Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Rh(III)-Catalyzed Simultaneous [3 + 3]/[5 + 1] Annulation of 1-Arylpyrazolidinones with *gem*-Difluorocyclopropenes Leading to Fluorinated Pyridopyrimidinone Derivatives

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Table of Contents

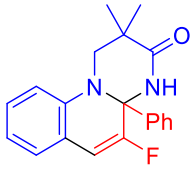
I. General experimental information

Unless otherwise noted, all reagents were purchased from commercial sources and used without further purification. All solvents were purified and dried according to standard methods prior to use. 1-Arylpyrazolidinones (**1**), [1-3] *gem*-difluorocyclopropenes (**2**)[4-6] and $[RhCp^*Cl_2]_2$[7] were prepared based on literature procedures, respectively. Melting points were recorded with a micro melting point apparatus and uncorrected. The ^1H NMR spectra were recorded at 400 MHz or 600 MHz. The ^{13}C NMR spectra were recorded at 100 MHz or 150 MHz. The ^{19}F NMR spectra were recorded at 376 MHz or 565 MHz. Chemical shifts were expressed in parts per million (δ), and were reported as s (singlet), d (doublet), t (triplet), dd (doublet of doublets), m (multiplet), etc. The coupling constants *J* were given in Hz. High resolution mass spectra (HRMS) were obtained *via* ESI mode by using a MicrOTOF mass spectrometer. All reactions were monitored by thin layer chromatography (TLC) using silica gel plates (silica gel 60 F254 0.25 mm), and components were visualized by observation under UV light (254 and 365 nm).

II. Experimental procedures and spectroscopic data

1. Typical procedure for the synthesis of 3a and spectroscopic data of 3a-3jj

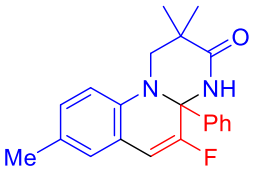
To a reaction tube equipped with a stir bar were added 4,4-dimethyl-1-phenylpyrazolidin-3-one (**1a**, 76.1 mg, 0.4 mmol), $[RhCp^*Cl_2]_2$ (6.2 mg, 0.01 mmol), KOAc (19.6 mg, 0.2 mmol), DCM (**2** mL) and (3,3-difluorocycloprop-1-en-1-yl)benzene (**2a**, 30.4 mg, 0.2 mmol). The tube was then sealed, and the mixture was stirred at 80 ℃ (oil bath) under air for 18 h. Upon completion, it was cooled to room temperature, filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether/ethyl acetate (3:1) as eluent to afford **3a**. Other products **3b-3jj** were obtained in a similar manner.



3a

5-Fluoro-2,2-dimethyl-4a-phenyl-4,4a-dihydro-1*H*-pyrimido[1,2-*a*]quinolin-3(2*H*)-one (3a)

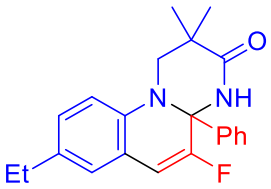
Eluent: petroleum ether/ethyl acetate (3:1). Yollow solid (50.3 mg, 78%), mp 181.3-181.7 ^oC. ^1H NMR (400 MHz, $CDCl_3$): δ 7.42-7.40 (m, 2H), 7.37-7.33 (m, 3H), 7.14 (t, J = 7.6 Hz, 1H), 7.03 (d, J = 7.2 Hz, 1H), 6.83 (s, 1H), 6.77-6.72 (m, 2H), 6.27 (d, J = 12.4 Hz, 1H), 3.66 (dd, J = 14.4 Hz, 1.6 Hz, 1H), 2.96 (d, J = 14.4 Hz, 1H), 1.27 (s, 3H), 1.19 (s, 3H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$): δ 176.2, 152.9 (d, J_{C-F} = 259.1 Hz), 141.5 (d, J_{C-F} = 2.3 Hz), 139.4, 129.1 (d, J_{C-F} = 3.0 Hz), 129.0, 128.7, 127.9 (d, J_{C-F} = 5.3 Hz), 125.8, 118.4, 116.9 (d, J_{C-F} = 6.7 Hz), 109.9, 104.3 (d, J_{C-F} = 16.4 Hz), 75.6 (d, J_{C-F} = 26.6 Hz), 48.8 (d, J_{C-F} = 2.1 Hz), 40.8, 26.0, 22.6. ^{19}F NMR (376 MHz, $CDCl_3$): δ -128.4 (d, J = 12.4 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{20}H_{20}FN_2O$ 323.1554; Found 323.1549.



3b

5-Fluoro-2,2,8-trimethyl-4a-phenyl-4,4a-dihydro-1*H*-pyrimido[1,2-*a*]quinolin-3(2*H*)-one (3b)

Eluent: petroleum ether/ethyl acetate (3:1). White solid (45.8 mg, 68%), mp 185.2-185.9 ^{o}C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.41-7.39 (m, 2H), 7.35-7.32 (m, 3H), 6.94 (d, *J* = 8.4 Hz, 1H), 6.85 (s, 2H), 6.62 (d, *J* = 8.4 Hz, 1H), 6.22 (d, *J* = 12.0 Hz, 1H), 3.61 (dd, *J* = 14.0 Hz, 2.0 Hz, 1H), 2.94 (d, *J* = 14.4 Hz, 1H), 2.25 (s, 3H), 1.27 (s, 3H), 1.18 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 176.2, 153.2 (d, $J_{C\text{-}F}$ = 258.9 Hz), 141.5 (d, $J_{C\text{-}F}$ = 1.8 Hz), 137.3, 129.6 (d, $J_{C\text{-}F}$ = 1.9 Hz), 129.0, 128.7, 128.4 (d, $J_{C\text{-}F}$ = 5.3 Hz) 127.6, 125.8, 116.9 (d, $J_{C\text{-}F}$ = 6.8 Hz), 110.0, 104.2 (d, $J_{C\text{-}F}$ = 15.8 Hz), 75.6 (d, $J_{C\text{-}F}$ = 26.1 Hz), 49.0 (d, $J_{C\text{-}F}$ = 1.4 Hz), 40.8, 26.1, 22.6, 20.2. ^{19}F NMR (376 MHz, $CDCl_3$): δ -128.2 (d, *J* = 12.8 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{21}H_{22}FN_2O$ 337.1711; Found 337.1704.

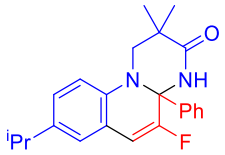


3c

8-Ethyl-5-fluoro-2,2-dimethyl-4a-phenyl-4,4a-dihydro-1*H*-pyrimido[1,2-*a*]quinolin-3(2*H*)-one (3c)

Eluent: petroleum ether/ethyl acetate (3:1). Yollow solid (49.1 mg, 70%), mp 146.8-147.7 ^{o}C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.42-7.40 (m, 2H), 7.37-7.33 (m, 3H), 6.97 (dd, *J* = 8.4 Hz, 2.0 Hz, 1H), 6.87 (d, *J* = 1.6 Hz, 1H), 6.75 (s, 1H), 6.65 (d, *J* = 8.4 Hz, 1H), 6.24 (d, *J* = 12.4 Hz, 1H), 3.62 (dd, *J* = 14.4 Hz, 2.0 Hz, 1H), 2.94 (d, *J* = 14.4 Hz, 1H), 2.56 (q, *J* = 7.6 Hz, 2H), 1.28 (s, 3H), 1.22 (t, *J* = 7.6 Hz, 3H), 1.18 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 176.1, 153.1 (d, $J_{C\text{-}F}$ = 259.3 Hz), 141.6 (d, $J_{C\text{-}F}$ = 1.7 Hz), 137.5, 134.1, 129.0, 128.7, 128.4 (d, $J_{C\text{-}F}$ = 2.1 Hz), 127.2 (d, $J_{C\text{-}F}$ = 5.9 Hz), 125.8, 116.9 (d, $J_{C\text{-}F}$ = 8.0 Hz), 109.9, 104.4 (d, $J_{C\text{-}F}$ =

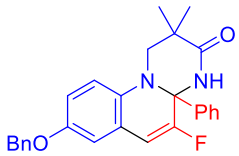
15.9 Hz), 75.6 (d, J_{C-F} = 26.5 Hz), 48.9 (d, J_{C-F} = 2.1 Hz), 40.8, 27.6, 26.1, 22.6, 15.6. ^{19}F NMR (376 MHz, $CDCl_3$): δ -128.6 (d, J = 9.8 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{22}H_{24}FN_2O$ 351.1867; Found 351.1845.



3d

5-Fluoro-8-isopropyl-2,2-dimethyl-4a-phenyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3d)

Eluent: petroleum ether/ethyl acetate (3:1). Yellowish solid (48.1 mg, 66%), mp 123.5-124.5 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.42-7.40 (m, 2H), 7.37-7.33 (m, 3H), 6.99 (dd, J = 8.4 Hz, 1.8 Hz, 1H), 6.89 (d, J = 2.4 Hz, 1H), 6.65 (d, J = 8.4 Hz, 1H), 6.62 (s, 1H), 6.26 (d, J = 12.6 Hz, 1H), 3.63 (dd, J = 13.8 Hz, 1.8 Hz, 1H), 2.94 (d, J = 13.8 Hz, 1H), 2.84-2.80 (m, 1H), 1.28 (s, 3H), 1.23 (d, J = 6.6 Hz, 6H), 1.18 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 176.1, 152.9 (d, J_{C-F} = 258.8 Hz), 141.6, 138.8, 137.5, 129.0, 128.7, 127.0 (d, J_{C-F} = 2.1 Hz), 125.9 (d, J_{C-F} = 4.8 Hz), 125.8, 116.7 (d, J_{C-F} = 5.3 Hz), 109.8, 104.5 (d, J_{C-F} = 15.6 Hz), 75.7 (d, J_{C-F} = 27.3 Hz), 48.9, 40.8, 32.9, 26.2, 24.1, 24.0, 22.7. ^{19}F NMR (565 MHz, $CDCl_3$): δ -128.9 (d, J = 12.4 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{23}H_{25}FN_2NaO$ 387.1843; Found 387.1838.

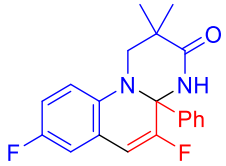


3e

8-(Benzyloxy)-5-fluoro-2,2-dimethyl-4a-phenyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3e)

Eluent: petroleum ether/ethyl acetate (3:1). White solid (59.1 mg, 69%), mp 179.4-180.5 °C.^{1}H NMR (400 MHz, $CDCl_3$): δ 7.44-7.31 (m, 10H), 6.78 (dd, J = 9.2 Hz, 2.8 Hz, 1H), 6.72-6.69 (m, 2H), 6.62 (d, J = 9.2 Hz, 1H), 6.23 (d, J = 12.0 Hz, 1H), 5.01 (s, 2H), 3.54 (dd, J = 13.6 Hz, 1.6 Hz, 1H), 2.93 (d, J = 14.4 Hz, 1H), 1.28 (s, 3H), 1.20 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 176.1, 154.1 (d, J_{C-F} = 261.6 Hz), 151.7, 141.0 (d, J_{C-F} = 1.9 Hz), 137.3, 134.0, 129.1, 128.7, 128.6, 128.0, 127.5, 125.8, 118.4 (d, J_{C-F} = 7.2 Hz), 115.3 (d, J_{C-F} =

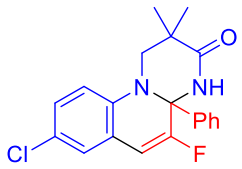
2.7 Hz), 114.4 (d, J_{C-F} = 6.2 Hz), 111.3, 104.4 (d, J_{C-F} = 16.8 Hz), 75.6 (d, J_{C-F} = 25.7 Hz), 70.8, 49.5, 40.6, 26.2, 22.7. ^{19}F NMR (376 MHz, $CDCl_3$): δ -126.5 (d, *J* = 12.4 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{27}H_{26}FN_2O_2$ 429.1973; Found 429.1979.



3f

5,8-Difluoro-2,2-dimethyl-4a-phenyl-4,4a-dihydro-1*H*-pyrimido[1,2-*a*]quinolin-3(2*H*)-one (3f)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (45.6 mg, 67%), mp 184.9-185.9 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.40-7.34 (m, 5H), 6.84 (td, *J* = 8.4 Hz, 2.8 Hz, 1H), 6.78 (dd, *J* = 8.4 Hz, 2.8 Hz, 1H), 6.74 (s, 1H), 6.63 (dd, *J* = 9.2 Hz, 4.4 Hz, 1H), 6.24 (d, *J* = 12.0 Hz, 1H), 3.56 (dd, *J* = 14.4 Hz, 2.4 Hz, 1H), 2.97 (d, *J* = 14.4 Hz, 1H), 1.28 (s, 3H), 1.20 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 175.9, 155.9 (d, J_{C-F} = 235.4 Hz), 154.3 (d, J_{C-F} = 261.9 Hz), 140.9 (d, J_{C-F} = 2.1 Hz), 135.8 (d, J_{C-F} = 1.8 Hz), 129.2, 128.8, 125.9, 118.5 (t, J_{C-F} = 8.0 Hz), 115.1 (dd, J_{C-F} = 22.2 Hz, 2.9 Hz), 114.1 (dd, J_{C-F} = 24.1 Hz, 6.9 Hz), 111.1 (d, J_{C-F} = 7.2 Hz), 103.8 (dd, J_{C-F} = 17.6 Hz, 2.3 Hz), 75.5 (d, J_{C-F} = 27.2 Hz), 49.5 (d, J_{C-F} = 1.3 Hz), 40.7, 26.0, 22.6. ^{19}F NMR (376 MHz, $CDCl_3$): δ -125.6 (d, *J* = 10.9 Hz), -127.0 (td, *J* = 8.6 Hz, 3.8 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{20}H_{19}F_2N_2O$ 341.1460; Found 341.1456.

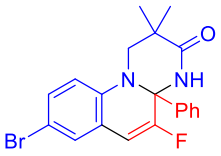


3g

8-Chloro-5-fluoro-2,2-dimethyl-4a-phenyl-4,4a-dihydro-1*H*-pyrimido[1,2-*a*]quinolin-3(2*H*)-one (3g)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (50.7 mg, 71%), mp 194.7-195.3 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.40-7.35 (m, 5H), 7.08 (dd, *J* = 9.0 Hz, 2.4 Hz, 1H), 7.02 (d, *J* = 2.4 Hz, 1H), 6.82 (s, 1H), 6.65 (d, *J* = 8.4 Hz, 1H), 6.22 (d, *J* = 12.0 Hz, 1H), 3.58 (dd, *J* = 14.4 Hz, 1.8 Hz, 1H), 2.98 (d, *J* = 14.4 Hz, 1H), 1.26 (s, 3H), 1.19 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 175.9, 153.8 (d, J_{C-F} = 262.4 Hz), 141.1 (d,

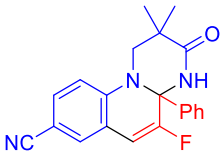
J_{C-F} = 2.4 Hz), 138.1, 129.3, 128.8, 128.6 (d, J_{C-F} = 2.5 Hz), 127.2 (d, J_{C-F} = 5.8 Hz), 125.7, 123.0, 118.6 (d, J_{C-F} = 8.5 Hz), 111.2, 103.5 (d, J_{C-F} = 16.2 Hz), 75.4 (d, J_{C-F} = 26.3 Hz), 49.2 (d, J_{C-F} = 2.3 Hz), 40.8, 25.9, 22.5. ^{19}F NMR (565 MHz, $CDCl_3$): δ -125.9 (d, J = 13.0 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}ClFN_2NaO$ 379.0984; Found 379.0968.



3h

8-Bromo-5-fluoro-2,2-dimethyl-4a-phenyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3h)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (58.6 mg, 73%), mp 199.8-200.3 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.39-7.35 (m, 5H), 7.21 (dd, J = 8.4 Hz, 1.8 Hz, 1H), 7.15 (d, J = 2.4 Hz, 1H), 6.82 (s, 1H), 6.60 (d, J = 9.0 Hz, 1H), 6.22 (d, J = 12.0 Hz, 1H), 3.58 (dd, J = 13.8 Hz, 1.8 Hz, 1H), 2.97 (d, J = 14.4 Hz, 1H), 1.26 (s, 3H), 1.19 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 175.8, 153.6 (d, J_{C-F} = 261.8 Hz), 141.1 (d, J_{C-F} = 2.1 Hz), 138.5, 131.5 (d, J_{C-F} = 1.8 Hz), 130.0 (d, J_{C-F} = 6.1 Hz), 129.3, 128.8, 125.7, 119.0 (d, J_{C-F} = 8.1 Hz), 111.6, 110.0, 103.4 (d, J_{C-F} = 18.0 Hz), 75.4 (d, J_{C-F} = 27.1 Hz), 49.1, 40.8, 25.9, 22.5. ^{19}F NMR (565 MHz, $CDCl_3$): δ -125.9 (d, J = 10.2 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}BrFN_2NaO$ 423.0479; Found 423.0467.

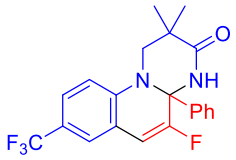


3i

5-Fluoro-2,2-dimethyl-3-oxo-4a-phenyl-2,3,4,4a-tetrahydro-1*H*-pyrimido[1,2-*a*]quinoline-8-carbonitrile (3i)

Eluent: petroleum ether/ethyl acetate (3:1). Yellowish solid (45.8 mg, 66%), mp 225.1-225.9 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.43-7.38 (m, 6H), 7.31 (d, J = 1.2 Hz, 1H), 6.78 (d, J = 8.4 Hz, 1H), 6.70 (s, 1H), 6.29 (d, J = 12.0 Hz, 1H), 3.68 (dd, J = 14.4 Hz, 1.2 Hz, 1H), 3.04 (d, J = 14.4 Hz, 1H), 1.26 (s, 3H), 1.21 (s, 3H). ^{13}C{^{1}H}

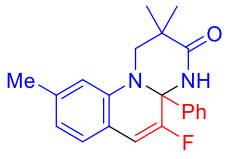
NMR (100 MHz, $CDCl_3$): δ 175.3, 153.4 (d, J_{C-F} = 261.2 Hz), 142.4, 140.9 (d, J_{C-F} = 2.0 Hz), 133.4 (d, J_{C-F} = 2.2 Hz), 131.3 (d, J_{C-F} = 6.5 Hz), 129.7, 129.0, 125.6, 119.2, 117.4 (d, J_{C-F} = 8.1 Hz), 110.1, 103.1 (d, J_{C-F} = 17.4 Hz), 101.0, 75.4 (d, J_{C-F} = 27.0 Hz), 49.1 (d, J_{C-F} = 1.3 Hz), 41.1, 25.7, 22.5. ^{19}F NMR (376 MHz, $CDCl_3$): δ -125.4 (d, J = 13.9 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{21}H_{18}FN_3NaO_2$ 370.1326; Found 370.1302.



3j

5-Fluoro-2,2-dimethyl-4a-phenyl-8-(trifluoromethyl)-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3j)

Eluent: petroleum ether/ethyl acetate (3:1). White solid (54.7 mg, 70%), mp 199.5-200.0 °C. ^1H NMR (400 MHz, $CDCl_3$): δ 7.41-7.37 (m, 6H), 7.28 (d, J = 2.0 Hz, 1H), 6.79 (d, J = 8.8 Hz, 2H), 6.31 (d, J = 12.0 Hz, 1H), 3.69 (dd, J = 12.4 Hz, 2.0 Hz, 1H), 3.03 (d, J = 14.4 Hz, 1H), 1.27 (s, 3H), 1.21 (s, 3H). $^{13}C\{^1H\}$ NMR (150 MHz, $CDCl_3$): δ 175.6, 153.4 (d, J_{C-F} = 260.6 Hz), 141.8, 141.2 (d, J_{C-F} = 2.3 Hz), 129.4, 128.9, 125.7, 125.6 (q, J_{C-F} = 211.4 Hz), 125.3, 123.5, 120.4 (q, J_{C-F} = 32.1 Hz), 116.8 (d, J_{C-F} = 9.6 Hz), 109.5, 103.6 (d, J_{C-F} = 16.7 Hz), 75.5 (d, J_{C-F} = 28.1 Hz), 49.1, 41.0, 25.8, 22.5. ^{19}F NMR (376 MHz, $CDCl_3$): δ -61.5 (s), -126.2 (d, J = 9.8 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{21}H_{18}F_4N_2NaO_2$ 413.1247; Found 413.1229.

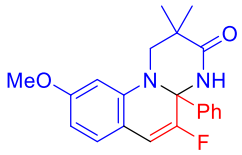


3k

5-Fluoro-2,2,9-trimethyl-4a-phenyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3k)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (43.7 mg, 65%), mp 193.2-193.9 °C. ^1H NMR (600 MHz, $CDCl_3$): δ 7.41-7.39 (m, 2H), 7.36-7.33 (m, 3H), 6.92 (d, J = 7.2 Hz, 1H), 6.75 (s, 1H), 6.58 (d, J = 7.8 Hz, 1H), 6.54 (s, 1H), 6.24 (d, J = 12.0 Hz, 1H), 3.65 (dd, J = 13.8 Hz, 1.2 Hz, 1H), 2.94 (d, J = 13.8 Hz, 1H), 2.29 (s, 3H), 1.28 (s, 3H), 1.20 (s, 3H). $^{13}C\{^1H\}$ NMR (150 MHz, $CDCl_3$): δ 176.1, 152.4 (d, J_{C-F} = 243.2 Hz),

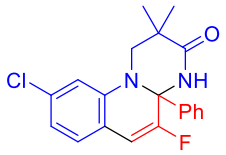
141.6, 139.4, 139.1 (d, J_{C-F} = 2.4 Hz), 129.0, 128.7, 127.7 (d, J_{C-F} = 5.0 Hz), 125.7, 119.3, 114.4 (d, J_{C-F} = 8.0 Hz), 110.7, 104.2 (d, J_{C-F} = 15.9 Hz), 75.6 (d, J_{C-F} = 26.4 Hz), 48.8, 40.8, 26.0, 22.6, 22.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ -130.1 (d, J = 13.2 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{21}H_{21}FN_2NaO$ 359.1530; Found 359.1525.



3l

5-Fluoro-9-methoxy-2,2-dimethyl-4a-phenyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3l)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (47.2 mg, 67%), mp 235.8-236.7 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.40-7.39 (m, 2H), 7.37-7.33 (m, 3H), 6.95 (d, J = 8.4 Hz, 1H), 6.70 (s, 1H), 6.31 (d, J = 8.4 Hz, 1H), 6.30 (s, 1H), 6.22 (d, J = 12.6 Hz, 1H), 3.79 (s, 3H), 3.57 (d, J = 13.8 Hz, 1H), 2.76 (d, J = 14,4 Hz, 1H), 1.28 (s, 3H), 1.18 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 175.9, 160.9 (d, J_{C-F} = 2.3 Hz), 151.6 (d, J_{C-F} = 255.8 Hz), 141.7 (d, J_{C-F} = 2.3 Hz), 140.8, 129.0, 128.7, 128.6, 125.7, 110.4 (d, J_{C-F} = 7.3 Hz), 103.8 (d, J_{C-F} = 16.8 Hz), 102.4, 97.6, 75.4 (d, J_{C-F} = 26.6 Hz), 55.3, 49.0 (d, J_{C-F} = 1.8 Hz), 40.8, 26.0, 22.6. ^{19}F NMR (376 MHz, $CDCl_3$): δ -132.4 (d, J = 12.8 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{21}H_{21}FN_2NaO_2$ 375.1479; Found 375.1473.

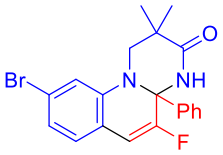


3m

9-Chloro-5-fluoro-2,2-dimethyl-4a-phenyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3m)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (52.8 mg, 74%), mp 228.7-229.6 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.40-7.35 (m, 5H), 6.95 (d, J = 8.4 Hz, 1H), 6.92 (s, 1H), 6.73 (dd, J = 7.8 Hz, 1.2 Hz, 1H), 6.71 (s, 1H), 6.24 (d, J = 12.0 Hz, 1H), 3.56 (dd, J = 14.4 Hz, 1.8 Hz, 1H), 2.98 (d, J = 13.8 Hz, 1H), 1.28 (s, 3H), 1.20 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 175.8, 153.0 (d, J_{C-F} = 260.0 Hz), 141.2 (d, J_{C-F} = 2.1

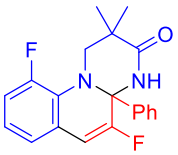
Hz), 140.4, 134.6 (d, J_{C-F} = 3.9 Hz), 129.3, 128.8, 128.7 (d, J_{C-F} = 6.0 Hz), 125.7, 118.4, 115.6 (d, J_{C-F} = 9.2 Hz), 110.2, 103.5 (d, J_{C-F} = 18.0 Hz), 75.3 (d, J_{C-F} = 25.5 Hz), 49.1, 40.8, 25.9, 22.5. ^{19}F NMR (565 MHz, $CDCl_3$): δ -127.7 (d, J = 12.4 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}ClFN_2NaO$ 379.0984; Found 379.0966.



3n

9-Bromo-5-fluoro-2,2-dimethyl-4a-phenyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3n)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (60.2 mg, 75%), mp 248.5-249.4 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.38-7.36 (m, 5H), 6.90-6.87 (m, 2H), 6.85 (s, 1H), 6.78 (s, 1H), 6.24 (d, J = 12.0 Hz, 1H), 3.55 (d, J = 14.4 Hz, 1H), 2.97 (d, J = 14.4 Hz, 1H), 1.29 (s, 3H), 1.20 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 175.7, 153.1 (d, J_{C-F} = 260.8 Hz), 141.1 (d, J_{C-F} = 2.6 Hz), 140.5, 129.3, 128.9 (d, J_{C-F} = 5.9 Hz), 128.8, 125.6, 122.7 (d, J_{C-F} = 2.6 Hz), 121.4, 116.1 (d, J_{C-F} = 7.7 Hz), 113.1, 103.6 (d, J_{C-F} = 16.3 Hz), 75.3 (d, J_{C-F} = 26.8 Hz), 49.1 (d, J_{C-F} = 2.1 Hz), 40.8, 25.9, 22.5. ^{19}F NMR (376 MHz, $CDCl_3$): δ -127.3 (d, J = 10.9 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}BrFN_2NaO$ 423.0479; Found 423.0468.

