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Electronic Supplementary Information

for

Photoredox-catalyzed difluoroacetylation or fluoroacetylation cascade cyclization of *N*-propargyl aromatic amines: access to 3-difluoroacetylated or 3-fluoroacetylated quinolines

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1. General Information

All reactions were run in a sealed tube with a Teflon lined cap under ambient Ar atmosphere. All commercially available reagent grade chemicals were used as received without further purification. The substrates **1** were prepared according to the literature procedures.[1] The NMR spectra were recorded on a Bruker Avance 400 spectrometers at 400 MHz (^{1}H), 100 MHz (^{13}C) and 376 MHz (^{19}F) in $CDCl_3$ or DMSO-d_6 using TMS as an internal standard. The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, dd = doublet of doublet, t = triplet, dt = doublet of triplet, td = triplet of doublet, q = quartet, m = multiplet, ddd = doublet of doublet of doublet. High-resolution mass spectra (HRMS) were obtained with a Waters Q-TOF mass spectrometer. Column chromatography was performed on silica gel (300-400 mesh). Melting points are uncorrected.

2. General procedure for the synthesis of 3-difluoroacetylated or 3-fluoroacetylated quinolines

An oven-dried Schlenk tube (25 mL) was charged with *N*-(3-aryl-2-propynyl)aniline derivatives (**1,** 0.2 mmol), ethyl bromodifluoroacetate (101.5 mg, 64 μL, 0.5 mmol) or ethyl bromofluoroacetate (92.5 mg, 59 μL, 0.5 mmol), *fac*-Ir(ppy)$_3$ (2.6 mg, 2 mol%), K_2CO_3 (69.1 mg, 0.5 mmol) and CH_3CN (2 mL). The reaction mixture was stirred under Ar atmosphere upon irradiation of 5 W blue LEDs at room temperature for 12 h. Upon completion, the resulting solution was diluted with water (10 mL), extracted with CH_2Cl_2 (15 mL × 3). The combined organic layers were washed with brine (15 mL), dried over anhydrous Na_2SO_4, filtered and concentrated in vacuo. The residue was purified by silica gel chromatography using hexane/ethyl acetate (8:1) as eluent to give the desired products (**3a**–**3y**, **5a**, **5e**, **5g**, **5r**).

Ethyl 2,2-difluoro-2-(4-phenylquinolin-3-yl)acetate (**3a**). Brown solid (56.3 mg, 86% yield); mp 69–71 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.31 (s, 1H), 8.23 (d, *J* = 8.4 Hz, 1H), 7.83–7.80 (m, 1H), 7.55–7.48 (m, 4H), 7.43 (d, *J* = 7.7 Hz, 1H), 7.28–7.26 (m, 2H), 3.99 (q, *J* = 7.2 Hz, 2H), 1.18 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.1 (t, *J* = 33.6 Hz), 148.9, 147.9 (t, *J* = 4.7 Hz) , 146.5 (t, *J* = 9.1 Hz), 133.4, 131.0, 130.1, 129.6, 129.0, 128.0, 127.5, 127.2, 126.9, 123.9 (t, *J* = 23.4 Hz), 113.2 (t, *J* = 251.6 Hz), 63.2, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.8; HRMS (ESI) m/z: calcd for $C_{19}H_{16}F_2NO_2$ $(M+H)^+$ 328.1144, found 328.1146.

Ethyl 2,2-difluoro-2-(6-methyl-4-phenylquinolin-3-yl)acetate (**3b**). Brown solid (55.9 mg, 82% yield); mp 78–80 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.23 (s, 1H), 8.11 (d, *J* = 8.6 Hz, 1H), 7.63 (dd, *J* = 8.6, 1.9 Hz, 1H), 7.56–7.49 (m, 3H), 7.29–7.25 (m, 2H), 7.16 (s, 1H), 3.99 (q, *J* = 7.2 Hz, 2H), 2.41 (s, 3H), 1.17 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.1 (t, *J* = 33.7 Hz), 147.2 (t, *J* = 4.6 Hz), 147.1, 145.5 (t, *J* = 9.2 Hz), 137.6, 133.6, 133.3, 130.1, 129.3, 128.9, 128.0, 127.2, 125.5, 123.9 (t, *J* = 23.2 Hz), 113.2 (t, *J* = 251.5 Hz), 63.1, 21.8, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.8; HRMS (ESI) m/z: calcd for $C_{20}H_{18}F_2NO_2$ $(M+H)^+$ 342.1300, found 342.1300.

Ethyl 2,2-difluoro-2-(8-methyl-4-phenylquinolin-3-yl)acetate (**3c**). Yellow oil (54.6 mg, 80% yield); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.34 (s, 1H), 7.66 (d, *J* = 6.9 Hz, 1H), 7.54–7.48 (m, 3H), 7.39 (dd, *J* = 8.5, 7.0 Hz, 1H), 7.28–7.25 (m, 3H), 4.00 (q, *J* = 7.2 Hz, 2H), 2.91 (s, 3H), 1.18 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) : δ (ppm) 163.1 (t, *J* = 33.7 Hz), 148.0 (t, *J* = 4.5 Hz), 145.2 (t, *J* = 9.1 Hz), 137.4, 133.8, 131.1, 130.1, 128.8, 128.2, 127.9, 127.2, 127.1, 124.9, 123.7 (t, *J* = 23.4 Hz), 113.3 (t, *J* = 251.4 Hz), 63.1, 18.4, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -96.0; HRMS (ESI) m/z: calcd for $C_{20}H_{18}F_2NO_2$ $(M+H)^+$ 342.1300, found 342.1301.

Ethyl 2,2-difluoro-2-(7-methyl-4-phenylquinolin-3-yl)acetate (**3d**) and **ethyl 2,2-difluoro-2-(5-methyl-4-phenylquinolin-3-yl)acetate** (**3d'**). Yellow oil (55.3 mg, 81% yield); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.26–9.24 (m, 1H), 8.10–7.97 (m, 1H), 7.64–7.60 (m, 1H), 7.51–7.46 (m, 1H), 7.43–7.39 (m, 2H), 7.29–7.27 (m, 1H), 7.25–7.22 (m, 2H), 3.99–3.90 (m, 2H), 2.55–1.81 (m, 3H), 1.16–1.12 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.1 (t, *J* = 33.7 Hz), 162.9 (t, *J* = 33.6 Hz), 150.5, 149.2, 148.0 (t, *J* = 4.6 Hz), 147.6 (t, *J* = 4.6 Hz), 146.4 (t, *J* = 9.1 Hz), 145.4 (t, *J* = 10.6 Hz), 141.6, 136.9, 136.2, 133.6, 131.4, 130.7, 130.5, 130.1, 129.7, 129.1, 129.0, 128.9, 128.5, 128.0, 127.6, 126.5, 125.8, 125.3 (t, *J* = 22.9 Hz), 125.2, 123.1 (t, *J* = 23.5 Hz), 113.3 (t, *J* = 251.5 Hz), 113.2 (t, *J* = 250.9 Hz), 63.1, 63.0, 23.9, 21.6, 13.6, 13.5; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.0, -95.7; HRMS (ESI) m/z: calcd for $C_{20}H_{18}F_2NO_2$ $(M+H)^+$ 342.1300, found 342.1300.

Ethyl 2,2-difluoro-2-(6-methoxy-4-phenylquinolin-3-yl)acetate (**3e**). Brown solid (59.3 mg, 83% yield); mp 69–71 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.17 (s, 1H), 8.18 (d, J = 8.9 Hz, 1H), 7.51 (dd, J = 20.1, 5.7 Hz, 4H), 7.28 (d, J = 4.6 Hz, 2H), 6.64 (d, J = 1.6 Hz, 1H), 4.00 (q, J = 7.1 Hz, 2H), 3.69 (s, 3H), 1.18 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.0 (t, J = 33.6 Hz), 158.5, 147.1 (t, J = 4.4 Hz), 144.4, 143.5 (t, J = 8.7 Hz), 133.5, 130.5, 130.0, 129.1, 128.6, 128.2, 124.0, 113.1 (t, J = 251.7 Hz), 104.5, 63.2, 55.4, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -96.0; HRMS (ESI) m/z: calcd for $C_{20}H_{18}F_2NO_3$ $(M+H)^+$ 358.1249, found 358.1249.

Ethyl 2,2-difluoro-2-(4-phenyl-6-(trifluoromethoxy)quinolin-3-yl)acetate (**3f**). Yellow solid (68.2 mg, 83% yield); mp 59–61 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.33 (s, 1H), 8.28 (d, J = 9.2 Hz, 1H), 7.68 (dd, J = 9.2, 1.7 Hz, 1H), 7.58–7.53 (m, 3H), 7.28–7.23 (m, 3H), 4.00 (q, J = 7.2 Hz, 2H), 1.18 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 162.8 (t, J = 33.3 Hz), 147.9 (t, J = 4.7 Hz), 147.6 (q, J = 1.8 Hz), 147.1, 147.0 (t, J = 9.2 Hz), 132.5, 131.9, 129.9, 129.4, 128.4, 128.3, 127.8, 124.9, 121.3 (q, J = 258.4 Hz), 117.3, 112.9 (t, J = 252.1 Hz), 63.3, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -57.9, -96.1; HRMS (ESI) m/z: calcd for $C_{20}H_{15}F_5NO_3$ $(M+H)^+$ 412.0967, found 412.0963.

Ethyl 2,2-difluoro-2-(6-fluoro-4-phenylquinolin-3-yl)acetate (**3g**). Yellow solid (55.2 mg, 80% yield); mp 51–53 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.25 (s, 1H), 8.20 (dd, J = 9.2, 5.4 Hz, 1H), 7.56–7.48 (m, 4H), 7.25–7.23 (m, 2H), 7.01 (dd, J = 9.8, 2.8 Hz, 1H), 3.98 (q, J = 7.2 Hz, 2H), 1.15 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 162.9 (t, J = 33.5 Hz), 162.2, 159.7, 147.3 (dd, J = 10.3, 5.0 Hz), 146.1, 145.8 (td, J = 9.1, 2.8 Hz), 133.0, 132.2 (d, J = 9.2 Hz), 129.9, 129.2, 128.2, 124.6 (t, J = 23.4 Hz), 121.3 (d, J = 26.0 Hz), 113.0 (t, J = 252.0 Hz), 110.2 (d, J = 23.5 Hz), 63.2, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -96.1, -110.5; HRMS (ESI) m/z: calcd for $C_{19}H_{15}F_3NO_2$ $(M+H)^+$ 346.1049, found 346.1050.

Ethyl 2-(6-chloro-4-phenylquinolin-3-yl)-2,2-difluoroacetate (**3h**). Pale yellow solid (44.1 mg, 61% yield); mp 77–79 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.27 (s, 1H), 8.12 (d, J = 9.0 Hz, 1H), 7.69 (dd, J = 9.0, 1.7 Hz, 1H), 7.54–7.49 (m, 3H), 7.37 (d, J = 2.3 Hz, 1H), 7.25–7.23 (m, 2H), 3.97 (q, J = 7.2 Hz, 2H), 1.15 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 162.8 (t, J = 33.4 Hz), 147.3, 147.1 (t, J = 4.7 Hz), 146.7 (t, J = 9.1 Hz), 133.5, 132.7, 131.9, 131.2, 130.0, 129.3, 128.3, 128.0, 125.5, 124.8 (t, J = 23.5 Hz), 113.0 (t, J = 252.0 Hz), 63.3, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -96.1; HRMS (ESI) m/z: calcd for $C_{19}H_{15}ClF_2NO_2$ $(M+H)^+$ 362.0754, found 362.0754.

Ethyl 2,2-difluoro-2-(4-phenyl-6-(trifluoromethyl)quinolin-3-yl)acetate (**3i**). Pale yellow solid (27.7 mg, 35% yield); mp 98–100 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.41 (s, 1H), 8.34 (d, J = 8.8 Hz, 1H), 7.97 (dd, J = 8.8, 1.6 Hz, 1H), 7.74 (s, 1H), 7.61–7.53 (m, 3H), 7.28 (d, J = 6.7 Hz, 2H), 3.99 (q, J = 7.2 Hz, 2H), 1.17 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 162.8 (t, J = 33.3 Hz), 149.8, 148.9 (t, J = 4.7 Hz), 148.6 (t, J = 9.1 Hz), 132.2, 131.0, 130.0, 129.6, 129.3 (q, J = 32.7 Hz), 128.8, 126.6 (dd, J = 5.6, 2.6 Hz), 126.5, 125.3 (t, J = 23.6 Hz), 124.7 (q, J = 4.5 Hz), 123.6 (q, J = 272.6 Hz), 112.8 (t, J = 252.1 Hz), 63.4, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -62.5, -96.1; HRMS (ESI) m/z: calcd for $C_{20}H_{15}F_5NO_2$ $(M+H)^+$ 396.1018, found 396.1016.

Ethyl 2,2-difluoro-2-(4-(*p*-tolyl)quinolin-3-yl)acetate (**3j**). Yellow oil (51.2 mg, 75% yield); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.31 (s, 1H), 8.26 (d, J = 8.4 Hz, 1H), 7.84–7.80 (m, 1H), 7.53–7.47 (m, 2H), 7.33 (d, J = 7.8 Hz, 2H), 7.16 (d, J = 7.9 Hz, 2H), 3.98 (q, J = 7.2 Hz, 2H), 2.49 (s, 3H), 1.17 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.0 (t, J = 33.6 Hz), 148.7 (t, J = 4.5 Hz), 148.4, 146.1 (t, J = 9.2 Hz), 139.0, 131.2, 130.1, 130.0, 129.2, 128.8, 127.6, 127.5, 127.0, 124.2 (t, J = 23.4 Hz), 113.1 (t, J = 251.4 Hz), 63.2, 21.5, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.5; HRMS (ESI) m/z: calcd for $C_{20}H_{18}F_2NO_2$ $(M+H)^+$ 342.1300, found 342.1300.

Ethyl 2,2-difluoro-2-(4-(*m*-tolyl)quinolin-3-yl)acetate (**3k**). Yellow solid (55.9 mg, 82% yield); mp 50–52 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.30 (s, 1H), 8.20 (d, J = 8.4 Hz, 1H), 7.78-7.73 (m, 1H), 7.46–7.45 (m, 2H), 7.38 (t, J = 7.8 Hz, 1H), 7.32 (d, J = 7.5 Hz, 1H), 7.06 (d, J = 5.7 Hz, 2H), 3.97 (q, J = 7.2 Hz, 2H), 2.42 (s, 3H), 1.16 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.0 (t, J = 33.6 Hz), 148.9, 148.1 (t, J = 4.7 Hz), 146.5 (t, J = 9.1 Hz), 137.7, 133.3, 130.9, 130.6, 129.6 (d, J = 17.0 Hz), 127.9, 127.4, 127.2 (d, J = 3.6 Hz), 127.0, 123.9 (t, J = 23.3 Hz), 113.2 (t, J = 251.4 Hz), 63.1, 21.4, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.34 (d, J_{F-F} = 277.5 Hz), -96.31 (d, J_{F-F} = 277.9 Hz); HRMS (ESI) m/z: calcd for $C_{20}H_{18}F_2NO_2$ $(M+H)^+$ 342.1300, found 342.1300.

Ethyl 2,2-difluoro-2-(4-(*o*-tolyl)quinolin-3-yl)acetate (**3l**). Yellow oil (55.3 mg, 81% yield); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.30 (s, 1H), 8.20 (d, J = 8.4 Hz, 1H), 7.74 (ddd, J = 8.4, 6.8, 1.4 Hz, 1H), 7.45–7.37 (m, 2H), 7.32–7.25 (m, 3H), 7.06 (d, J = 7.6 Hz, 1H), 4.03–3.95 (m, 2H), 1.88 (s, 3H), 1.15 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.0 (t, J = 33.6 Hz), 148.9, 147.5 (t, J = 4.7 Hz), 146.9 (t, J = 8.9 Hz), 137.0, 133.1, 131.0, 130.0, 129.8, 129.2, 127.7, 126.4, 125.4, 123.9 (t, J = 23.4 Hz), 113.2 (t, J = 252.2 Hz), 63.2, 19.8, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.2 (d, $J_{F\text{-}F}$ = 275.2 Hz), -100.1 (d, $J_{F\text{-}F}$ = 275.2 Hz); HRMS (ESI) m/z: calcd for $C_{20}H_{18}F_2NO_2$ $(M+H)^+$ 342.1300, found 342.1301.

Ethyl 2,2-difluoro-2-(4-(4-methoxyphenyl)quinolin-3-yl)acetate (**3m**). Yellow solid (61.4 mg, 86% yield); mp 57-59 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.29 (s, 1H), 8.21 (d, J = 8.4 Hz, 1H), 7.79 (dt, J = 8.4, 4.1 Hz, 1H), 7.49 (d, J = 3.7 Hz, 2H), 7.19 (d, J = 8.7 Hz, 2H), 7.05–7.01 (m, 2H), 3.99 (q, J = 7.2 Hz, 2H), 3.91 (s, 3H), 1.17 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.1 (t, J = 33.5 Hz), 160.1, 149.0, 148.0 (t, J = 4.8 Hz), 146.5 (t, J = 9.1 Hz), 131.5, 130.9, 129.5, 127.6, 127.4, 126.9, 125.2, 124.4 (t, J = 23.2 Hz), 115.7, 113.2 (t, J = 251.0 Hz), 63.1, 55.3, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.5; HRMS (ESI) m/z: calcd for $C_{20}H_{18}F_2NO_3$ $(M+H)^+$ 358.1249, found 358.1249.

Ethyl 2-(4-(4-chlorophenyl)quinolin-3-yl)-2,2-difluoroacetate (**3n**). Yellow solid (46.2 mg, 64% yield); mp 69–71 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.27 (s, 1H), 8.21 (d, J = 8.4 Hz, 1H), 7.81–7.77 (m, 1H), 7.52-7.47 (m, 3H), 7.39 (dd, J = 8.5, 0.8 Hz, 1H), 7.21 (d, J = 8.4 Hz, 2H), 4.04 (q, J = 7.2 Hz, 2H), 1.19 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100MHz, $CDCl_3$): δ (ppm) 163.1 (t, J = 33.6 Hz), 148.9, 146.6 (t, J = 4.4 Hz), 146.5 (t, J = 9.0 Hz), 135.2, 131.9, 131.4, 131.1, 129.7, 128.4, 127.7, 127.0, 126.5, 124.0 (t, J = 23.4 Hz), 113.1 (t, J = 252.4 Hz), 63.4, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -96.1; HRMS (ESI) m/z: calcd for $C_{19}H_{15}ClF_2NO_2$ $(M+H)^+$ 362.0754, found 362.0754.

Ethyl 2-(4-(4-cyanophenyl)quinolin-3-yl)-2,2-difluoroacetate (**3o**). Brown solid (49.3 mg, 70% yield); mp 138–140 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.25 (s, 1H), 8.24 (d, J = 8.4 Hz, 1H), 7.87–7.82 (m, 3H), 7.54 (t, J = 7.7 Hz, 1H), 7.42 (d, J = 8.1 Hz, 2H), 7.28 (d, J = 8.1 Hz, 1H), 4.11 (q, J = 7.1 Hz, 2H), 1.23 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.0 (t, J = 33.9 Hz), 148.9, 146.6 (t, J = 8.6 Hz), 145.6 (t, J = 4.0 Hz), 138.8, 131.8, 131.4, 130.7, 129.9, 128.1, 126.3, 126.2, 123.5 (t, J = 23.5 Hz), 118.3, 113.0 (t, J = 253.4 Hz), 113.0, 63.6, 13.8; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -96.5; HRMS (ESI) m/z: calcd for $C_{20}H_{15}F_2N_2O_2$ $(M+H)^+$ 353.1096, found 353.1097.

Ethyl 2-(4-(4-acetylphenyl)quinolin-3-yl)-2,2-difluoroacetate (**3p**). Brown solid (58.3 mg, 79% yield); mp 74–76 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.28 (s, 1H), 8.25 (d, J = 8.4 Hz, 1H), 8.11 (d, J = 8.4 Hz, 2H), 7.86–7.81 (m, 1H), 7.54–7.50 (m, 1H), 7.40 (d, J = 8.2 Hz, 2H), 7.34 (d, J = 7.9 Hz, 1H), 4.06 (q, J = 7.2 Hz, 2H), 2.72 (s, 3H), 1.19 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 197.5, 163.0 (t, J = 33.9 Hz), 148.7, 146.8 (t, J = 4.1 Hz), 146.5 (t, J = 8.8 Hz), 138.6, 137.2, 131.3, 130.3, 129.6, 127.9 (d, J = 7.8 Hz), 126.7, 126.5, 123.6 (t, J = 23.5 Hz), 115.6, 113.0 (t, J = 252.6 Hz), 63.5, 26.8, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -96.4; HRMS (ESI) m/z: calcd for $C_{21}H_{18}F_2NO_3$ $(M+H)^+$ 370.1249, found 370.1249.

Ethyl 4-(3-(2-ethoxy-1,1-difluoro-2-oxoethyl)quinolin-4-yl)benzoate (**3q**). Yellow oil (63.9 mg, 80% yield); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.28 (s, 1H), 8.25–8.18 (m, 3H), 7.82 (ddd, J = 8.3, 6.9, 1.3 Hz, 1H), 7.50 (ddd, J = 8.2, 6.9, 1.1 Hz, 1H), 7.35 (t, J = 9.0 Hz, 3H), 4.45 (q, J = 7.1 Hz, 2H), 4.06 (q, J = 7.2 Hz, 2H), 1.45 (t, J = 7.1 Hz, 3H), 1.19 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 166.0, 163.0 (t, J = 33.8 Hz), 148.8, 146.9 (t, J = 4.3 Hz), 146.5 (t, J = 8.8 Hz), 138.3, 131.2, 131.0, 130.0, 129.7, 129.2, 127.8, 126.7, 126.5, 123.7 (t, J = 23.4 Hz), 113.1 (t, J = 252.6 Hz), 63.4, 61.3, 14.4, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -96.3; HRMS (ESI) m/z: calcd for $C_{22}H_{20}F_2NO_4$ $(M+H)^+$ 400.1355, found 400.1355.

Ethyl 2-(4-([1,1'-biphenyl]-4-yl)quinolin-3-yl)-2,2-difluoroacetate (**3r**). Yellow solid (66.9 mg, 83% yield); mp 99–101 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.35 (s, 1H), 8.28 (d, J = 8.2 Hz, 1H), 7.84 (dd, J = 7.8, 3.8 Hz, 1H), 7.78–7.72 (m, 4H), 7.54 (dd, J = 9.8, 5.7 Hz, 4H), 7.44 (t, J = 7.3 Hz, 1H), 7.37 (d, J = 7.9 Hz, 2H), 4.00 (q, J = 7.1 Hz, 2H), 1.16 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.2 (t, J = 33.4 Hz), 148.8, 148.0 (t, J = 4.3 Hz), 146.4 (td, J = 8.7, 2.0 Hz), 141.8, 140.1, 132.2, 131.2, 130.7, 129.5, 129.0, 127.9, 127.6, 127.3, 127.2, 126.9, 126.7, 124.1 (t, J = 25.0 Hz), 113.2 (t, J = 251.9 Hz), 63.3, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.6; HRMS (ESI) m/z: calcd for $C_{25}H_{20}F_2NO_2$ $(M+H)^+$ 404.1457, found 404.1456.

Ethyl 2-(4-(4-(9*H*-fluoren-2-yl)phenyl)quinolin-3-yl)-2,2-difluoroacetate (**3s**). Yellow solid (71.4 mg, 86% yield); mp 88–90 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.36 (s, 1H), 8.27 (d, *J* = 8.4 Hz, 1H), 7.91 (dd, *J* = 14.1, 7.6 Hz, 2H), 7.82 (ddd, *J* = 8.4, 6.5, 1.7 Hz, 1H), 7.62 (d, *J* = 7.4 Hz, 1H), 7.56–7.50 (m, 2H), 7.48–7.44 (m, 2H), 7.40 (td, *J* = 7.4, 1.2 Hz, 1H), 7.30 (d, *J* = 8.7 Hz, 1H), 4.01 (s, 2H), 3.98–3.92 (m, 2H), 1.10 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.1 (t, *J* = 33.6 Hz), 149.0, 148.4 (t, *J* = 4.7 Hz), 146.6 (t, *J* = 9.0 Hz), 143.5, 142.9, 142.5, 140.9, 131.6, 131.0, 129.6, 128.9, 127.5, 127.4, 127.1, 127.0, 126.9, 125.2, 124.2 (t, *J* = 23.4 Hz), 120.3, 119.4, 113.3 (t, *J* = 251.4 Hz), 63.2, 37.0, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.0 (d, $J_{F\text{-}F}$ = 277.5 Hz), -96.0 (d, $J_{F\text{-}F}$ = 277.5 Hz); HRMS (ESI) m/z: calcd for $C_{26}H_{20}F_2NO_2$ $(M+H)^+$ 416.1457, found 416.1458.

Ethyl 2,2-difluoro-2-(4-(thiophen-2-yl)quinolin-3-yl)acetate (**3t**). Yellow solid (60.6 mg, 91% yield); mp 57–59 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.31 (s, 1H), 8.22 (d, *J* = 8.6 Hz, 1H), 7.80 (ddd, *J* = 8.3, 6.8, 1.4 Hz, 1H), 7.69 (dd, *J* = 8.6, 1.3 Hz, 1H), 7.63 (dd, *J* = 5.1, 1.2 Hz, 1H), 7.54 (ddd, *J* = 8.3, 6.9, 1.2 Hz, 1H), 7.21 (dd, *J* = 5.1, 3.5 Hz, 1H), 7.15 (d, *J* = 3.1 Hz, 1H), 4.08 (q, *J* = 7.2 Hz, 2H), 1.20 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 162.7 (t, *J* = 33.5 Hz), 148.6, 146.1 (t, *J* = 9.4 Hz), 141.4 (t, *J* = 4.7 Hz), 132.1, 131.5, 131.3, 129.4, 128.8, 128.1, 127.9, 127.1, 126.6, 125.8 (t, *J* = 23.4 Hz), 112.9 (t, *J* = 251.1 Hz), 63.4, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -91.7 ,-92.5, -99.0, -99.7; HRMS (ESI) m/z: calcd for $C_{17}H_{14}F_2NO_2S$ $(M+H)^+$ 334.0708, found 334.0708.

Ethyl 2,2-difluoro-2-(6-methyl-4-(*p*-tolyl)quinolin-3-yl)acetate (**3v**). Yellow solid (56.8 mg, 80% yield); mp 48–50 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.23 (s, 1H), 8.13 (d, *J* = 8.6 Hz, 1H), 7.64 (dd, *J* = 8.6, 1.8 Hz, 1H), 7.33 (d, *J* = 7.8 Hz, 2H), 7.20 (s, 1H), 7.14 (d, *J* = 7.9 Hz, 2H), 3.99 (q, *J* = 7.2 Hz, 2H), 2.50 (s, 3H), 2.43 (s, 3H), 1.17 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.1 (t, *J* = 33.7 Hz), 147.7 (t, *J* = 4.7 Hz), 147.3, 145.4 (t, *J* = 9.2 Hz), 138.8, 137.6, 133.3, 130.4, 130.0, 129.1, 128.7, 127.4, 125.6, 124.1 (t, *J* = 23.3 Hz), 113.2 (t, *J* = 251.3 Hz), 63.1, 21.8, 21.5, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.8; HRMS (ESI) m/z: calcd for $C_{21}H_{20}F_2NO_2$ $(M+H)^+$ 356.1457, found 356.1457.

Ethyl 2-(4-(4-cyanophenyl)-6-methylquinolin-3-yl)-2,2-difluoroacetate (**3w**). Yellow solid (52.0 mg, 71% yield); mp 108–110 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.19 (s, 1H), 8.15 (d, *J* = 8.6 Hz, 1H), 7.85–7.82 (m, 2H), 7.68 (dd, *J* = 8.6, 1.7 Hz, 1H), 7.41 (d, *J* = 8.2 Hz, 2H), 6.99 (s, 1H), 4.13 (q, *J* = 7.1 Hz, 2H), 2.44 (s, 3H), 1.25 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.1 (t, *J* = 34.0 Hz), 147.5, 145.7 (t, *J* = 8.6 Hz), 144.8 (t, *J* = 3.9 Hz), 139.0, 138.4, 133.7, 131.8, 130.7, 129.5, 126.3, 124.8, 123.5 (t, *J* = 23.4 Hz), 118.3, 113.1 (t, *J* = 253.4 Hz), 110.6, 63.5, 21.9, 13.8; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -96.4; HRMS (ESI) m/z: calcd for $C_{21}H_{17}F_2N_2O_2$ $(M+H)^+$ 367.1253, found 367.1252.

