4, 62.0, 93.1 (t, *J* = 27.3 Hz), 111.7 (t, *J* = 248.7 Hz), 122.1, 132.2, 159.5, 163.4 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –112.89 (1F, d, *J* = 291.3 Hz, F_a of CHF_2), –136.01 (1F, d, *J* = 291.3 Hz, F_b of CHF_2) ppm.

Anal. calcd. for: $C_9H_{11}F_2NO_4$ (235.18): C, 45.96; H, 4.71; N, 5.96. Found C, 45.83; H, 4.78; N, 6.10.

ESI-MS (*m/z*): calcd. for $C_9H_{11}F_2NNaO_4$ (258.0548). Found 258.0549.



Ethyl (2*Z*,4*Z*)-6-chloro-6,6-difluoro-2-formamido-5-hydroxyhexa-2,4-dienoate (5c) was obtained from enone **1a** (1.47 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.44) giving compound **5c** as light yellow oil. Yield: 1.38 g (64%).

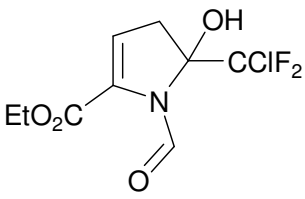
^1H NMR (500 MHz, DMSO-d_6): δ = 1.24 (3H, t, *J* = 7.1 Hz, CH_3), 4.17 (2H, q, *J* = 7.1 Hz, OCH_2), 5.82 (1H, d, *J* = 12.1 Hz, CH), 7.27 (1H, d, *J* = 12.1 Hz, CH), 8.14 (1H, s, CHO), 9.71 (1H, s, NH), 11.55 (1H, br. s, OH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.5, 61.3, 99.0, 123.4, 126.0, 148.8 (t, *J* = 26.6 Hz), 160.5, 164.3 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = – 57.81 (s, CF_2Cl) ppm.

Anal. calcd. for: $C_9H_{10}ClF_2NO_4$ (269.63): C, 40,09; H, 3,74; N, 5,19. Found C, 39.98; H, 3.69; N, 5.32.

ESI-MS (*m/z*): calcd. for $C_9H_{10}ClF_2NNaO_4$ (292.0159). Found 292.0156.



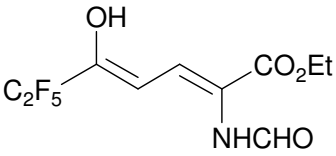
Ethyl 5-(chlorodifluoromethyl)-1-formyl-5-hydroxy-4,5-dihydro-1H-pyrrole-2-carboxylate (8c) was found to be tautomer of **5c** which is the major compound in $CDCl_3$ solution (see **Table 1**).

IR ($CHCl_3$): ν = 1635, 1320, 1020, 1047, 1188, 1241, 1287, 1376, 1666, 1726, 3022, 3389 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 1.36 (3H, t, *J* = 6.9 Hz, CH_3), 3.00 (1H, d, *J* = 20.3 Hz, H_a of CH_2), 3.21 (1H, d, *J* = 20.3 Hz, H_b of CH_2), 4.32 (2H, q, *J* = 6.9 Hz, OCH_2), 6.21 (1H, s, CH), 6.78 (1H, s, OH), 9.81 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.2, 39.6, 62.1, 96.9 (t, *J* = 27.6 Hz), 121.9, 128.5 (t, *J* = 302.8 Hz), 133.5, 159.3, 164.4 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –72.31 (1F, *J* = 164.6 Hz, F_a of CF_2Cl), –69.84 (1F, d, *J* = 164.6 Hz, F_b of CF_2Cl) ppm.



Ethyl (2*Z*,4*Z*)-6,6,7,7,7-pentafluoro-2-formamido-5-hydroxyhepta-2,4-dienoate (5d) was obtained from enone **1d** (1.74 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.52) giving compound **5d** as light yellow oil. Yield: 1.65 g (68 %).

IR (KBr): ν = 998, 1079, 1107, 1156, 1175, 1221, 1300, 1334, 1376, 1502, 1621, 1667, 1691 2991, 3270 cm^{-1}.

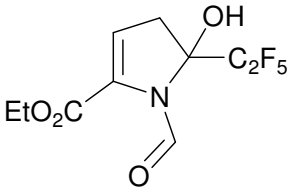
^1H NMR (500 MHz, DMSO-d_6): δ = 1.24 (3H, t, *J* = 7.0 Hz, CH_3), 4.18 (2H, q, *J* = 7.0 Hz, OCH_2), 5.88 (1H, d, *J* = 11.9 Hz, CH), 7.32 (1H, d, *J* = 11.9 Hz, CH), 8.14 (1H, s, CHO), 9.73 (1H, s, NH), 11.55 (1H, br. s, OH) ppm.

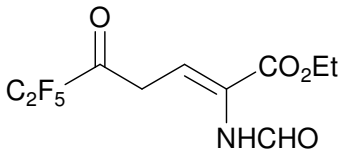
^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.5, 61.3, 102.5, 123.3, 126.0, 144.8 (t, *J* = 22.8 Hz), 160.5, 164.3 ppm. Low intensity and high multiplicity signals of C_2F_5-fragment C-atoms are in the area of 110–130 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –118.9 (2F, s, CF_2), –81.89 (3F, s, CF_3) ppm.

Anal. calcd. for: $C_{10}H_{10}F_5NO_4$ (303.05): C, 39.62; H, 3.32; N, 4.62. Found C, 39.48; H, 3.20; N, 4.64.

ESI-MS (*m/z*): calcd. for $C_{10}H_{10}F_5NNaO_4$ (326.0422). Found 326.0420.





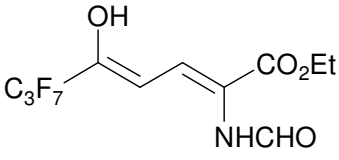
Ethyl 1-formyl-5-hydroxy-5-(perfluoroethyl)-4,5-dihydro-1H-pyrrole-2-carboxylate (8d) and **ethyl 6,6,7,7,7-Pentafluoro-2-formylamino-5-oxo-hept-2-enoate (7d)** were found to be tautomers of **5d** which are major compounds in $CDCl_3$ solution (see **Table 1**).

IR ($CHCl_3$): ν = 1241, 1286, 1318, 1638, 1668, 1702, 1726, 1761, 3024, 3390, 3692 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$), signals of **7d**: δ = 1.36 (3H, t, *J* = 7.2 Hz, CH_3), 3.78 (2H, d, *J* = 6.7 Hz, CH_2), 4.32 (2H, q, *J* = 7.2 Hz, OCH_2), 6.90 (1H, t, *J* = 6.7 Hz, CH), 7.43 (1H, s, NH), 8.27 (1H, s, CHO); signals of **8d**: δ = 1.36 (3H, t, *J* = 7.2 Hz, CH_3), 3.00 (1H, d, *J* = 19.8 Hz, Ha of CH_2), 3.25 (1H, d, *J* = 19.8 Hz, Hb of CH_2), 4.32 (2H, m, OCH_2), 6.28 (1H, s, CH), 6.63 (1H, s, OH), 9.29 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): (signals of **7d** and **8d**) δ = 14.0, 14.1, 38.0, 39.3, 62.1, 62.5, 94.5 (t, *J* = 25.4 Hz), 121.7, 122.1, 126.83, 133.1, 158.5, 159.1, 163.6, 164.6, 190.5 (t, *J* = 27.3 Hz) ppm. Low intensity and high multiplicity signals of C_2F_5-fragment C-atoms are in the area of 110–130 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$), signals of **7d**: δ = –123.48 (2F, s, CF_2), -82.35 (3F, s, CF_3); signals of **8d**: δ = –127.0 (1F, d, *J* = 279.2 Hz, F_a of CF_2), –125.18 (1F, d, J = 279.2 Hz, F_b of CF_2), –80.36 (3F, s, CF_3) ppm.



ethyl (2*Z*,4*Z*)-6,6,7,7,8,8,8-heptafluoro-2-formamido-5-hydroxyocta-2,4-dienoate (5e) was obtained from enone **1e** (2.14 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.61) giving compound **5e** as light yellow oil. Yield: 1.44 g (51 %).

IR (KBr): ν = 1091, 1198, 1225, 1290, 1522, 1618, 1642, 1665, 1697, 3315 cm^{-1}.

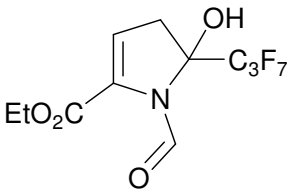
^{1}H NMR (500 MHz, DMSO-d_6): δ = 1.25 (3H, t, *J* = 7.0 Hz, CH_3), 4.18 (2H, q, *J* = 7.0 Hz, CH_2), 5.87 (1H, d, *J* = 11.9 Hz, CH), 7.32 (1H, d, *J* = 11.9 Hz, CH), 8.13 (1H, s, CHO), 9.73 (1H, s, NH), 11.56 (1H, br. s, OH) ppm.

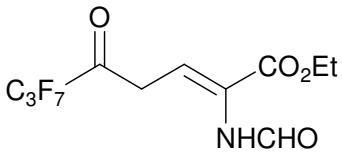
^{13}C NMR (126 MHz, DMSO-d_6): δ = 14.5, 61.4, 102.9, 123.2, 126.2, 144.8 (t, *J* = 24.0 Hz), 160.5, 164.3 ppm. Low intensity and high multiplicity signals of C_3F_7-fragment C-atoms are in the area of 110–130 ppm.

^{19}F NMR (470.8 Hz, DMSO-d_6): δ = –126.44 (2H, s, CF_2), –117.36 (2H, q, *J* = 8.3 Hz, CF_2), –80.67 (3H, t, *J* = 8.3 Hz, CF_3) ppm.

Anal. calcd. for: $C_{11}H_{10}F_7NO_4$ (353.19): C, 37.41; H, 2.85; N, 3.97. Found C, 37.60; H, 2.70; N, 4.02.

ESI-MS (*m/z*): calcd. for $C_{11}H_{10}F_7NNaO_4$ (376.0390). Found 376.0393.





Ethyl (*Z*)-6,6,7,7,8,8,8-heptafluoro-2-formamido-5-oxooct-2-enoate (7e) and **ethyl 1-formyl-5-hydroxy-5-(perfluoropropyl)-4,5-dihydro-1H-pyrrole-2-carboxylate (8e)** were found to be tautomers of **5e** which are major compounds in $CDCl_3$ solution (see **Table 1**).

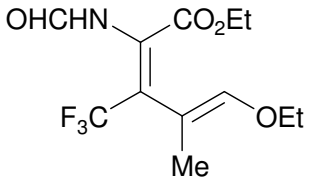
IR ($CHCl_3$): ν = 1124, 1237, 1285, 1492, 1702, 1726, 1762, 3020, 3385 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$), signals of **7e**: δ = 1.36 (3H, t, *J* = 6.5 Hz, CH_3), 3.78 (2H, d, *J* = 5.6 Hz, CH_2), 4.32 (2H, q, *J* = 6.5 Hz, CH_2O), 6.9 (1H, t, J = 5.6 Hz, CH), 7.45 (1H, s, NH), 8.28 (1H, s, CHO); signals of **8e**: δ = 1.36 (3H, t, *J* = 6.5 Hz,CH_3), 3.02 (1H, d, *J* = 19.5 Hz, H_a of CH_2), 3.24 (1H, d, *J* = 19.5 Hz, H_b of CH_2), 6.29 (1H, s, CH), 6.69 (1H, s, OH), 9.29 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): (signals of **7e** and **8e**) δ = 14.0, 14.1, 38.6, 39.5, 62.2, 62.5, 95.0 (t, *J* = 24.5 Hz), 122.0, 122.1, 126.7, 133.1, 158.4, 159.2, 163.6, 164.8, 190.5 (t, *J* = 26.0 Hz) ppm. Low intensity and high multiplicity signals of C_3F_7-fragment C-atoms are in the area of 110–130 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$), signals of **7e**: δ = –127.00 (2F, s, CF_2), –121.30 (2F, q, *J* = 9.0 Hz, CF_2), –81.00 (3F, t, *J* = 9.0 Hz, CF_3); signals of **8e**: –126.58 (1F, dd, J_1 = 293.5, J_2 = 14.6 Hz, F_a of CF_2), –124.65 (1F, dd, J_1 = 293.5, J_2 = 13.5 Hz, F_b

of CF_2), –123.17 (1F, d, J = 282.6 Hz, F_a of CF_2), –121.93 (1F, d, J = 282.6 Hz, F_b of CF_2), –81.44 (3F, m, CF_3) ppm.



Ethyl (2*Z*,4*E*)-5-ethoxy-2-formamido-4-methyl-3-(trifluoromethyl)penta-2,4-dienoate (4f) was obtained from enone **1f** (1.46 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:1, R_f = 0.62) giving compound **4f** as light yellow oil. Yield: 1.32 g (56%).

IR ($CHCl_3$) ν = 1116, 1199, 1237, 1278, 1478, 1643, 1716, 2985, 3021, 3440 cm^{-1}.

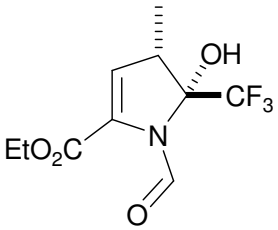
^1H NMR (500 MHz, $CDCl_3$): δ = 1.25 (3H, t, J = 7.0 Hz, CH_3), 1.29 (3H, t, J = 7.0 Hz, CH_3), 1.74 (3H, s, CH_3), 3.84 (2H, q, J = 7.0 Hz, CH_2O), 4.25 (2H, q, J = 7.0 Hz, CH_2O), 6.00 (1H, s, CH), 8.09 (1H, br. s, NH), 8.18 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 13.1, 13.7, 15.2, 61.9, 68.2, 106.0, 119.0 (q, J = 30.5 Hz), 123.6 (q, J = 276.2 Hz), 131.2 (q, J = 2.6 Hz), 147.6, 158.6, 163.7 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –59.93 (s, CF_3) ppm.

Anal. calcd. for: $C_{12}H_{16}F_3NO_4$ (295.25): C, 48.81; H, 5.46; N, 4.74. Found C, 49.01; H, 5.32; N, 4.88.

ESI-MS (*m/z*): calcd. for $C_{12}H_{16}F_3NNaO_4$ (318.0924). Found 318.0924.



Ethyl *cis*-1-formyl-5-hydroxy-4-methyl-5-(trifluoromethyl)-4,5-dihydro-1H-pyrrole-2-carboxylate (8f) was obtained from enone **1f** (1.46 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:1, R_f = 0.44) giving compound **8f** as light yellow oil.. Yield: 0.41 g (19%).

IR ($CHCl_3$): ν = 943, 981, 1027, 1095, 1175, 1242, 1323, 1376, 1423, 1634, 1663, 1727, 2940, 2986, 3028, 3363 cm^{-1}.

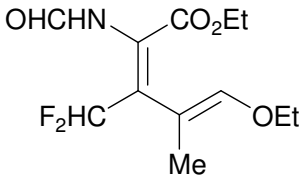
^1H NMR (500 MHz, $CDCl_3$): δ = 1.19 (3H, d, J = 7.0 Hz, CH_3), 1.34 (3H, t, J = 7.0 Hz, CH_3), 3.19 (1H, q, J = 7.0 Hz, CH), 4.29 (2H, q, J = 7.0 Hz, CH_2O), 6.24 (1H, s, CH), 6.69 (1H, s, OH), 9.29 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 12.9, 14.0, 41.4, 62.1, 93.1 (q, *J* = 33.0 Hz), 123.7 (q, *J* = 288.4 Hz), 127.9, 131.3, 159.5, 164.4 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –85.45 (s, CF_3) ppm.

Anal. calcd. for: $C_{12}H_{16}F_3NO_4$ (267.20): C, 44.95; H, 4.53; N, 5.24. Found C, 45.19; H, 4.51; N, 5.02.

ESI-MS (*m/z*): calcd. for $C_{10}H_{12}F_3NNaO_4$ (290.0616). Found 290.0612.



(2*Z*,4*E*)-3-Difluoromethyl-5-ethoxy-2-formylamino-4-methyl-penta-2,4-dienoic acid ethyl ester 4g was obtained from enone **1g** (1.31 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.11) giving compound **4g** as light yellow oil. Yield: 0.40 g (17%).

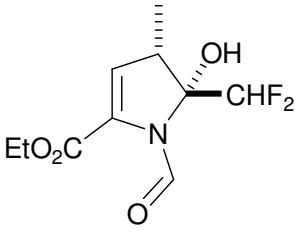
^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.24 (3H, t, *J* = 7.0 Hz, CH_3), 1.29 (3H, t, *J* = 7.0 Hz, CH_3), 1.76 (3H, s, CH_3), 3.83 (2H, q, *J* = 7.0 Hz, CH_2O), 4.24 (2H, q, *J* = 7.0 Hz, CH_2O), 5.99 (1H, s, CH), 6.33 (1H, t, *J* = 55.1 Hz, CHF_2), 7.69 (1H, br. s, NH), 8.20 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 13.1, 13.9, 15.4, 61.8, 68.3, 107.4, 113.4 (t, *J* = 24.5 Hz), 116.1 (t, *J* = 250.0 Hz), 130.3, 146.7, 158.8, 164.5 ppm

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –115.29 (d, *J* = 55.1 Hz, CHF_2) ppm.

Anal. calcd. for: $C_{12}H_{17}F_2NO_4$ (277.26): C, 51.98; H, 6.18; N, 5.05. Found C, 51.79; H, 6.09; N, 5.26.

ESI-MS (*m/z*): calcd. for $C_{12}H_{17}F_2NNaO_4$ (300.1018). Found 300.1020.



Ethyl *cis*-5-(difluoromethyl)-1-formyl-5-hydroxy-4-methyl-4,5-dihydro-1H-pyrrole-2-carboxylate (8g) was obtained from enone **1g** (1.31 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.42) giving compound **8g** as light yellow oil. Yield: 1.02 g (54 %).

IR ($CHCl_3$) ν = 1025, 1085, 1186, 1210, 1241, 1323, 1630, 1652, 1725, 2986, 3026, 3418 cm^{-1}.

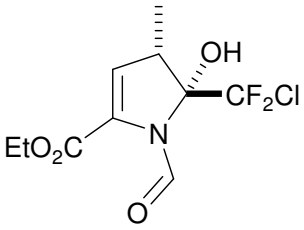
^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.22 (3H, d, *J* = 7.3 Hz, CH_3), 1.36 (3H, t, J = 7.1 Hz, CH_3), 3.38 (1H, q, *J* = 7.3 Hz, CH), 4.30 (2H, q, *J* = 7.1 Hz, CH_2O), 5.24 (1H, s, OH), 6.19 (1H, s, CH), 6.32 (1H, t, *J* = 56.0 Hz, CHF_2), 9.37 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 12.7, 14.0, 38.7, 61.9, 92.8 (t, *J* = 26.5 Hz), 112.4 (t, *J* = 249.3 Hz), 128.7, 130.5, 159.8, 163.7 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –138.15 (1F, dd, *J* = 56.0, 290.0 Hz, F_a of CHF_2), –130.25 (1F, dd, *J* = 56.0, 290.0 Hz, F_b of CHF_2) ppm.

Anal. calcd. for: $C_{10}H_{13}F_2NO_4$ (249.21): C, 48.19; H, 5.26; N, 5.62. Found C, 48.15; H, 5.45; N, 5.52.

ESI-MS (*m/z*): calcd. for $C_{10}H_{13}F_2NNaO_4$ (272.0705). Found 272.0709.



Ethyl *cis*-5-(chlorodifluoromethyl)-1-formyl-5-hydroxy-4-methyl-4,5-dihydro-1H-pyrrole-2-carboxylate (8h) was obtained from enone **1h** (1.59 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.58) giving compound **8h** as light yellow oil.. Yield: 1.04 g (46%).

IR ($CHCl_3$) ν = 1027, 1094, 1137, 1189, 1220, 1316, 1316, 1634, 1664, 1726, 2939, 2986, 3027, 3354 cm^{-1}.

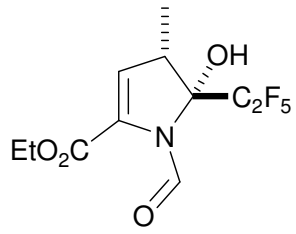
^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.14 (3H, d, *J* = 7.0 Hz, CH_3), 1.28 (3H, t, *J* = 7.0 Hz, CH_3), 3.20 (1H, m, CH), 4.24 (2H, q, *J* = 7.0 Hz, CH_2O), 6.22 (1H, s, CH), 6.86 (1H, br. s, OH), 9.21 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 13.0, 13.8, 42.4, 61.9, 96.3 (t, *J* = 27.3 Hz), 128.1, 129.0 (t, *J* = 304.5 Hz), 131.4, 159.4, 164.6 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = – 71.50 (1F, d, *J* = 163.7 Hz, F_a of CF_2), –70.56 (1F, d, *J* = 163.7 Hz, F_b of CF_2) ppm.

Anal. calcd. for: $C_{10}H_{12}ClF_2NO_4$ (283.65): C, 42.34; H, 4.26; N, 4.94. Found C, 42.10; H, 4.12; N, 5.17.

ESI-MS (*m/z*): calcd. for $C_{10}H_{12}ClF_2NNaO_4$ (306.0315). Found 306.0312.



Ethyl *cis*-1-formyl-5-hydroxy-4-methyl-5-(perfluoroethyl)-4,5-dihydro-1H-pyrrole-2-carboxylate (8i) was obtained from enone **1i** (1.86 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.63) giving compound **8i** as light yellow oil. Yield: 1.67 g (66%).

IR ($CHCl_3$) ν = 1194, 1226, 1333, 1376, 1637, 1728, 3024, 3385 cm^{-1}.

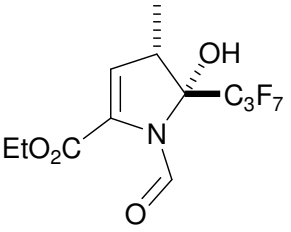
^1H NMR (500 MHz, $CDCl_3$): δ = 1.19 (3H, d, *J* = 7.2 Hz, CH_3), 1.35 (3H, t, *J* = 7.2 Hz, CH_3), 3.31 (1H, qd, J_1 = 7.2 Hz, J_2 = 2.9 Hz, CH), 4.31 (2H, q, *J* = 7.2 Hz, CH_2O), 6.27 (1H, d, *J* = 2.9 Hz, CH), 6.90 (1H, s, NH), 9.27 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 12.9, 13.9, 41.9, 62.1, 94.6 (t, *J* = 23.5 Hz), 128.5, 131.3, 159.5, 165.1. Low intensity and high multiplicity signals of C_2F_5-fragment C-atoms are in the area of 110–130 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –130.82 (1F, d, *J* = 276.8 Hz, F_a of CF_2), –120.11 (1F, d, *J* = 276.8 Hz, F_b of CF_2), –82.80 (3F, s, CF_3) ppm.

Anal. calcd. for: $C_{11}H_{12}F_5NO_4$ (317.21): C, 41.65; H, 3.81; N, 4.42. Found C, 41.73; H, 3.94; N, 4.69.

ESI-MS (*m/z*): calcd. for $C_{11}H_{12}F_5NNaO_4$ (340.1985). Found 340.1989.



Ethyl *cis*-1-formyl-5-hydroxy-4-methyl-5-(perfluoropropyl)-4,5-dihydro-1H-pyrrole-2-carboxylate (8j) was obtained from enone **1j** (2.26 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.49) giving compound **8j** as light yellow oil. Yield: 2.05 g (70%).

IR ($CHCl_3$) ν = 1027, 1122, 1186, 1210, 1236, 1315, 1520, 1637, 1664, 1726, 2940, 2987, 3027, 3383 cm^{-1}.

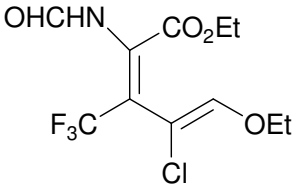
^1H NMR (500 MHz, $CDCl_3$): δ = 1.20 (3H, d, *J* = 7.2 Hz, CH_3), 1.33 (3H, t, *J* = 7.0 Hz, CH_3), 3.30 (1H, m, CH), 4.30 (2H, q, *J* = 7.2 Hz, CH_2O), 6.28 (1H, s, CH), 6.98 (1H, s, NH), 9.28 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 12.8, 14.0, 42.1, 62.1, 95.5 (t, *J* = 25.0 Hz), 127.8, 131.3, 160.2, 165.3 ppm. Low intensity and high multiplicity signals of C_3F_7-fragment C-atoms are in the area of 110–130 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –127.39 (1F, d, *J* = 294.5 Hz, F_a of CF_2), –123.64 (2F, s, CF_2), –123.50 (1F, d, *J* = 294.5 Hz, F_b of CF_2), –81.72 (3F, t, *J* = 11.4 Hz) ppm.

Anal. calcd. for: $C_{12}H_{12}F_7NO_4$ (367,21): C, 39.25; H, 3.29; N, 3.81. Found C, 39.43; H, 3.11; N, 3.66.

ESI-MS (*m/z*): calcd. for $C_{12}H_{12}F_7NNaO_4$ (390.0547). Found 390.0548.



Ethyl (*2E,4Z*)-4-chloro-5-ethoxy-2-formamido-3-(trifluoromethyl)penta-2,4-dienoate (4k) was obtained from enone **1g** (1.62 g, 8 mmol) and was purified by crystallization from hexane giving compound **4j** as light yellow solid. Yield: 2.29 g (91%). M.p. 80-82 °C.

IR ($CHCl_3$): ν = 1127, 1200, 1274, 1634, 1724, 2986, 3024, 3435 cm^{-1}.

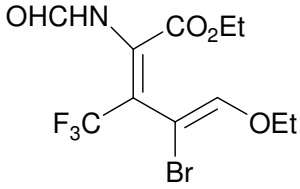
^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.25-1.41 (6H, m, $2CH_3$), 4.00 (2H, q, *J* = 6.9 Hz, CH_2O), 4.31 (2H, q, *J* = 6.9 Hz, CH_2O), 6.43 (1H, s, CH), 8.20 (1H, br. s, NH), 8.23 (1H, s, CHO) ppm.

^{13}C (126 MHz, $CDCl_3$): δ = 13.7, 15.2, 62.6, 69.8, 99.8, 111.0 (q, *J* = 34.5 Hz), 122.9 (q, *J* = 276.4 Hz), 135.7, 148.4, 158.4, 162.6 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –59.73 (s, CF_3) ppm.

Anal. calcd. for: $C_{12}H_{12}F_7NO_4$ (315.67): C, 41.85; H, 4.15; N, 4.44. Found C, 41.73; H, 4.01; N, 4.24.

ESI-MS (*m/z*): calcd. for $C_{11}H_{13}ClF_3NNaO_4$ (338.0377). Found 338.0379.



Ethyl (*2E,4Z*)-4-bromo-5-ethoxy-2-formamido-3-(trifluoromethyl)penta-2,4-dienoate (4l) was obtained from enone **1l** (1.98 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.54) giving

compound **4l** as light yellow oil. Yield: 1.81 g (63%).

IR ($CHCl_3$): ν = 1125, 1200, 1272, 1298, 1631, 1725, 2986, 3028, 3435 cm^{-1}.

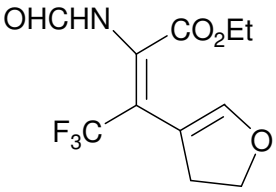
^1H NMR (500 MHz, $CDCl_3$): δ = 1.29-1.40 (6H, m, $2CH_3$), 4.03 (2H, q, *J* = 6.8 Hz, CH_2O), 4.33 (2H, *J* = 6.8 Hz, CH_2O), 6.55 (1H, s, CH), 7.69 (1H, s, NH), 8.25 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 13.8, 15.2, 62.6, 69.7, 87.5, 111.8 (q, *J* = 31.7 Hz), 123.0 (q, *J* = 276.0 Hz), 135.7, 150.3, 158.6, 162.7 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –59.58 (s, CF_3) ppm.

Anal. calcd. for: $C_{11}H_{13}BrF_3NO_4$ (360.12): C, 36.69; H, 3.64; N, 3.89. Found C, 36.81; H, 3.49; N, 3.65.

ESI-MS (*m/z*): calcd. for $C_{11}H_{13}BrF_3NNaO_4$ (381.9872). Found 381.9875.



Ethyl (Z)-3-(4,5-dihydrofuran-3-yl)-4,4,4-trifluoro-2-formamidobut-2-enoate (4m) was obtained from enone **1m** (1.32 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.40) giving compound **4m** as light yellow oil. Yield: 1.37 g (62%).

IR ($CHCl_3$): ν = 1018, 1119, 1219, 1352, 1374, 1478, 1631, 1717, 2901, 2986, 3020, 3440 cm^{-1}.

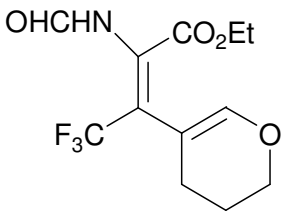
^1H NMR (500 MHz, $CDCl_3$): δ = 1.31 (3H, t, *J* = 7.0 Hz, CH_3), 2.77 (2H, t, *J* = 9.0 Hz, CH_2), 4.28 (2H, q, *J* = 7.0 Hz, CH_2O), 4.45 (2H, t, *J* = 9.0 Hz, CH_2O), 6.39 (1H, s, CH), 8.04 (1H, br. s, NH), 8.18 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 13.6, 32.0, 62.2, 71.4, 106.0, 111.7 (q, *J* = 31.5 Hz), 123.3 (q, *J* = 275.3 Hz), 130.8, 148.6, 158.2, 163.5 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –60.08 (s, CF_3) ppm.

Anal. calcd. for: $C_{11}H_{12}F_3NO_4$ (279.21): C, 47.32; H, 4.33; N, 5,02. Found C, 47.51; H, 4.51; N, 4.84.

ESI-MS (*m/z*): calcd. for $C_{11}H_{12}F_3NNaO_4$ (302.0611). Found 302.0612.



Ethyl (*Z*)-3-(3,4-dihydro-2H-pyran-5-yl)-4,4,4-trifluoro-2-formamidobut-2-enoate (4n) was obtained from enone **1n** (1.44 g, 8 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.48) giving compound **4n** as light yellow oil. Yield: 1.31 g (56%).

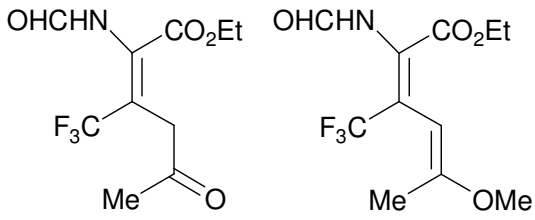
^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.33 (3H, t, *J* = 7.2 Hz, CH_3), 1.88 (2H, m, CH_2), 2.17 (2H, t, *J* = 5.6 Hz, CH_2), 3.97 (2H, t, *J* = 5.0 Hz, CH_2O), 4.29 (2H, t, *J* = 7.2 Hz, CH_2O), 6.35 (1H, s, CH), 7.70 (1H, s, NH), 8.19 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 13.9, 21.6, 23.5, 62.1, 65.5, 105.7, 117.3 (q, *J* = 30.0 Hz), 123.7 (q, *J* = 275.6), 131.9, 146.0, 158.1, 163.3 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –55.59 (s, CF_3) ppm.

Anal. calcd. for: $C_{12}H_{14}F_3NO_4$ (293.24): C, 49.15; H, 4.81; N, 4.78. Found C, 49.11; H, 4.97; N, 4.60.

ESI-MS (*m/z*): calcd. for $C_{12}H_{14}F_3NNaO_4$ (302.0611). Found 302.0612.



Ethyl (2*Z*,4*E*)-2-formamido-5-methoxy-3-(trifluoromethyl)hexa-2,4-dienoate 4o and **ethyl (Z)-2-formamido-5-oxo-3-(trifluoromethyl)hex-2-enoate (10)** was obtained as mixture 59:41 (1.60 g) from enone **1n** (1.34 g, 8mmol). The ratio of **4o/10** 50:50 (1.62 g) was obtained when 15% citric acid was used instead 1N HCl. Only compound **10** was isolated by column chromatography (EtOAc/c-Hex, 1:1, R_f = 0.47) Yield: 1.05 g (49%).

Compound **4o**:

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.40 (3H, t, *J* = 7.0 Hz, CH_3), 1.78 (3H, s, CH_3), 3.61 (3H, s, CH_3O), 4.36 (3H, q, *J* = 7.0 Hz, CH_2O), 4.81 (1H, s, CH), 6.73 (1H, s, NH), 9.14 (1H, s, CHO) ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –57.78 (s, CF_3) ppm.

Compound **10:**

IR ($CHCl_3$): ν = 1040, 1131, 1192, 1273, 1658, 1734, 3019, 3437 cm^{-1}.

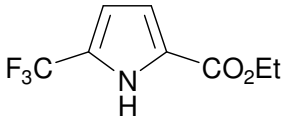
^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.29 (3H, t, *J* = 6.8 Hz, CH_3), 2.22 (3H, s, CH_3), 3.62 (3H, s, CH_3O), 4.27 (2H, q, *J* = 6.8 Hz, CH_2O), 7.98 (1H, br. s, NH), 8.22 (1H, s, CHO) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 13.7, 29.3, 41.2, 62.5, 116.9 (q, *J* = 30.6 Hz), 123.2 (q, *J* = 274.6 Hz), 132.9, 158.9, 162.5, 202.6 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –61.86 (s, CF_3) ppm.

ESI-MS (*m/z*): calcd. for $C_{10}H_{12}F_3NNaO_4$ (290.0611). Found 290.0609.

3. Preparation of pyrroles 11-14.



Ethyl 5-(trifluoromethyl)-1H-pyrrole-2-carboxylate (11a). A mixture of compound **8a** (1.27 g, 5.0 mmol) [8] and 50 mL of 15% aqueous HCl were vigorously stirred for 24 h at r.t. The precipitate obtained was filtered, washed with water, dried and purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.64), giving compound **11a** as white solid. Yield: 0.65 g (63%). M.p. > 80 °C (sublimation).

IR ($CHCl_3$): ν = 1132, 1175, 1279, 1333, 1578, 1709, 3021, 3434 cm^{-1}.

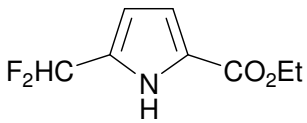
^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.39 (3H, t, *J* = 7.0 Hz, CH_3), 4.38 (2H, q, *J* = 7.0 Hz, CH_2O), 6.59 (1H, s, CH), 6.88 (1H, s, CH), 10.20 (1H, br. s, NH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.3, 61.3, 110.8, 114.8, 120.4 (q, *J* = 267.2 Hz), 124.6 (q, *J* = 39.2 Hz), 125.4, 160.9 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –60.86 (s, CF_3) ppm.

Anal. calcd. for: $C_8H_8F_3NO_2$ (207.15): C, 46.38; H, 3.89; N, 6.76. Found C, 46.56; H, 3.99; N, 6.62.

ESI-MS (*m/z*): calcd. for $C_8H_8F_3NNaO_2$ (230.0399). Found 230.0403.



Ethyl 5-(difluoromethyl)-1H-pyrrole-2-carboxylate (11b) was obtained by the same procedure as compound **11a** from compound **8b** (1.18 g, 5 mmol) and was purified by column chromatography (EtOAc/Hex, 1:1, R_f = 0.73), giving compound **11b** as white solid. Yield: 0.71 g (75%). M.p. 72-73 °C.

IR ($CHCl_3$): ν = 1027, 1077, 1165, 1229, 1314, 1369, 1706, 3022, 3440 cm^{-1}.

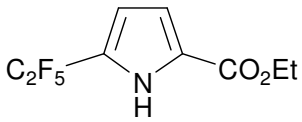
^1H NMR (500 MHz, $CDCl_3$): δ = 1.38 (3H, t, *J* = 7.1 Hz, CH_3), 4.38 (2H, q, *J* = 7.1 Hz, CH_2O), 6.45 (1H, s, CH), 6.70 (1H, t, *J* = 55.2 Hz, CHF_2), 6.88 (1H, s, CH), 10.51 (1H, br. s, NH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.2, 61.0, 109.6 (t, *J* = 235.5 Hz), 110.2 (t, *J* = 5.2 Hz), 115.0, 124.7, 129.2 (t, *J* = 26.5 Hz), 161.4 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –110.80 (d, *J* = 55.2 Hz, CHF_2) ppm.

Anal. calcd. for: $C_8H_9F_2NO_2$ (189.16): C, 50.80; H, 4.80; N, 7.40. Found C, 50.66; H, 4.82; N, 7.58.

ESI-MS (*m/z*): calcd. for $C_8H_9F_2NNaO_2$ (212.0494). Found 212.0491.



Ethyl 5-(perfluoroethyl)-1H-pyrrole-2-carboxylate (11d) was obtained by the same procedure as compound **11a** from compound **8d** (1.51 g, 5 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.60), giving compound **11d** as white solid. Yield: 0.98 g (76%). M.p. 68-70 °C.

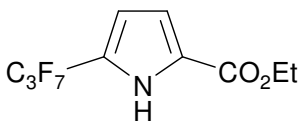
IR ($CHCl_3$): ν = 1024, 1045, 1207, 1211, 1219, 1225, 1261, 1323, 1707, 2985, 3023, 3269, 3435 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 1.37 (3H, t, *J* = 6.8 Hz, CH_3), 4.38 (2H, q, *J* = 6.8 Hz, CH_2O), 6.60 (1H, s, CH), 6.93 (1H, s, CH), 10.72 (1H, br. s, NH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.1, 61.2, 110.3 (tq, J_1 = 251.6 Hz, J_2 = 40.0 Hz), 112.2, 115.3, 118.7 (qt, J_1 = 286.5 Hz, J_2 = 38.6 Hz), 122.9 (t, *J* = 29.6 Hz), 126.2, 161.3 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –112.25 (2F, s, CF_2), –85.37 (3F, s, CF_3) ppm.

ESI-MS (*m/z*): calcd. for $C_9H_8F_5NNaO_2$ (280.0367). Found 280.0365.



Ethyl 5-(perfluoropropyl)-1H-pyrrole-2-carboxylate (11e) was obtained by the same procedure as compound **11a** from compound **8e** (1.77 g, 5 mmol) and was purified by

column chromatography (EtOAc/Hex, 1:2, R_f = 0.57), giving compound **11e** as white solid. Yield: 0.80 g (52%). M.p. 50-52 °C (sublimation).

IR ($CHCl_3$): ν = 981, 1017, 1093, 1114, 1184, 1208, 1257, 1323, 1370, 1636, 1707, 3020, 3276, 3434 cm^{-1}.

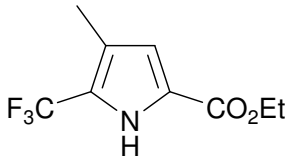
^1H NMR (500 MHz, $CDCl_3$): δ = 1.38 (3H, t, *J* = 6.8 Hz, CH_3), 4.38 (2H, q, *J* = 6.8 Hz, CH_2O), 6.61 (1H, s, CH), 6.94 (1H, s, CH), 10.56 (1H, br. s, NH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.1, 61.1, 108.5 (tq, J_1 = 265.3 Hz, J_2 = 37.9 Hz), 112.2 (tt, J_1 = 253.5 Hz, J_2 = 31.9 Hz), 112.7, 115.2, 117.3 (qt, J_1 = 289.6 Hz, J_2 = 34.0 Hz), 122.7 (t, *J* = 30.4 Hz), 128.2, 160.8 ppm.

^{19}F NMR (470.8 Hz, $CDCl_3$): δ = –127.20 (2F, s, CF_2), –109.81 (2F, q, *J* = 9.4 Hz, CF_2), –80.70 (3F, t, *J* = 9.4 Hz, CF_3) ppm.

Anal. calcd. for: $C_{10}H_8F_7NO_2$ (307.16): C, 39.10; H, 2.63; N, 4.56. Found C, 38.96; H, 2.72; N, 4.58.

ESI-MS (*m/z*): calcd. for $C_{10}H_8F_7NNaO_2$ (330.0335). Found 330.0336.



Ethyl 4-methyl-5-(trifluoromethyl)-1H-pyrrole-2-carboxylate (11f was obtained by the same procedure as compound **11a** from compound **8f** (1.33 g, 5 mmol) and was purified by crystallization from EtOH, giving compound **11f** as white solid. Yield: 0.53 g (48%). M.p. > 80 °C (sublimation).

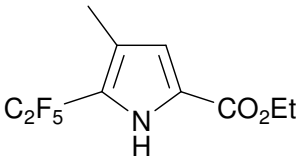
^1H NMR (500 MHz, $CDCl_3$): δ = 1.30 (3H, t, *J* = 7.2 Hz, CH_3), 2.12 (3H, q, *J* = 2.3 Hz, CH_3), 4.28 (2H, q, *J* = 7.2 Hz, CH_2O), 6.62 (1H, s, CH), 9.26 (1H, br. s, NH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 10.9, 13.9, 60.9, 117.3, 119.8 (q, *J* = 270.5 Hz), 121.6 (q, *J* = 38.5 Hz), 123.9, 124.5, 160.3 ppm.

^{19}F NMR (282 MHz, $CDCl_3$): δ = – 54.30 (s, CF_3) ppm.

Anal. calcd. for: $C_9H_{10}F_3NO_2$ (221.18): C, 48.87; H, 4.56; N, 6.33. Found C, 48.99; H, 4.47; N, 6.51.

ESI-MS (*m/z*): calcd. for $C_9H_{10}F_3NNaO_2$ (244.0556). Found 244.0556.



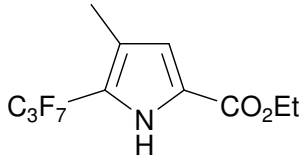
Ethyl 4-methyl-5-(perfluoroethyl)-1H-pyrrole-2-carboxylate (11i) was obtained by the same procedure as compound **11a** from compound **8i** (1.59 g, 5 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.83), giving compound **11i** as white solid. Yield: 0.82 (61%). M.p. 66-68 °C (sublimation).

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.37 (3H, t, *J* = 7.1 Hz, CH_3), 2.12 (3H, s, CH_3), 4.34 (2H, q, *J* = 7.1 Hz, OCH_2), 6.73 (1H, s, CH), 9.40 (1H, br. s, NH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 11.0, 14.4, 61.1, 117.3, 118.2 (t, *J* = 29.4 Hz), 124.0, 124.7, 160.6 ppm. Low intensity and high multiplicity signals of C_2F_5-fragment C-atoms are in the area of 110–130 ppm.

^{19}F NMR (282 MHz, $CDCl_3$): δ = –85.44 (3F, t, *J* = 3.3 Hz, CF_3), –113.65 (2F, q, *J* = 3.3 Hz, CF_2) ppm.

ESI-MS (*m/z*): calcd. for $C_{10}H_{10}F_5NNaO_2$ (294.0524). Found 294.0526.



Ethyl 4-methyl-5-(perfluoropropyl)-1H-pyrrole-2-carboxylate (11j) was obtained by the same procedure as compound **11a** from compound **8j** (1.83 g, 5 mmol) and was purified by column chromatography (EtOAc/Hex, 1:2, R_f = 0.73), giving compound **11j** as white solid. Yield: 0.90 g (56%). M.p. 70-71 °C (sublimation).

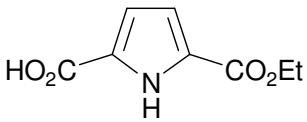
^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.38 (3H, t, *J* = 7.2 Hz, CH_3), 2.20 (3H, s, CH_3), 4.36 (2H, q, *J* = 7.2 Hz, OCH_2), 6.75 (1H, s, CH), 9.54 (1H, br. s, NH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 11.1, 14.3, 61.0, 117.2, 118.5 (t, *J* = 29.4 Hz), 124.4, 124.8, 160.6 ppm.

^{19}F NMR (282 MHz, $CDCl_3$): δ = –127.14 (2F, s, CF_2), –110.48 (2F, q, *J* = 9.8 Hz, CF_2), –80.84 (3F, t, *J* = 9.8 Hz, CF_3) ppm.

Anal. calcd. for: $C_{11}H_{10}F_7NO_2$ (221.18): C, 48.87; H, 4.56; N, 6.33. Found C, 48.99; H, 4.47; N, 6.51.

ESI-MS (*m/z*): calcd. for $C_{11}H_{10}F_7NNaO_2$ (294.0524). Found 294.0526.



5-(Ethoxycarbonyl)-1H-pyrrole-2-carboxylic acid (12a) was obtained by the same procedure as compound **11a** from 1.35 g of compound **8c** and was purified by column chromatography (EtOAc/Hex, 1:2 R_f = 0.86), giving compound **12a** as white solid. Yield: 0.48 g (52%). M.p. 98-100 °C.

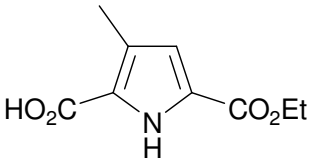
IR ($CHCl_3$): ν = 944, 1022, 1210, 1216, 1257, 1369, 1713, 1801, 3022, 3426 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 1.41 (3H, t, *J* = 7.2 Hz, CH_3), 4.44 (2H, q, *J* = 7.2 Hz, OCH_2), 6.94 (1H, s, CH), 7.09 (1H, s, CH), 10.47 (2H, br. s, NH, OH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 14.3, 61.8, 115.7, 120.1, 129.7, 129.8, 151.9, 160.1 ppm.

Anal. calcd. for: $C_8H_9NO_4$ (183.16): C, 52.46; H, 4.95; N, 7.65. Found C, 52.38; H, 4.81; N, 7.87.

ESI-MS (*m/z*): calcd. for $C_8H_9NNaO_4$ (206.0424). Found 206.0420.



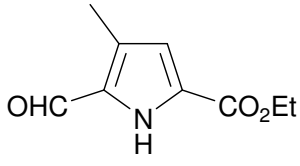
5-(Ethoxycarbonyl)-3-methyl-1H-pyrrole-2-carboxylic acid (12b) was obtained by the same procedure as compound **11a** from compound **8h** (1.42 g, 5 mmol) and was purified by crystallization from EtOH, giving compound **12b** as white solid. Yield: 0.63 g (64%). M.p. 103-105 °C.

IR ($CHCl_3$): ν = 1023, 1102, 1225, 1337, 1469, 1659, 1712, 3020, 3431 cm^{-1}.

^1H NMR (500 MHz, $CDCl_3$): δ = 1.36 (3H, t, *J* = 6.8 Hz, CH_3), 2.38 (3H, s, CH_3), 4.35 (2H, q, *J* = 6.8 Hz, CH_2O), 6.71 (1H, s, CH), 9.78 (1H, s, NH), 9.97 (1H, br. s, OH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 10.5, 14.2, 61.2, 116.7, 127.6, 131.0, 131.2, 160.4, 179.1 ppm.

ESI-MS (*m/z*): calcd. for $C_9H_{11}NNaO_4$ (220.0580). Found 220.0577.



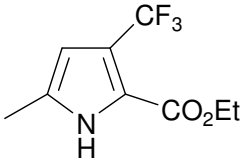
Ethyl 5-formyl-4-methyl-1H-pyrrole-2-carboxylate (13) was obtained by the same procedure as compound **11a** from compound **8g** (1.25 g, 5 mmol) and was purified by

crystallization from EtOH, giving compound **13** as white solid. Yield: 0.52 g (58%). M.p. > 60 °C (sublimation).

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.37 (3H, t, *J* = 7.2 Hz, CH_3), 2.39 (3H, s, CH_3), 4.36 (2H, q, *J* = 7.2 Hz, CH_2O), 6.72 (1H, s, CH), 9.79 (2H, br. s, CHO, NH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 10.5, 14.2, 61.3, 116.7, 127.6, 131.0, 131.2, 160.3, 179.0 ppm.

ESI-MS (*m/z*): calcd. for $C_9H_{11}NNaO_3$ (204.0631). Found 204.0630.



Ethyl 5-methyl-3-(trifluoromethyl)-1H-pyrrole-2-carboxylate (14) was obtained by the same procedure as compound **11a** from compound **9** (1.33 g, 5 mmol) and was purified by crystallization from EtOH, giving compound **14** as white solid. Yield: 0.32 g (29%). M.p. > 80 °C (sublimation).

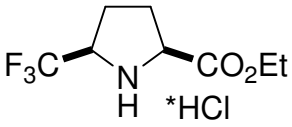
IR ($CHCl_3$): ν = 1105, 1129, 1173, 1276, 1339, 1695, 2985, 3023, 3439 cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.39 (3H, t, *J* = 6.9 Hz, CH_3), 2.35 (3H, s, CH_3), 4.37 (2H, q, J = 6.9 Hz, CH_2O), 6.43 (1H, s, CH), 9.44 (1H, br. s, NH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$): δ = 12.6, 14.3, 60.9, 112.6, 120.6 (q, *J* = 267.4 Hz), 121.8, 123.4 (q, *J* = 39.9 Hz), 127.4, 161.8 ppm.

^{19}F NMR (282 MHz, $CDCl_3$): δ = –61.24 (s, CF_3) ppm.

ESI-MS (*m/z*): calcd. for $C_9H_{10}F_3NNaO_2$ (244.0556). Found 244.0553.



Ethyl 5-(trifluoromethyl)pyrrolidine-2-carboxylate hydrochloride (15). A mixture of compound **11a** (0.62 g, 3 mmol) and 60 mg of 10% Pd/C in 30 mL of ethanol were stirred in autoclave (Hydrogen preassure: 100 atm) at 80 ^{o}C for 48 h. The reaction progress was monitored by ^{19}F NMR spectroscopy and by TLC. After complete hydrogenation, the mixture was filtered and 1 mL 6 N HCl was added. The mixture was stirred for 15 min, extracted with diethyl ether and the water layer was evaporated under reduced pressure giving crude compound **15** (contains ~ 10% of

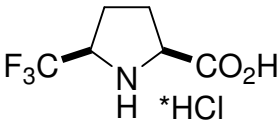
compound **16** by NMR) as white hydrophilic solid which was used for the following step without additional purification. Yield 0.38 g (51%).

^{1}H NMR (500 MHz, D_2O): δ = 1.34 (3H, t, *J* = 7.2 Hz, CH_3), 2.21-2.62 (4H, m, CH_2CH_2), 4.37 (2H, q, *J* = 7.2 Hz, CH_2O), 4.61 (1H, m, CH), 4.73 (1H, m, CH) ppm.

^{13}C NMR (126 MHz, D_2O): δ = 13.2, 23.9, 27.2, 59.8 (q, J = 32.0), 61.6, 64.2, 123.0 (q, *J* = 282 Hz), 168.6 ppm.

^{19}F NMR (282 MHz, D_2O): δ = –71.59 (d, *J* = 7.0 Hz, CF_3) ppm.

ESI-MS (*m/z*): calcd. for $C_8H_{12}F_3NNaO_2$ (234.0712). Found 234.0715.



5-Trifluoromethyl-pyrrolidine-2-carboxylic acid hydrochloride (16). A Solution of compound **15** (0.25 g, 1 mmol) in 6 N HCl (10 mL) was refluxed. The reaction progress was monitored by ^{1}H and ^{19}F NMR spectroscopy. When complited the solution was evaporated, treated with CCl_4 and the precipitate formed was filtered giving compound **16** as white hydrophilic solid. Yield: 0.16 g (69%). M.p. 95-97 °C.

^{1}H NMR (500 MHz, D_2O): δ = 2.06-2.52 (4H, m, CH_2CH_2) 4.41-4.55 (1H, m, $CHCF_3$), 4.56 (1H, t, *J* = 6.5 Hz, $CHCO_2H$) ppm.

^{13}C NMR (126 MHz, D_2O): δ = 23.6, 26.8, 59.5 (q, *J* = 32.1), 61.1, 64.2, 122.9 (q, *J* = 281 Hz), 170.7 ppm.

^{19}F NMR (282 MHz, D_2O): δ = –71.16 (d, *J* = 7.0 Hz, CF_3) ppm.

ESI-MS (*m/z*): calcd. for $C_6H_8F_3NNaO_2$ (206.0399). Found 206.0398.

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[1] Hojo, M.; Masuda, R.; Kokuryo, Y.; Shioda, H.; Matsuo, S. *Chem. Lett*. **1976**, 499.

[2] Gerus, I. I.; Gorbunova, M. G.; Kukhar, V. P. *J. Fluorine Chem.* **1994**, *69*, 195.

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[4] Colla, A.; Martins, M. A. P.; Clar, G.; Krimmer, S.; Fischer, P. *Synthesis* **1991**, 483-486.

[5] Gerus, I. I.; Kacharova, L. M.; Vdovenko, S. I. *Synthesis* **2001**, 431-436.

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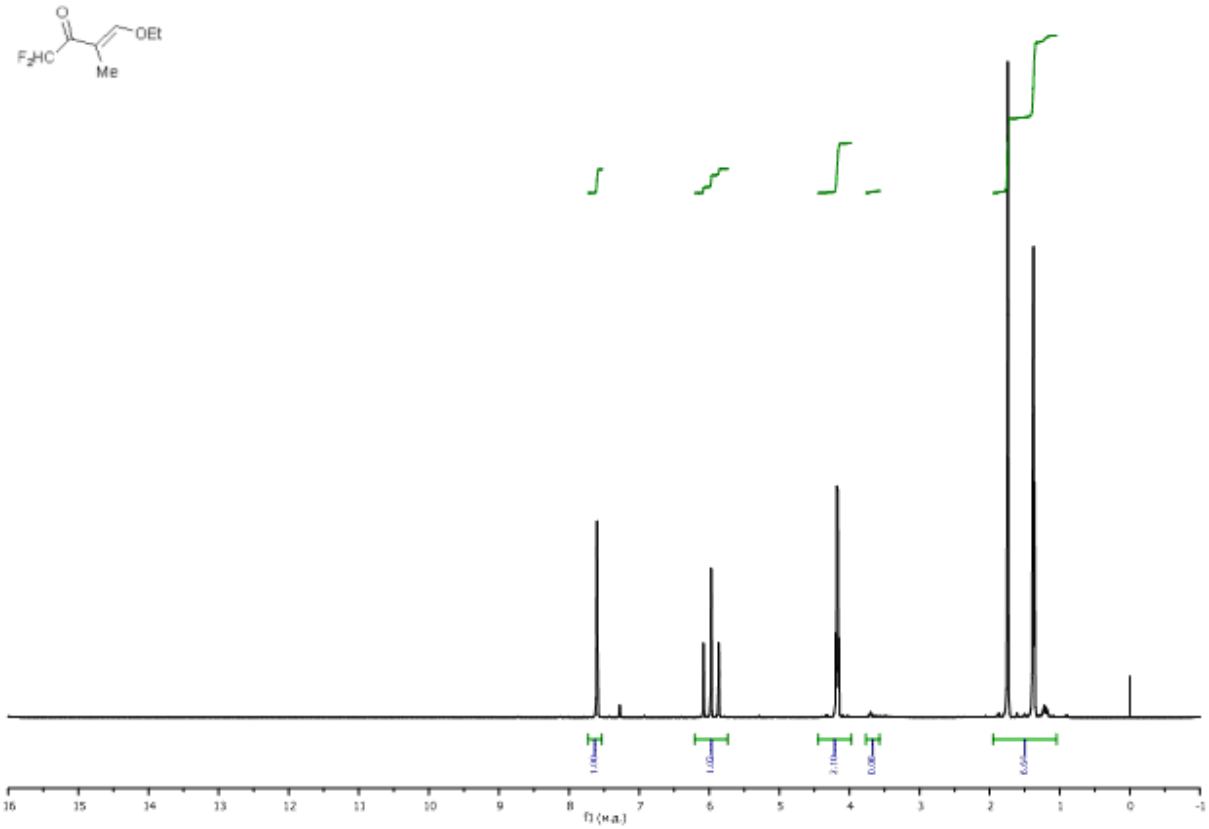
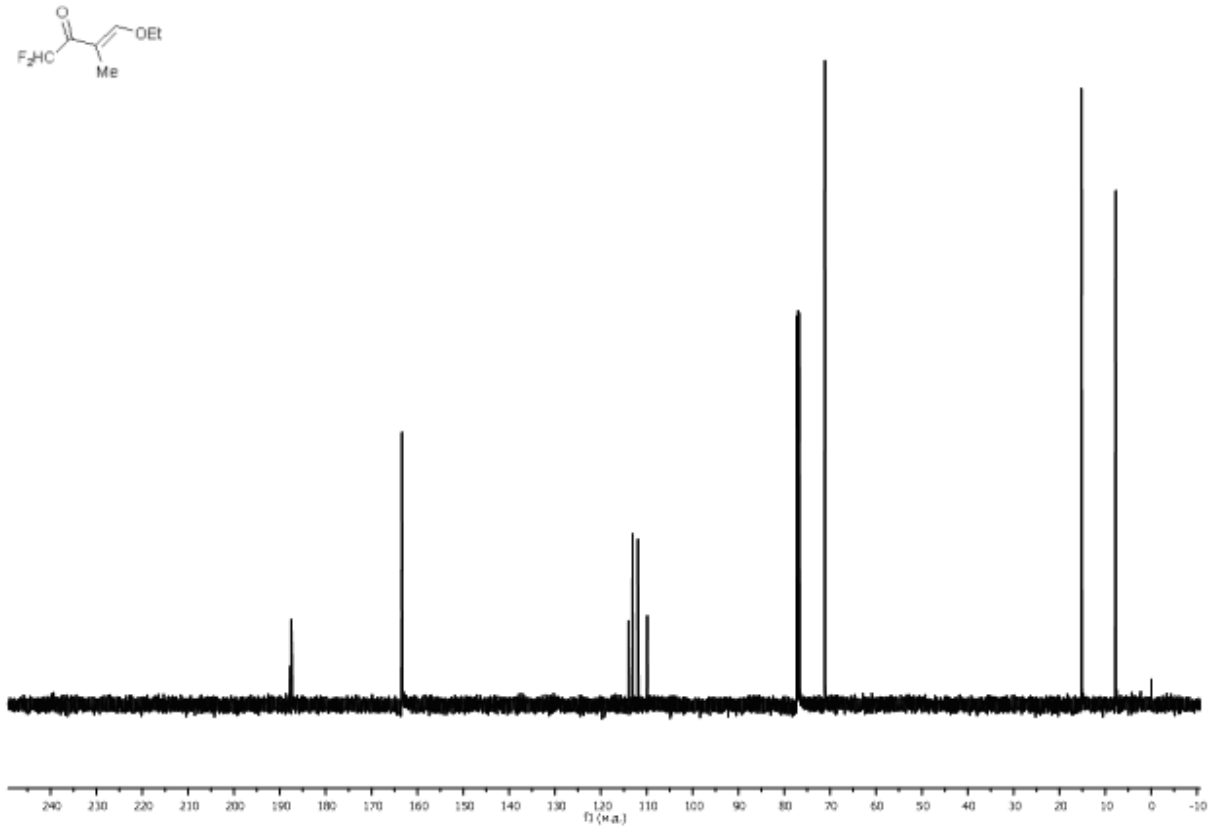
[7] Tarasenko, K. V.; Kukhar, V. P.; Gerus, I. I.; Manoylenko, O. V.; Röschenthaler, G.-V. *Tetrahedron Lett.* **2010**, *51*, 4623-4626.