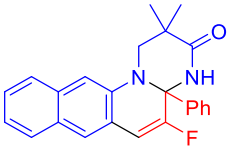


3o

5,10-Difluoro-2,2-dimethyl-4a-phenyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3o)

Eluent: petroleum ether/ethyl acetate (3:1). Yellowish solid (31.3 mg, 46%), mp 149.7-150.9 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.51 (d, J = 7.8 Hz, 2H), 7.34-7.31 (m, 3H), 6.91-6.87 (m, 1H), 6.84-6.79 (m, 2H), 6.32 (s, 1H), 6.29 (d, J = 11.4 Hz, 1H), 3.76 (d, J = 13.2 Hz, 1H), 3.16 (d, J = 13.2 Hz, 1H), 1.39 (s, 3H), 1.23 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 175.5, 155.4 (d, J_{C-F} = 272.1 Hz), 152.8 (d, J_{C-F} = 240.5 Hz), 141.1 (d, J_{C-F} = 3.5 Hz), 129.2, 128.8, 128.3 (d, J_{C-F} = 8.1 Hz), 125.5, 124.7 (dd, J_{C-F} = 7.0 Hz, 3.1 Hz), 122.8 (dd, J_{C-F} = 5.5 Hz, 2.7 Hz), 122.3 (d, J_{C-F} = 8.2 Hz), 116.3 (d, J_{C-F} = 20.0 Hz), 103.2 (dd, J_{C-F} = 17.0 Hz, 3.9 Hz), 75.1 (d, J_{C-F}

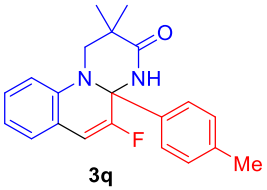
= 23.0 Hz), 55.1 (d, J_{C-F} = 10.1 Hz), 40.0, 23.7, 23.5. ^{19}F NMR (565 MHz, $CDCl_3$): δ -118.2 (d, *J* = 13.6 Hz), -124.5 (d, *J* = 13.6 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}F_2N_2NaO$ 363.1279; Found 363.1270.



3p

5-Fluoro-2,2-dimethyl-4a-phenyl-1,2,4,4a-tetrahydro-3*H*-benzo[g]pyrimido[1,2-*a*]quinolin-3-one (3p)

Eluent: petroleum ether/ethyl acetate (3:1). Brown solid (51.4 mg, 69%), mp 272.4-273.1°C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.68 (d, *J* = 8.4 Hz, 1H), 7.58 (d, *J* = 8.4 Hz, 1H), 7.52 (s, 1H), 7.37-7.35 (m, 3H), 7.33-7.32 (m, 3H), 7.27-7.24 (m, 1H), 6.94 (s, 1H), 6.73(s, 1H), 6.46 (d, *J* = 12.0 Hz, 1H), 3.78 (d, *J* = 13.8 Hz, 1H), 2.98 (d, *J* = 14.4 Hz, 1H), 1.32 (s, 3H), 1.25 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 176.1, 155.4 (d, J_{C-F} = 263.4 Hz), 140.6 (d, J_{C-F} = 2.1 Hz), 138.0, 134.7, 129.2, 128.8, 127.9, 127.3, 126.8 (d, J_{C-F} = 7.7 Hz), 126.7, 126.2, 125.5, 123.5, 120.1 (d, J_{C-F} = 8.1 Hz), 105.2, 104.5 (d, J_{C-F} = 17.4 Hz), 75.0 (d, J_{C-F} = 26.4 Hz), 49.1, 40.7, 26.2, 22.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -126.3 (d, *J* = 11.9 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{24}H_{21}FN_2NaO$ 395.1530; Found 395.1519.

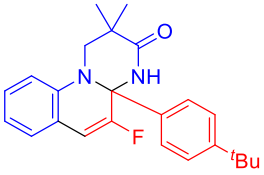


3q

5-Fluoro-2,2-dimethyl-4a-(*p*-tolyl)-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3q)

Eluent: petroleum ether/ethyl acetate (3:1). Brown solid (39.0 mg, 58%), mp 190.2-191.2 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.28 (d, *J* = 7.8 Hz, 2H), 7.16-7.12 (m, 3H), 7.03 (d, *J* = 7.2 Hz, 1H), 6.76-6.71 (m, 2H), 6.66 (s, 1H), 6.26 (d, *J* = 12.0 Hz, 1H), 3.64 (d, *J* = 13.8 Hz, 1H), 2.97 (d, *J* = 13.8 Hz, 1H), 2.33 (s, 3H), 1.27 (s, 3H), 1.19 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 176.0, 153.0 (d, J_{C-F} = 257.7 Hz), 139.5, 139.1, 138.6, 129.4, 129.1 (d, J_{C-F} = 2.1 Hz), 127.9 (d, J_{C-F} = 7.1 Hz), 125.7, 118.3, 117.0 (d, J_{C-F} = 7.7 Hz), 109.9, 104.1 (d,

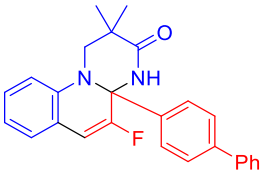
J_{C-F} = 16.1 Hz), 75.5 (d, J_{C-F} = 27.3 Hz), 48.7, 40.8, 26.1, 22.6, 21.1. ^{19}F NMR (565 MHz, $CDCl_3$): δ -128.7 (d, J = 12.4 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{21}H_{21}FN_2NaO$ 359.1530; Found 359.1518.



3r

4a-(4-(*tert*-butyl)phenyl)-5-Fluoro-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3r)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (45.4 mg, 60%), mp 194.3-195.0 ^{o}C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36-7.29 (m, 4H), 7.12 (t, J = 7.6 Hz, 1H), 7.02 (dd, J = 7.2 Hz, 1.2 Hz, 1H), 6.76-6.71 (m, 2H), 6.66 (s, 1H), 6.25 (d, J = 12.0 Hz, 1H), 3.64 (dd, J = 14.0 Hz, 2.0 Hz, 1H), 3.00 (d, J = 14.0 Hz, 1H), 1.29 (s, 9H), 1.27(s, 3H), 1.20 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 176.0, 153.1(d, J_{C-F} = 259.5 Hz), 152.1, 139.5, 138.4 (d, J_{C-F} = 2.2 Hz), 129.0 (d, J_{C-F} = 1.9 Hz), 127.8 (d, J_{C-F} = 5.5 Hz), 125.6, 125.4, 118.3, 117.1 (d, J_{C-F} = 6.8 Hz), 109.9, 104.1 (d, J_{C-F} = 16.3 Hz), 75.5 (d, J_{C-F} = 26.2 Hz), 48.8 (d, J_{C-F} = 1.3 Hz), 40.8, 34.6, 31.3, 26.0, 22.6. ^{19}F NMR (376 MHz, $CDCl_3$): δ -128.4 (d, J = 10.5 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{24}H_{27}FN_2NaO$ 401.2000; Found 401.1991.

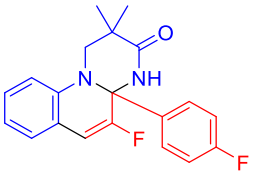


3s

4a-([1,1'-biphenyl]-4-yl)-5-Fluoro-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3s)

Eluent: petroleum ether/ethyl acetate (3:1). Brownish solid (56.6 mg, 71%), mp 120.1-120.8 ^{o}C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.58-7.54 (m, 4H), 7.48-7.41 (m, 4H), 7.35 (t, J = 7.2 Hz, 1H), 7.15 (t, J = 7.6 Hz, 1H), 7.05 (dd, J = 7.2 Hz, 1.2 Hz, 1H), 6.80 (s, 1H), 6.76 (t, J = 8.0 Hz, 2H), 6.30 (d, J = 12.0 Hz, 1H), 3.69 (dd, J = 14.4 Hz, 2.0 Hz, 1H), 3.03 (d, J = 14.4 Hz, 1H), 1.29 (s, 3H), 1.22(s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ

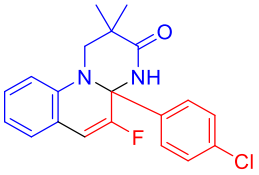
176.1, 152.9 (d, J_{C-F} = 259.4 Hz), 142.0, 140.4 (d, J_{C-F} = 1.3 Hz), 140.1, 139.4, 129.2 (d, J_{C-F} = 2.3 Hz), 128.9, 128.0 (d, J_{C-F} = 6.5 Hz), 127.7, 127.4, 127.2, 126.2, 118.5, 116.9 (d, J_{C-F} = 7.5 Hz), 110.0, 104.3 (d, J_{C-F} = 15.6 Hz), 75.5 (d, J_{C-F} = 26.9 Hz), 48.9, 40.9, 26.1, 22.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -128.6 (d, J = 11.9 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{26}H_{23}FN_2NaO$ 421.1687; Found 421.1671.



3t

5-Fluoro-4a-(4-fluorophenyl)-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3t)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (51.1 mg, 75%), mp 167.6-168.7 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.41-7.37 (m, 2H), 7.15 (t, J = 8.8 Hz, 1H), 7.05-7.01 (m, 3H), 6.82 (s, 1H), 6.78-6.73 (m, 2H), 6.28 (d, J = 12.0 Hz, 1H), 3.67 (dd, J = 14.0 Hz, 2.0 Hz, 1H), 2.94 (d, J = 14.4 Hz, 1H), 1.27 (s, 3H), 1.19 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 176.0, 163.0 (d, J_{C-F} = 246.7 Hz), 152.7 (d, J_{C-F} = 259.3 Hz), 139.3, 137.5 (d, J_{C-F} = 3.0 Hz), 129.2 (d, J_{C-F} = 2.8 Hz), 128.0 (d, J_{C-F} = 5.8 Hz), 127.7 (d, J_{C-F} = 8.5 Hz), 118.6, 116.8 (d, J_{C-F} = 7.5 Hz), 115.6 (d, J_{C-F} = 21.7 Hz), 110.0, 104.3 (d, J_{C-F} = 16.1 Hz), 75.2 (d, J_{C-F} = 26.9 Hz), 48.8 (d, J_{C-F} = 1.4 Hz), 40.8, 26.0, 22.6. ^{19}F NMR (376 MHz, $CDCl_3$): δ -112.7--112.8 (m), -128.7 (d, J = 10.5 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{20}H_{19}F_2N_2O$ 341.1460; Found 341.1458.

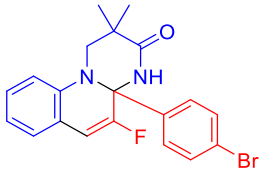


3u

4a-(4-Chlorophenyl)-5-fluoro-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3u)

Eluent: petroleum ether/ethyl acetate (3:1). Brownish solid (57.1 mg, 80%), mp 167.6-168.7 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.36 (d, J = 8.4 Hz, 2H), 7.31 (d, J = 8.4 Hz, 2H), 7.15 (t, J = 7.2 Hz, 1H), 7.11 (s, 1H), 7.04 (d, J = 7.2 Hz, 1H), 6.78-6.74 (m, 2H), 6.27 (d, J = 12.0 Hz, 1H), 3.68 (dd, J = 13.8 Hz, 1.2 Hz, 1H), 2.93 (d, J = 14.4 Hz, 1H), 1.26 (s, 3H), 1.19 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 176.1, 152.6 (d, J_{C-F} = 259.7 Hz),

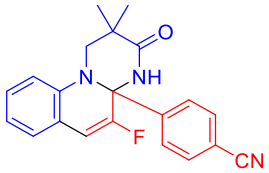
140.2 (d, J_{C-F} = 2.0 Hz), 139.3, 135.1, 129.3 (d, J_{C-F} = 2.6 Hz), 128.9, 128.0 (d, J_{C-F} = 5.6 Hz), 127.3, 118.7, 116.8 (d, J_{C-F} = 7.1 Hz), 110.0, 104.4 (d, J_{C-F} = 15.5 Hz), 75.2 (d, J_{C-F} = 26.6 Hz), 48.9, 40.8, 26.0, 22.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -128.4 (d, J = 13.0 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}ClFN_2NaO$ 379.0984; Found 379.0965.



3v

4a-(4-Bromophenyl)-5-fluoro-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3v)

Eluent: petroleum ether/ethyl acetate (3:1). White solid (65.0 mg, 81%), mp 165.9-166.7 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.48-7.45 (m, 2H), 7.31-7.26 (m, 2H), 7.17-7.13 (m, 1H), 7.08 (s, 1H), 7.03 (dd, J = 7.6 Hz, 1.6 Hz, 1H), 6.78-6.73 (m, 2H), 6.27 (d, J = 12.4 Hz, 1H), 3.68 (dd, J = 14.4 Hz, 2.4 Hz, 1H), 2.93 (d, J = 14.4 Hz, 1H), 1.26 (s, 3H), 1.18 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 176.1, 152.5 (d, J_{C-F} = 259.6 Hz), 140.8 (d, J_{C-F} = 1.2 Hz), 139.3, 131.9, 129.3 (d, J_{C-F} = 2.1 Hz), 128.0 (d, J_{C-F} = 5.9 Hz), 127.6, 123.4, 118.7, 116.8 (d, J_{C-F} = 7.9 Hz), 110.0, 104.5 (d, J_{C-F} = 16.0 Hz), 75.3 (d, J_{C-F} = 26.8 Hz), 48.9 (d, J_{C-F} = 1.9 Hz), 40.8, 26.0, 22.6. ^{19}F NMR (376 MHz, $CDCl_3$): δ -128.4 (d, J = 12.8 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}BrFN_2NaO$ 423.0479; Found 423.0467.

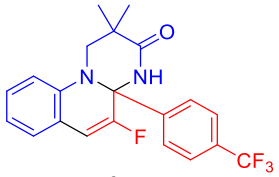


3w

4-(5-Fluoro-2,2-dimethyl-3-oxo-1,2,3,4-tetrahydro-4a*H*-pyrimido[1,2-*a*]quinolin-4a-yl)benzonitrile (3w)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (52.1 mg, 75%), mp 207.5-208.1 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.83 (s, 1H), 7.63 (d, J = 8.4 Hz, 2H), 7.59 (d, J = 9.0 Hz, 2H), 7.18 (t, J = 8.4 Hz, 1H), 7.05 (dd, J = 7.8 Hz, 1.8 Hz, 1H), 6.80-6.78 (m, 2H), 6.29 (d, J = 12.0 Hz, 1H), 3.75 (dd, J = 14.4 Hz, 1.8 Hz, 1H), 2.87 (d, J = 15.0 Hz, 1H), 1.26 (s, 3H), 1.19 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 176.3, 152.1 (d, J_{C-F}

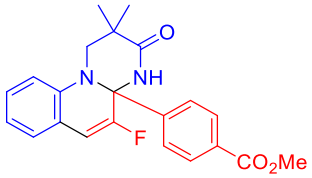
= 260.3 Hz), 146.7 (d, J_{C-F} = 2.6 Hz), 139.2, 132.6, 129.5 (d, J_{C-F} = 2.6 Hz), 128.2 (d, J_{C-F} = 6.2 Hz), 126.7, 119.0, 118.2, 116.6 (d, J_{C-F} = 7.7 Hz), 113.0, 110.2, 104.8 (d, J_{C-F} = 14.7 Hz), 75.3 (d, J_{C-F} = 27.2 Hz), 49.2, 40.8, 25.8, 22.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -127.9 (d, J = 13.0 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{21}H_{19}FN_3O$ 348.1507; Found 348.1500.



3x

5-Fluoro-2,2-dimethyl-4a-(4-(trifluoromethyl)phenyl)-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3x)

Eluent: petroleum ether/ethyl acetate (3:1). Brown solid (67.9 mg, 87%), mp 154.9-155.3 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.72 (s, 1H), 7.59 (s, 4H), 7.17 (t, J = 7.6 Hz, 1H), 7.05 (d, J = 7.2 Hz, 1H), 6.80-6.76 (m, 2H), 6.28 (d, J = 12.0 Hz, 1H), 3.73 (d, J = 14.4 Hz, 1H), 2.91 (d, J = 14.4 Hz, 1H), 1.27 (s, 3H), 1.19 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 176.3, 152.4 (d, J_{C-F} = 261.0 Hz), 145.6, 139.3, 131.2 (q, J_{C-F} = 31.8 Hz), 129.4 (d, J_{C-F} = 2.0 Hz), 128.1 (d, J_{C-F} = 5.9 Hz), 126.3, 125.7 (q, J_{C-F} = 3.7 Hz), 123.8 (q, J_{C-F} = 270.7 Hz), 118.8, 116.7 (d, J_{C-F} = 7.3 Hz), 110.1, 104.6 (d, J_{C-F} = 16.1 Hz), 75.3 (d, J_{C-F} = 26.9 Hz), 49.1, 40.8, 25.9, 22.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -62.6 (s), -127.8 (d, J = 11.9 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{21}H_{19}F_4N_2O$ 391.1428; Found 391.1429.

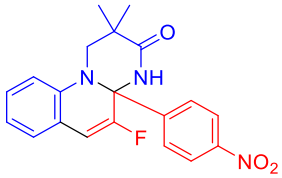


3y

Methyl 4-(5-fluoro-2,2-dimethyl-3-oxo-1,2,3,4-tetrahydro-4a*H*-pyrimido[1,2-*a*]quinolin-4a-yl)benzoate (3y)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (70.8 mg, 93%), mp 193.5-194.1 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.02 (d, J = 8.8 Hz, 2H), 7.51 (d, J = 8.4 Hz, 2H), 7.16 (t, J = 7.2 Hz, 1H), 7.05 (dd, J = 7.2 Hz,

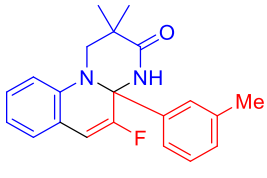
1.2 Hz, 1H), 6.70 (s, 1H), 6.80-6.74 (m, 2H), 6.30 (d, *J* = 12.0 Hz, 1H), 3.91 (s, 3H), 3.70 (dd, *J* = 14.4 Hz, 2.0 Hz, 1H), 2.90 (d, *J* = 14.4 Hz, 1H), 1.28 (s, 3H), 1.19 (s, 3H). $^{13}C\{^{1}H\}$ NMR (150 MHz, $CDCl_3$): δ 176.0, 166.4, 152.4 (d, J_{C-F} = 259.4 Hz), 146.2 (d, J_{C-F} = 1.8 Hz), 139.3, 130.9, 130.0, 129.3(d, J_{C-F} = 2.0 Hz), 128.1 (d, J_{C-F} = 5.9 Hz), 125.9, 118.7, 116.7 (d, J_{C-F} = 7.1 Hz), 110.0, 104.7 (d, J_{C-F} = 14.9 Hz), 75.5 (d, J_{C-F} = 27.3 Hz), 52.3, 49.0, 40.8, 26.0, 22.6. ^{19}F NMR (376 MHz, $CDCl_3$): δ -128.2 (d, *J* = 10.9 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{22}H_{22}FN_2O_3$ 381.1609; Found 381.1611.



3z

5-Fluoro-2,2-dimethyl-4a-(4-nitrophenyl)-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3z)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (67.6 mg, 92%), mp 216.5-217.1 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.20 (d, *J* = 8.8 Hz, 2H), 7.65 (d, *J* = 8.8 Hz, 2H), 7.49 (s, 1H), 7.19 (t, *J* = 7.6 Hz, 1H), 7.07 (d, *J* = 6.8 Hz, 1H), 6.83-6.78 (m, 2H), 6.32 (d, *J* = 12.4 Hz, 1H), 3.76 (d, *J* = 14.4 Hz, 1H), 2.88 (d, *J* = 14.4 Hz, 1H), 1.28 (s, 3H), 1.20 (s, 3H). $^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$): δ 176.3, 152.0 (d, J_{C-F} = 261.3 Hz), 148.4 (d, J_{C-F} = 1.8 Hz), 148.2, 139.1, 129.5 (d, J_{C-F} = 2.1 Hz), 128.2 (d, J_{C-F} = 6.2 Hz), 127.0, 123.9, 119.1, 116.6 (d, J_{C-F} = 7.1 Hz), 110.3, 104.9 (d, J_{C-F} = 15.5 Hz), 75.2 (d, J_{C-F} = 26.9 Hz), 49.3, 40.8, 25.8, 22.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -128.3 (d, *J* = 11.9 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}FN_3NaO_3$ 390.1224; Found 390.1221.

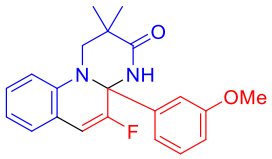


3aa

5-Fluoro-2,2-dimethyl-4a-(*m*-tolyl)-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3aa)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (37.0 mg, 55%), mp 186.5-187.2 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.25-7.21 (m, 3H), 7.15-7.12 (m, 2H), 7.03 (d, *J* = 6.8 Hz, 1H), 6.76-6.73 (m, 3H), 6.25 (d, *J* =

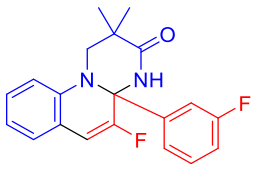
12.4 Hz, 1H), 3.67 (d, J = 14.4 Hz, 1H), 2.98 (d, J = 14.4 Hz, 1H), 2.32 (s, 3H), 1.27 (s, 3H), 1.19 (s, 3H). $^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$): δ 176.0, 152.8 (d, J_{C-F} = 258.7 Hz), 141.6 (d, J_{C-F} = 1.7 Hz), 139.5, 138.5, 129.8, 129.1 (d, J_{C-F} = 1.9 Hz), 128.6, 127.9 (d, J_{C-F} = 6.3 Hz), 126.4, 123.0, 118.3, 116.8 (d, J_{C-F} = 7.2 Hz), 109.8, 104.2 (d, J_{C-F} = 15.5 Hz), 75.6 (d, J_{C-F} = 26.6 Hz), 48.8, 40.9, 26.1, 22.6, 21.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -128.4 (d, J = 12.4 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{21}H_{22}FN_2O$ 337.1711; Found 337.1710.



3bb

5-Fluoro-4a-(3-methoxyphenyl)-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3bb)

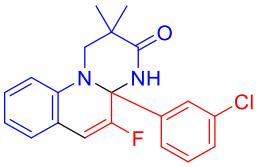
Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (36.7 mg, 52%), mp 133.0-133.7 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.29-7.25 (m, 1H), 7.13 (t, J = 8.0 Hz, 1H), 7.03-6.98 (m, 2H), 6.95 (s, 1H), 6.87 (dd, J = 8.4 Hz, 2.4 Hz, 1H), 6.76-6.72 (m, 3H), 6.26 (d, J = 12.4 Hz, 1H), 3.74 (s, 3H), 3.66 (dd, J = 14.0 Hz, 1.6 Hz, 1H), 3.00 (d, J = 14.4 Hz, 1H), 1.27 (s, 3H), 1.19 (s, 3H). $^{13}C\{^{1}H\}$ NMR (150 MHz, $CDCl_3$): δ 176.0, 159.9, 152.8 (d, J_{C-F} = 259.2 Hz), 143.2, 139.4, 129.7, 129.1 (d, J_{C-F} = 1.8 Hz), 127.9 (d, J_{C-F} = 6.2 Hz), 118.4, 118.1, 116.9 (d, J_{C-F} = 7.5 Hz), 114.0, 112.0, 109.9, 104.3 (d, J_{C-F} = 15.5 Hz), 75.5 (d, J_{C-F} = 27.6 Hz), 55.3, 48.9, 40.8, 26.0, 22.7. ^{19}F NMR (565 MHz, $CDCl_3$): δ -128.5 (d, J = 11.9 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{21}H_{21}FN_2NaO_2$ 375.1479; Found 375.1473.



3cc

5-Fluoro-4a-(3-fluorophenyl)-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3cc)

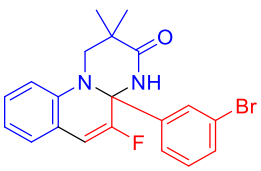
Eluent: petroleum ether/ethyl acetate (3:1). White solid (47.7 mg, 70%), mp 148.2-148.8 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.33-7.29 (m, 1H), 7.23-7.21 (m, 2H), 7.16-7.14 (m, 2H), 7.04-7.01 (m, 2H), 6.78-6.75 (m, 2H), 6.27 (d, *J* = 12.0 Hz, 1H), 3.70 (dd, *J* = 14.4 Hz, 1.8 Hz, 1H), 2.96 (d, *J* = 14.4 Hz, 1H), 1.27 (s, 3H), 2.00 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 176.1, 163.0 (d, J_{C-F} = 246.9 Hz), 152.5 (d, J_{C-F} = 258.3 Hz), 144.4 (d, J_{C-F} = 5.0 Hz), 139.3, 130.2 (d, J_{C-F} = 8.0 Hz), 129.3 (d, J_{C-F} = 2.7 Hz), 128.0 (d, J_{C-F} = 7.4 Hz), 121.5 (d, J_{C-F} = 1.7 Hz), 118.7, 116.7 (d, J_{C-F} = 8.1 Hz), 116.1 (d, J_{C-F} = 22.2 Hz), 113.2 (d, J_{C-F} = 21.2 Hz), 110.0, 104.5 (d, J_{C-F} = 16.4 Hz), 75.2 (d, J_{C-F} = 27.3 Hz), 49.0, 40.8, 25.9, 22.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -111.5–-111.6 (m), -128.4 (d, *J* = 11.3 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{21}H_{19}F_2N_2O$ 341.1460; Found 341.1459.