Ethyl 2-(6-chloro-4-(4-methoxyphenyl)quinolin-3-yl)-2,2-difluoroacetate (**3x**). Yellow oil (43.8 mg, 56% yield); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.28 (s, 1H), 8.16 (d, *J* = 9.0 Hz, 1H), 7.73 (dd, *J* = 9.0, 2.3 Hz, 1H), 7.44 (d, *J* = 2.3 Hz, 1H), 7.18 (d, *J* = 8.7 Hz, 2H), 7.07–7.04 (m, 2H), 4.00 (q, *J* = 7.2 Hz, 2H), 3.93 (s, 3H), 1.18 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 162.9 (t, *J* = 33.4 Hz), 160.3, 147.4, 147.3 (t, *J* = 4.8 Hz), 146.7 (t, *J* = 9.2 Hz), 133.5, 131.9, 131.5, 131.2, 128.5, 125.6, 125.2 (t, *J* = 23.4 Hz), 124.5, 115.5, 113.0 (t, *J* = 252.7 Hz), 63.2, 55.4, 13.6; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.7; HRMS (ESI) m/z: calcd for $C_{20}H_{17}ClF_2NO_3$ $(M+H)^+$ 392.0860, found 392.0860.

Ethyl 2-(4-([1,1'-biphenyl]-4-yl)-6-chloroquinolin-3-yl)-2,2-difluoroacetate (**3y**). Pale yellow solid (79.6 mg, 91% yield); mp 90–92 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.33 (s, 1H), 8.19 (d, *J* = 9.0 Hz, 1H), 7.79–7.72 (m, 5H), 7.54–7.50 (m, 3H), 7.43 (t, *J* = 7.3 Hz, 1H), 7.35 (d, *J* = 8.1 Hz, 2H), 4.01 (q, *J* = 7.1 Hz, 2H), 1.16 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.0 (t, *J* = 33.3 Hz), 147.4, 147.0 (t, *J* = 4.6 Hz), 146.8 (t, *J* = 9.0 Hz), 142.1, 140.0, 133.7, 132.0, 131.6, 131.3, 130.6, 129.0, 128.1, 128.0, 127.2, 126.8, 125.6, 125.0 (t, *J* = 23.4 Hz), 113.1 (t, *J* = 252.4 Hz), 63.4, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -95.8; HRMS (ESI) m/z: calcd for $C_{25}H_{19}ClF_2NO_2$ $(M+H)^+$ 438.1067, found 438.1067.

Ethyl 2-fluoro-2-(4-phenylquinolin-3-yl)acetate (**5a**). Yellow oil (30.9 mg, 50% yield); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.08 (s, 1H), 8.20 (d, *J* = 8.4 Hz, 1H), 7.76 (ddd, *J* = 8.2, 6.3, 1.5 Hz, 1H), 7.58–7.47 (m, 5H), 7.45-7.42 (m, 1H), 7.38–7.35 (m, 1H), 5.79 (d, *J* = 46.8 Hz, 1H), 4.29–4.16 (m, 2H), 1.25 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 168.2 (d, *J* = 27.9 Hz), 148.8 (d, *J* = 4.9 Hz), 148.3 (d, *J* = 3.9 Hz), 134.1, 130.5, 130.4, 129.6, 129.4, 129.0, 128.5 (d, *J* = 7.4 Hz), 127.3, 127.1, 125.1 (d, *J* = 19.8 Hz), 85.8 (d, *J* = 184.2 Hz), 62.2, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm)

-173.4; HRMS (ESI) m/z: calcd for $C_{19}H_{17}FNO_2$ $(M+H)^+$ 310.1238, found 310.1238.

Ethyl 2-fluoro-2-(6-methoxy-4-phenylquinolin-3-yl)acetate (**5e**). Yellow solid (41.4 mg, 61% yield); mp 108–110 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.92 (s, 1H), 8.09 (d, J = 9.2 Hz, 1H), 7.60–7.54 (m, 3H), 7.45–7.36 (m, 2H), 7.37 (dt, J = 5.4, 2.1 Hz, 1H), 6.75 (d, J = 2.8 Hz, 1H), 5.75 (d, J = 46.8 Hz, 1H), 4.27–4.18 (m, 2H), 3.71 (s, 3H), 1.25 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 168.3 (d, J = 27.9 Hz), 158.3, 147.3 (d, J = 5.0 Hz), 146.3 (d, J = 4.0 Hz), 144.5 (d, J = 2.1 Hz), 134.4, 131.0, 130.3, 129.3, 128.9, 128.7 (d, J = 6.4 Hz), 125.3 (d, J = 19.7 Hz), 122.7, 105.0, 85.9 (d, J = 184.2 Hz), 62.1, 55.4, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -173.3; HRMS (ESI) m/z: calcd for $C_{20}H_{19}FNO_3$ $(M+H)^+$ 340.1344, found 340.1343.

Ethyl 2-fluoro-2-(6-fluoro-4-phenylquinolin-3-yl)acetate (**5g**). Yellow solid (36.0 mg, 55% yield); mp 78–80 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.04 (s, 1H), 8.19 (dd, J = 9.2, 5.5 Hz, 1H), 7.59–7.51 (m, 4H), 7.44–7.41 (m, 1H), 7.36–7.34 (m, 1H), 7.13 (dd, J = 9.9, 2.8 Hz, 1H), 5.78 (d, J = 46.7 Hz, 1H), 4.28–4.19 (m, 2H), 1.26 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 168.1 (d, J = 27.7 Hz), 162.1, 159.7, 148.1 (dd, J = 3.8, 2.9 Hz), 145.5, 133.6, 132.2 (d, J = 8.6 Hz), 130.3, 129.2 (d, J = 4.3 Hz), 128.8 (d, J = 7.5 Hz), 128.1 (d, J = 9.6 Hz), 125.7 (d, J = 19.8 Hz), 120.6 (d, J = 26.1 Hz), 110.5 (dd, J = 23.3, 0.7 Hz), 85.7 (d, J = 184.5 Hz), 62.3, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -111.0, -111.1, -174.0, -174.1; HRMS (ESI) m/z: calcd for $C_{19}H_{16}F_2NO_2$ $(M+H)^+$ 328.1144, found 328.1143.

Ethyl 2-(4-([1,1'-biphenyl]-4-yl)quinolin-3-yl)-2-fluoroacetate (**5r**). Pale yellow solid (53.9 mg, 70% yield); mp 79–81 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 9.13 (s, 1H), 8.24 (d, J = 8.3 Hz, 1H), 7.83–7.77 (m, 3H), 7.74–7.72 (m, 2H), 7.65 (d, J = 8.0 Hz, 1H), 7.56–7.50 (m, 4H), 7.47–7.41 (m, 2H), 5.90 (d, J = 46.8 Hz, 1H), 4.30–4.22 (m, 2H), 1.28 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 168.3 (d, J = 27.8 Hz), 148.9 (d, J = 3.9 Hz), 148.5 (d, J = 5.0 Hz), 148.4, 141.8, 140.2, 133.0, 131.0, 130.5, 130.0, 129.7, 129.0, 127.9, 127.4, 127.3, 127.2, 127.1, 125.1 (d, J = 19.8 Hz), 85.9 (d, J = 184.4 Hz), 62.2, 14.1; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -173.0; HRMS (ESI) m/z: calcd for $C_{25}H_{21}FNO_2$ $(M+H)^+$ 386.1551, found 386.1551.

3. The reduction of 3a

To a stirred solution of **3a** (65.4 mg, 0.2 mmol) in MeOH (2.0 mL) was added $NaBH_4$ (22.7 mg, 0.6 mmol) under argon at room temperature. When the reaction was completed (monitored by TLC), the reaction mixture was quenched with water (10 mL). The aqueous layer was extracted with ethyl acetate (3 × 15 mL). The combined organic layer was dried over anhydrous Na_2SO_4 and then concentrated in vacuo. The crude residue was purified by flash column chromatography on silica gel (hexane/EtOAc = 8:1) to afford the product **6**.

2,2-Difluoro-2-(4-phenylquinolin-3-yl)ethan-1-ol (**6**). Pale yellow solid (51.9 mg, 91% yield); mp 150–151 °C; ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm) 9.13 (s, 1H), 8.16 (d, J = 8.3 Hz, 1H), 7.84–7.80 (m, 1H), 7.55–7.51 (m, 4H), 7.36 (dd, J = 6.3, 2.7 Hz, 2H), 7.25 (d, J = 8.3 Hz, 1H), 5.72 (s, 1H), 3.79–3.72 (m, 2H); ^{13}C NMR (100 MHz, DMSO-d_6): δ (ppm) 148.4 (t, J = 8.5 Hz), 148.3, 147.2 (t, J = 3.4 Hz), 135.5, 131.1, 129.6, 129.5, 128.7, 128.3, 127.9, 127.6, 127.0, 125.4 (t, J = 23.4 Hz), 122.2 (t, J = 246.0 Hz), 64.7 (t, J = 31.3 Hz); ^{19}F NMR (376 MHz, DMSO-d_6): δ (ppm) -97.3; HRMS (ESI) m/z: calcd for $C_{17}H_{14}F_2NO$ $(M+H)^+$ 286.1038, found 286.1038.

4. The hydrolysis of 3a

To a solution of **3a** (65.4 mg, 0.2 mmol) in EtOH (4.0 mL) was added NaOH aq. (160.0 mg, 4.0 mmol in 4 mL of H_2O) at room temperature and stirred at room temperature for 3 h. Then the reaction mixture was diluted with water (20 mL), washed with CH_2Cl_2 (15 mL × 3). The aqueous solution was acidified to pH 1 with HCl aq. (2 M). The suspension was extracted with CH_2Cl_2 (15 mL × 3). The combined organic layers were dried with anhydrous Na_2SO_4, and then concentrated in vacuo. The residue was recrystallized from the solvents of CH_2Cl_2 and hexane (1:1) to afford the desired product **7**.

2,2-Difluoro-2-(4-phenylquinolin-3-yl)acetic acid (**7**). Brown solid (53.8 mg, 90% yield); mp 125–127 °C; ^{1}H NMR (400 MHz, DMSO-d_6): δ (ppm) 9.20 (s, 1H), 8.17 (d, J = 8.4 Hz, 1H), 7.88–7.84 (m, 1H), 7.59–7.49 (m, 4H), 7.31–7.25 (m, 3H); ^{13}C NMR (100 MHz, DMSO-d_6): δ (ppm) 164.5 (t, J = 32.5 Hz), 148.6, 147.7 (t, J = 3.9 Hz), 146.7 (t, J = 8.8 Hz), 133.9, 131.6, 129.9, 129.5, 129.1, 128.5,

128.3, 127.1, 126.9, 124.4 (t, J = 23.1 Hz), 113.9 (t, J = 251.2 Hz); ^{19}F NMR (376 MHz, DMSO-d_6): δ (ppm) -96.2; HRMS (ESI) m/z: calcd for $C_{17}H_{12}F_2NO_2$ $(M+H)^+$ 300.0831, found 300.0831.

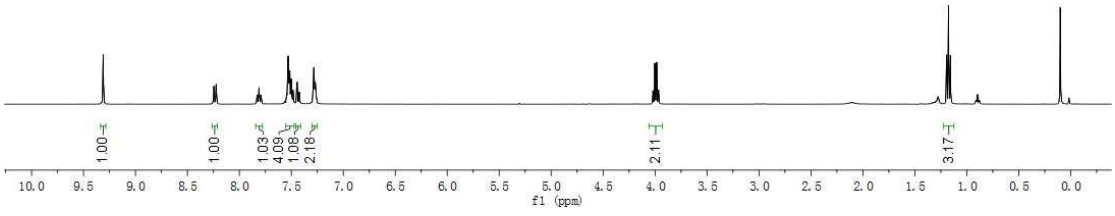
Ethyl 2,2-difluoro-4,4-diphenylbut-3-enoate (**8**).[2] Colorless oil (99.7 mg, 66% yield); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.48–7.44 (m, 3H), 7.42–7.35 (m, 5H), 7.34–7.31 (m, 2H), 6.42 (t, J = 11.8 Hz, 1H), 3.99 (q, J = 7.2 Hz, 2H), 1.24 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 163.5 (t, J = 33.9 Hz), 151.1 (t, J = 9.5 Hz), 140.5, 137.2, 130.0, 129.3, 128.7, 128.5, 128.1, 128.0, 119.6 (t, J = 28.5 Hz), 112.8 (t, J = 244.8 Hz), 62.8, 13.7; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) -90.8.

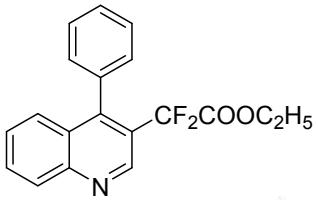
5. References

1. L.-L. Zhang, S. Chen, Y.-Z. Gao, P.-B. Zhang, Y.-L. Wu, G. Tang and Y.-F. Zhao, *Org. Lett*., 2016, **18**, 1286.
2. Y.-T. He, Q. Wang, L.-H. Li, X.-Y. Liu, P.-F. Xu and Y.-M. Liang, *Org. Lett*., 2015, **17**, 5188.

6. Copies of ^{1}H and ^{13}C NMR spectra of the products

3a (^{1}H NMR)





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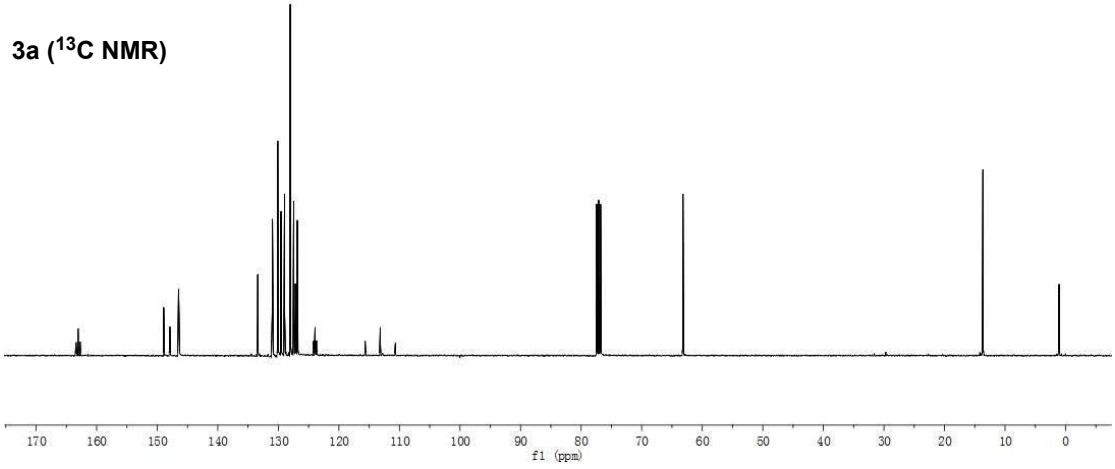
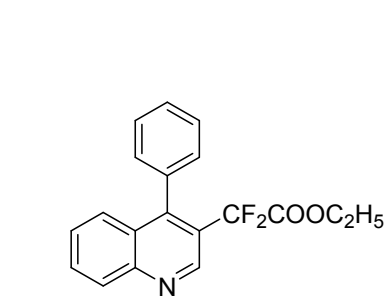
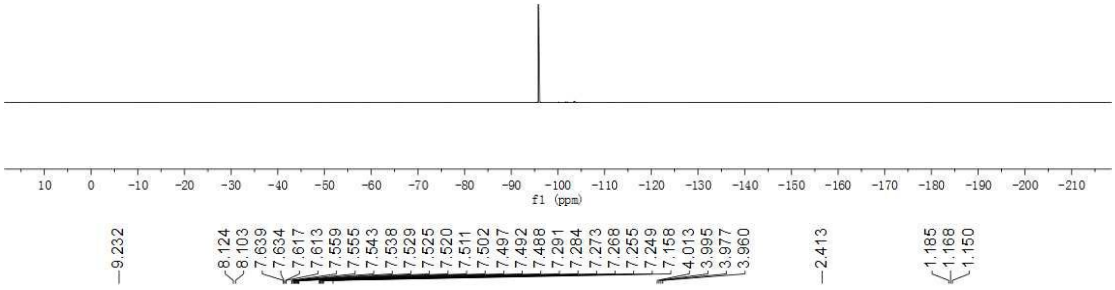
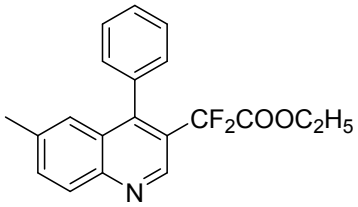


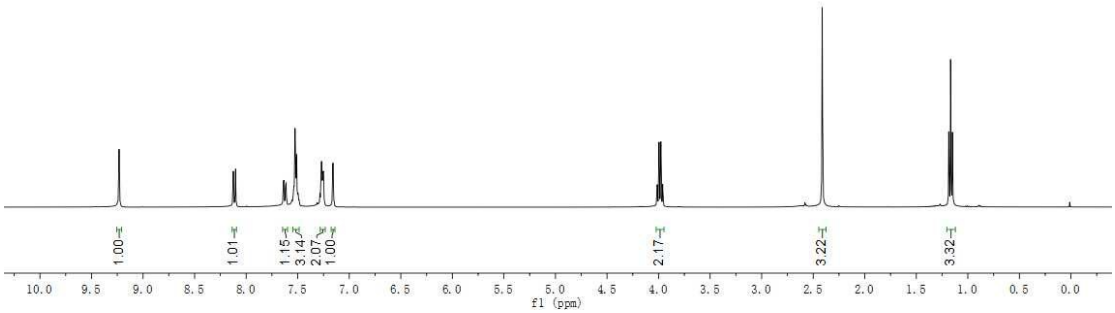


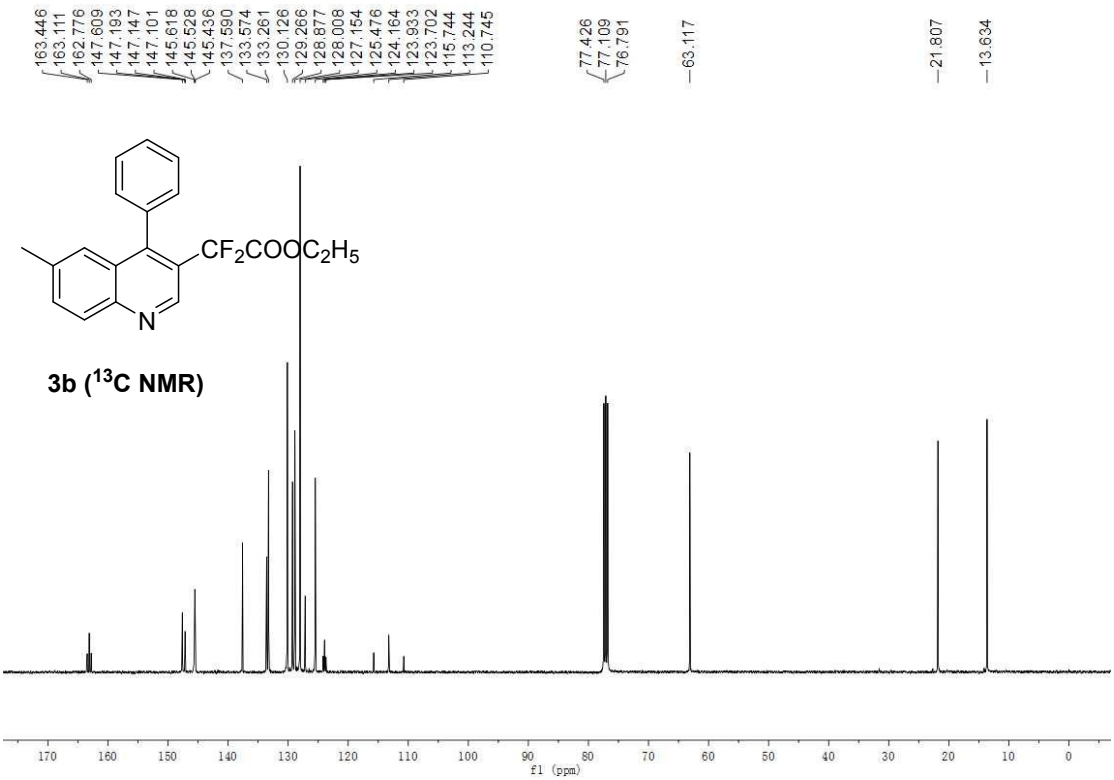
3a (^{19}F NMR)



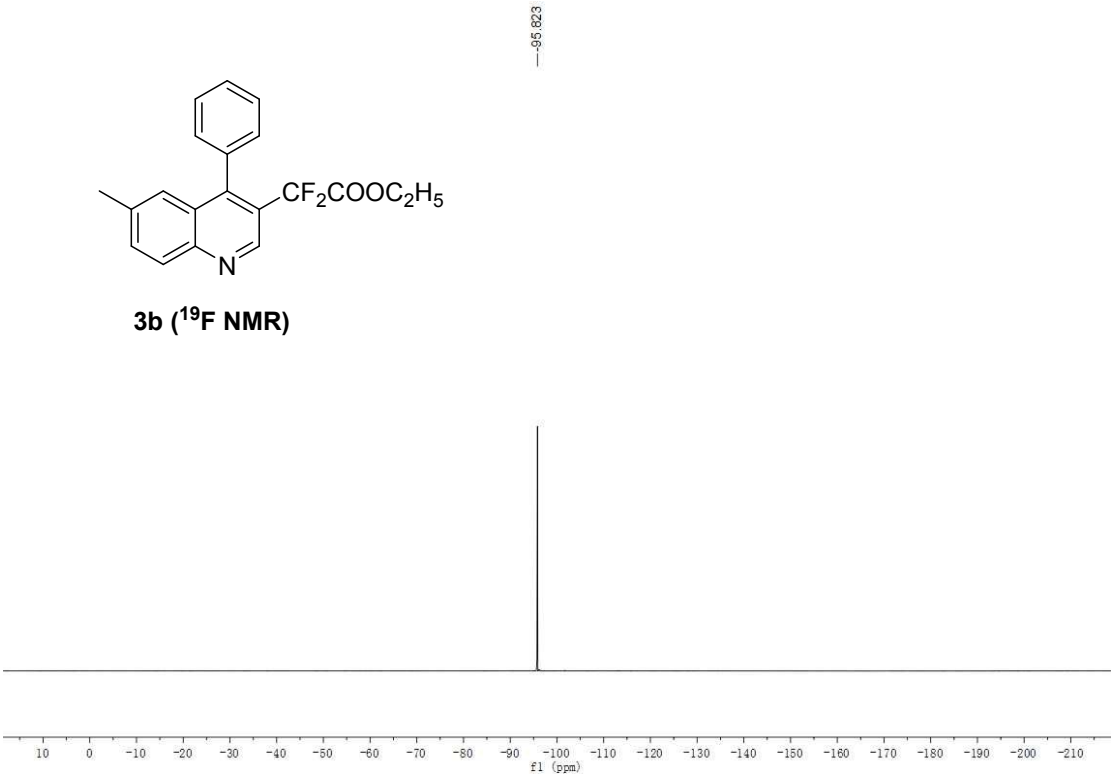


3b (^{1}H NMR)

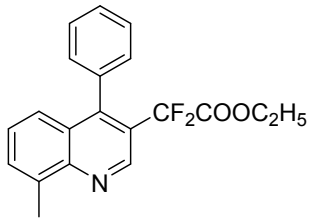




3b (^{13}C NMR)



3b (^{19}F NMR)



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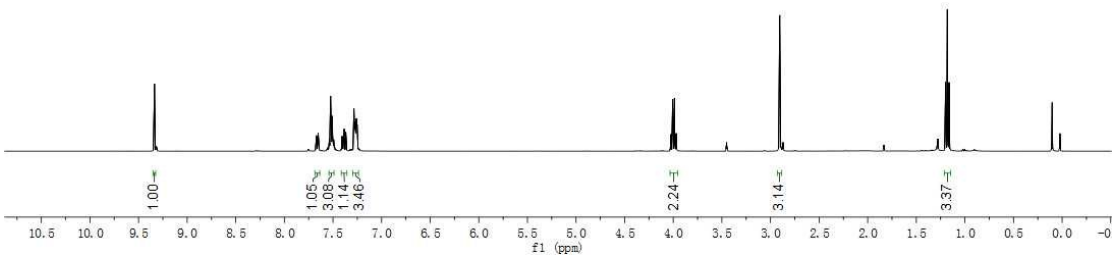
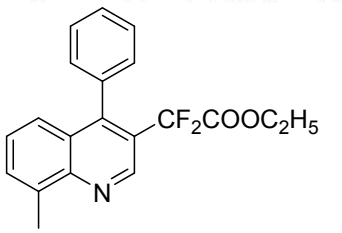
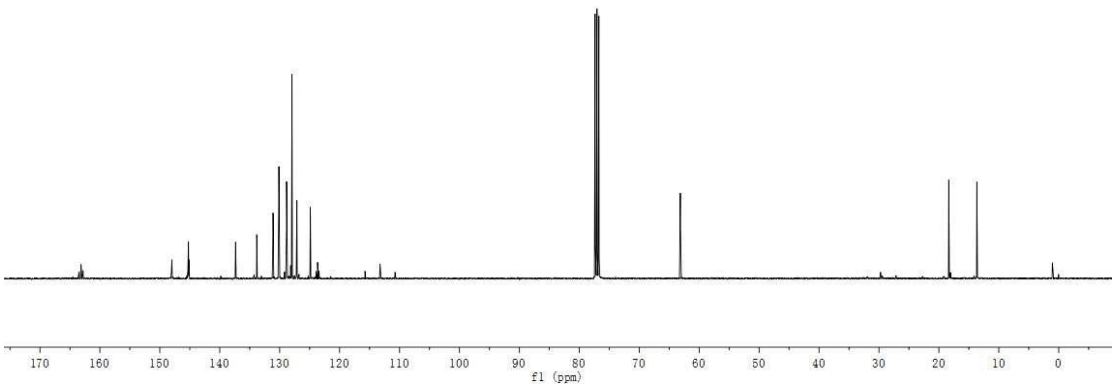




3c (^{13}C NMR)



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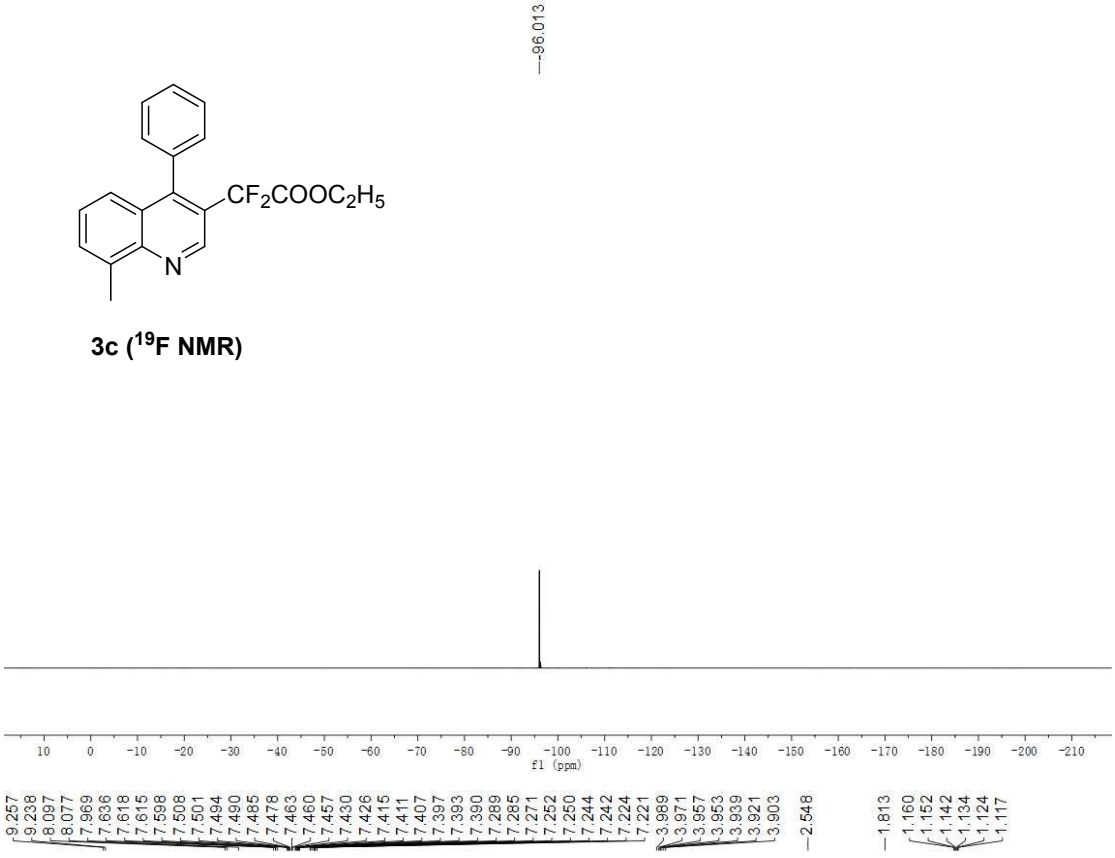
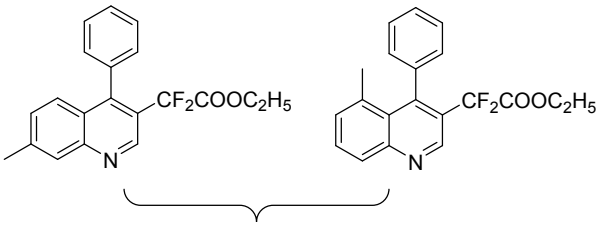
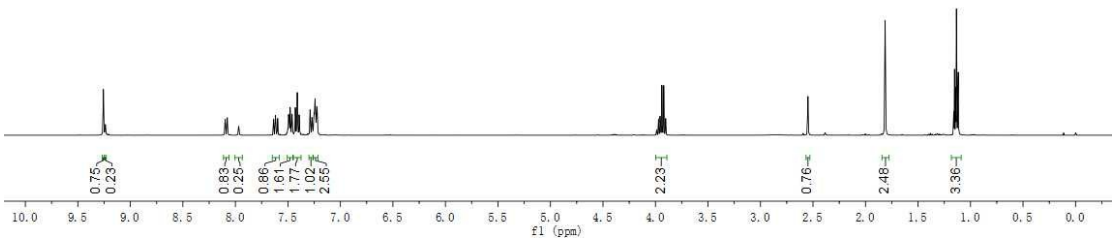
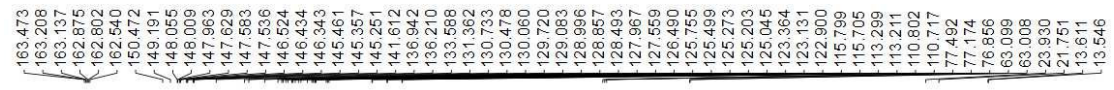
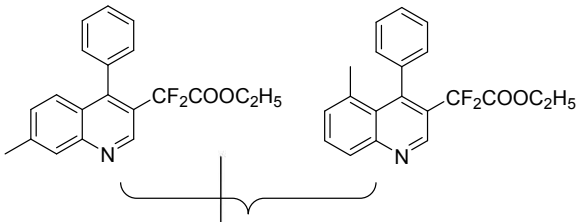