[8] For clearness just tautomers **8** are mentioned in order to avoid complication of schemes and text with other tautomers **5** and **7**.

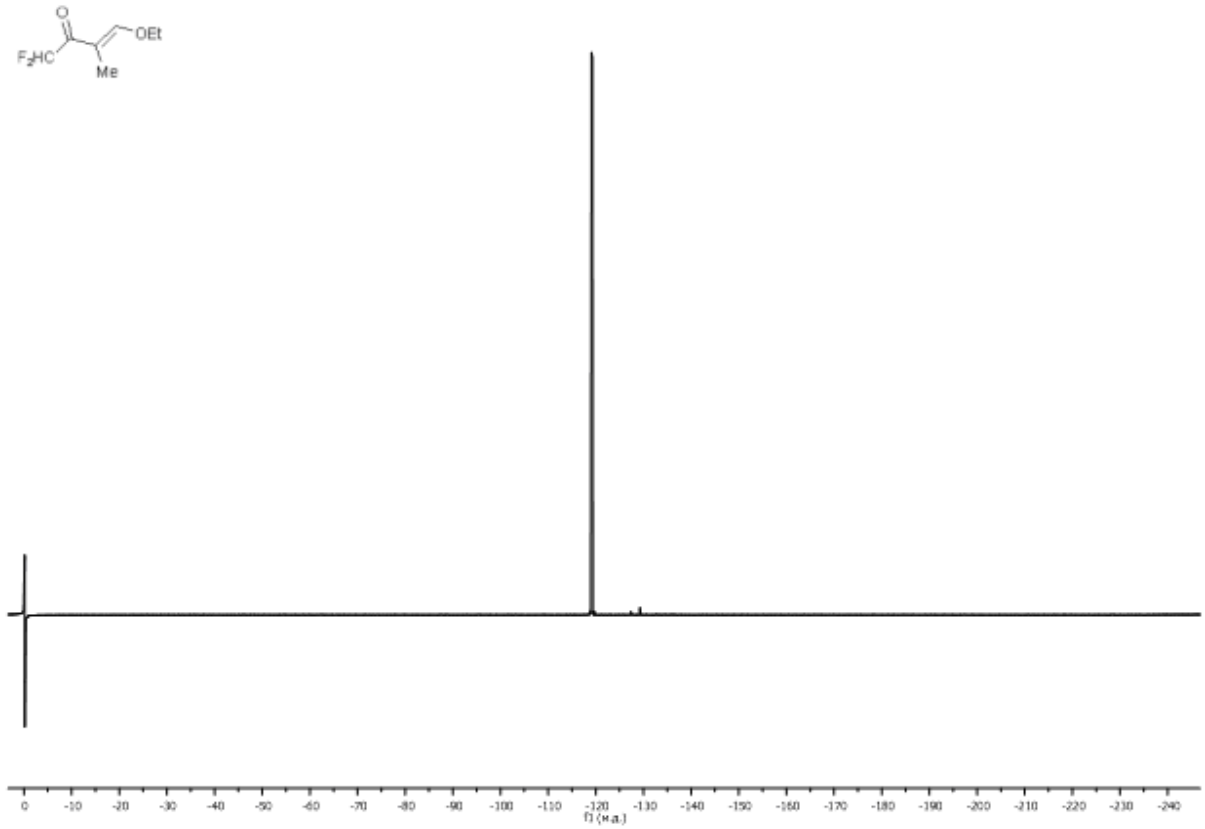
Compound 1g. ^{1}H NMR ($CDCl_3$)



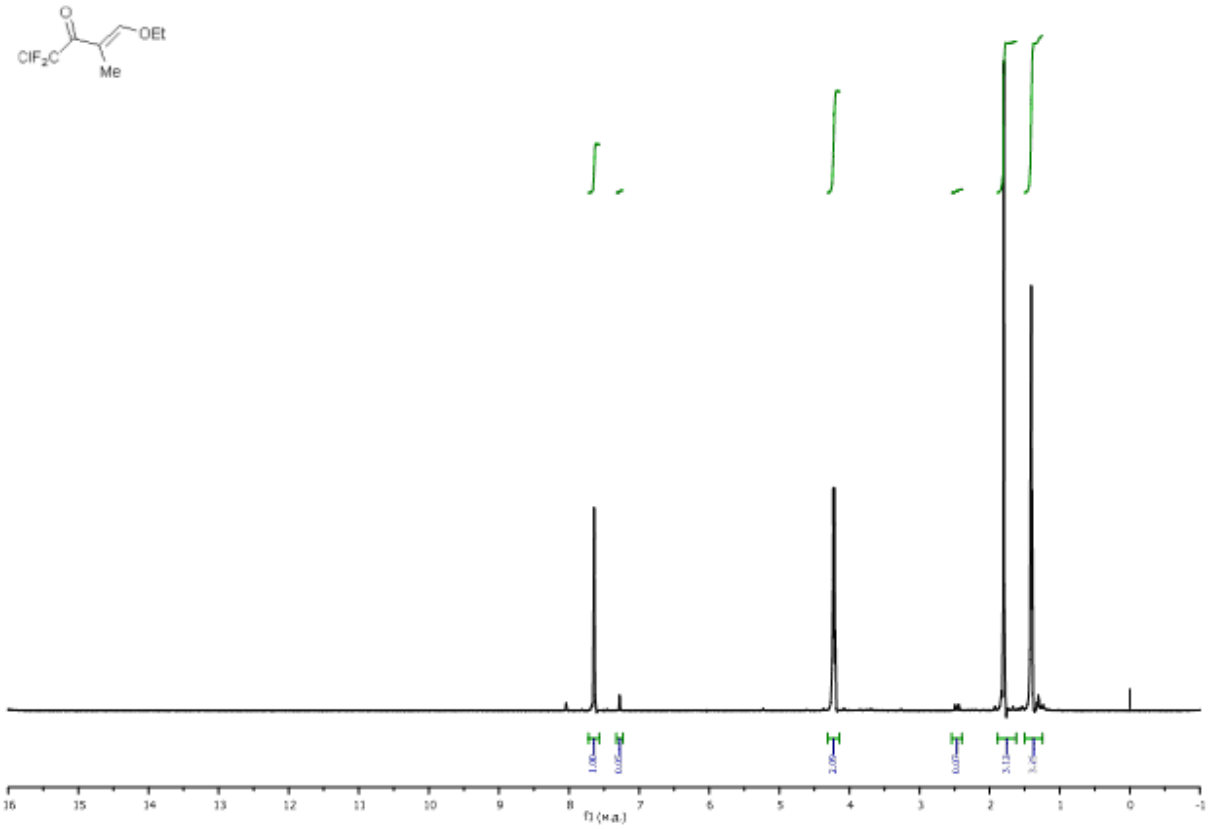
Compound 1g. ^{13}C NMR ($CDCl_3$)



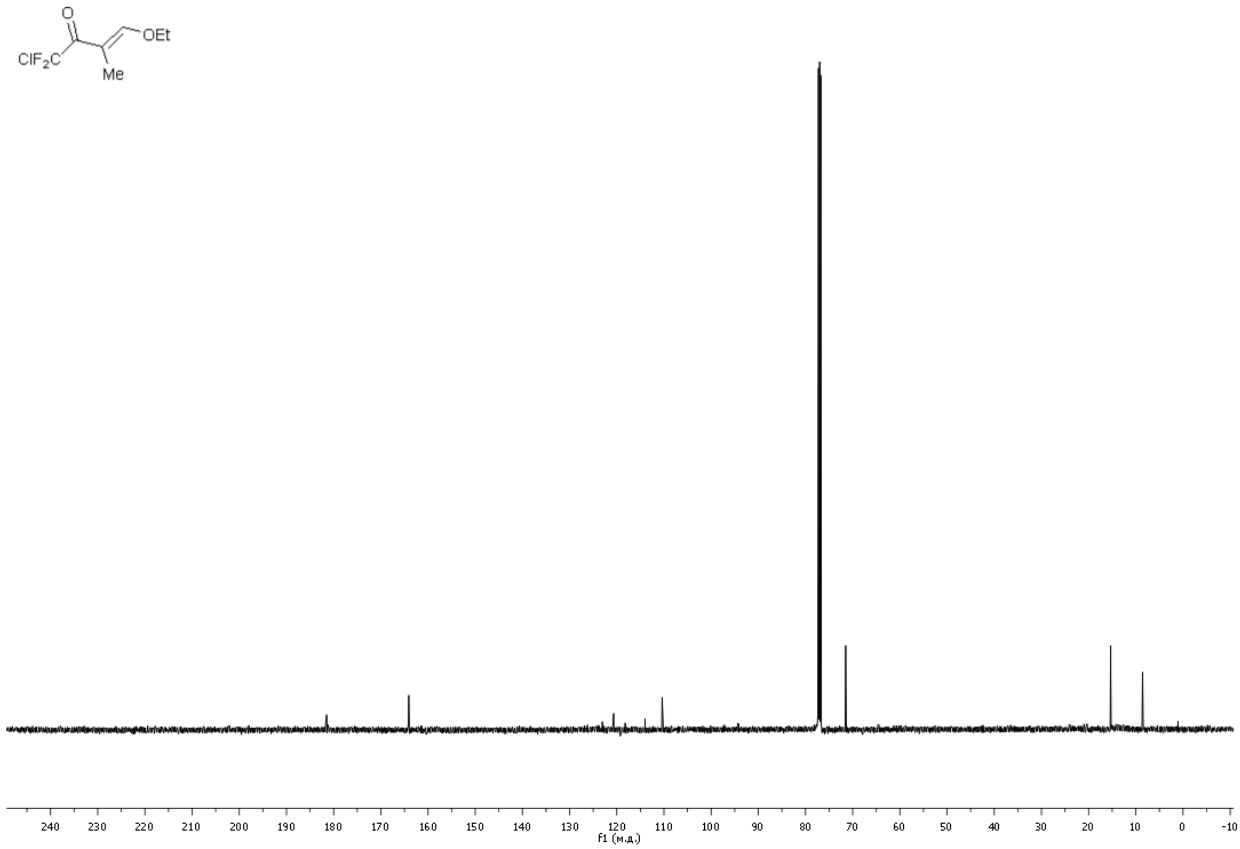
Compound 1g. ^{19}F NMR ($CDCl_3$)



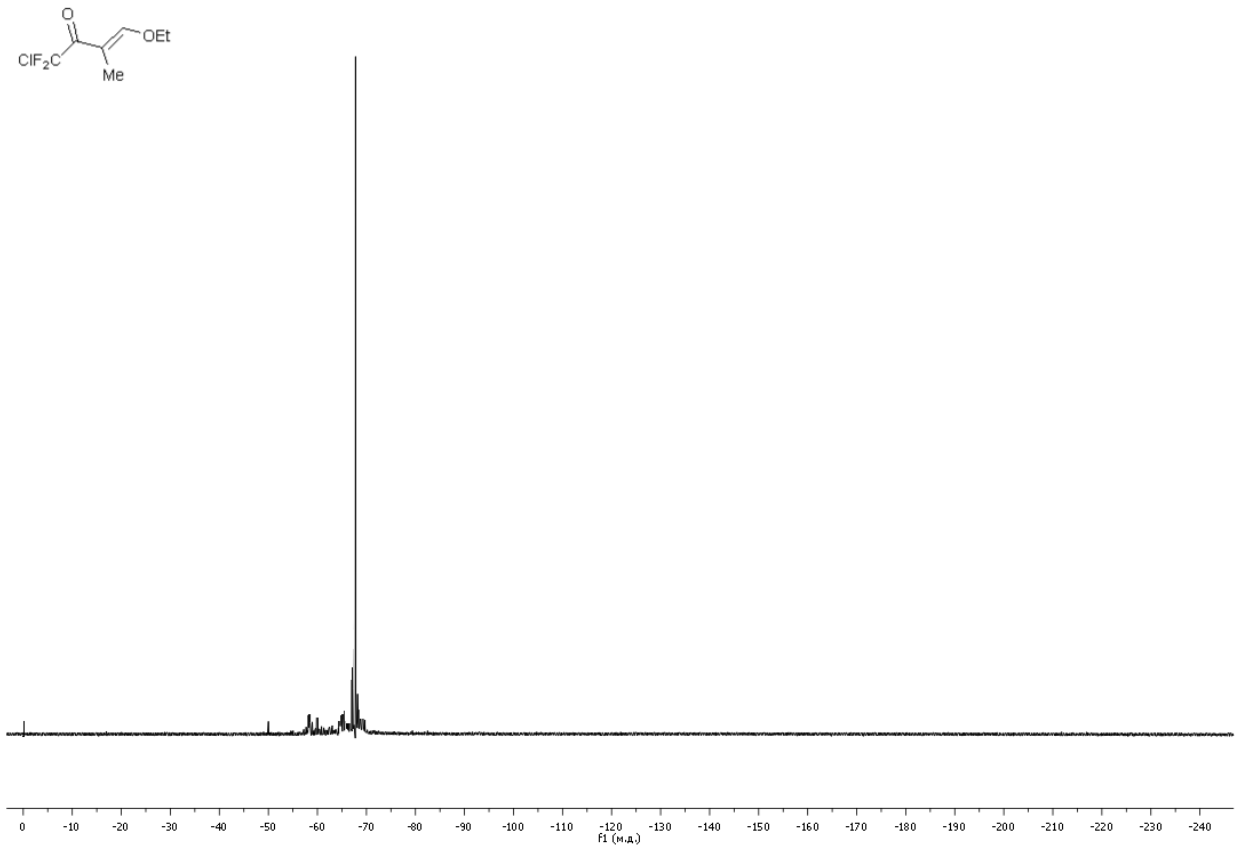
Compound 1h. ^{1}H NMR ($CDCl_3$)



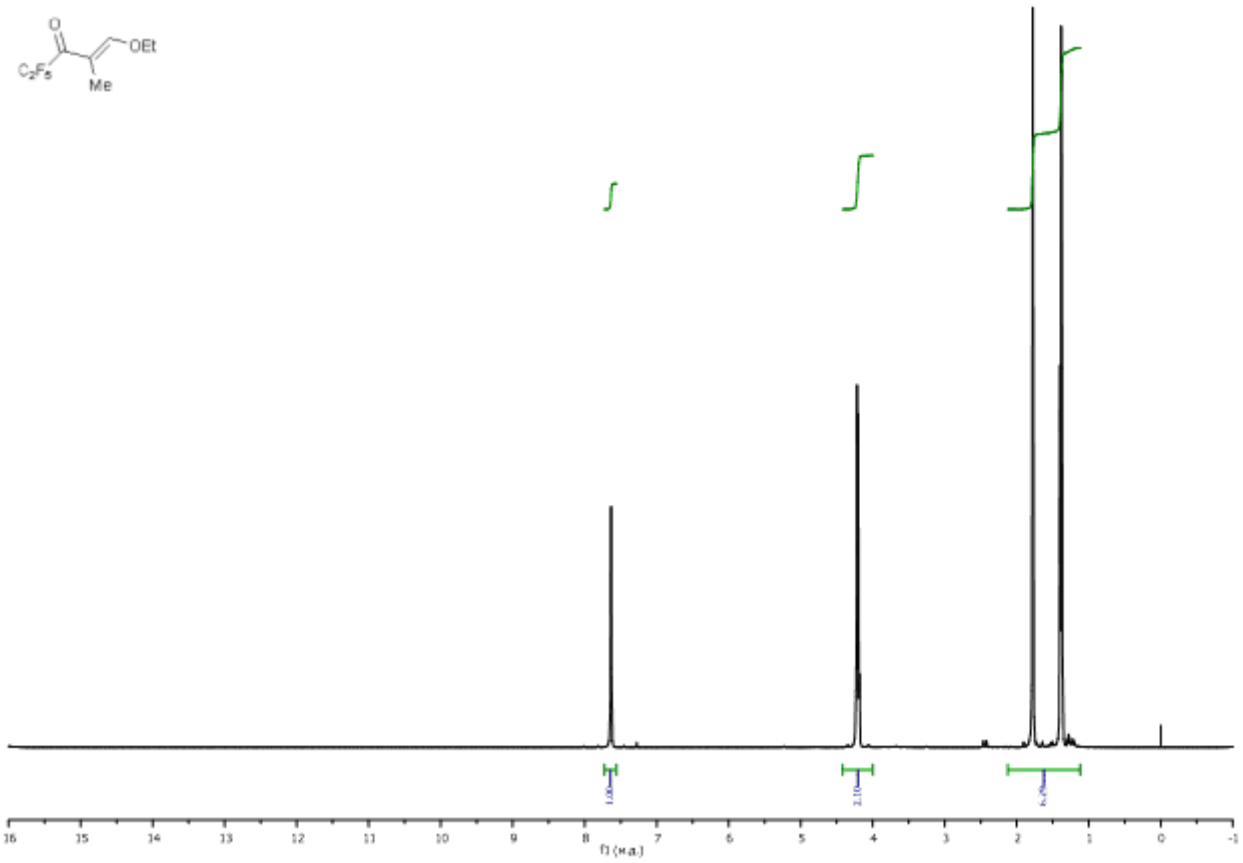
Compound 1h. ^{13}C NMR ($CDCl_3$)



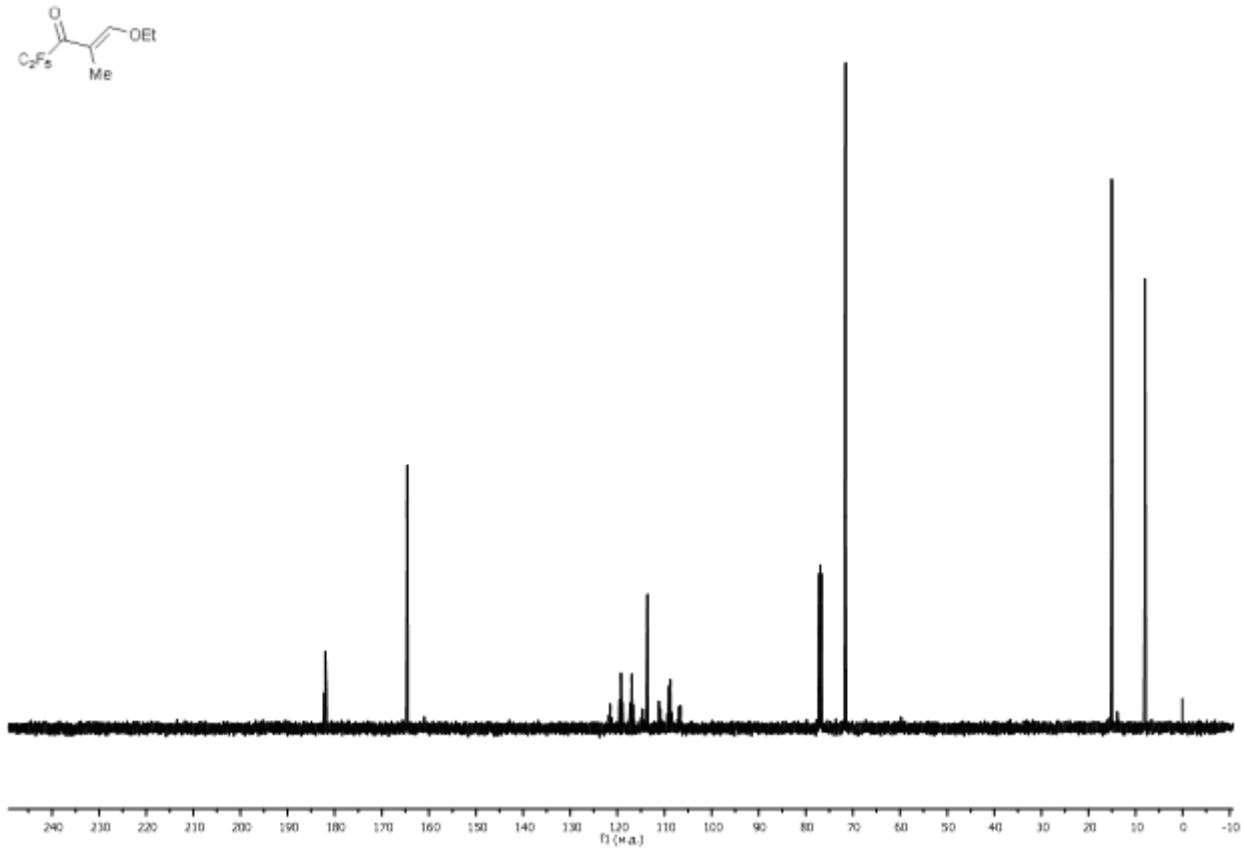
Compound 1h. ^{19}F NMR ($CDCl_3$)



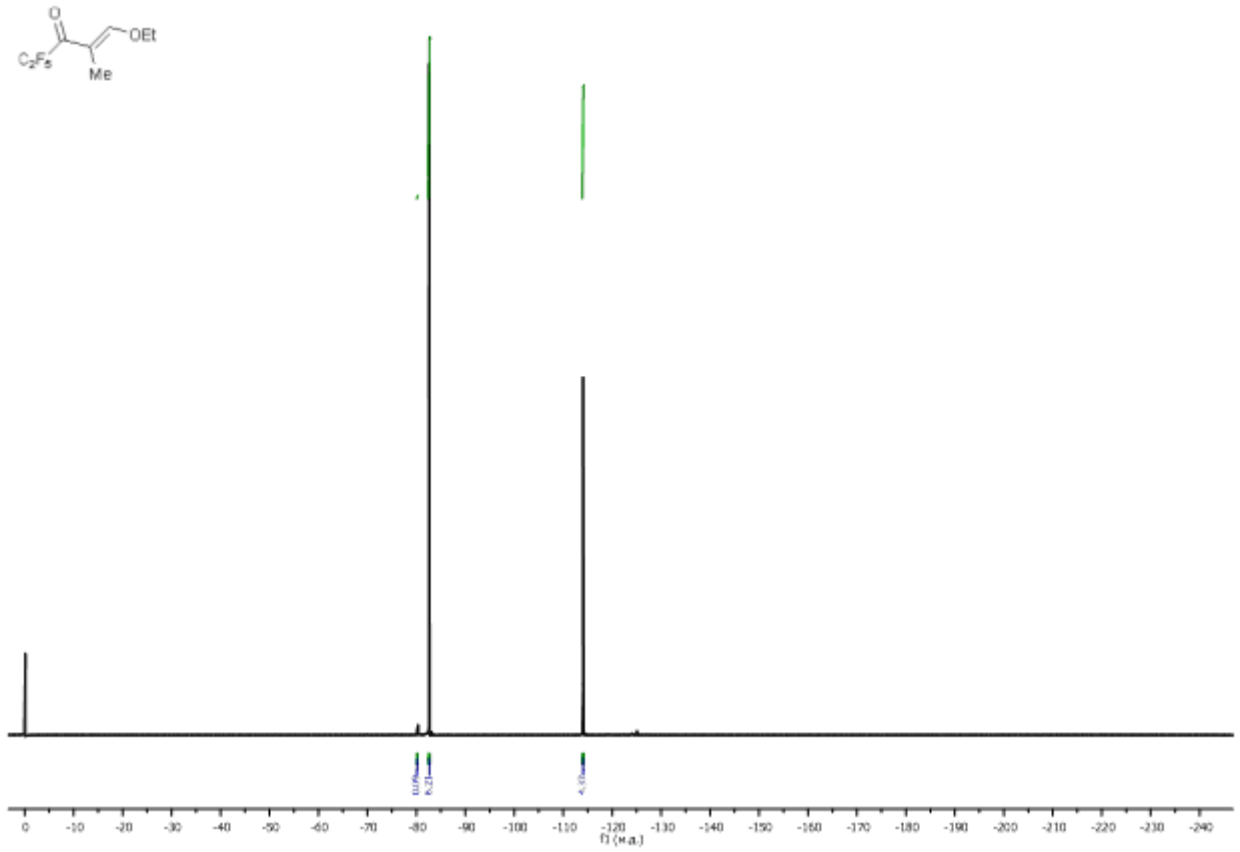
Compound 1i. ^{1}H NMR ($CDCl_3$)



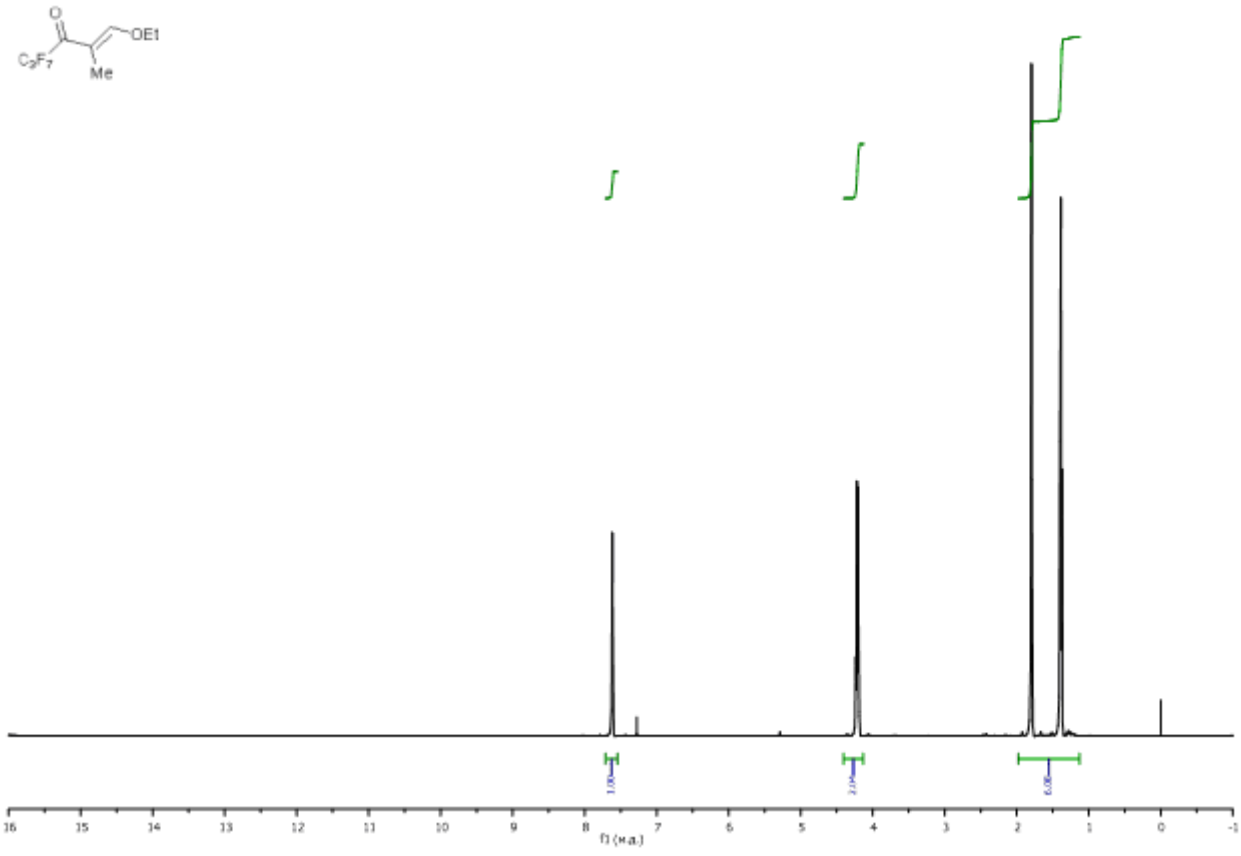
Compound 1i. ^{13}C NMR ($CDCl_3$)



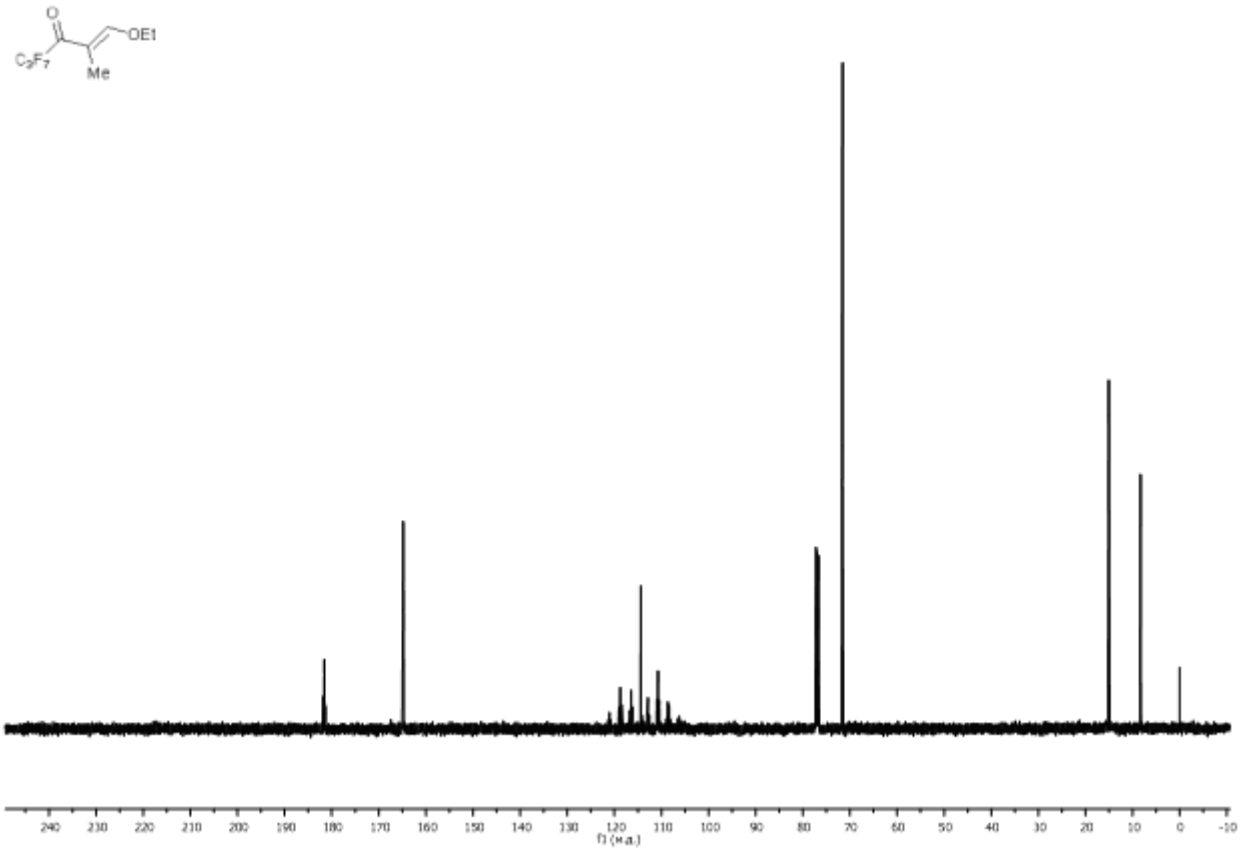
Compound 1i. ^{19}F NMR ($CDCl_3$)



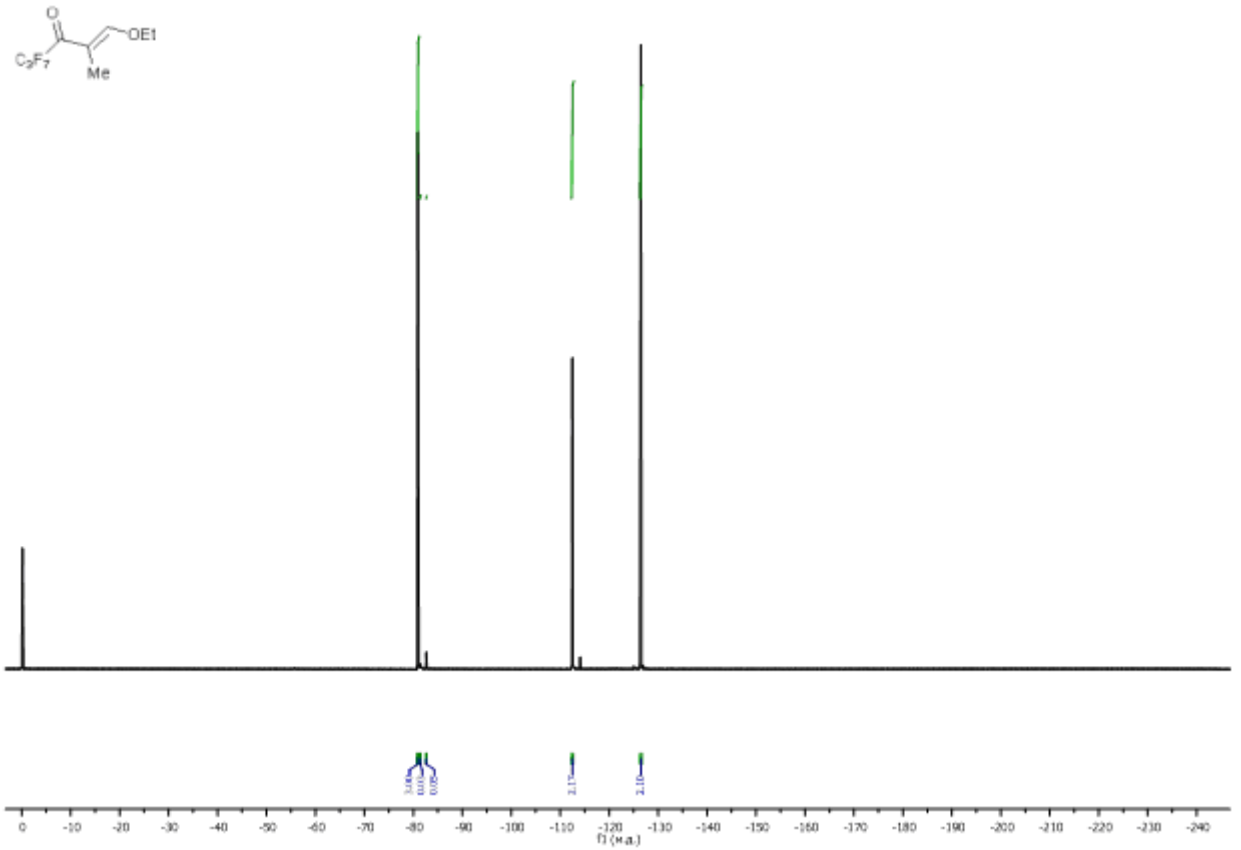
Compound 1j. ^{1}H NMR ($CDCl_3$)



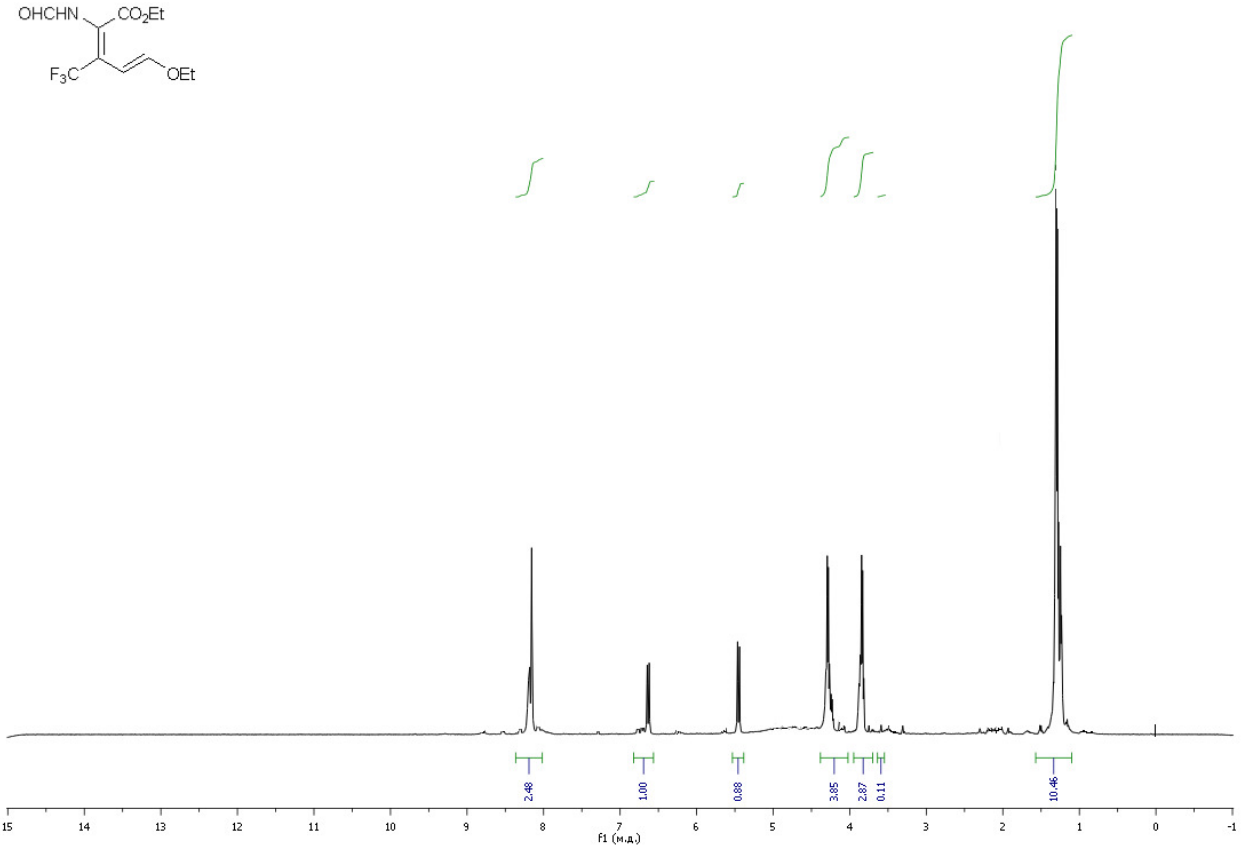
Compound 1j. ^{13}C NMR ($CDCl_3$)



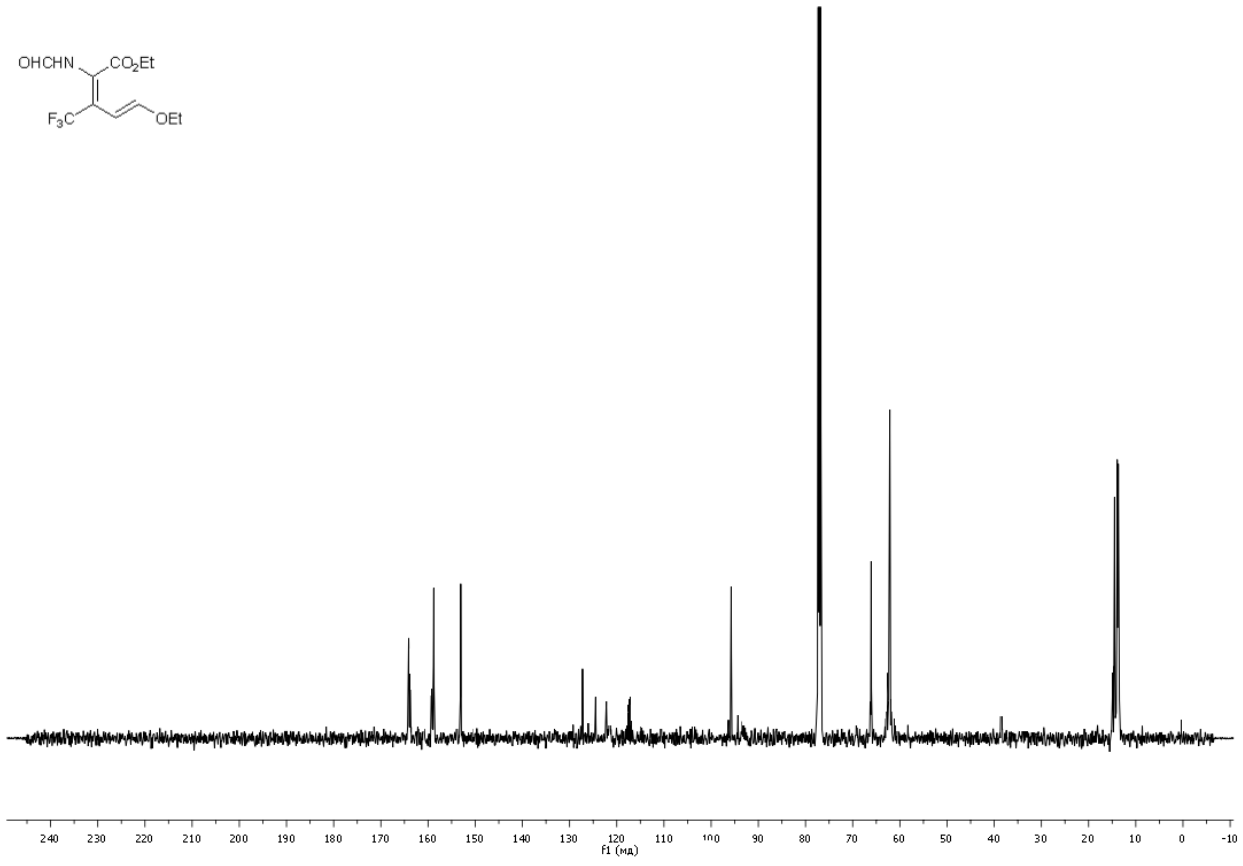
Compound 1j. ^{19}F NMR ($CDCl_3$)



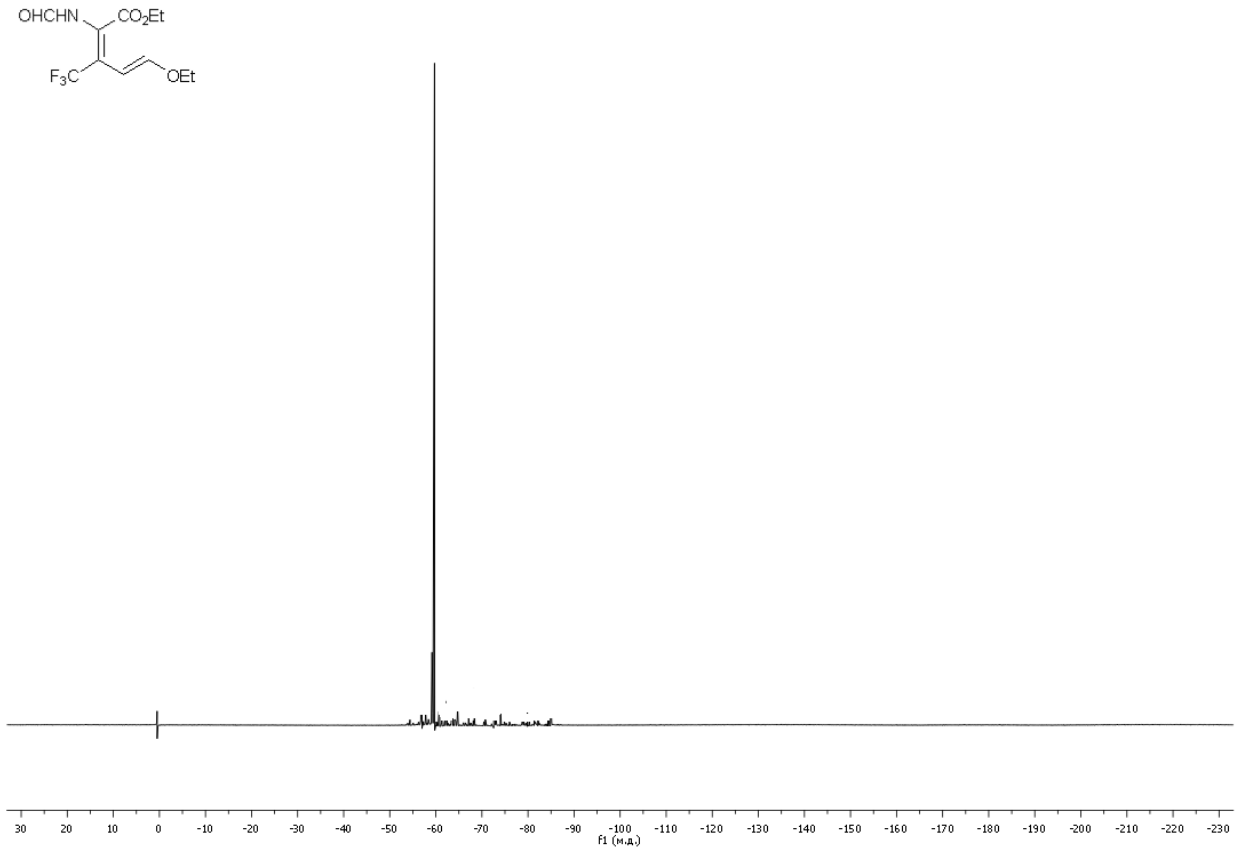
Compound 4a. ^{1}H NMR ($CDCl_3$)



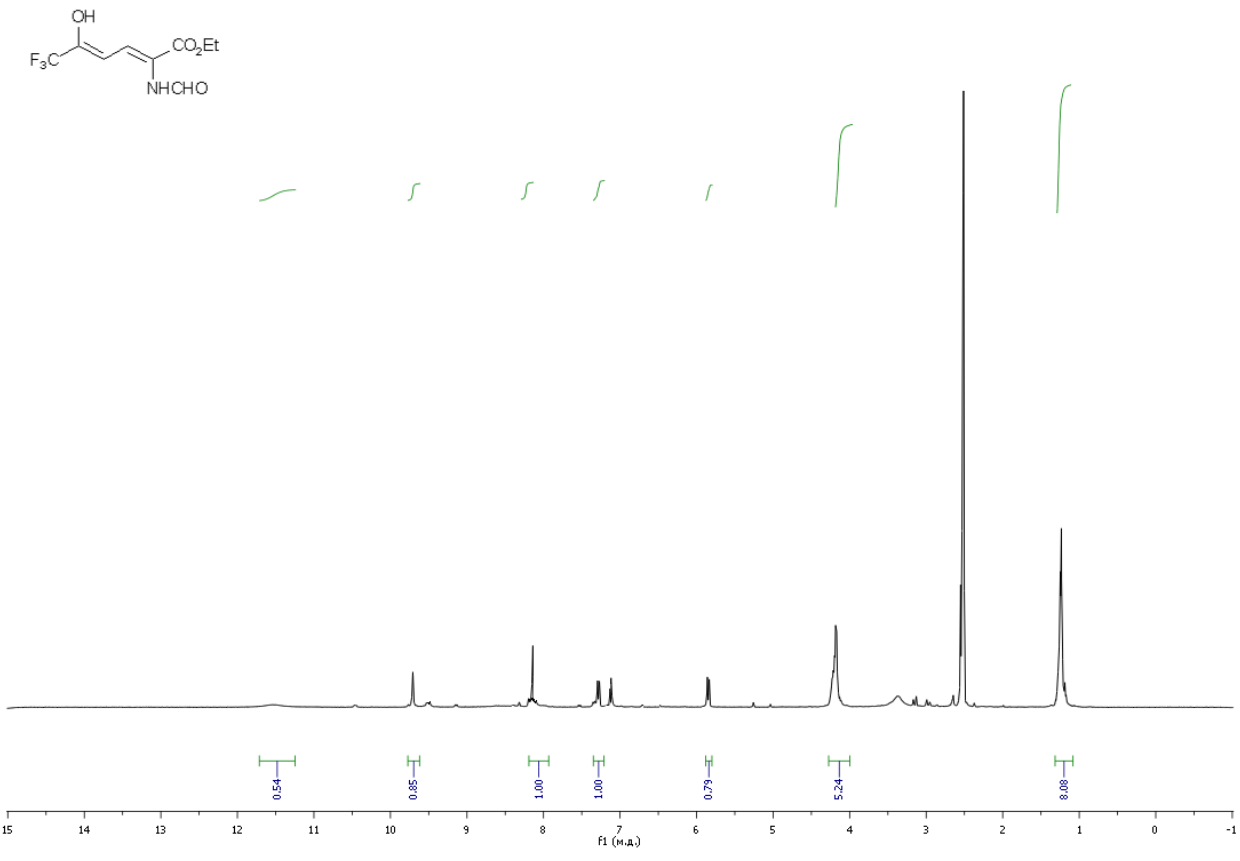
Compound 4a. ^{13}C NMR ($CDCl_3$)



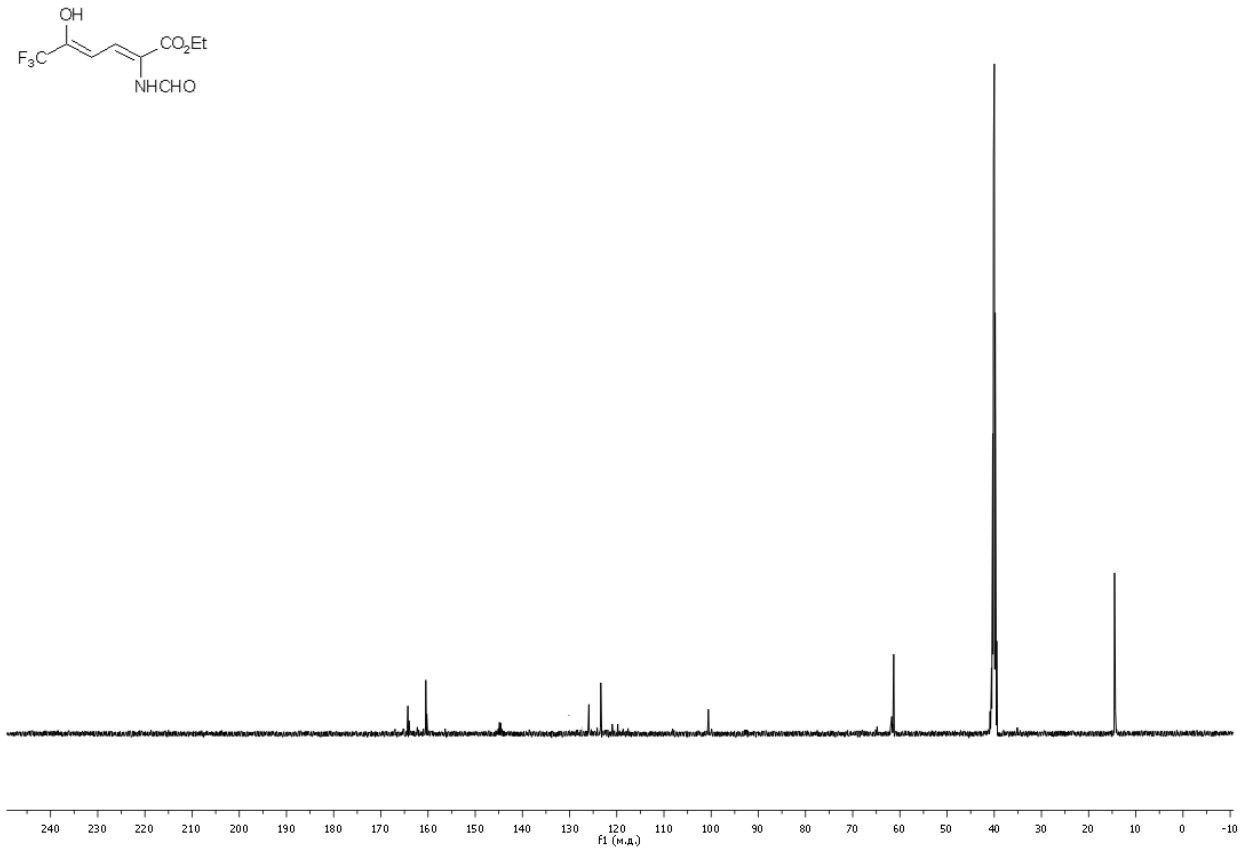
Compound 4a. ^{19}F NMR ($CDCl_3$)



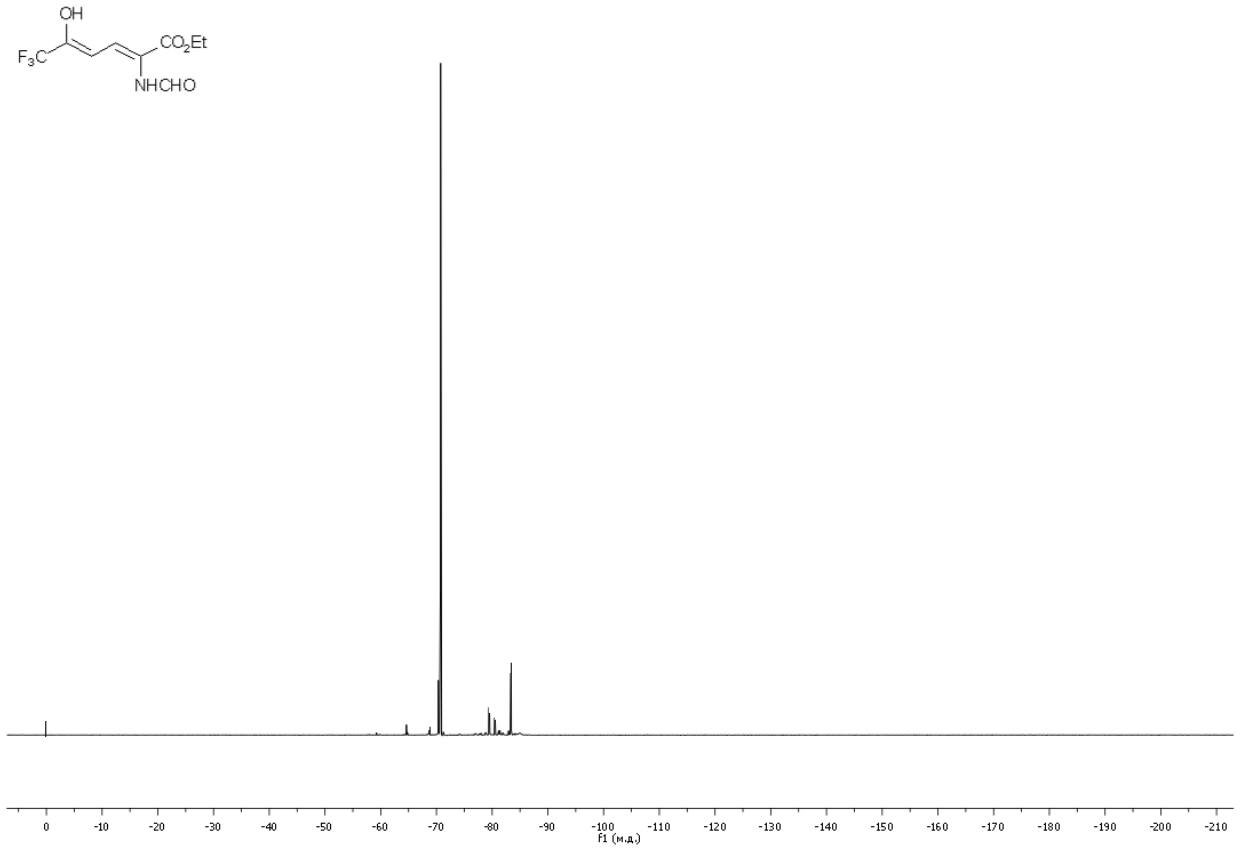
Compound 5a. ^{1}H NMR (DMSO-d_6)