3dd

4a-(3-Chlorophenyl)-5-fluoro-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3dd)

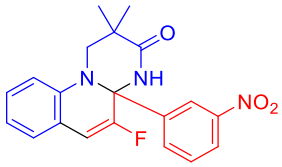
Eluent: petroleum ether/ethyl acetate (3:1). Brown solid (54.2 mg, 76%), mp 130.6-131.2 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.52 (s, 1H), 7.44 (t, *J* = 1.8 Hz, 1H), 7.34-7.32 (m, 1H), 7.30-7.29 (m, 1H), 7.27-7.24 (m, 1H), 7.15 (t, *J* = 8.4 Hz, 1H), 7.03 (dd, *J* = 7.8 Hz, 1.8 Hz, 1H), 6.78-6.74 (m, 2H), 6.26 (d, *J* = 12.0 Hz, 1H), 3.72 (dd, *J* = 14.4 Hz, 2.4 Hz, 1H), 2.96 (d, *J* = 14.4 Hz, 1H), 1.26 (s, 3H), 1.19 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 176.2, 152.3 (d, J_{C-F} = 260.0 Hz), 144.0 (d, J_{C-F} = 1.7 Hz), 139.3, 135.0, 130.0, 129.3 (d, J_{C-F} = 2.1 Hz), 129.2, 128.1 (d, J_{C-F} = 6.1 Hz), 126.1, 124.1, 118.7, 116.7 (d, J_{C-F} = 7.4 Hz), 110.0, 104.5 (d, J_{C-F} = 15.7 Hz), 75.2 (d, J_{C-F} = 26.8 Hz), 49.0, 40.8, 25.9, 22.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -127.9 (d, *J* = 11.9 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}ClFN_2NaO$ 379.0984; Found 379.0972.



3ee

4a-(3-Bromophenyl)-5-fluoro-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3ee)

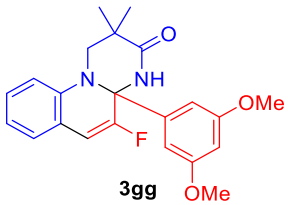
Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (64.2 mg, 80%), mp 133.8-134.3 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.58 (d, *J* = 1.6 Hz, 1H), 7.46 (d, *J* = 7.6 Hz, 1H), 7.37 (d, *J* = 8.0 Hz, 1H), 7.23-7.19 (m, 2H), 7.17-7.13 (m, 1H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.78-6.74 (m, 2H), 6.27 (d, *J* = 12.0 Hz, 1H), 3.72 (dd, *J* = 14.4 Hz, 2.0 Hz, 1H), 2.95 (d, *J* = 14.4 Hz, 1H), 1.26 (s, 3H), 1.20 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 176.1, 152.3 (d, J_{C-F} = 259.1 Hz), 144.2 (d, J_{C-F} = 2.0 Hz), 139.3, 132.2, 130.2, 129.3 (d, J_{C-F} = 2.9 Hz), 129.0, 128.1 (d, J_{C-F} = 7.4 Hz), 124.6, 123.1, 118.7, 116.6 (d, J_{C-F} = 7.4 Hz), 110.1, 104.6 (d, J_{C-F} = 15.0 Hz), 75.2 (d, J_{C-F} = 27.2 Hz), 49.0, 40.9, 26.0, 22.7. ^{19}F NMR (565 MHz, $CDCl_3$): δ -128.1 (d, *J* = 12.4 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}BrFN_2NaO$ 423.0479; Found 423.0476.



3ff

5-Fluoro-2,2-dimethyl-4a-(3-nitrophenyl)-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3ff)

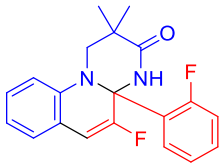
Eluent: petroleum ether/ethyl acetate (3:1). Brown solid (60.3 mg, 82%), mp 177.1-178.0 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.34 (s, 1H), 8.19 (d, *J* = 8.0 Hz, 1H), 8.00 (s, 1H), 7.82 (d, *J* = 7.6 Hz, 1H), 7.54 (t, *J* = 8.0 Hz, 1H), 7.18 (t, *J* = 8.0 Hz, 1H), 7.06 (d, *J* = 7.2 Hz, 1H), 6.83-6.78 (m, 2H), 6.32 (d, *J* = 12.0 Hz, 1H), 3.79 (d, *J* = 14.4 Hz, 1H), 2.96 (d, *J* = 14.4 Hz, 1H), 1.28 (s, 3H), 1.20 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 176.4, 152.0 (d, J_{C-F} = 260.3 Hz), 148.5, 144.3 (d, J_{C-F} = 1.5 Hz), 139.2, 131.8, 129.9, 129.5 (d, J_{C-F} = 2.7 Hz), 128.2 (d, J_{C-F} = 5.6 Hz), 124.0, 120.9, 119.1, 116.6 (d, J_{C-F} = 7.2 Hz), 110.4, 104.9 (d, J_{C-F} = 15.5 Hz), 75.1 (d, J_{C-F} = 26.7 Hz), 49.2, 40.8, 25.8, 22.5. ^{19}F NMR (565 MHz, $CDCl_3$): δ -127.7 (d, *J* = 11.9 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{20}H_{18}FN_3NaO_3$ 390.1224; Found 390.1218.



3gg

4a-(3,5-Dimethoxyphenyl)-5-fluoro-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3gg)

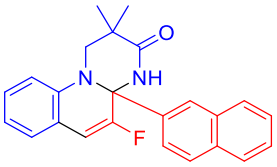
Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (40.5 mg, 53%), mp 188.9-189.7 ^{o}C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.12 (t, *J* = 6.8 Hz, 1H), 7.01 (dd, *J* = 8.0 Hz, 1.6 Hz, 1H), 6.88 (s, 1H), 6.75-6.71 (m, 2H), 6.56 (d, *J* = 2.0 Hz, 2H), 6.42 (t, *J* = 2.4 Hz, 1H), 6.25 (d, *J* = 12.4 Hz, 1H), 3.71 (s, 6H), 3.67 (dd, *J* = 14.4 Hz, 2.0 Hz, 1H), 3.04 (d, *J* = 14.0 Hz, 1H), 1.26 (s, 3H), 1.19 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 176.1, 161.1, 152.8 (d, J_{C-F} = 259.8 Hz), 144.1 (d, J_{C-F} = 2.4 Hz), 139.4, 129.1 (d, J_{C-F} = 2.3 Hz), 127.9 (d, J_{C-F} = 7.1 Hz), 118.4, 116.9 (d, J_{C-F} = 7.8 Hz), 110.0, 104.4, 104.2 (d, J_{C-F} = 15.6 Hz), 100.3, 75.5 (d, J_{C-F} = 26.3 Hz), 55.4, 49.0, 40.8, 26.0, 22.7. ^{19}F NMR (376 MHz, $CDCl_3$): δ -128.8 (d, *J* = 10.9 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{22}H_{24}FN_2O_3$ 383.1765; Found 383.1762.



3hh

5-Fluoro-4a-(2-fluorophenyl)-2,2-dimethyl-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3hh)

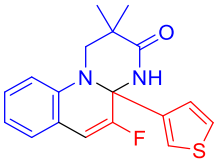
Eluent: petroleum ether/ethyl acetate (3:1). Yellowish solid (34.7 mg, 51%), mp 198.5-199.2 ^{o}C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.38 (td, *J* = 7.8 Hz, 1.2 Hz, 1H), 7.35-7.32 (m, 1H), 7.16 (t, *J* = 8.4 Hz, 1H), 7.11 (t, *J* = 7.8 Hz, 1H), 7.09-7.06 (m, 1H), 7.01 (dd, *J* = 7.2 Hz, 1.2 Hz, 1H), 6.95 (s, 1H), 6.81 (d, *J* = 7.8 Hz, 1H), 6.75 (t, *J* = 7.8 Hz, 1H), 6.21 (d, *J* = 12.0 Hz, 1H), 3.81 (d, *J* = 14.4 Hz, 1H), 3.06 (d, *J* = 13.8 Hz, 1H), 1.25 (s, 3H), 1.18 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 175.7, 160.1 (d, J_{C-F} = 248.3 Hz), 151.2 (d, J_{C-F} = 259.8 Hz), 139.5, 131.2 (d, J_{C-F} = 9.0 Hz), 129.1 (d, J_{C-F} = 2.1 Hz), 128.2 (dd, J_{C-F} = 10.1 Hz, 2.3 Hz), 128.0, 127.9 (d, J_{C-F} = 5.7 Hz), 124.2 (d, J_{C-F} = 3.2 Hz), 118.5, 117.4 (d, J_{C-F} = 23.0 Hz), 117.0 (d, J_{C-F} = 7.5 Hz), 109.7, 104.3 (d, J_{C-F} = 15.9 Hz), 74.4 (d, J_{C-F} = 27.2 Hz), 49.5, 41.0, 25.7, 22.4. ^{19}F NMR (565 MHz, $CDCl_3$): δ -111.56–-111.62 (m), -129.1 (t, *J* = 12.4 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{20}H_{19}F_2N_2O$ 341.1460; Found 341.1460.



3ii

5-Fluoro-2,2-dimethyl-4a-(naphthalen-2-yl)-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3ii)

Eluent: petroleum ether/ethyl acetate (3:1). Yellow solid (47.7 mg, 64%), mp 232.5-233.1 ^{o}C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.88-7.79 (m, 4H), 7.53-7.47 (m, 3H), 7.16 (t, *J* = 8.4 Hz, 1H), 7.07 (dd, *J* = 7.2 Hz, 1.2 Hz, 1H), 6.86 (s, 1H), 6.79-6.75 (m, 2H), 6.32 (d, *J* = 12.0 Hz, 1H), 3.68 (d, *J* = 14.4 Hz, 2.0 Hz, 1H), 2.99 (d, *J* = 14.4 Hz, 1H), 1.30 (s, 3H), 1.19 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 176.2, 152.5 (d, J_{C-F} = 259.8 Hz), 139.5, 138.8 (d, J_{C-F} = 2.0 Hz), 133.4, 132.5, 129.3 (d, J_{C-F} = 1.7 Hz), 129.2, 128.7, 128.1 (d, J_{C-F} = 5.4 Hz), 127.6, 127.0, 126.8, 124.9, 123.4, 118.4, 116.8 (d, J_{C-F} = 6.9 Hz), 109.9, 104.6 (d, J_{C-F} = 15.8 Hz), 75.8 (d, J_{C-F} = 27.3 Hz), 48.8, 41.0, 26.1, 22.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -128.6 (d, *J* = 10.2 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{24}H_{22}FN_2O$ 373.1711; Found 373.1717.



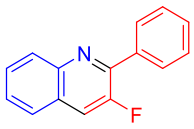
3jj

5-Fluoro-2,2-dimethyl-4a-(thiophen-3-yl)-1,2,4,4a-tetrahydro-3*H*-pyrimido[1,2-*a*]quinolin-3-one (3jj)

Eluent: petroleum ether/ethyl acetate (3:1). Brown solid (43.3 mg, 66%), mp 177.5-178.2 ^{o}C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.26-7.23 (m ,2H), 7.14 (t, *J* = 8.4 Hz, 1H), 7.03 (d, *J* = 7.2 Hz, 1H), 6.97 (s, 1H), 6.90 (dd, *J* = 4.8 Hz, 1.6 Hz, 1H), 6.77 (t, *J* = 7.2 Hz, 1H), 6.71 (d, *J* = 8.4 Hz, 1H), 6.24 (d, *J* = 12.0 Hz, 1H), 3.63 (d, *J* = 14.0 Hz, 2.0 Hz, 1H), 3.06 (d, *J* = 13.6 Hz, 1H), 1.28 (s, 3H), 1.22 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 175.8, 153.3 (d, J_{C-F} = 261.1 Hz), 142.8 (d, J_{C-F} = 1.8 Hz), 139.3, 129.0 (d, J_{C-F} = 2.6 Hz), 127.7 (d, J_{C-F} = 5.6 Hz), 127.3, 125.4, 123.1, 118.8, 117.7 (d, J_{C-F} = 8.2 Hz), 110.4, 103.7 (d, J_{C-F} = 15.9 Hz), 73.5 (d, J_{C-F} = 26.1 Hz), 49.1, 40.5, 26.0, 22.6. ^{19}F NMR (565 MHz, $CDCl_3$): δ -128.3 (d, *J* = 13.0 Hz). HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{18}H_{17}FN_2NaOS$ 351.0938; Found 351.0930.

2. Typical procedure for the synthesis of 4a and spectroscopic data of 4a-4h

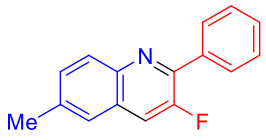
To an oven-dried flask equipped with a magnetic stir bar were charged with **3a** (32.2 mg, 0.1 mmol), Lawseeon reagent (32.4 mg, 0.08 mmol) and toluene (2 mL). The resulting mixture was refluxed (oil bath) under air for 12 h. Upon completion, it was quenched with saturated brine, extracted with diethyl ether (10 mL × 3). The combined organic phases were dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified through silica gel column chromatography using petroleum ether/ethyl acetate (30:1) as eluent to give product **4a** (16.3 mg, 73%). Other products **4b-4h** were obtained in a similar manner.



4a

3-Fluoro-2-phenylquinoline (4a)[8]

Eluent: petroleum ether/ethyl acetate (30:1). White solid (16.3 mg, 73%), mp 47.0-47.8 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.08 (d, *J* = 9.0 Hz, 1H), 7.99-7.98 (m, 2H), 7.75 (d, *J* = 10.8 Hz, 1H), 7.69 (d, *J* = 8.4 Hz, 1H), 7.59 (t, *J* = 8.4 Hz, 1H), 7.46-7.43 (m, 3H), 7.41-7.38 (m, 1H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 155.1 (d, J_{C-F} = 259.4 Hz), 149.2 (d, J_{C-F} = 13.5 Hz), 145.3 (d, J_{C-F} = 2.3 Hz), 135.8 (d, J_{C-F} = 4.7 Hz), 129.7 (d, J_{C-F} = 5.9 Hz), 129.4 (d, J_{C-F} = 6.0 Hz), 128.8 (d, J_{C-F} = 3.2 Hz), 128.6, 128.3 (d, J_{C-F} = 5.9 Hz), 127.4, 126.8 (d, J_{C-F} = 4.5 Hz), 119.7(d, J_{C-F} = 20.3 Hz). ^{19}F NMR (565 MHz, $CDCl_3$): δ -124.4 (d, *J* = 10.7 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{15}H_{11}FN$ 224.0870; Found 224.0866.

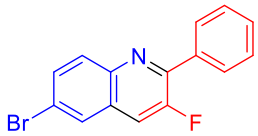


4b

3-Fluoro-6-methyl-2-phenylquinoline (4b)

Eluent: petroleum ether/ethyl acetate (30:1). White solid (20.1 mg, 85%), mp 87.7-88.6 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.07-8.04 (m, 3H), 7.74 (d, *J* = 11.2 Hz, 1H), 7.54-7.47 (m, 5H), 2.53 (s, 3H). ^{13}C{^{1}H} NMR (100

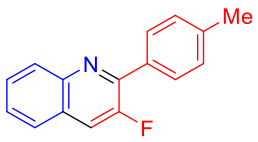
MHz, $CDCl_3$): δ 155.3 (d, J_{C-F} = 259.5 Hz), 148.1 (d, J_{C-F} = 14.3 Hz), 143.9 (d, J_{C-F} = 2.9 Hz), 137.4, 135.9 (d, J_{C-F} = 5.4 Hz), 131.1 (d, J_{C-F} = 2.5 Hz), 129.4, 129.3 (d, J_{C-F} = 3.7 Hz), 129.2, 128.5, 128.4 (d, J_{C-F} = 4.6 Hz), 125.6 (d, J_{C-F} = 4.7 Hz), 119.1 (d, J_{C-F} = 19.4 Hz), 21.7. ^{19}F NMR (376 MHz, $CDCl_3$): δ -124.8 (d, J = 10.9 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{16}H_{13}FN$ 238.1027; Found 238.1029.



4c

6-Bromo-3-fluoro-2-phenylquinoline (4c)

Eluent: petroleum ether/ethyl acetate (30:1). White solid (23.3 mg, 77%), mp 96.8-97.2 °C. ^1H NMR (600 MHz, $CDCl_3$): δ 8.06 (d, J = 7.2 Hz, 2H), 8.00 (d, J = 9.6 Hz, 1H), 7.93 (s, 1H), 7.74-7.73 (m, 2H), 7.53-7.50 (m, 3H). $^{13}C\{^1H\}$ NMR (150 MHz, $CDCl_3$): δ 155.5 (d, J_{C-F} = 261.2 Hz), 149.5 (d, J_{C-F} = 14.3 Hz), 143.8 (d, J_{C-F} = 2.9 Hz), 135.3 (d, J_{C-F} = 4.8 Hz), 132.4 (d, J_{C-F} = 1.8 Hz), 131.3, 129.9, 129.4 (d, J_{C-F} = 5.9 Hz), 129.3 (d, J_{C-F} = 5.7 Hz), 128.8 (d, J_{C-F} = 3.9 Hz), 128.6, 121.5, 118.8 (d, J_{C-F} = 21.0 Hz). ^{19}F NMR (565 MHz, $CDCl_3$): δ -122.6 (d, J = 9.0 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{15}H_{10}BrFN$ 301.9975; Found 301.9969.

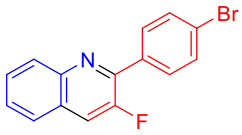


4d

3-Fluoro-2-(*p*-tolyl)quinoline (4d)[8]

Eluent: petroleum ether/ethyl acetate (30:1). Yellowish oil (20.9 mg, 88%). ^1H NMR (600 MHz, $CDCl_3$): δ 8.08 (d, J = 8.4 Hz, 1H), 7.91 (dd, J = 8.4 Hz, 1.8 Hz, 2H), 7.75 (d, J = 11.4 Hz, 1H), 7.70 (d, J = 7.8 Hz, 1H), 7.60 (t, J = 8.4 Hz, 1H), 7.46 (t, J = 7.2 Hz, 1H), 7.26 (d, J = 8.4 Hz, 2H), 2.36 (s, 3H). $^{13}C\{^1H\}$ NMR (150 MHz, $CDCl_3$): δ 155.1 (d, J_{C-F} = 259.1 Hz), 149.2 (d, J_{C-F} = 14.4 Hz), 145.3 (d, J_{C-F} = 3.0 Hz), 139.8, 133.0 (d, J_{C-F} = 3.8 Hz), 129.6, 129.3, 129.2 (d, J_{C-F} = 5.6 Hz), 128.7 (d, J_{C-F} = 2.1 Hz), 128.2 (d, J_{C-F} = 5.7 Hz), 127.2, 126.8 (d,

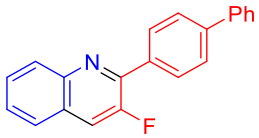
J_{C-F} = 3.9 Hz), 119.6 (d, J_{C-F} = 20.4 Hz), 21.5. ^{19}F NMR (565 MHz, $CDCl_3$): δ -124.2 (d, J = 10.7 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{16}H_{13}FN$ 238.1027; Found 238.1032.



4e

2-(4-Bromophenyl)-3-fluoroquinoline (4e)[8]

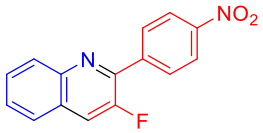
Eluent: petroleum ether/ethyl acetate (30:1). White solid (21.5 mg, 71%), mp 93.4-94.3 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.14 (d, J = 8.4 Hz, 1H), 7.98 (dd, J = 8.4 Hz, 1.8 Hz, 2H), 7.85 (d, J = 11.4 Hz, 1H), 7.79 (d, J = 8.4 Hz, 1H), 7.69 (t, J = 7.2 Hz, 1H), 7.66-7.64 (m, 2H), 7.56 (t, J = 7.2 Hz, 1H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 155.0 (d, J_{C-F} = 258.9 Hz), 147.7 (d, J_{C-F} = 13.4 Hz), 145.2 (d, J_{C-F} = 3.0 Hz), 134.6 (d, J_{C-F} = 5.1 Hz), 131.8, 130.9 (d, J_{C-F} = 5.8 Hz), 129.6, 129.0 (d, J_{C-F} = 2.0 Hz), 128.4 (d, J_{C-F} = 5.2 Hz), 127.6, 126.8 (d, J_{C-F} = 4.8 Hz), 124.3, 119.9 (d, J_{C-F} = 19.9 Hz). ^{19}F NMR (565 MHz, $CDCl_3$): δ -124.3 (d, J = 11.3 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{15}H_{10}BrFN$ 301.9975; Found 301.9979.



4f

2-([1,1'-Biphenyl]-4-yl)-3-fluoroquinoline (4f)

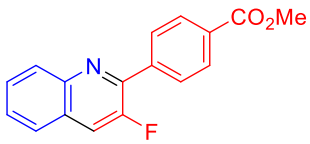
Eluent: petroleum ether/ethyl acetate (30:1). Yellow solid (19.8 mg, 66%), mp 142.8-143.7 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.19-8.17 (m, 3H), 7.86 (d, J = 11.4 Hz, 1H), 7.79 (d, J = 8.4 Hz, 1H), 7.76 (d, J = 8.4 Hz, 2H), 7.70-7.67 (m, 3H), 7.55 (t, J = 7.8 Hz, 1H), 7.47 (t, J = 7.8 Hz, 2H), 7.38 (t, J = 7.2 Hz, 1H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ 155.2 (d, J_{C-F} = 258.9 Hz), 148.7 (d, J_{C-F} = 14.7 Hz), 145.3 (d, J_{C-F} = 2.9 Hz), 142.4, 140.6, 134.7 (d, J_{C-F} = 4.9 Hz), 129.8 (d, J_{C-F} = 5.4 Hz), 129.7, 128.9, 128.8 (d, J_{C-F} = 2.0 Hz), 128.3 (d, J_{C-F} = 4.6 Hz), 127.7, 127.4, 127.30, 127.26, 126.8 (d, J_{C-F} = 5.7 Hz), 119.7 (d, J_{C-F} = 18.6 Hz). ^{19}F NMR (565 MHz, $CDCl_3$): δ -124.2 (d, J = 9.0 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{21}H_{15}FN$ 300.1183; Found 300.1178.



4g

3-Fluoro-2-(4-nitrophenyl)quinoline (4g)

Eluent: petroleum ether/ethyl acetate (30:1). White solid (19.3 mg, 72%), mp 155.1-156.8 ^{o}C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.38-8.36 (m, 2H), 8.30 (dd, *J* = 9.0 Hz, 1.2 Hz, 2H), 8.18 (d, *J* = 8.4 Hz, 1H), 7.93 (d, *J* = 11.4 Hz, 1H), 7.84 (d, *J* = 8.4 Hz, 1H), 7.74 (td, *J* = 7.2 Hz, 1.2 Hz,, 1H), 7.62 (t, *J* = 7.2 Hz, 1H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 155.1 (d, $J_{C\text{-}F}$ = 260.7 Hz), 148.4, 146.1 (d, $J_{C\text{-}F}$ = 14.7 Hz), 145.3 (d, $J_{C\text{-}F}$ = 2.1 Hz), 141.7 (d, $J_{C\text{-}F}$ = 5.6 Hz), 130.3 (d, $J_{C\text{-}F}$ = 4.7 Hz), 129.9, 129.4 (d, $J_{C\text{-}F}$ = 1.5 Hz), 128.8 (d, $J_{C\text{-}F}$ = 5.4 Hz), 128.3, 126.9 (d, $J_{C\text{-}F}$ = 5.1 Hz), 123.7, 120.4 (d, $J_{C\text{-}F}$ = 19.7 Hz). ^{19}F NMR (565 MHz, $CDCl_3$): δ -124.4 (d, *J* = 11.3 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{15}H_{10}FN_2O_2$ 269.0721; Found 269.0724.



4h

Methyl 4-(3-fluoroquinolin-2-yl)benzoate (4h)

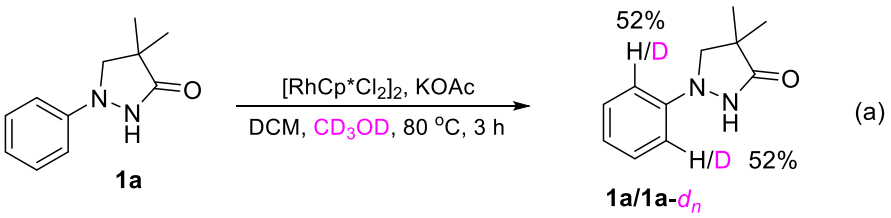
Eluent: petroleum ether/ethyl acetate (30:1). Yellow solid (17.4 mg, 62%), mp 113.5-114.7 ^{o}C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.20-8.16 (m, 5H), 7.88 (d, *J* = 11.4 Hz, 1H), 7.81 (d, *J* = 7.8 Hz, 1H), 7.71 (t, *J* = 7.2 Hz, 1H), 7.58 (t, *J* = 7.2 Hz, 1H), 3.96 (s, 3H). ^{13}C{^{1}H} NMR (150 MHz, $CDCl_3$): δ 166.9, 155.1 (d, $J_{C\text{-}F}$ = 258.2 Hz), 147.8 (d, $J_{C\text{-}F}$ = 14.3 Hz), 145.3 (d, $J_{C\text{-}F}$ = 3.0 Hz), 139.9 (d, $J_{C\text{-}F}$ = 6.2 Hz), 130.9, 129.8, 129.7, 129.3 (d, $J_{C\text{-}F}$ = 5.3 Hz), 129.0 (d, $J_{C\text{-}F}$ = 3.3 Hz), 128.6 (d, $J_{C\text{-}F}$ = 5.4 Hz), 127.8, 126.9 (d, $J_{C\text{-}F}$ = 3.8 Hz), 120.0 (d, $J_{C\text{-}F}$ = 19.7 Hz), 52.3. ^{19}F NMR (565 MHz, $CDCl_3$): δ -124.3 (d, *J* = 13.0 Hz). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{17}H_{13}FNO_2$ 282.0925; Found 282.0924.