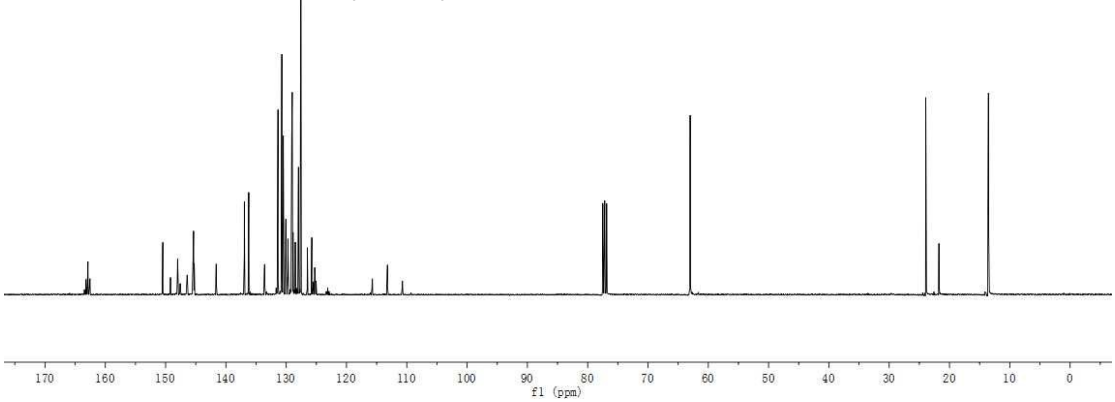
3d+3d′ (^{1}H NMR)

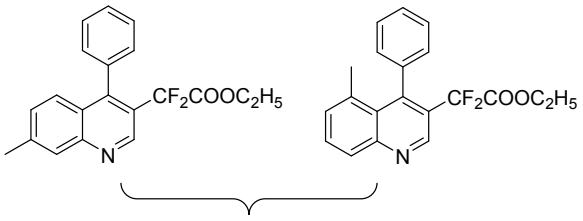




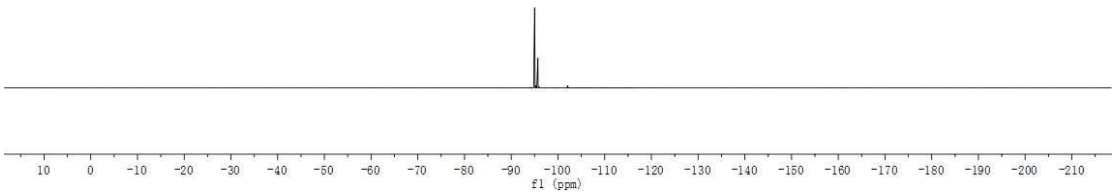


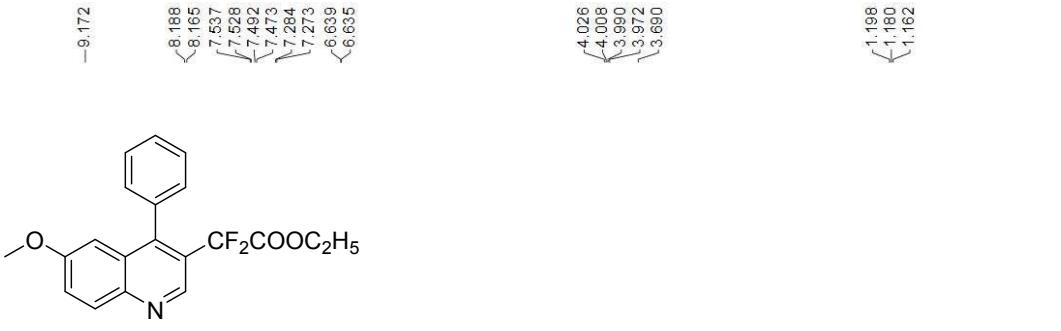
3d+3d′(¹³C NMR)



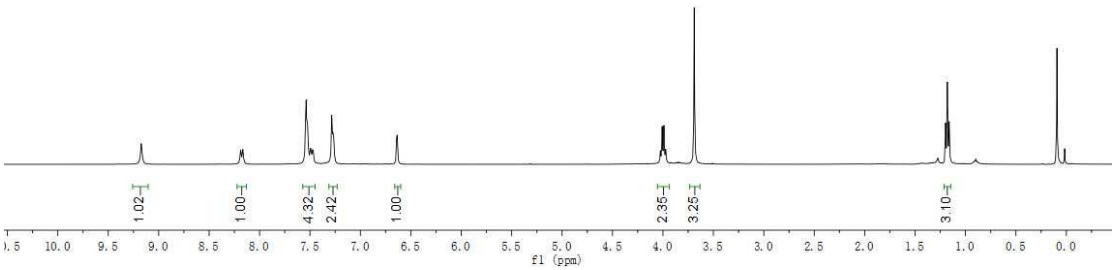


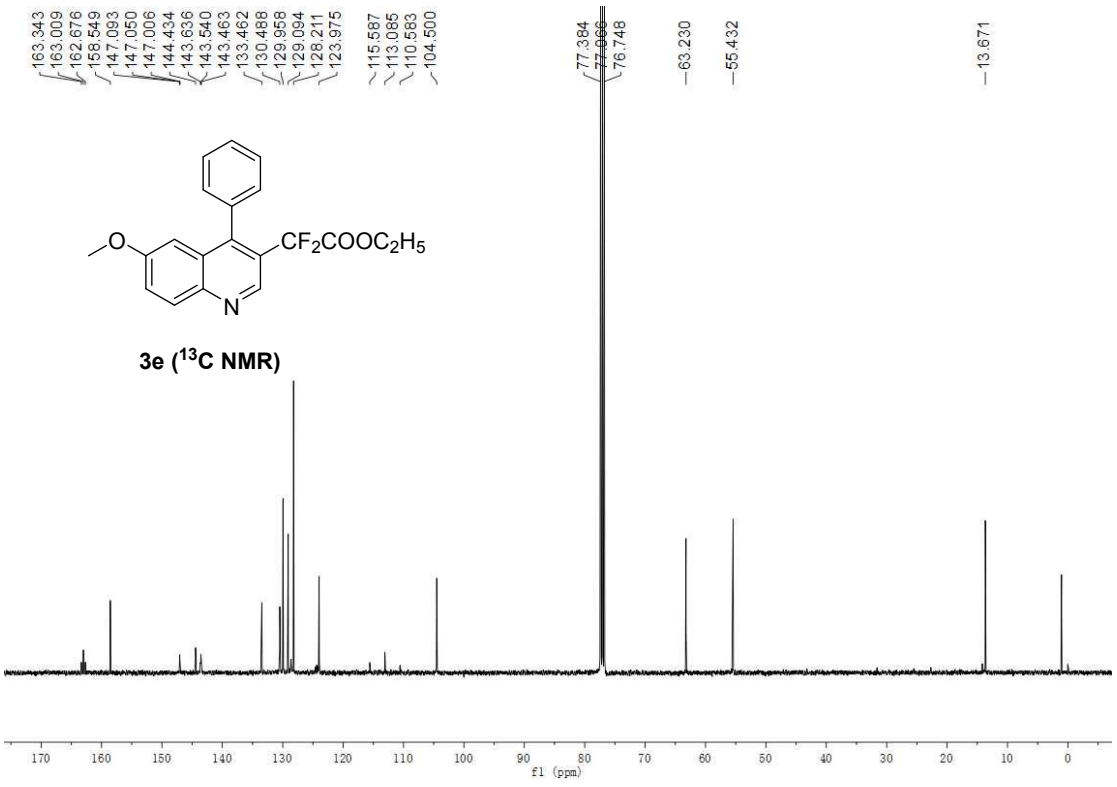
3d+3d′(¹⁹F NMR)





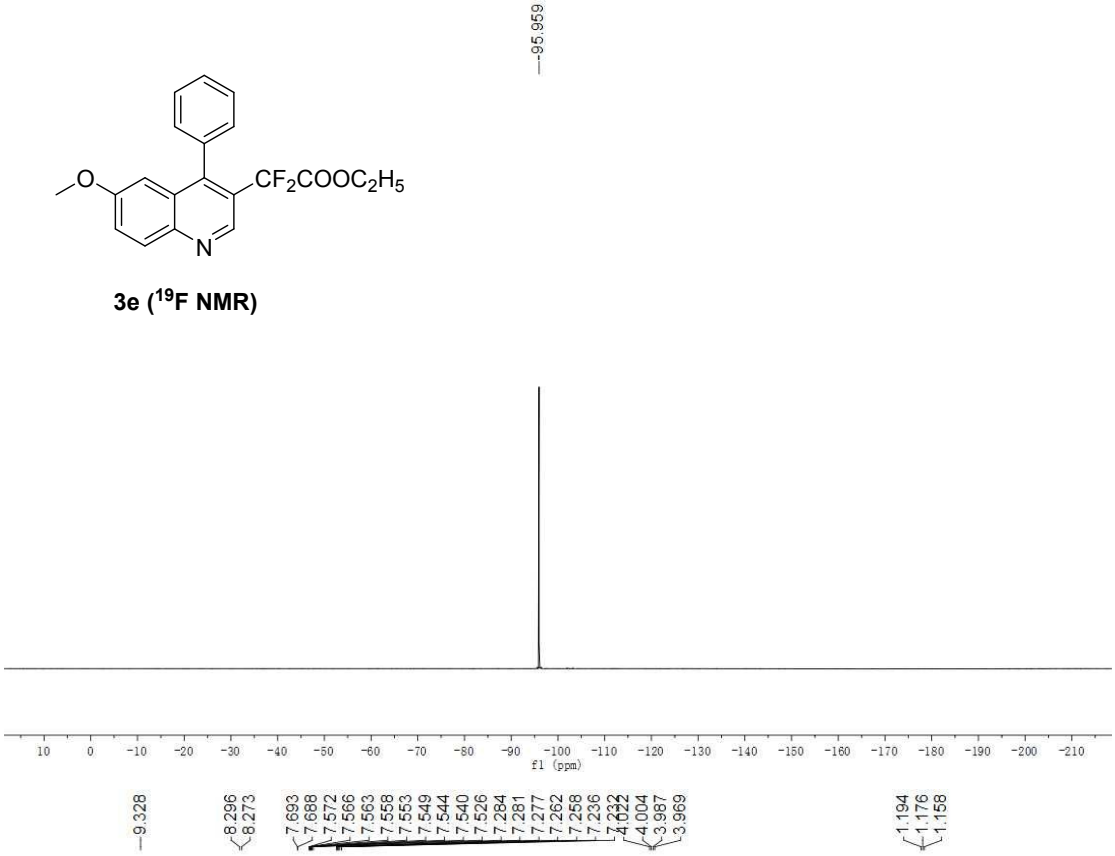
3e (^{1}H NMR)

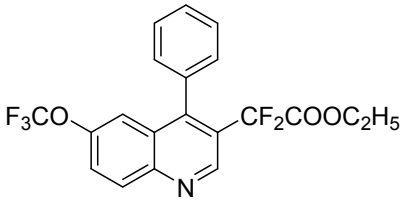




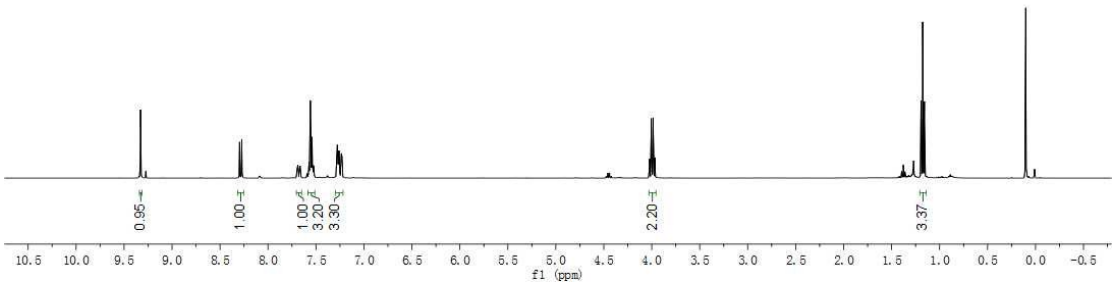
3e (^{13}C NMR)

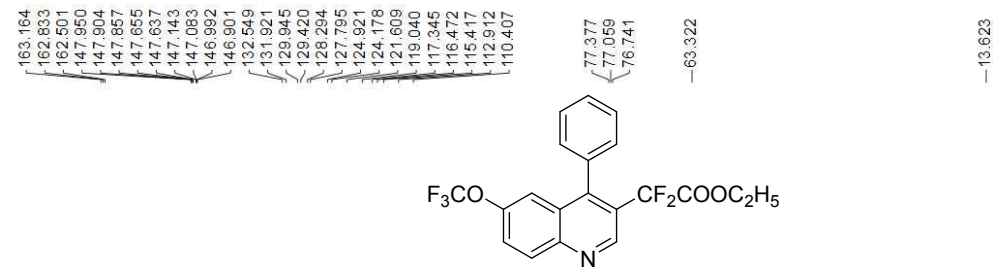
3e (^{19}F NMR)



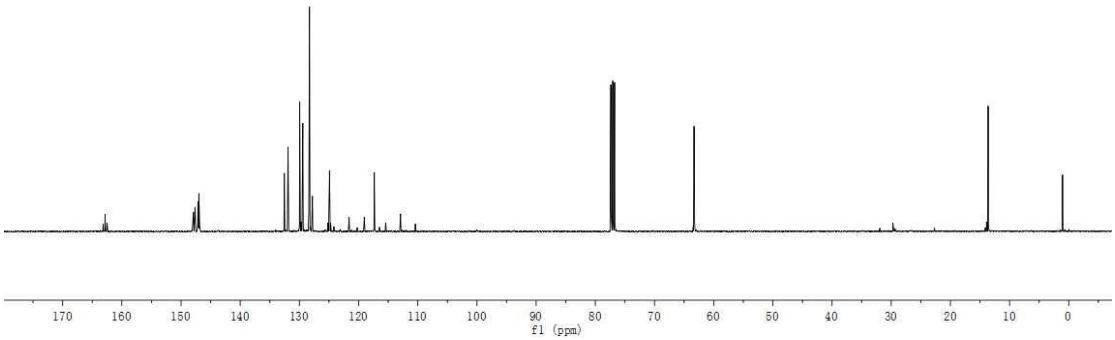


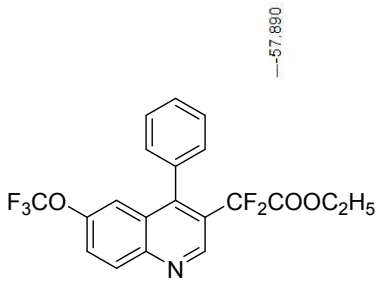
3f (^{1}H NMR)





3f (^{13}C NMR)





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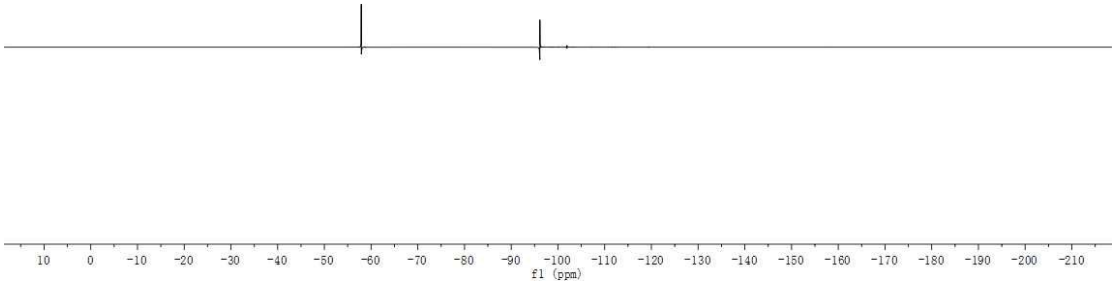
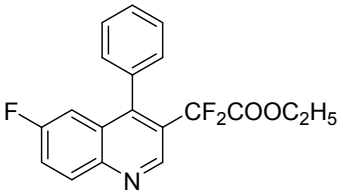
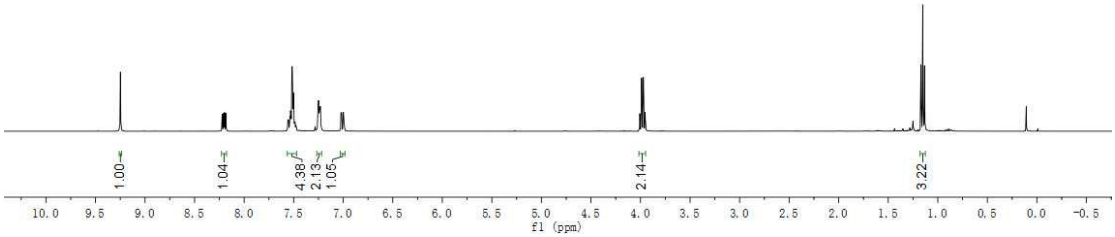
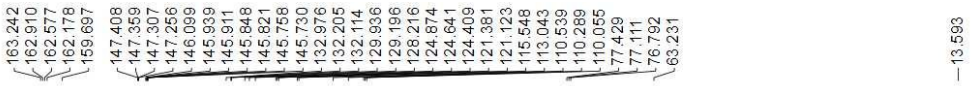
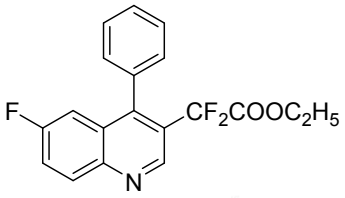




3g (^{1}H NMR)







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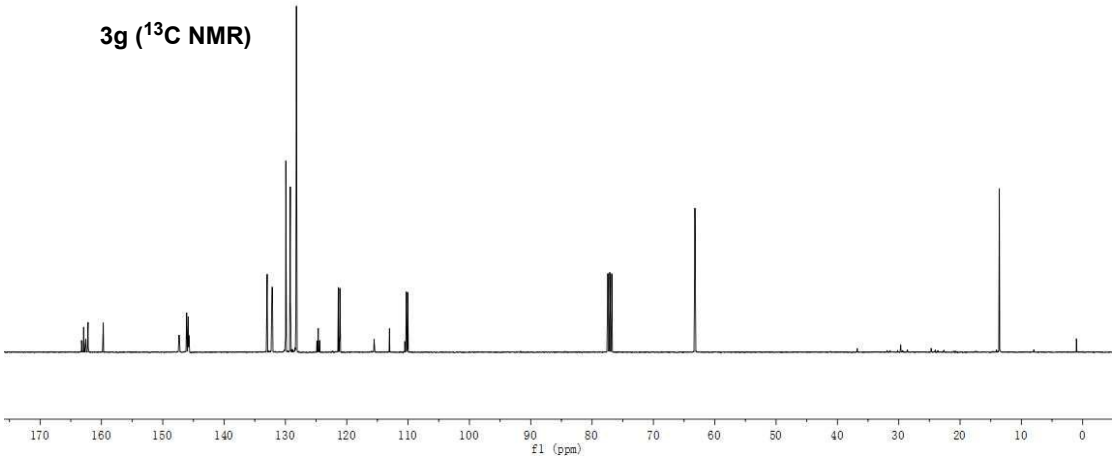

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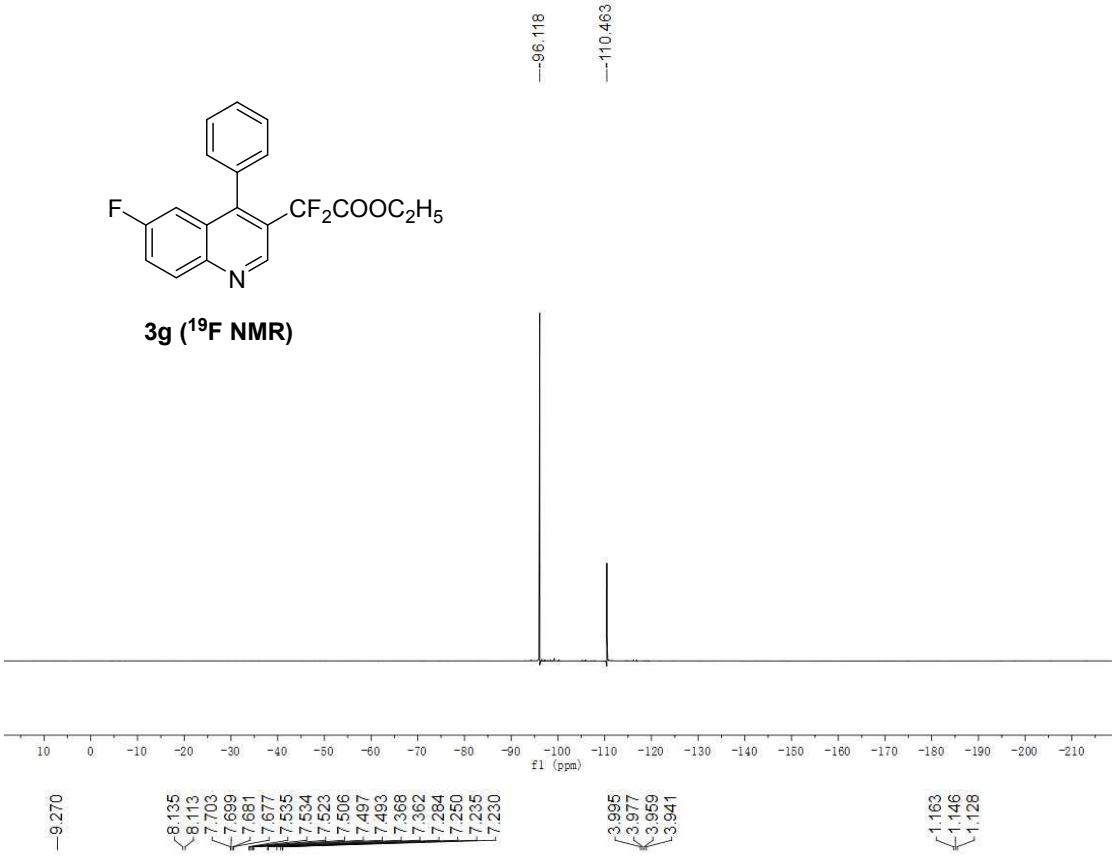
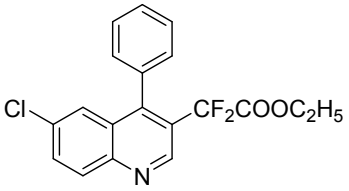
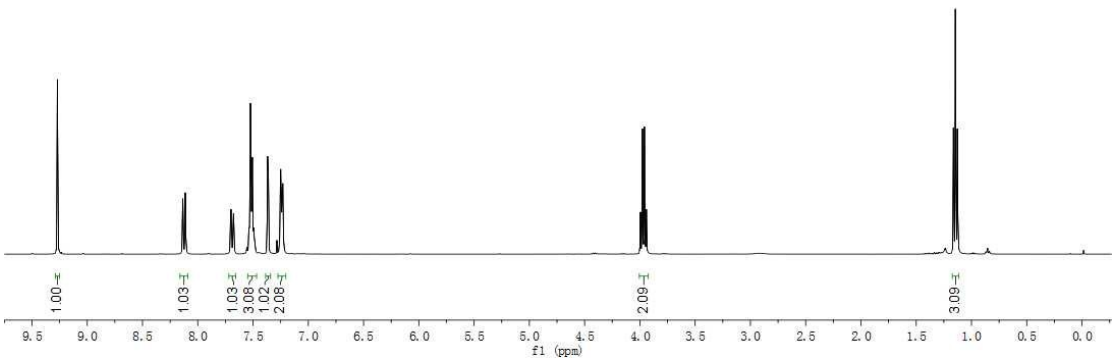
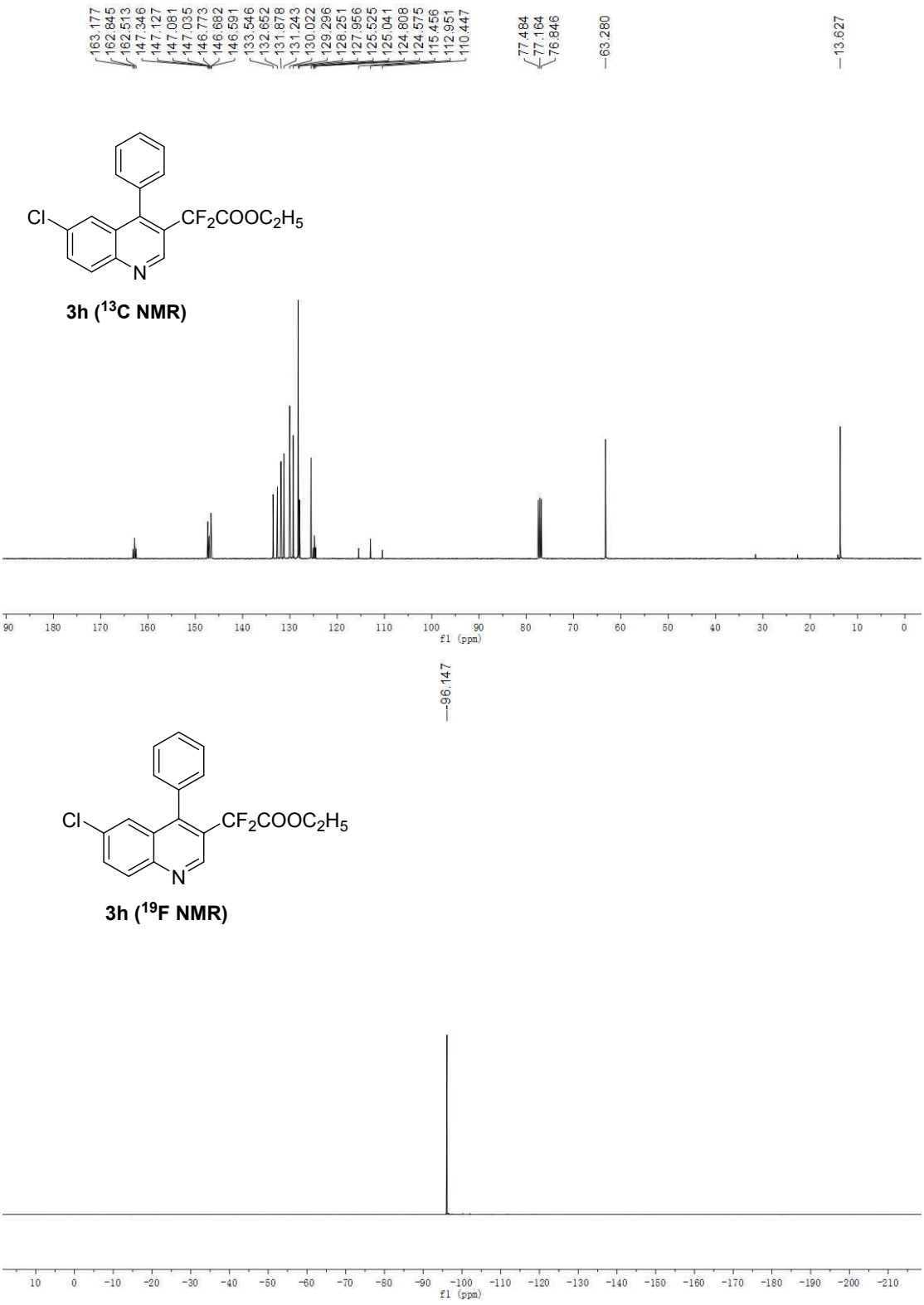