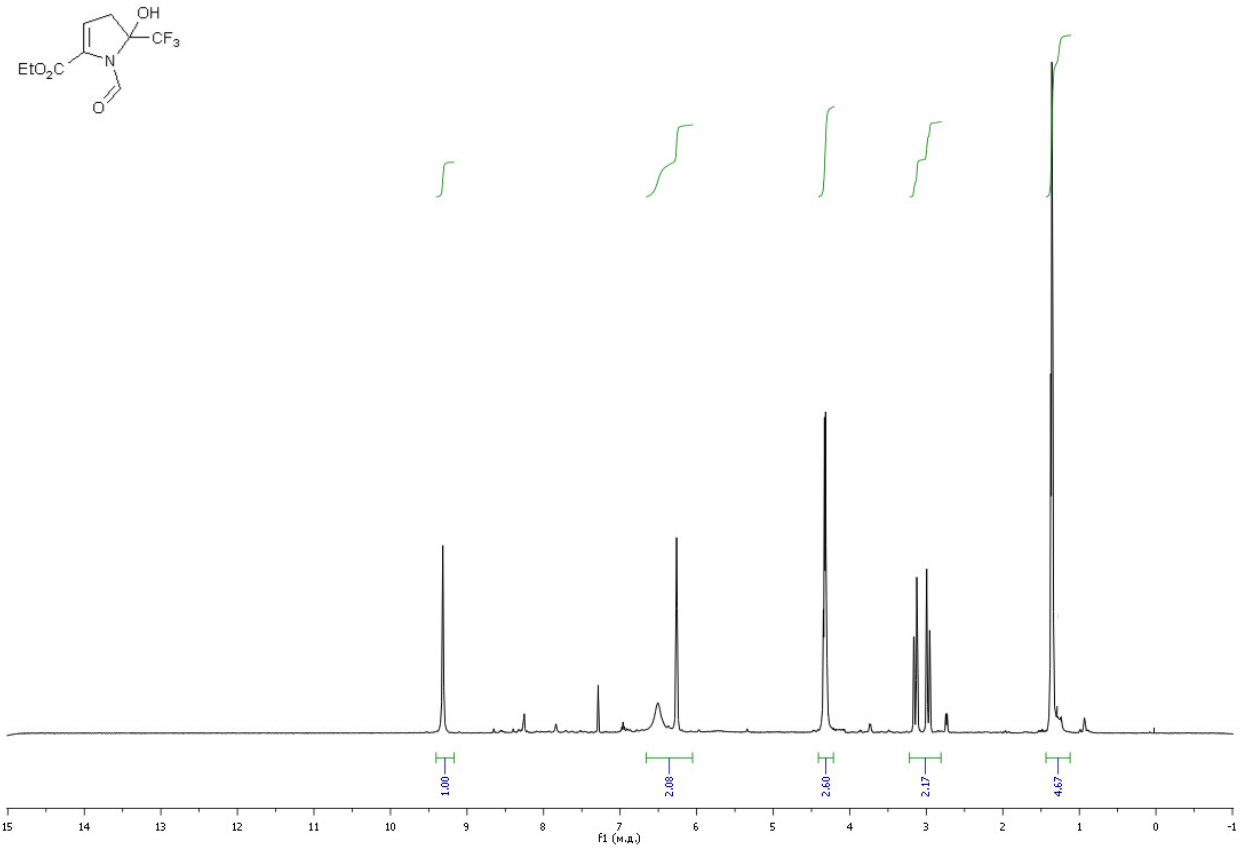
Compound 5a. ^{13}C NMR (DMSO-d_6)



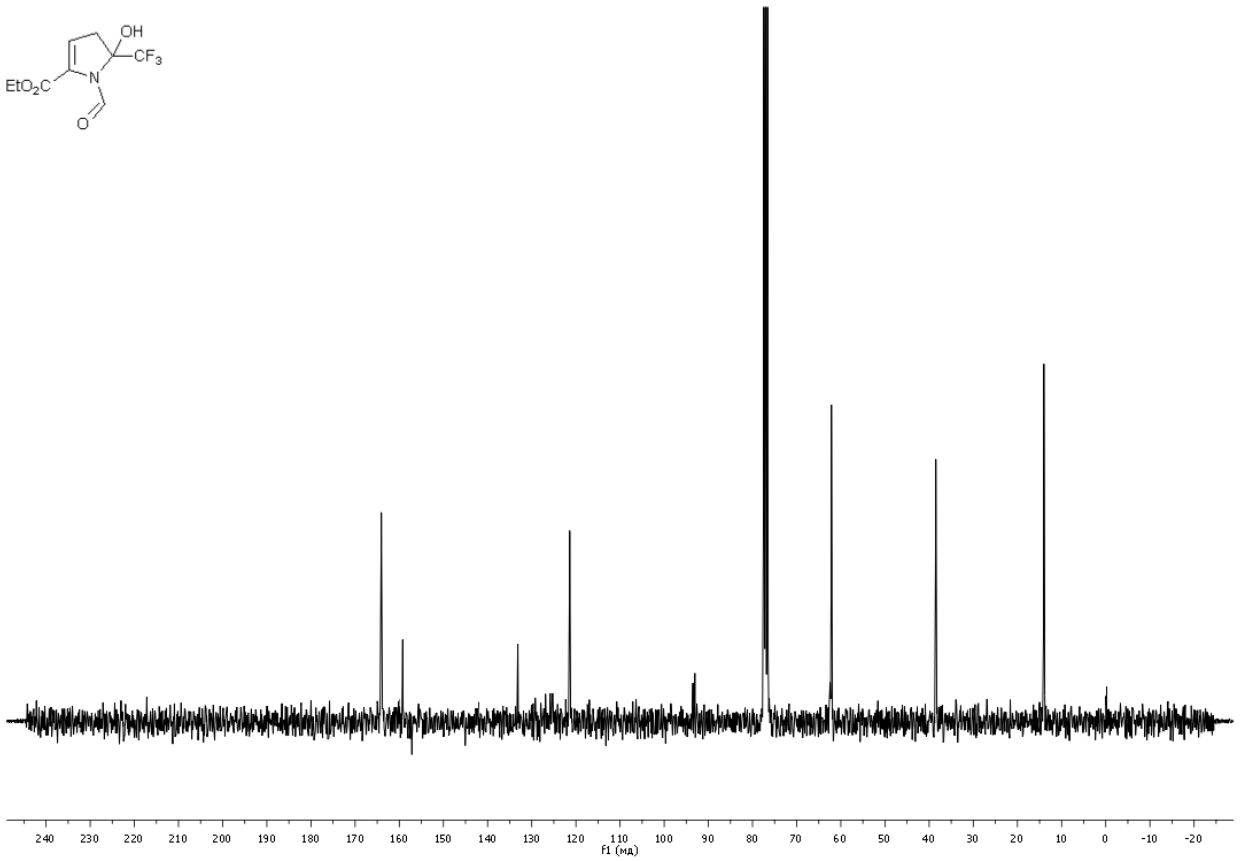
Compound 5a. ^{19}F NMR (DMSO-d_6)



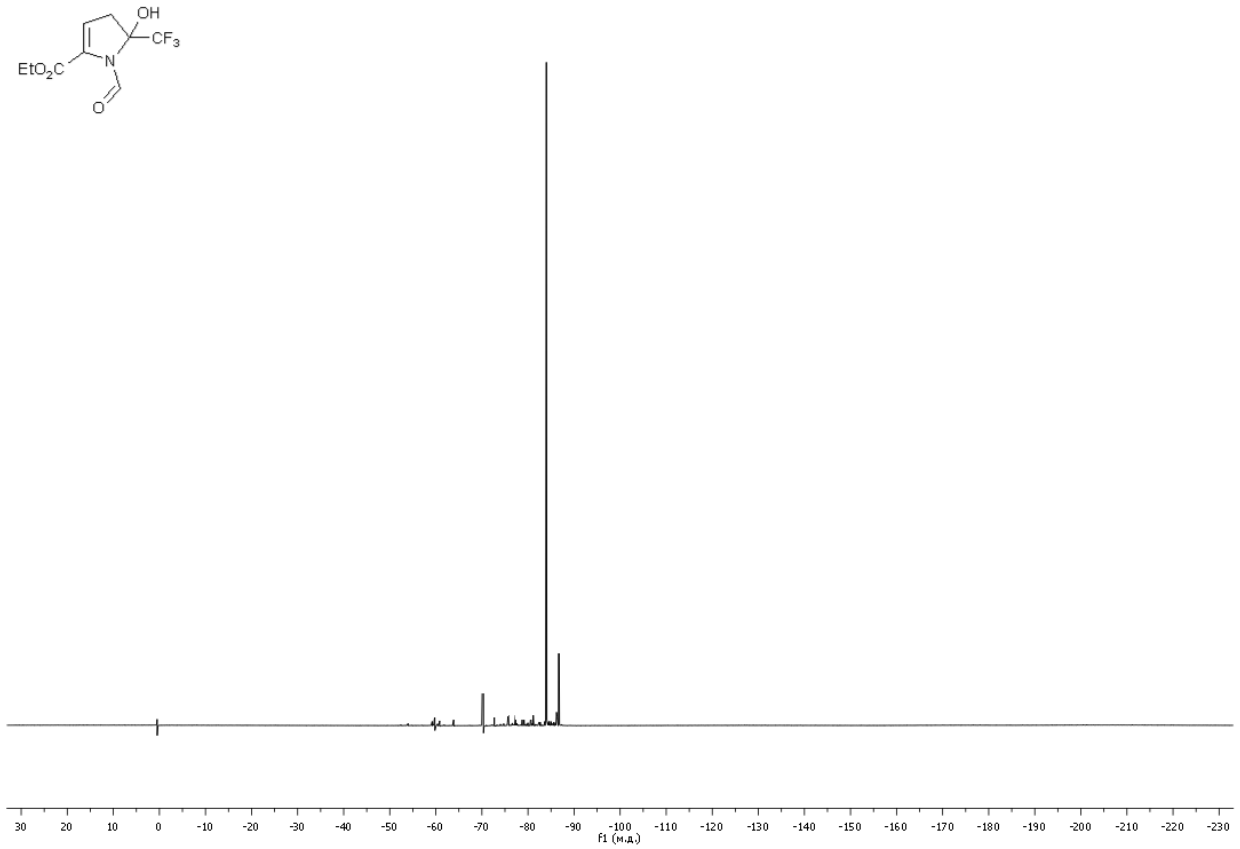
Compound 8a. ^{1}H NMR ($CDCl_3$)



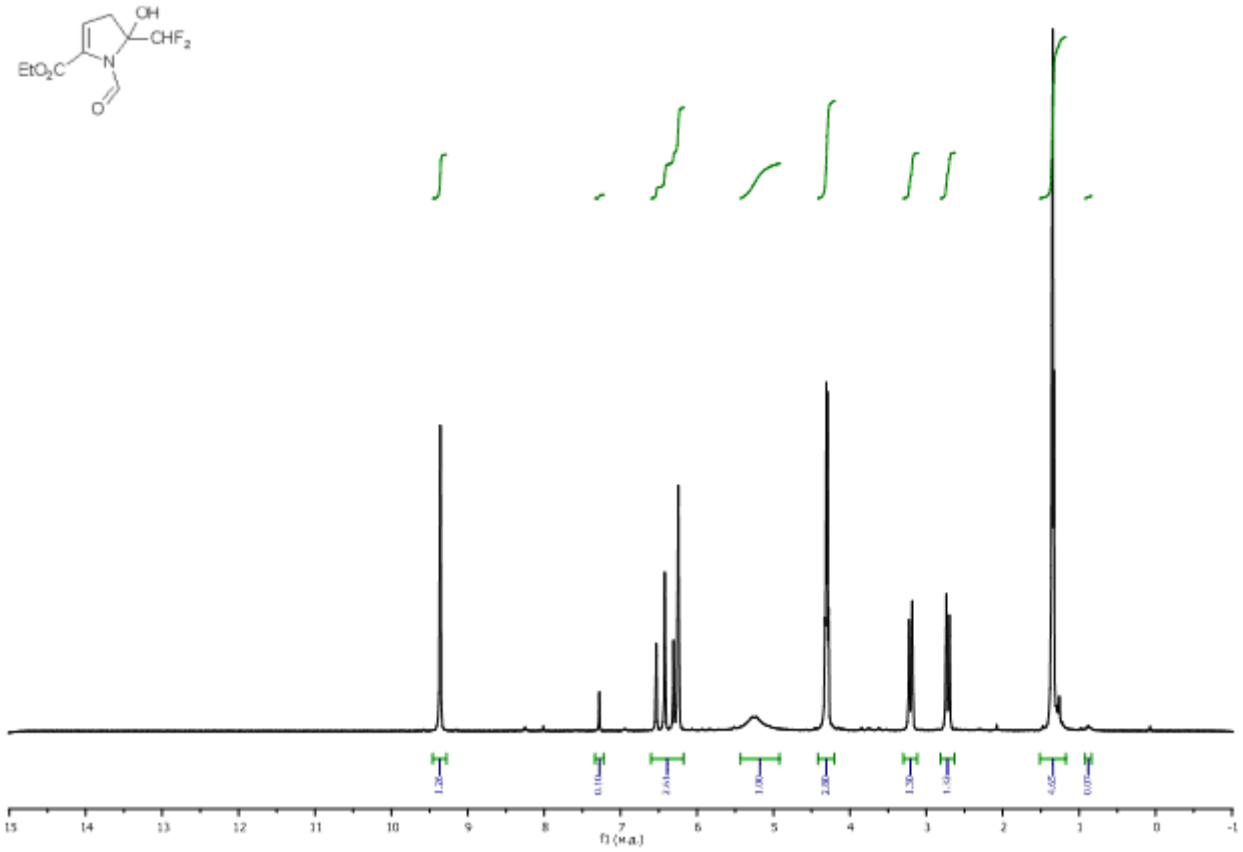
Compound 8a. ^{13}C NMR ($CDCl_3$)



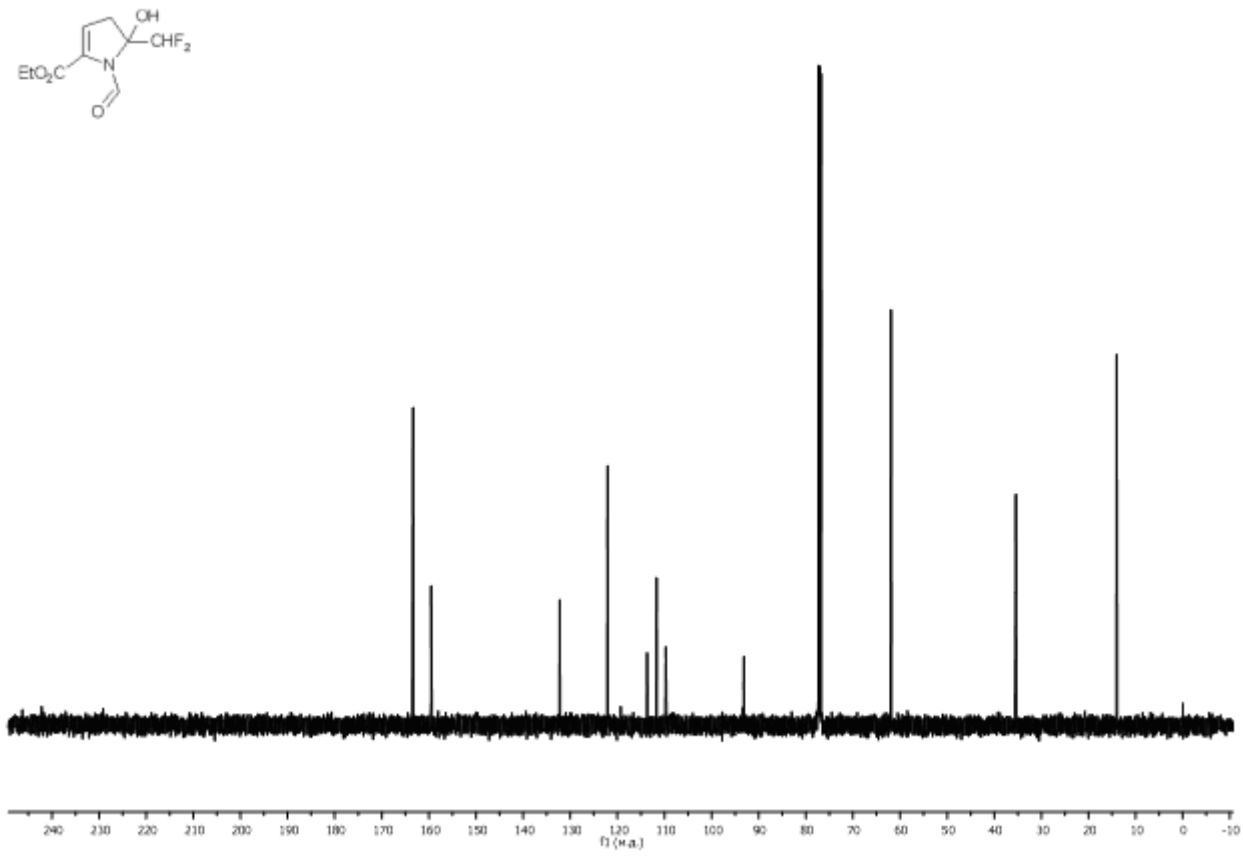
Compound 8a. ^{19}F NMR ($CDCl_3$)



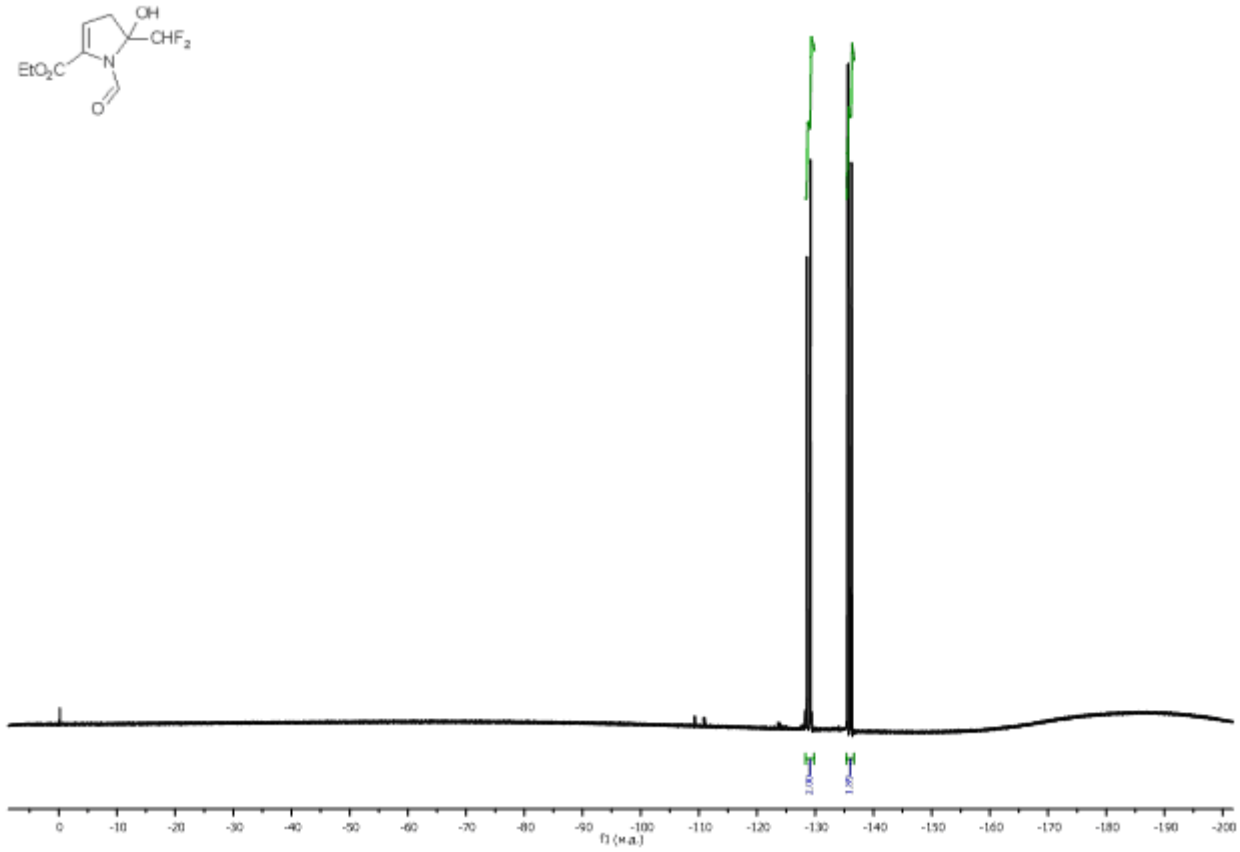
Compound 8b. ^{1}H NMR ($CDCl_3$)



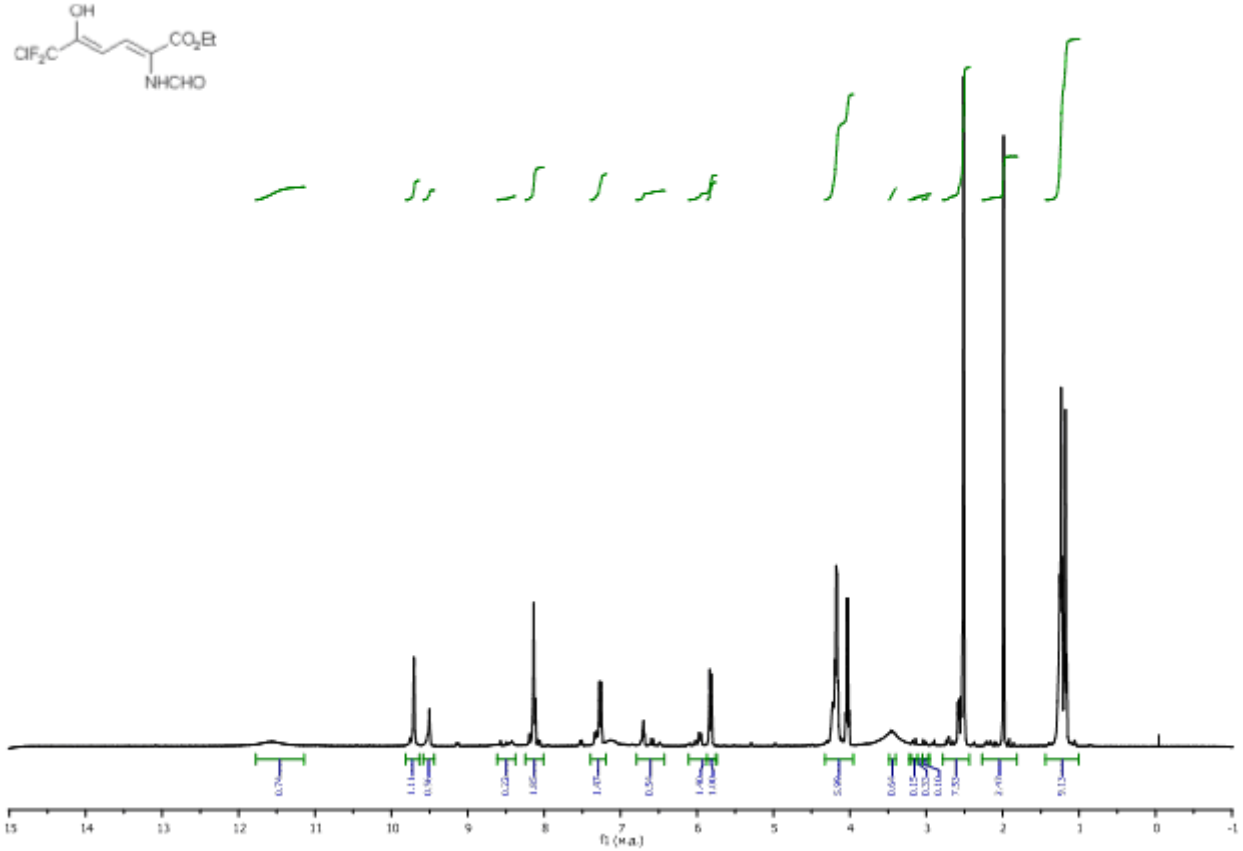
Compound 8b. ^{13}C NMR ($CDCl_3$)



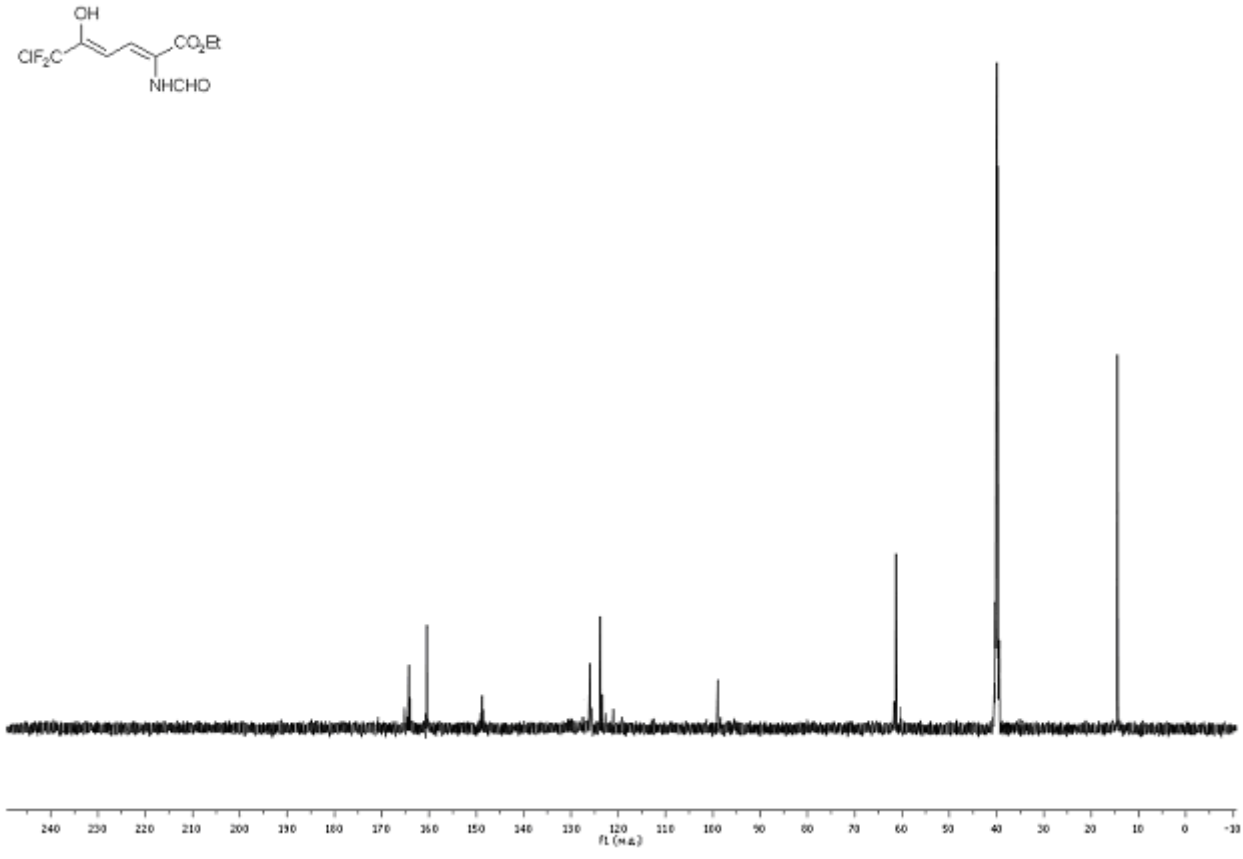
Compound 8b. ^{19}F NMR ($CDCl_3$)



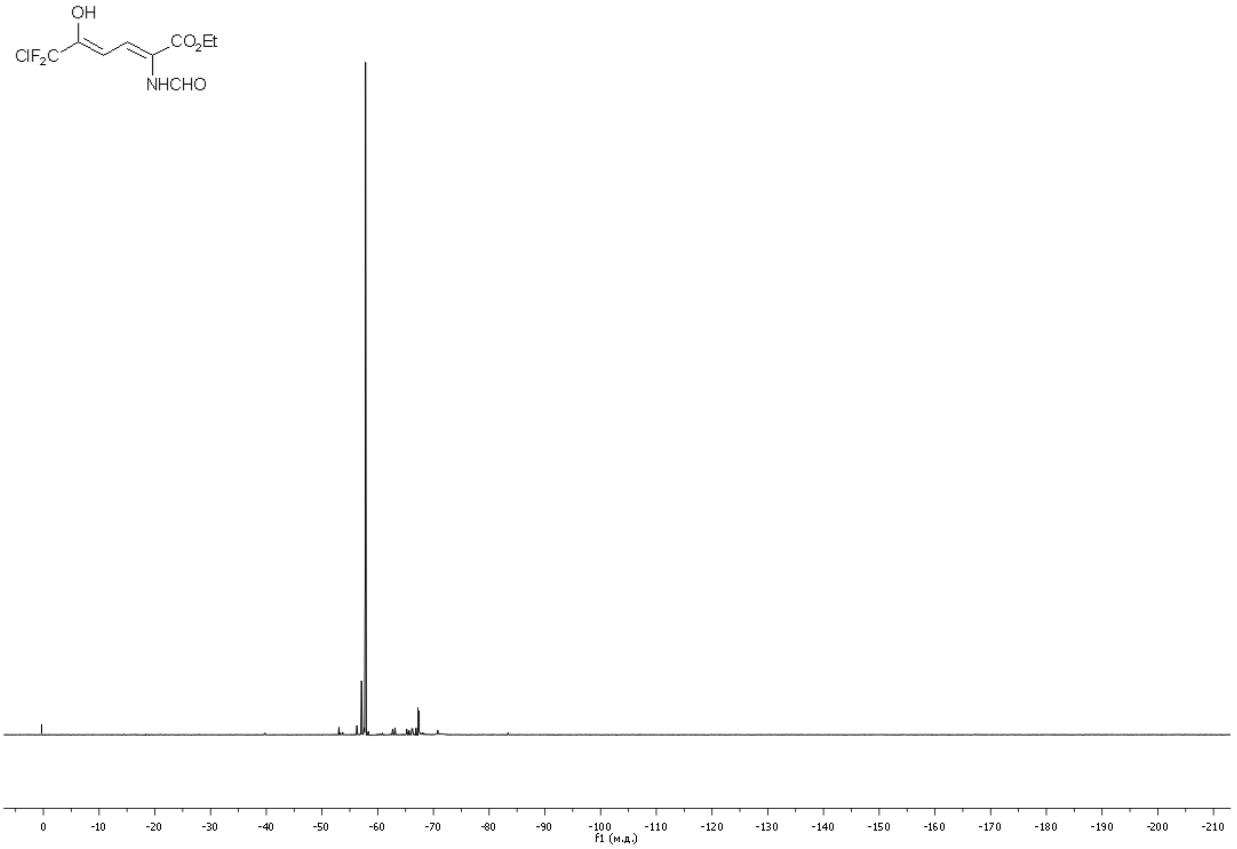
Compound 5c. ^{1}H NMR (DMSO-d_6)



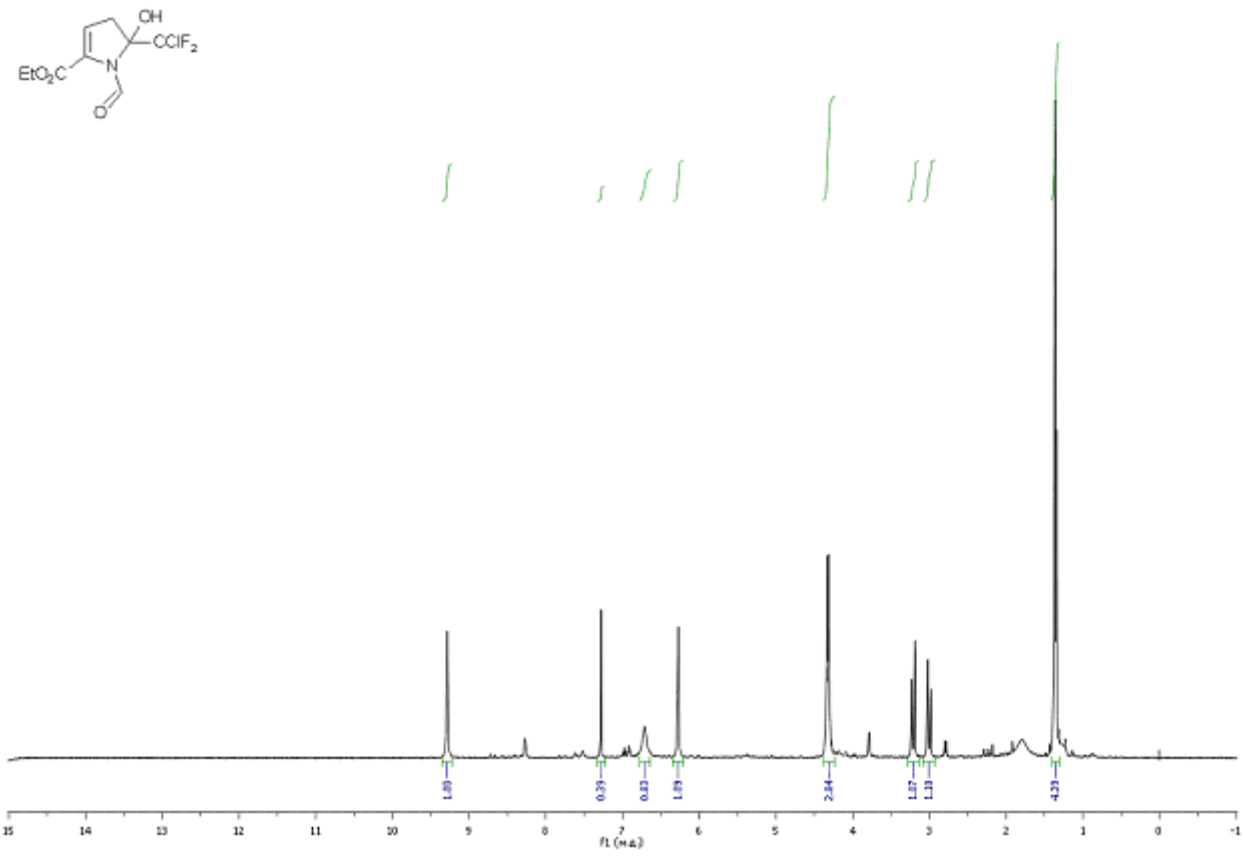
Compound 5c. ^{13}C NMR (DMSO-d_6)



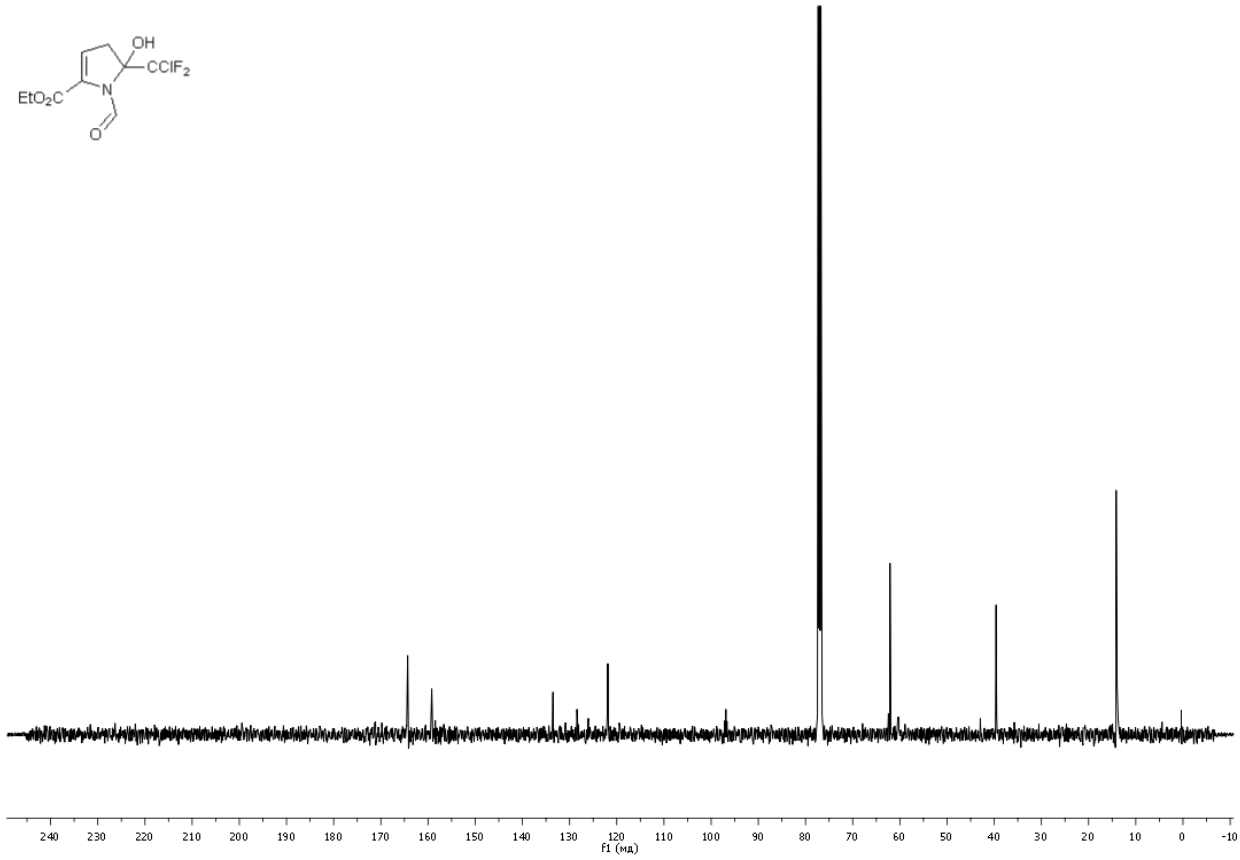
Compound 5c. ^{19}F NMR (DMSO-d_6)



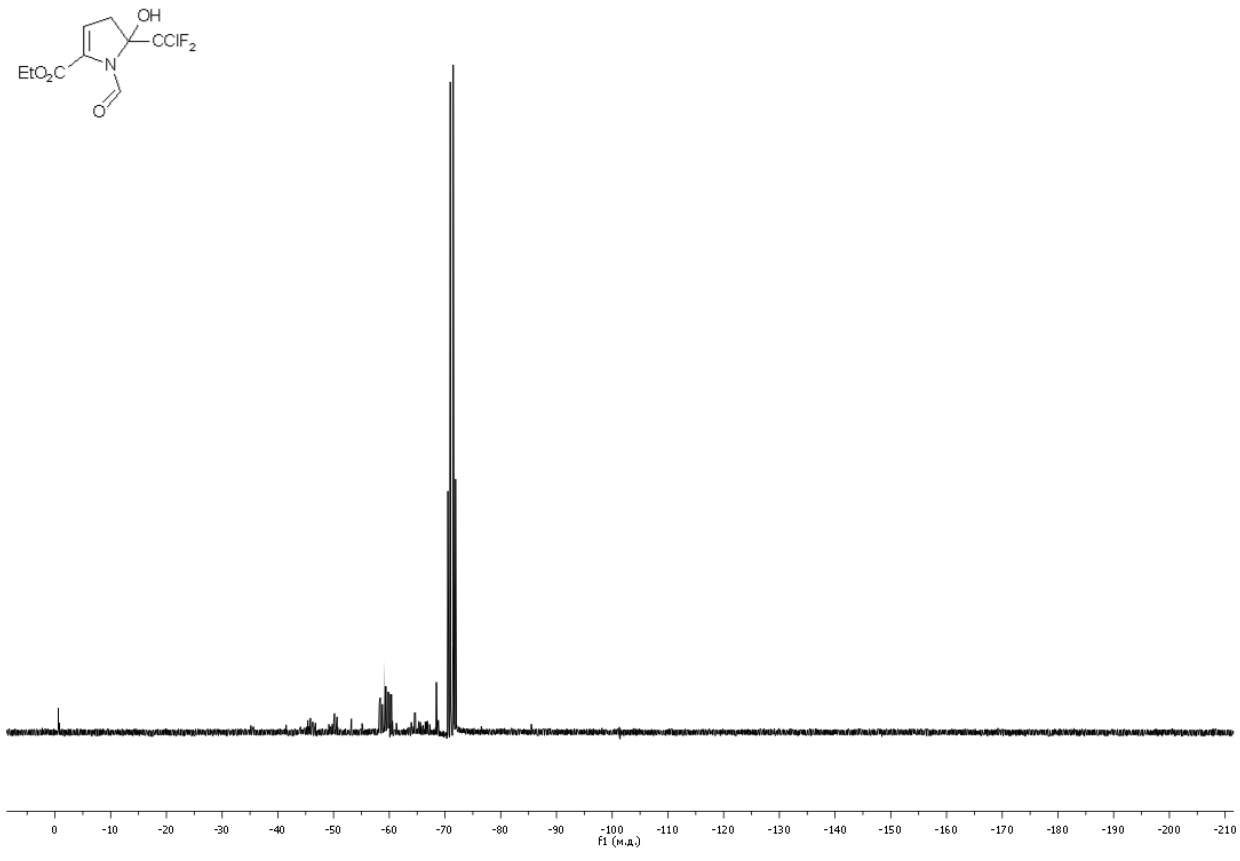
Compound 8c. ^{1}H NMR ($CDCl_3$)



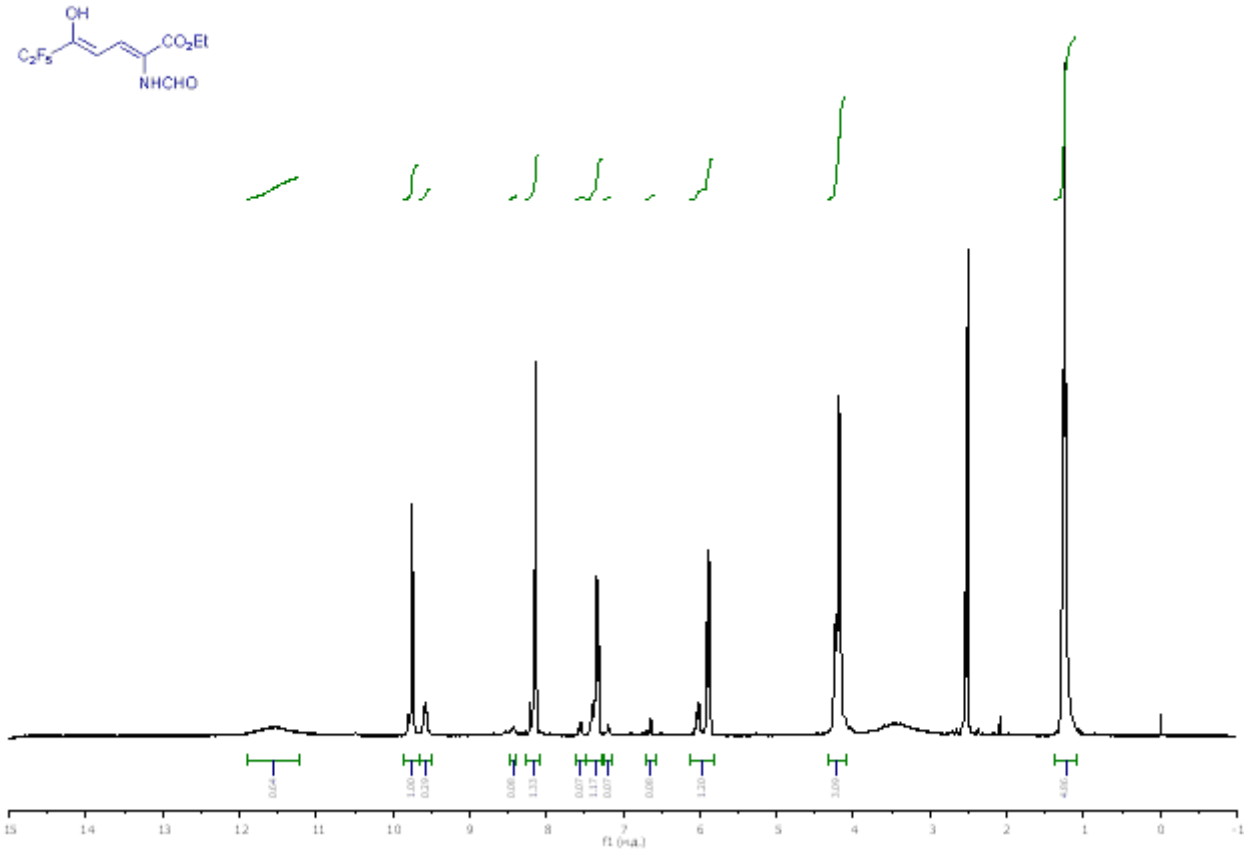
Compound 8c. ^{13}C NMR ($CDCl_3$)



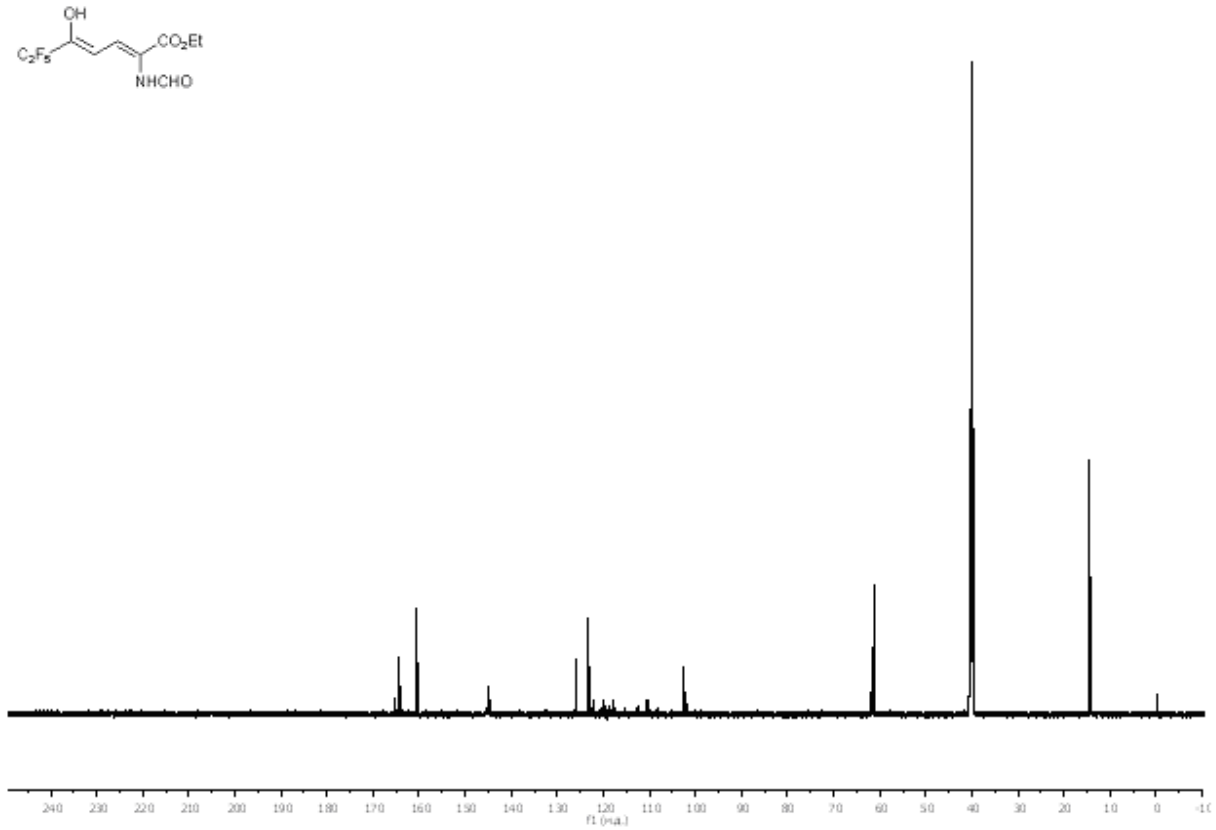
Compound 8c. ^{19}F NMR ($CDCl_3$)



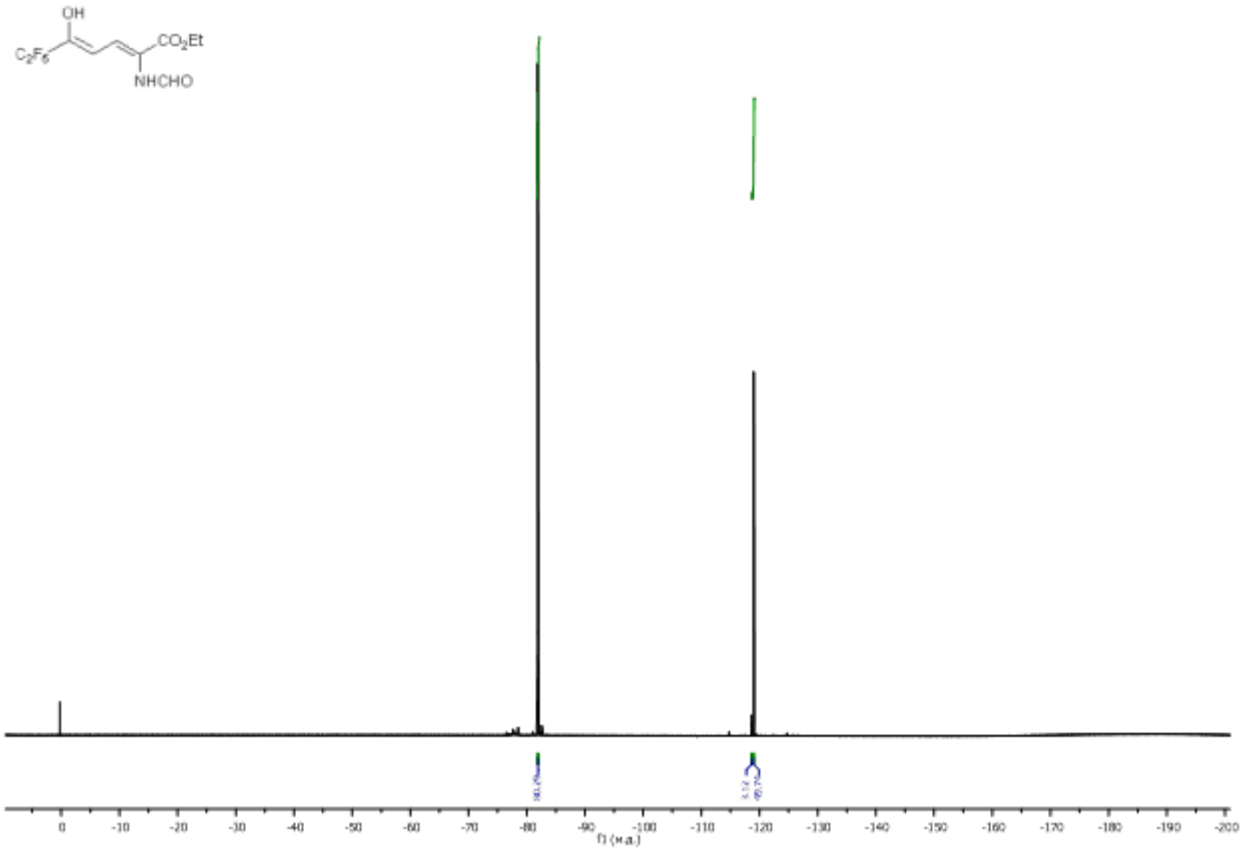
Compound 5d. ^{1}H NMR (DMSO-d_6)



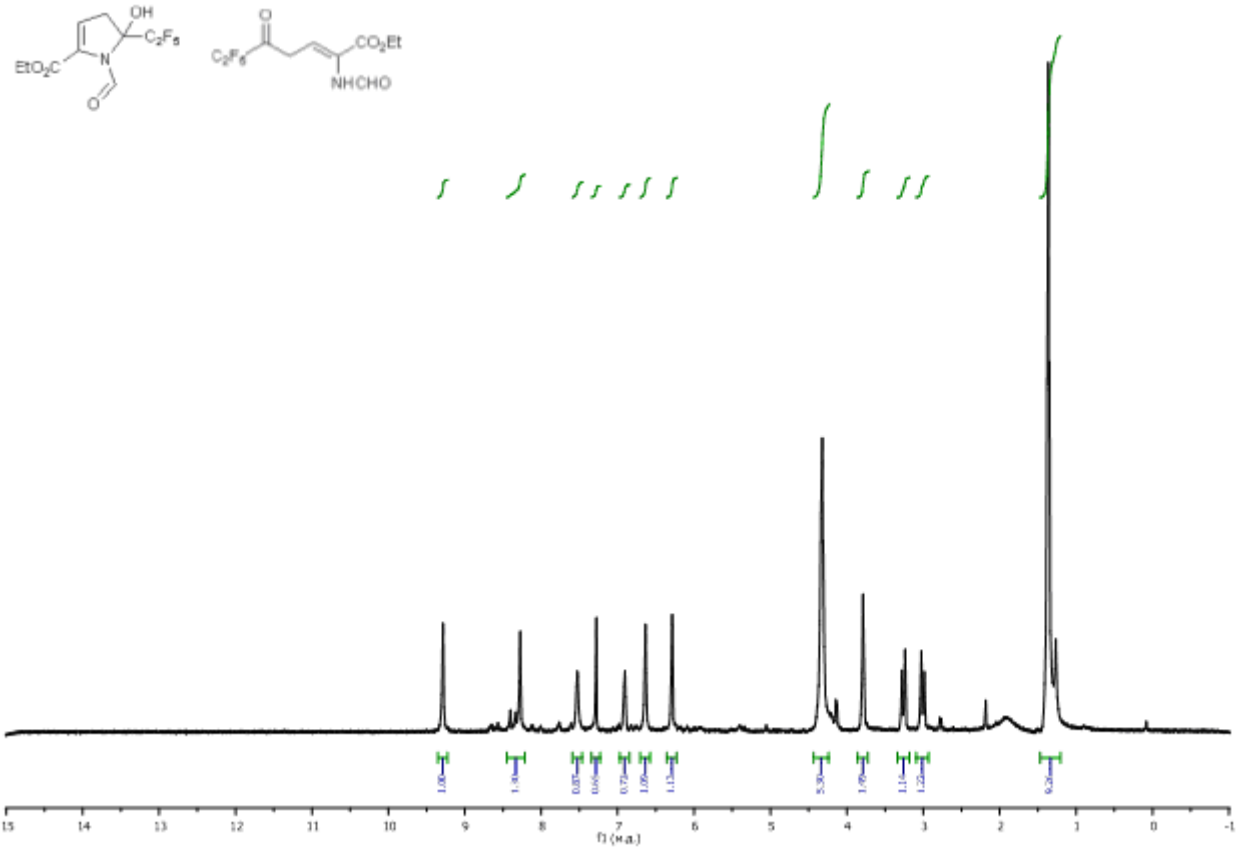
Compound 5d. ^{13}C NMR (DMSO-d_6)