3. Gram-Scale Synthesis of 3a

To a reaction tube equipped with a stir bar were added 4,4-dimethyl-1-phenylpyrazolidin-3-one (**1a**, 1902.4 mg, 10 mmol), $[RhCp^*Cl_2]_2$ (92.7 mg, 0.15 mmol), KOAc (490.7 mg, 5 mmol), DCM (30 mL) and (3,3-difluorocycloprop-1-en-1-yl)benzene (**2a**, 760.7 mg, 5 mmol). The tube was then sealed, and the mixture was stirred at 80 ℃ (oil bath) under air for 18 h. Upon completion, it was cooled to room temperature, filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether/ethyl acetate (3:1) as eluent to afford **3a** (1.12 g, 69%).

III. Mechanistic studies

1. H/D exchange experiments



To a reaction tube equipped with a stir bar were added 4,4-dimethyl-1-phenylpyrazolidin-3-one (**1a**, 76.1 mg, 0.4 mmol), $[RhCp^*Cl_2]_2$ (6.2 mg, 0.01 mmol), KOAc (19.6 mg, 0.2 mmol), DCM (**2** mL) and CD_3OD (0.16 mL, 4 mmol). The tube was then sealed, and the mixture was stirred at 80 ℃ (oil bath) under air for 3 h. It was then cooled to room temperature, filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether/ethyl acetate (3:1) as eluent to afford **1a** and **1a-*d*$_n$**. Upon analyzing the ^{1}H NMR spectrum of the product as shown in Figure S1, the deuteration percentage was determined to be 52%.

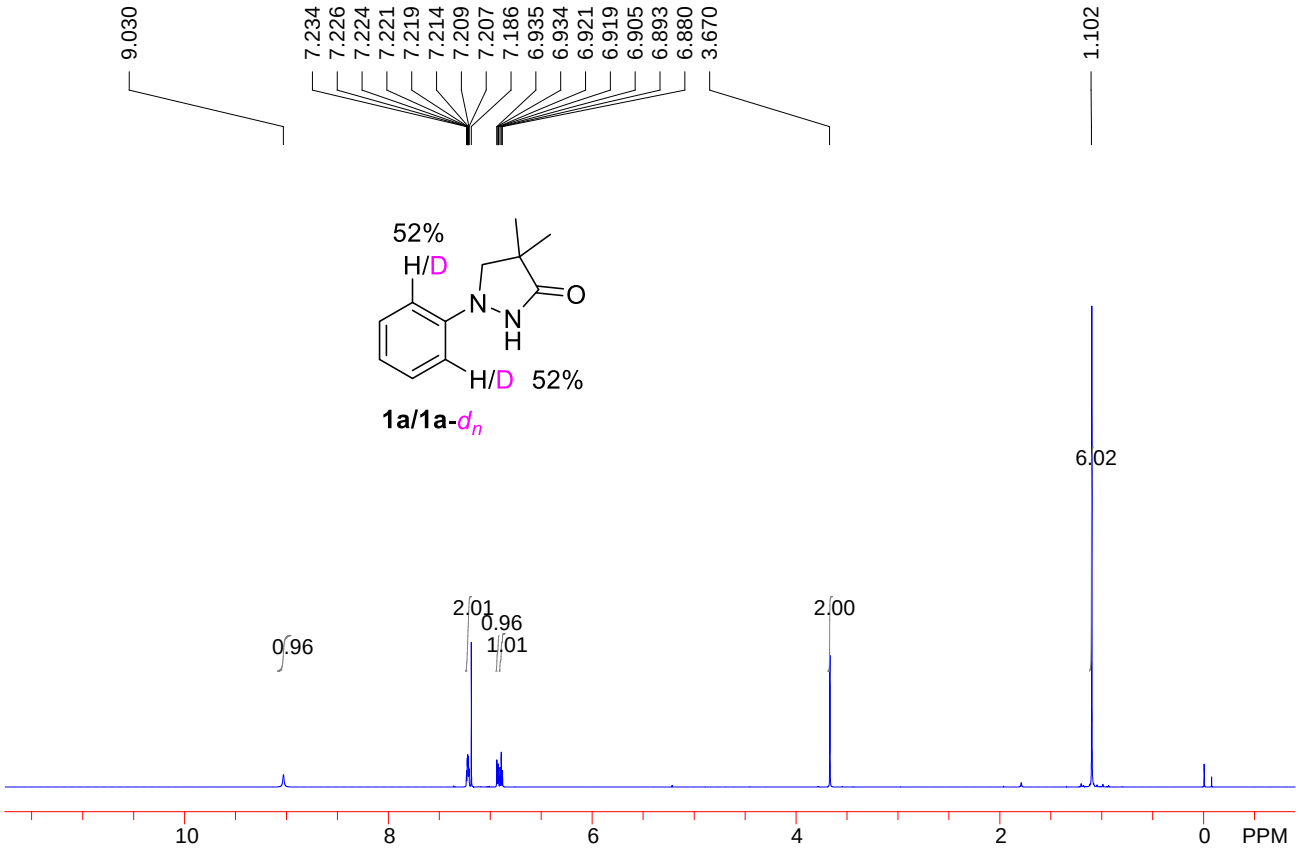
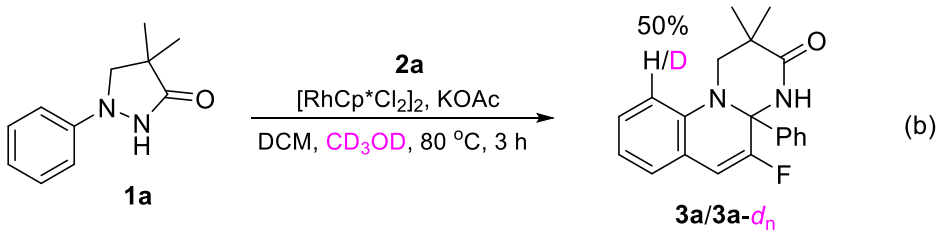


Figure S1. The ^{1}H NMR spectrum of products obtained from H/D exchange experiment (I)



(b)

To a reaction tube equipped with a stir bar were added 4,4-dimethyl-1-phenylpyrazolidin-3-one (**1a**, 76.1 mg, 0.4 mmol), $[RhCp^*Cl_2]_2$ (6.2 mg, 0.01 mmol), KOAc (19.6 mg, 0.2 mmol), DCM (**2** mL), (3,3-difluorocycloprop-1-en-1-yl)benzene (**2a**, 30.4 mg, 0.2 mmol) and CD_3OD (0.16 mL, 4 mmol). The tube was then sealed, and the mixture was stirred at 80 ℃ (oil bath) under air for 3 h. It was then cooled to room temperature, filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether/ethyl acetate (3:1) as eluent to afford **3a** and **3a-*d*$_n$**. Upon analyzing the ^{1}H NMR spectrum of the product as shown in Figure S2, the deuteration percentage was determined as 50%.

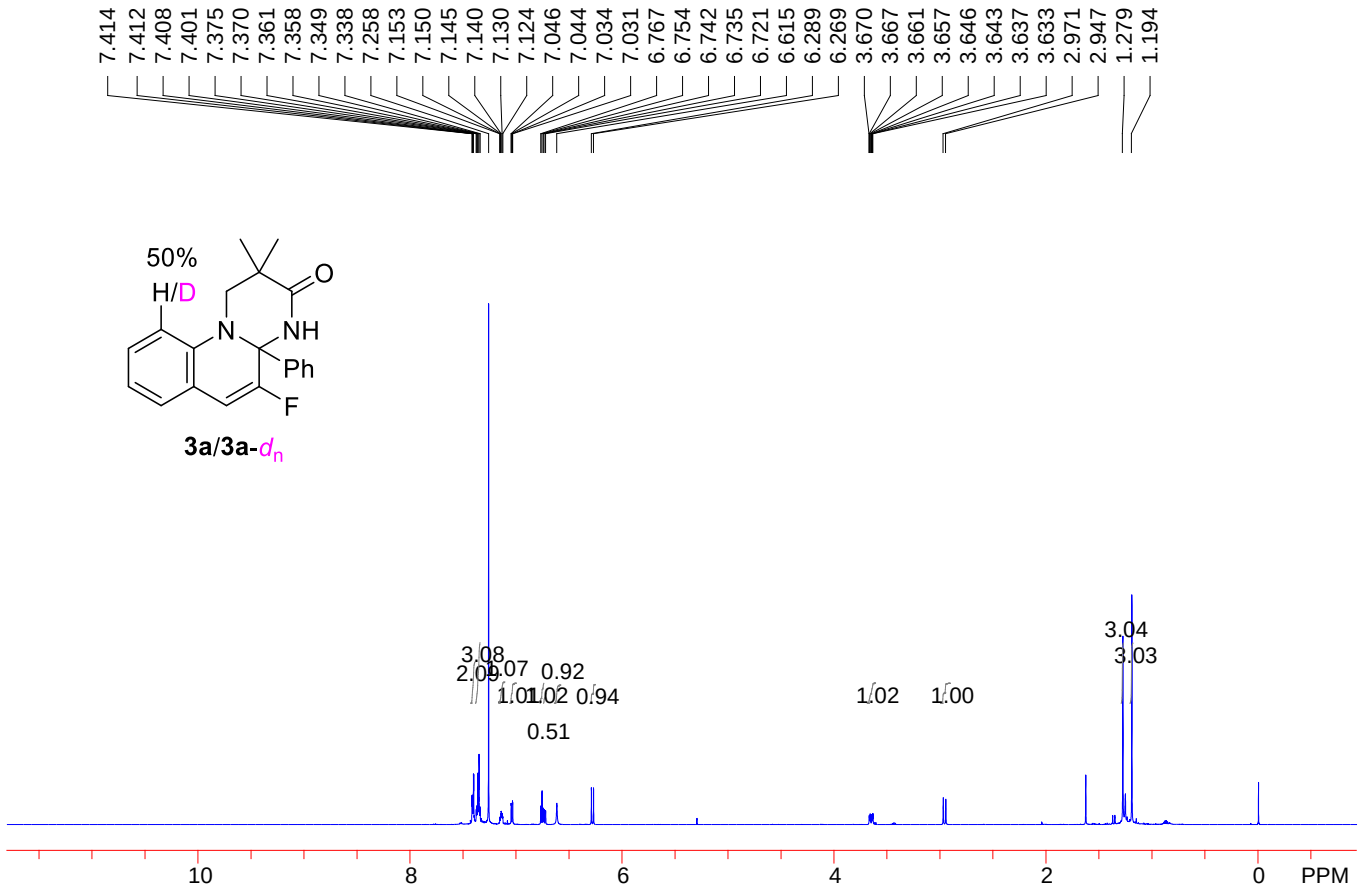


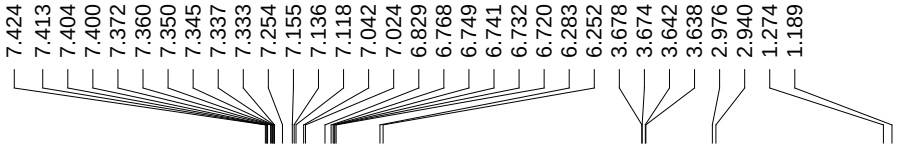
Figure S2. The ^{1}H NMR spectrum of products obtained from H/D exchange experiment (II)

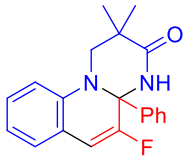
2. Competition experiments

To a reaction tube equipped with a stir bar were added 4,4-dimethyl-1-(*p*-tolyl)pyrazolidin-3-one (**1b**, 40.9 mg, 0.2 mmol), 4,4-dimethyl-1-(4-(trifluoromethyl)phenyl)pyrazolidin-3-one (**1j**, 51.6 mg, 0.2 mmol), $[RhCp^*Cl_2]_2$ (6.2 mg, 0.01 mmol), KOAc (19.6 mg, 0.2 mmol), DCM (2 mL) and (3,3-difluorocycloprop-1-en-1-yl)benzene (**2a**, 30.4 mg, 0.2 mmol). The tube was then sealed, and the mixture was stirred at 80 ℃ (oil bath) under air for 3 h. Upon completion, it was cooled to room temperature, filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether/ethyl acetate (3:1) as eluent to afford **3b** (10.8 mg, 16%) and **3j** (37.6 mg, 48%).

To a reaction tube equipped with a stir bar were add 4,4-dimethyl-1-phenylpyrazolidin-3-one (**1a**, 38.0 mg, 0.2 mmol), $[RhCp^*Cl_2]_2$ (6.2 mg, 0.01 mmol), KOAc (19.6 mg, 0.2 mmol), DCM (2 mL) and 1-(3,3-difluoro-cycloprop-1-en-1-yl)-4-methylbenzene (**2b**, 33.2 mg, 0.2 mmol), 1-(3,3-difluorocycloprop-1-en-1-yl)-4-nitro-benzene (**2k**, 39.4 mg, 0.2 mmol). The tube was then sealed, and the mixture was stirred at 80 ℃ (oil bath) under air for 3 h. Upon completion, it was cooled to room temperature, filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether/ethyl acetate (3:1) as eluent to afford **3q** (trace) and **3z** (56.2 mg, 76%).

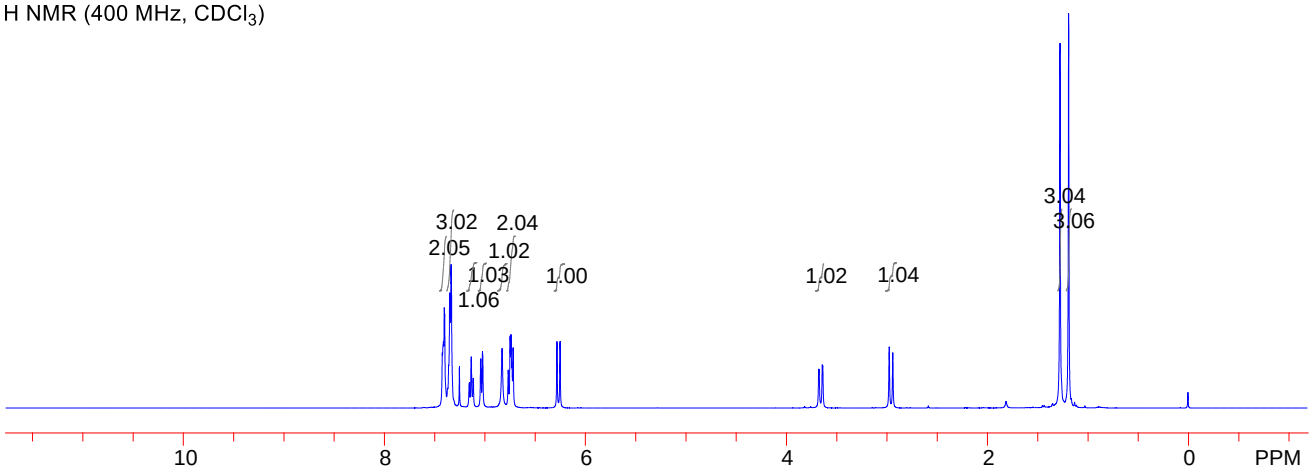
IV. Copies of NMR spectra of 3a-3jj

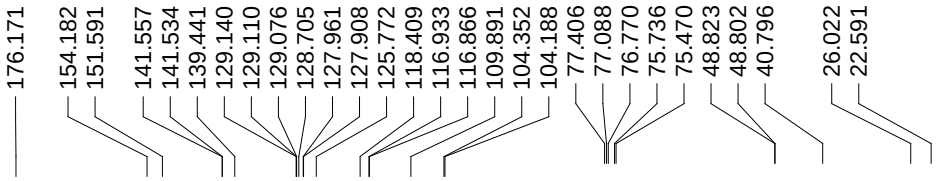


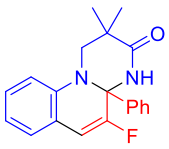


3a

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

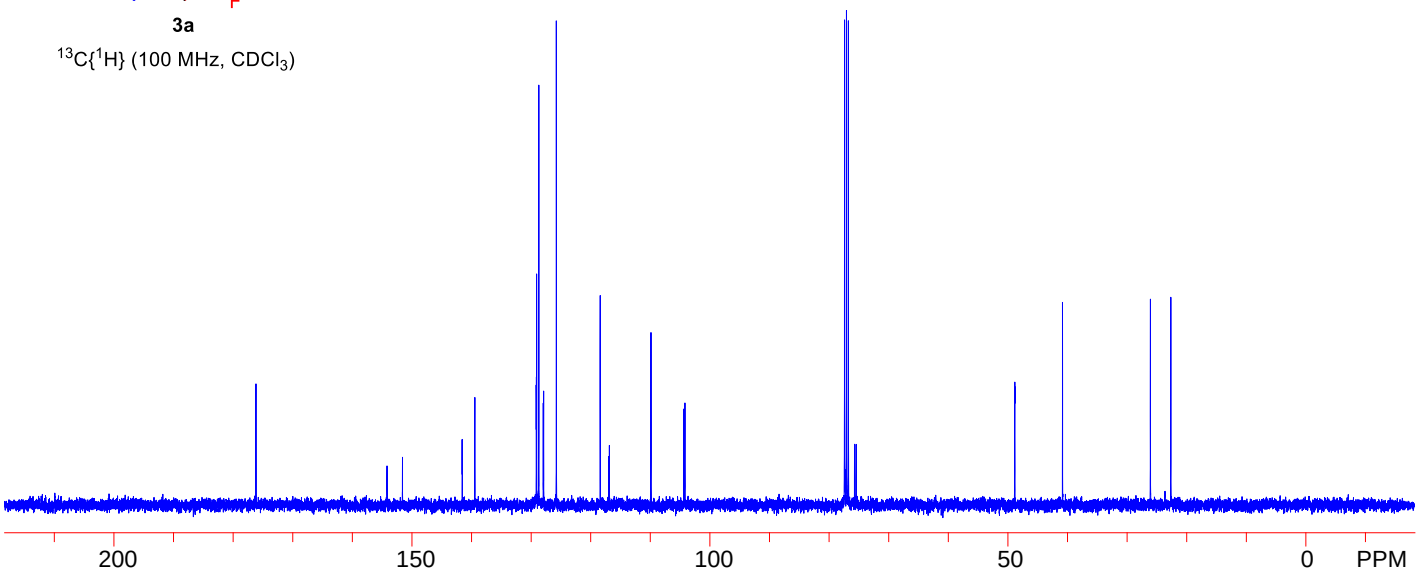


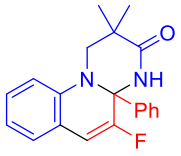




3a

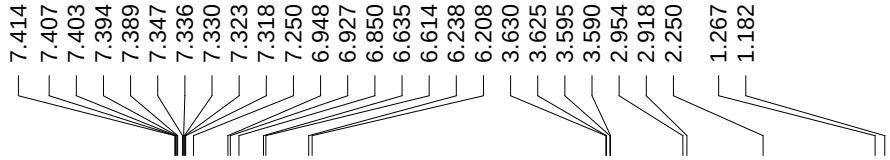
^{13}C{^{1}H} (100 MHz, $CDCl_3$)

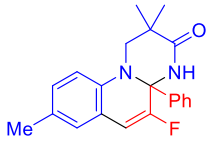




3a

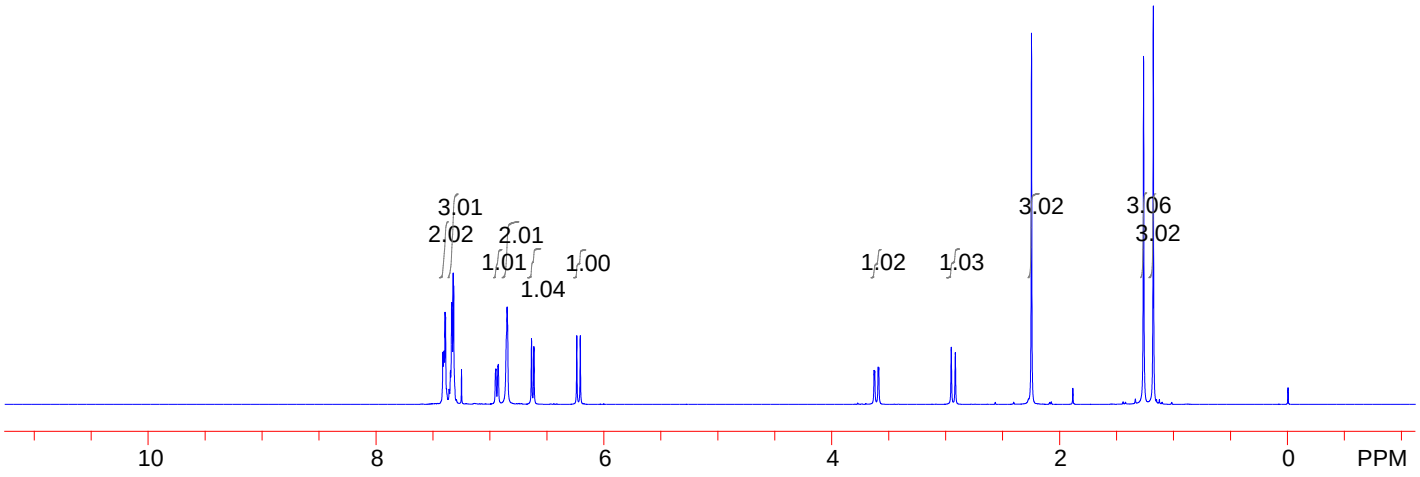
^{19}F NMR (376 MHz, $CDCl_3$)

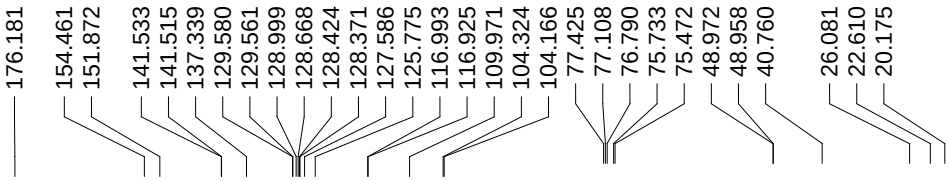


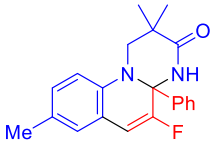


3b

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

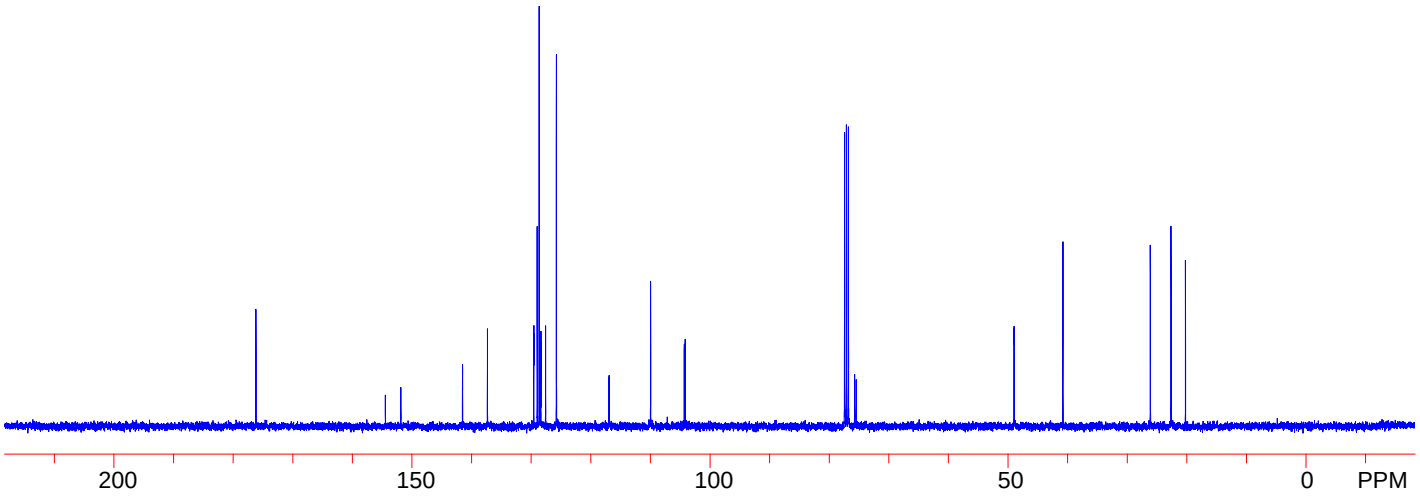


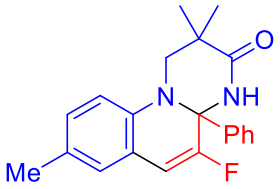




3b

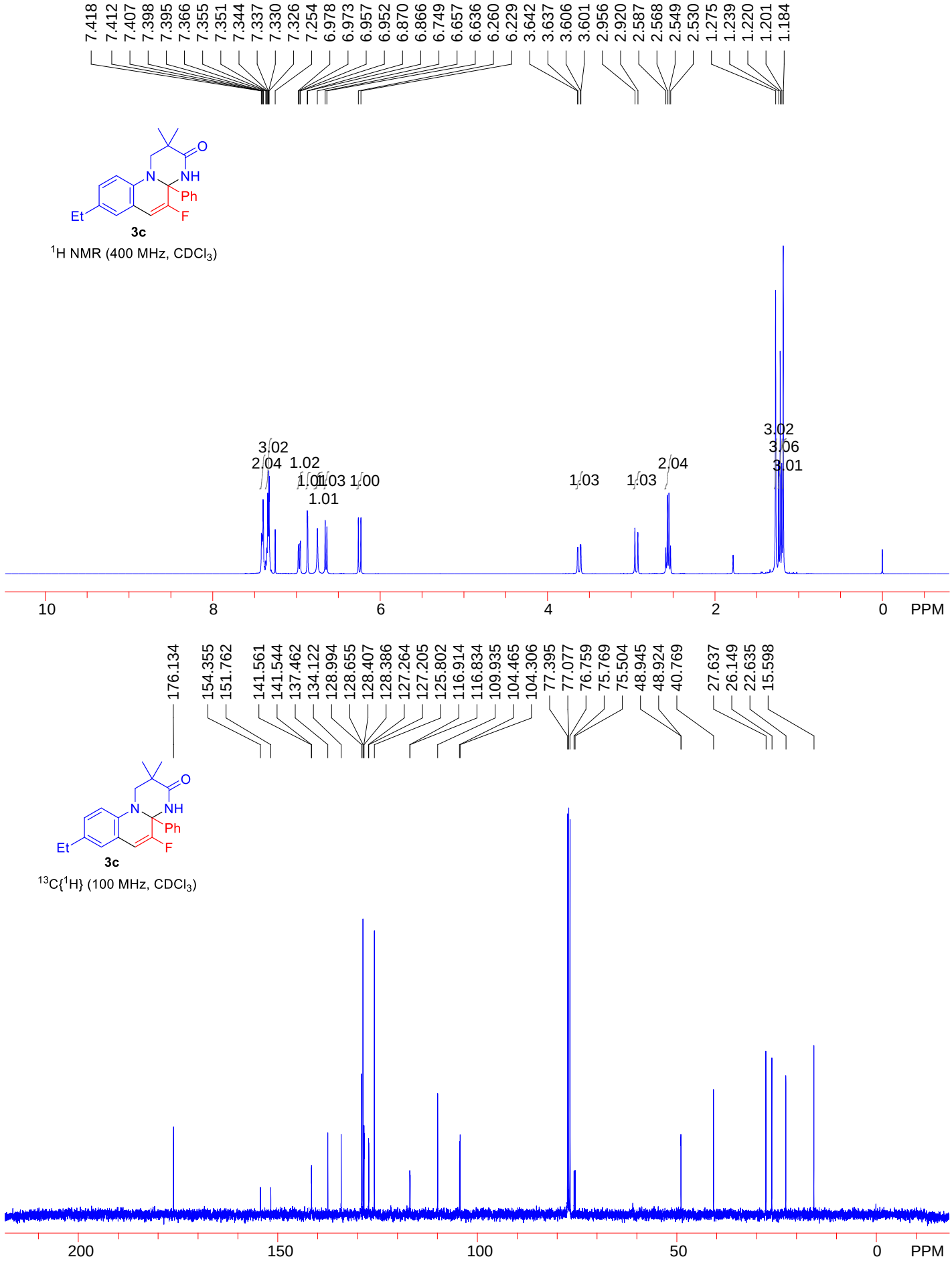
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)