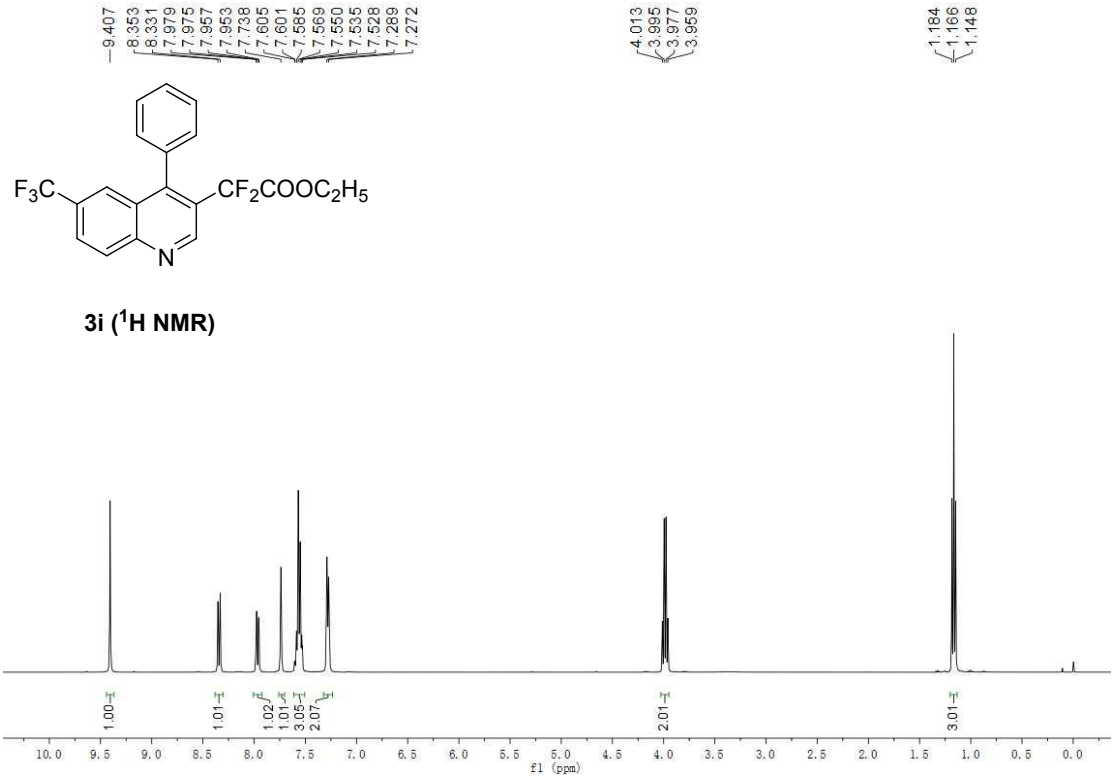
3h (^{1}H NMR)



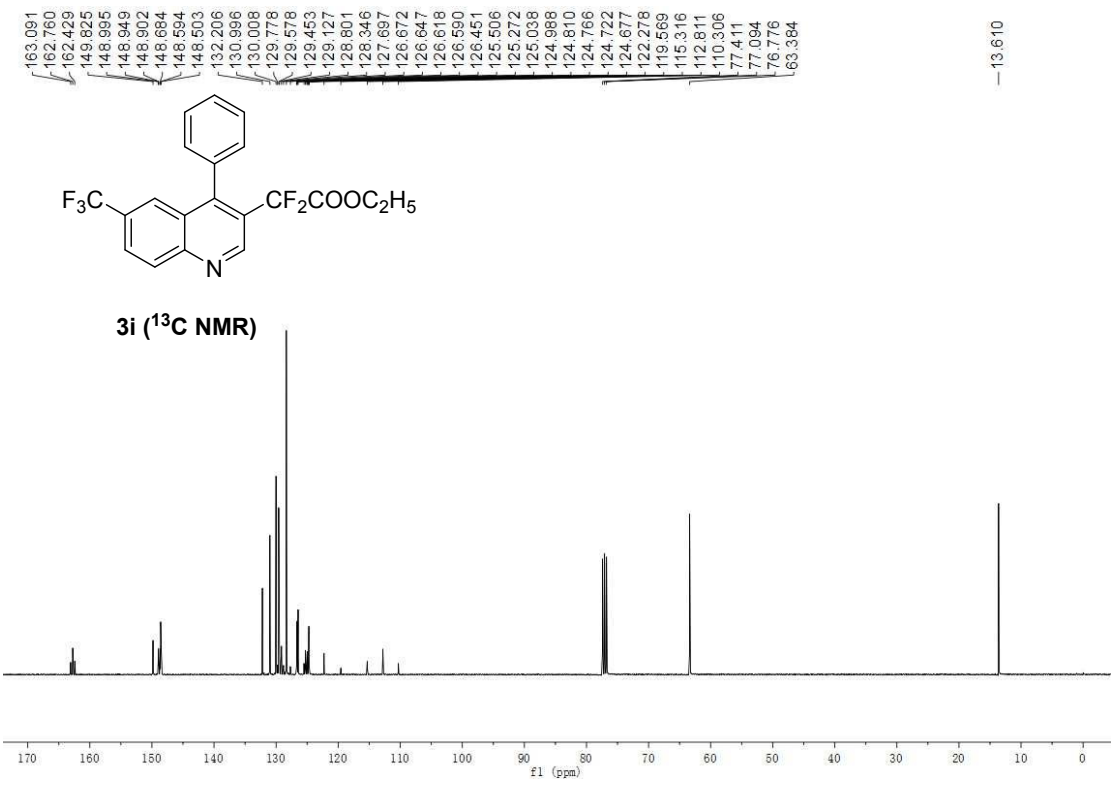


3h (^{13}C NMR)

3h (^{19}F NMR)

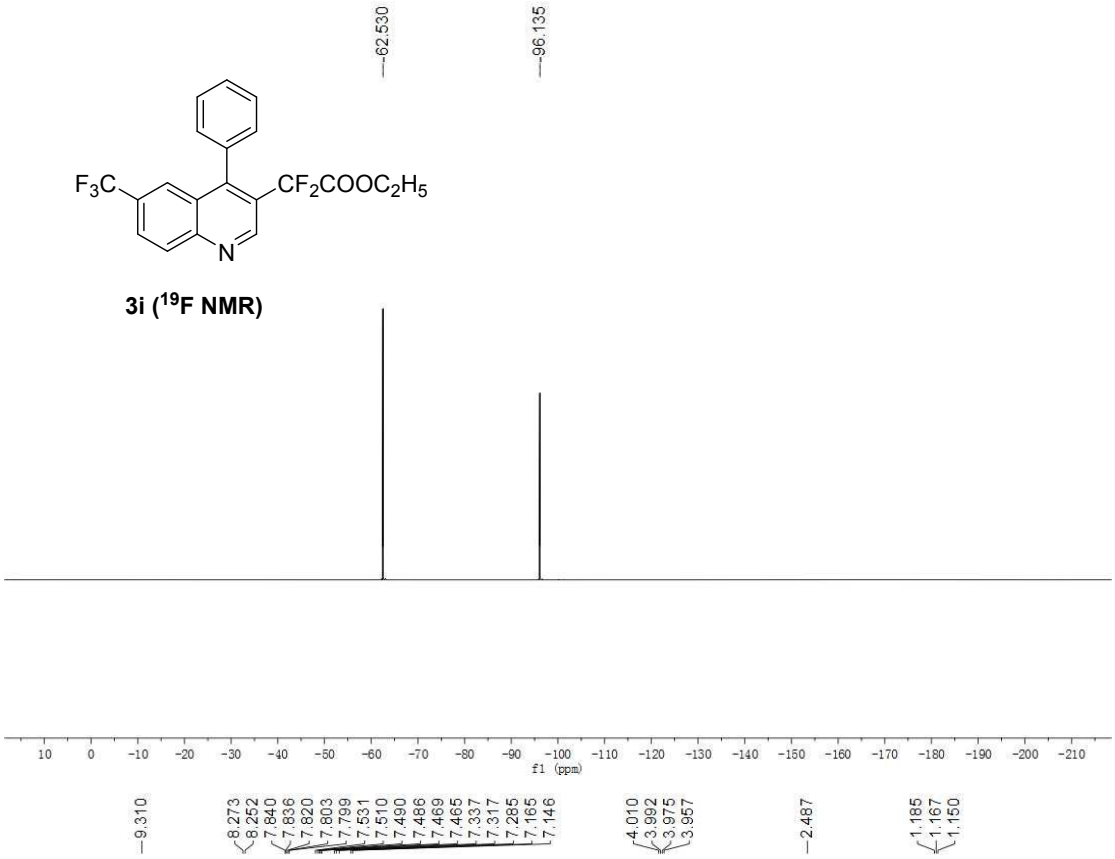


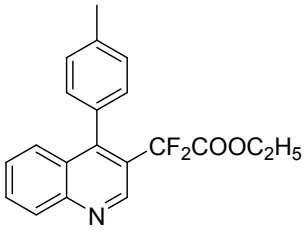
3i (^{1}H NMR)



3i (^{13}C NMR)

3i (^{19}F NMR)





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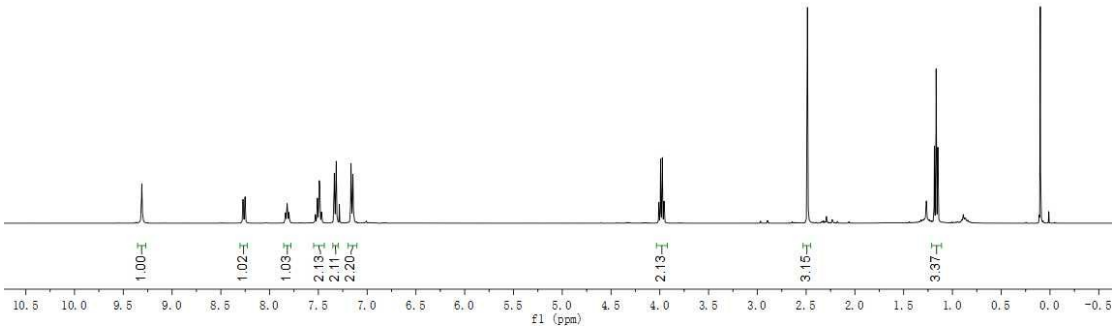
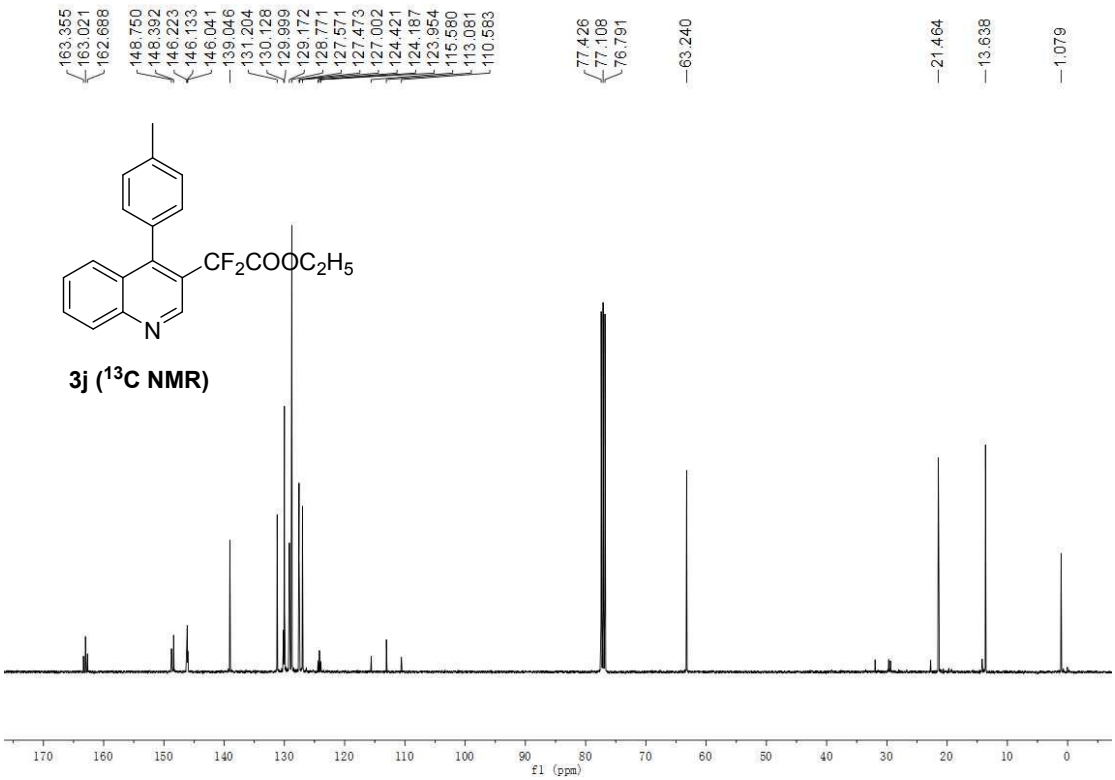
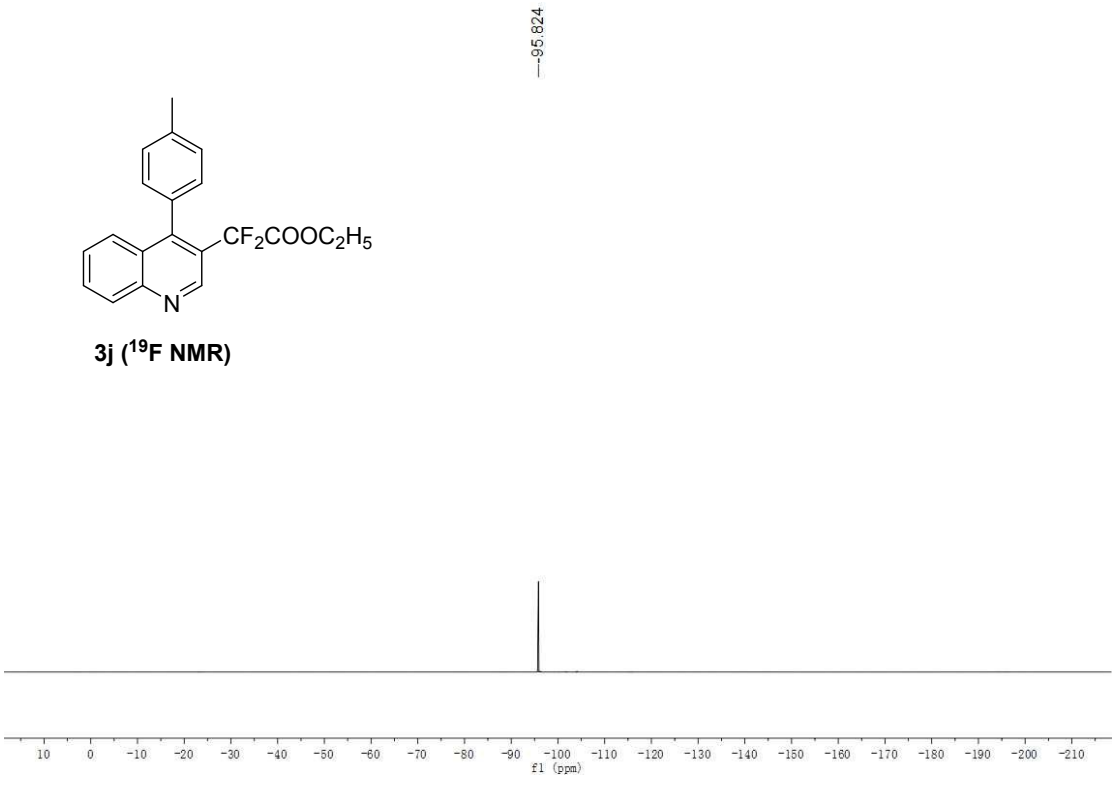
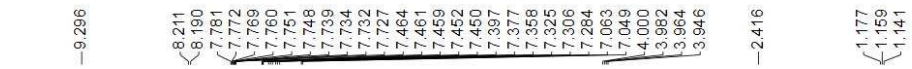


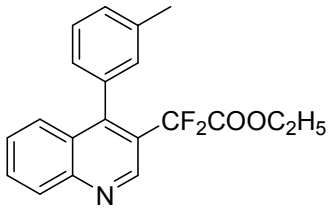


3j (^{13}C NMR)

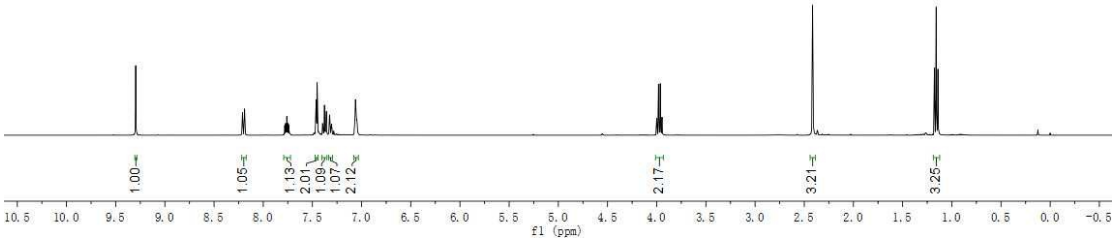


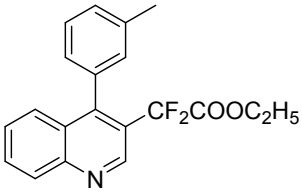
3j (^{19}F NMR)





3k (^{1}H NMR)





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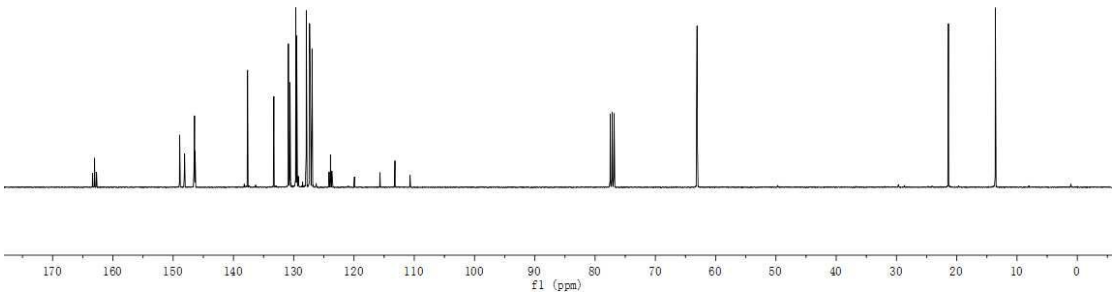

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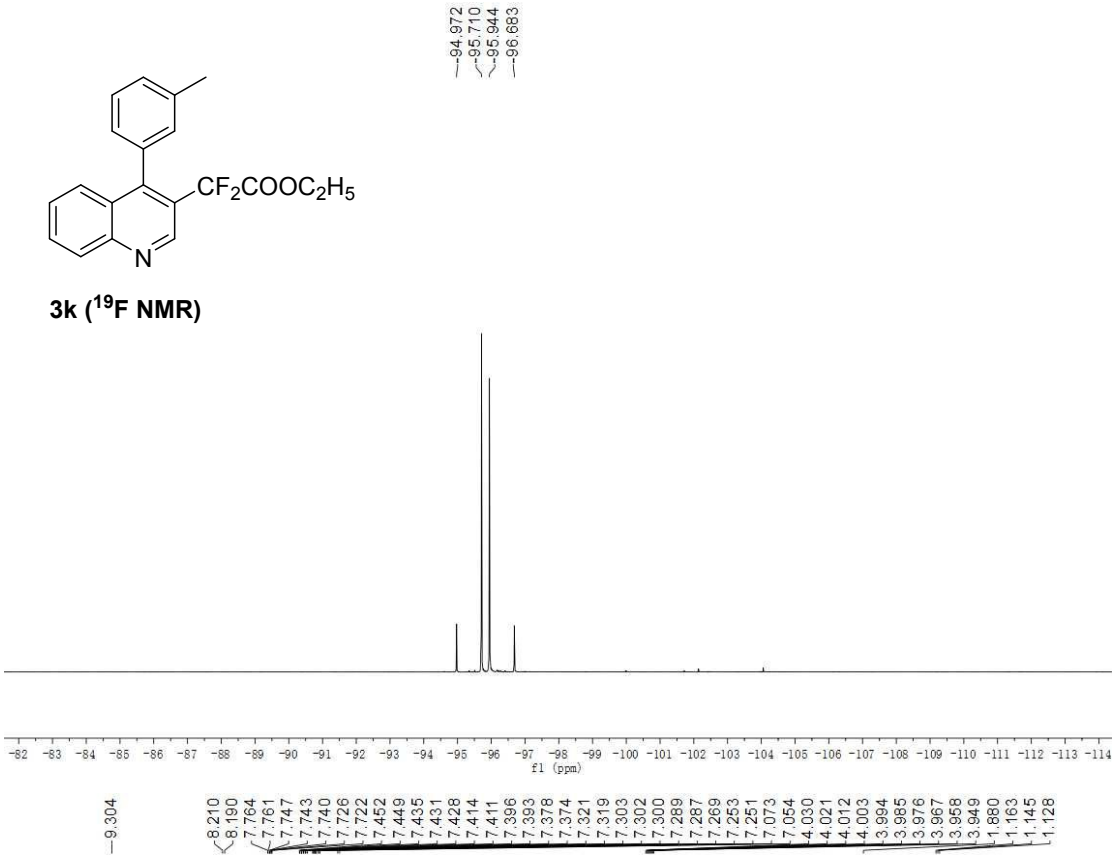

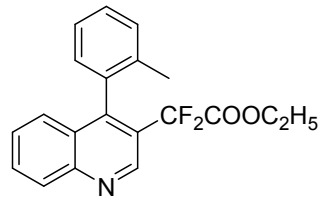

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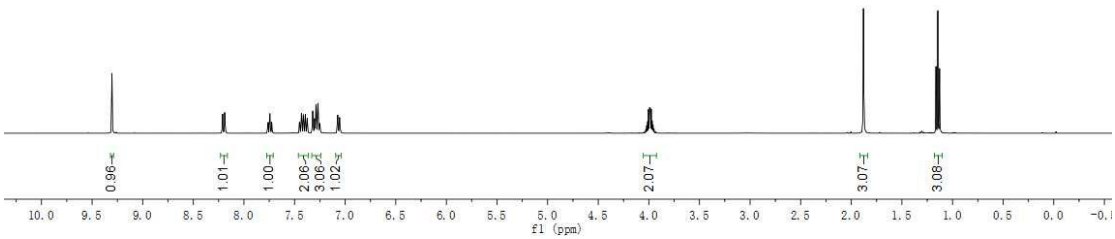

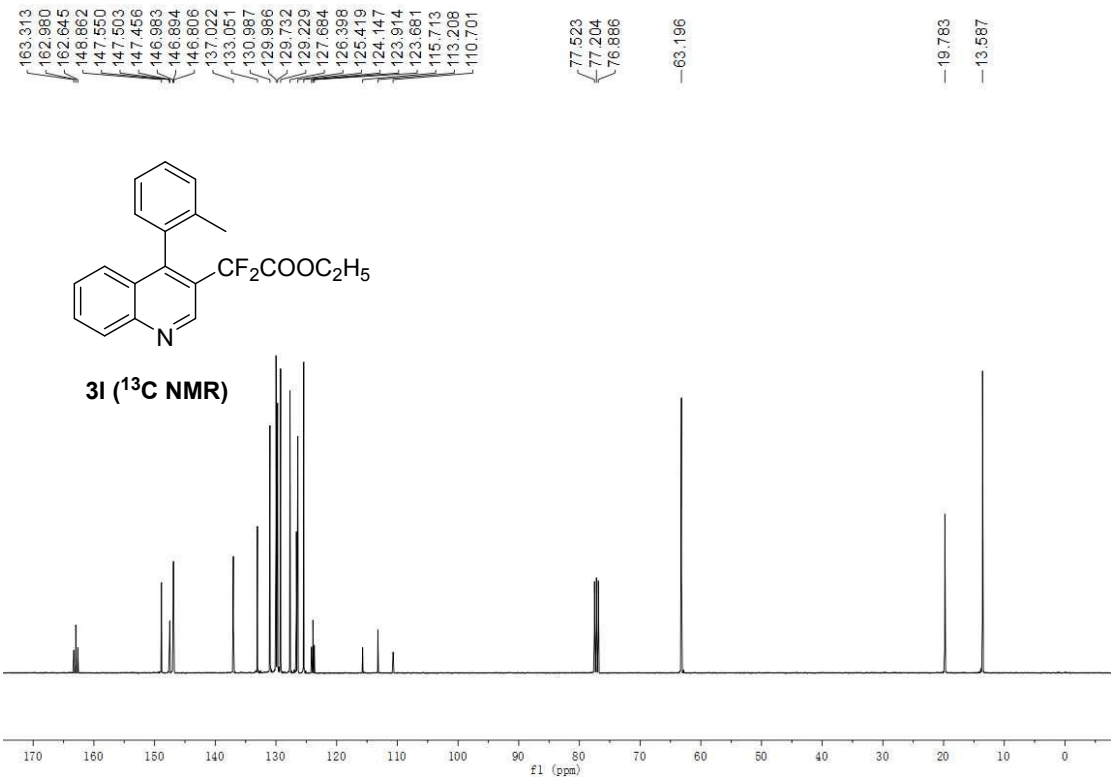

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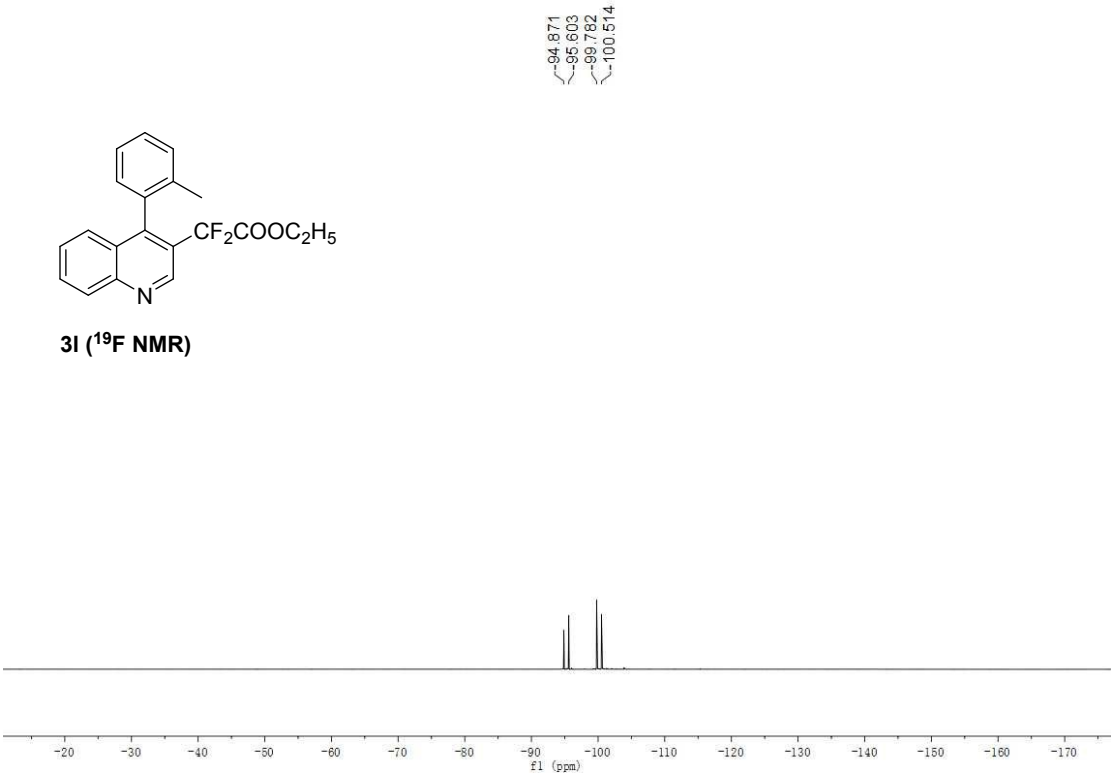