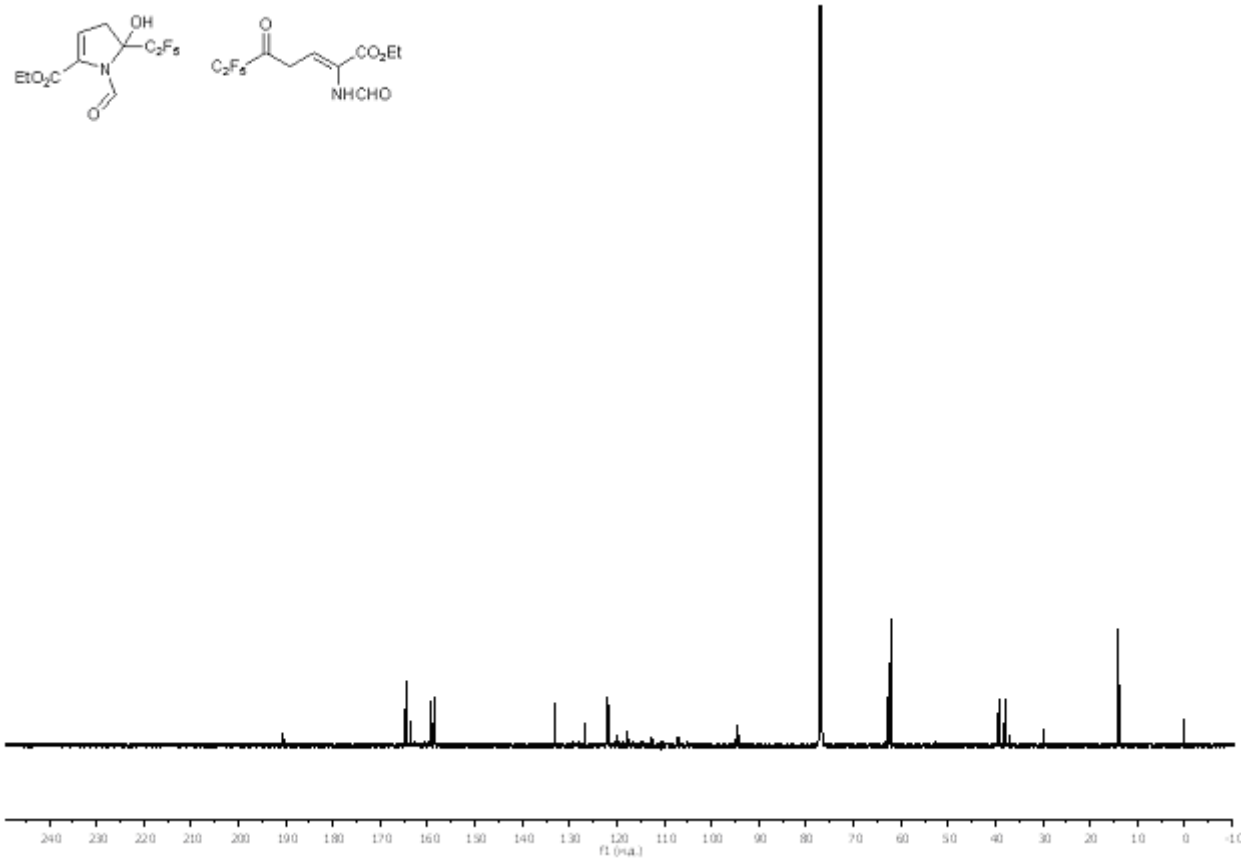
Compound 5d. ^{19}F NMR (DMSO-d_6)



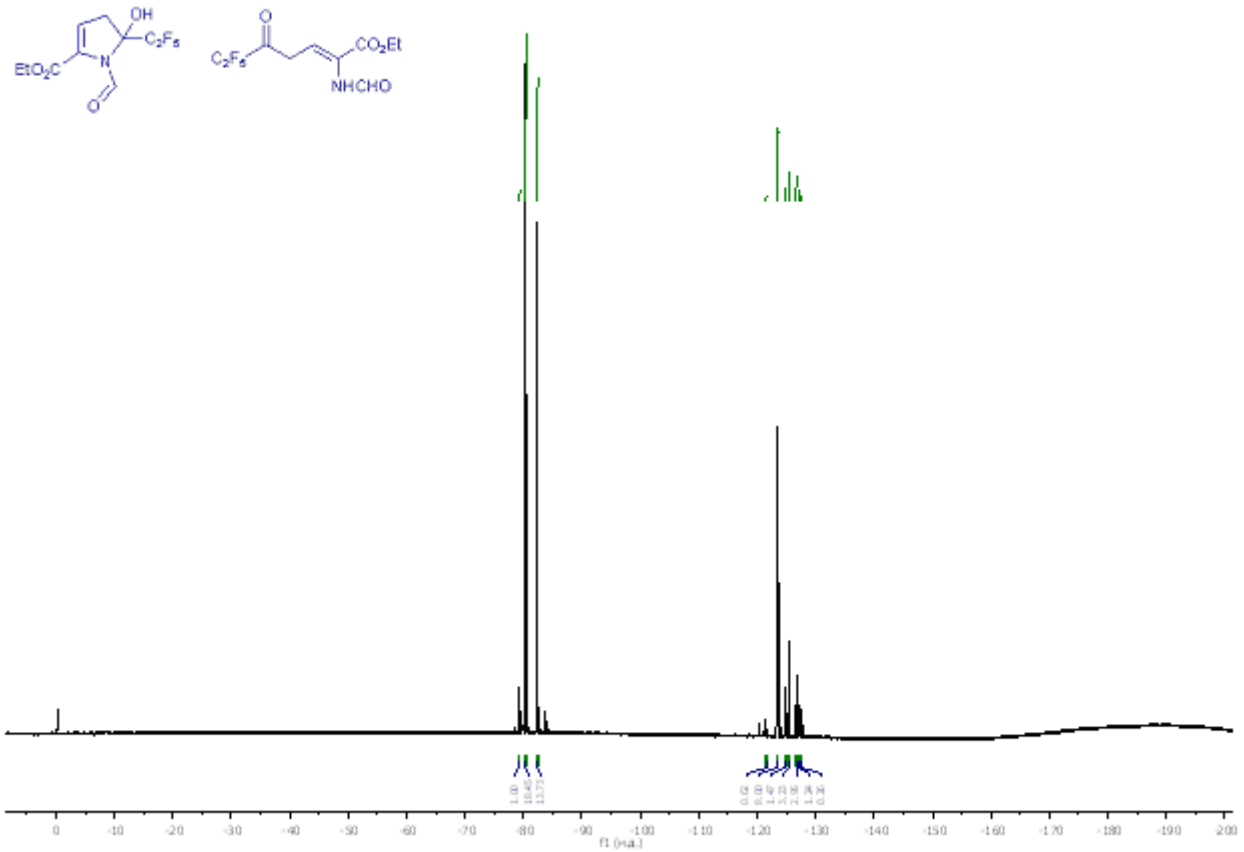
Compounds 7d and 8d. ^{1}H NMR ($CDCl_3$)



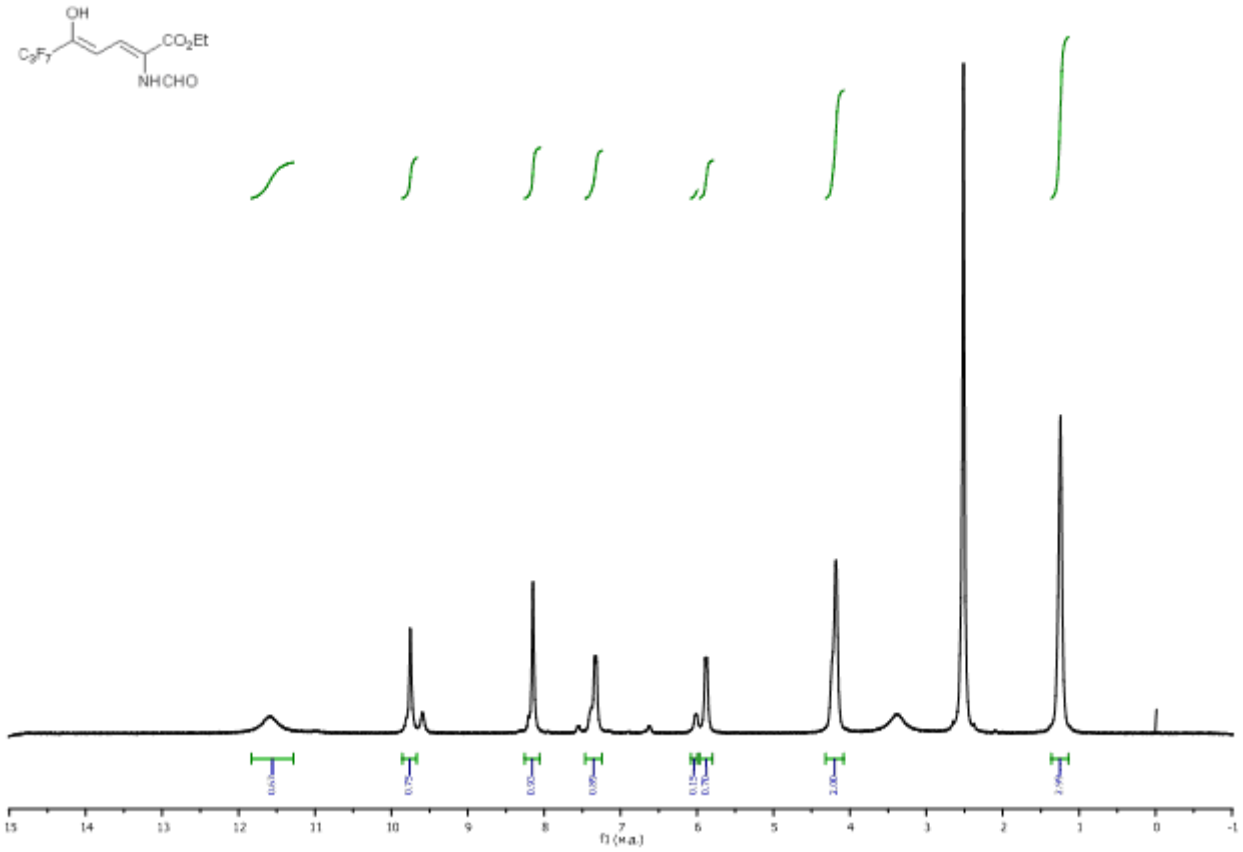
Compounds 7d and 8d. ^{13}C NMR ($CDCl_3$)



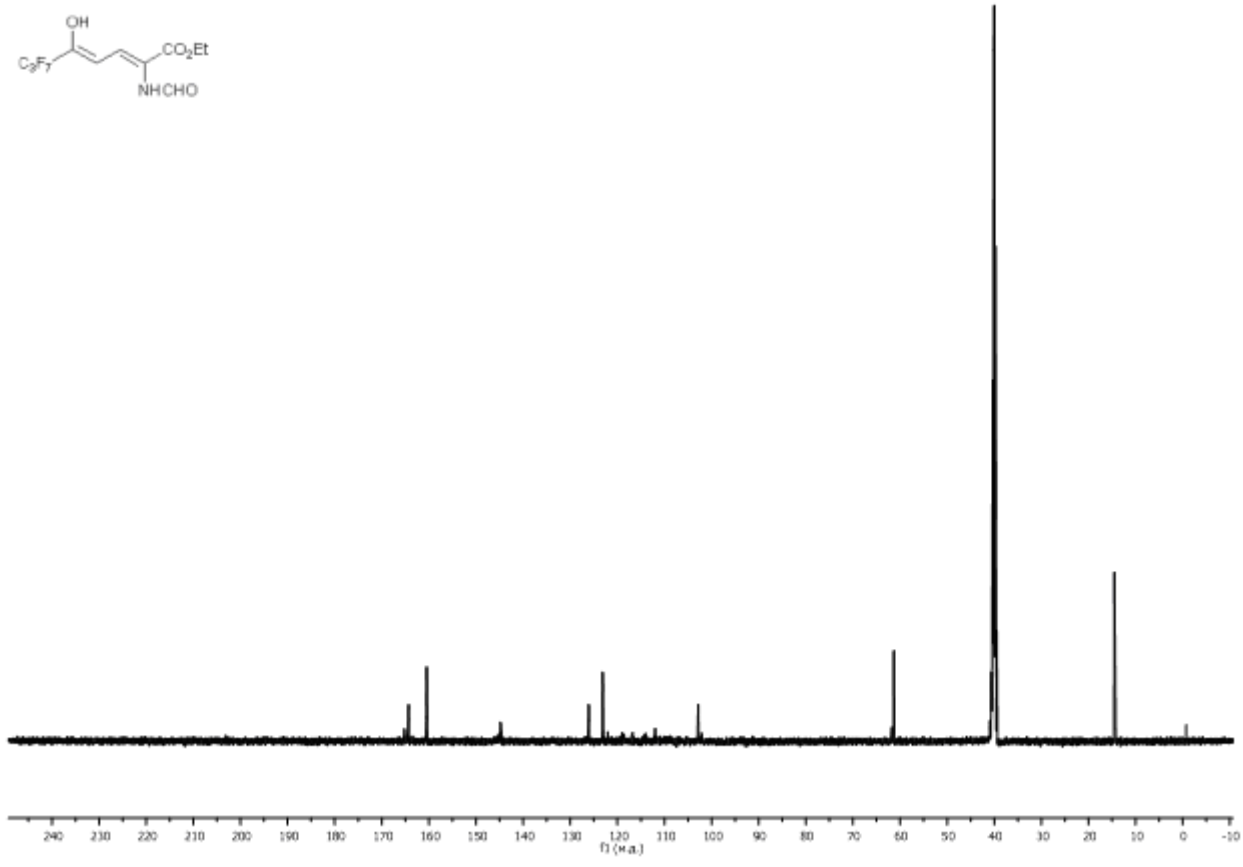
Compounds 7d and 8d. ^{19}F NMR ($CDCl_3$)



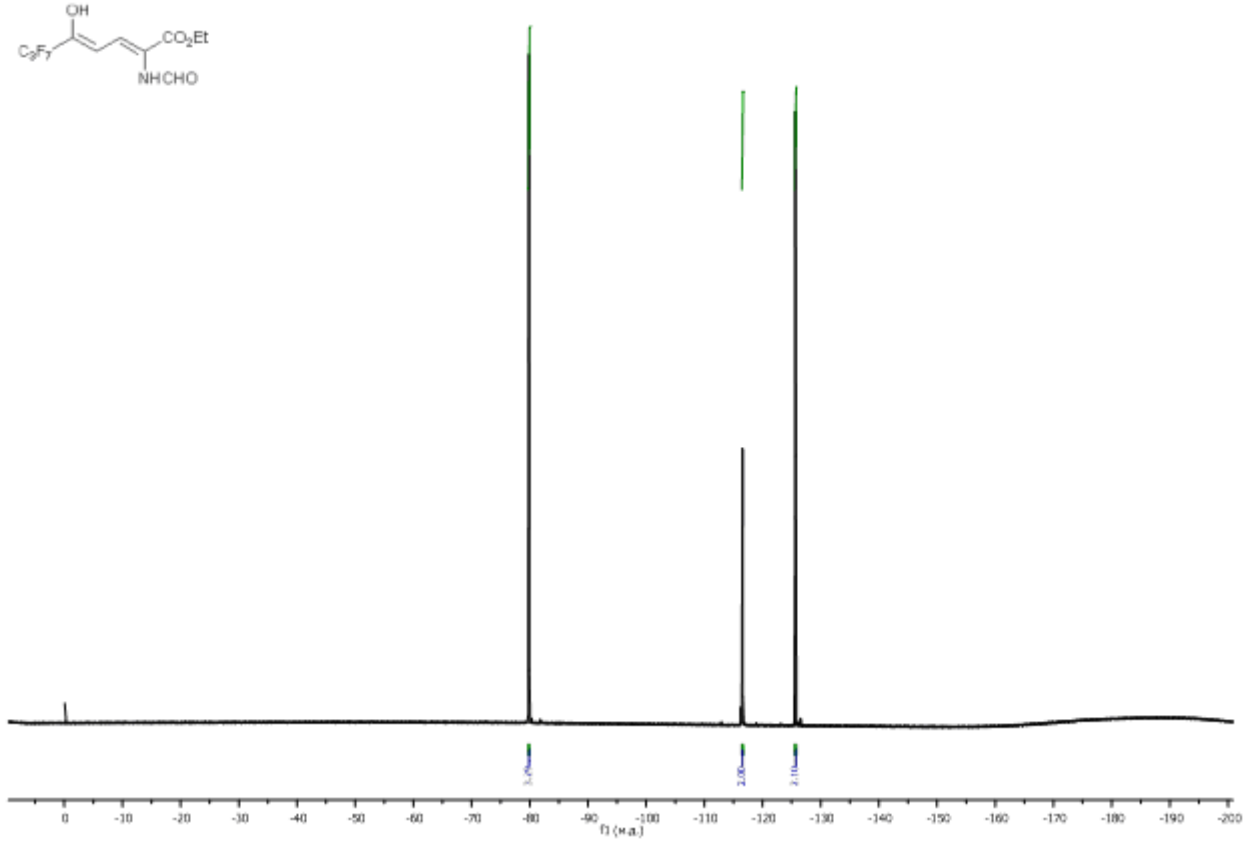
Compound 5e. ^{1}H NMR (DMSO-d_6)



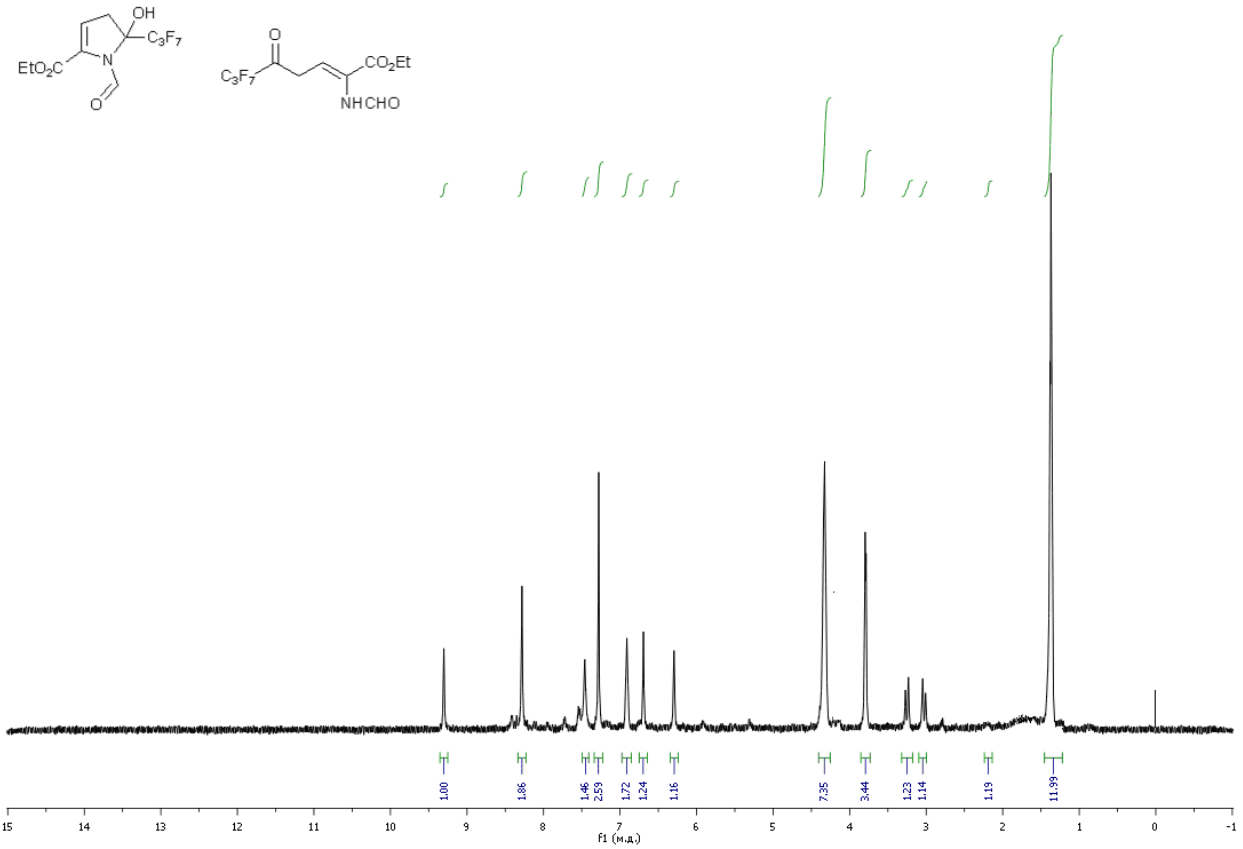
Compound 5e. ^{13}C NMR (DMSO-d_6)



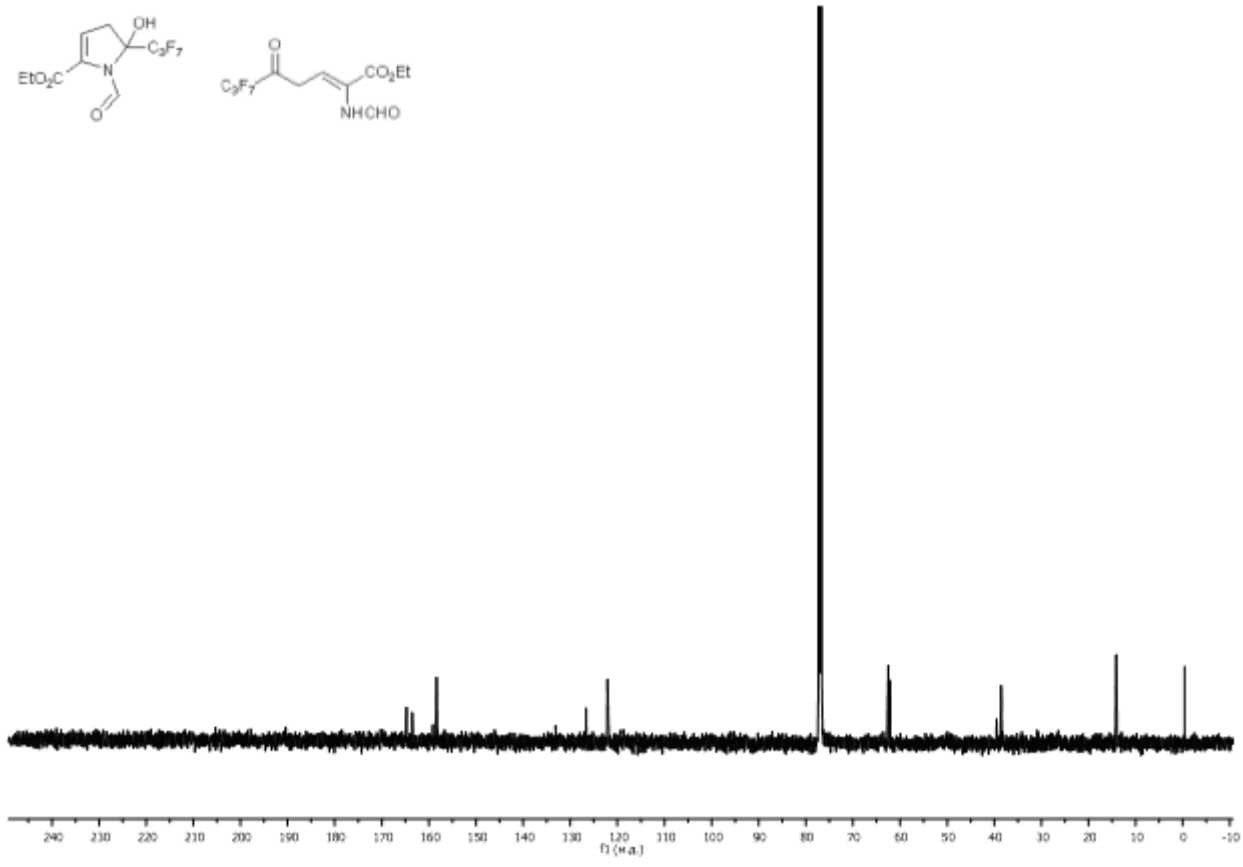
Compound 5e. ^{19}F NMR (DMSO-d_6)



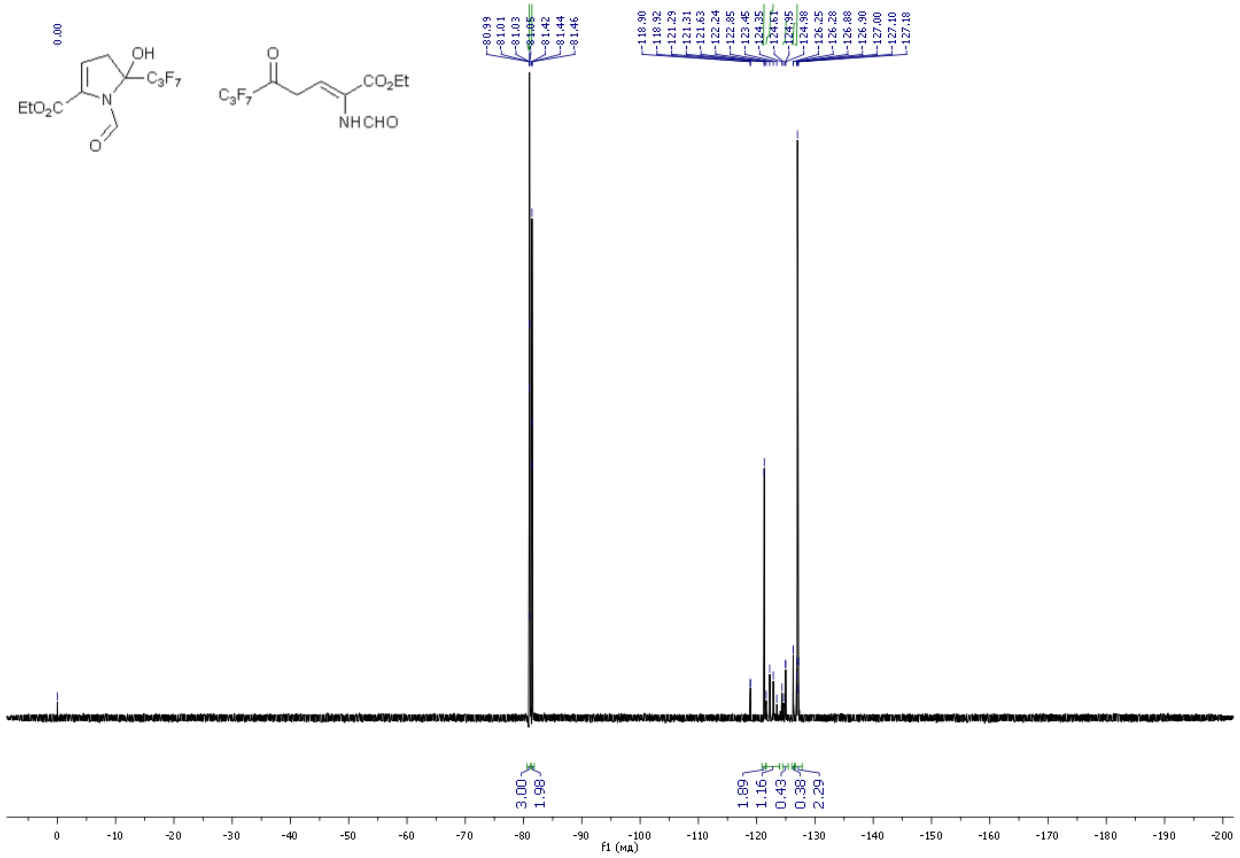
Compounds 7e and 8e. ^{1}H NMR ($CDCl_3$)



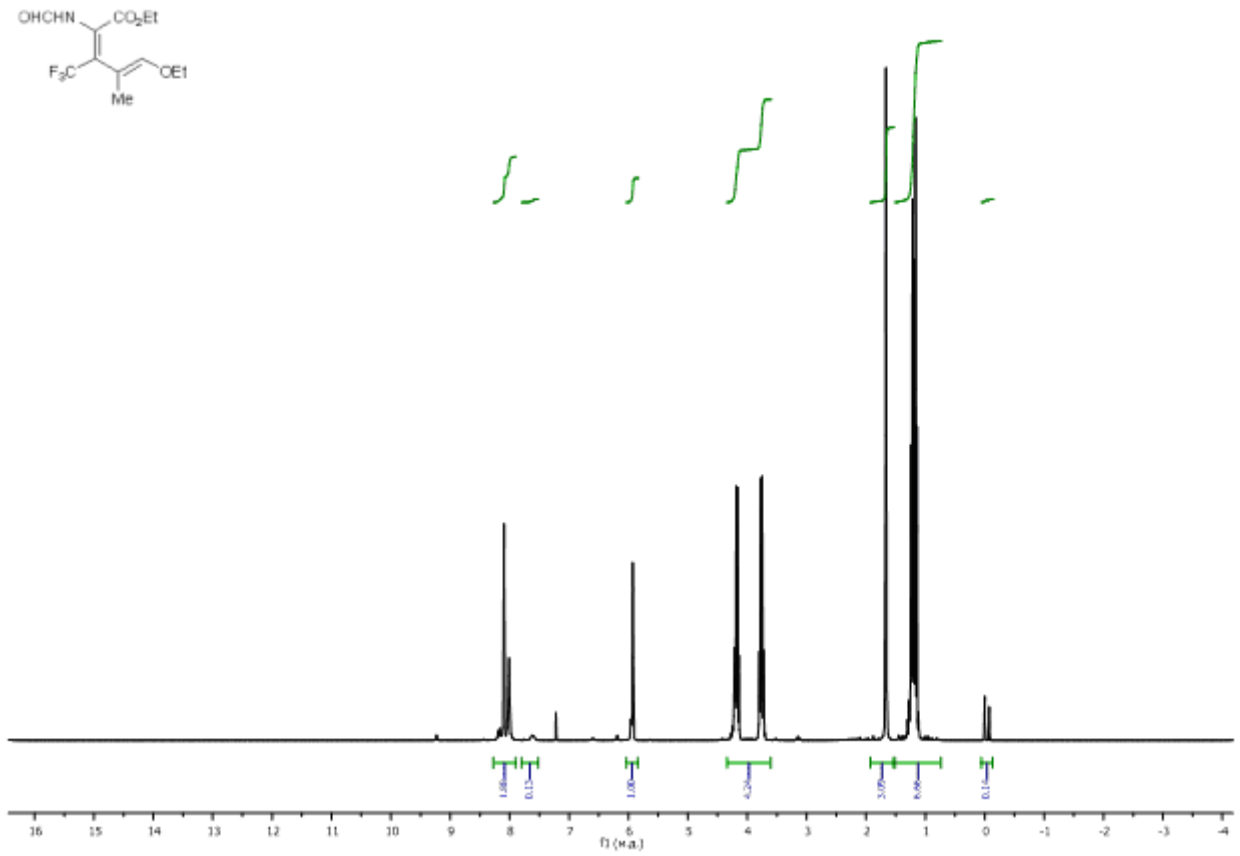
Compounds 7e and 8e. ^{13}C NMR ($CDCl_3$)



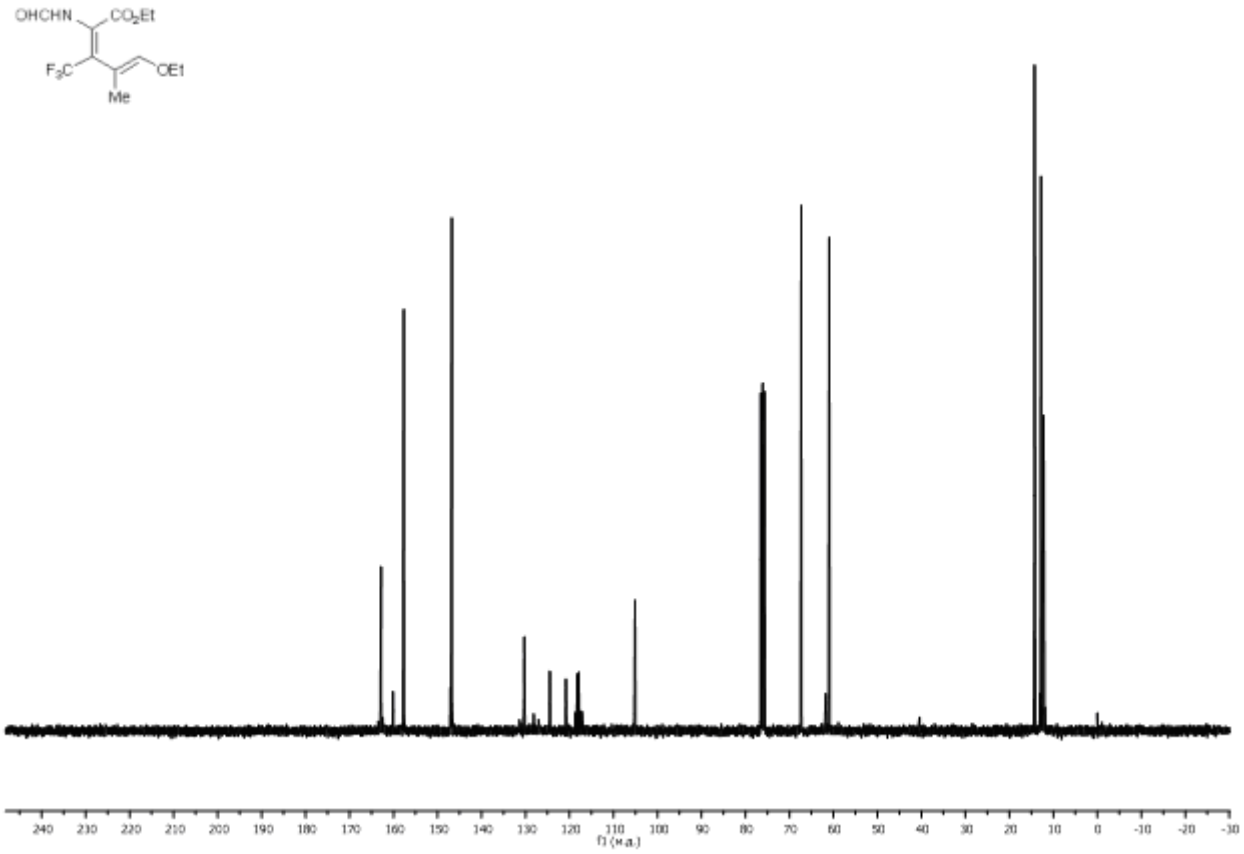
Compounds 7e and 8e. ^{19}F NMR ($CDCl_3$)



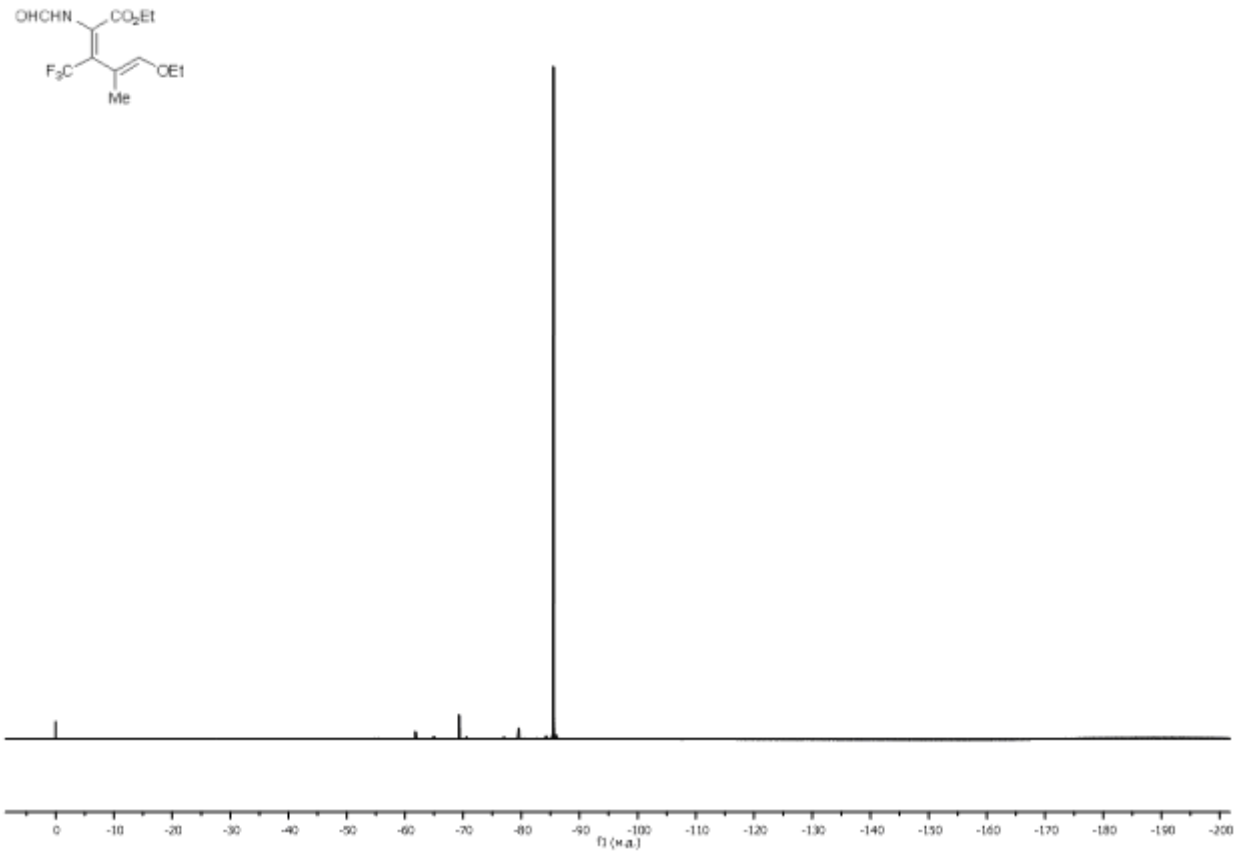
Compound 4f. ^{1}H NMR ($CDCl_3$)



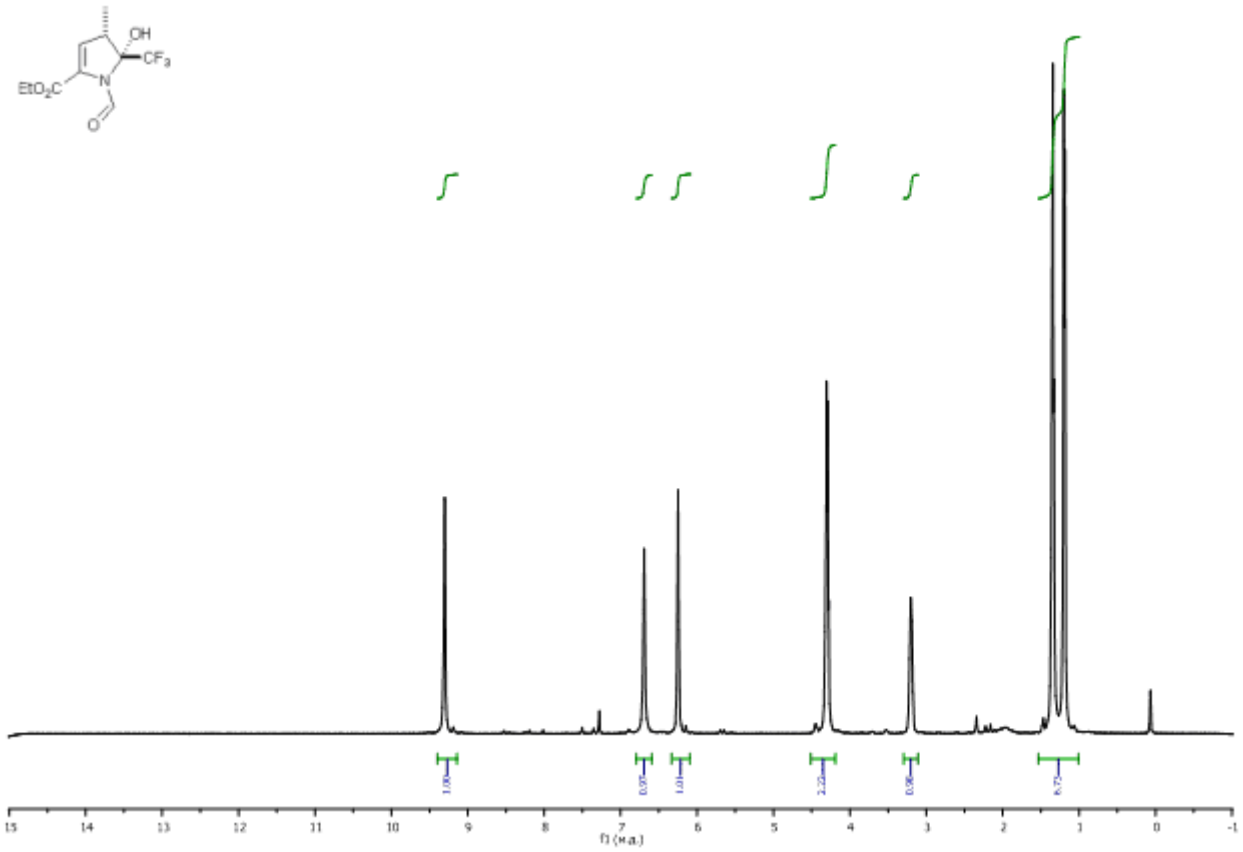
Compound 4f. ^{13}C NMR ($CDCl_3$)



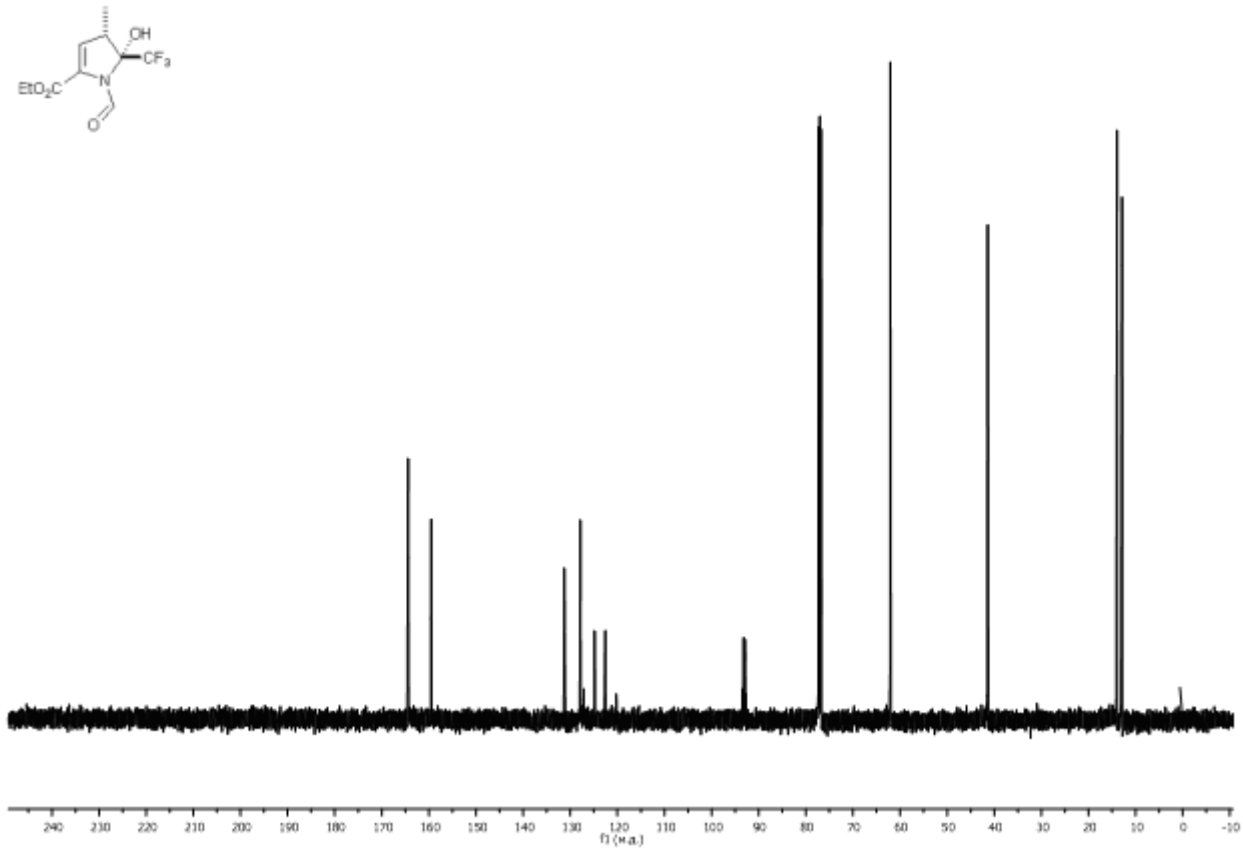
Compounds 4f. ^{19}F NMR ($CDCl_3$)



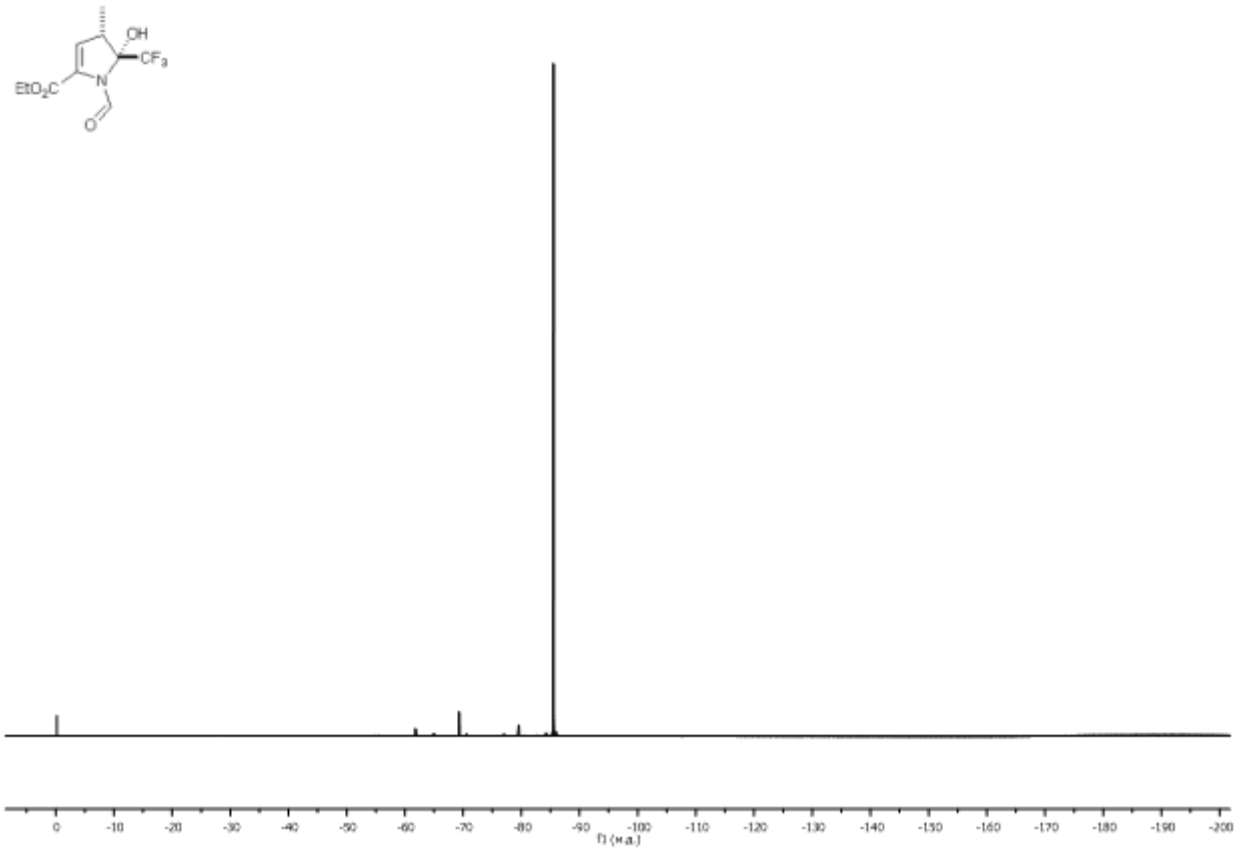
Compound 8f. ^{1}H NMR ($CDCl_3$)



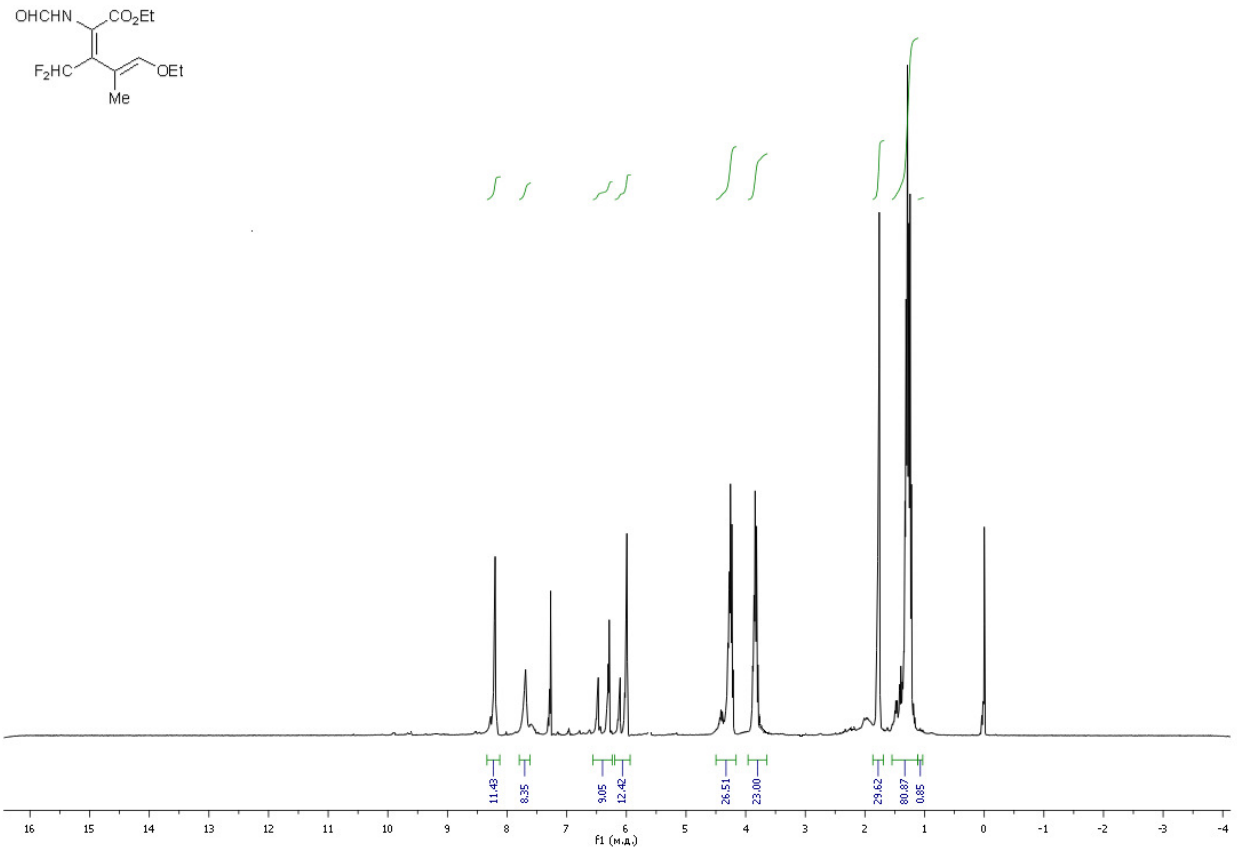
Compound 8f. ^{13}C NMR ($CDCl_3$)



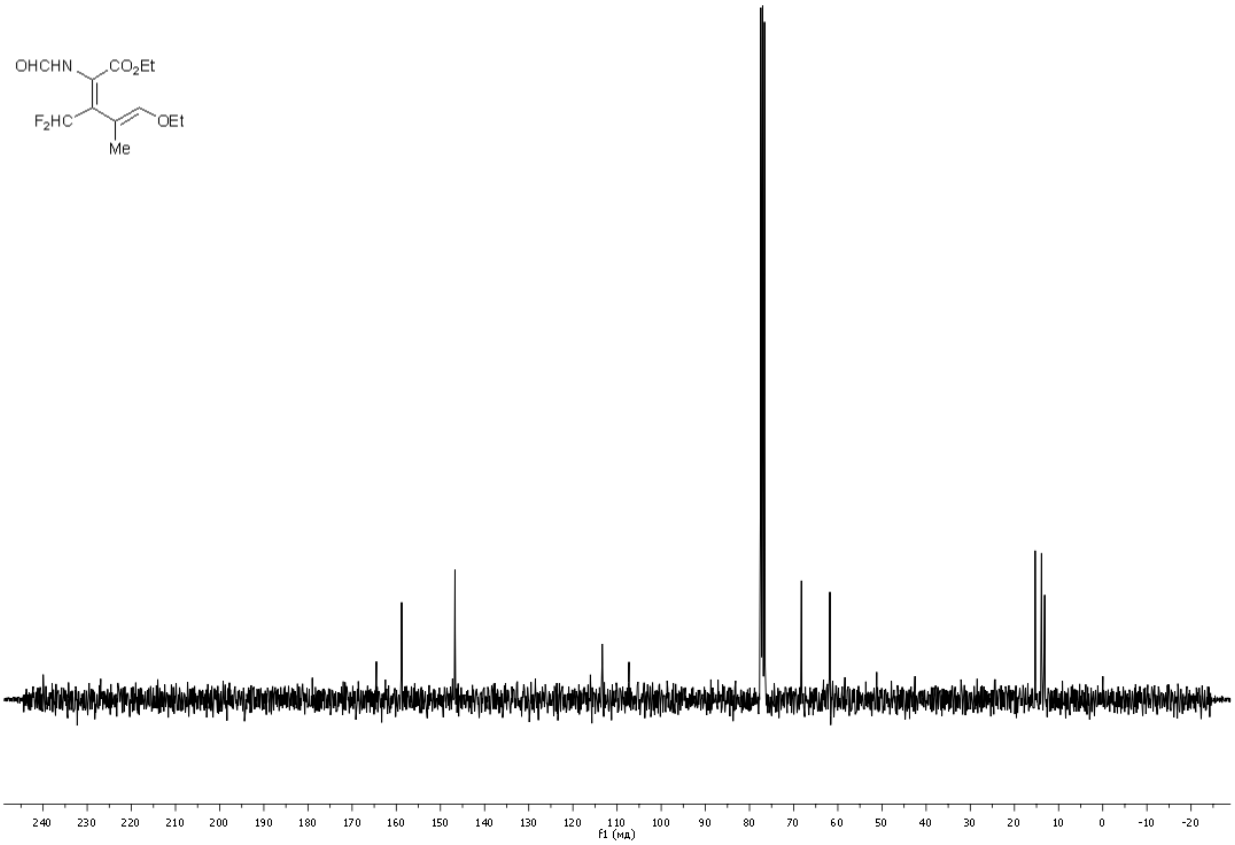
Compound 8f. ^{19}F NMR ($CDCl_3$)



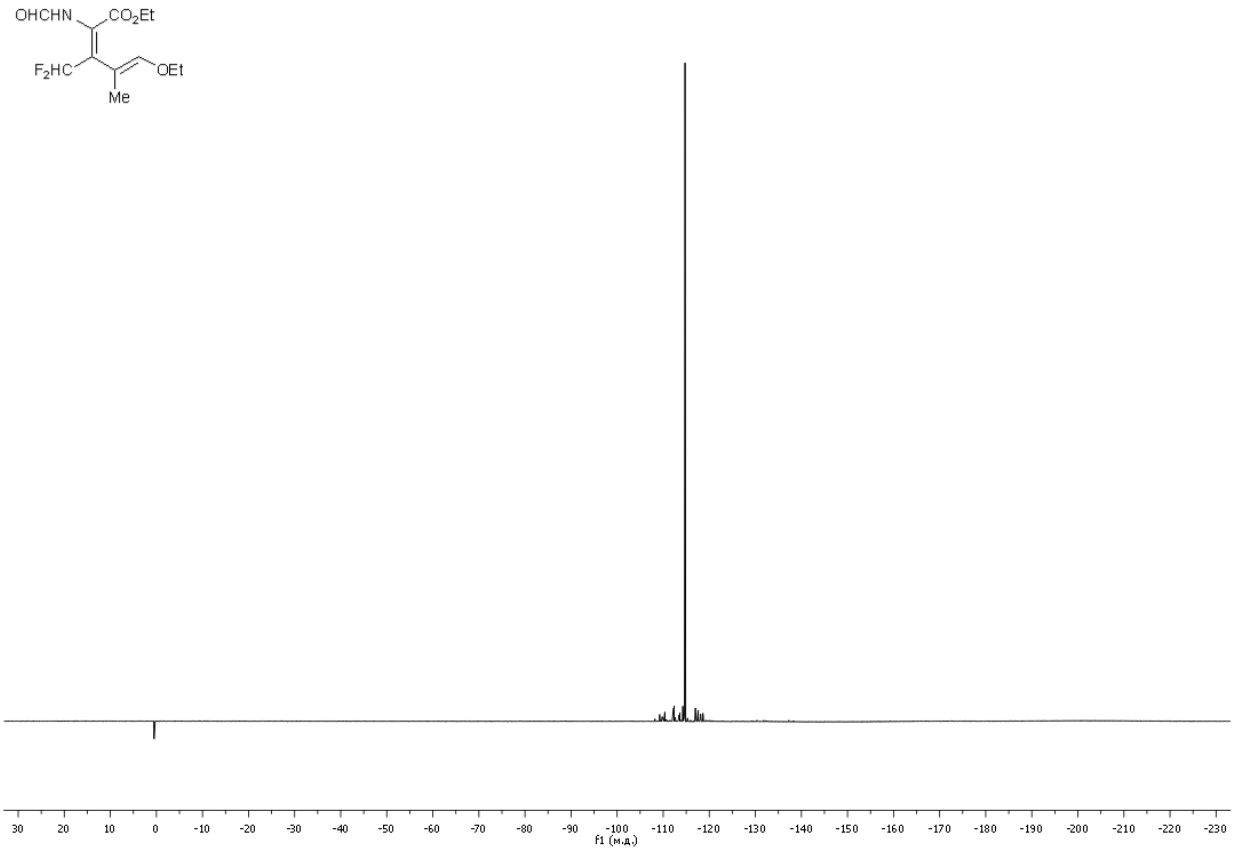
Compound 4g. ^{1}H NMR ($CDCl_3$)