3b

^{19}F NMR (376 MHz, $CDCl_3$)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7.330
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7.254
6.978
6.973
6.957
6.952
6.870
6.866
6.749
6.657
6.636
6.260
6.229
3.642
3.637
3.606
3.601
2.956
2.920
2.587
2.568
2.549
2.530
1.275
1.239
1.220
1.201
1.184
O
NH
N
Ph
Et
F
3c
1H NMR (400 MHz, CDCl3)
3.02
2.04
1.02
1.01
1.03
1.00
1.03
1.03
2.04
3.02
3.06
3.01
10
8
6
4
2
0
PPM
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154.355
151.762
141.561
141.544
137.462
134.122
128.994
128.655
128.407
128.386
127.264
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Et
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100
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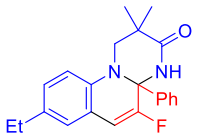
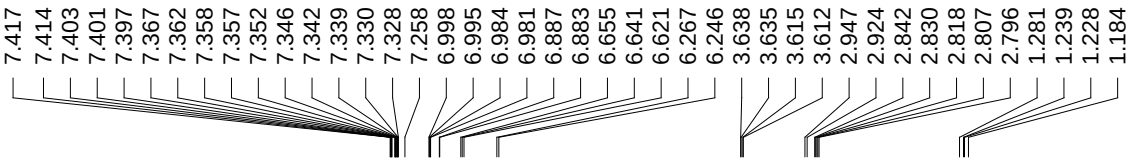
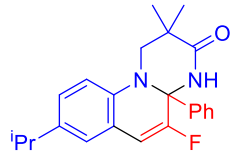
PPM



3c

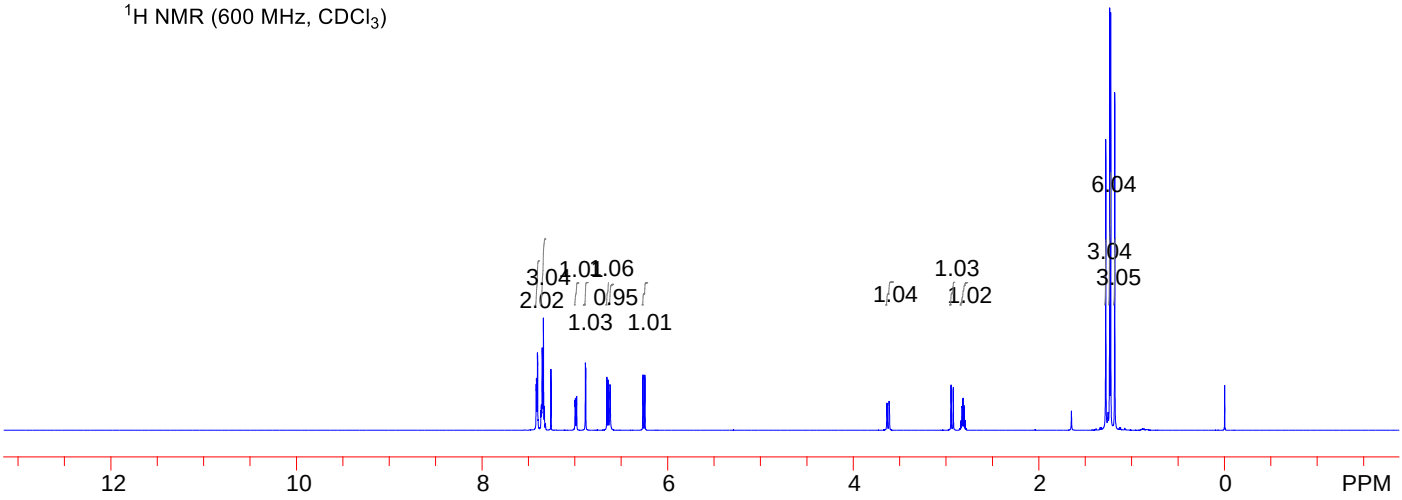
^{19}F NMR (376 MHz, $CDCl_3$)

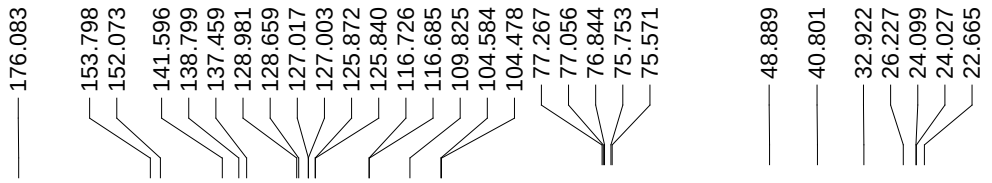


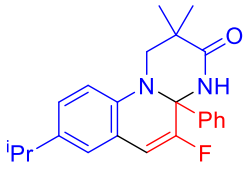


3d

^{1}H NMR (600 MHz, $CDCl_3$)

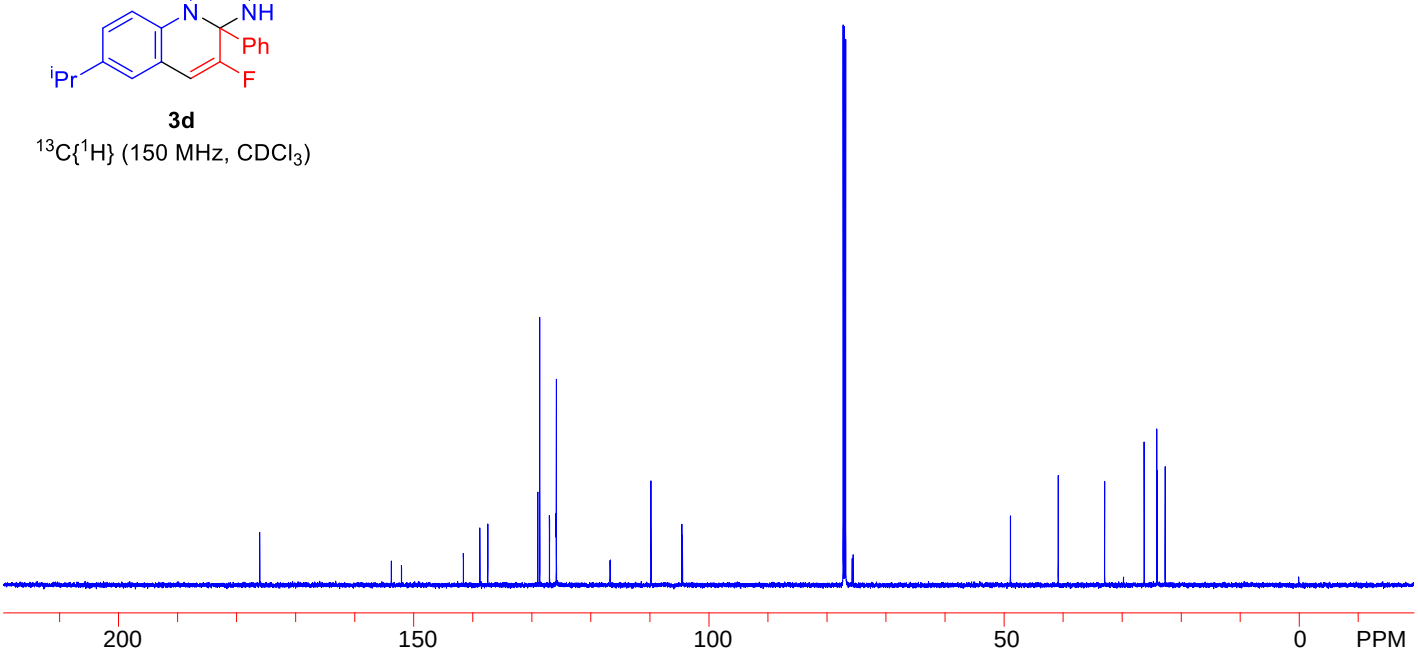


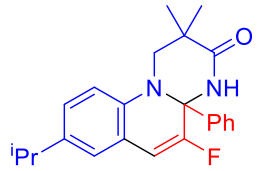




3d

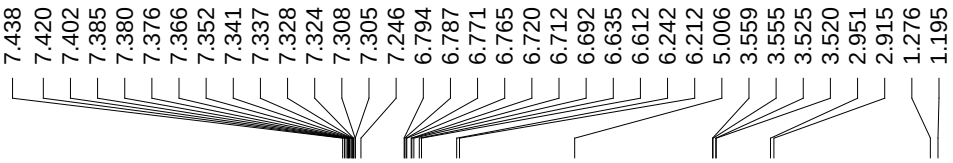
^{13}C{^{1}H} (150 MHz, $CDCl_3$)

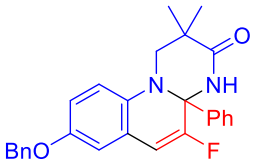




3d

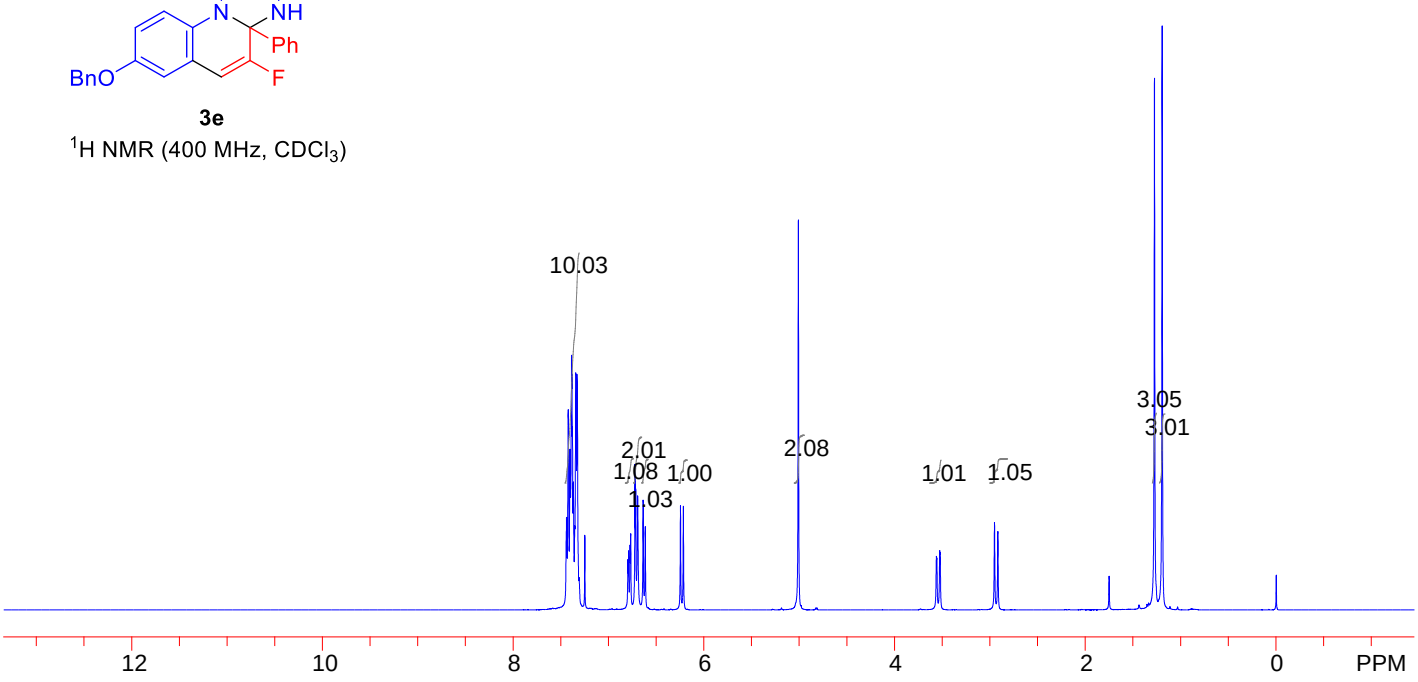
^{19}F NMR (565 MHz, $CDCl_3$)

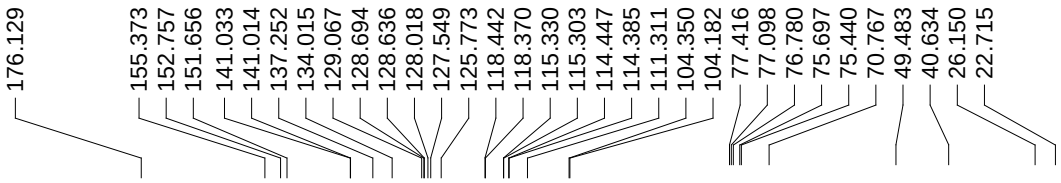


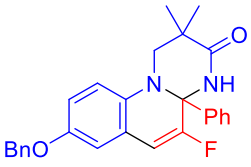


3e

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

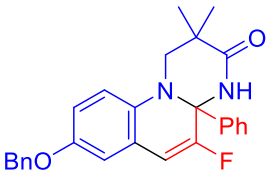






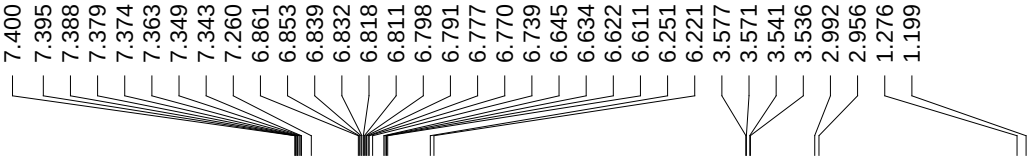
3e

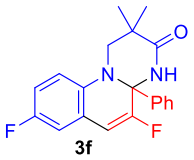
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)



3e

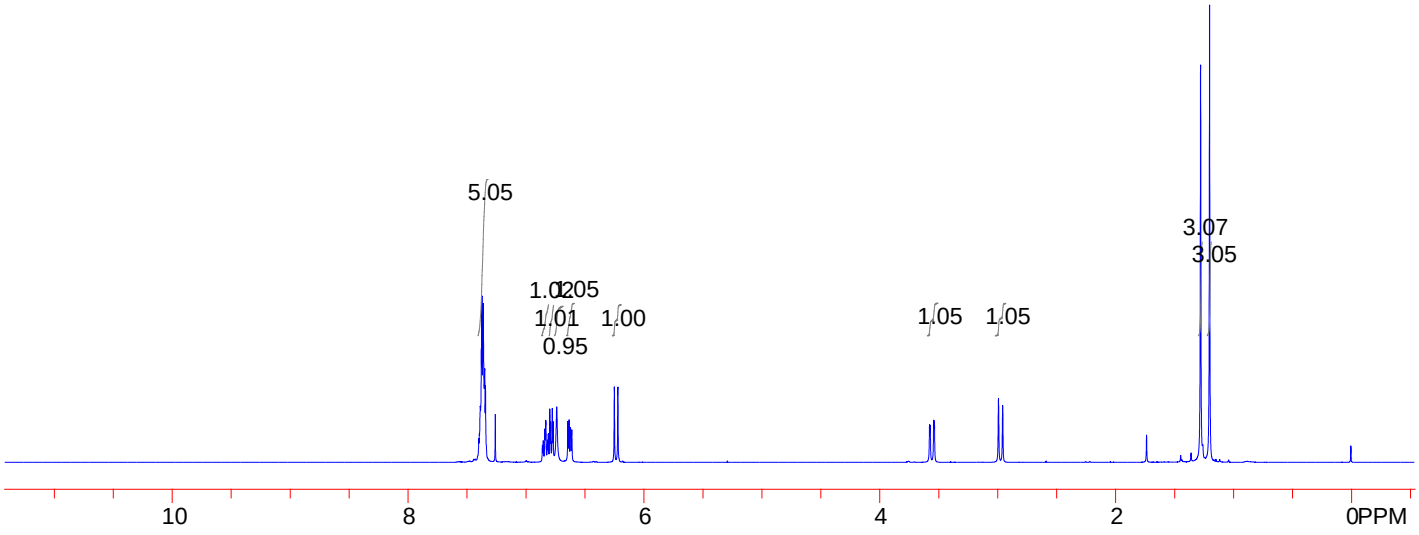
^{19}F NMR (376 MHz, $CDCl_3$)

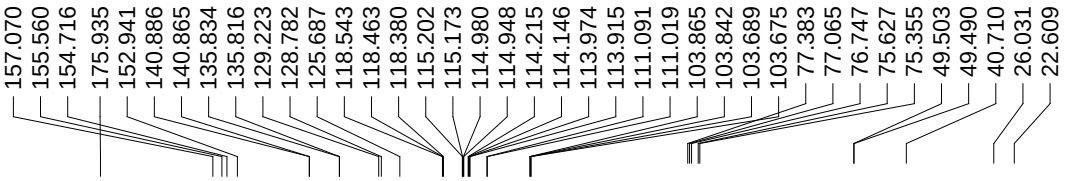


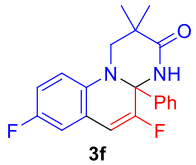


3f

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

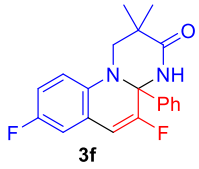






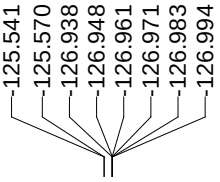
3f

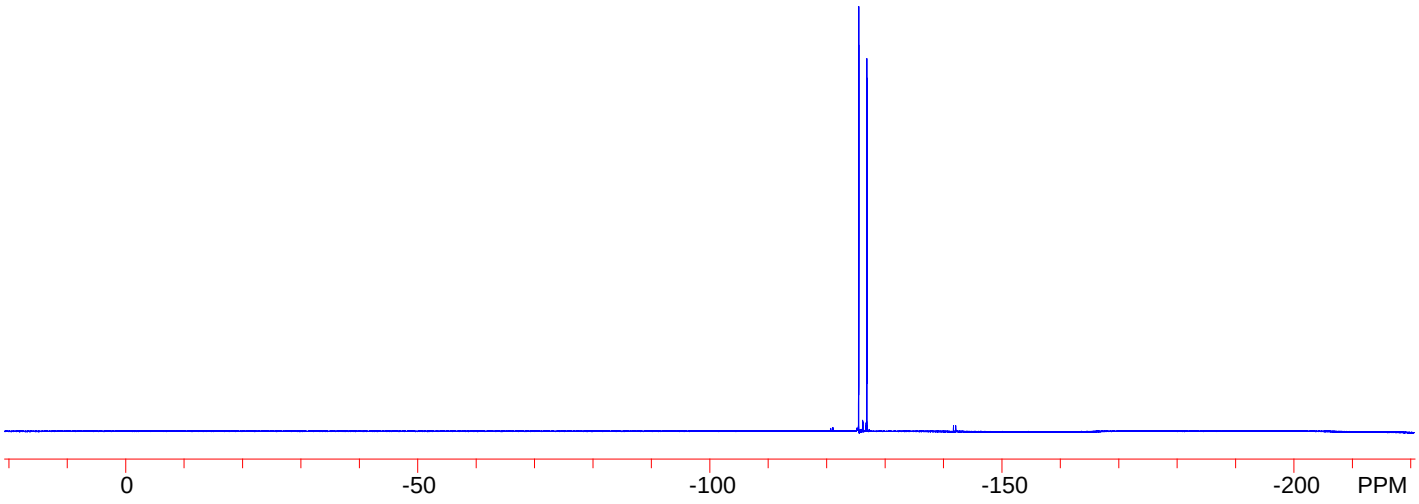
^{13}C{^{1}H} (100 MHz, $CDCl_3$)

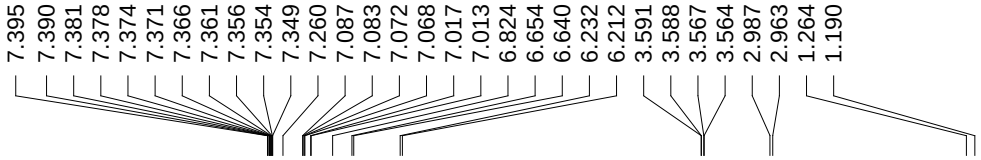


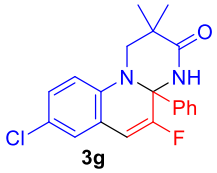
3f

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



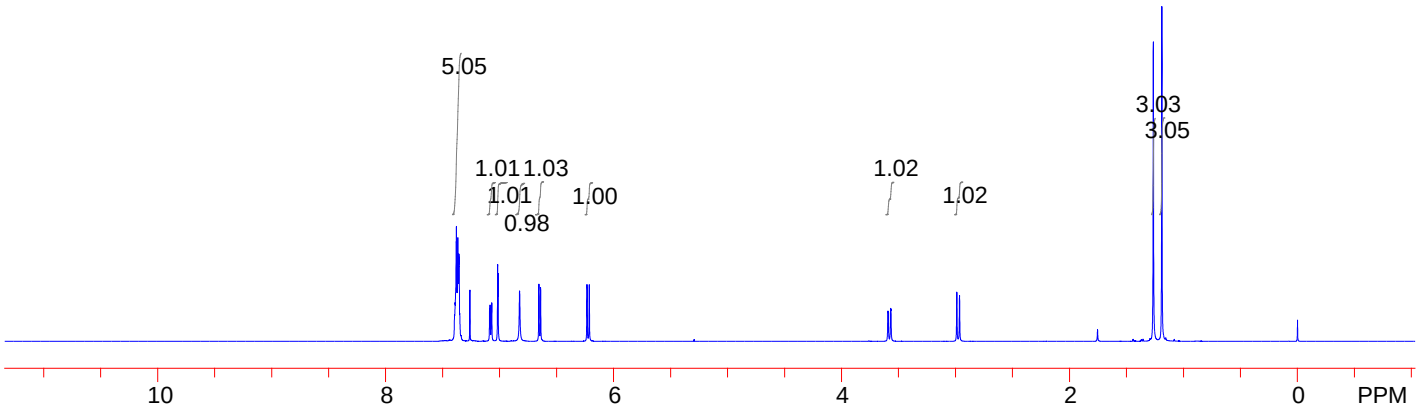


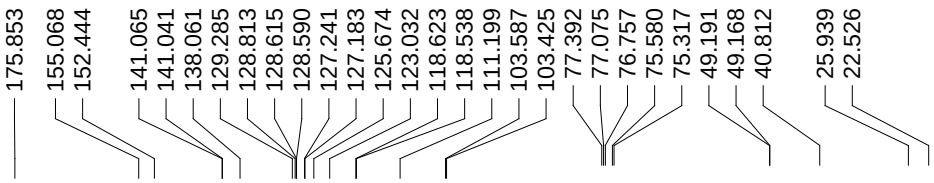


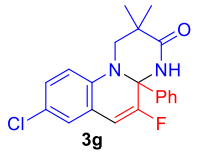


3g

^{1}H NMR (600 MHz, $CDCl_3$)