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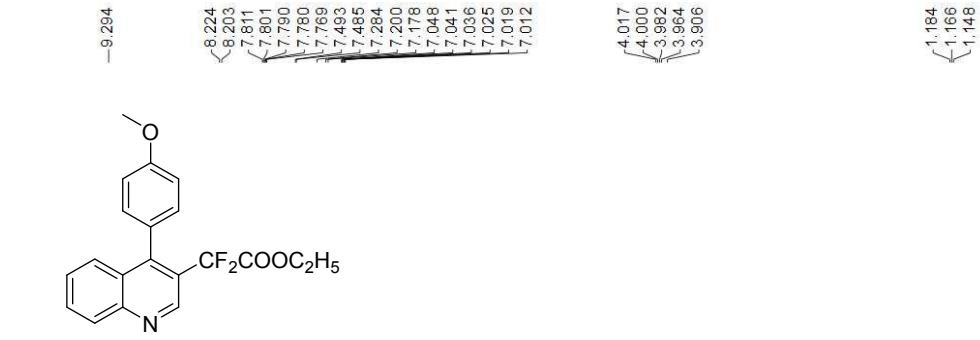
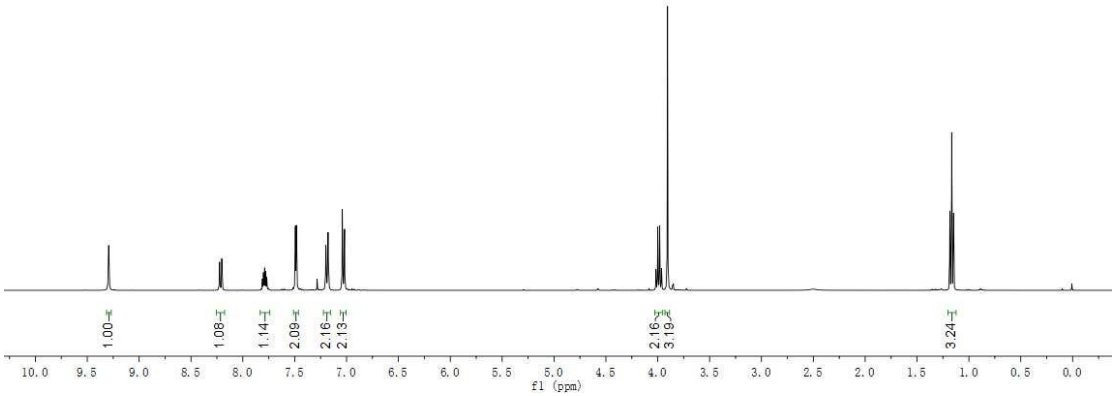
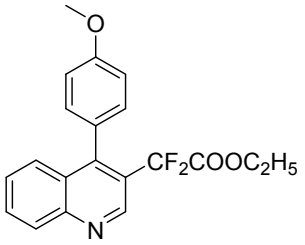


3m (^{1}H NMR)





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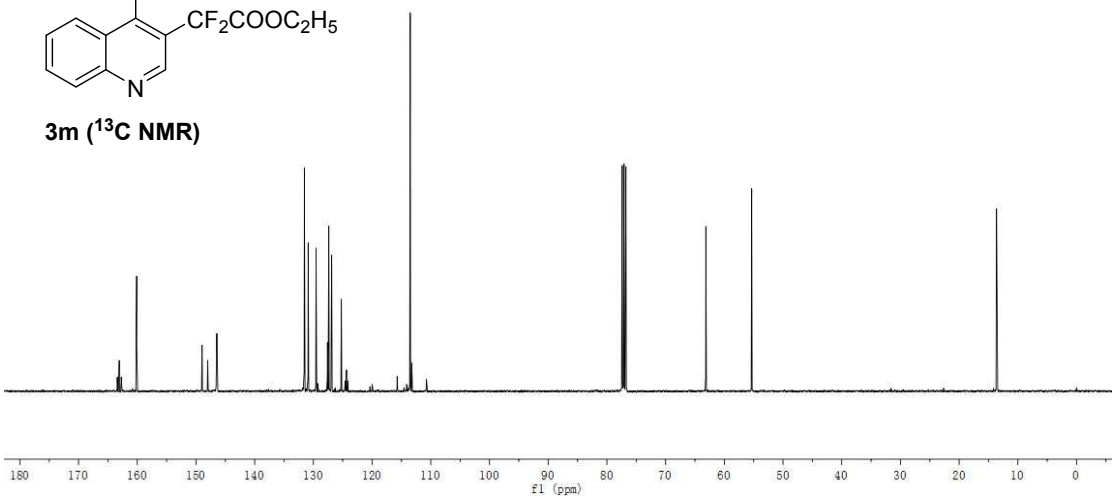
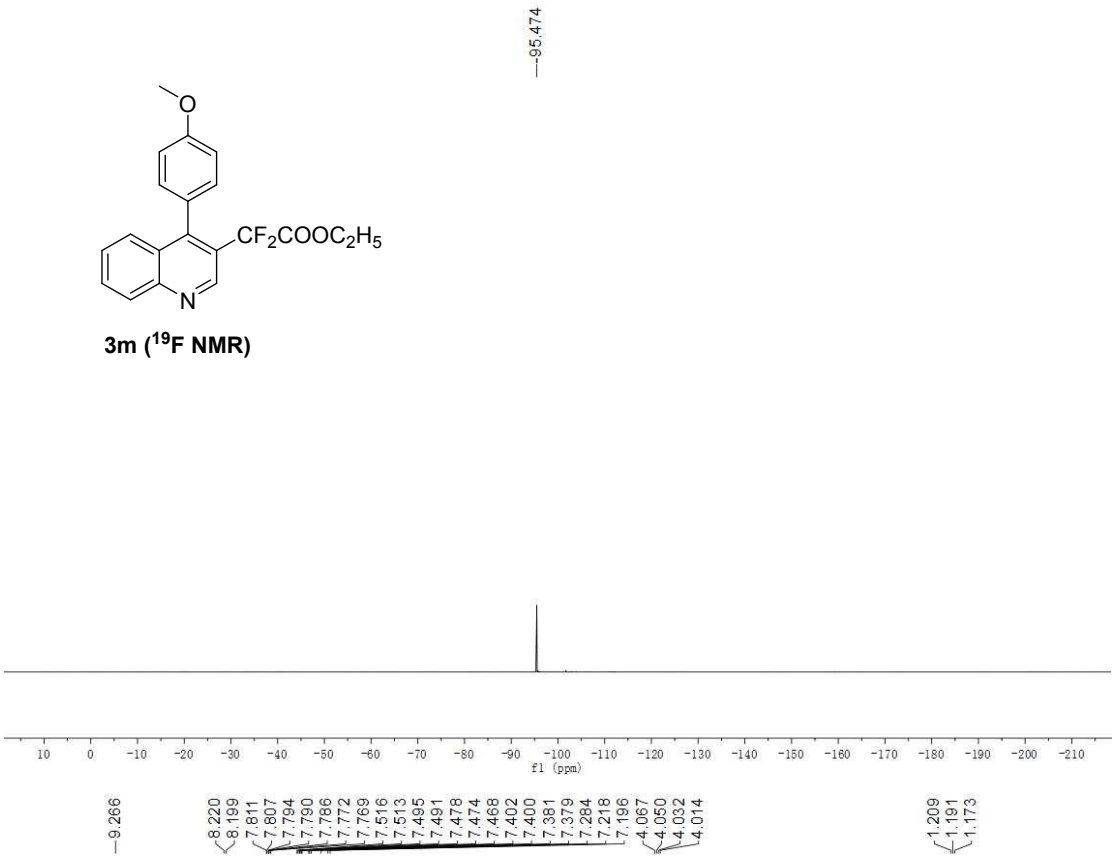
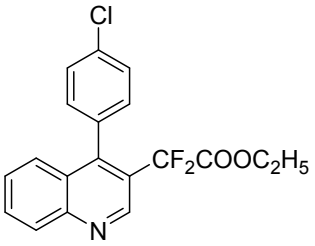
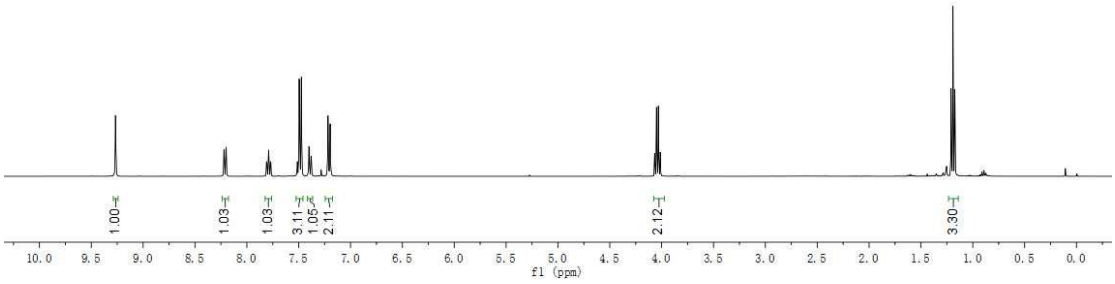


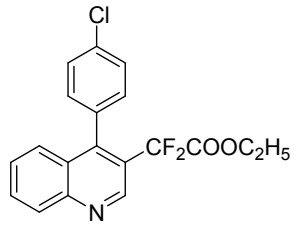
3m (^{19}F NMR)



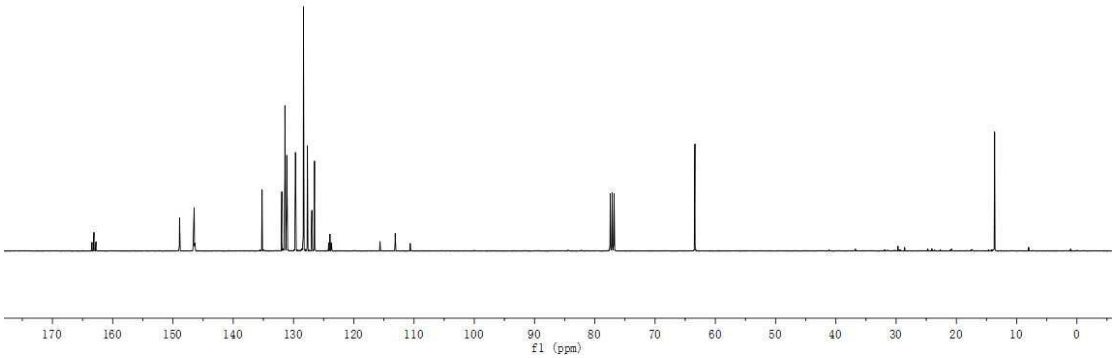


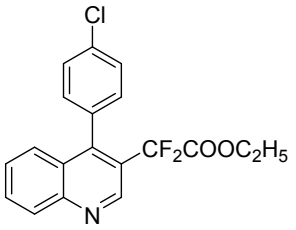
3n (^{1}H NMR)



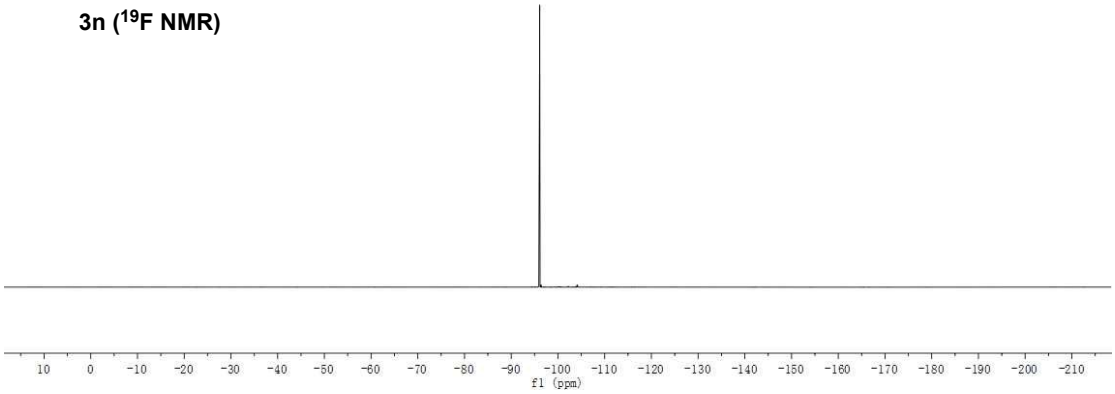


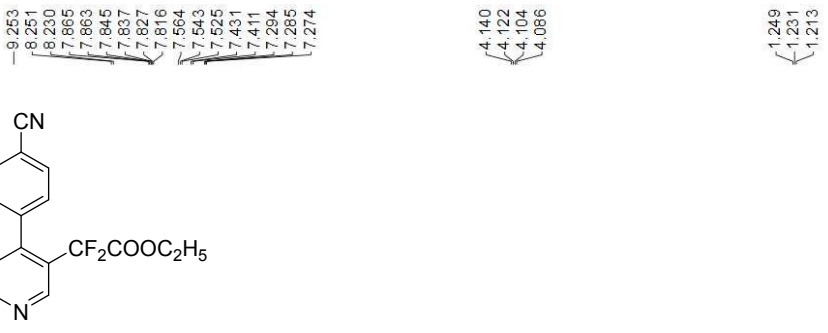
3n (^{13}C NMR)



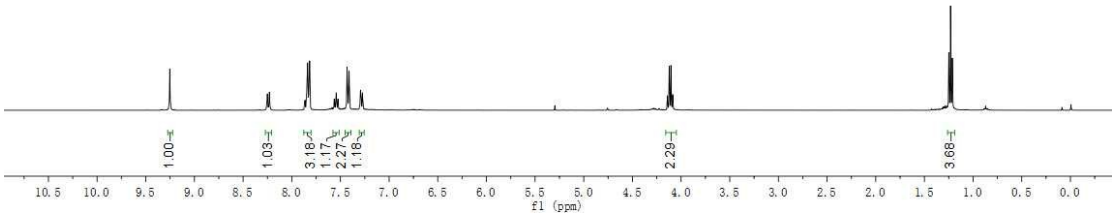


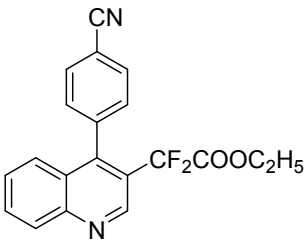
3n (^{19}F NMR)



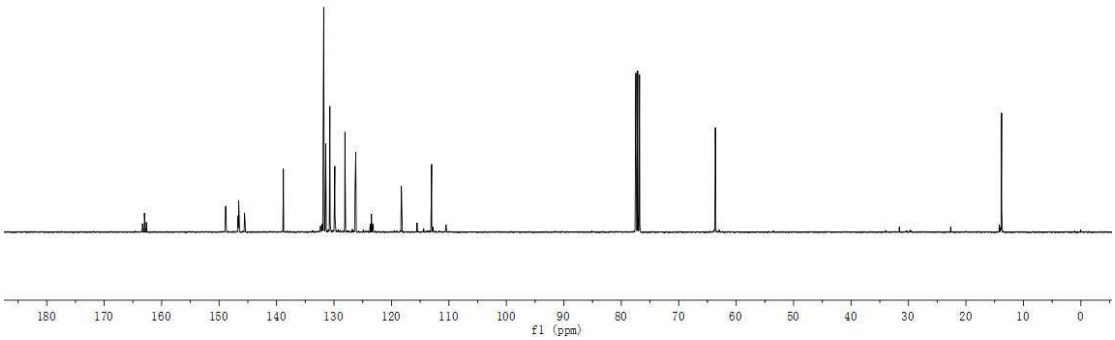


3o (^{1}H NMR)





3o (^{13}C NMR)



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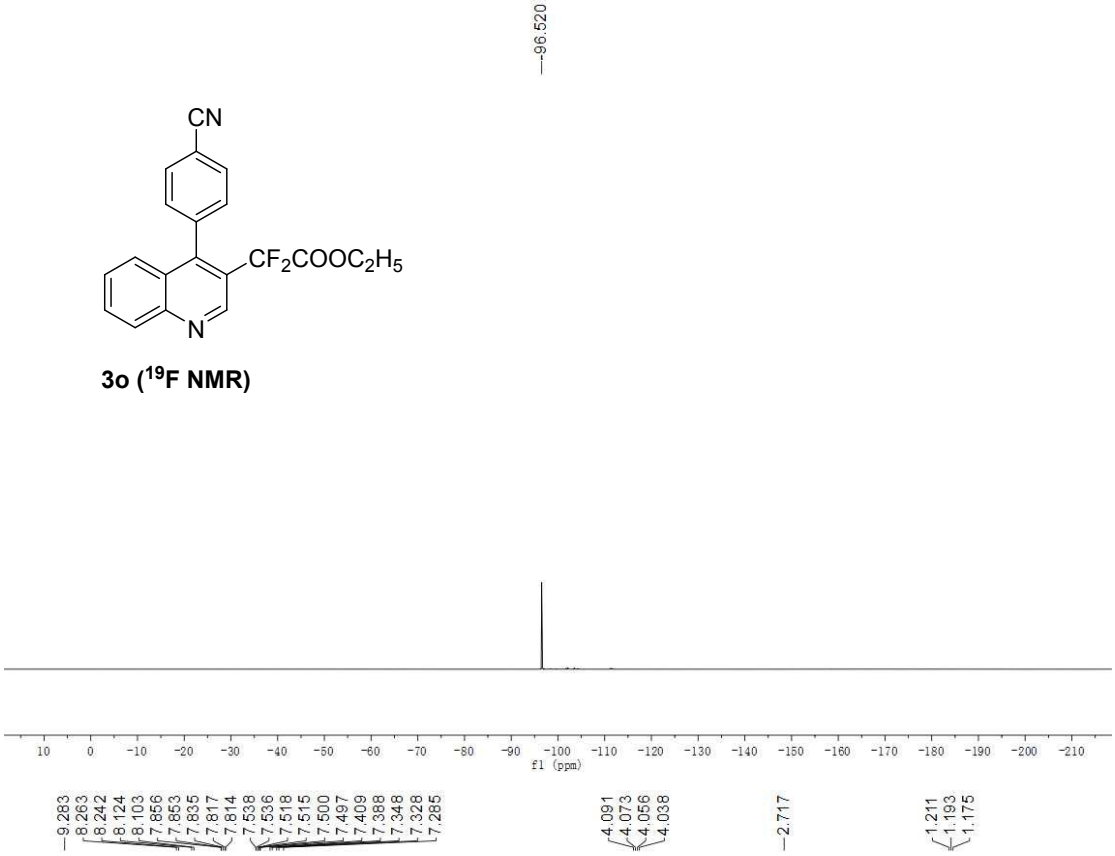
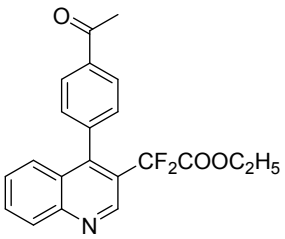
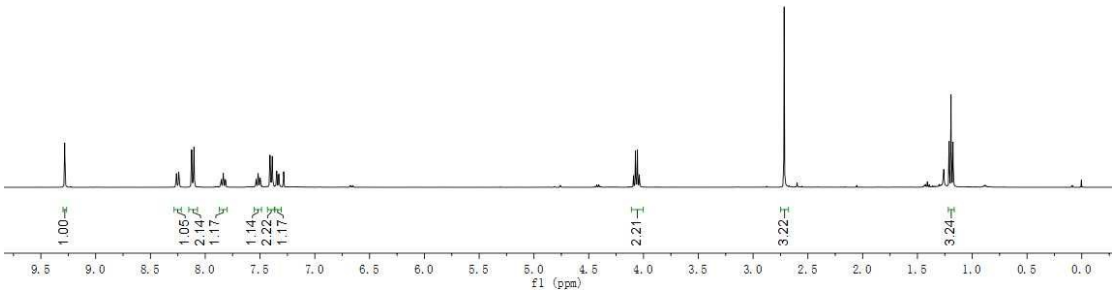
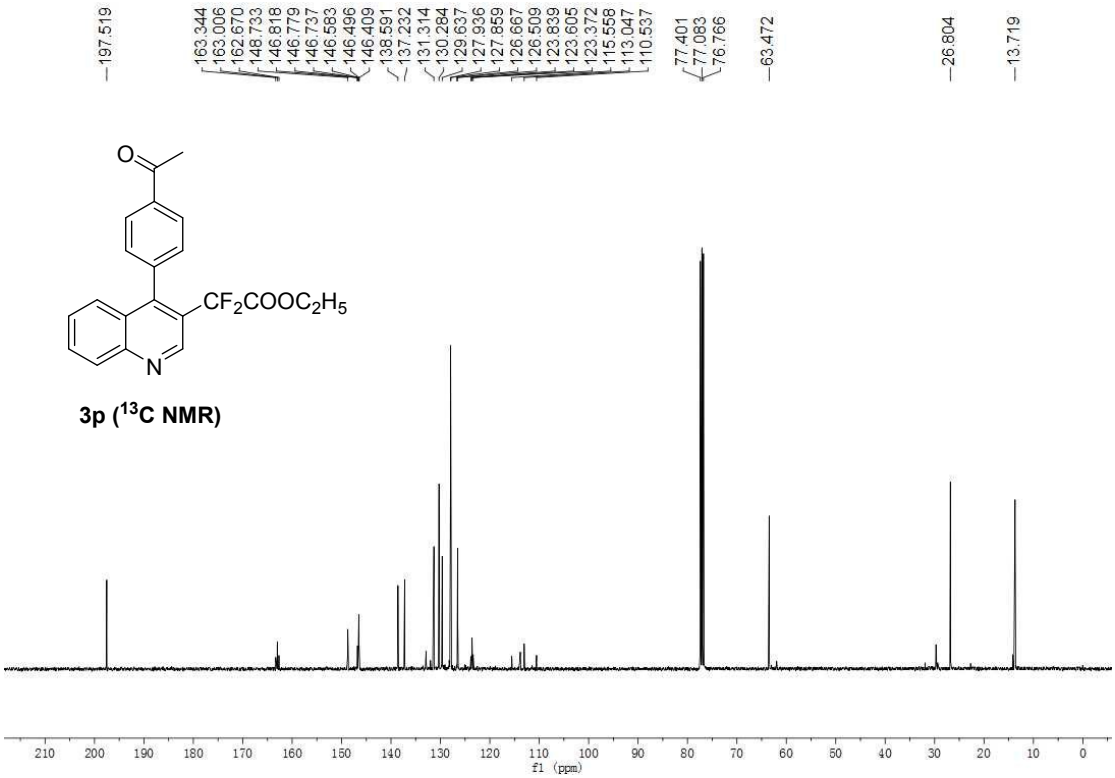


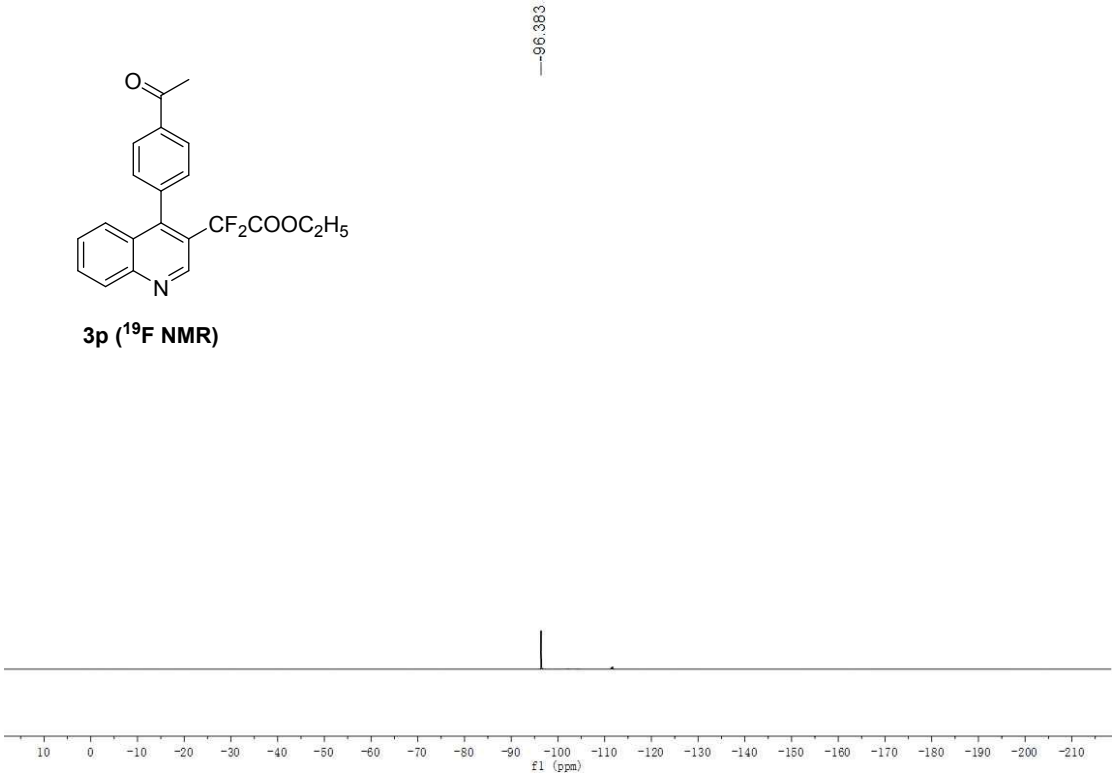


3p (^{1}H NMR)





3p (^{13}C NMR)



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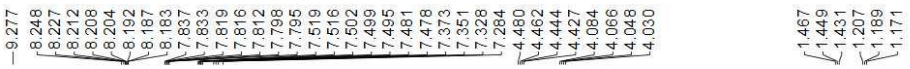
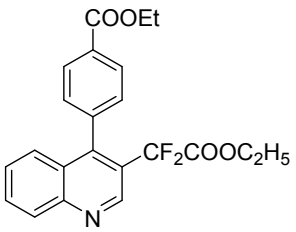
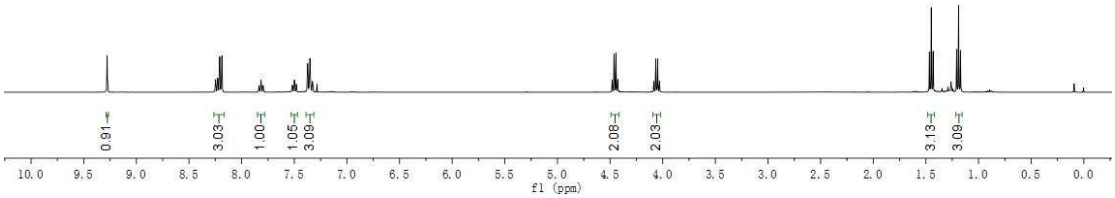
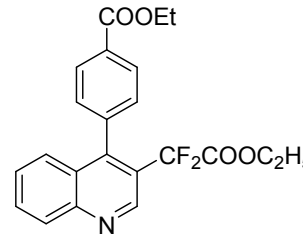




3q (^{1}H NMR)





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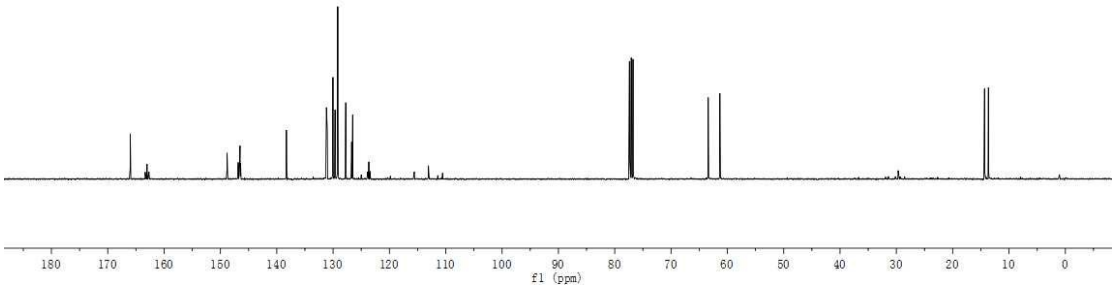