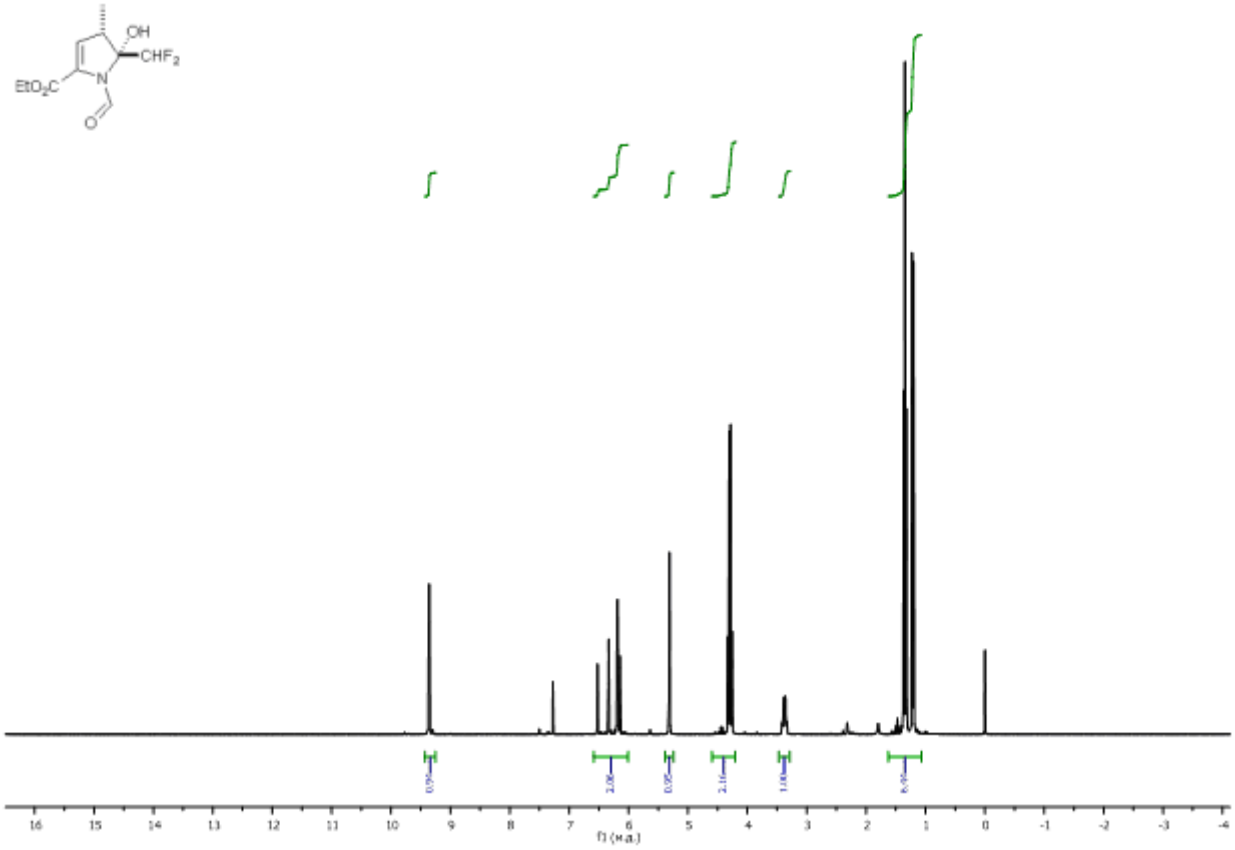
Compound 4g. ^{13}C NMR ($CDCl_3$)



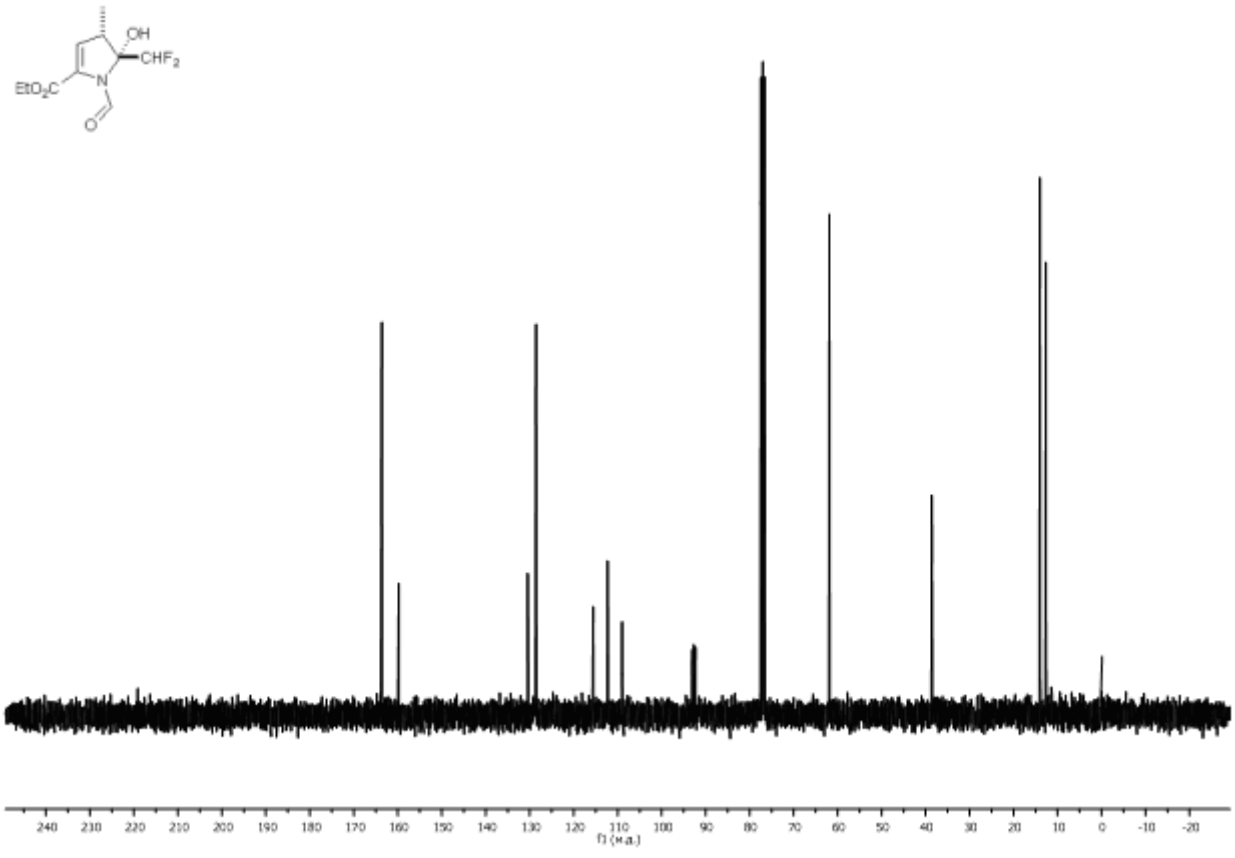
Compound 4g. ^{19}F NMR ($CDCl_3$)



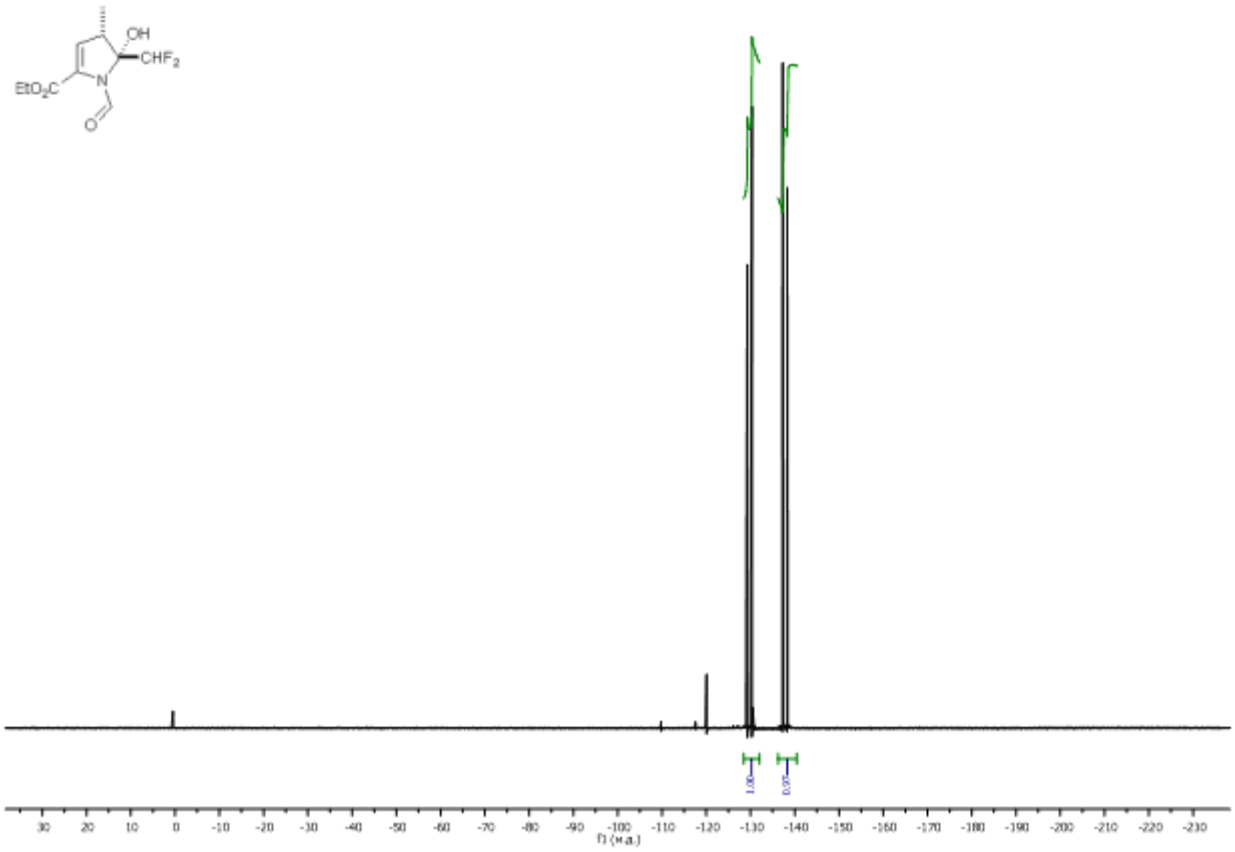
Compound 8g. ^{1}H NMR ($CDCl_3$)



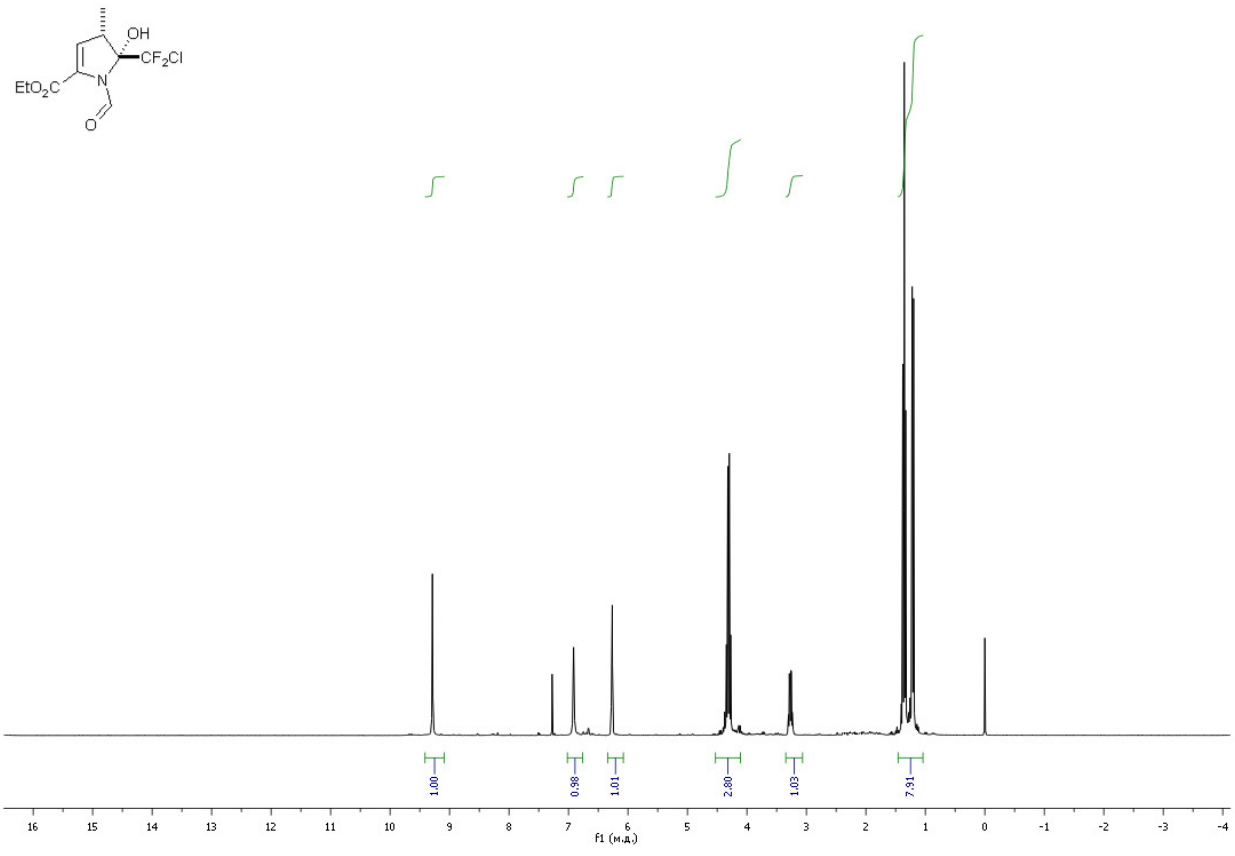
Compound 8g. ^{13}C NMR ($CDCl_3$)



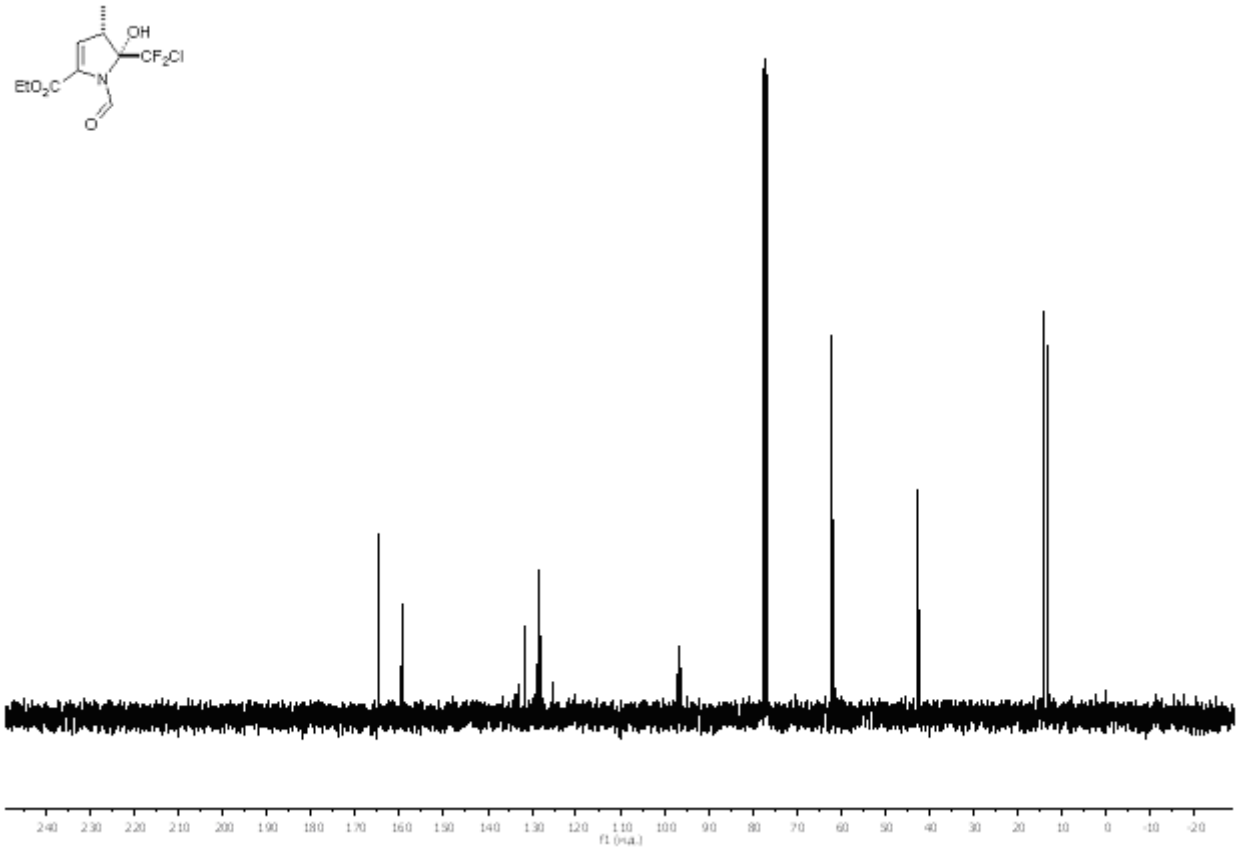
Compound 8g. ^{19}F NMR ($CDCl_3$)



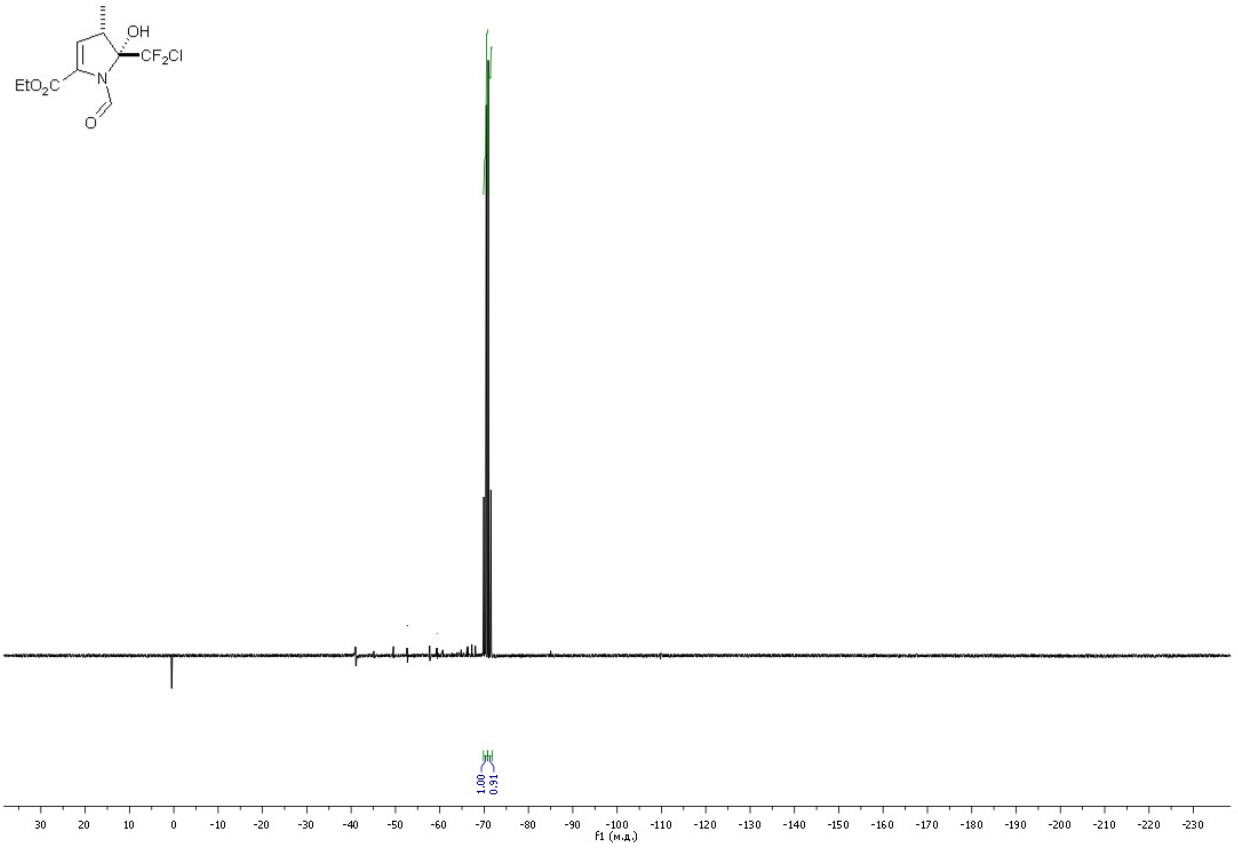
Compound 8h. ^{1}H NMR ($CDCl_3$)



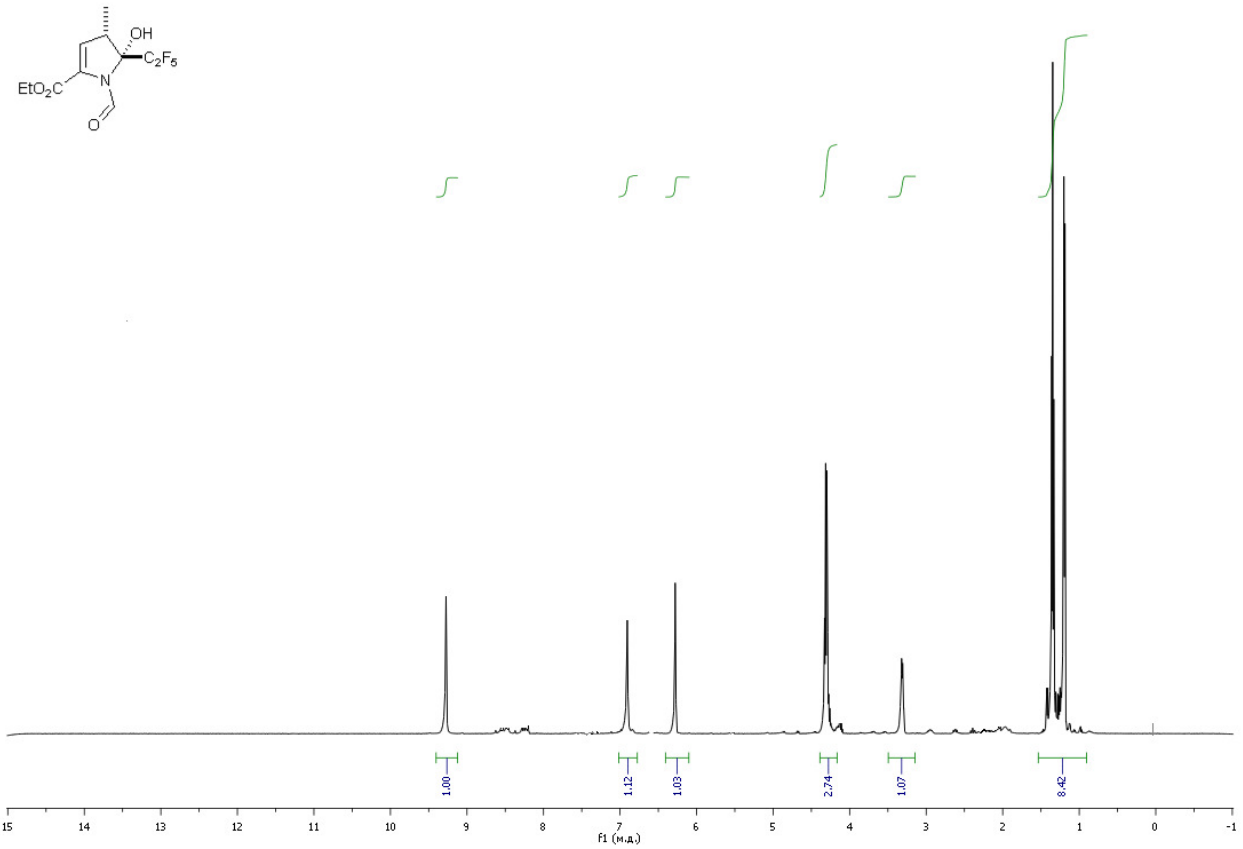
Compound 8h. ^{13}C NMR ($CDCl_3$)



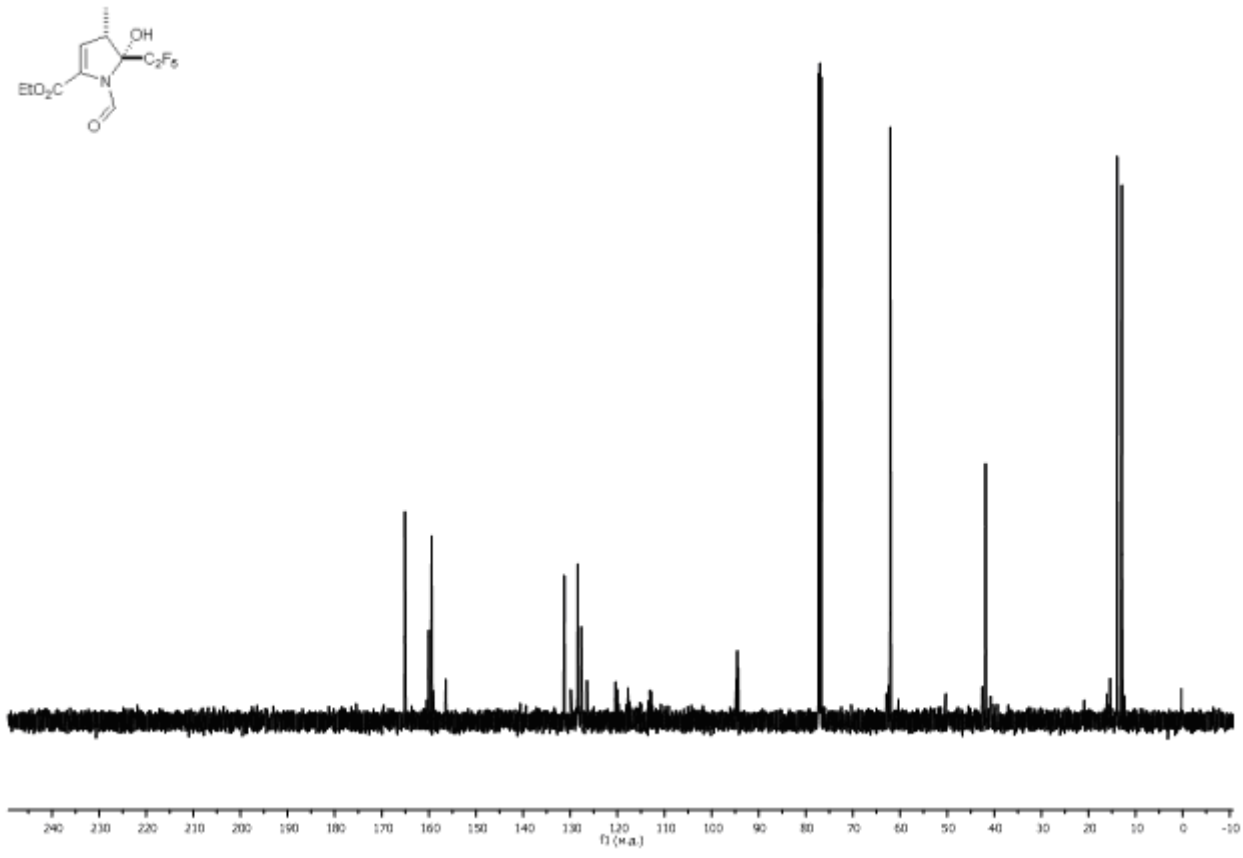
Compound 8h. ^{19}F NMR ($CDCl_3$)



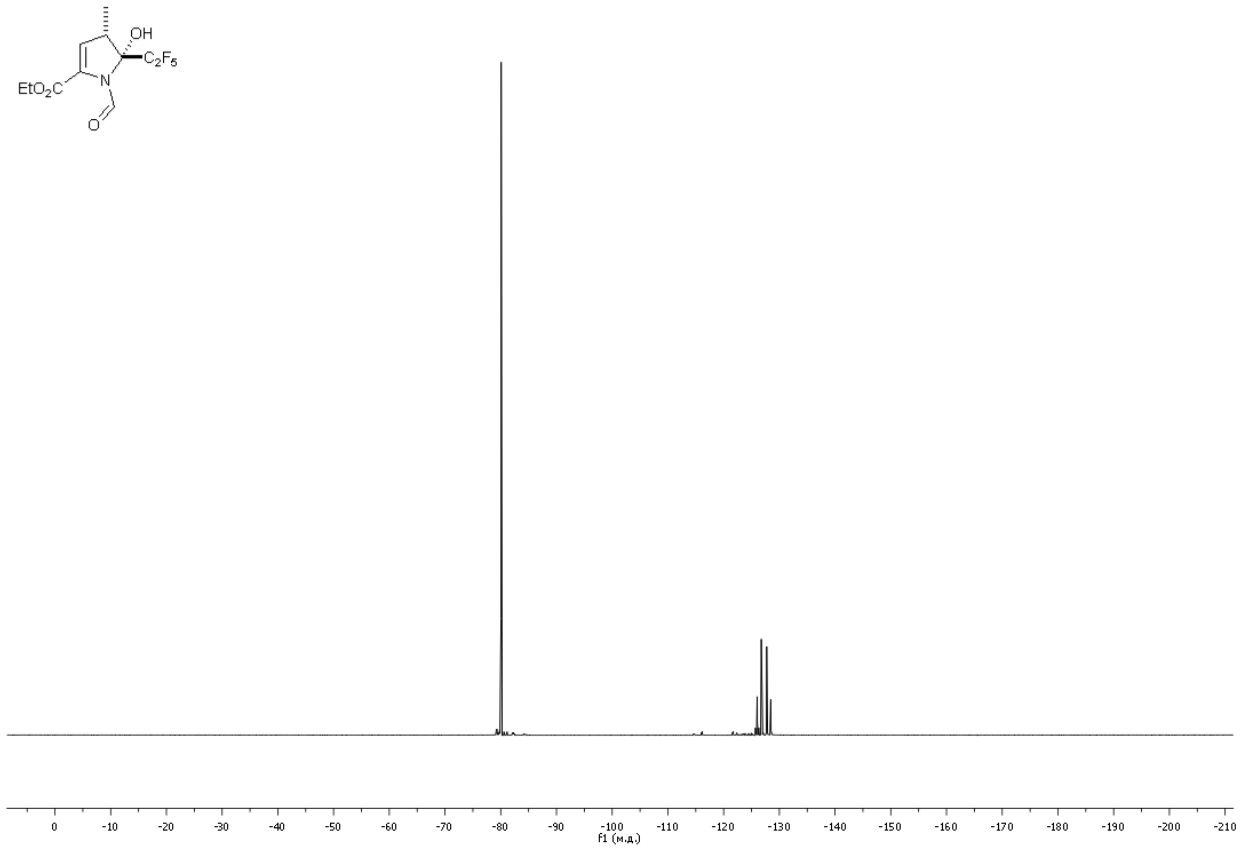
Compound 8i. ^{1}H NMR ($CDCl_3$)



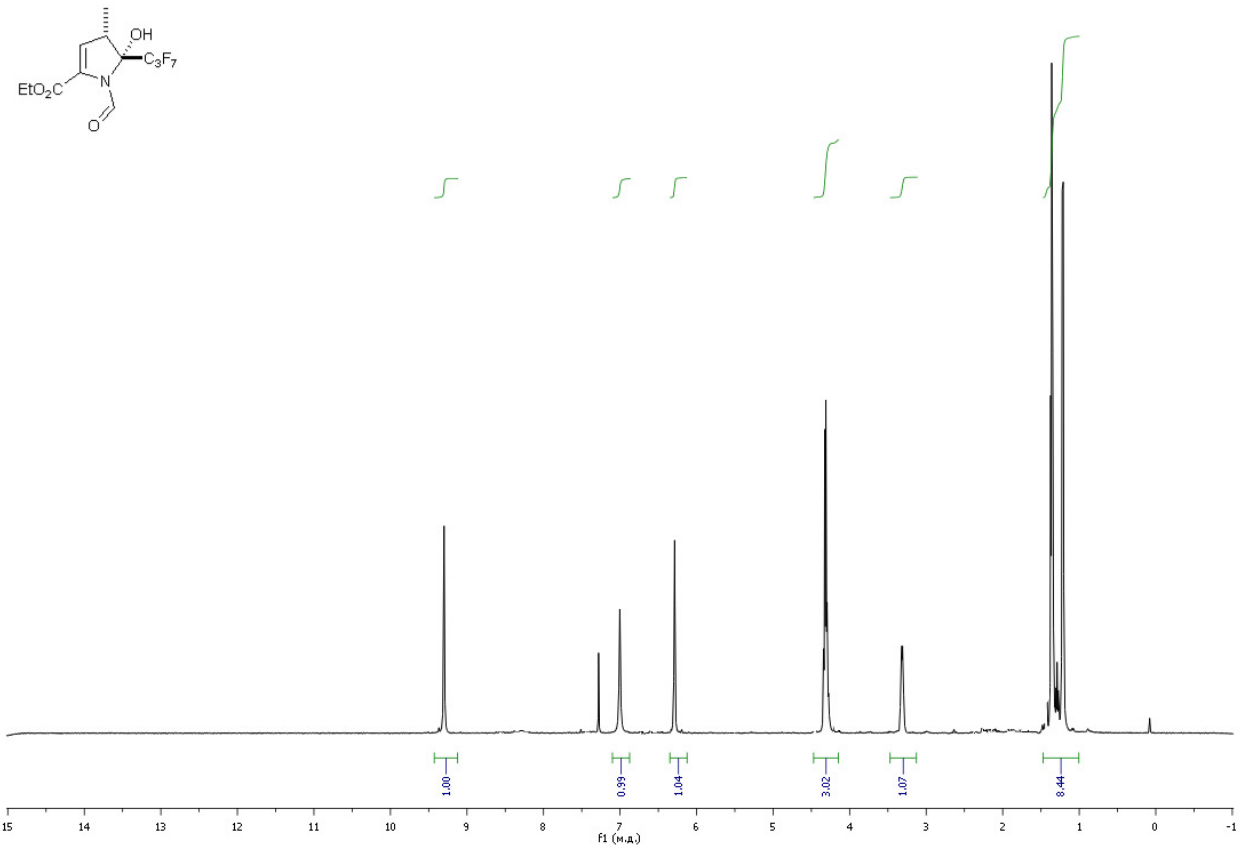
Compound 8i. ^{13}C NMR ($CDCl_3$)



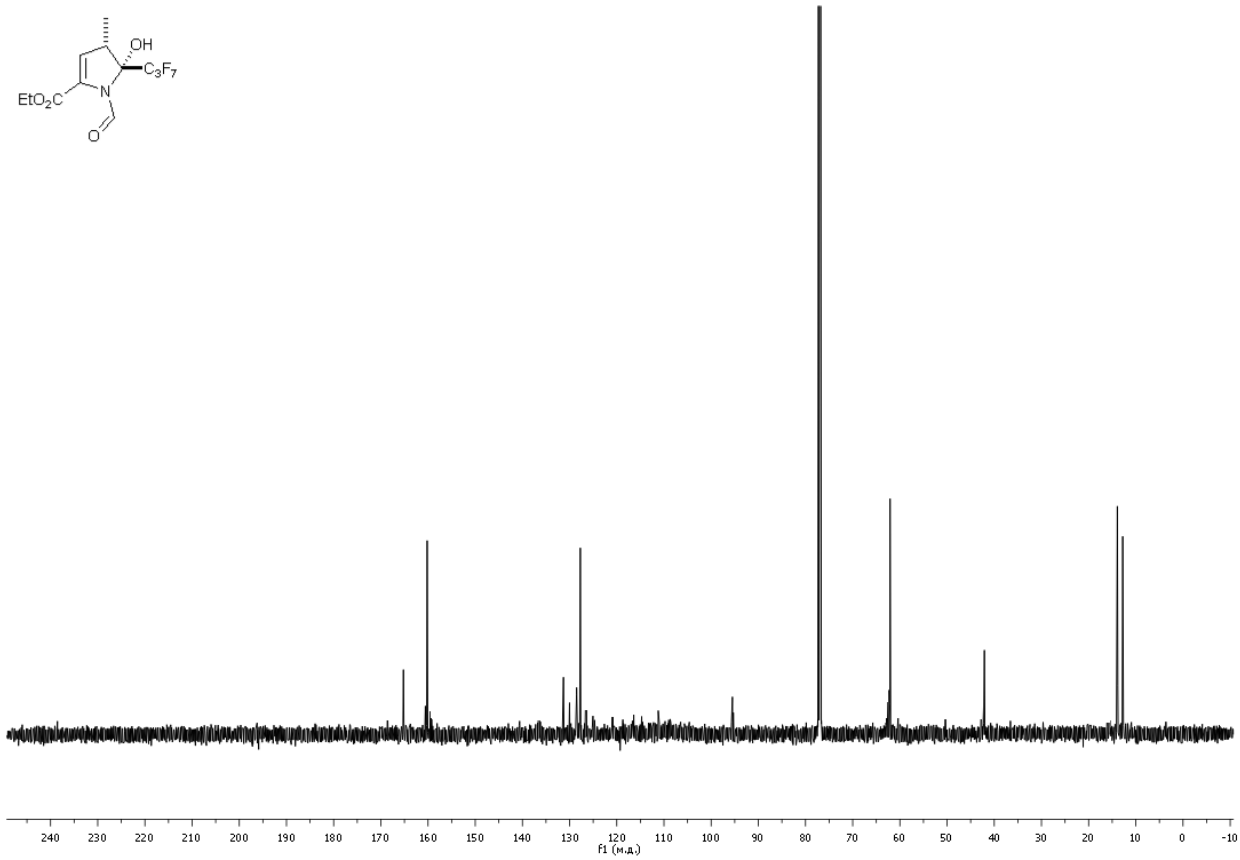
Compound 8i. ^{19}F NMR ($CDCl_3$)



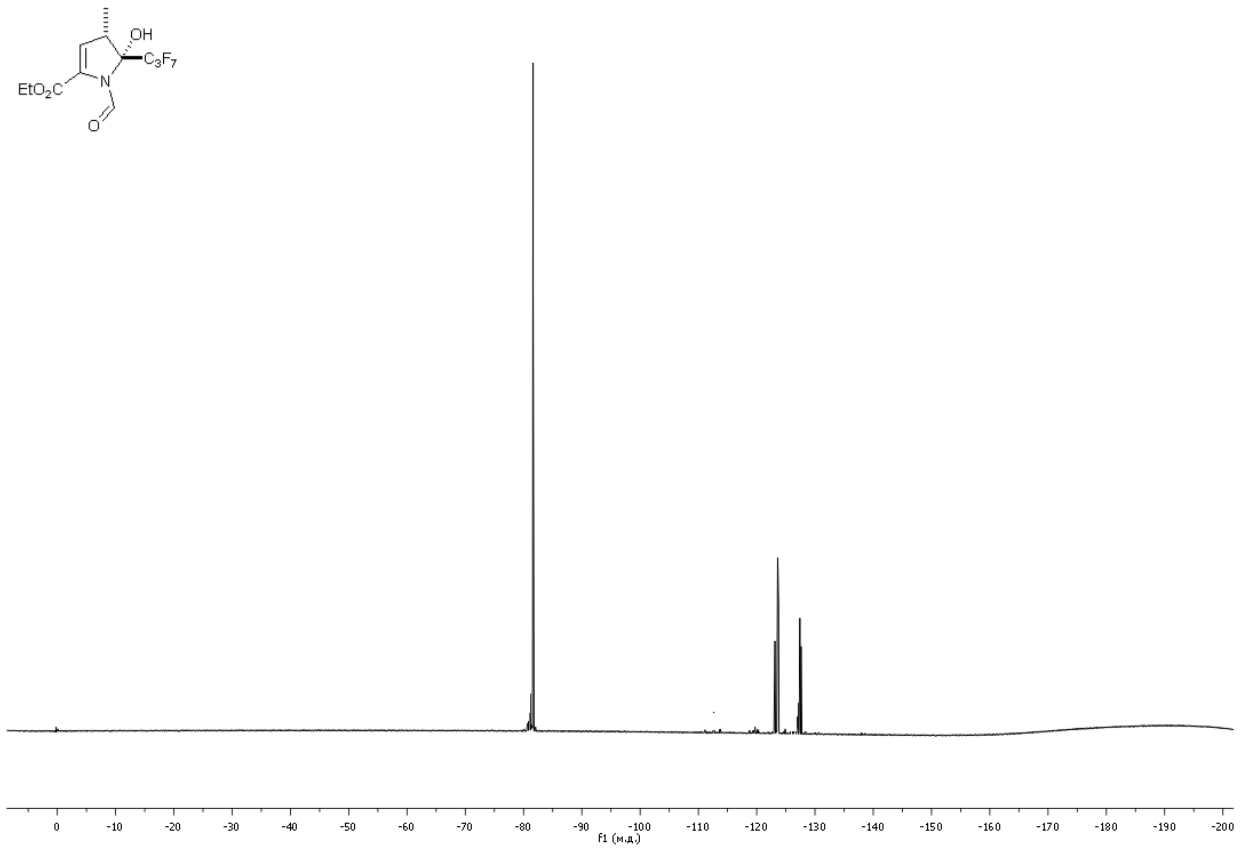
Compound 8j. ^{1}H NMR ($CDCl_3$)



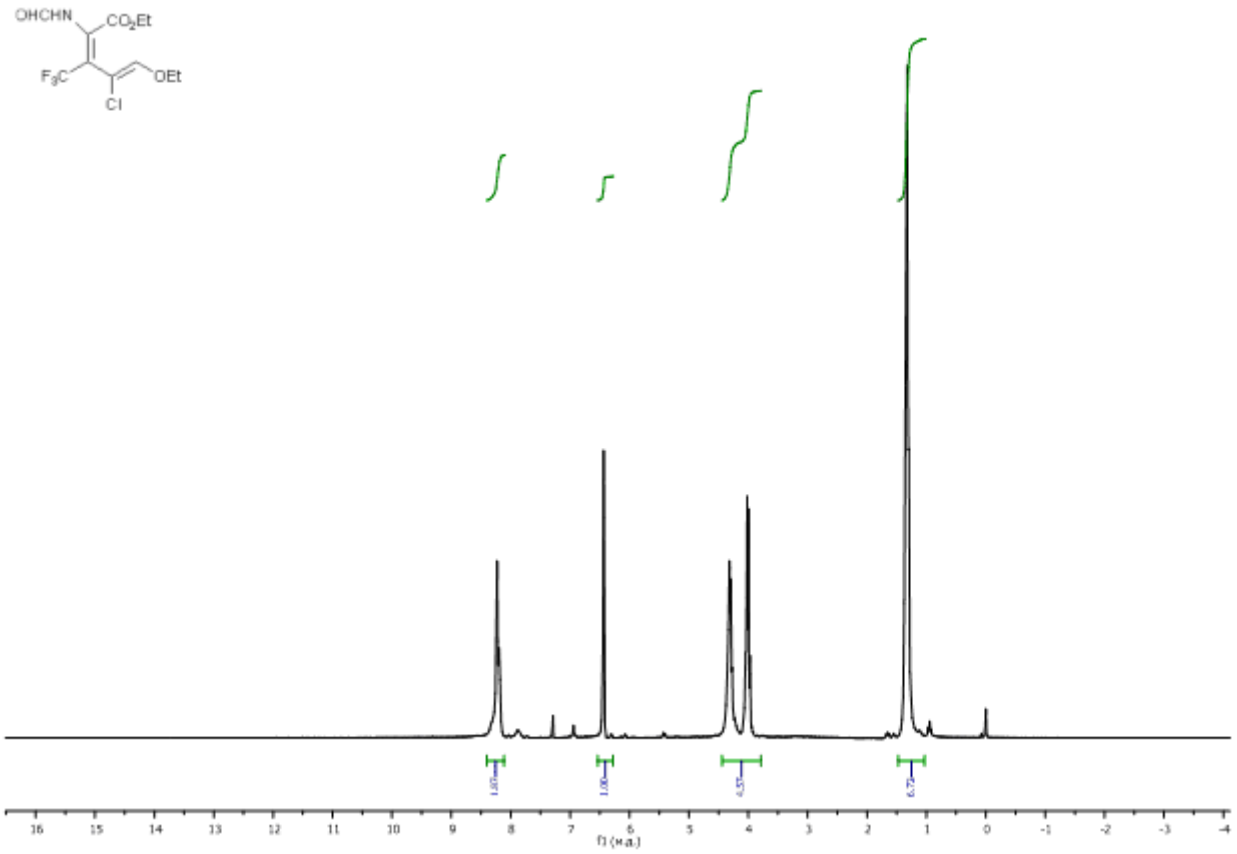
Compound 8j. ^{13}C NMR ($CDCl_3$)



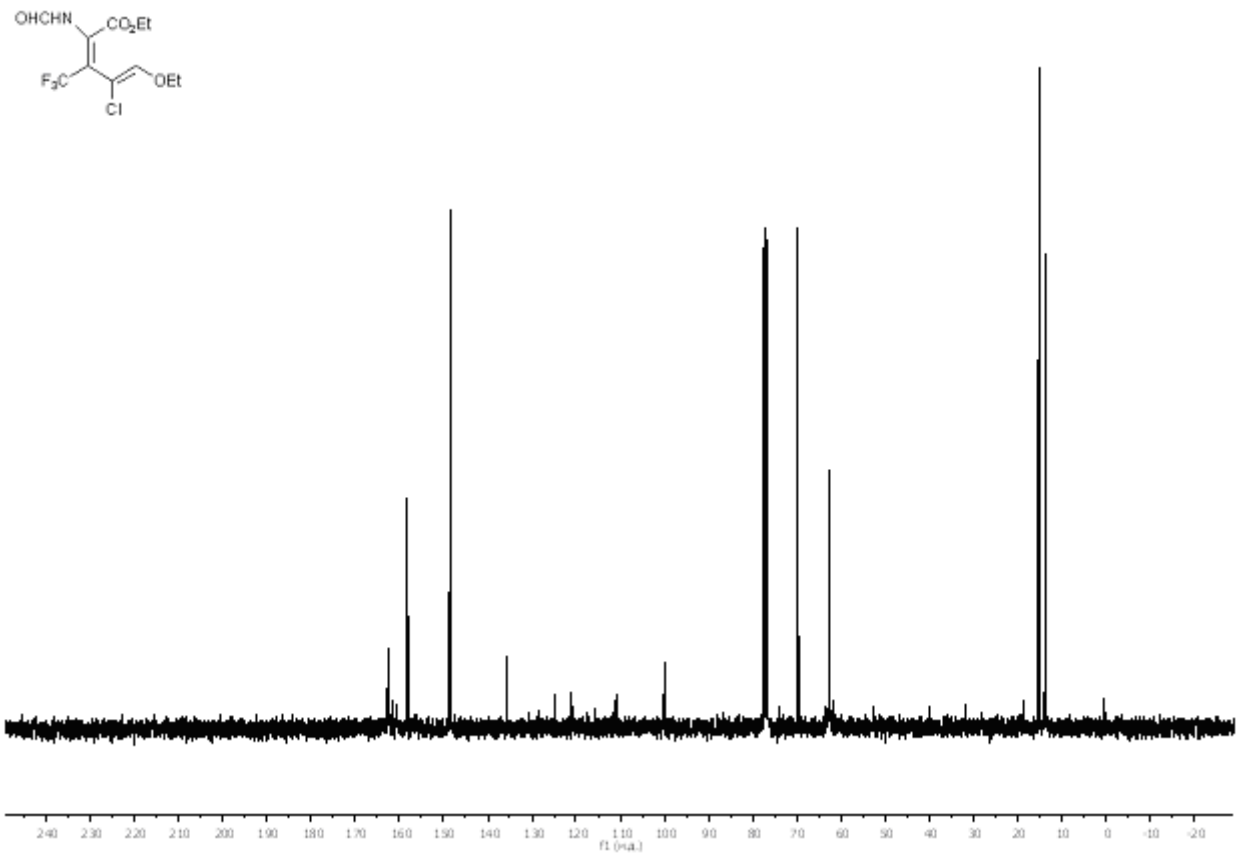
Compound 8j. ^{19}F NMR ($CDCl_3$)



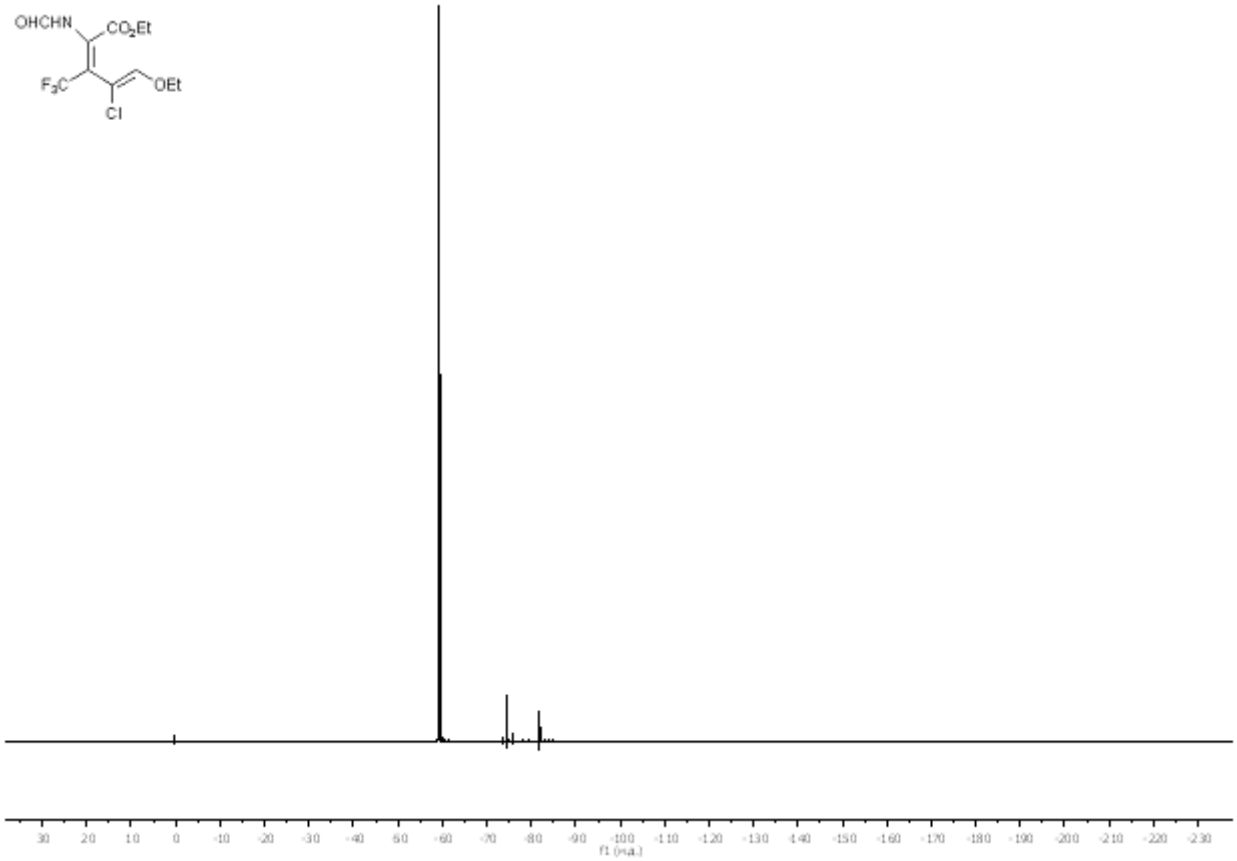
Compound 4k. ^{1}H NMR ($CDCl_3$)



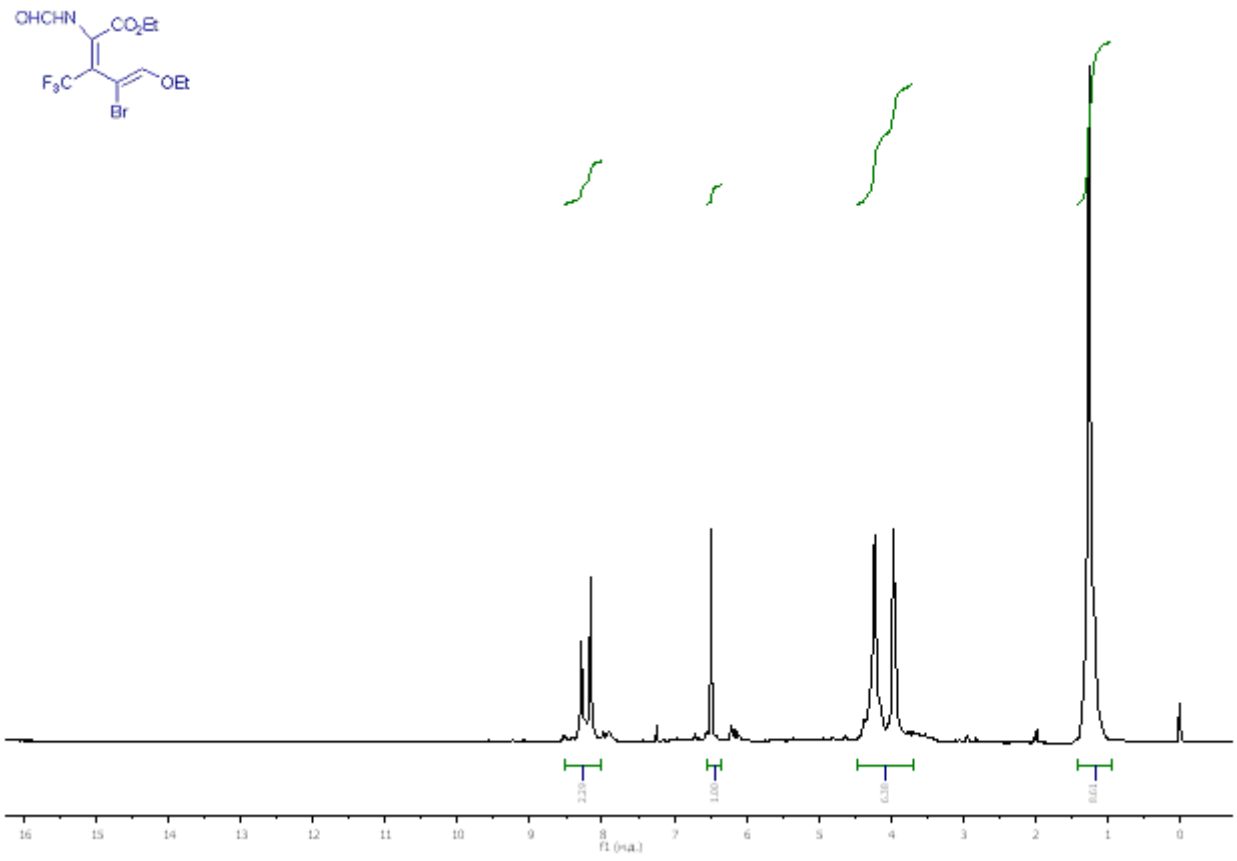
Compound 4k. ^{13}C NMR ($CDCl_3$)