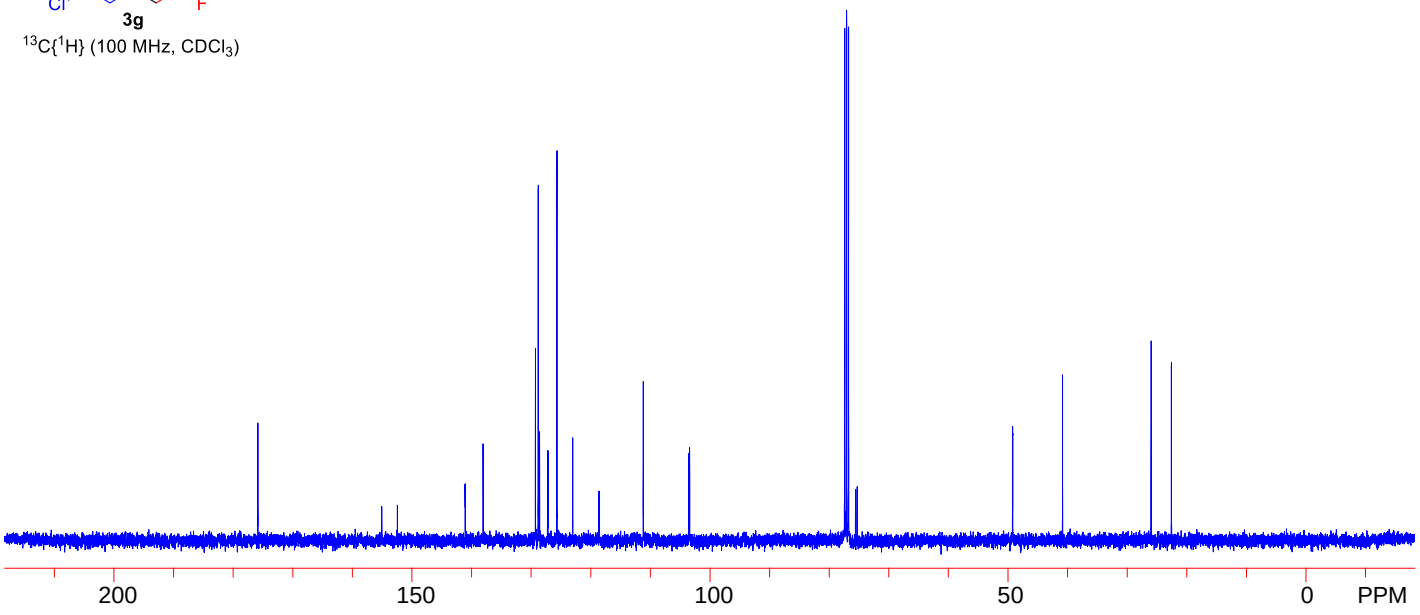


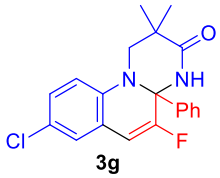




3g

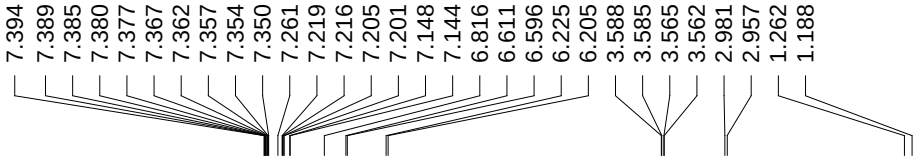
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)

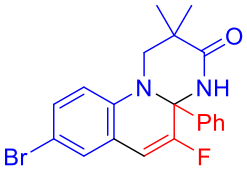




3g

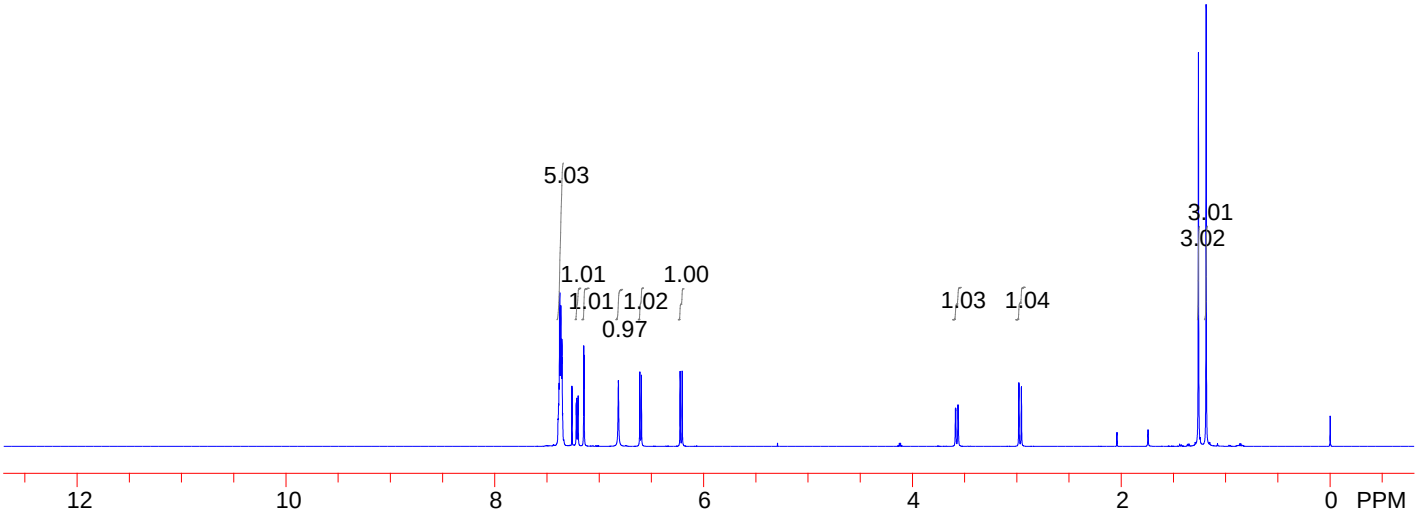
^{19}F NMR (565 MHz, $CDCl_3$)

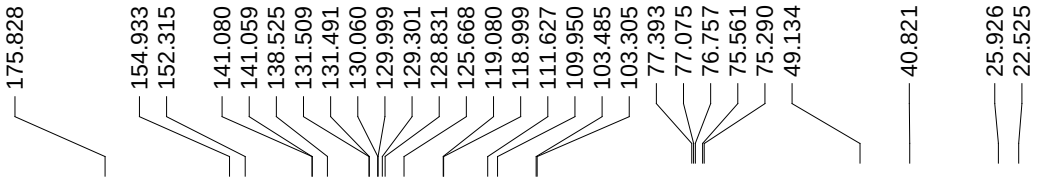


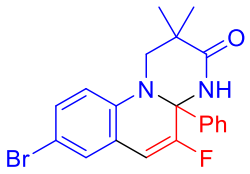


3h

^{1}H NMR (600 MHz, $CDCl_3$)

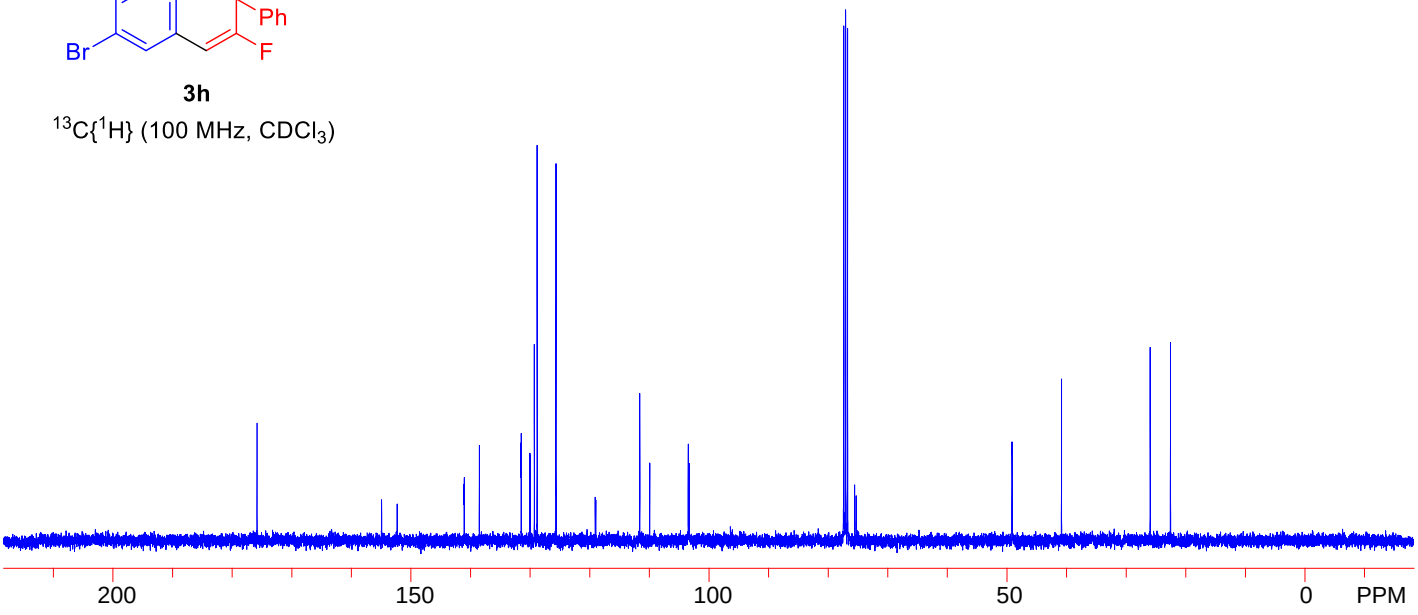


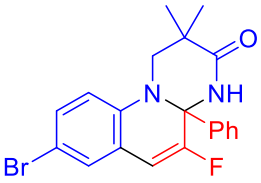




3h

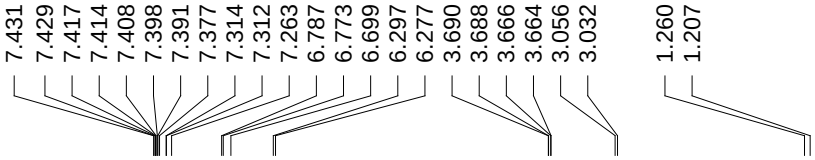
^{13}C{^{1}H} (100 MHz, $CDCl_3$)

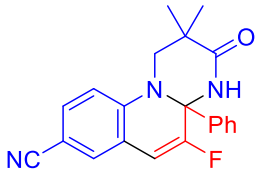




3h

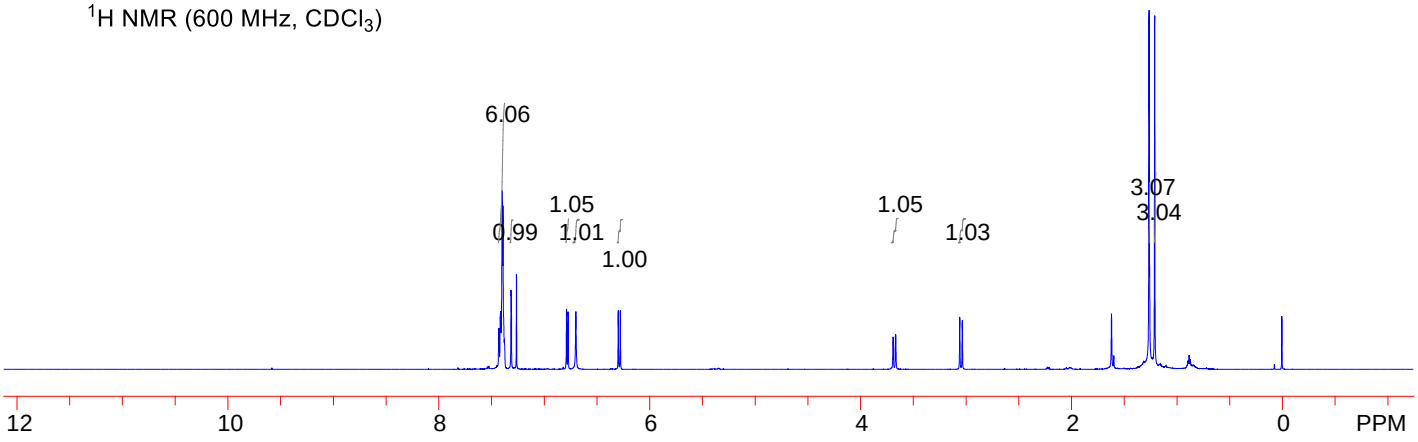
^{19}F NMR (565 MHz, $CDCl_3$)

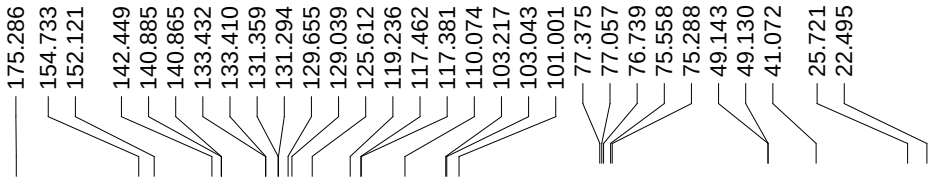


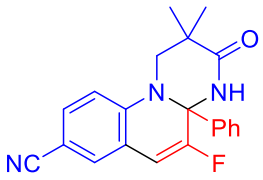


3i

^{1}H NMR (600 MHz, $CDCl_3$)

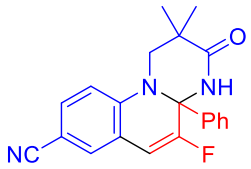






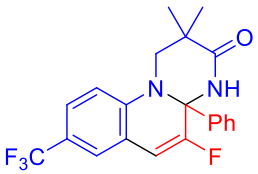
3i

$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)



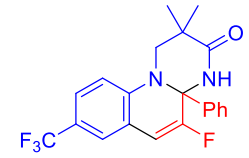
3i

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



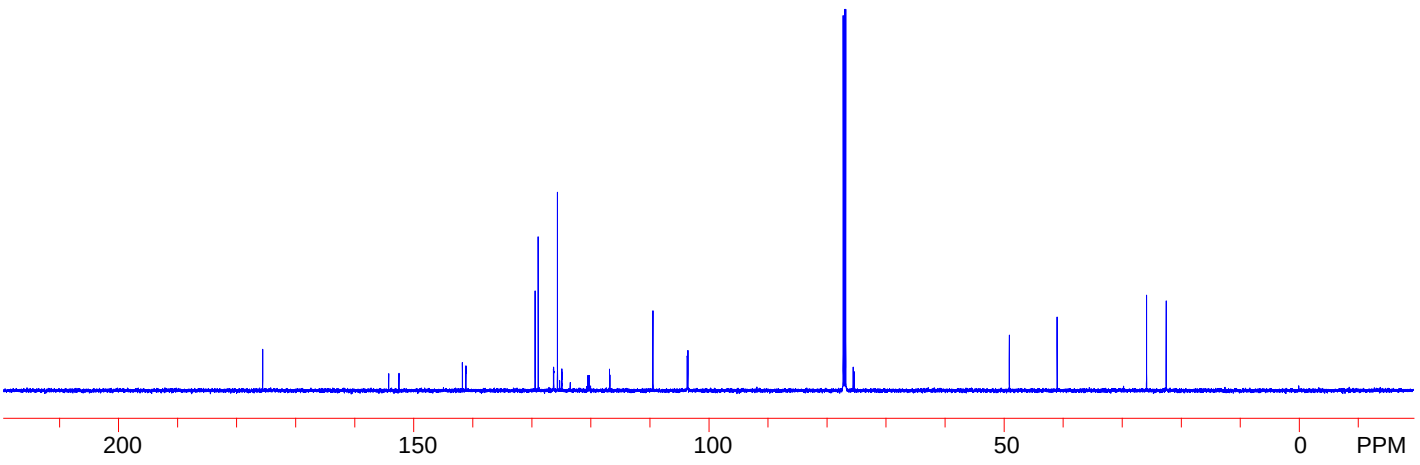
3j

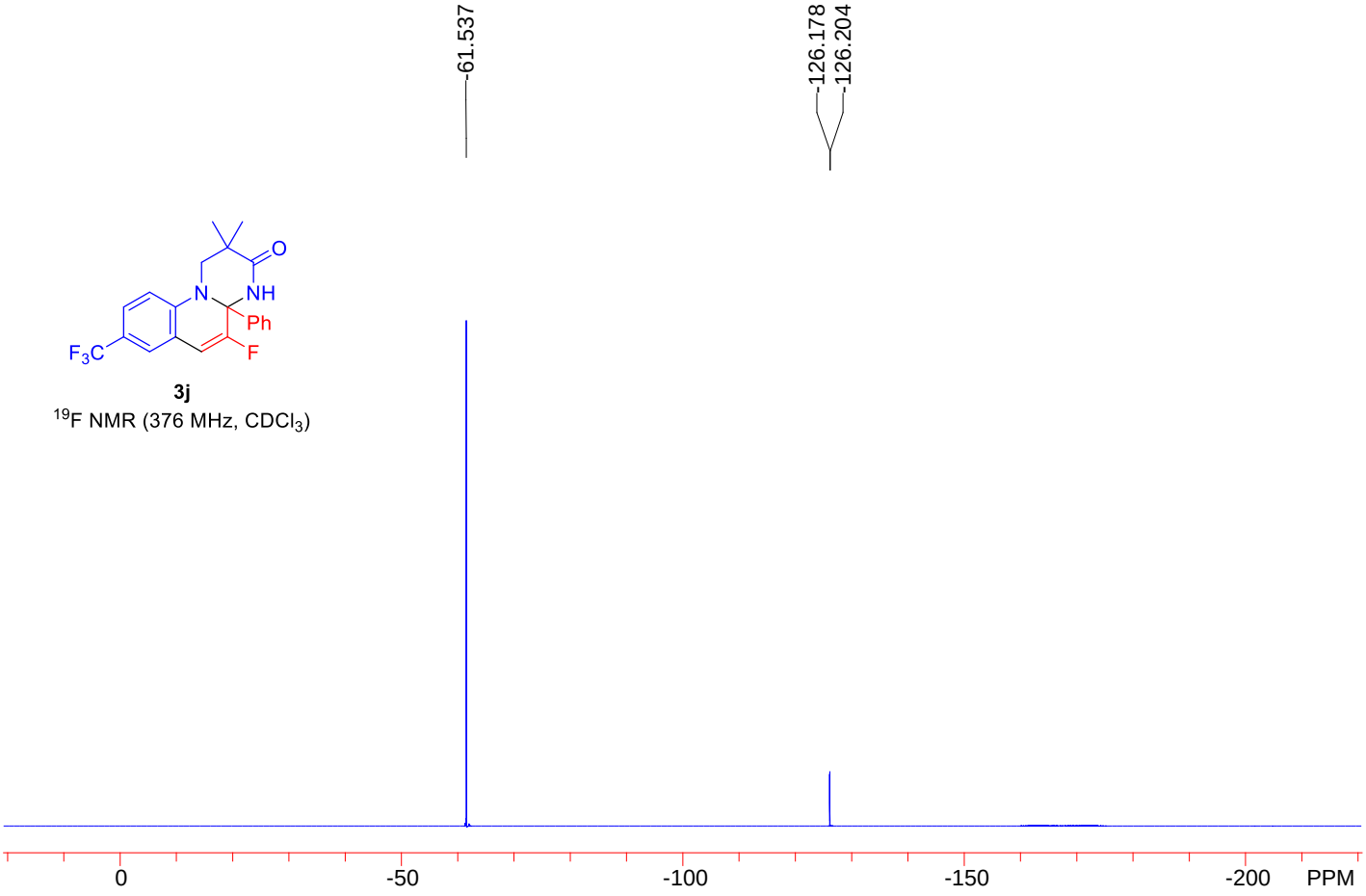
^{1}H NMR (400 MHz, $CDCl_3$)



3j

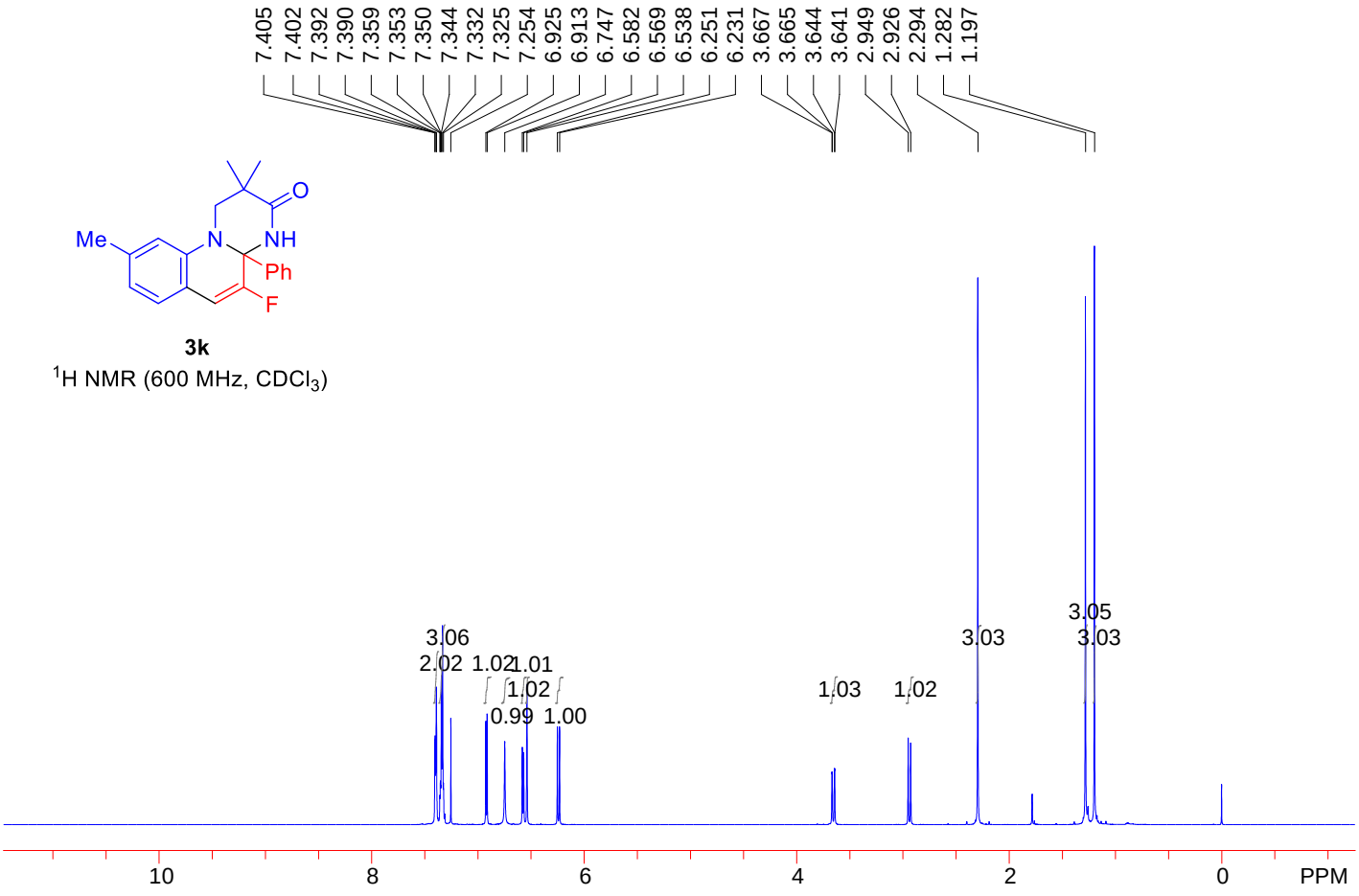
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)