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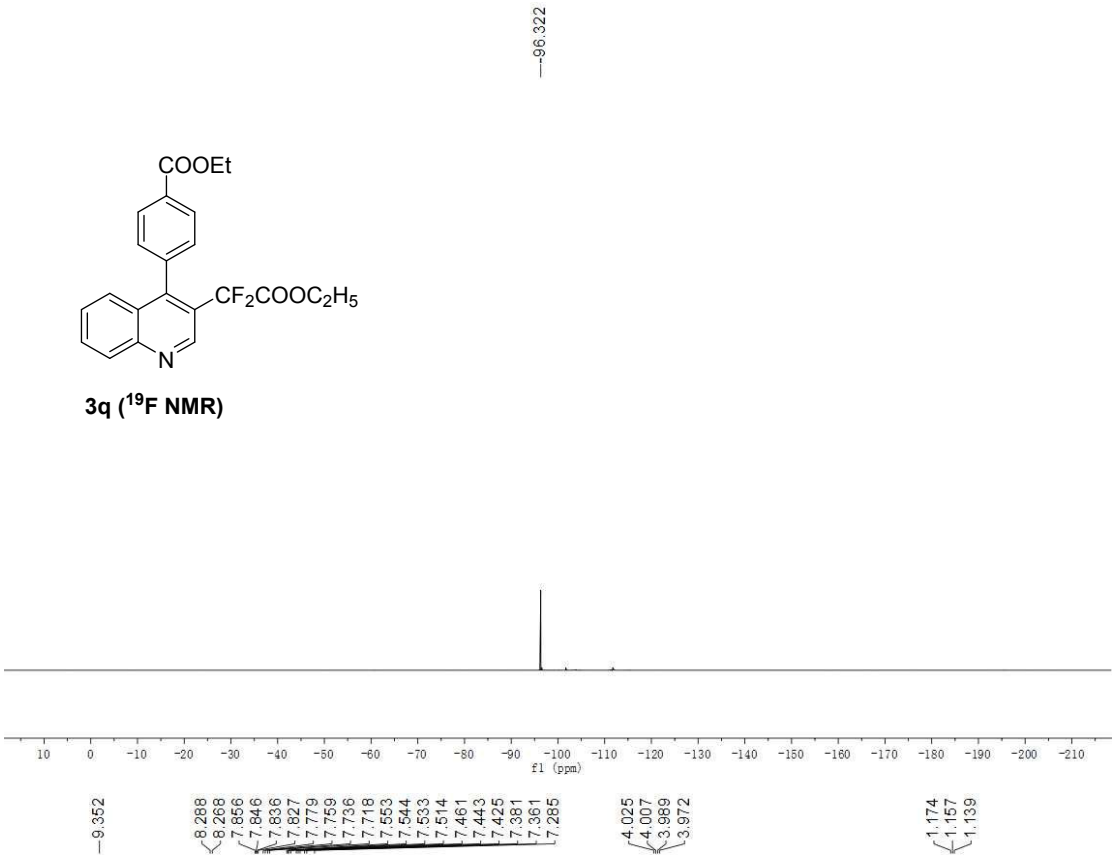
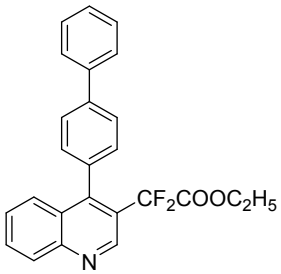
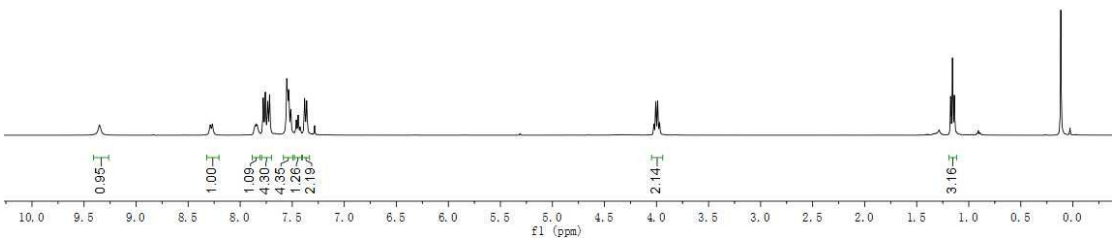
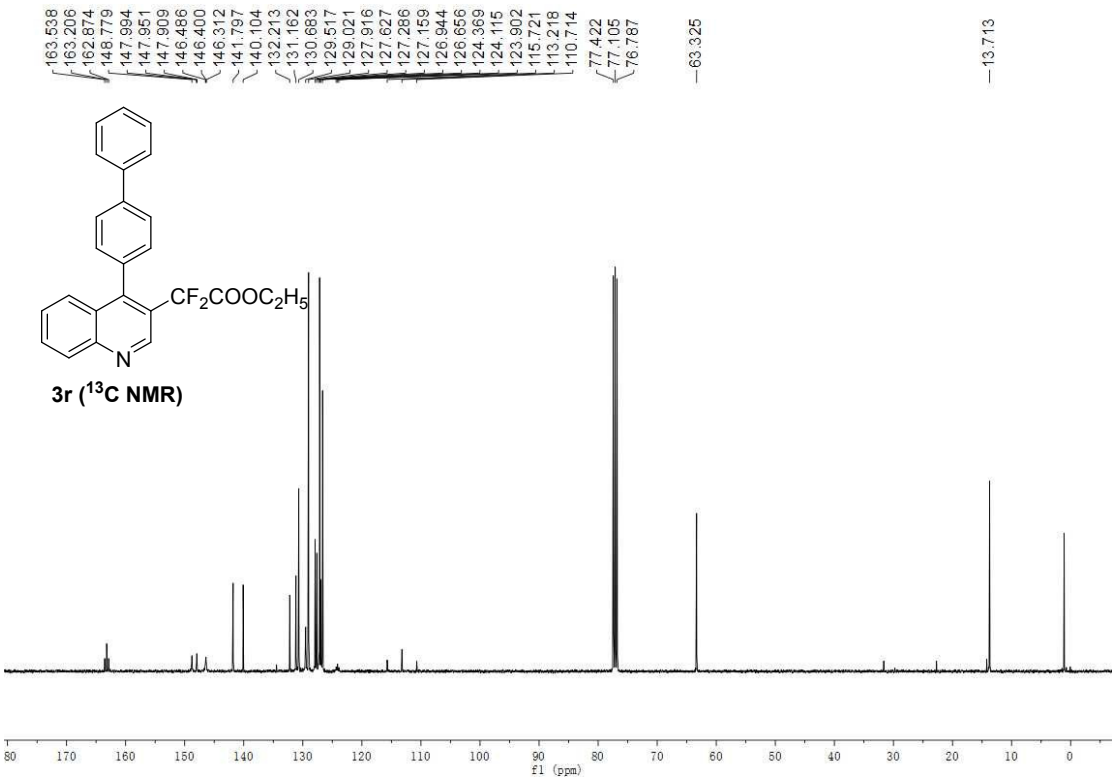




3r (^{1}H NMR)





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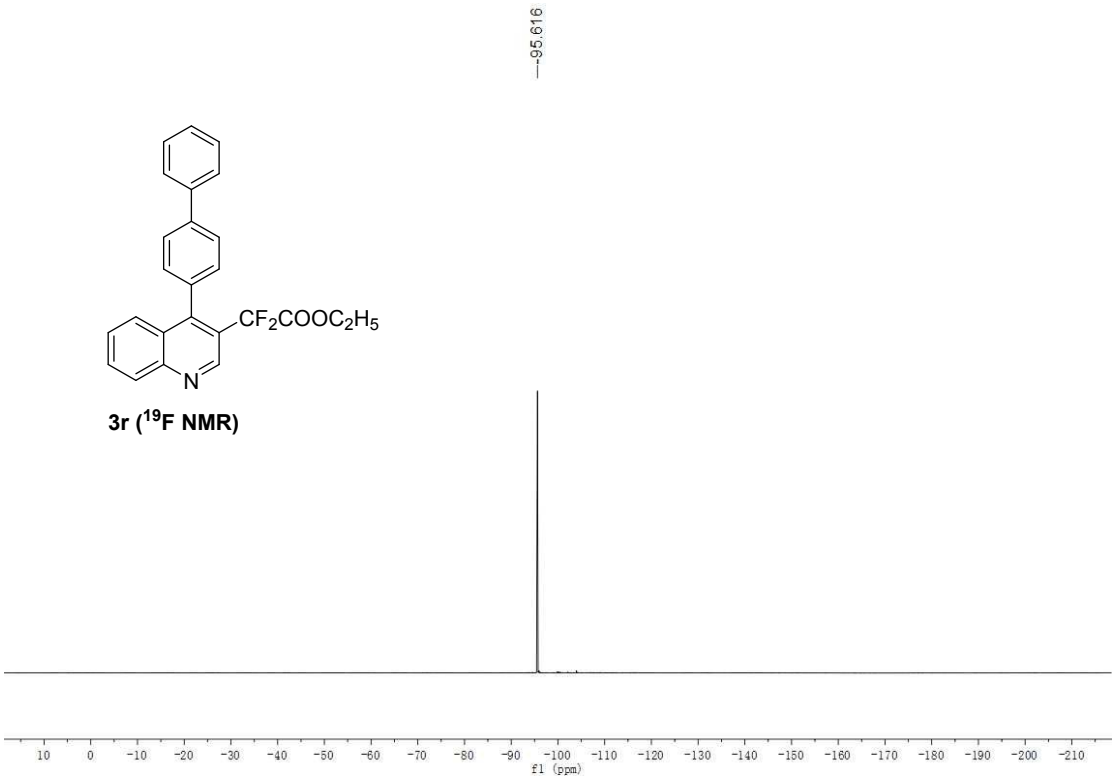

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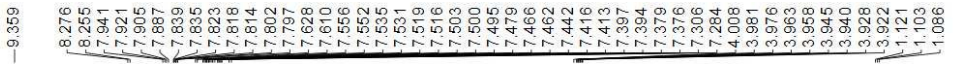
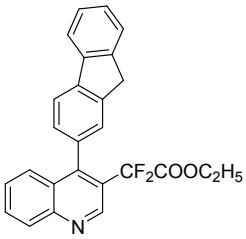
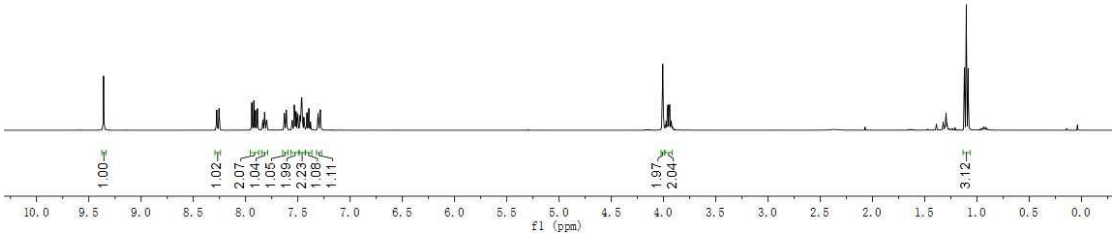
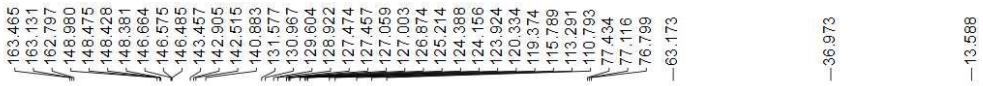
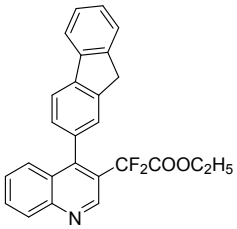




3s (^{1}H NMR)







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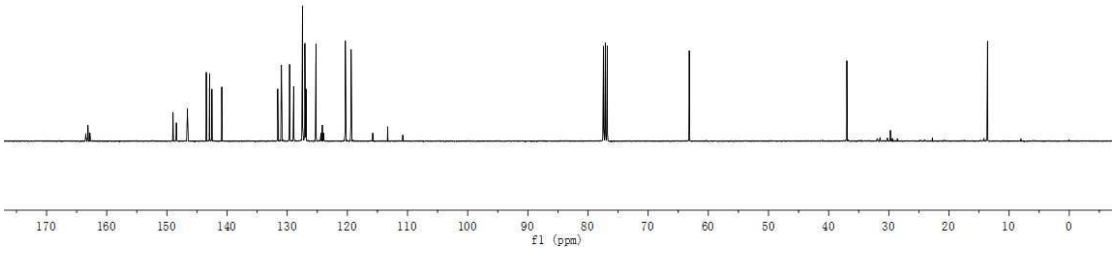
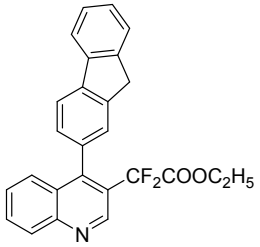
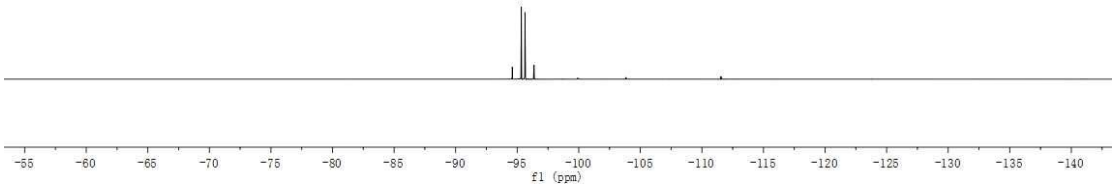
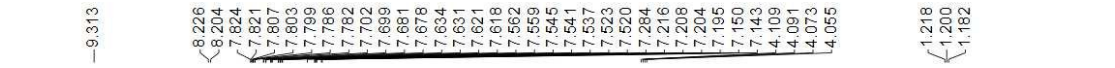
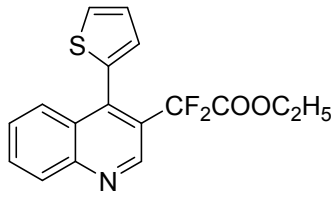




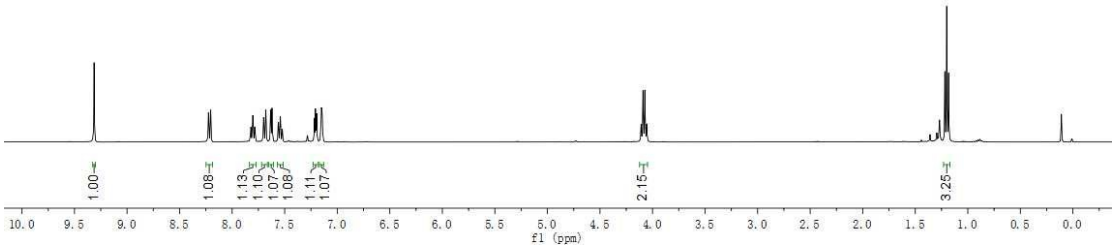
3s (^{19}F NMR)

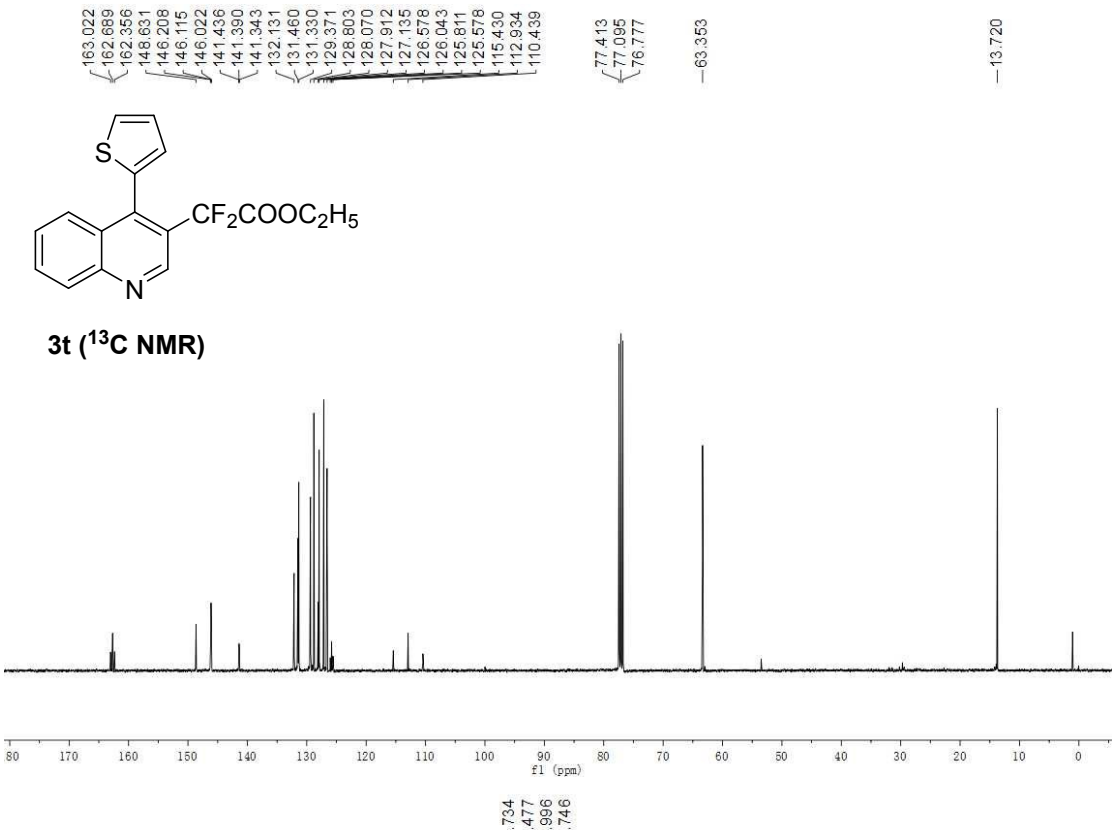




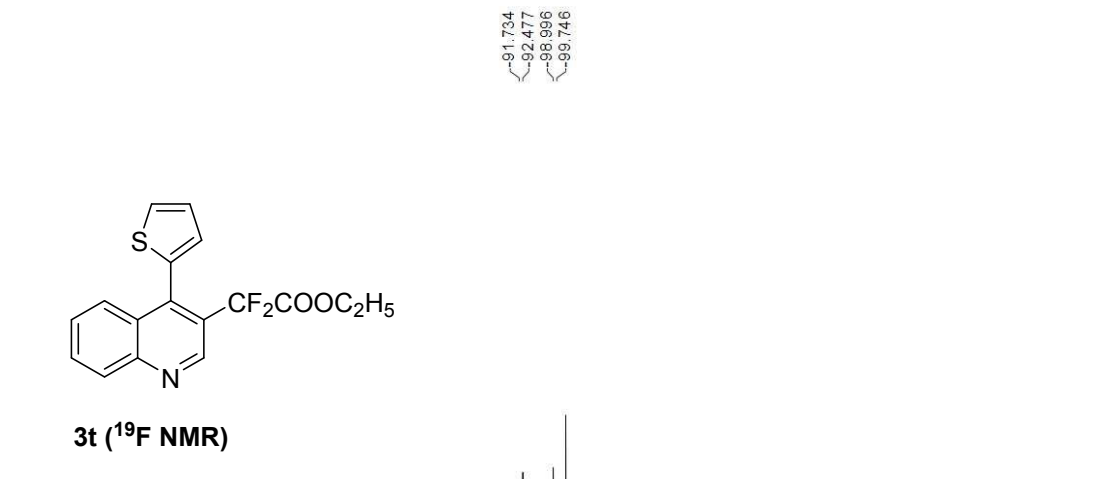


3t (^{1}H NMR)

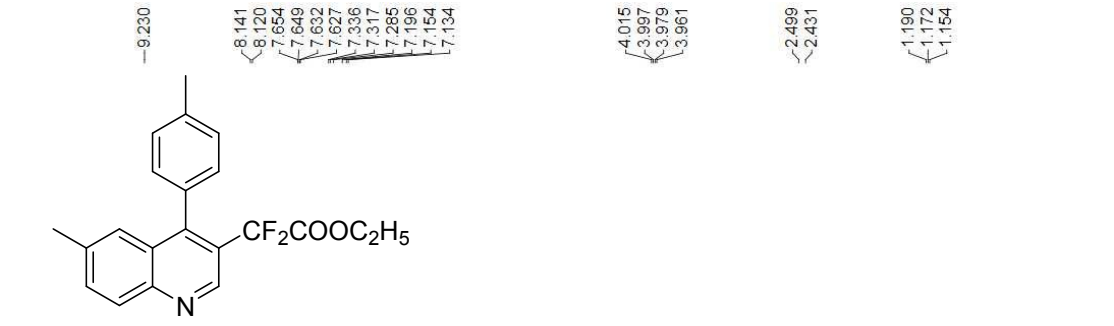




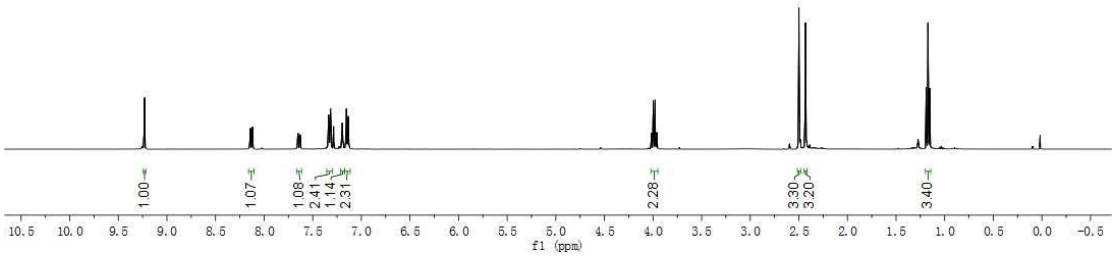
3t (^{13}C NMR)

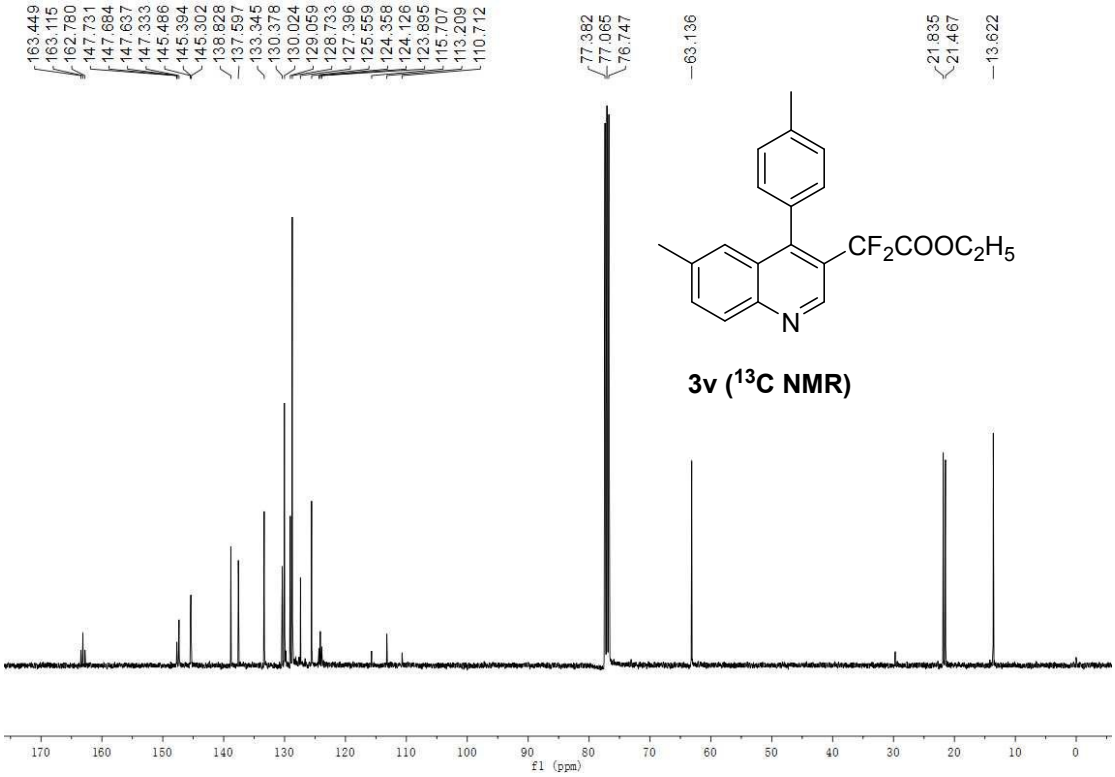


3t (^{19}F NMR)



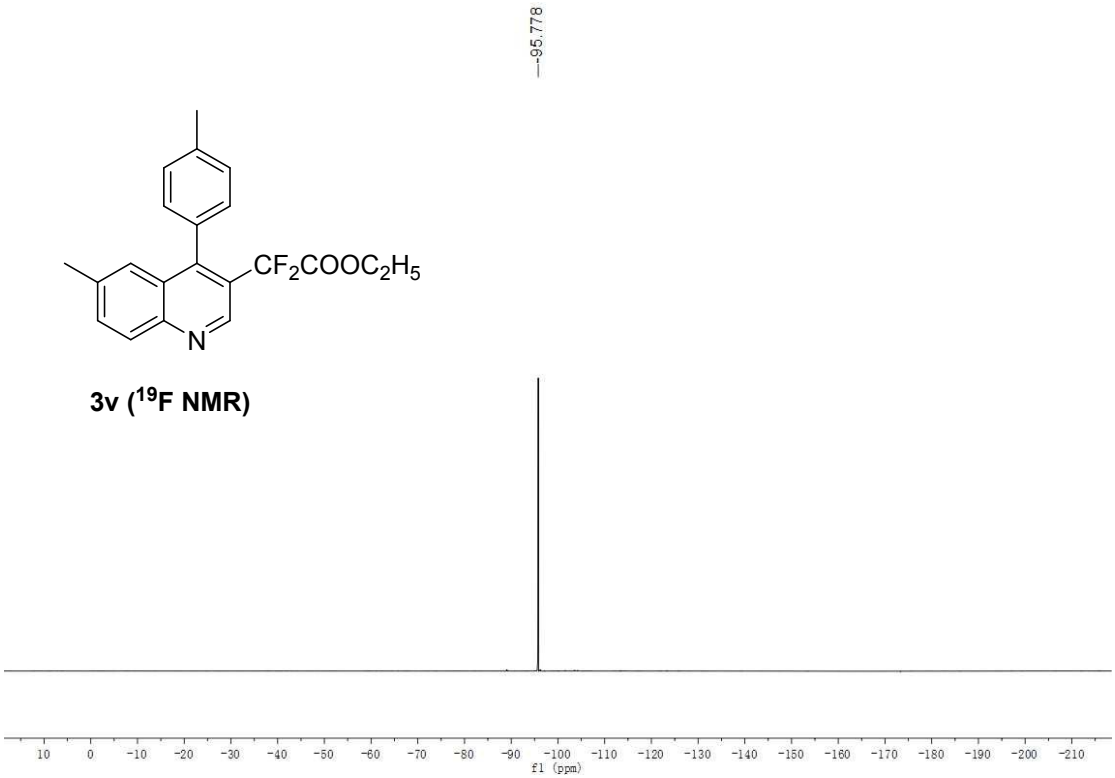
3v (^{1}H NMR)



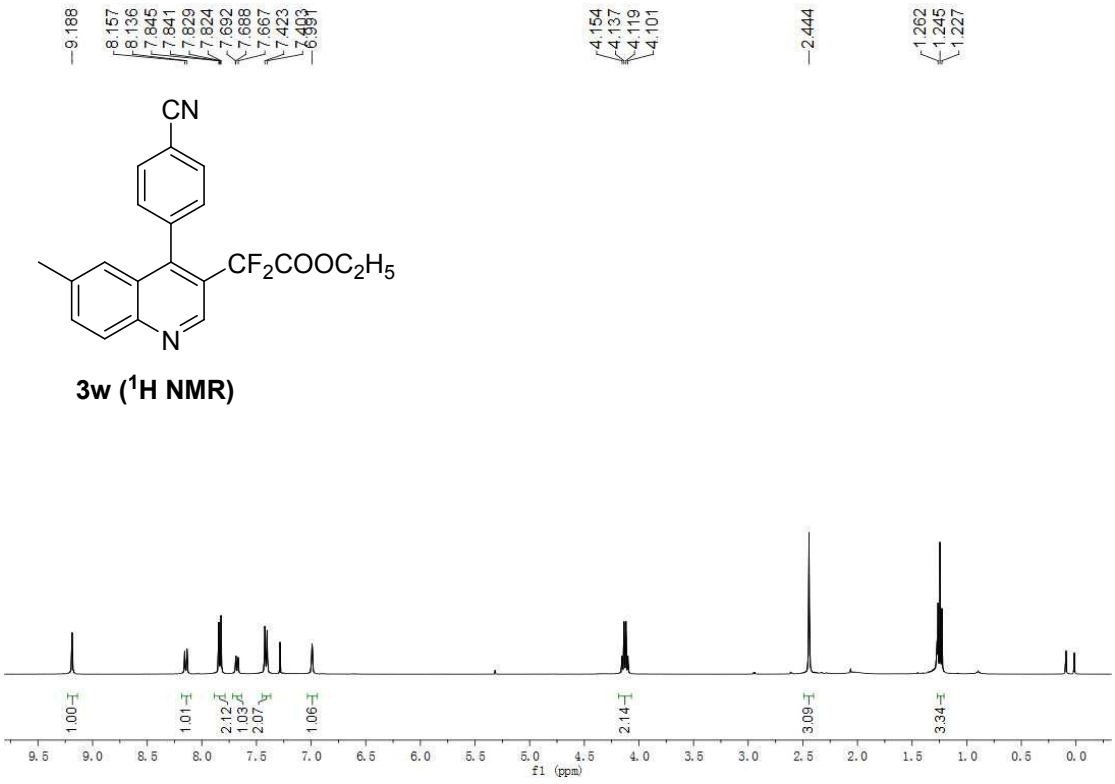


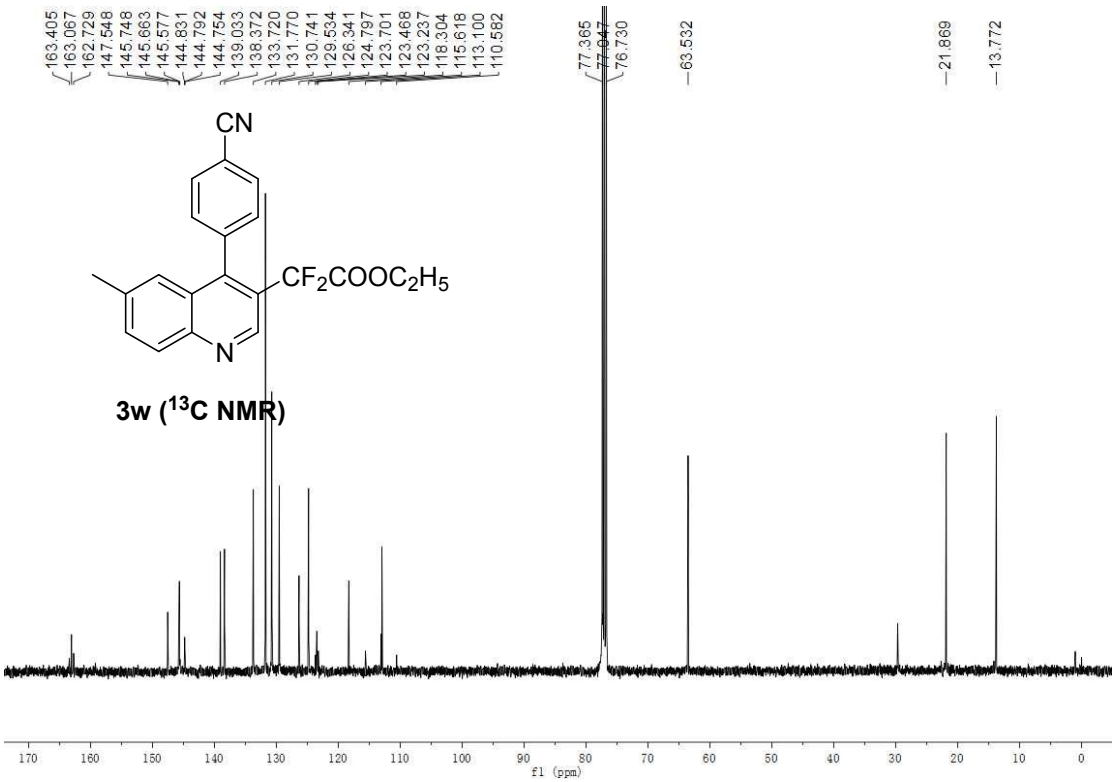
3v (^{13}C NMR)