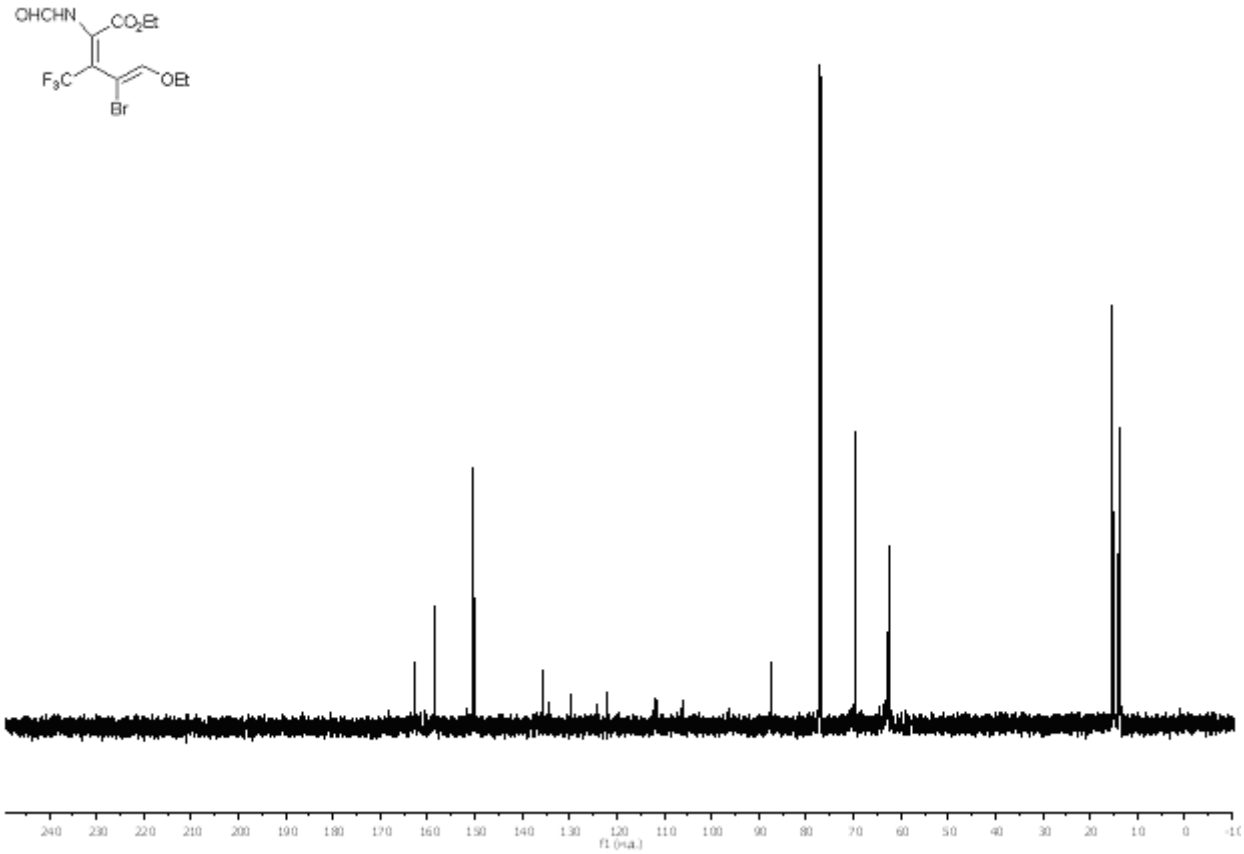
Compound 4k. ^{19}F NMR ($CDCl_3$)



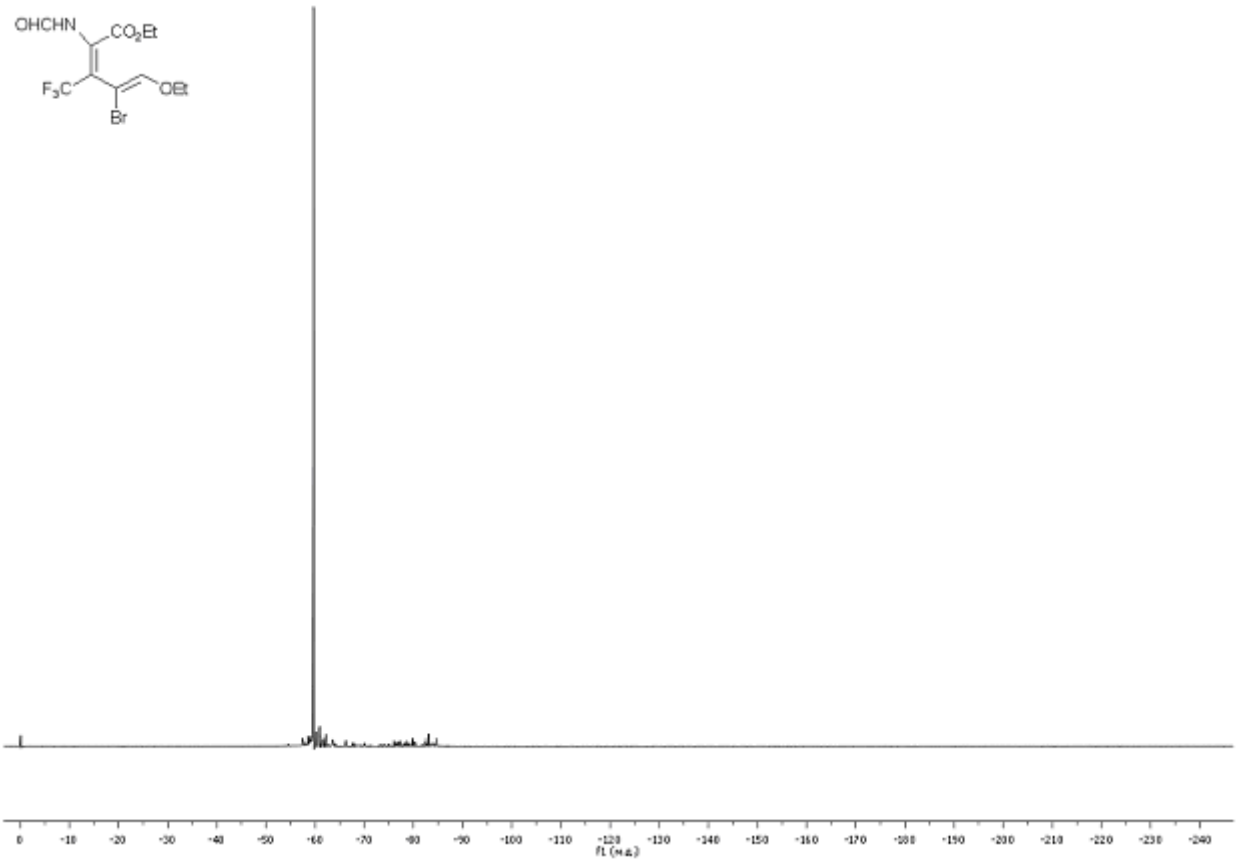
Compound 4l. ^{1}H NMR ($CDCl_3$)



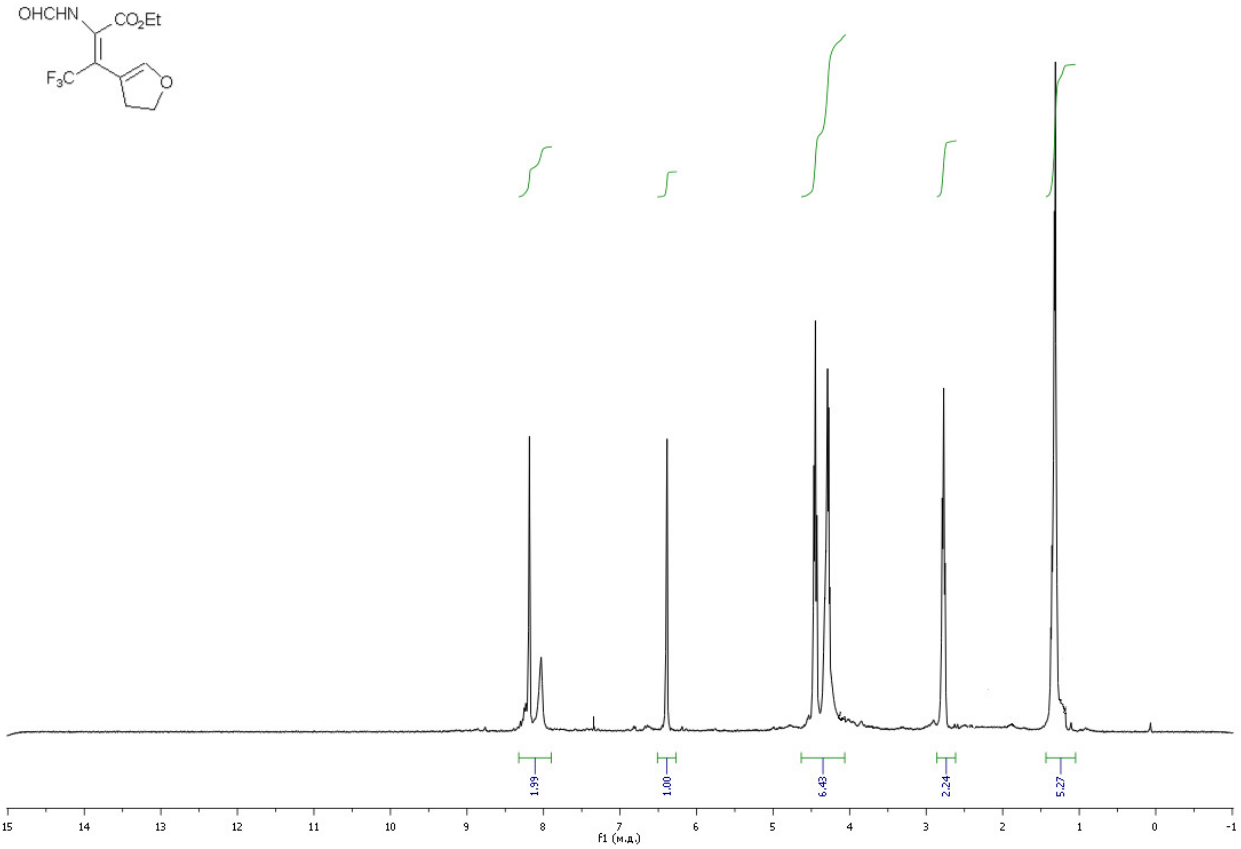
Compound 4l. ^{13}C NMR ($CDCl_3$)



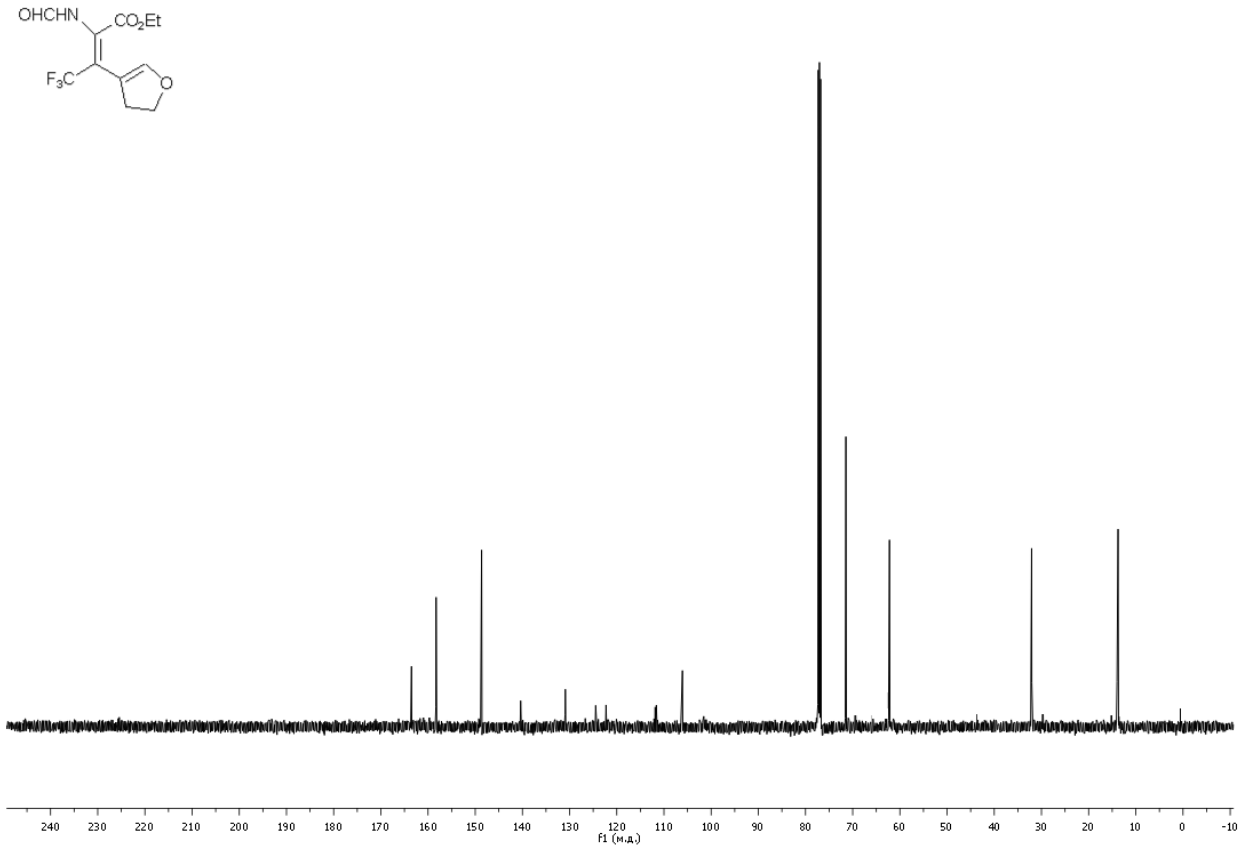
Compound 4l. ^{19}F NMR ($CDCl_3$)



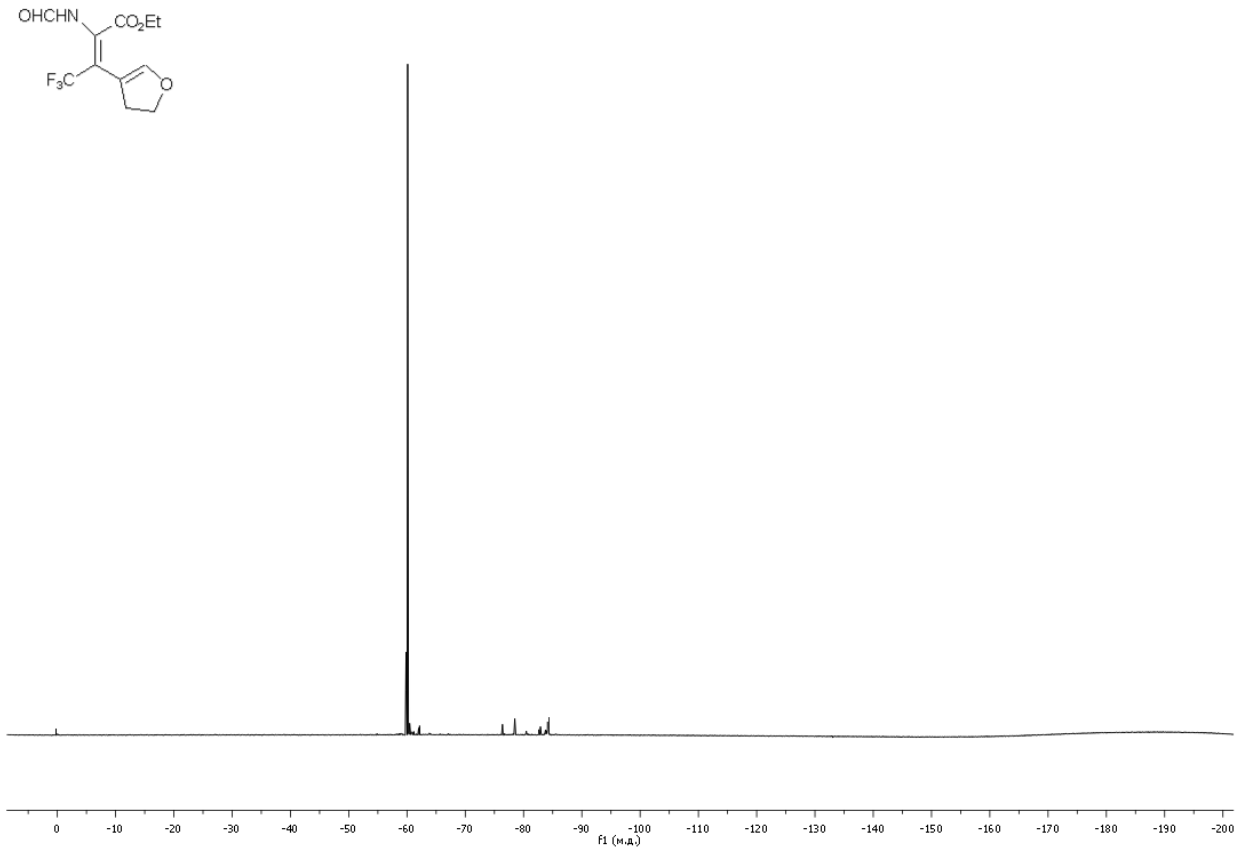
Compound 4m. ^{1}H NMR ($CDCl_3$)



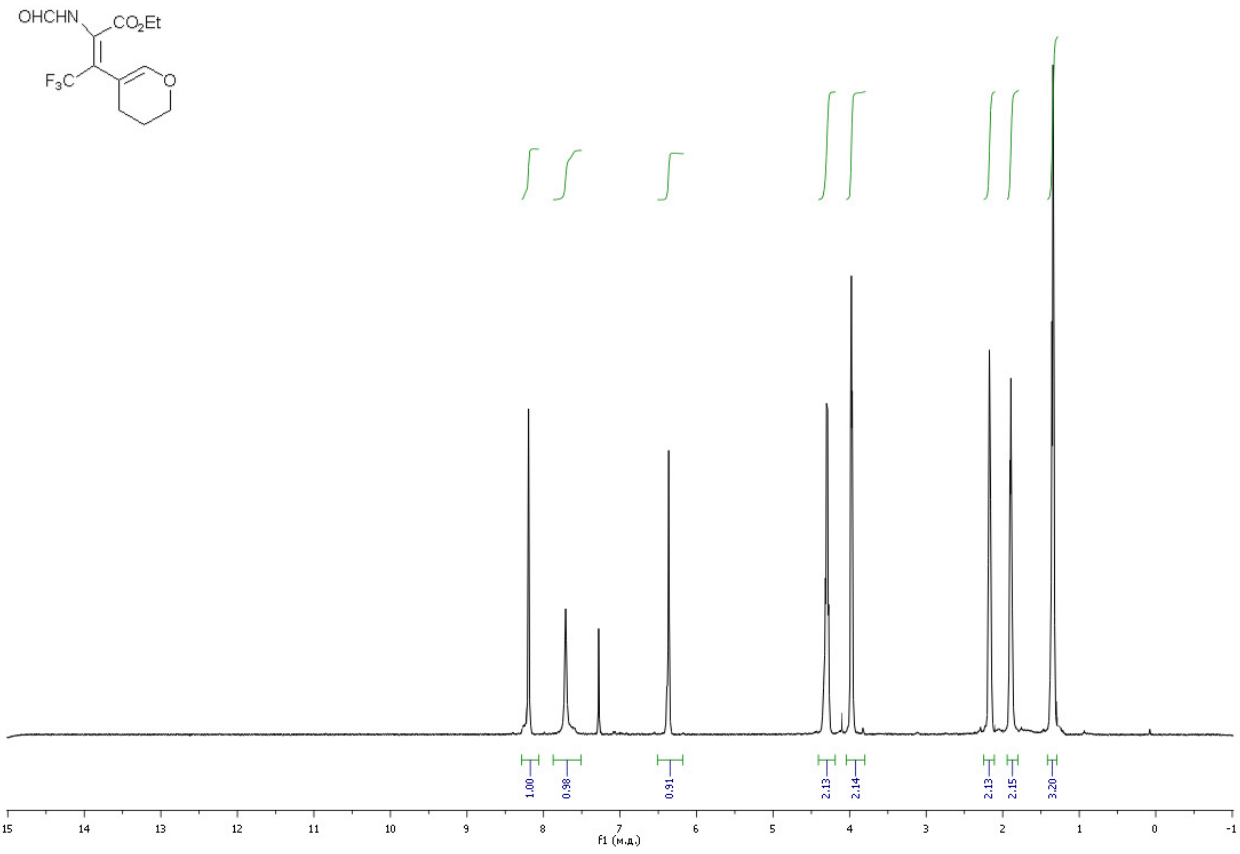
Compound 4m. ^{13}C NMR ($CDCl_3$)



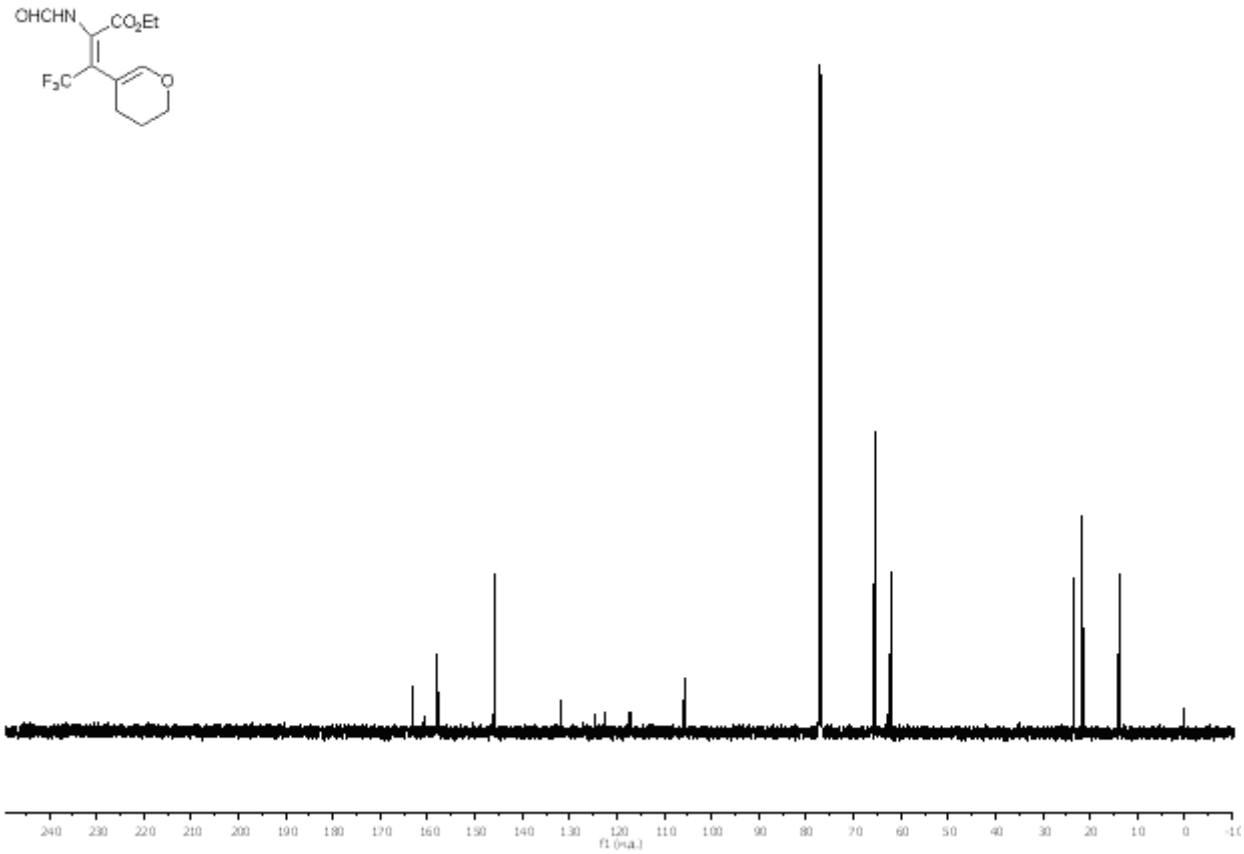
Compound 4m. ^{19}F NMR ($CDCl_3$)



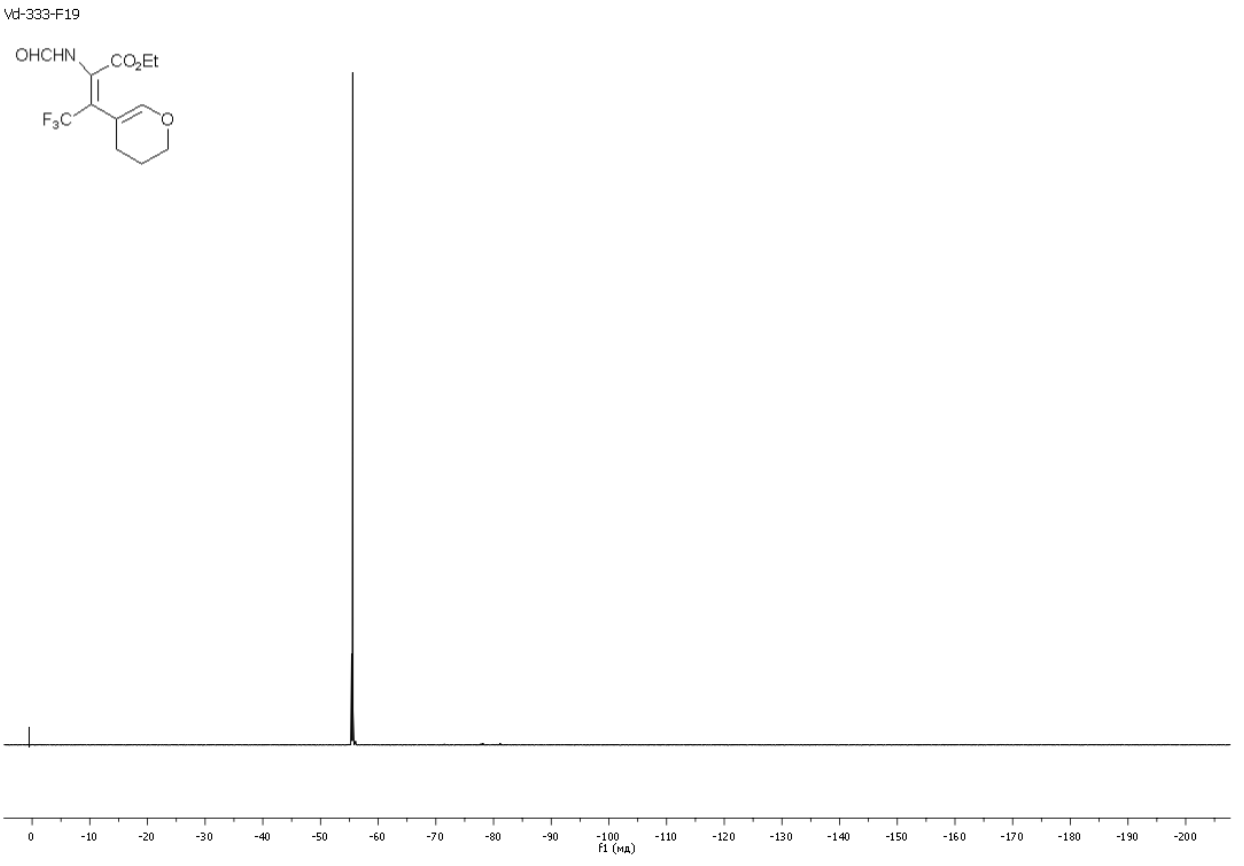
Compound 4n. ^{1}H NMR ($CDCl_3$)



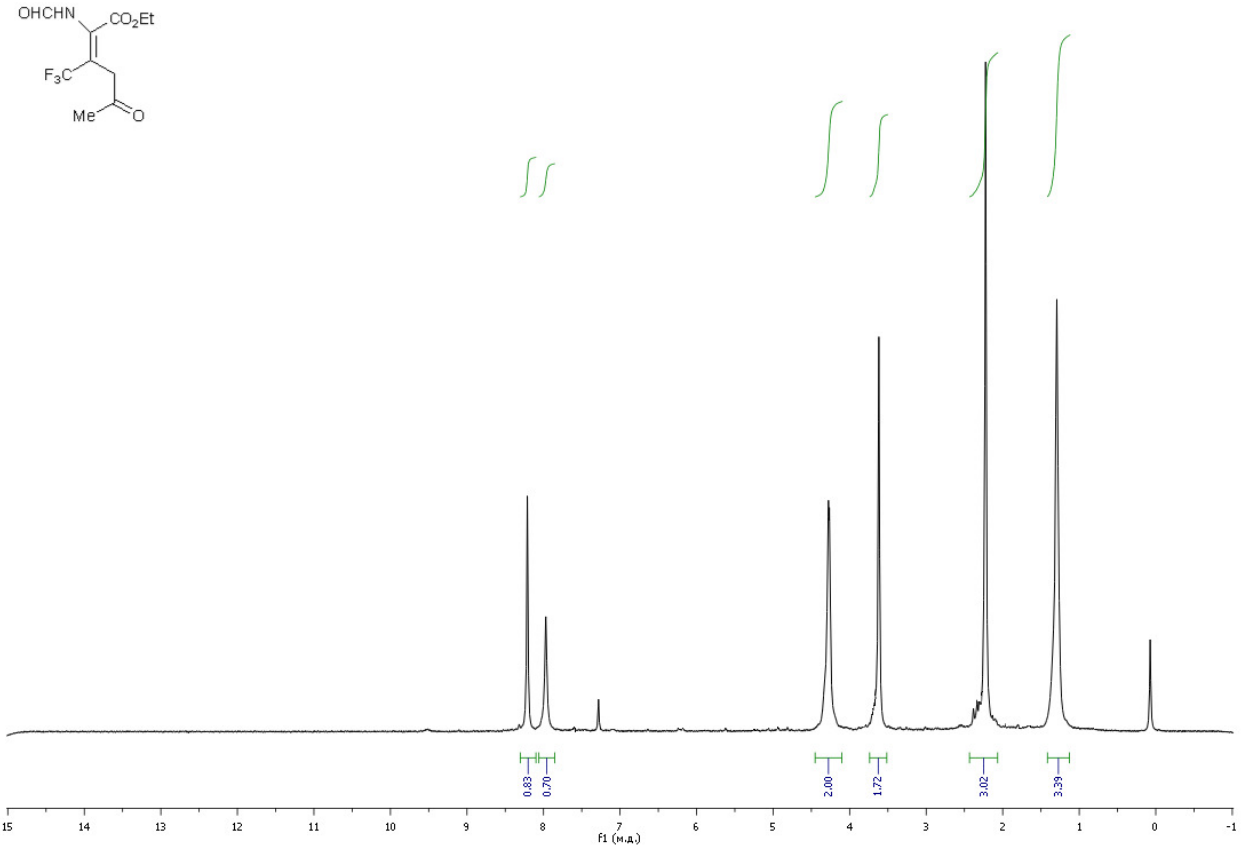
Compound 4n. ^{13}C NMR ($CDCl_3$)



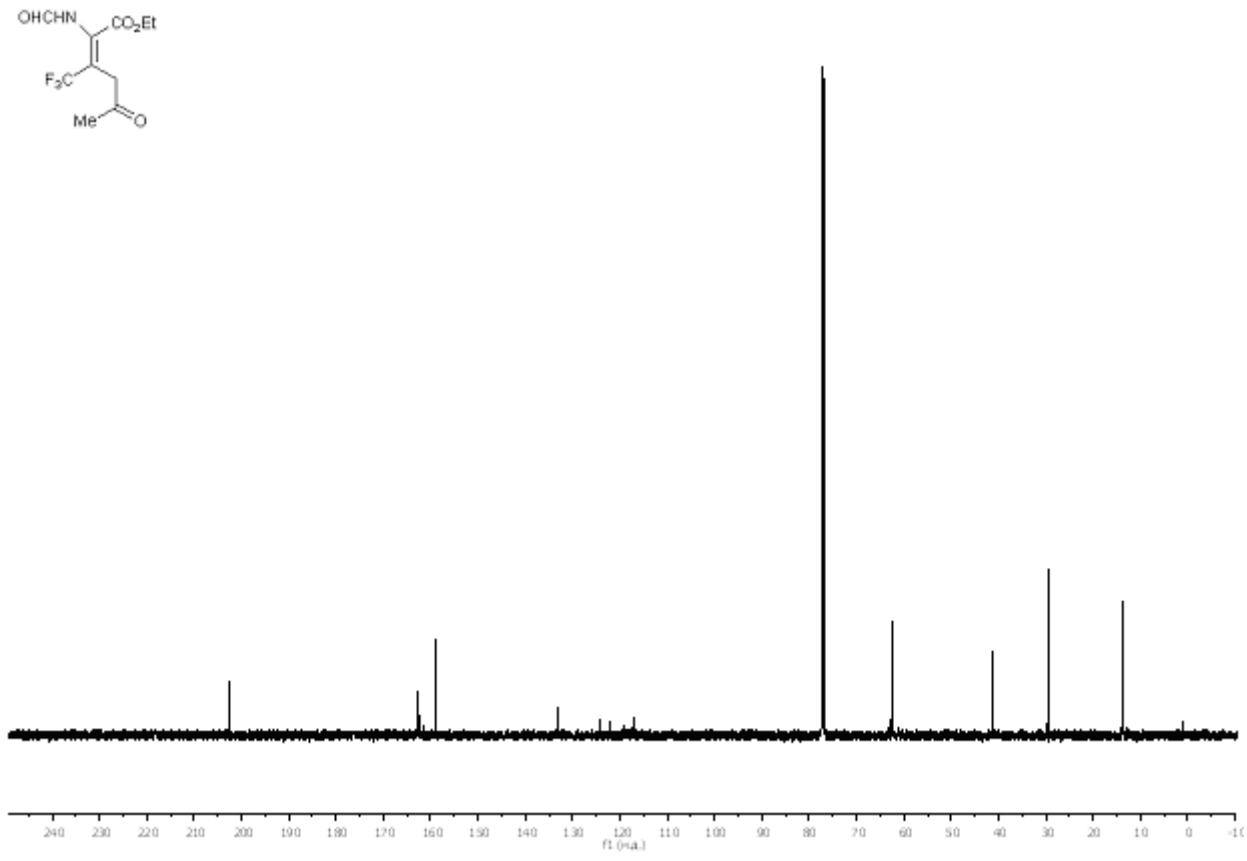
Compound 4n. ^{19}F NMR ($CDCl_3$)



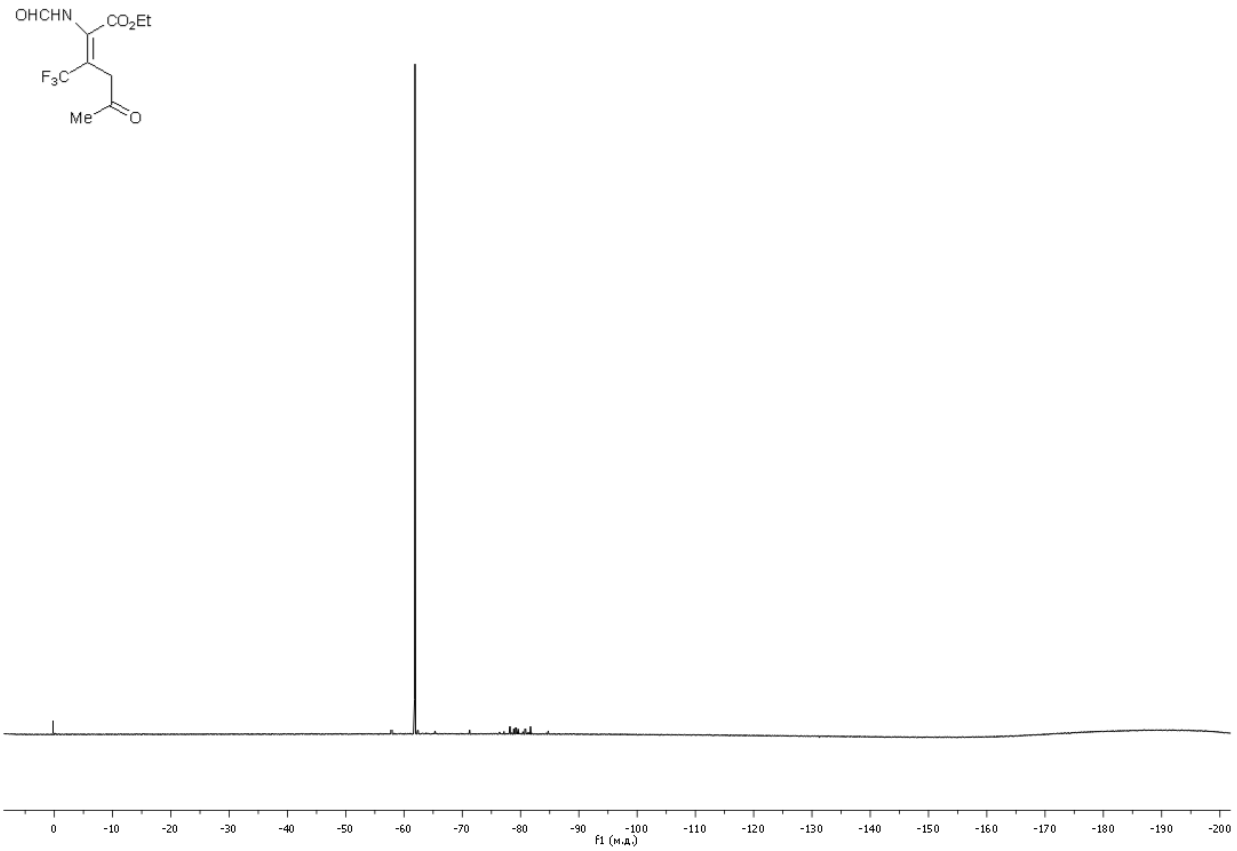
Compound 9. ^{1}H NMR ($CDCl_3$)



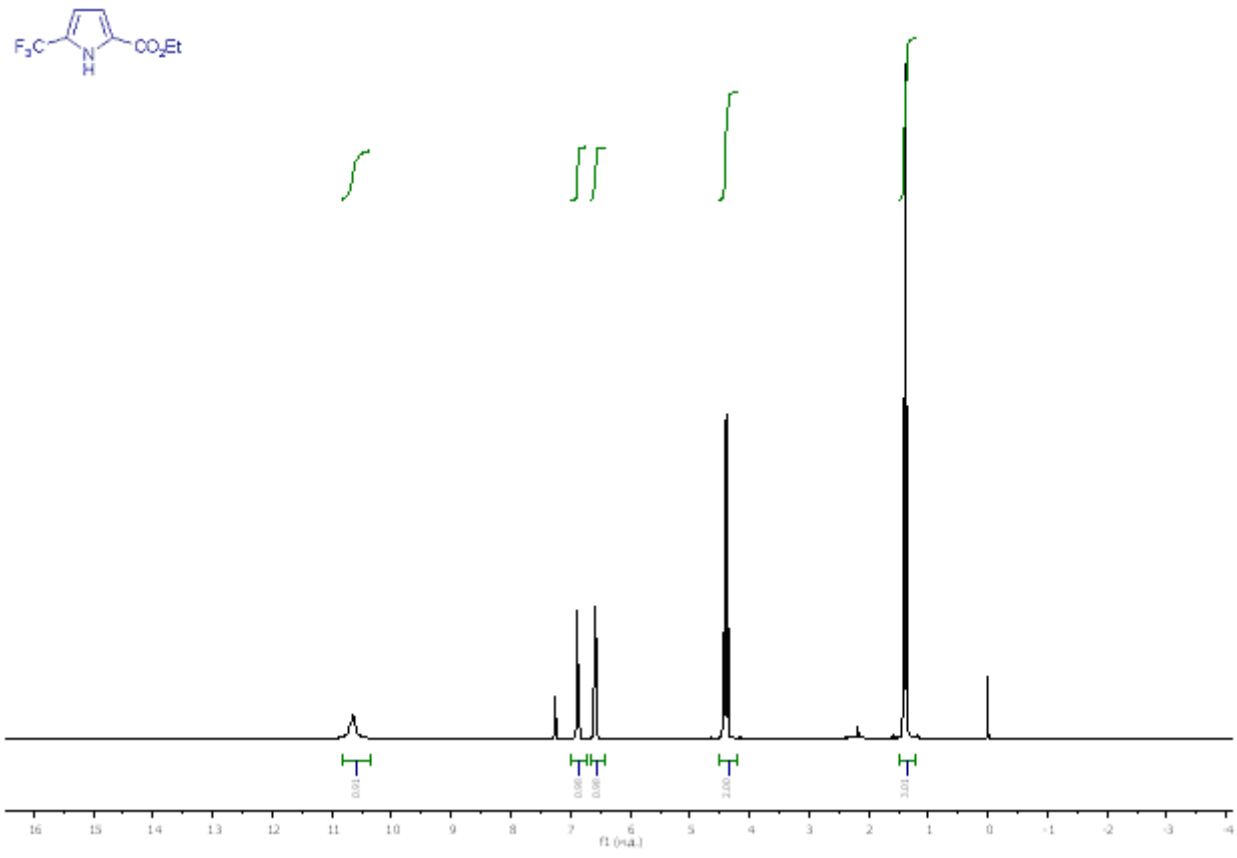
Compound 9. ^{13}C NMR ($CDCl_3$)



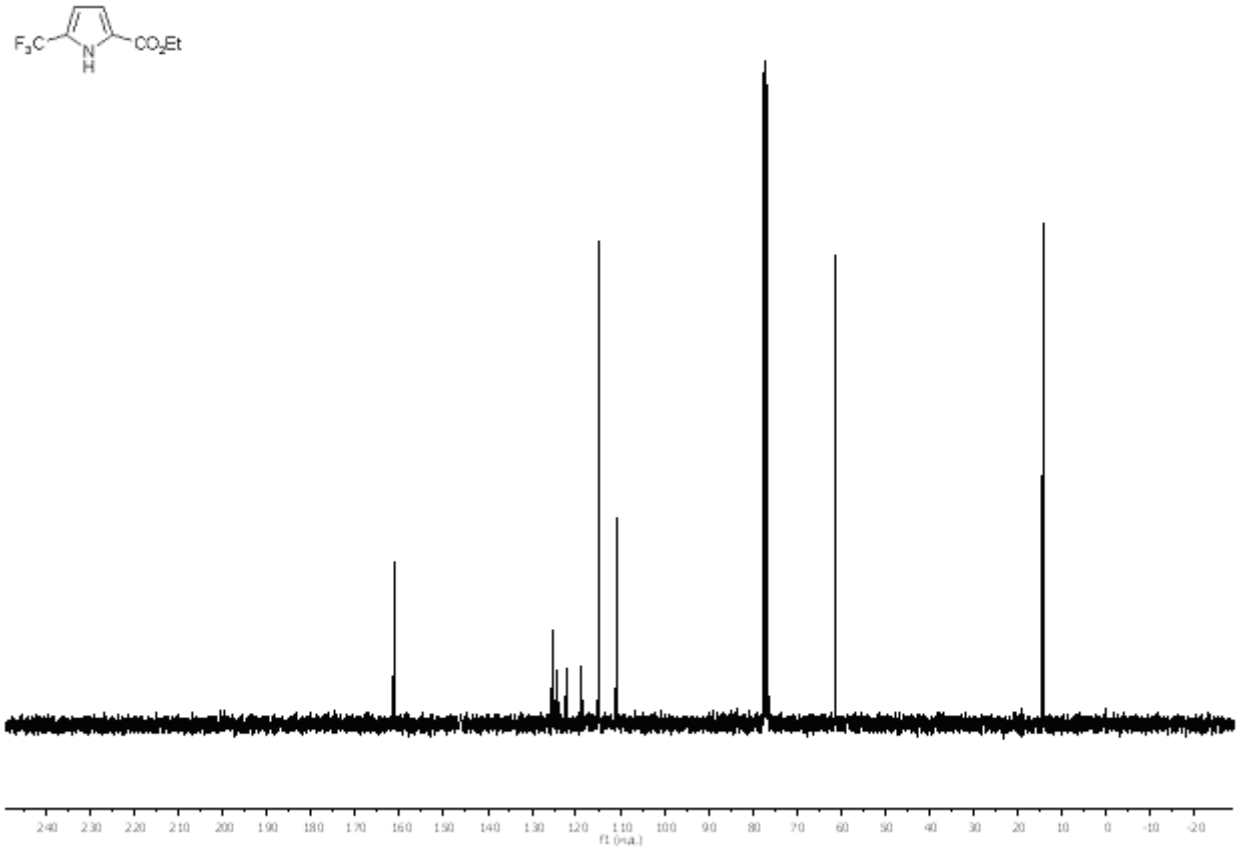
Compound 9. ^{19}F NMR ($CDCl_3$)



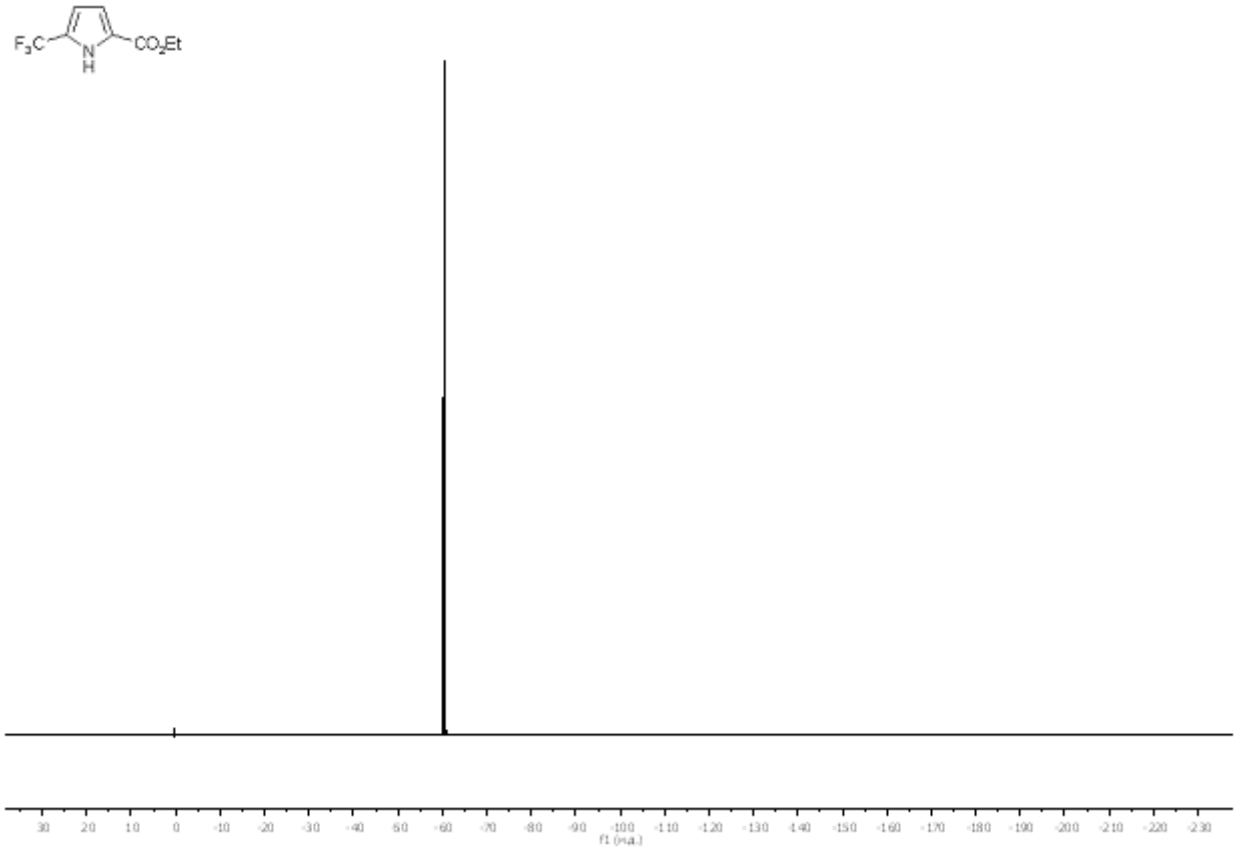
Compound 11a. ^{1}H NMR ($CDCl_3$)



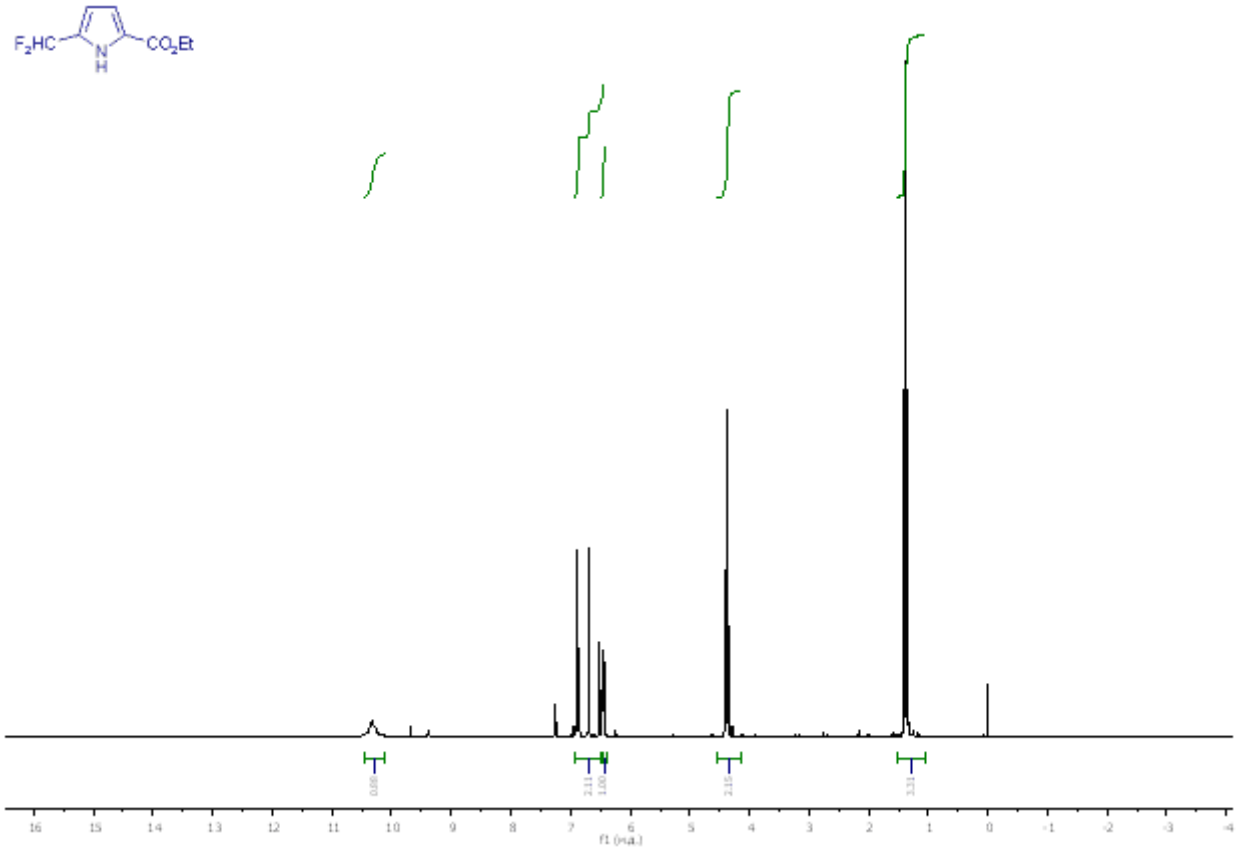
Compound 11a. ^{13}C NMR ($CDCl_3$)



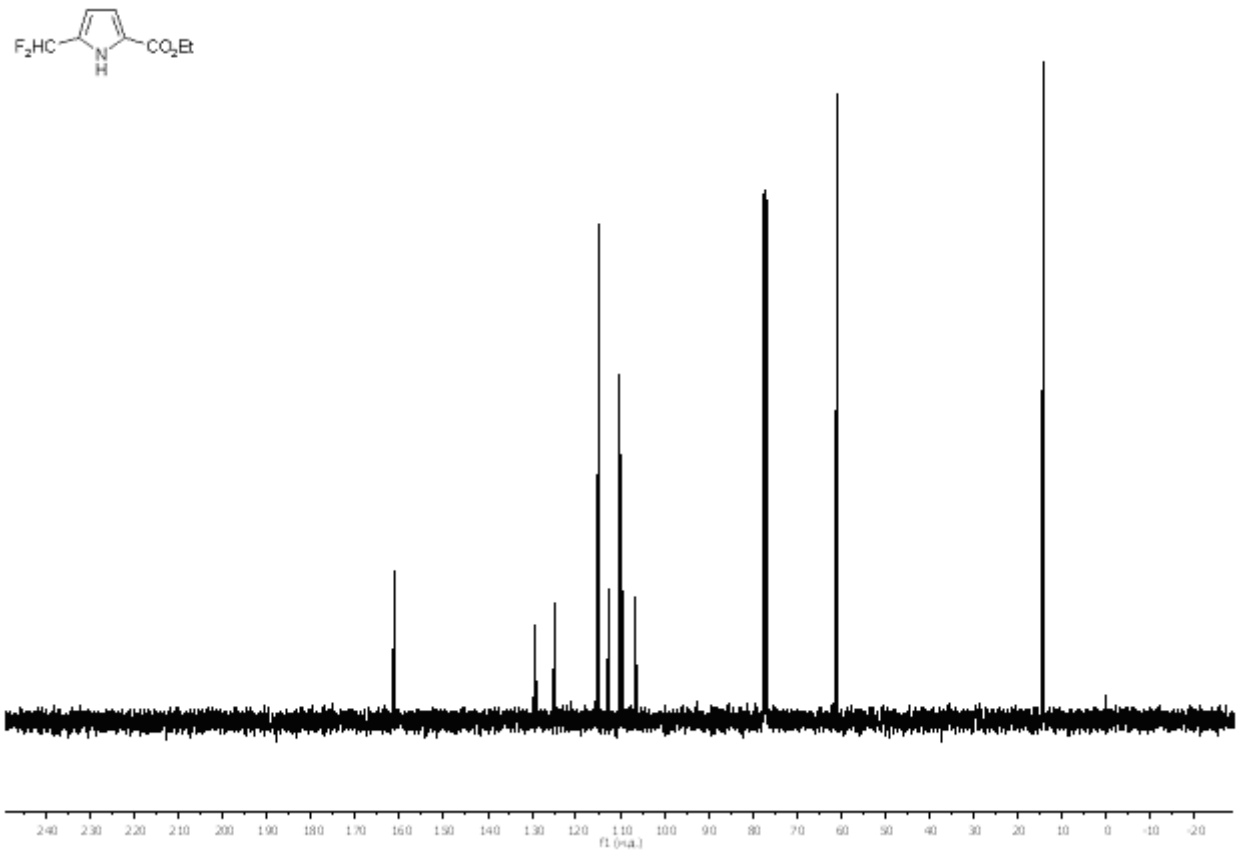
Compound 11a. ^{19}F NMR ($CDCl_3$)



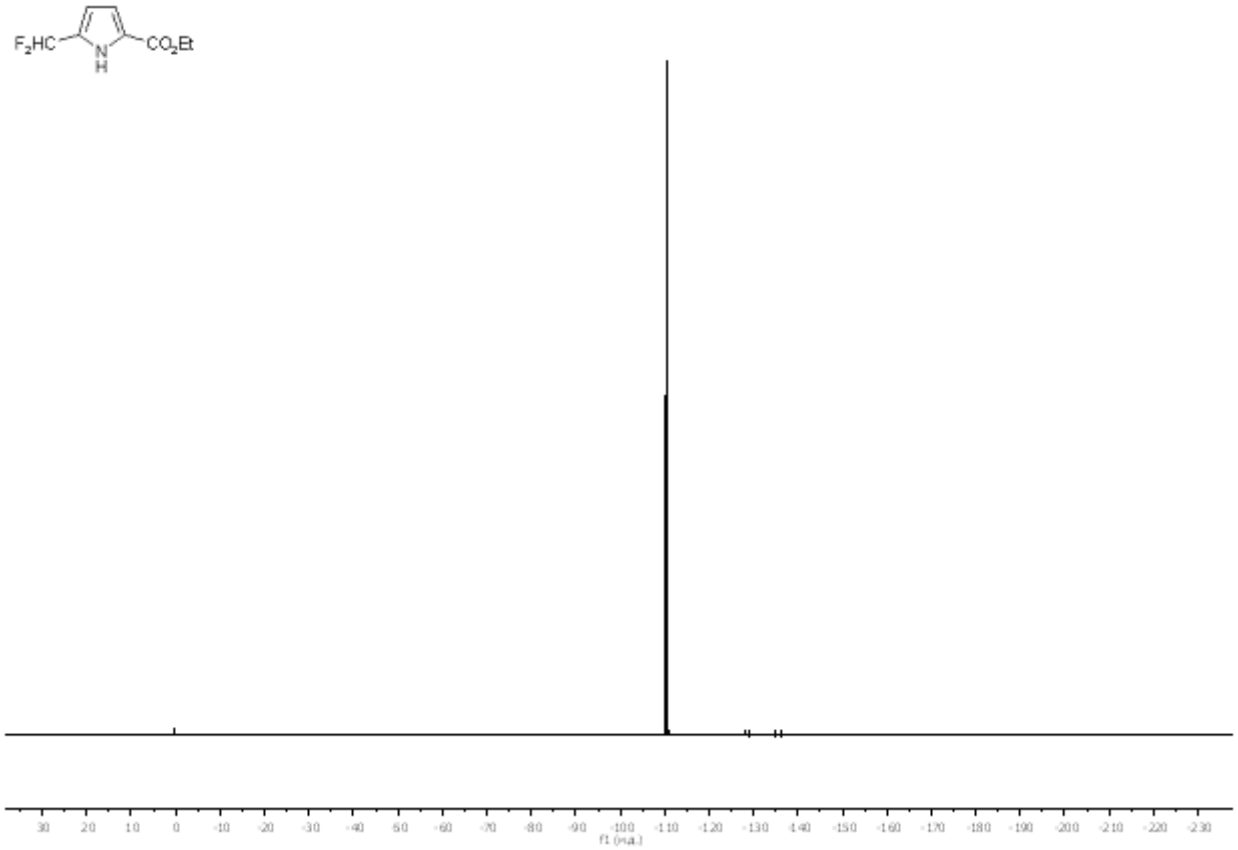
Compound 11b. ^{1}H NMR ($CDCl_3$)