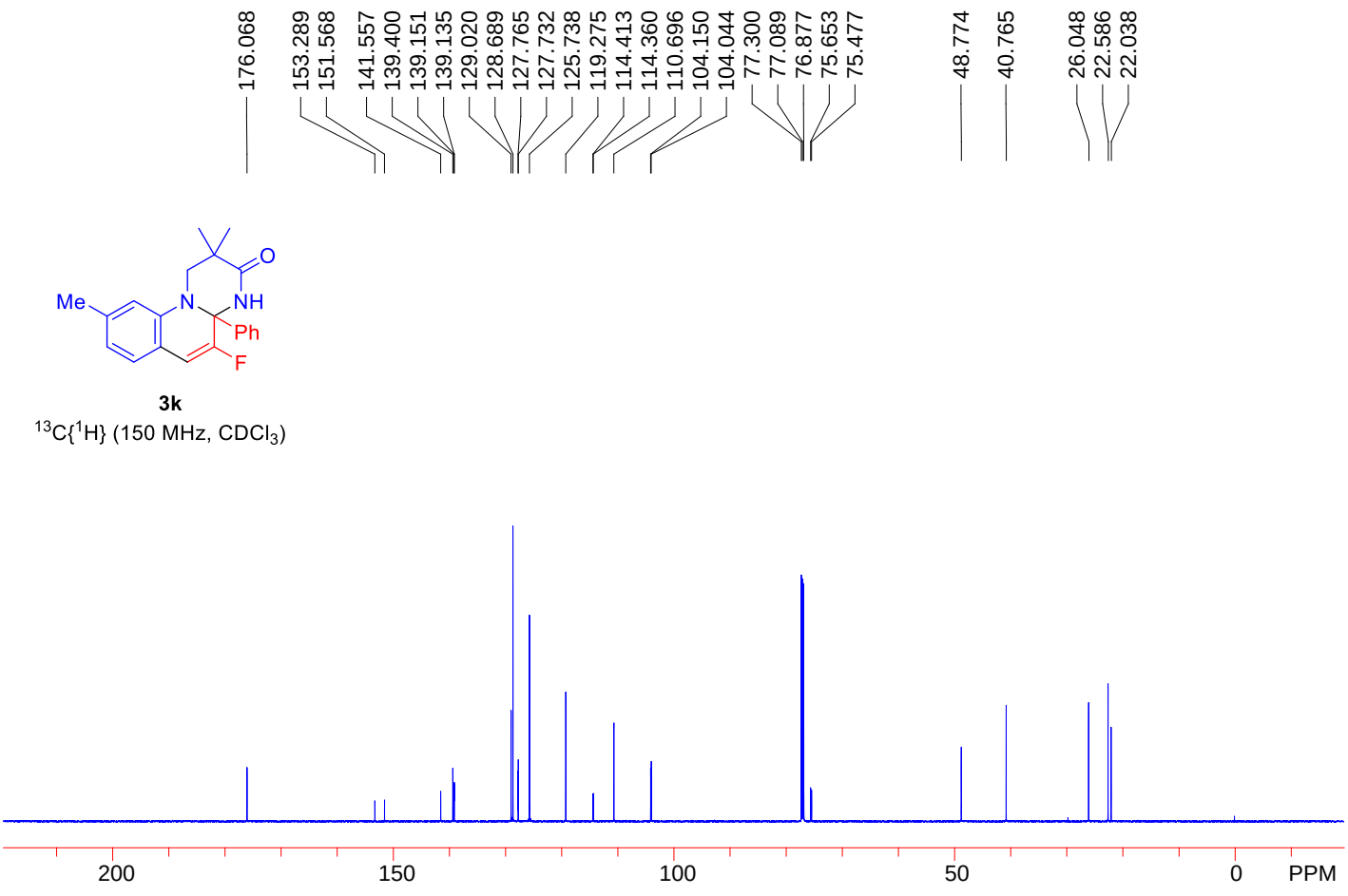
3j

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



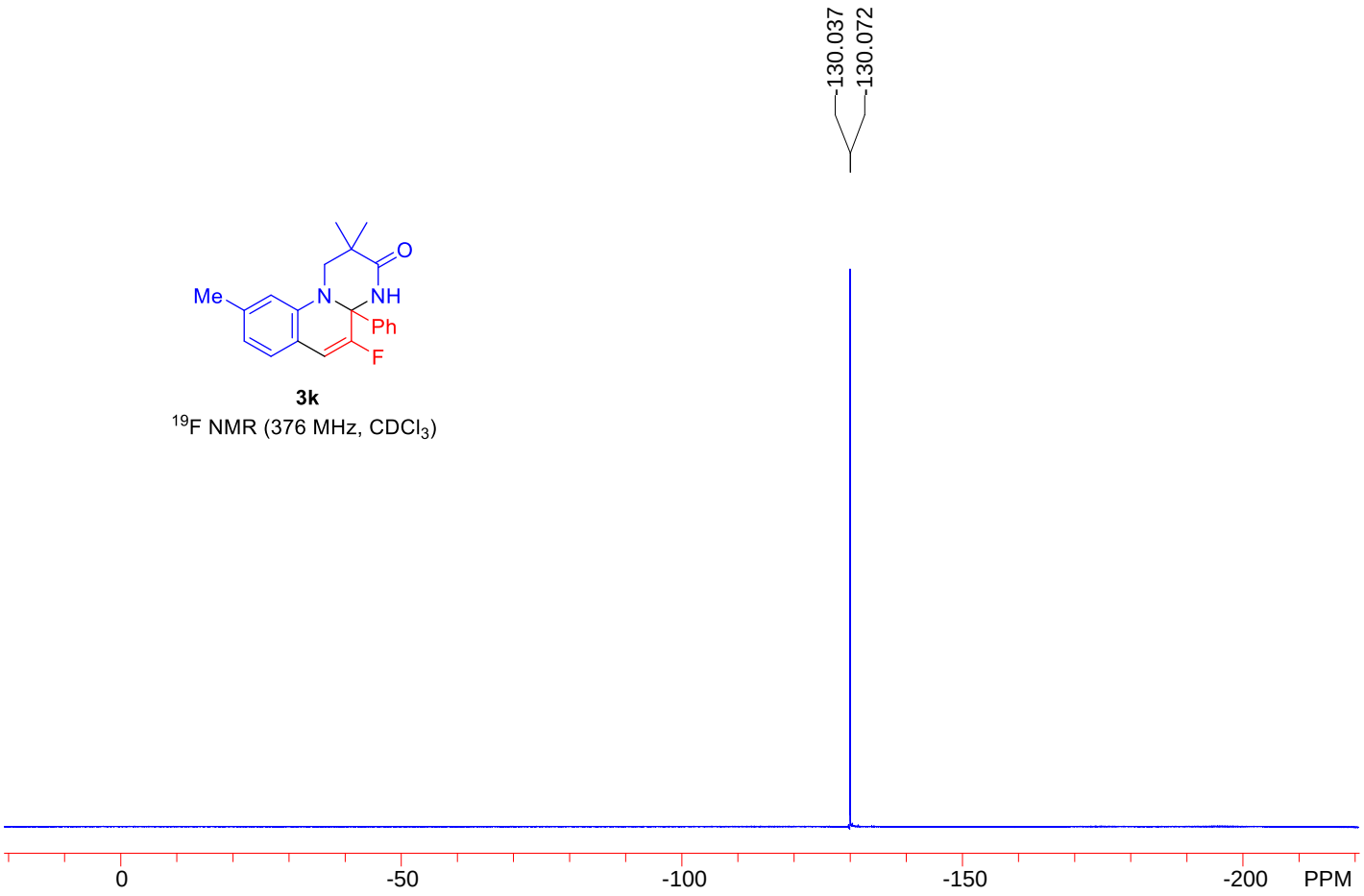
3k

^{1}H NMR (600 MHz, $CDCl_3$)



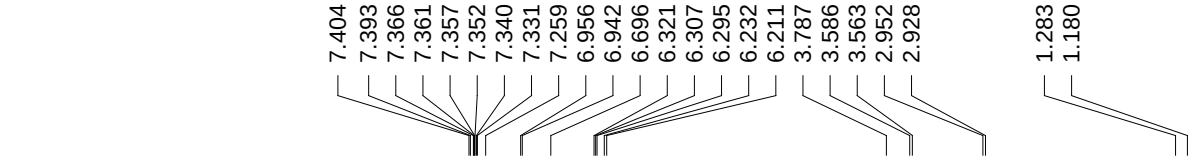
3k

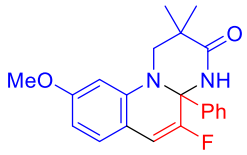
^{13}C{^{1}H} (150 MHz, $CDCl_3$)



3k

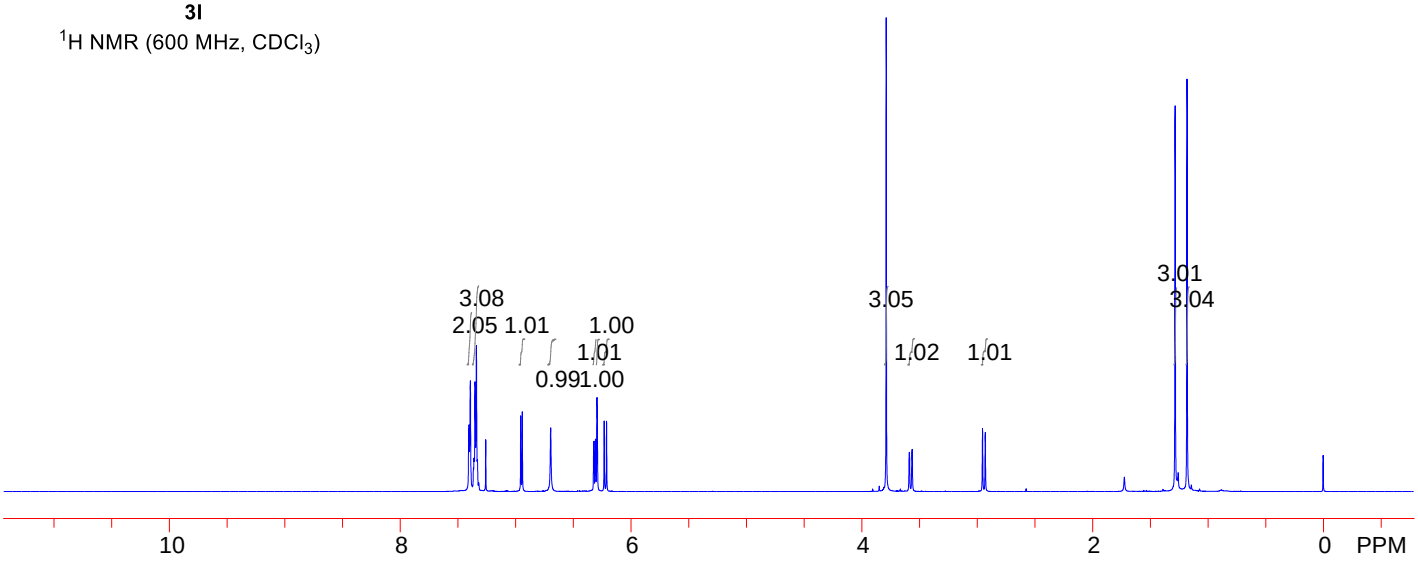
^{19}F NMR (376 MHz, $CDCl_3$)

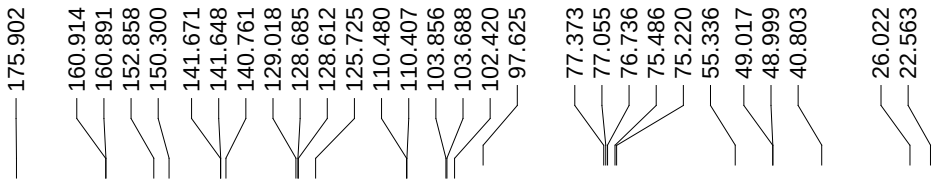


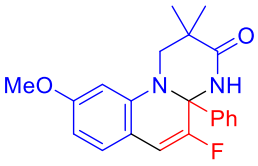


3l

^{1}H NMR (600 MHz, $CDCl_3$)

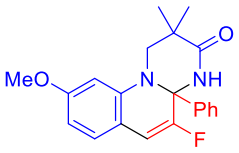






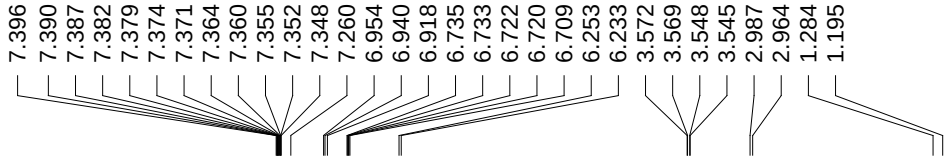
3l

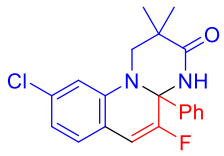
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)



3l

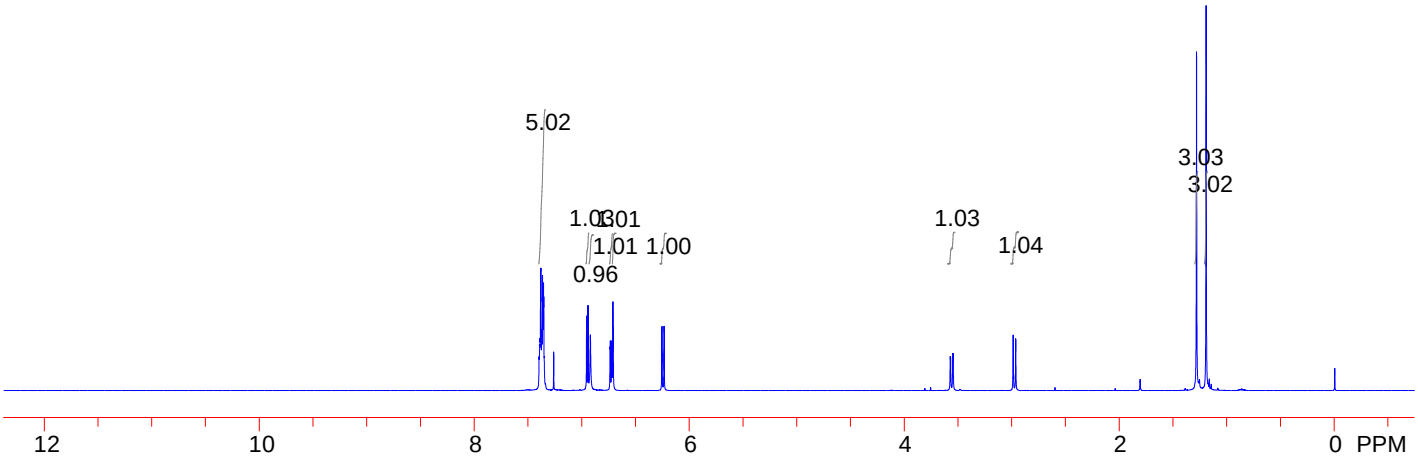
^{19}F NMR (376 MHz, $CDCl_3$)

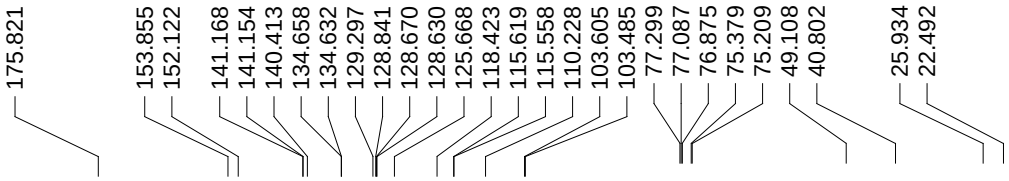


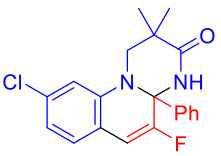


3m

^{1}H NMR (600 MHz, $CDCl_3$)

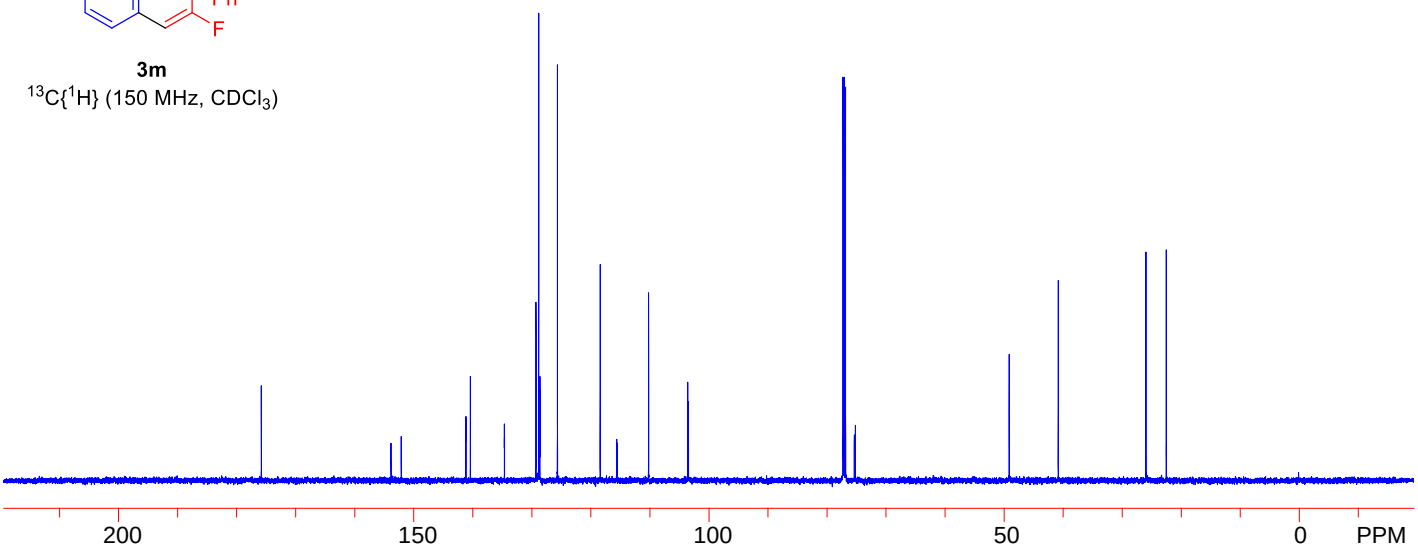


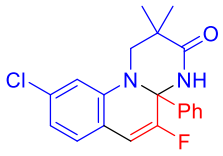




3m

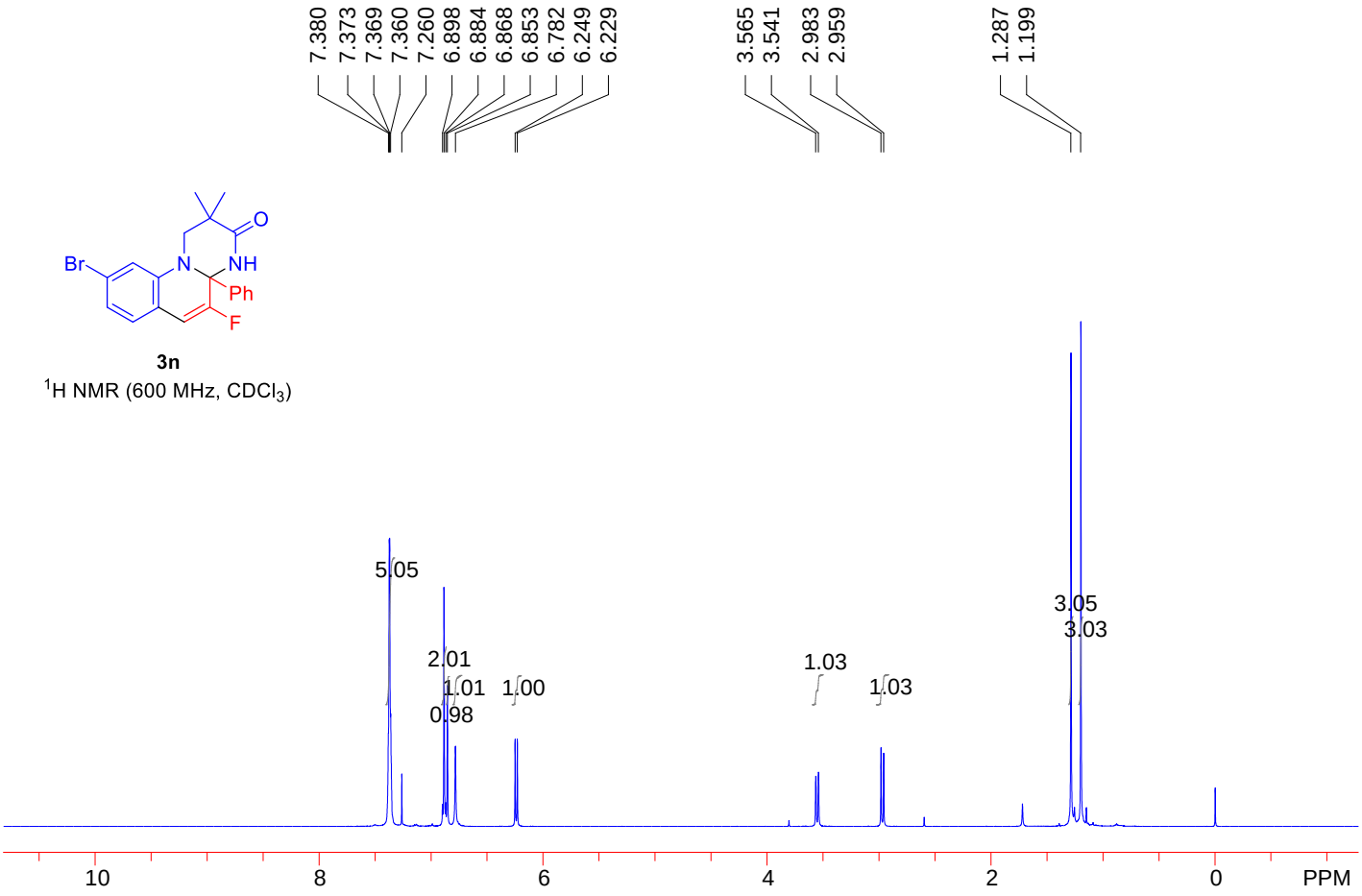
^{13}C{^{1}H} (150 MHz, $CDCl_3$)





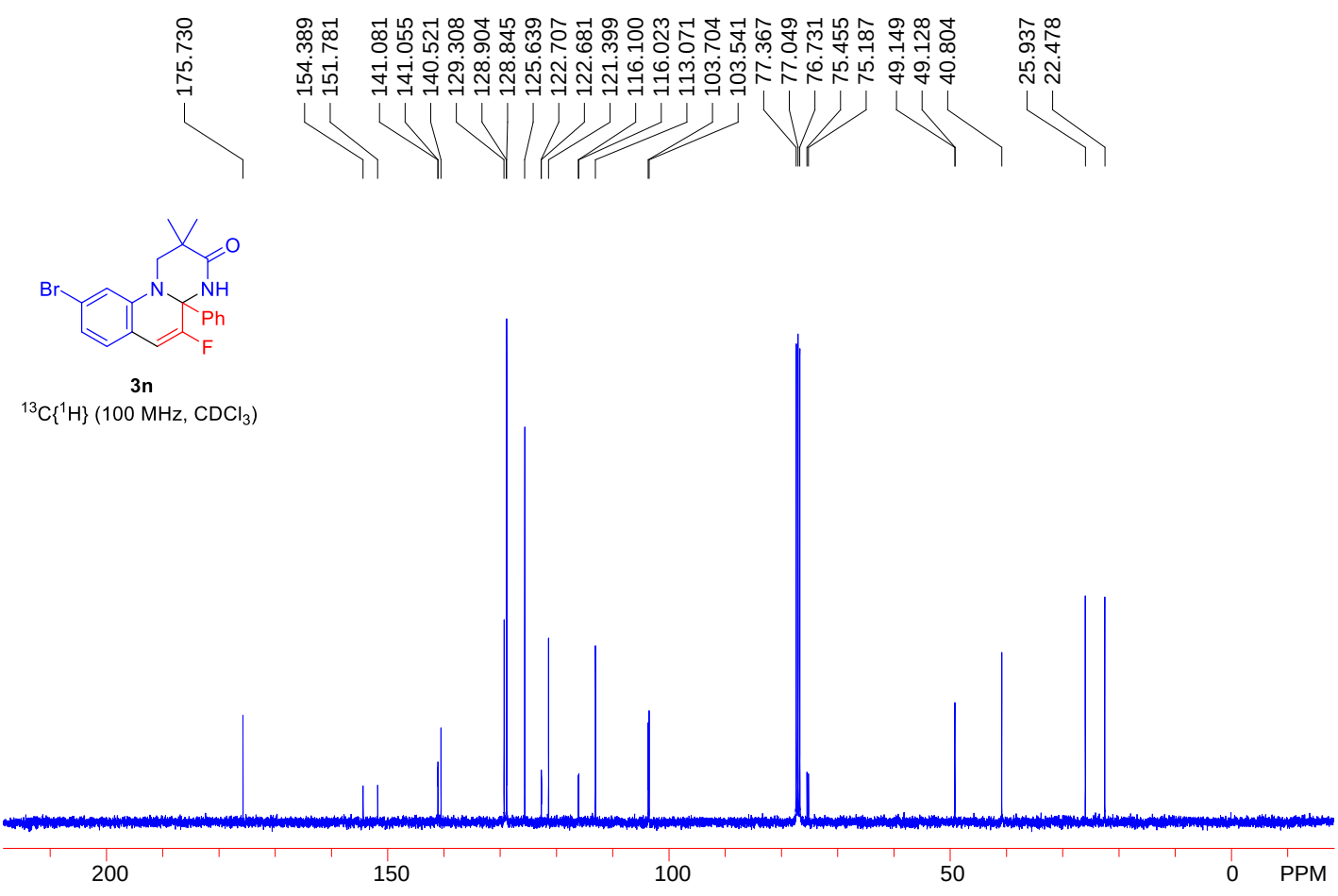
3m

^{19}F NMR (565 MHz, $CDCl_3$)



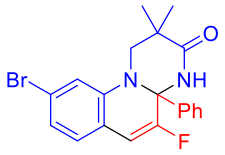
3n

^{1}H NMR (600 MHz, $CDCl_3$)



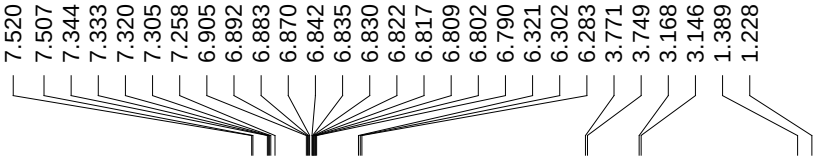
3n

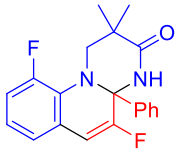
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)



3n

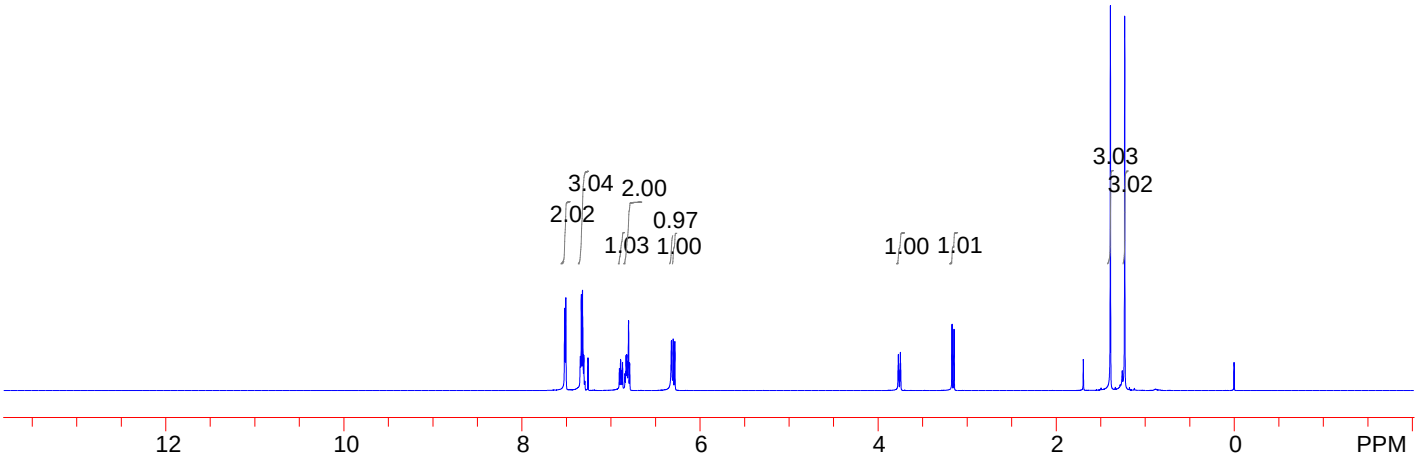
^{19}F NMR (376 MHz, $CDCl_3$)