3v (^{19}F NMR)

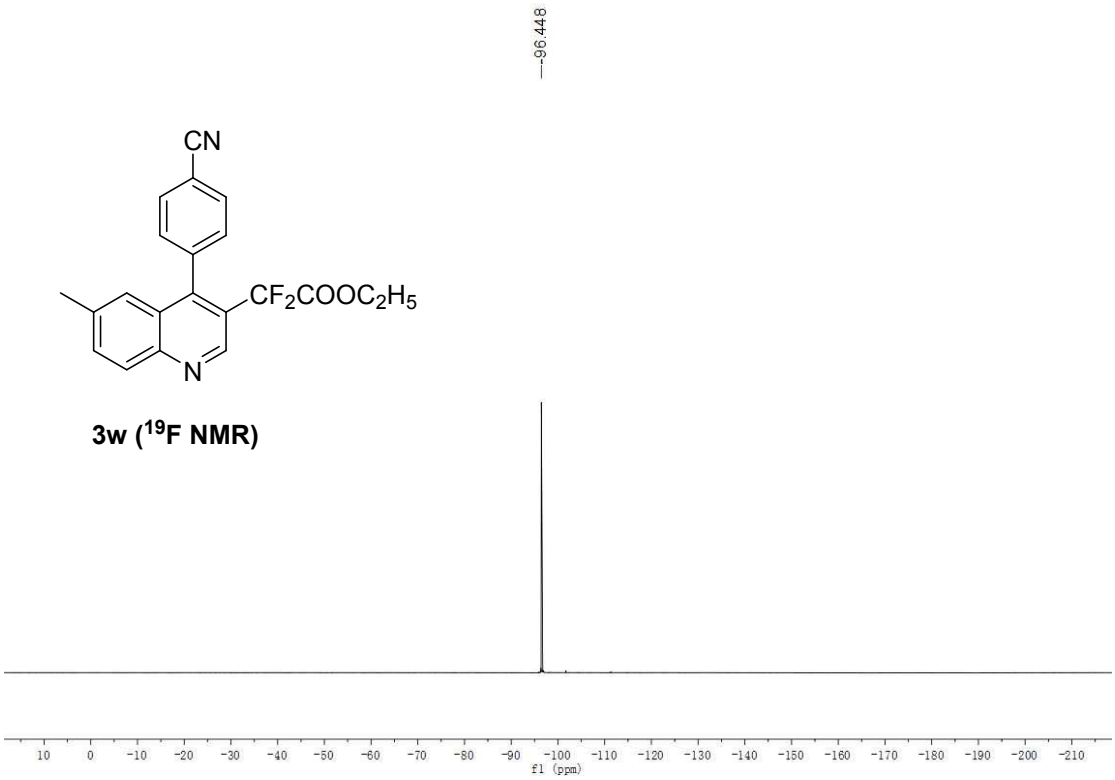


3w (^{1}H NMR)

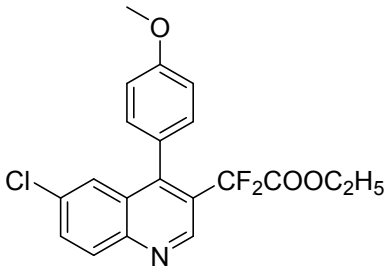




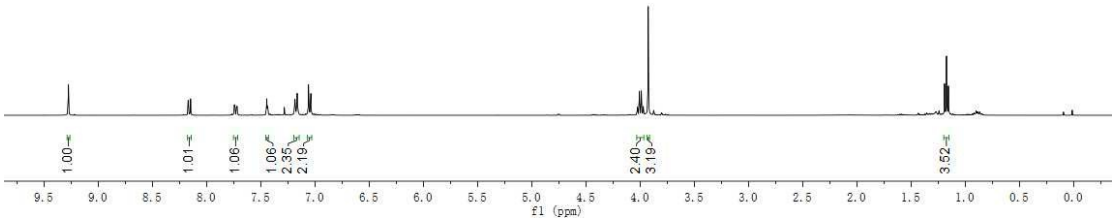
3w (^{13}C NMR)

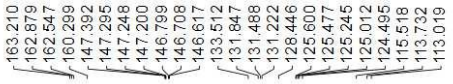


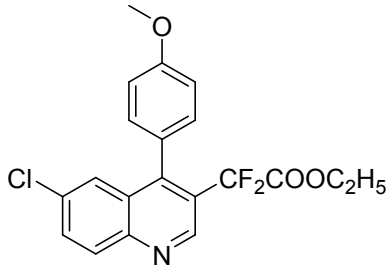
3w (^{19}F NMR)



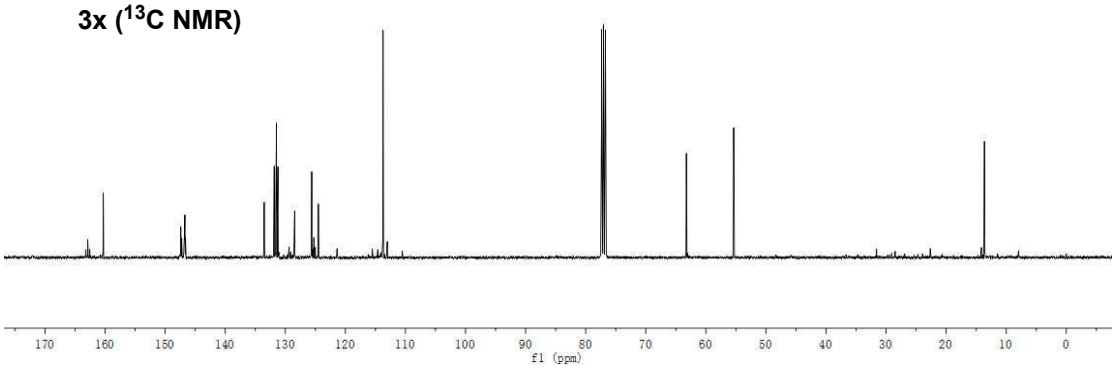
3x (^{1}H NMR)



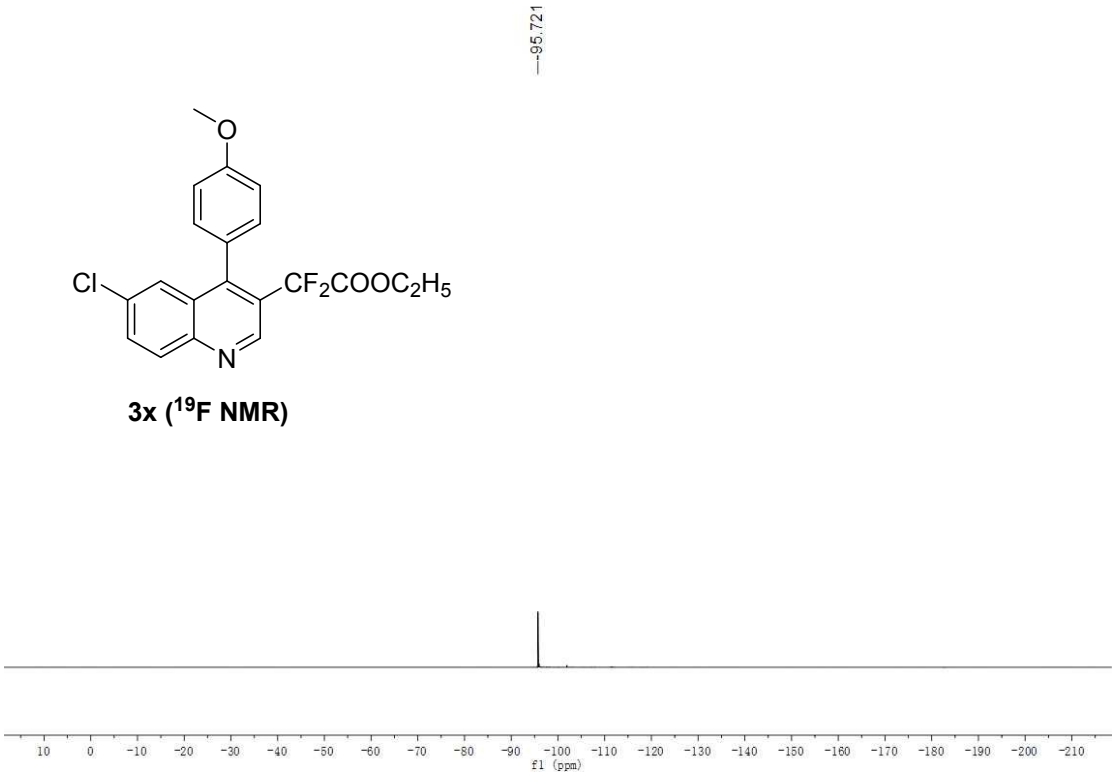




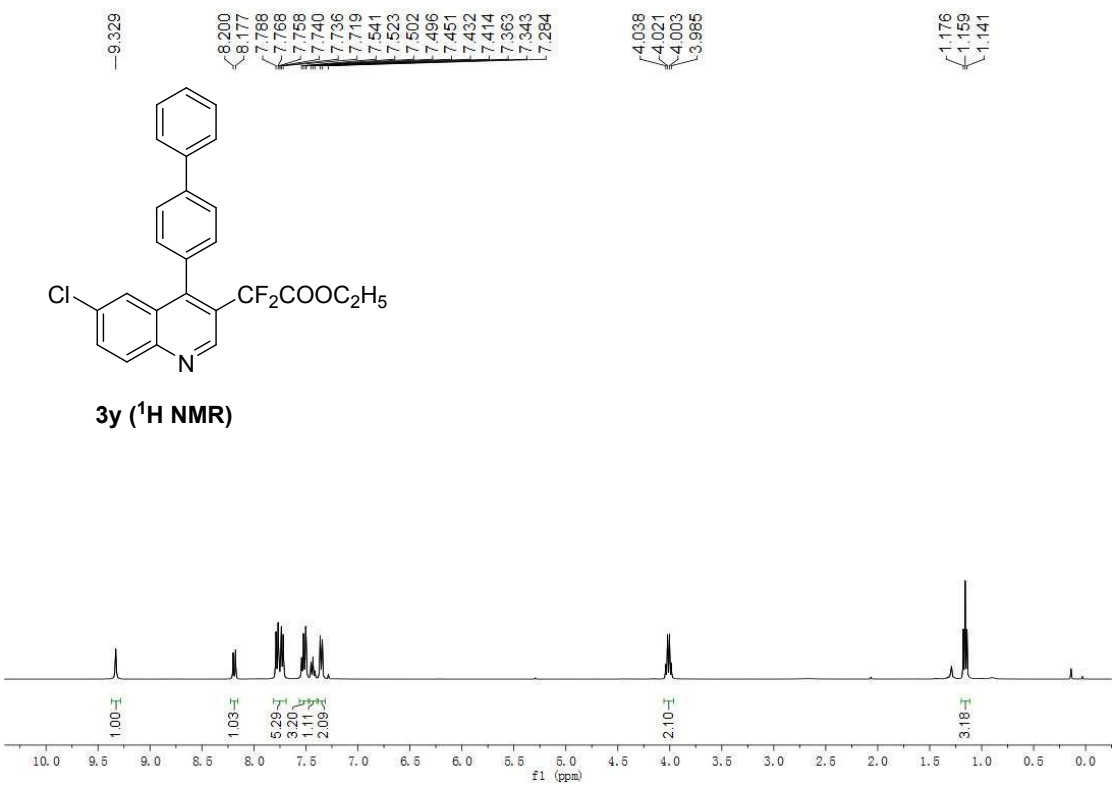
3x (^{13}C NMR)

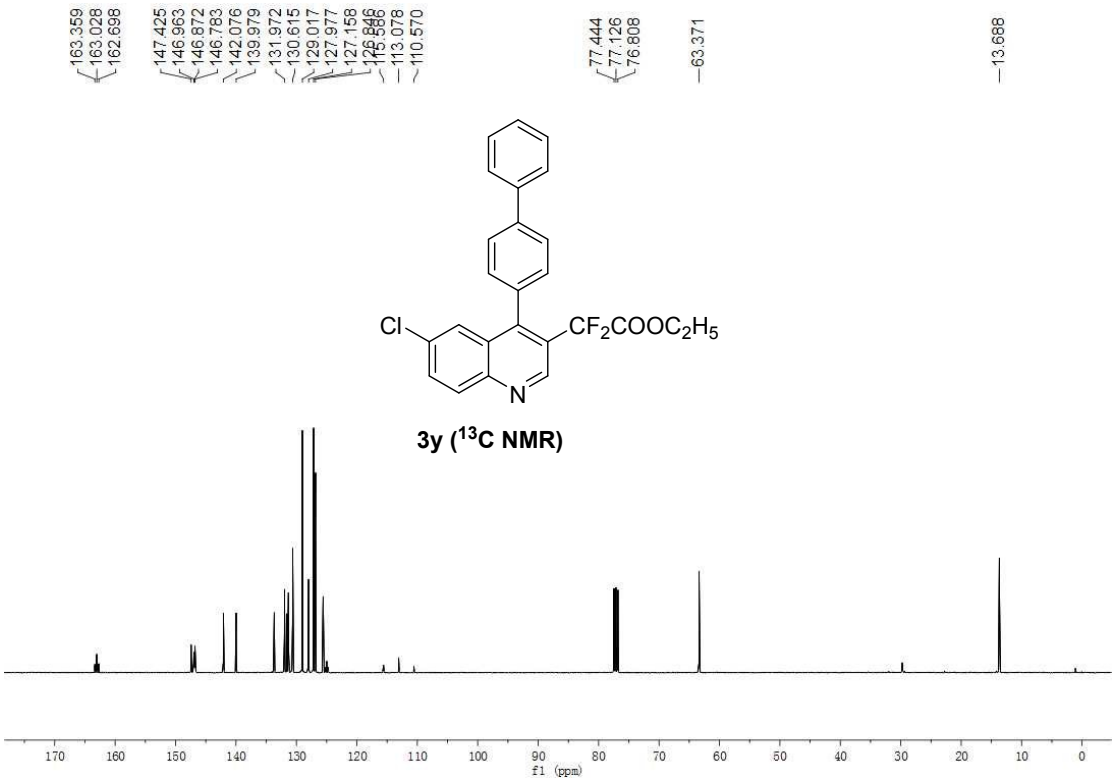


3x (^{19}F NMR)

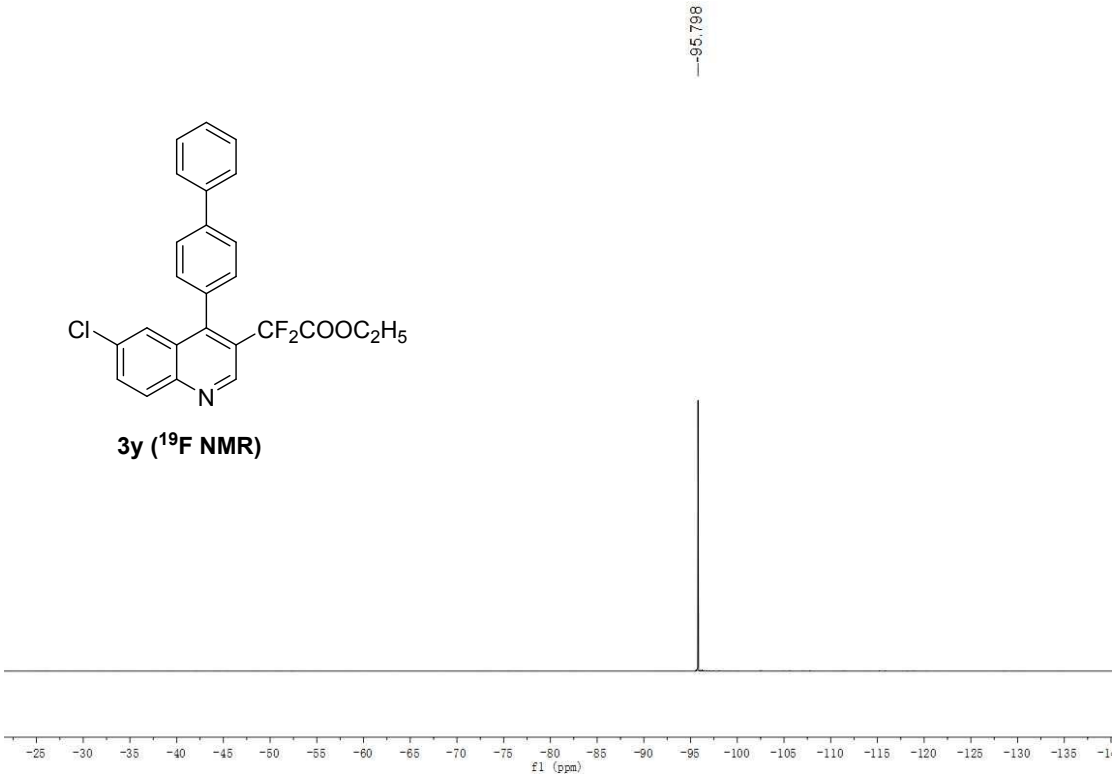


3y (^{1}H NMR)

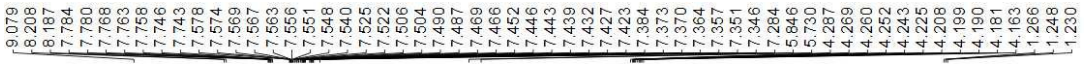


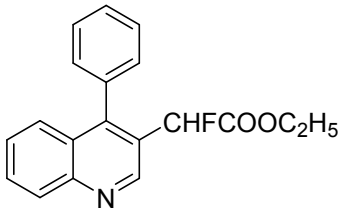


3y (^{13}C NMR)

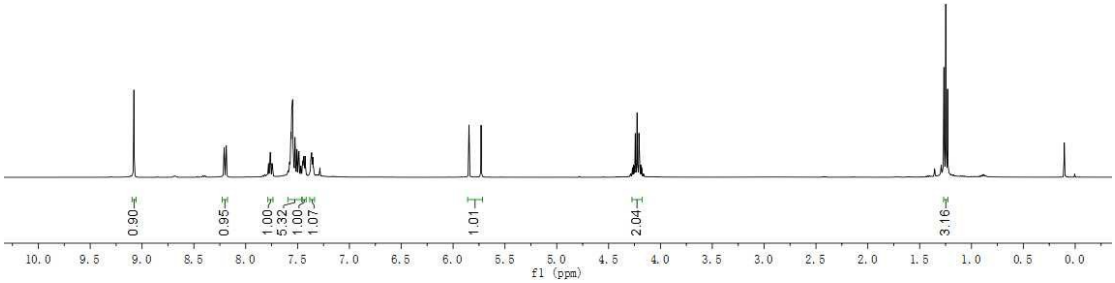


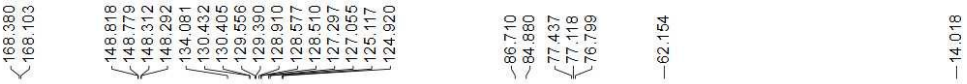
3y (^{19}F NMR)

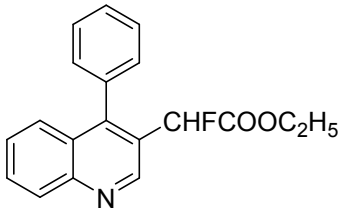




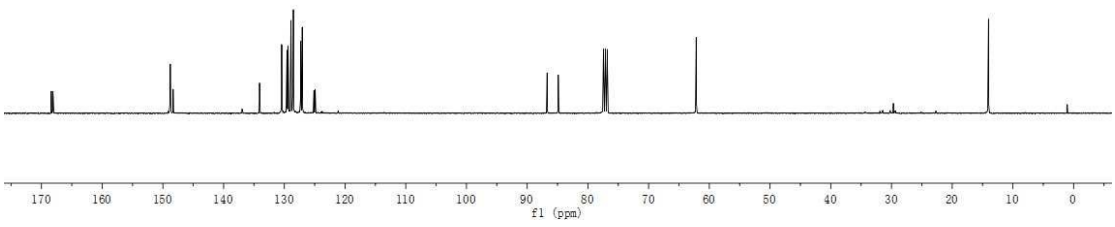
5a (^{1}H NMR)



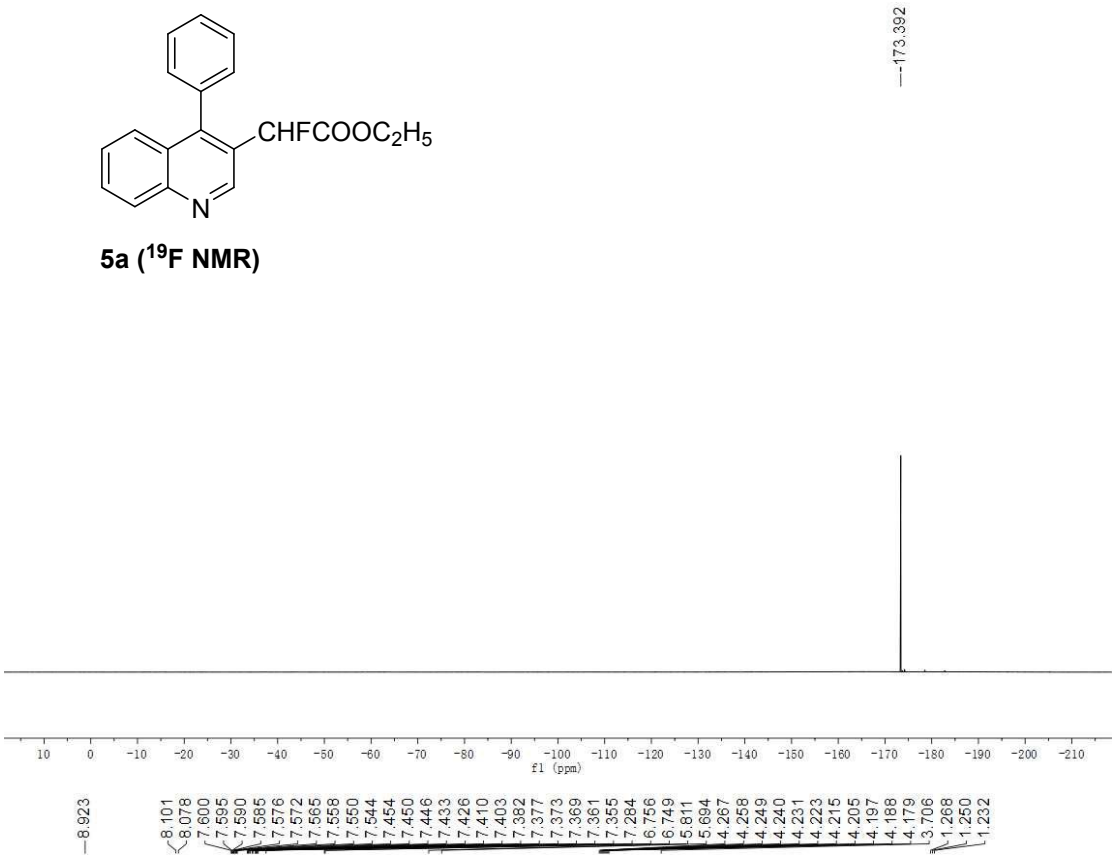


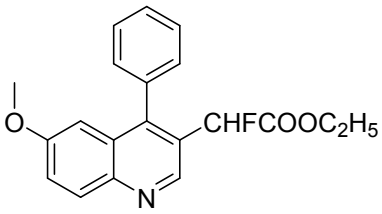


5a (^{13}C NMR)

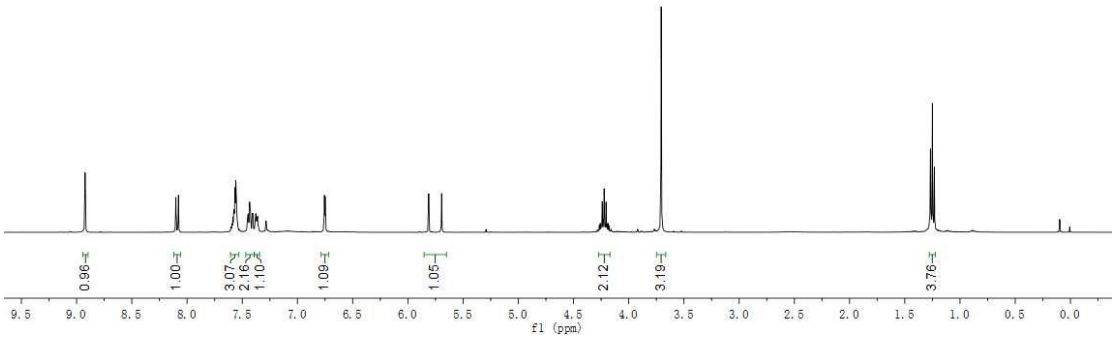


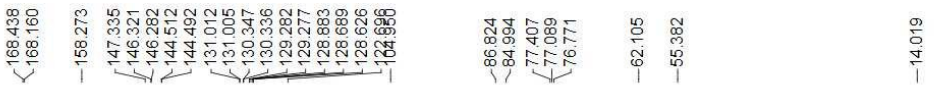
5a (^{19}F NMR)

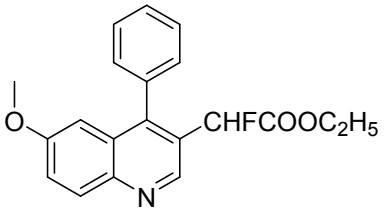




5e (^{1}H NMR)







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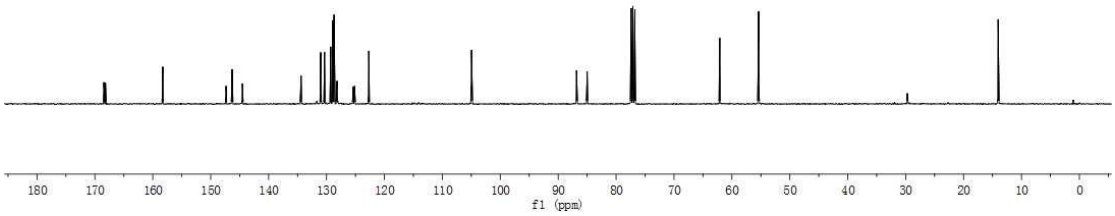