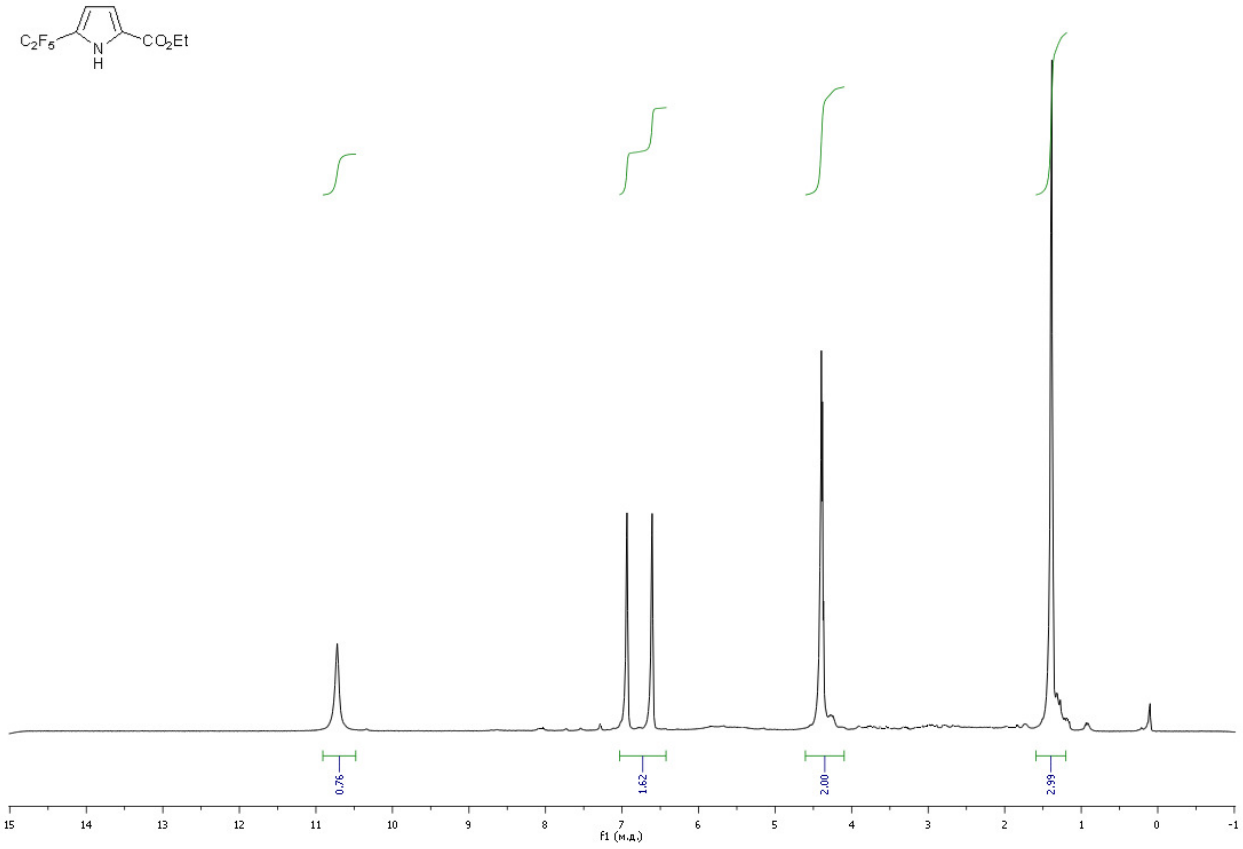
Compound 11b. ^{13}C NMR ($CDCl_3$)



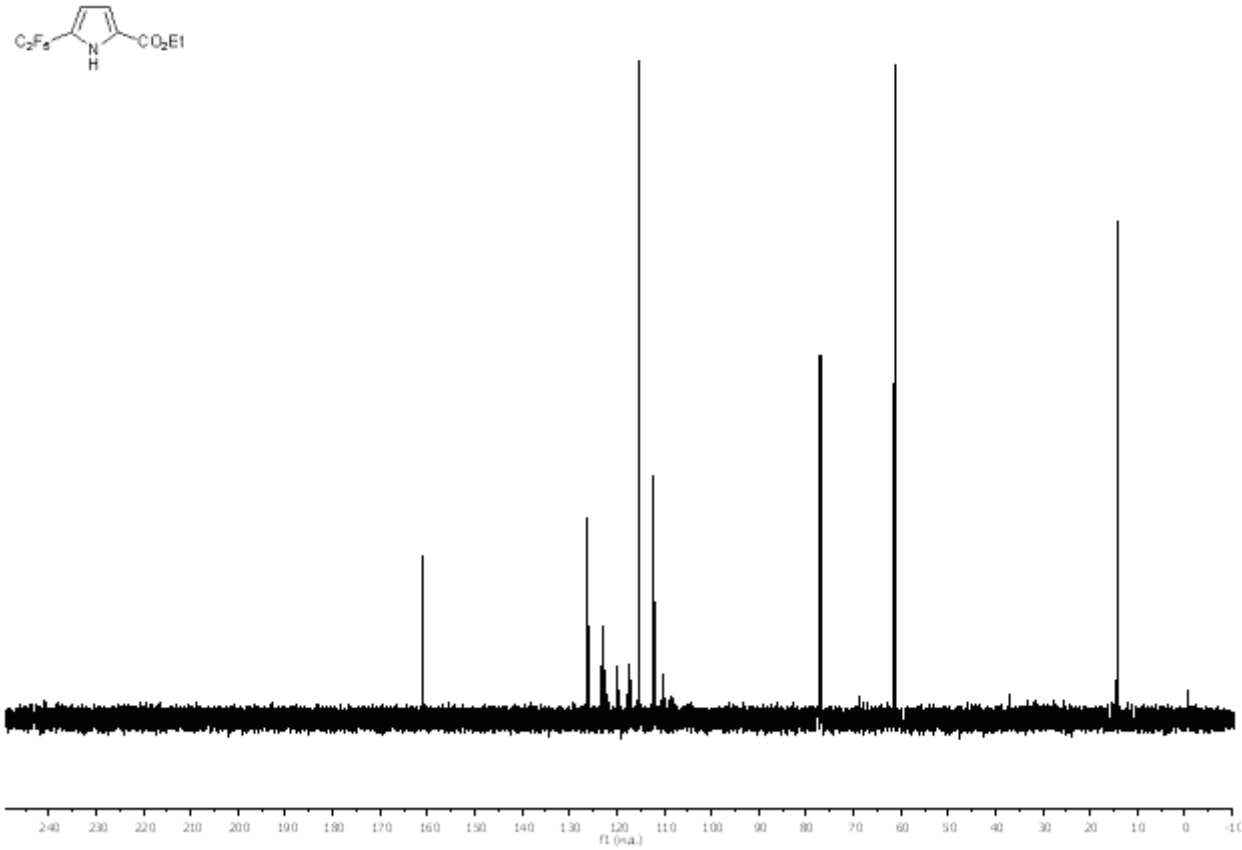
Compound 11b. ^{19}F NMR ($CDCl_3$)



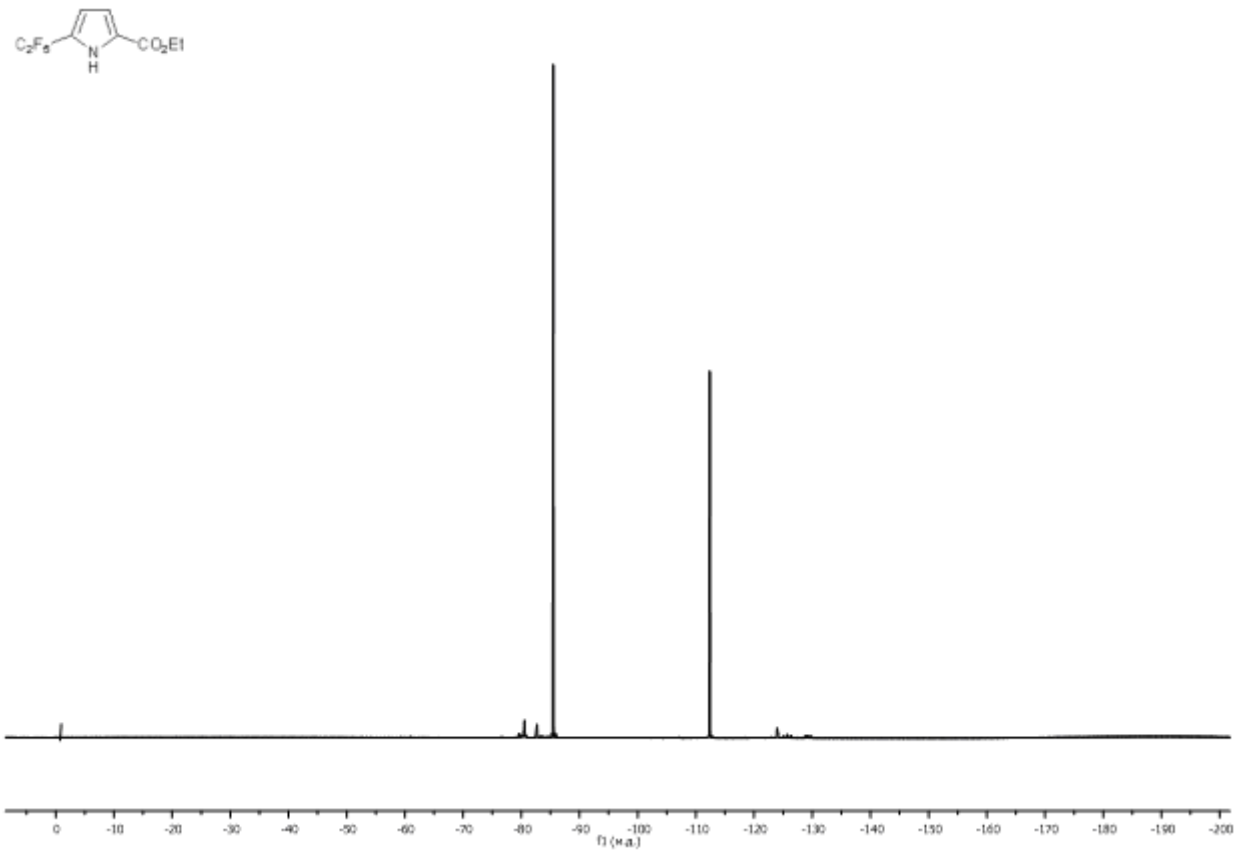
Compound 11d. ^{1}H NMR ($CDCl_3$)



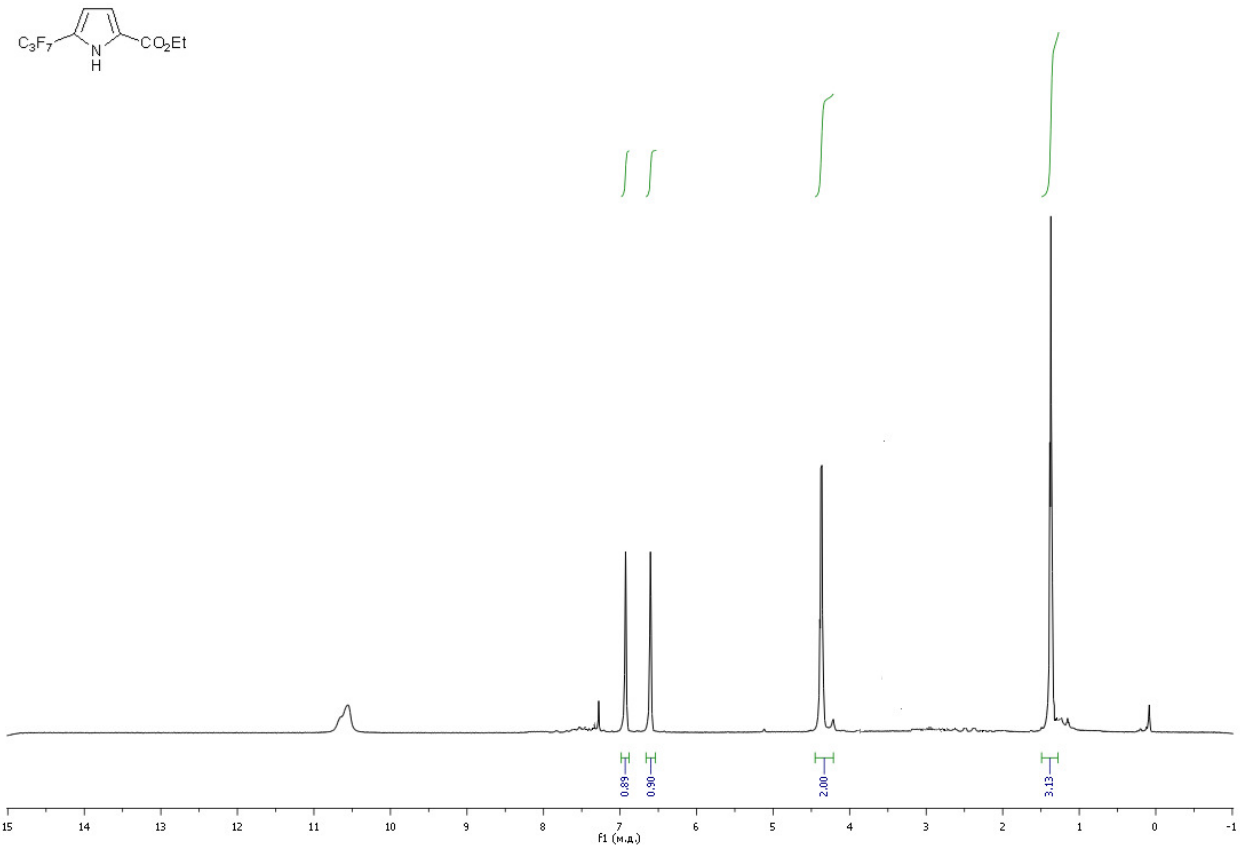
Compound 11d. ^{13}C NMR ($CDCl_3$)



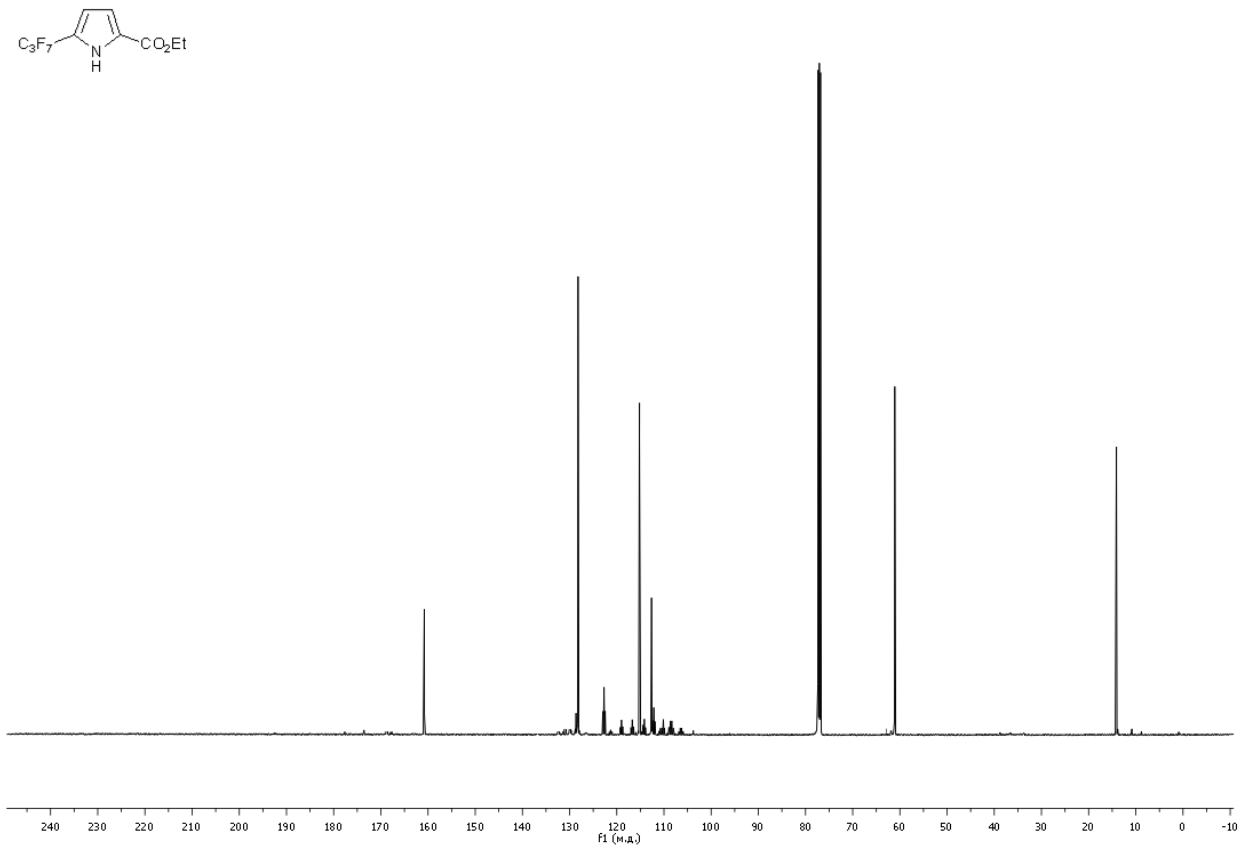
Compound 11d. ^{19}F NMR ($CDCl_3$)



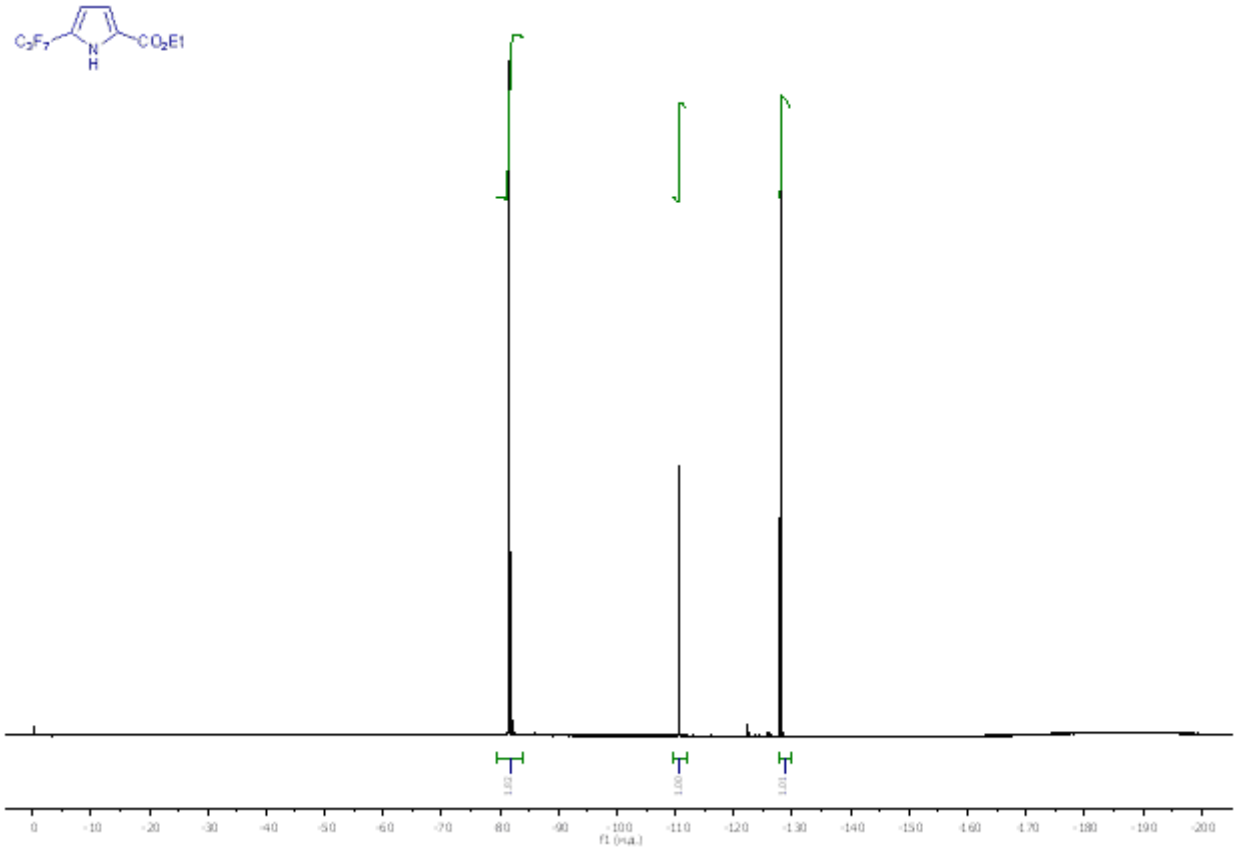
Compound 11e. ^{1}H NMR ($CDCl_3$)



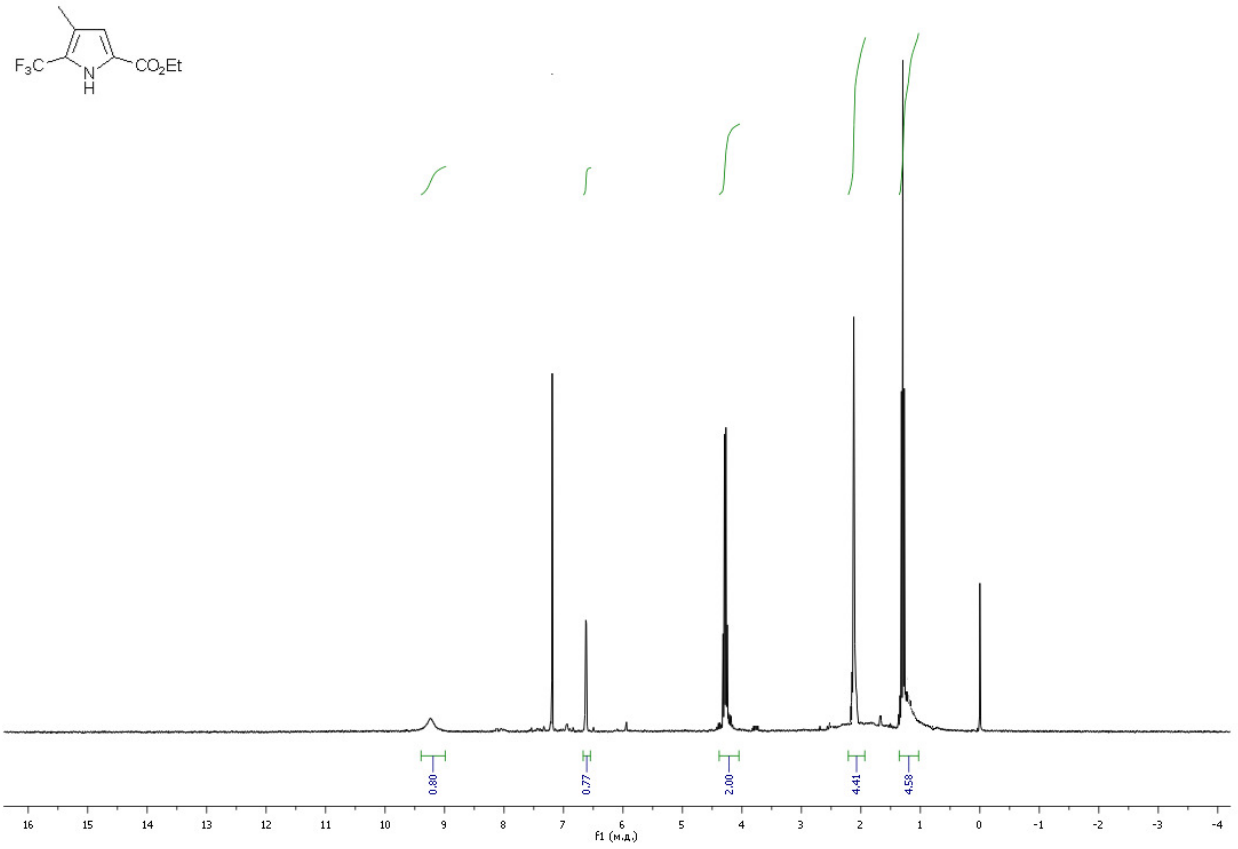
Compound 11e. ^{13}C NMR ($CDCl_3$)



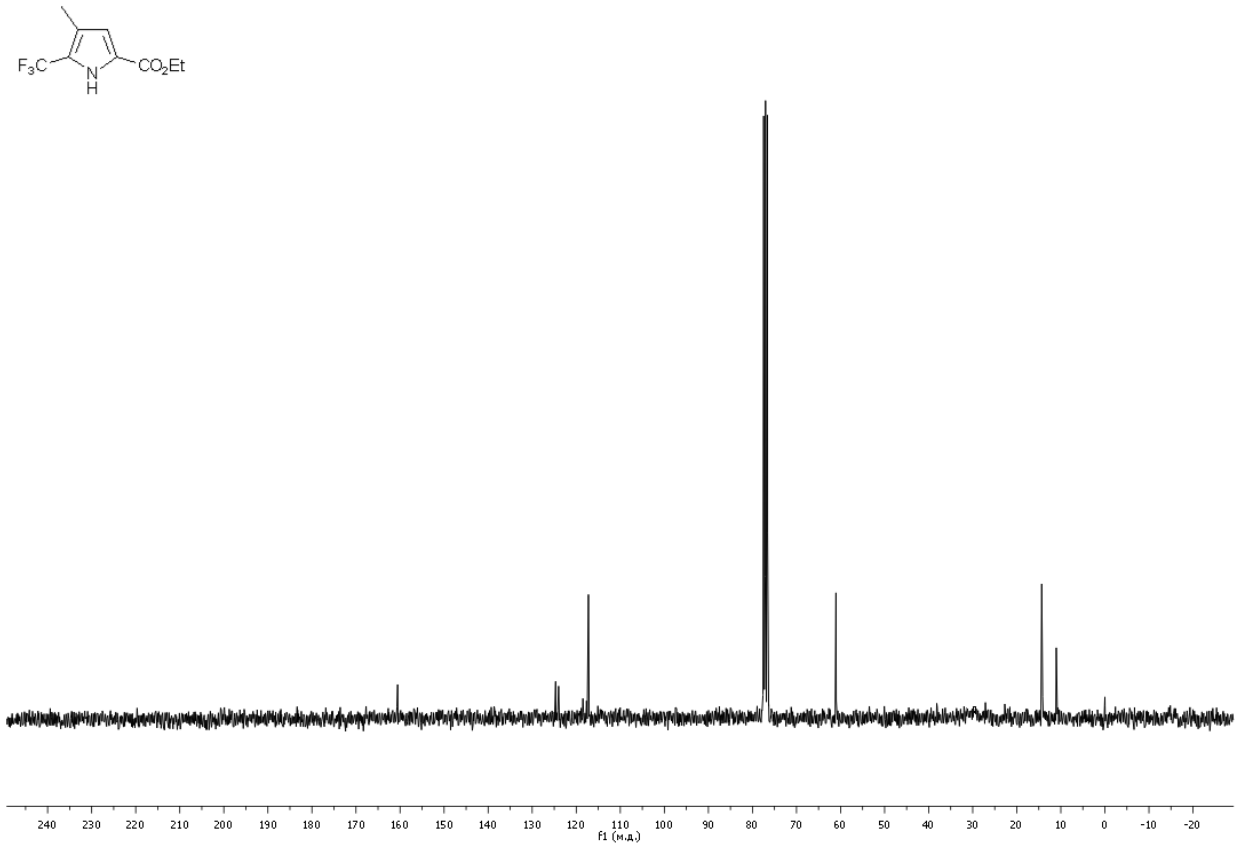
Compound 11e. ^{19}F NMR ($CDCl_3$)



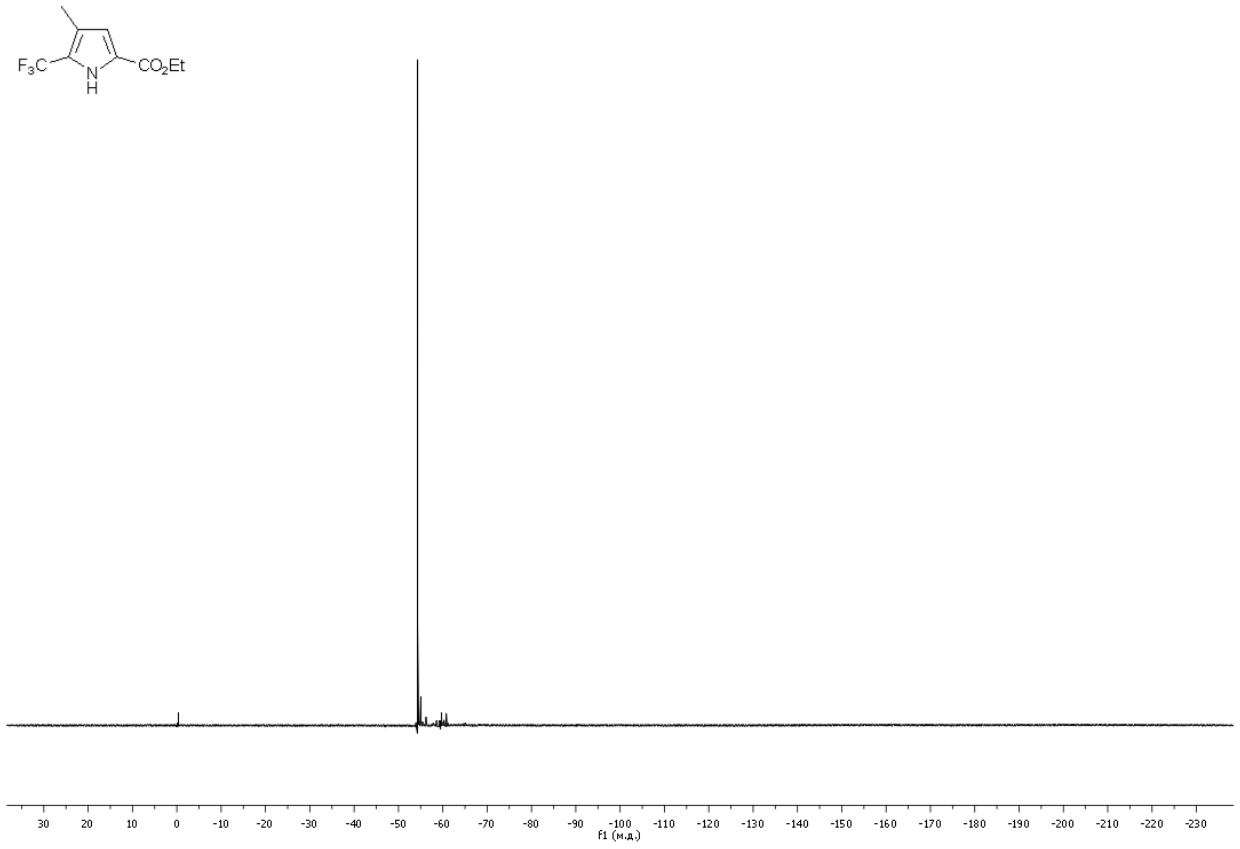
Compound 11f. ^{1}H NMR ($CDCl_3$)



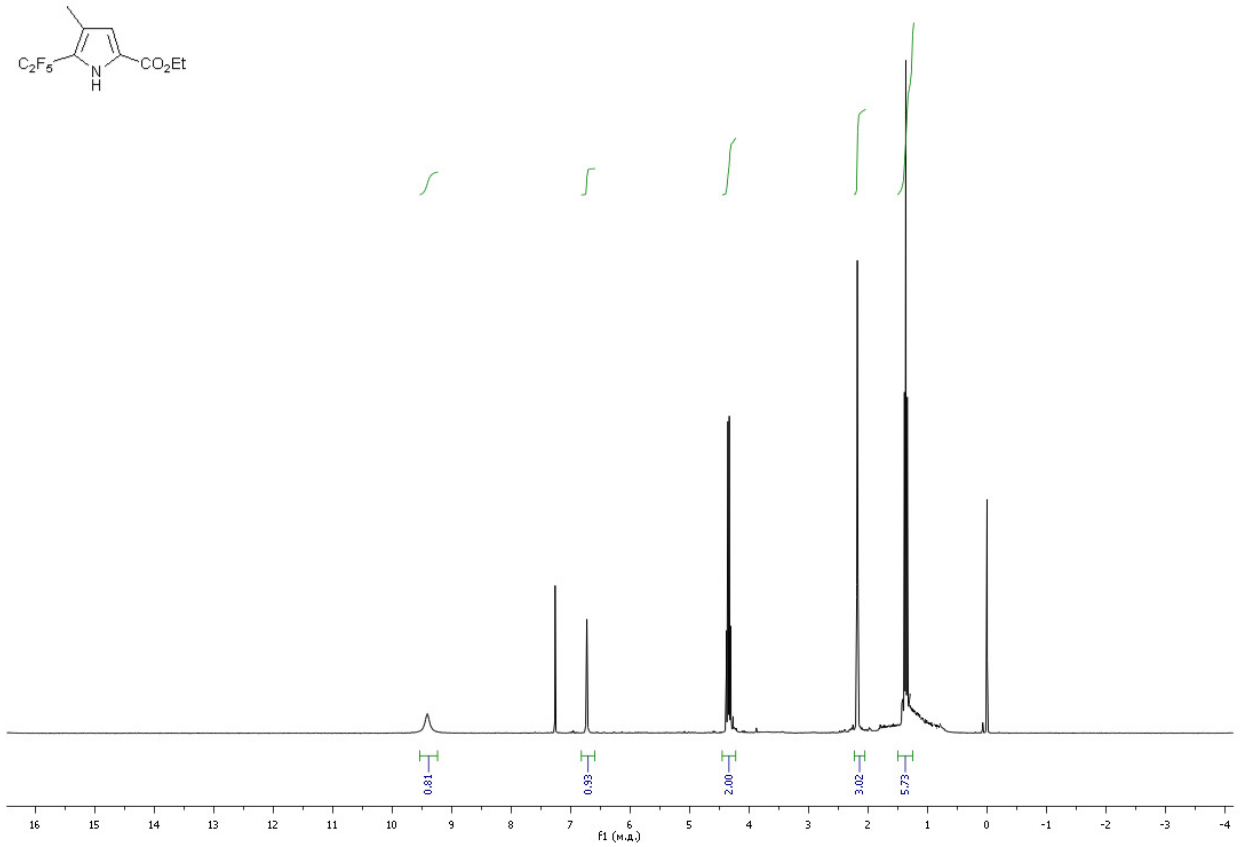
Compound 11f. ^{13}C NMR ($CDCl_3$)



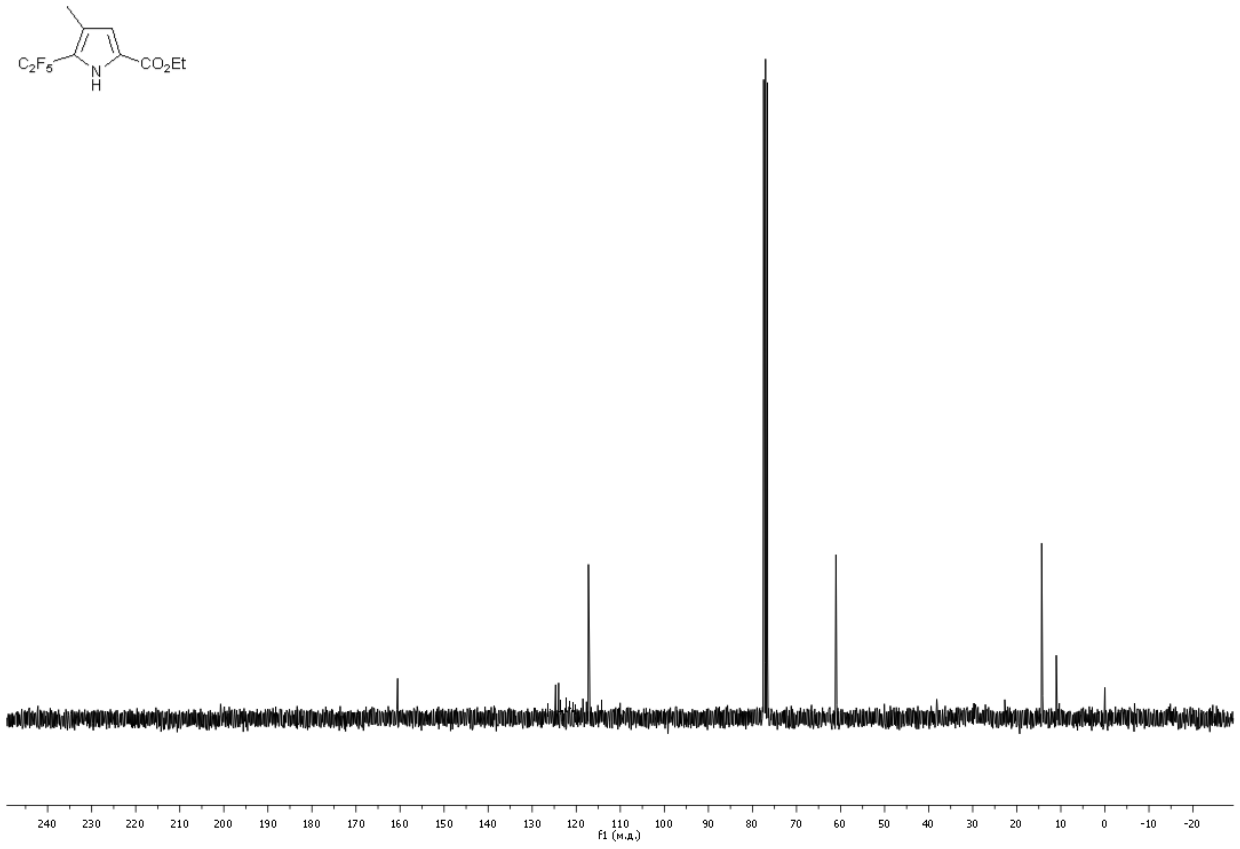
Compound 11f. ^{19}F NMR ($CDCl_3$)



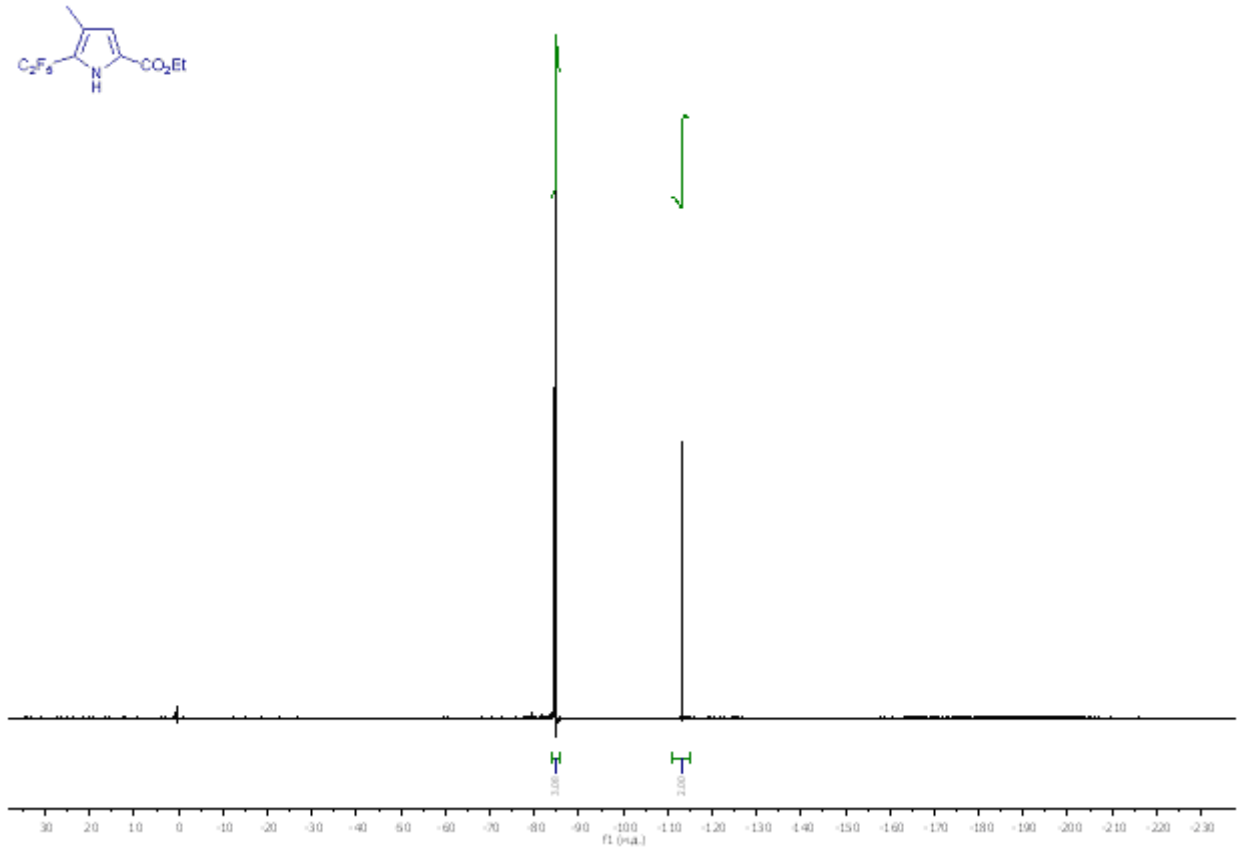
Compound 11g. ^{1}H NMR ($CDCl_3$)



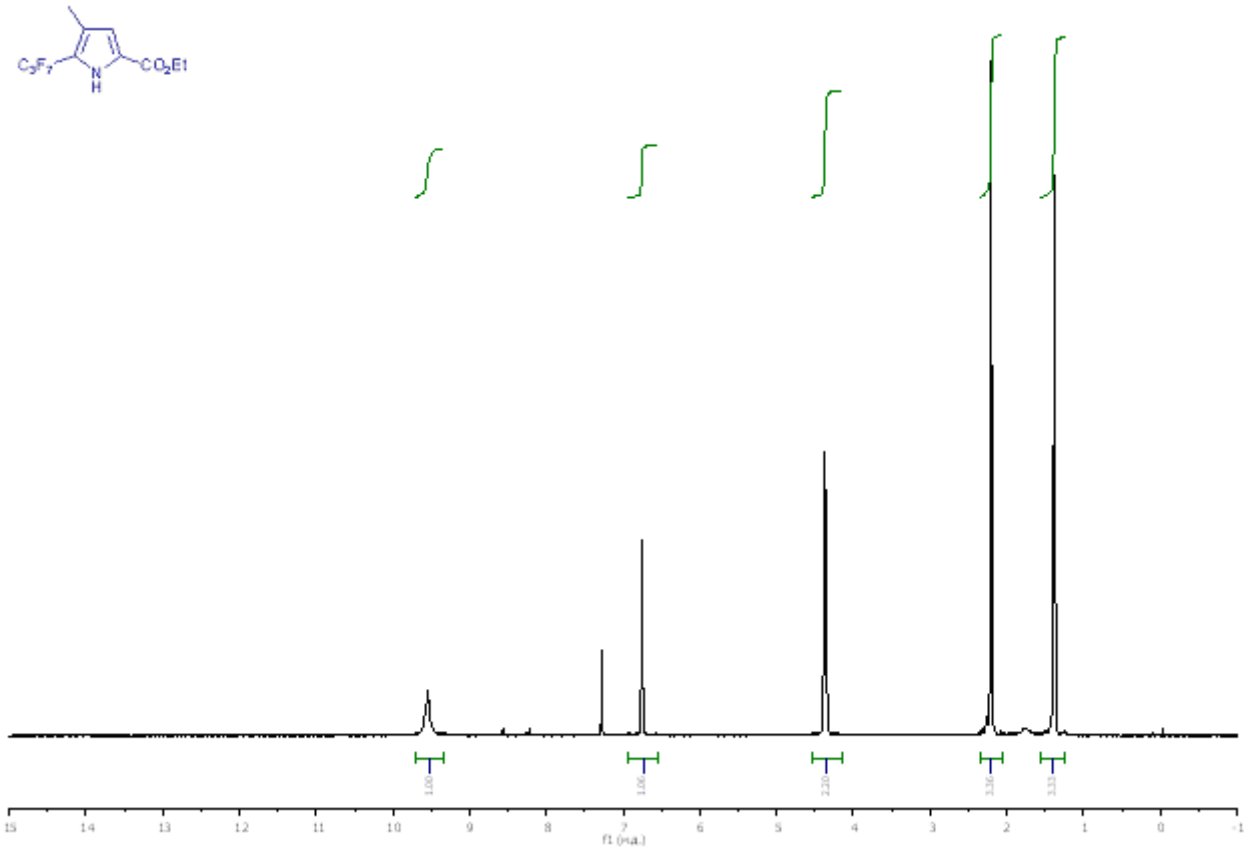
Compound 11g. ^{13}C NMR ($CDCl_3$)



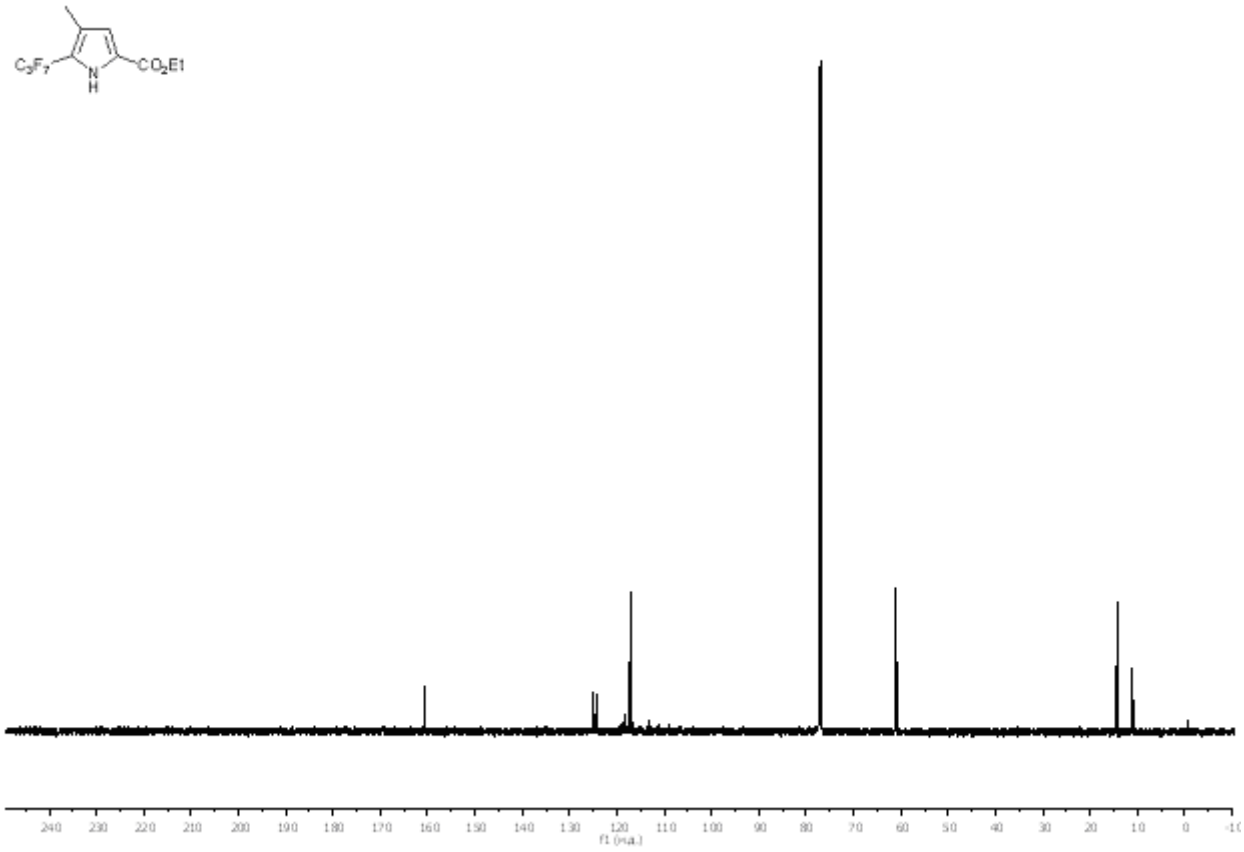
Compound 11g. ^{19}F NMR ($CDCl_3$)



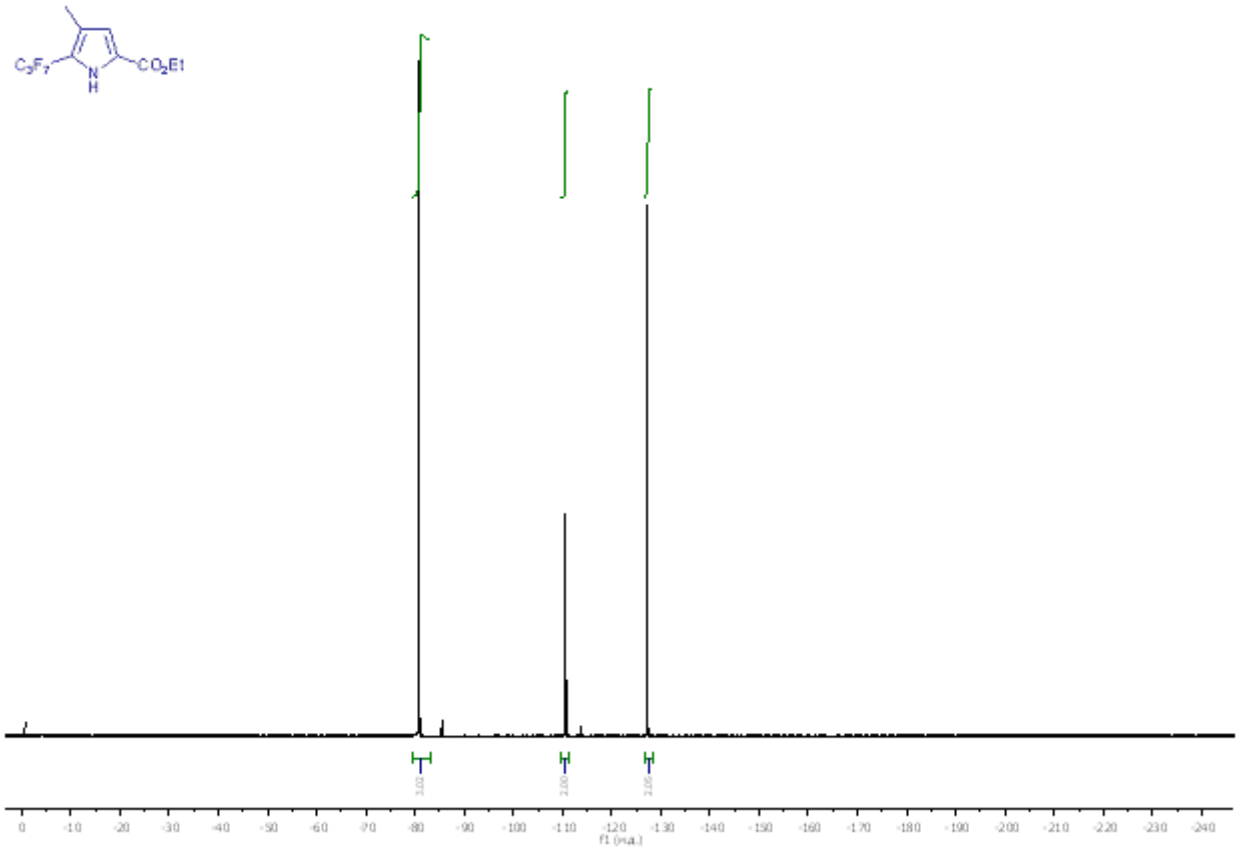
Compound 11h. ^{1}H NMR ($CDCl_3$)



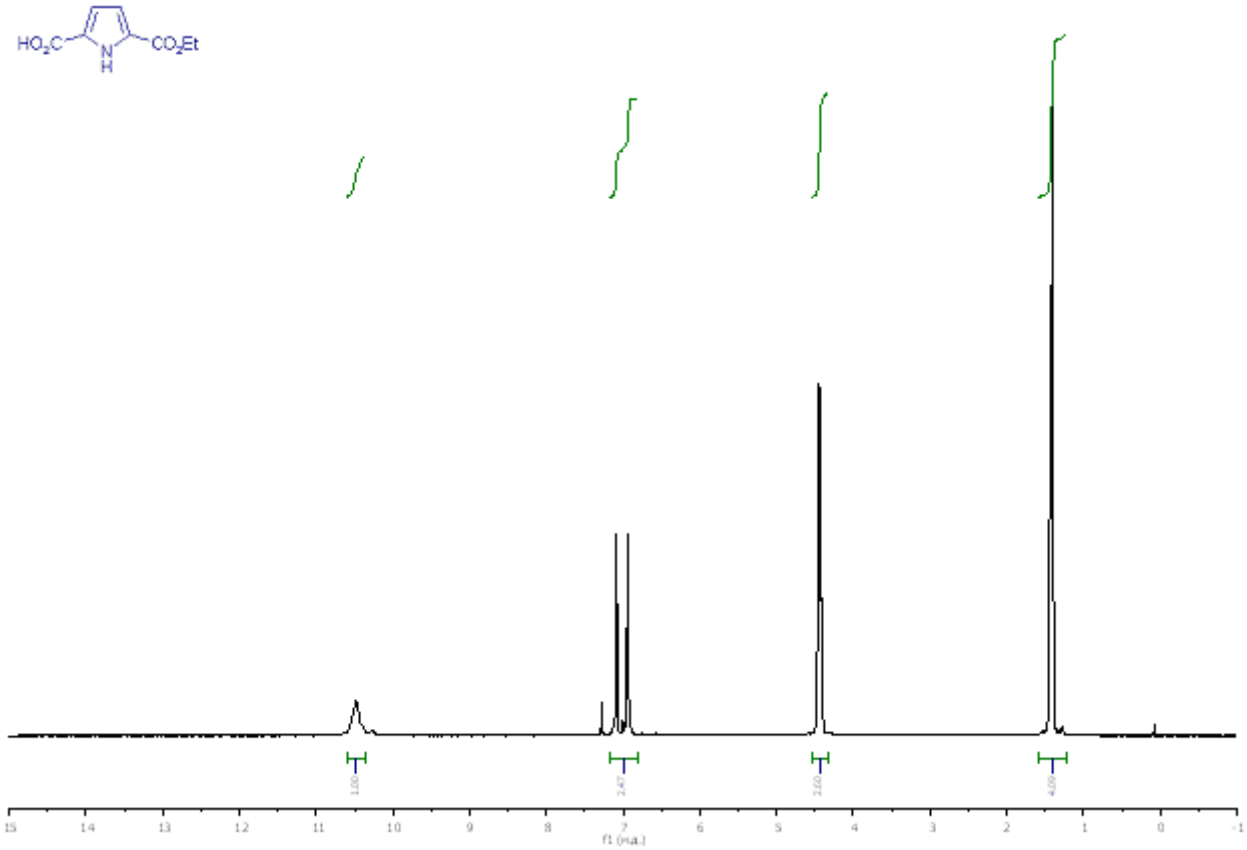
Compound 11h. ^{13}C NMR ($CDCl_3$)