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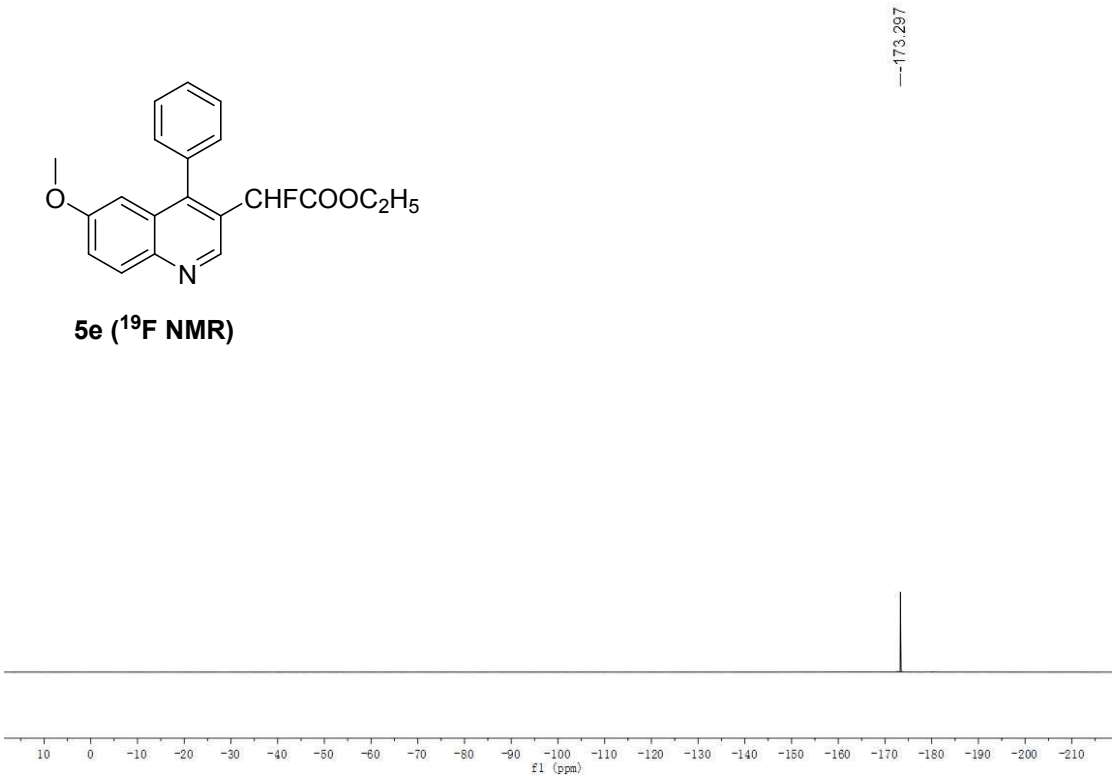
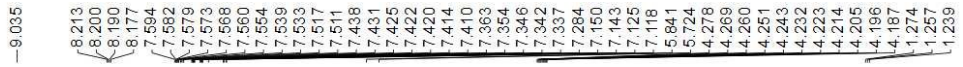
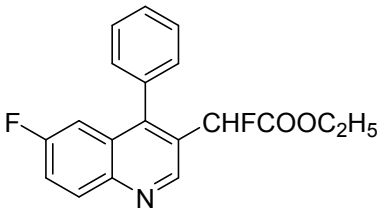
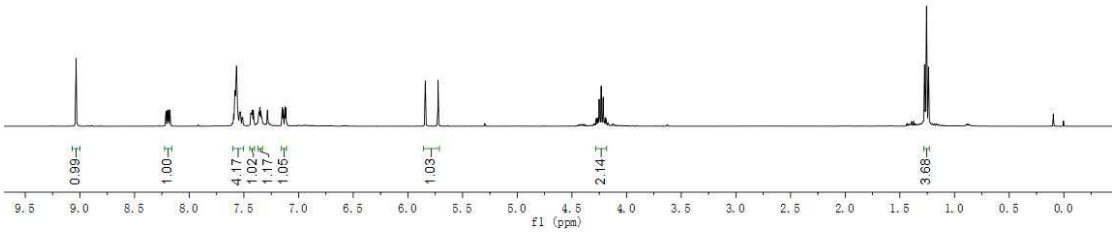
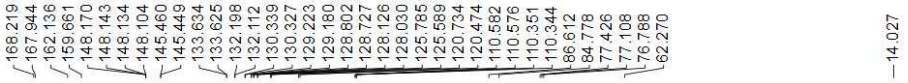


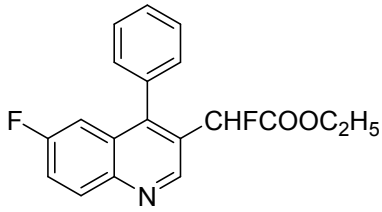




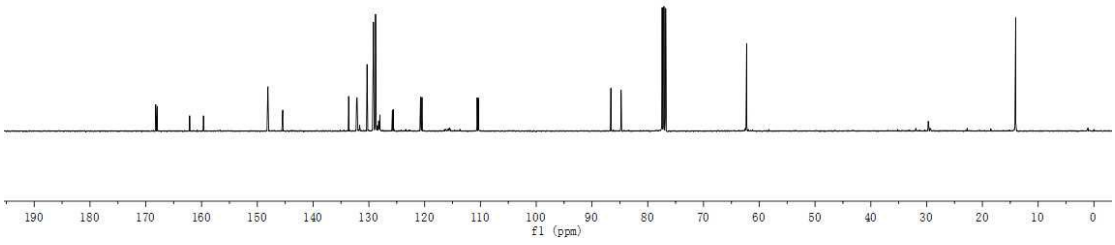
5g (^{1}H NMR)

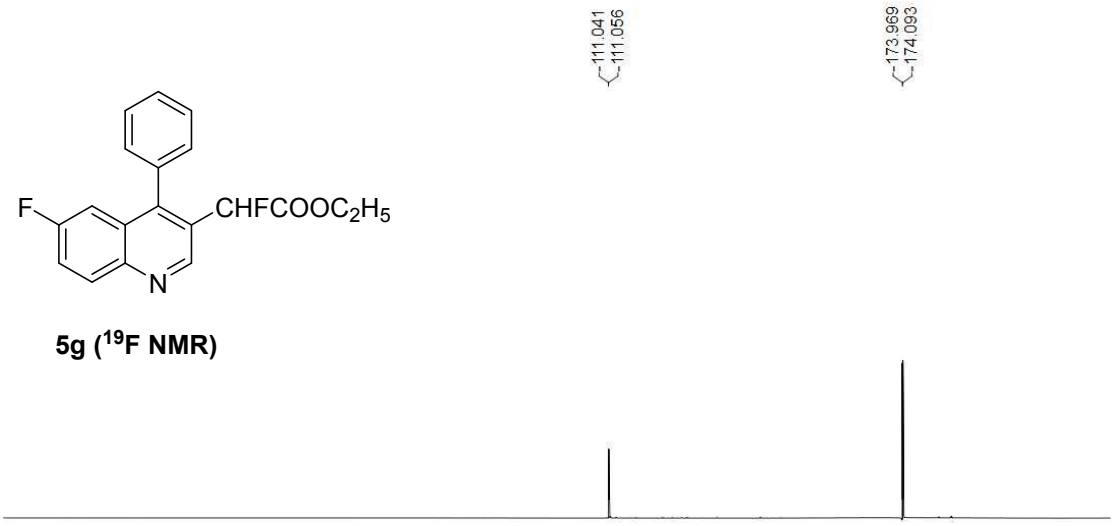






5g (^{13}C NMR)





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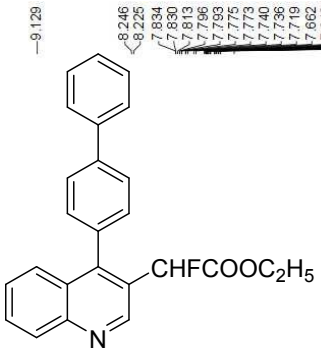
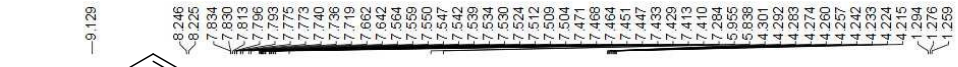
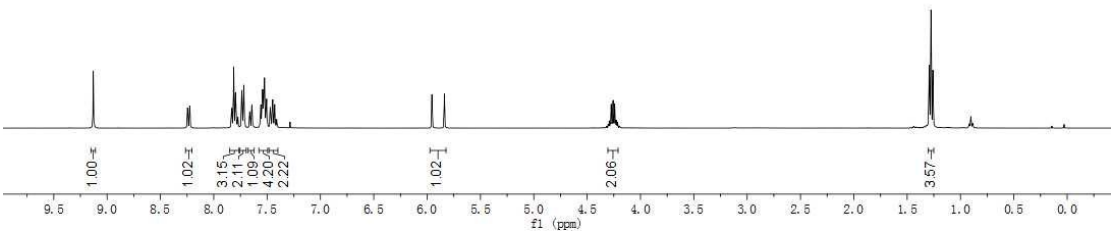
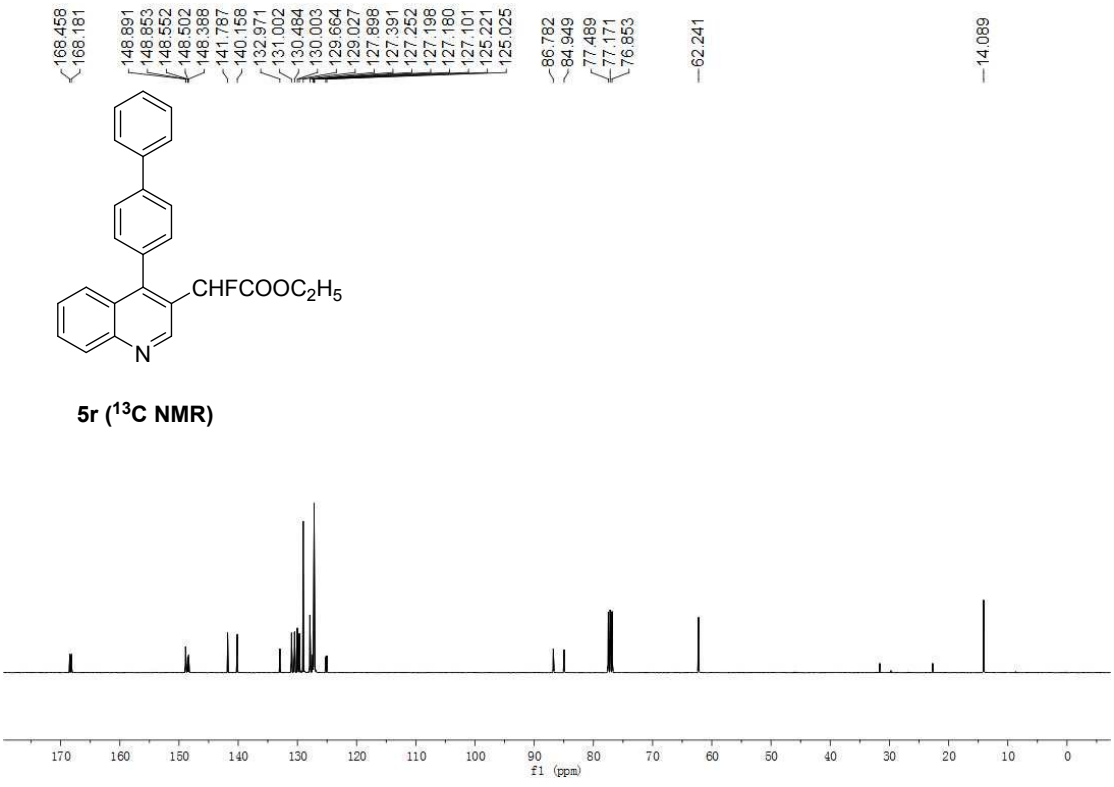


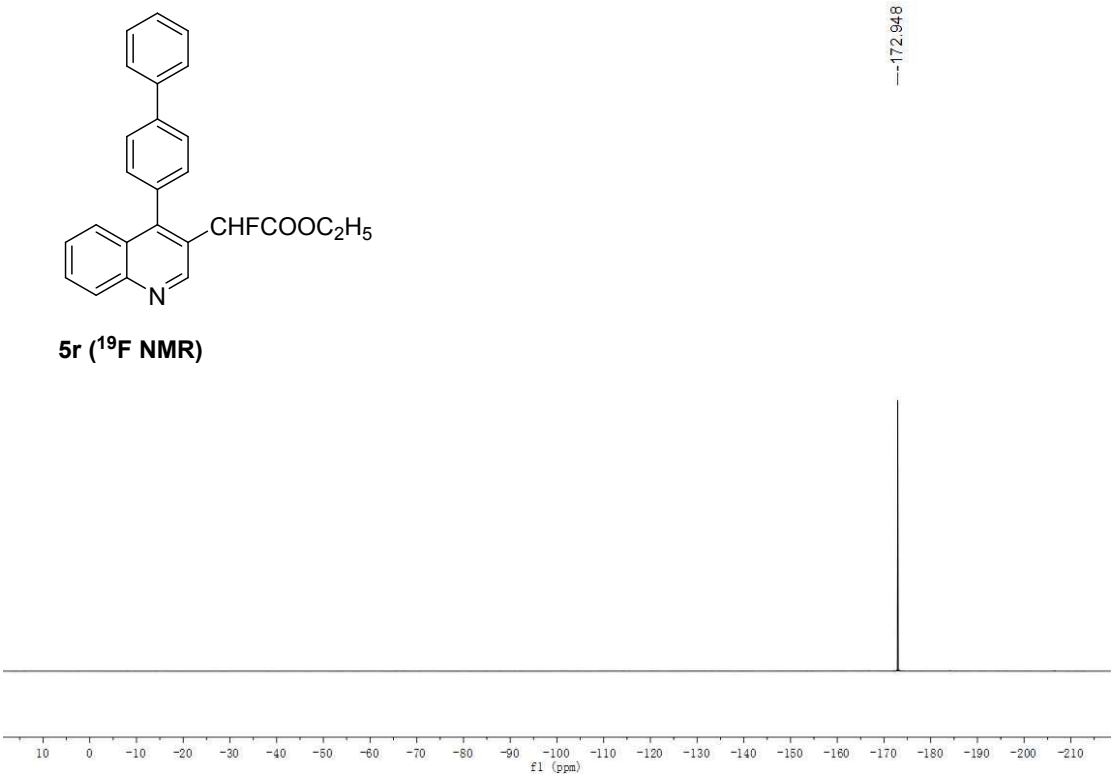


5r (^{1}H NMR)

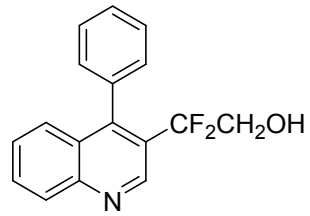




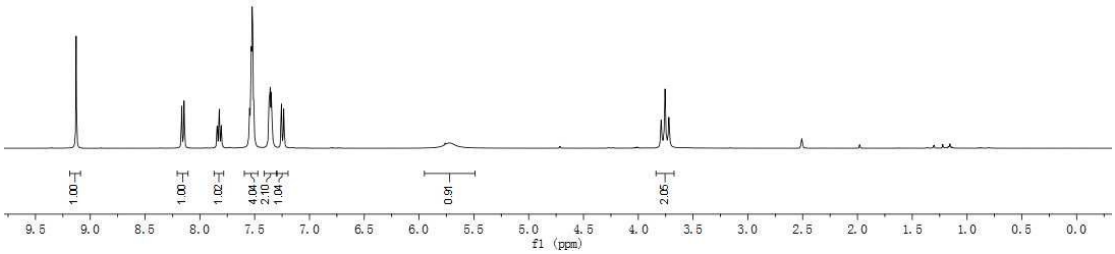
5r (^{13}C NMR)

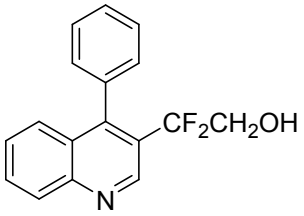


5r (^{19}F NMR)

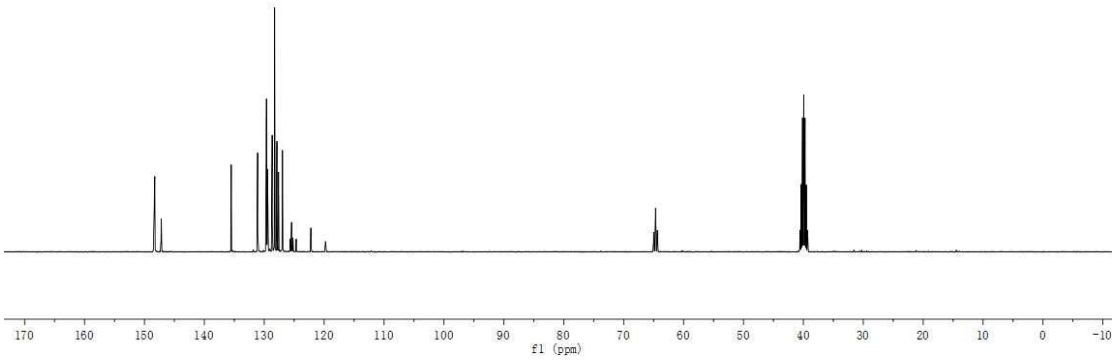


6 (^{1}H NMR)

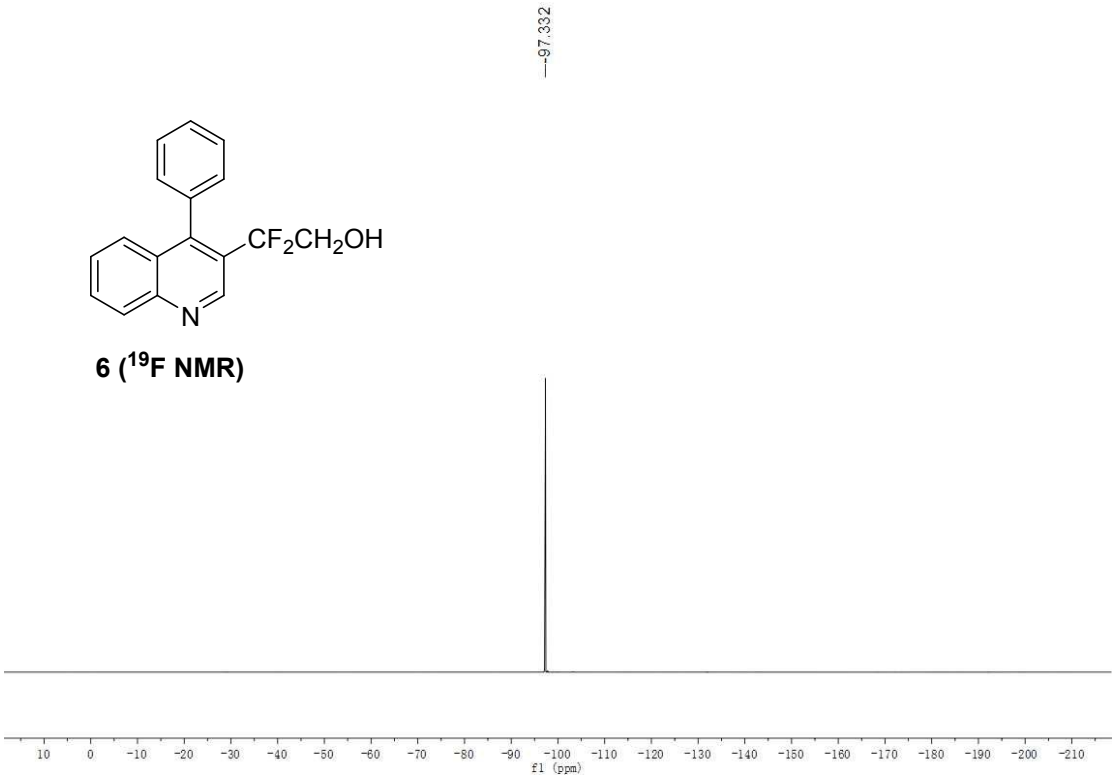


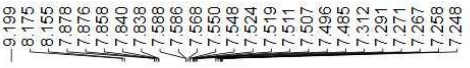


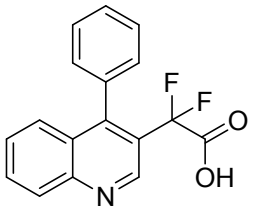
6 (^{13}C NMR)



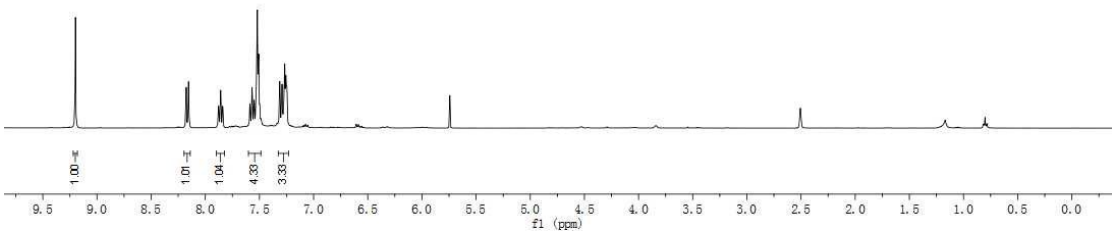
6 (^{19}F NMR)

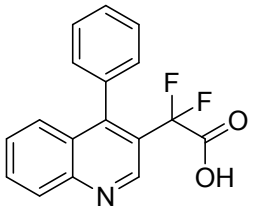




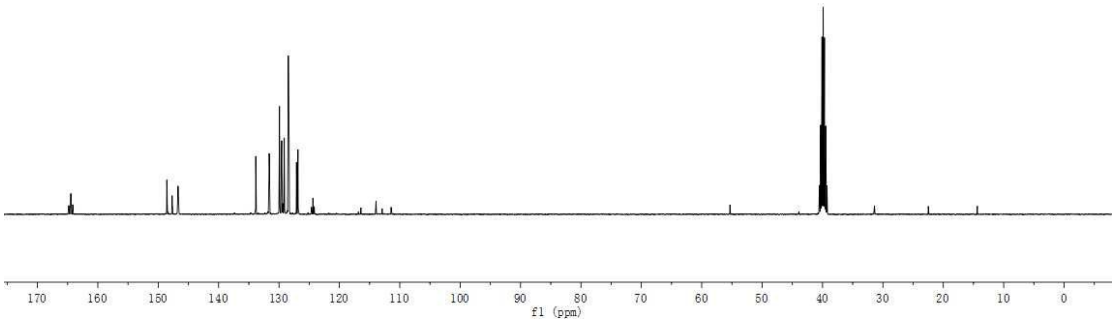


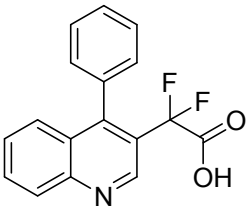
7 (^{1}H NMR)



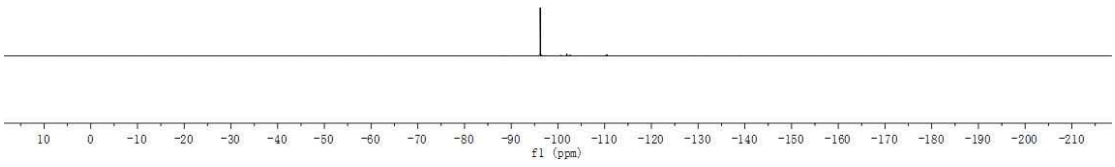


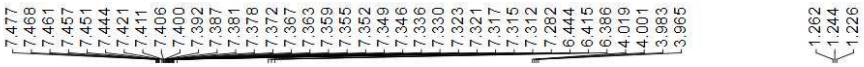
7 (^{13}C NMR)

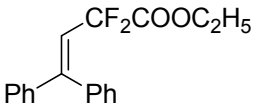




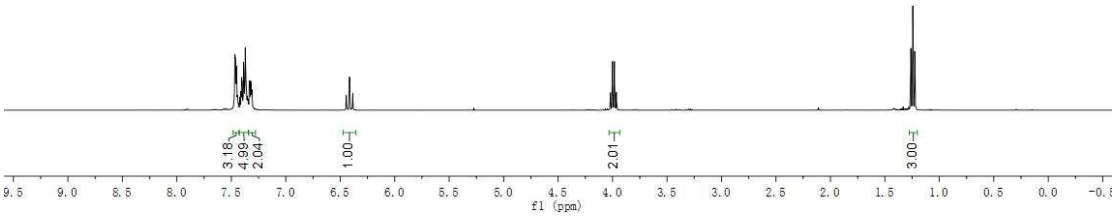
7 (^{19}F NMR)

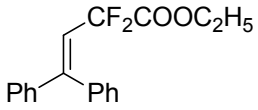




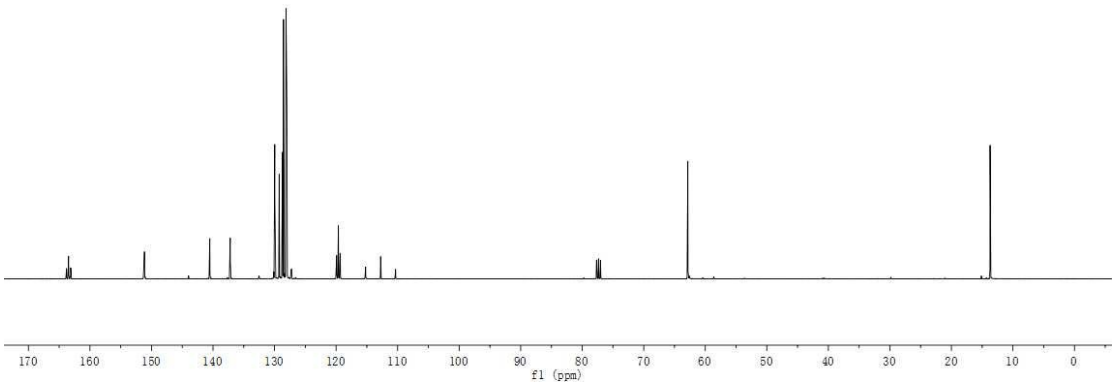


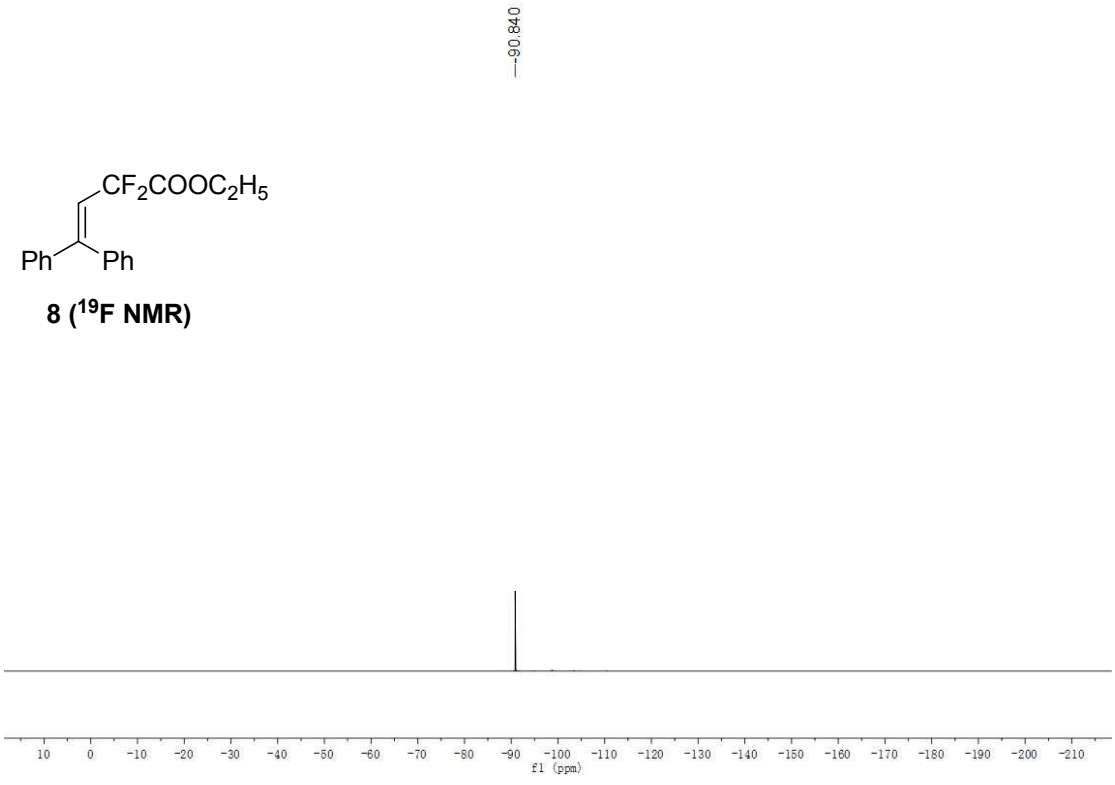
8 (^{1}H NMR)





8 (^{13}C NMR)

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Ph
Ph
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f1 (ppm)

8 (^{19}F NMR)