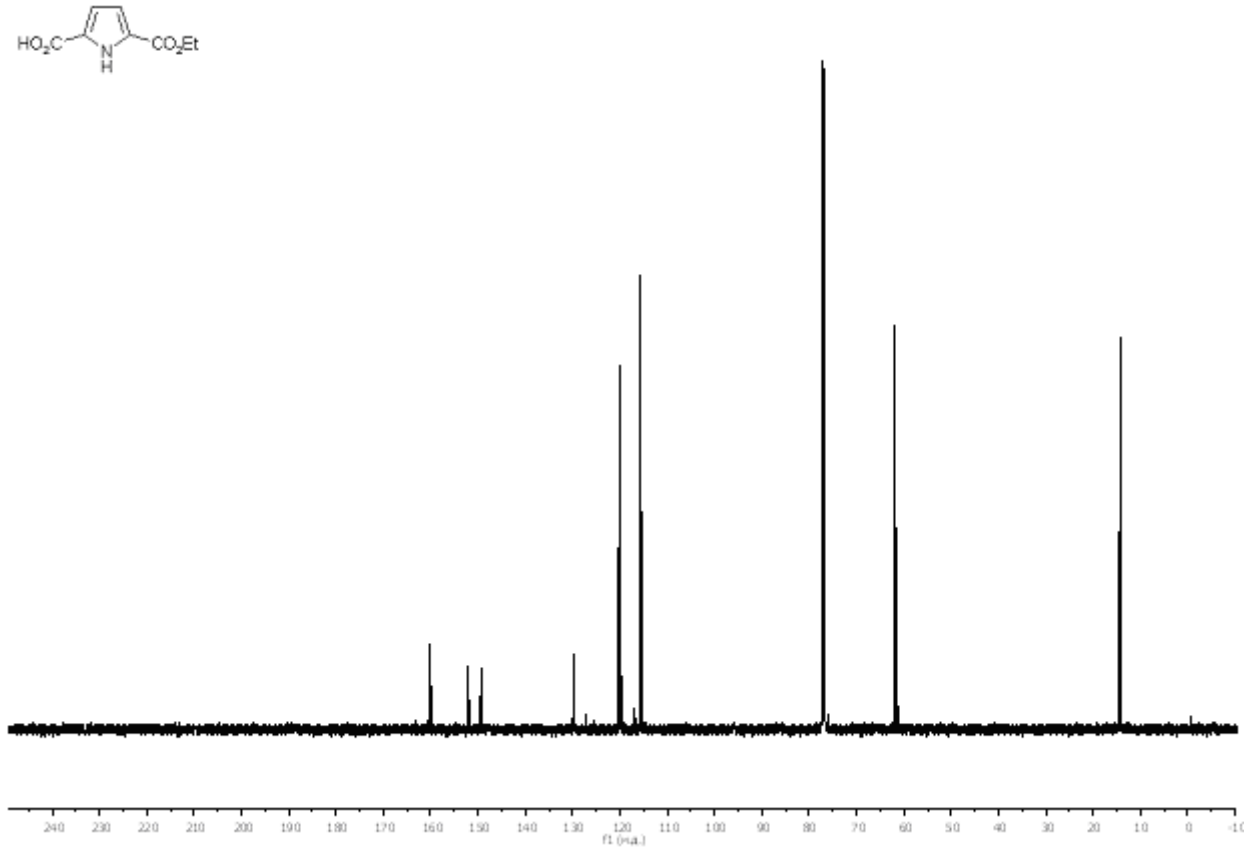
Compound 11h. ^{19}F NMR ($CDCl_3$)



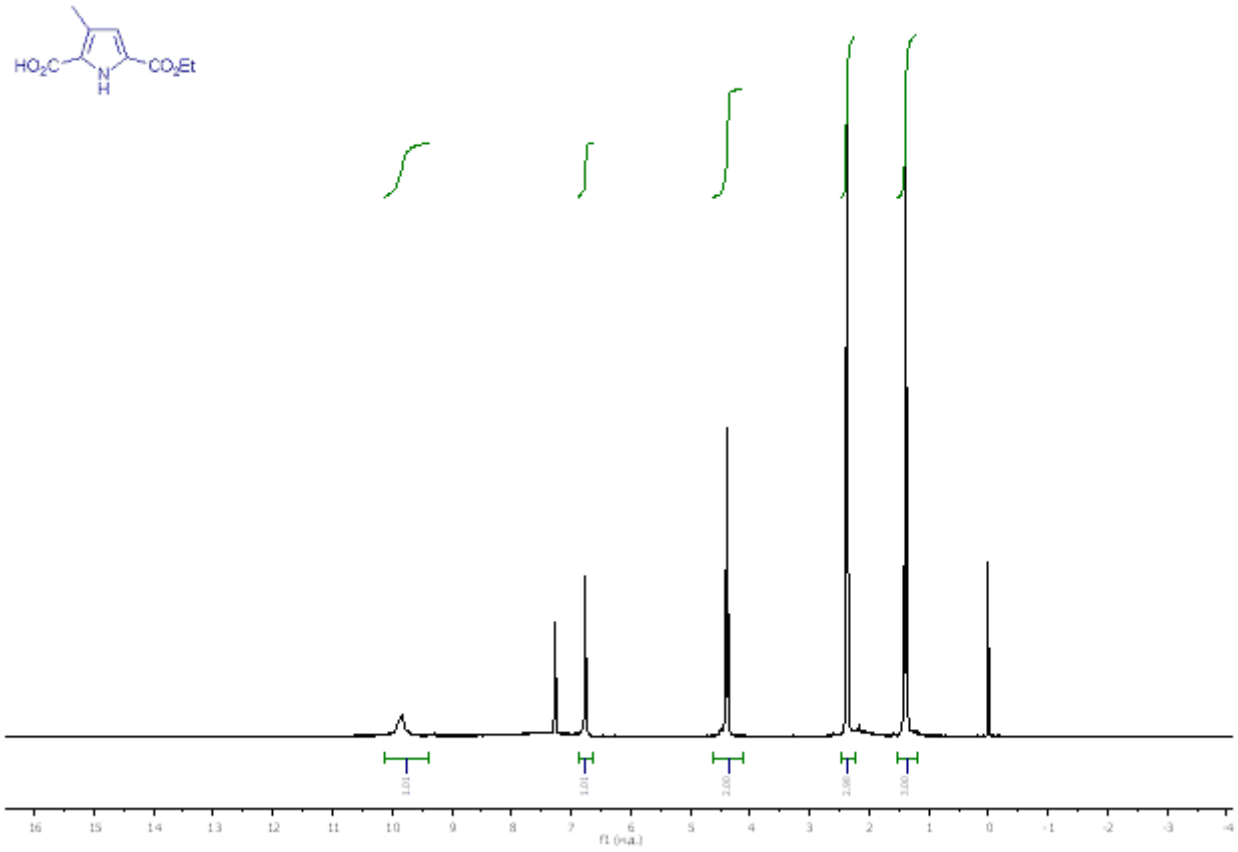
Compound 12a. ^{1}H NMR ($CDCl_3$)



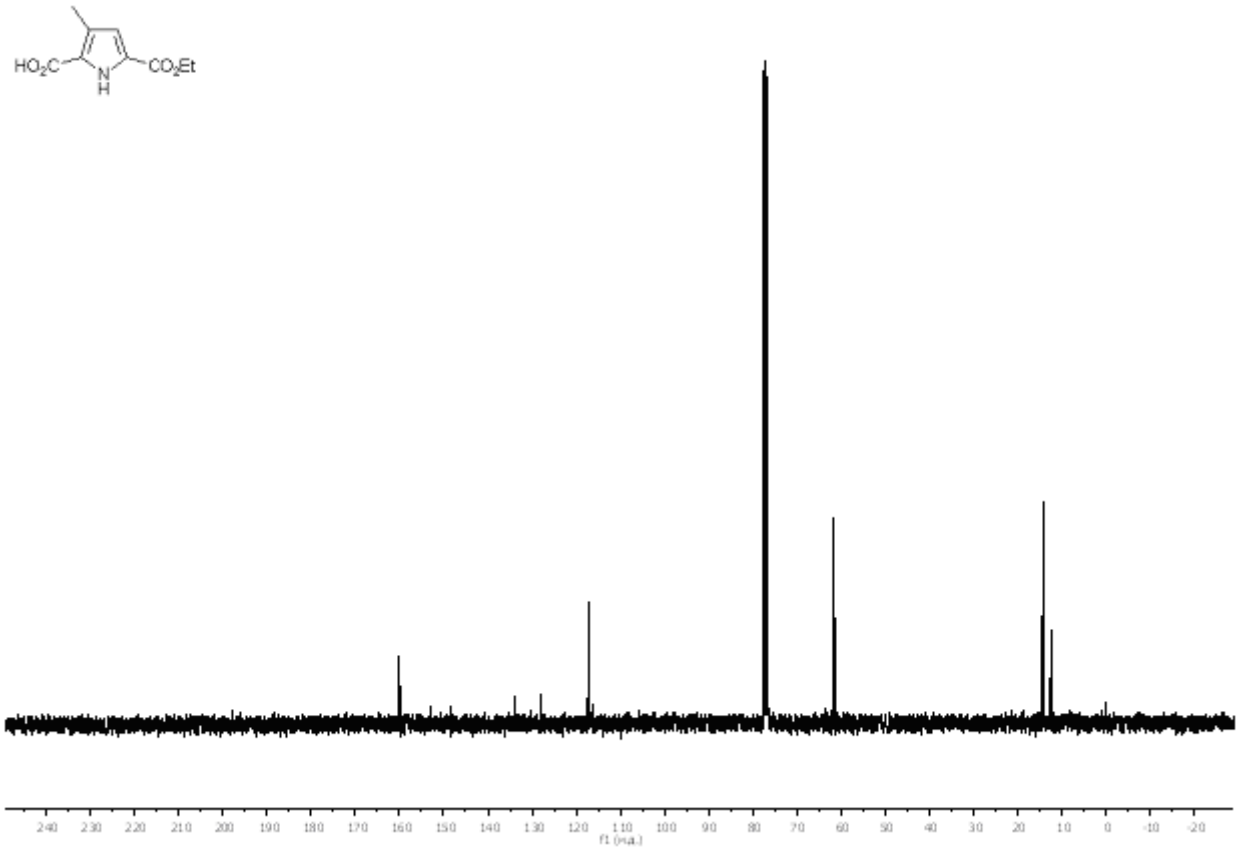
Compound 12a. ^{13}C NMR ($CDCl_3$)



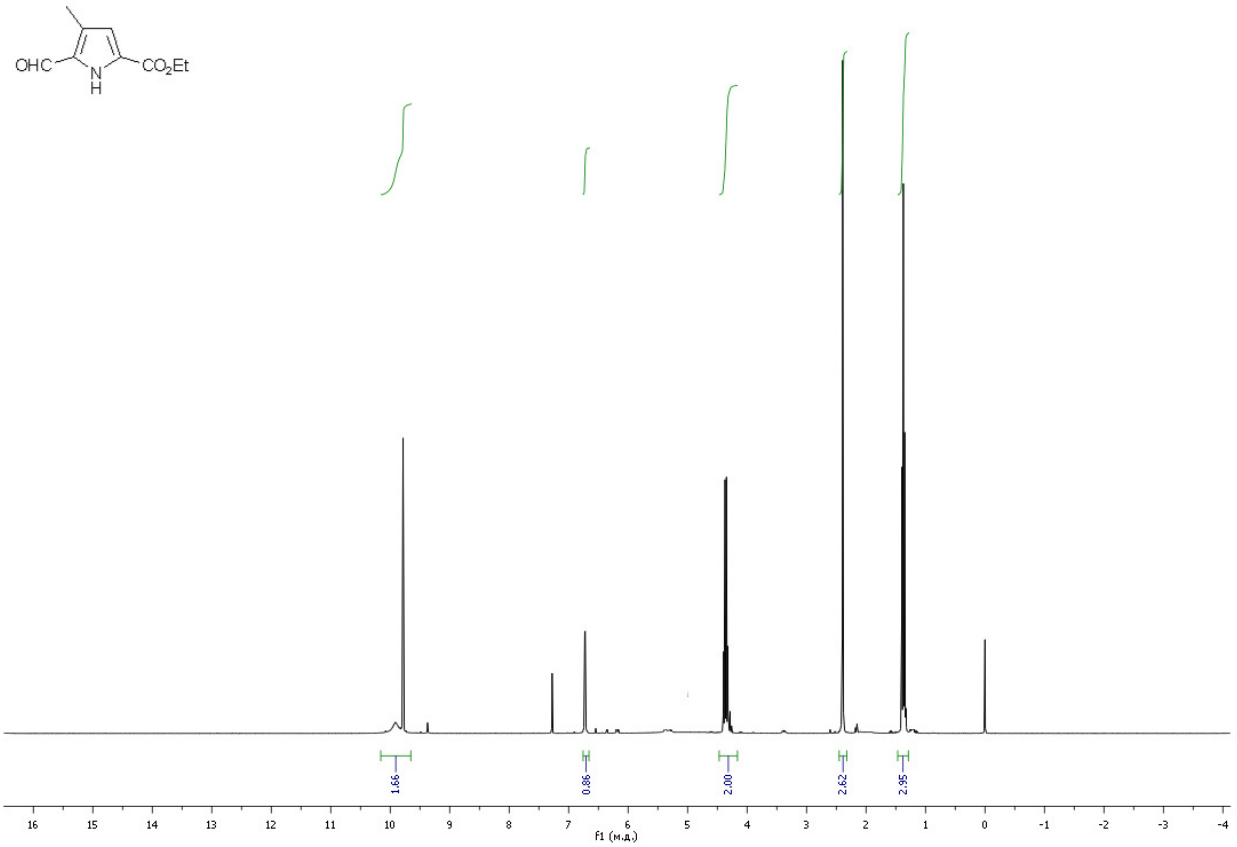
Compound 12b. ^{1}H NMR ($CDCl_3$)



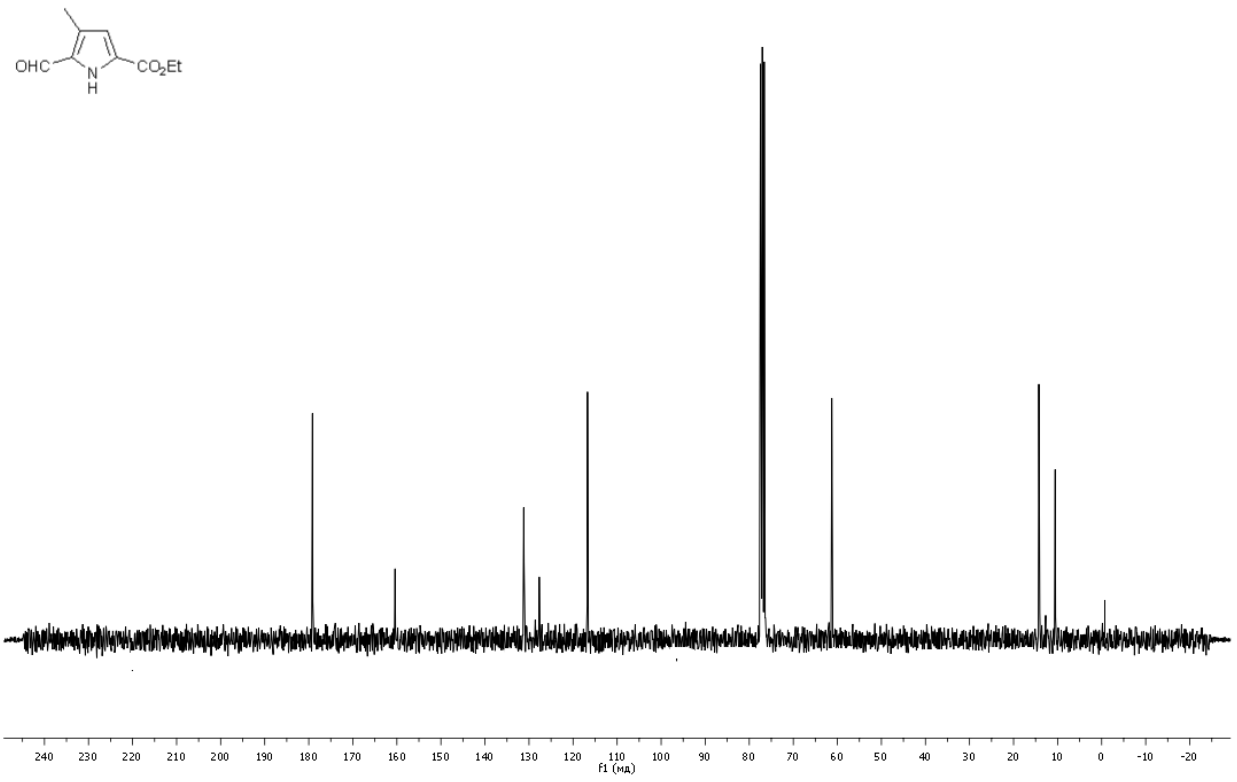
Compound 12b. ^{13}C NMR ($CDCl_3$)



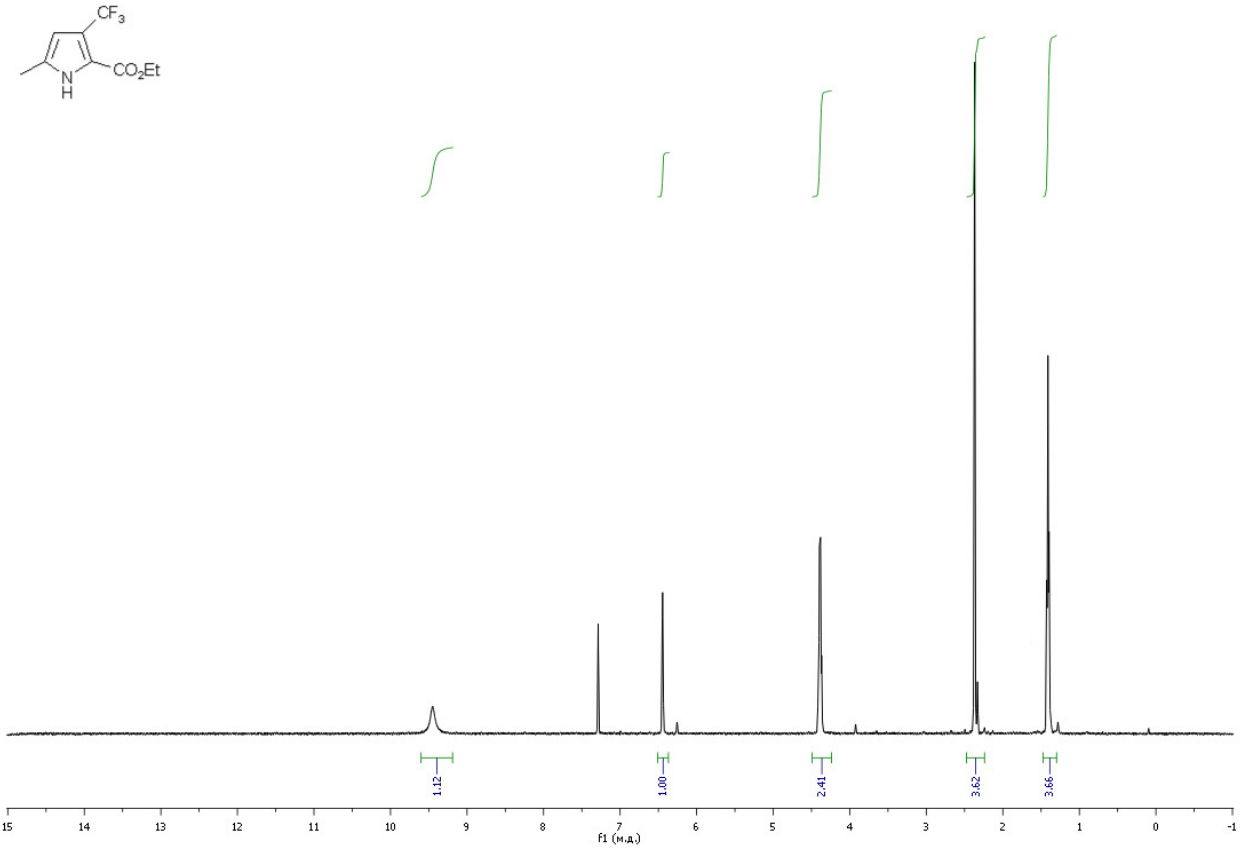
Compound 13. ^{1}H NMR ($CDCl_3$)



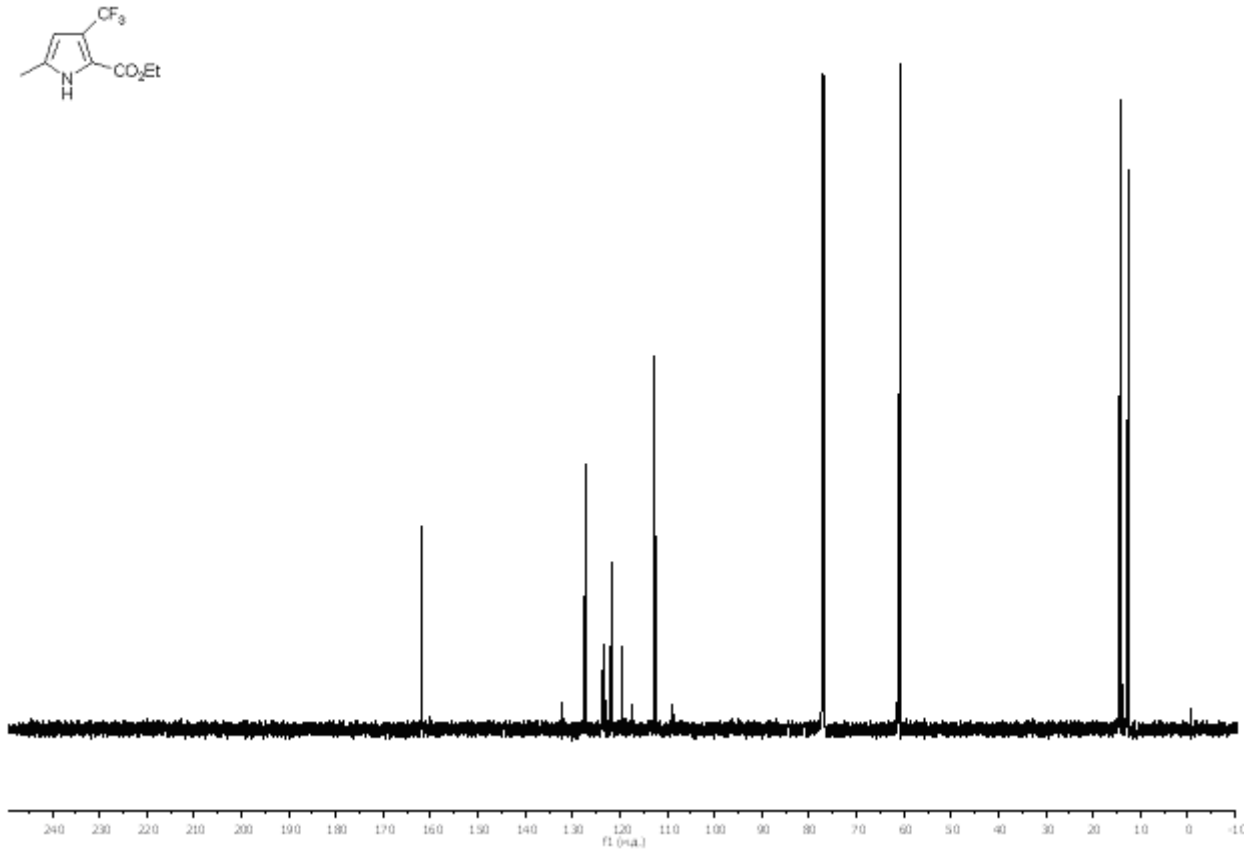
Compound 13. ^{13}C NMR ($CDCl_3$)



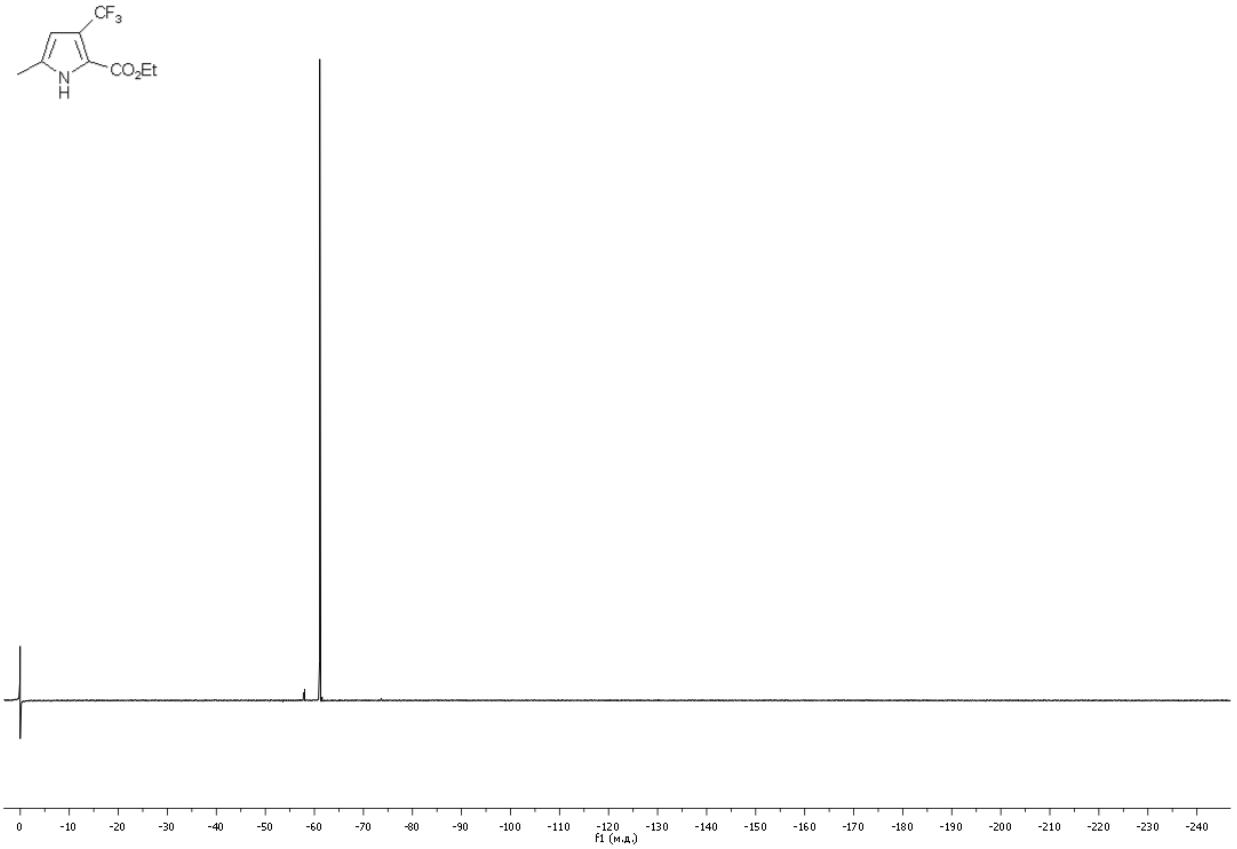
Compound 14. ^{1}H NMR ($CDCl_3$)



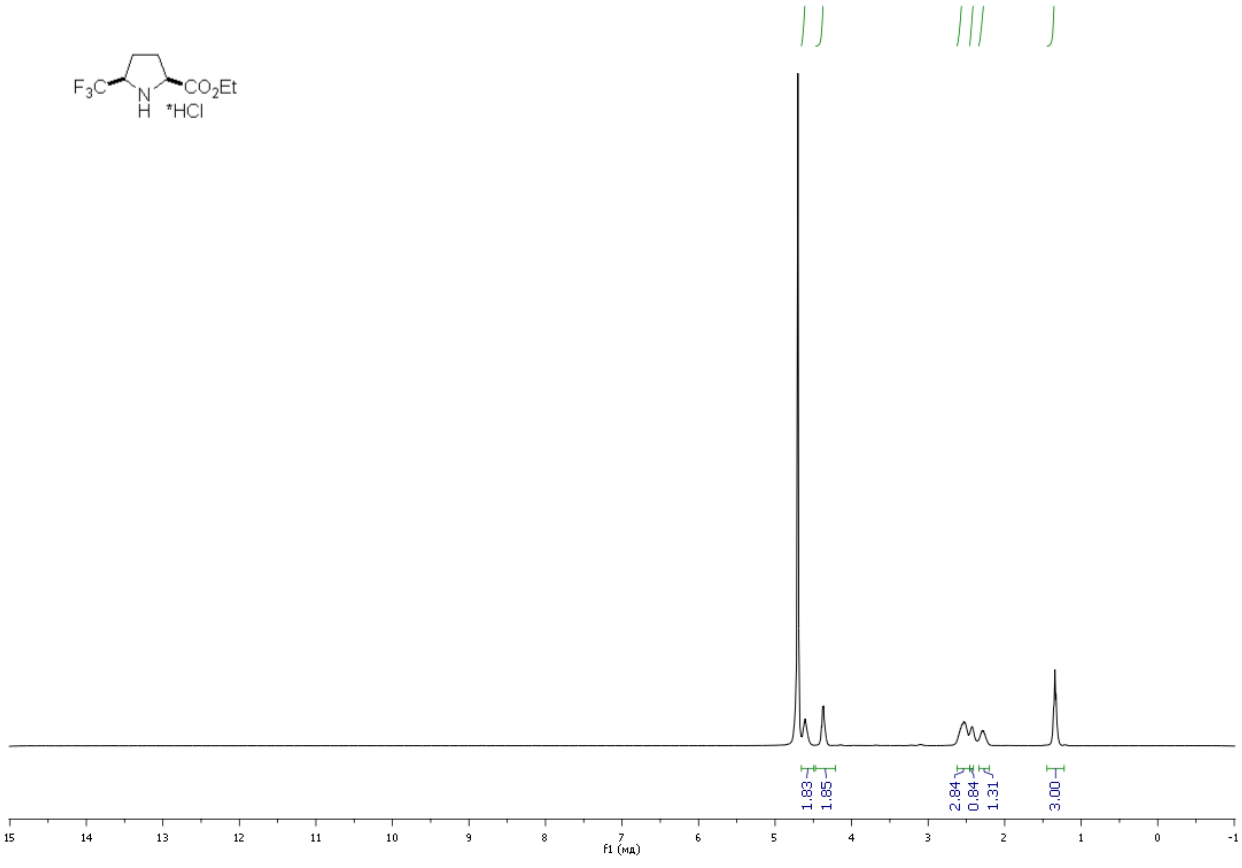
Compound 14. ^{13}C NMR ($CDCl_3$)



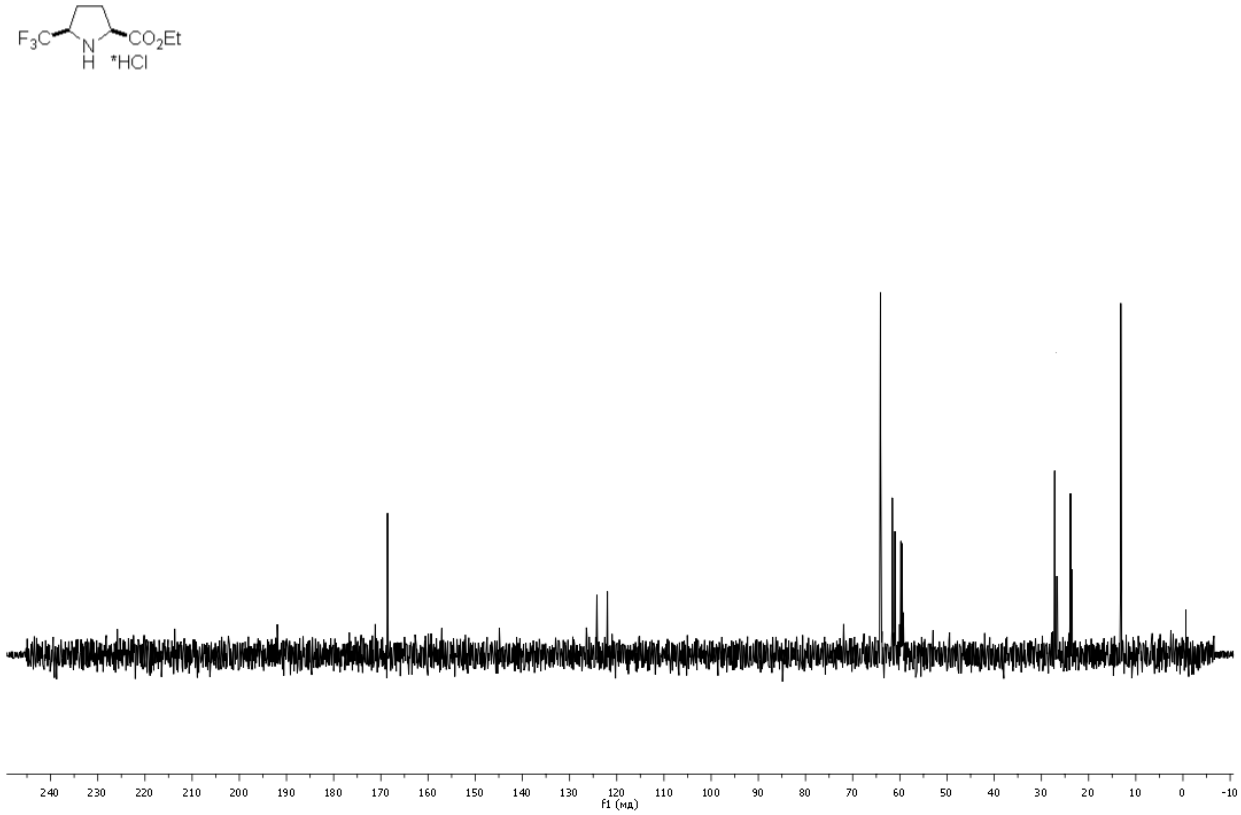
Compound 14. ^{19}F NMR ($CDCl_3$)



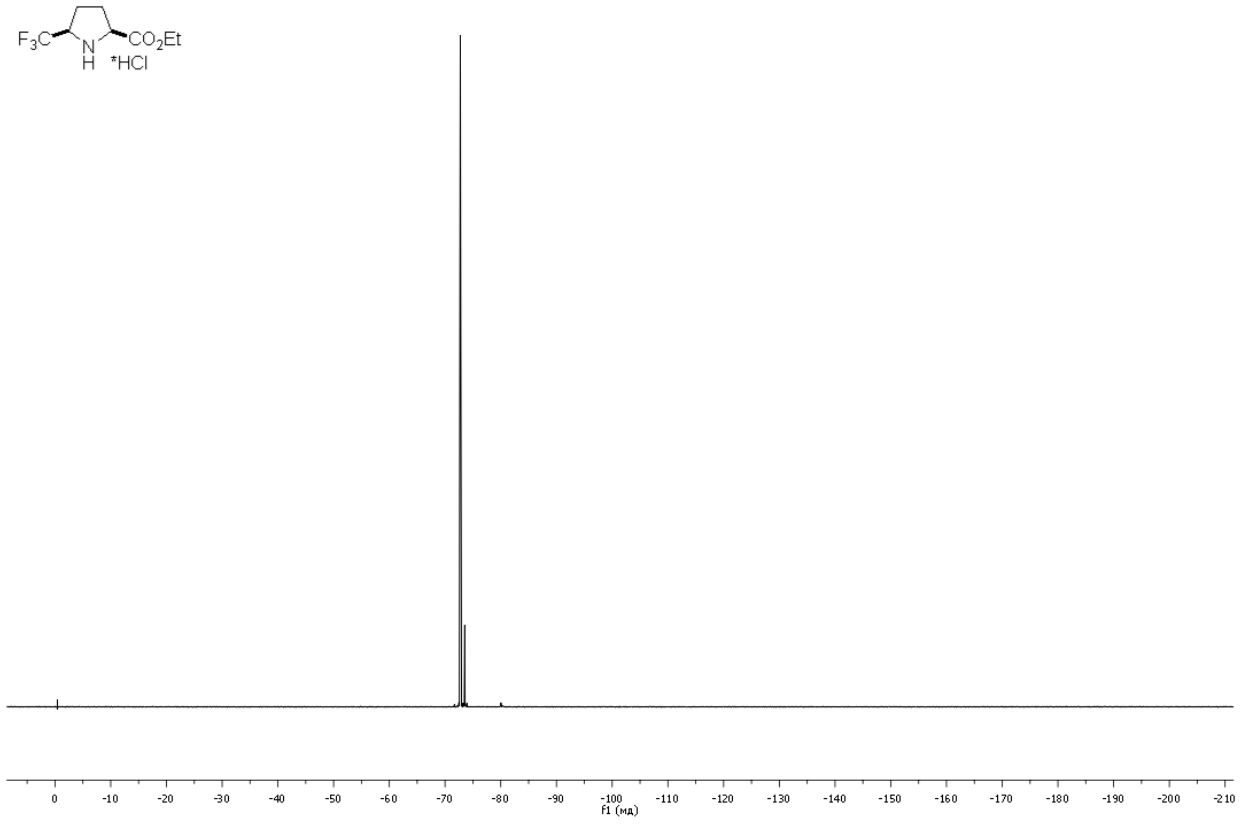
Compound 15. ^{1}H NMR (D_2O)



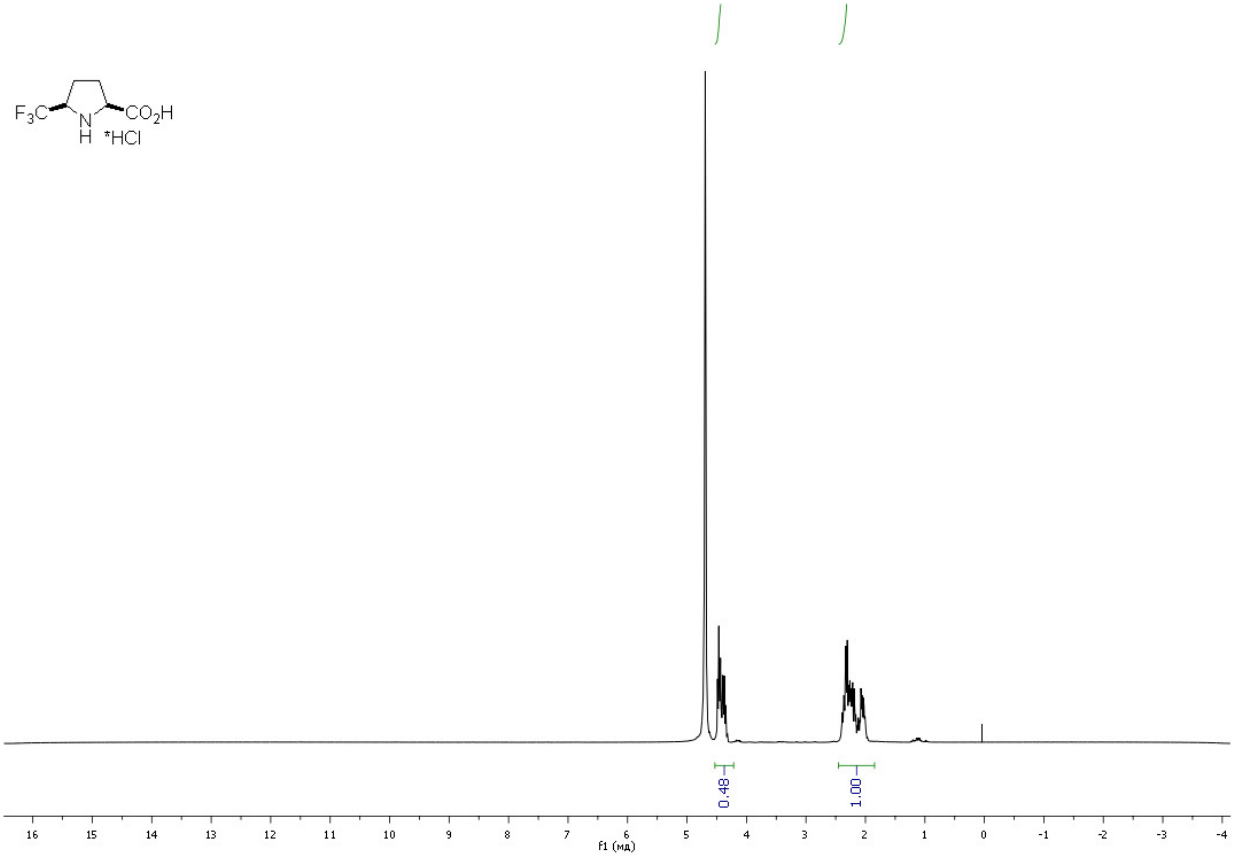
Compound 15. ^{13}C NMR (D_2O)



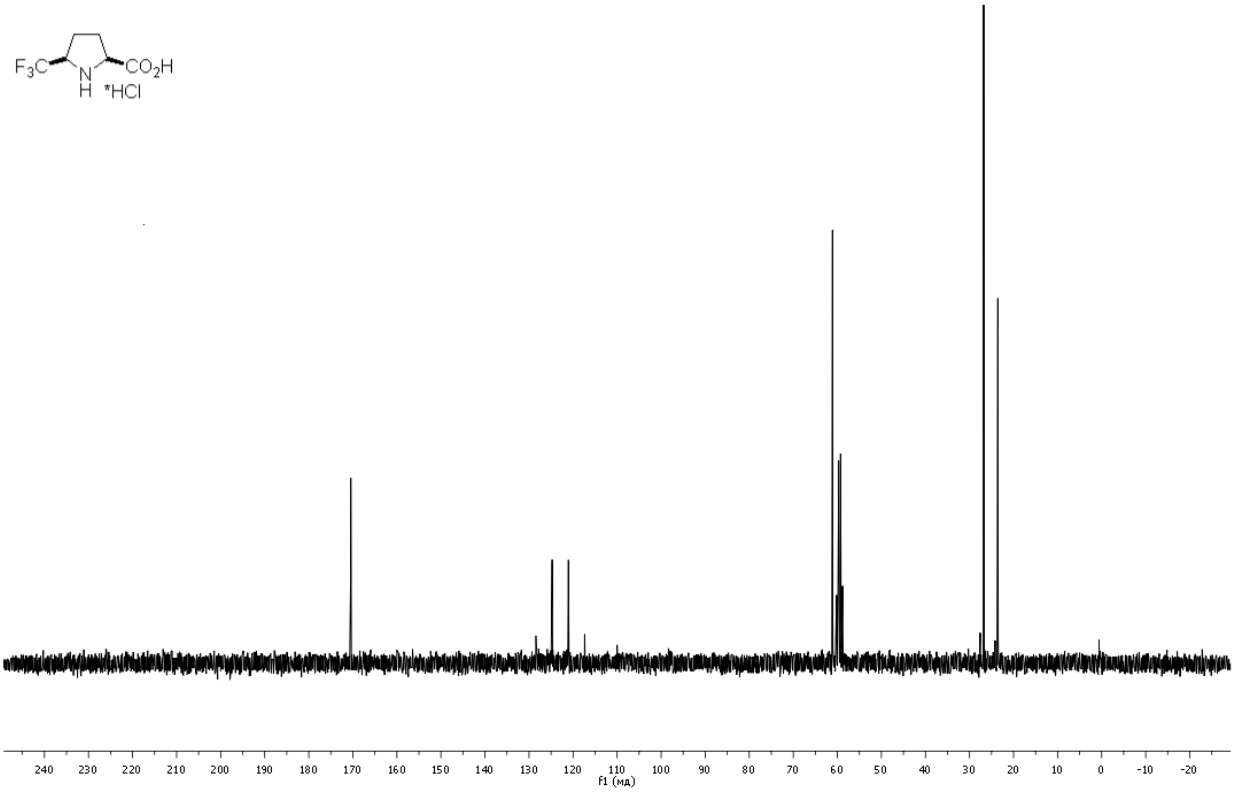
Compound 15. ^{19}F NMR (D_2O)



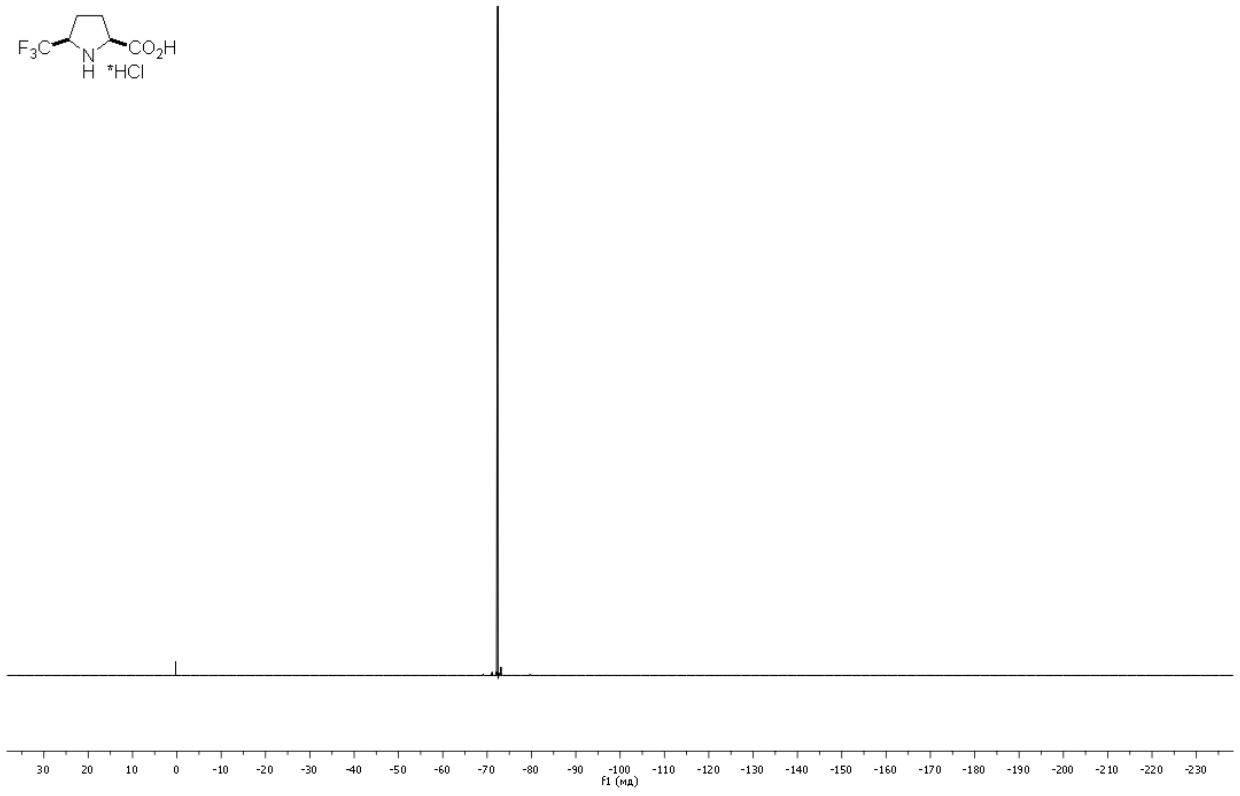
Compound 16. ^{1}H NMR (D_2O)



Compound 16. ^{13}C NMR (D_2O)

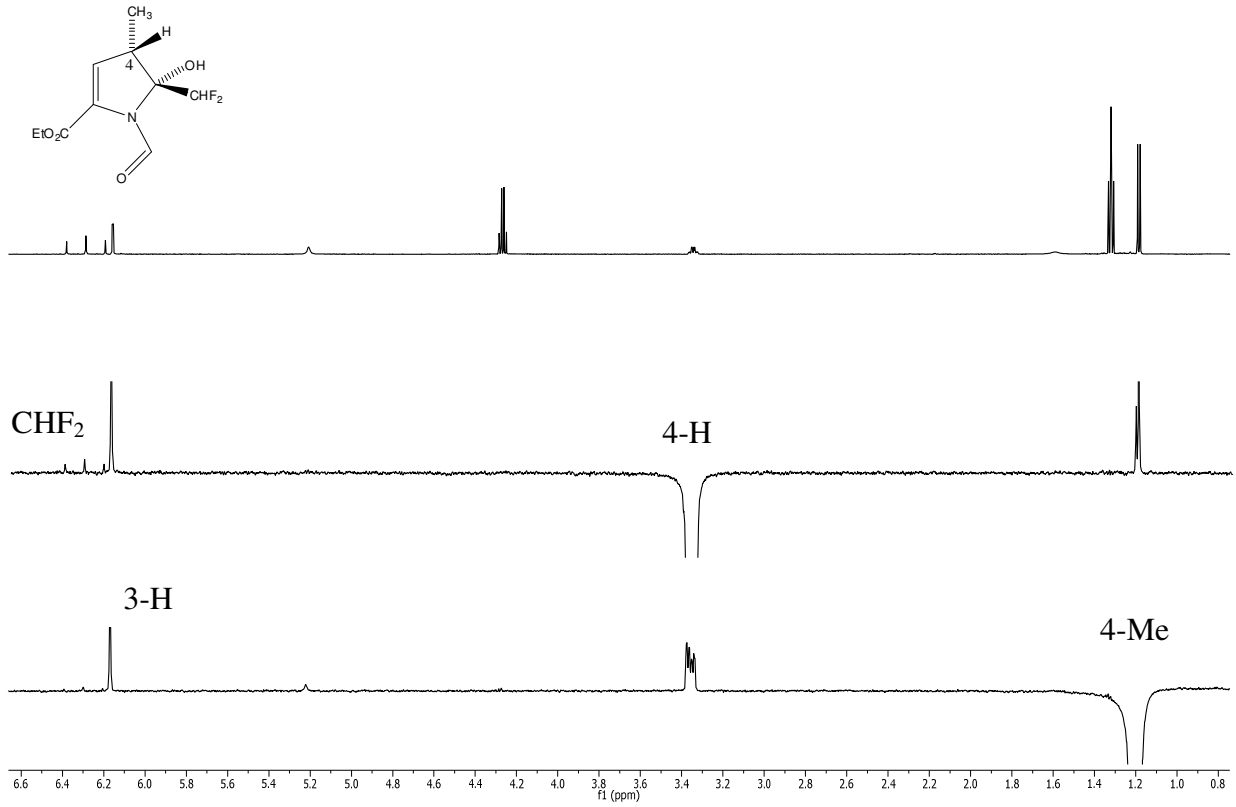


Compound 16. ^{19}F NMR (D_2O)

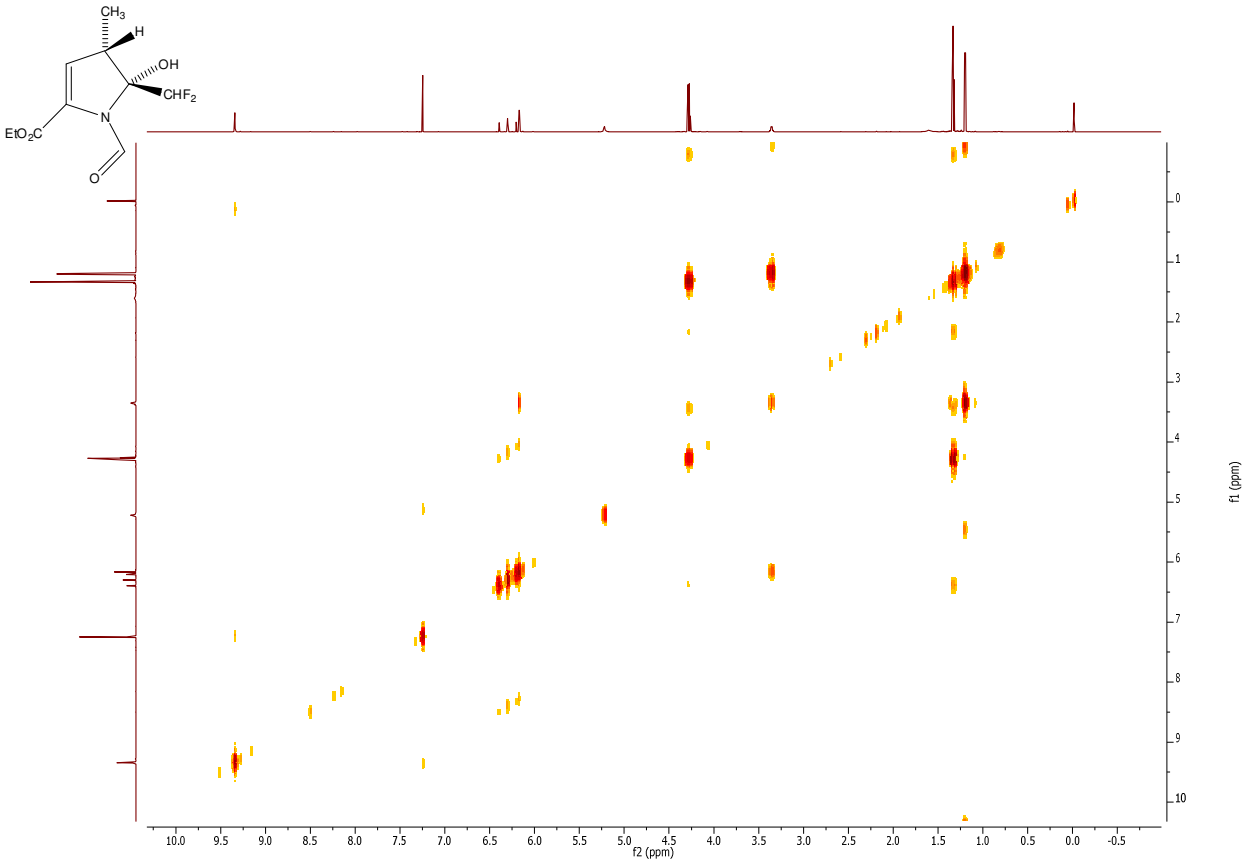


NMR investigations of compound 8g.

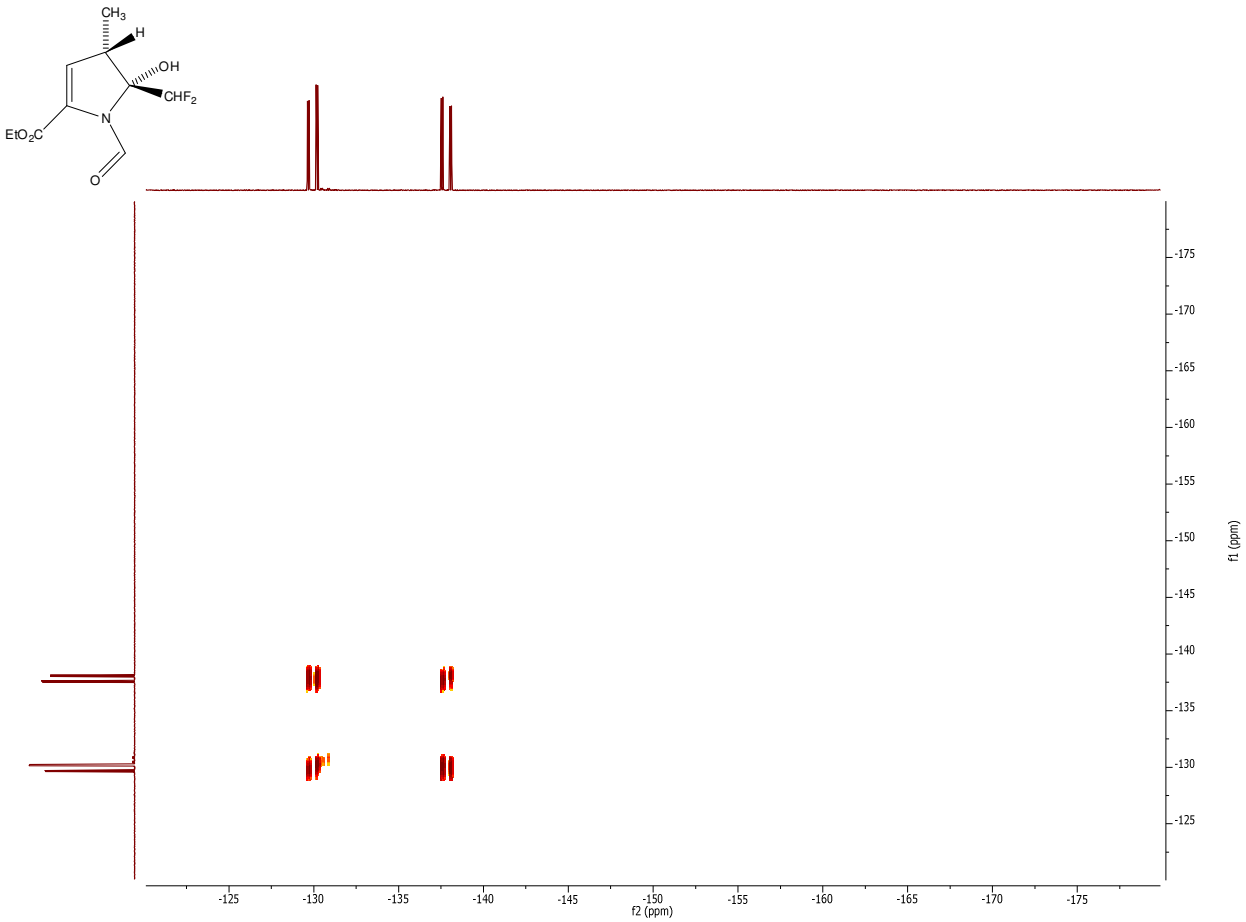
^{1}H-dpfgNOE (4-Me and 4-H are irradiated)



HH-gCOSY



$^{19}F\{^{19}F\}$-gCOSY



$^{1}H\{^{19}F\}$-HOESY