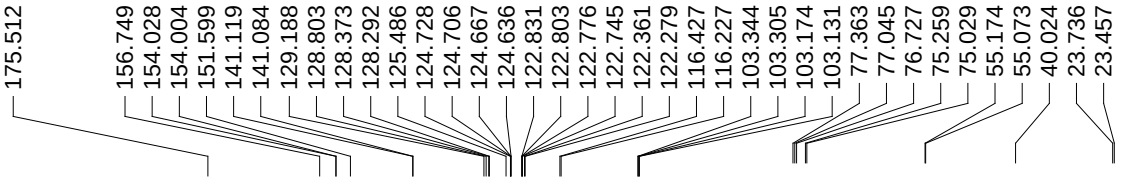


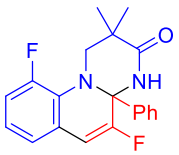


3o

^{1}H NMR (600 MHz, $CDCl_3$)

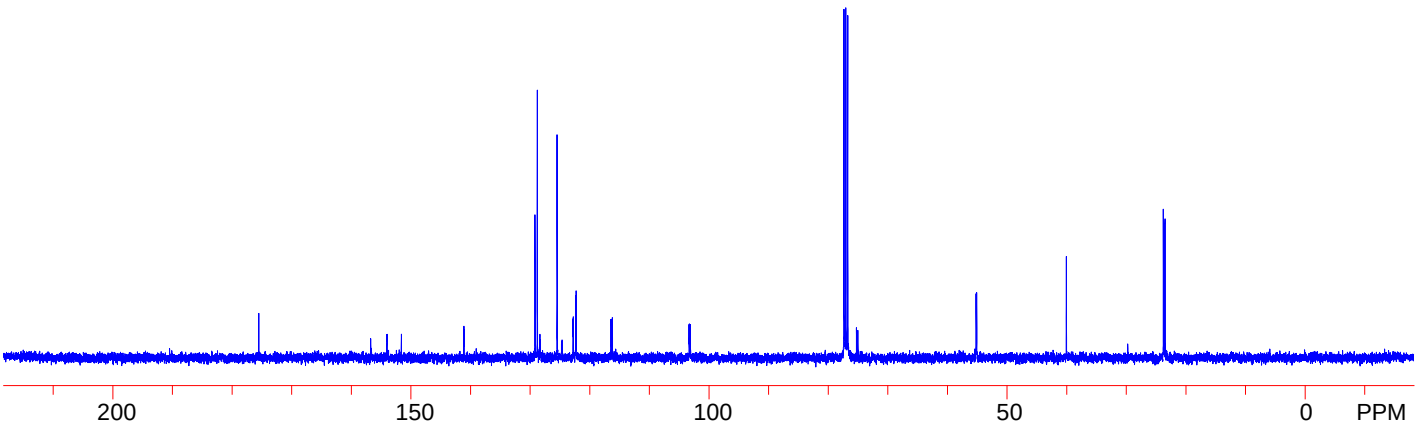


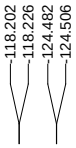


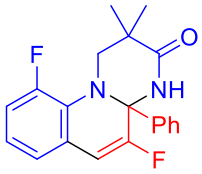


3o

$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)

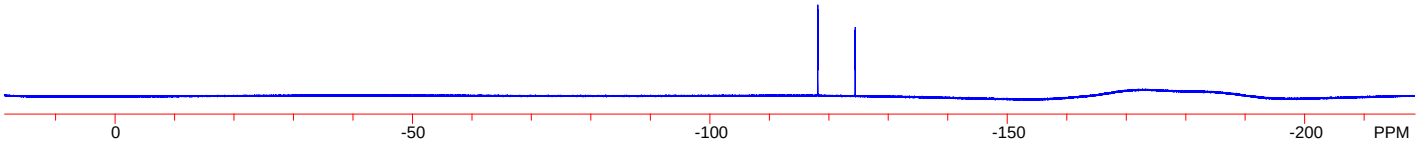


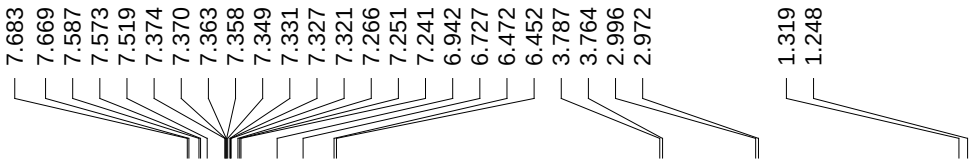


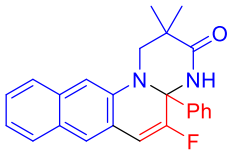


3o

^{19}F NMR (565 MHz, $CDCl_3$)

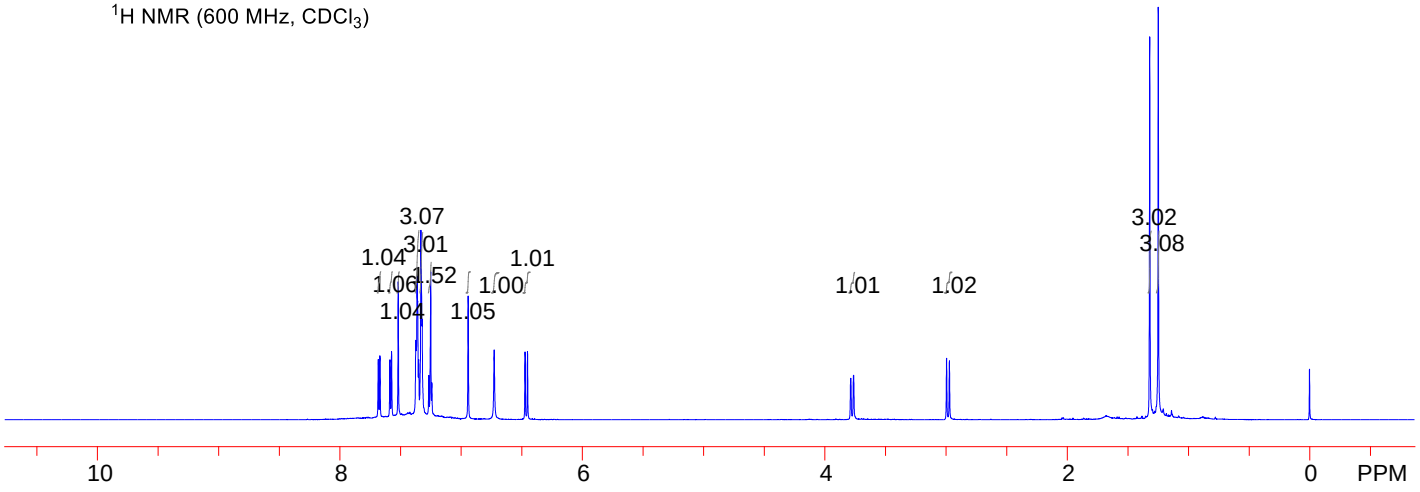


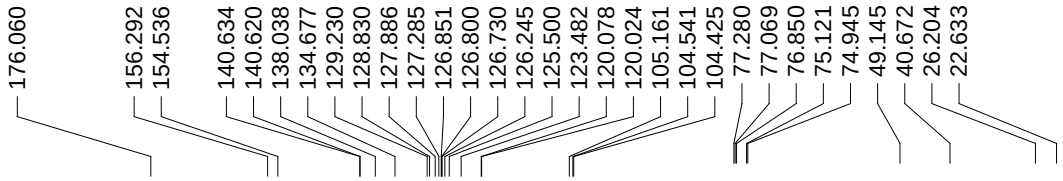


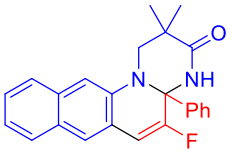


3p

^{1}H NMR (600 MHz, $CDCl_3$)

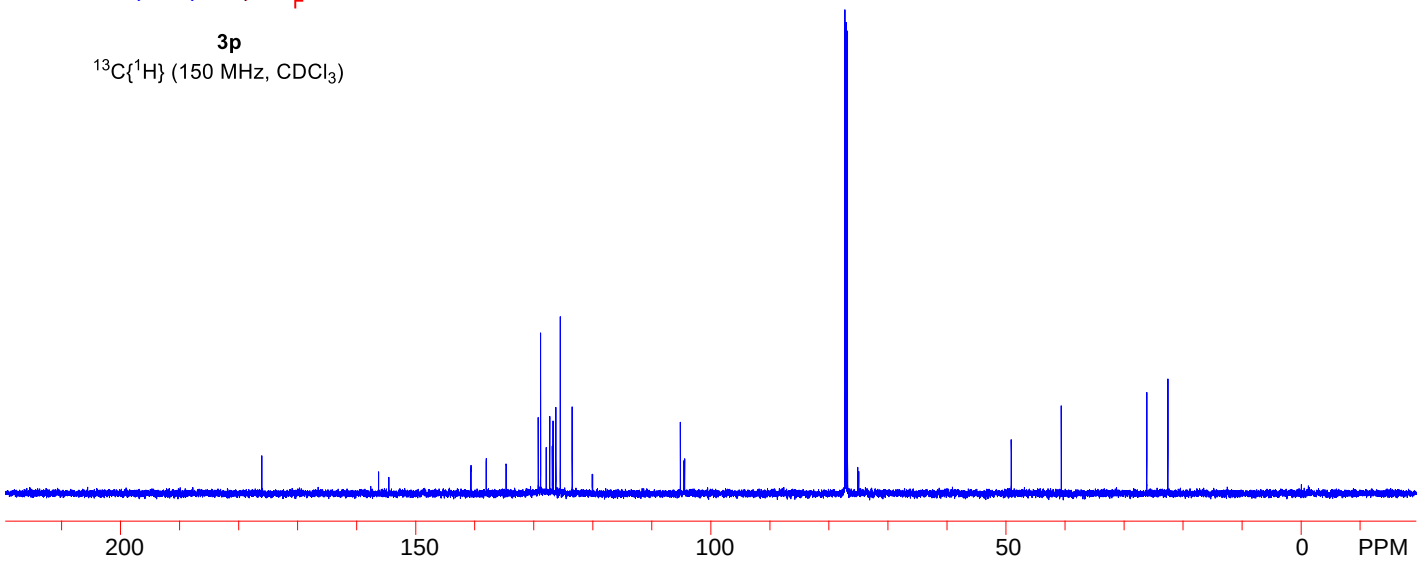


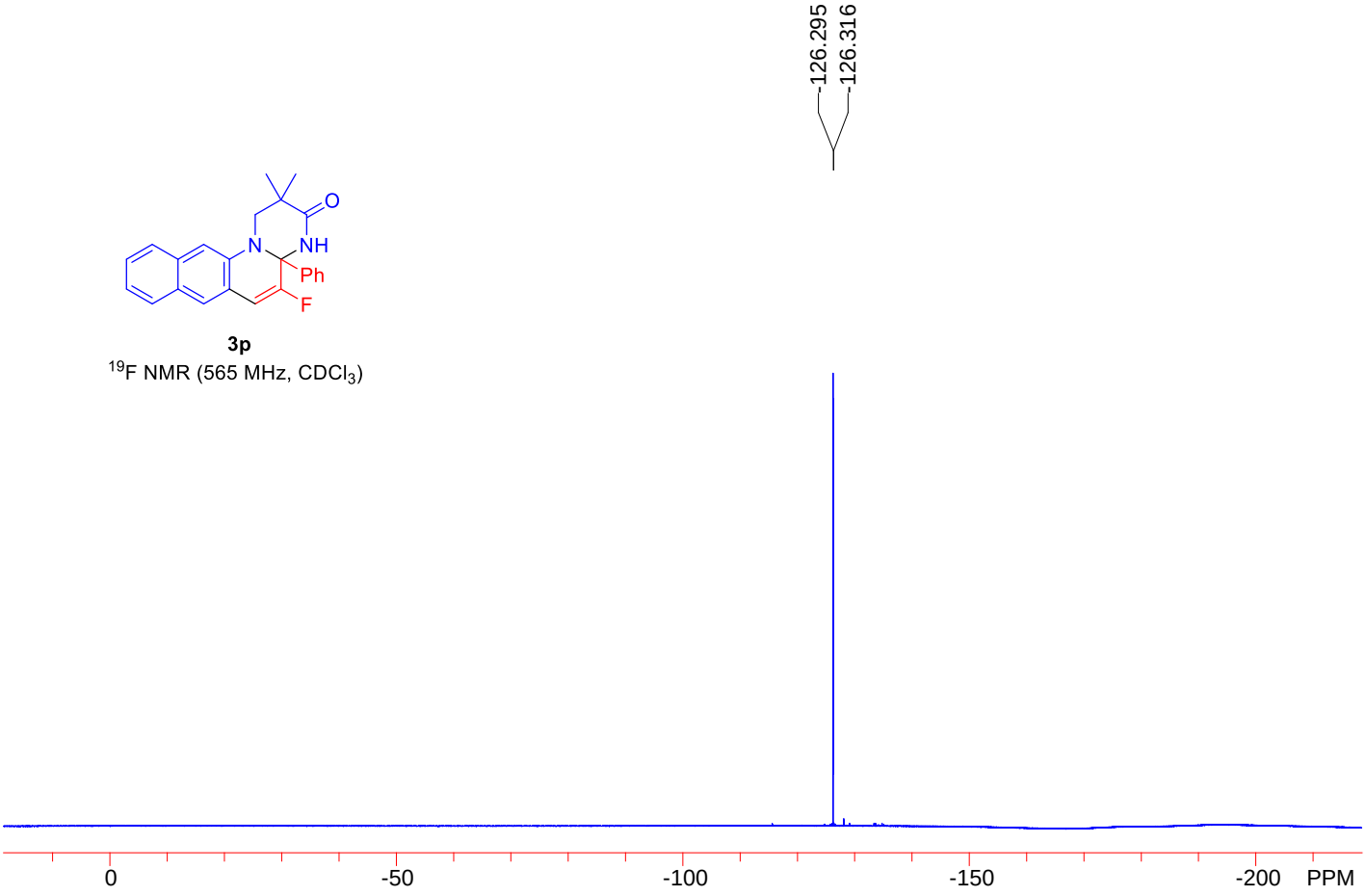




3p

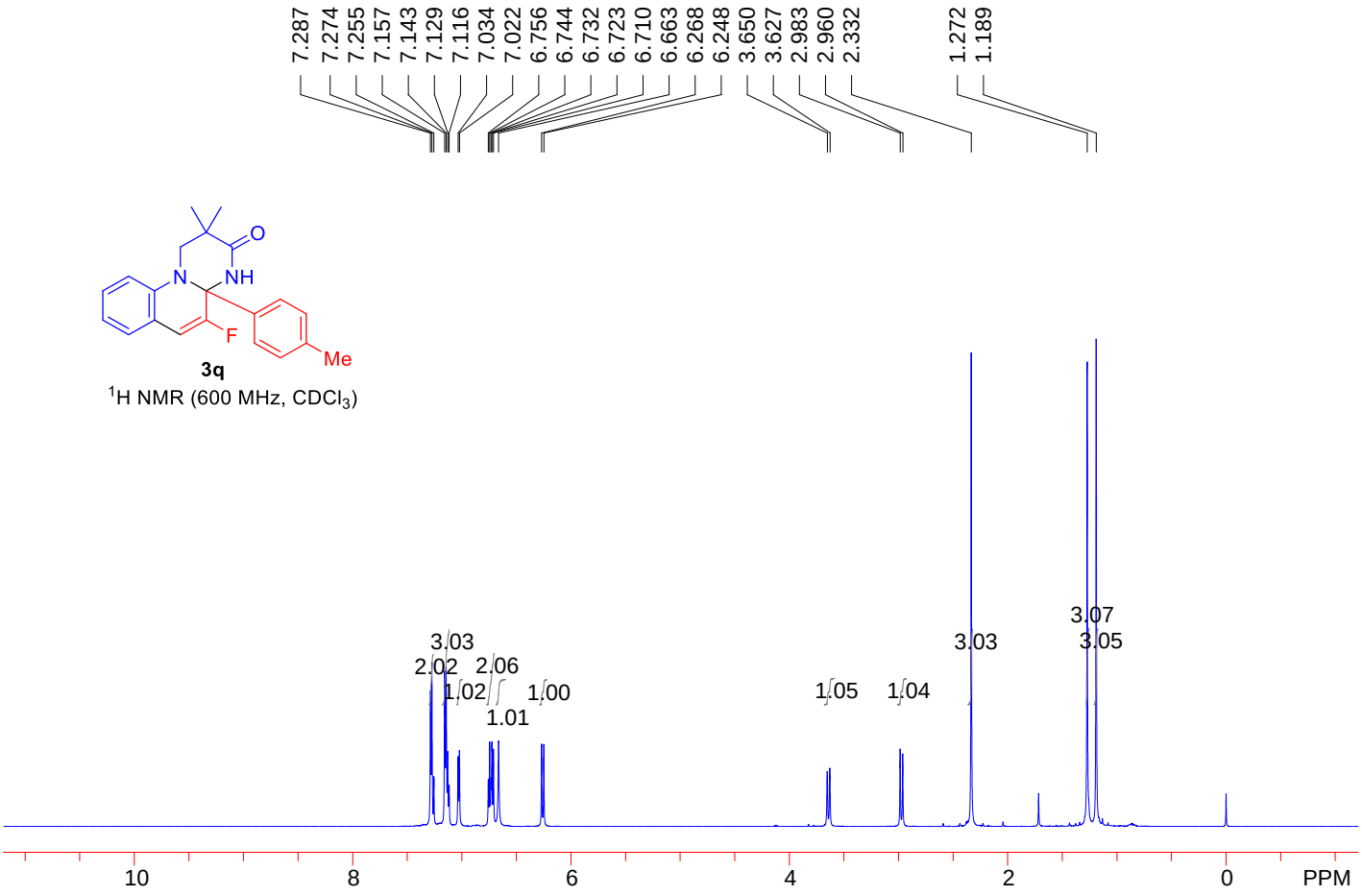
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)





3p

^{19}F NMR (565 MHz, $CDCl_3$)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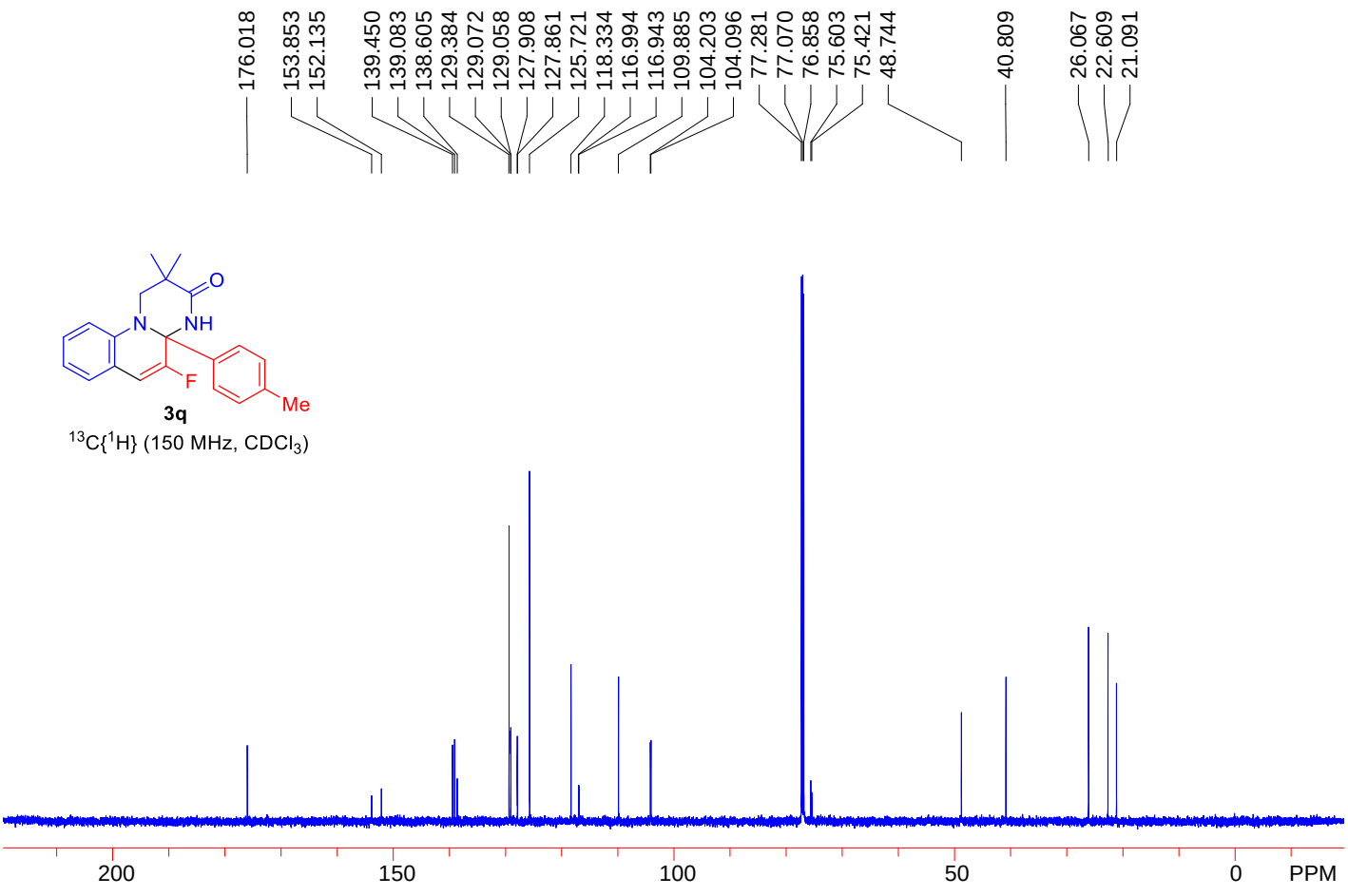
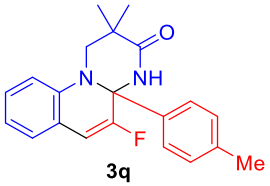
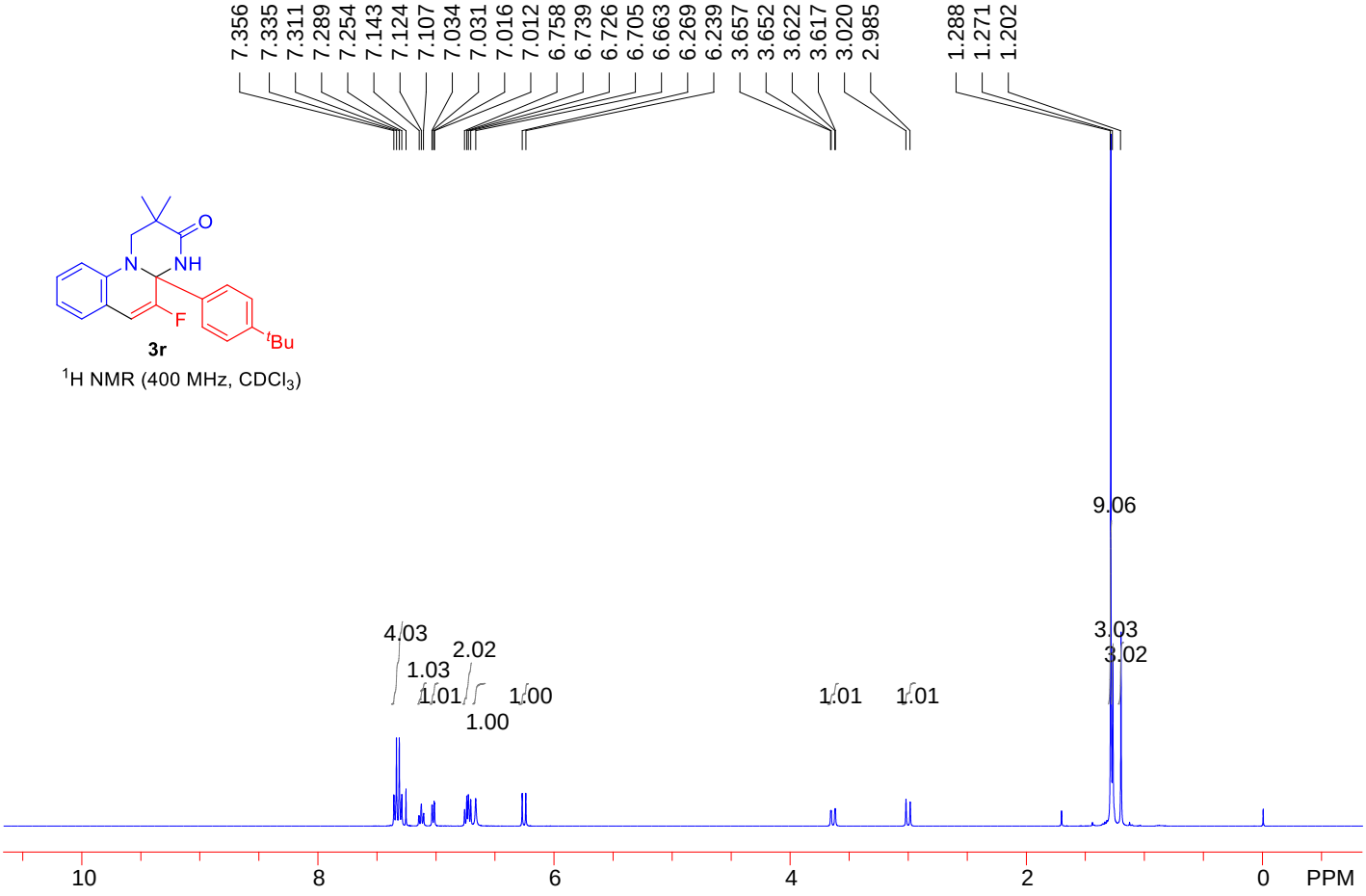
7.274
7.255
7.157
7.143
7.129
7.116
7.034
7.022
6.756
6.744
6.732
6.723
6.710
6.663
6.268
6.248
3.650
3.627
2.983
2.960
2.332
1.272
1.189
O
NH
N
F
Me
3q
1H NMR (600 MHz, CDCl3)
3.03
2.02
2.06
1.02
1.00
1.01
1.05
1.04
3.03
3.07
3.05
10
8
6
4
2
0
PPM

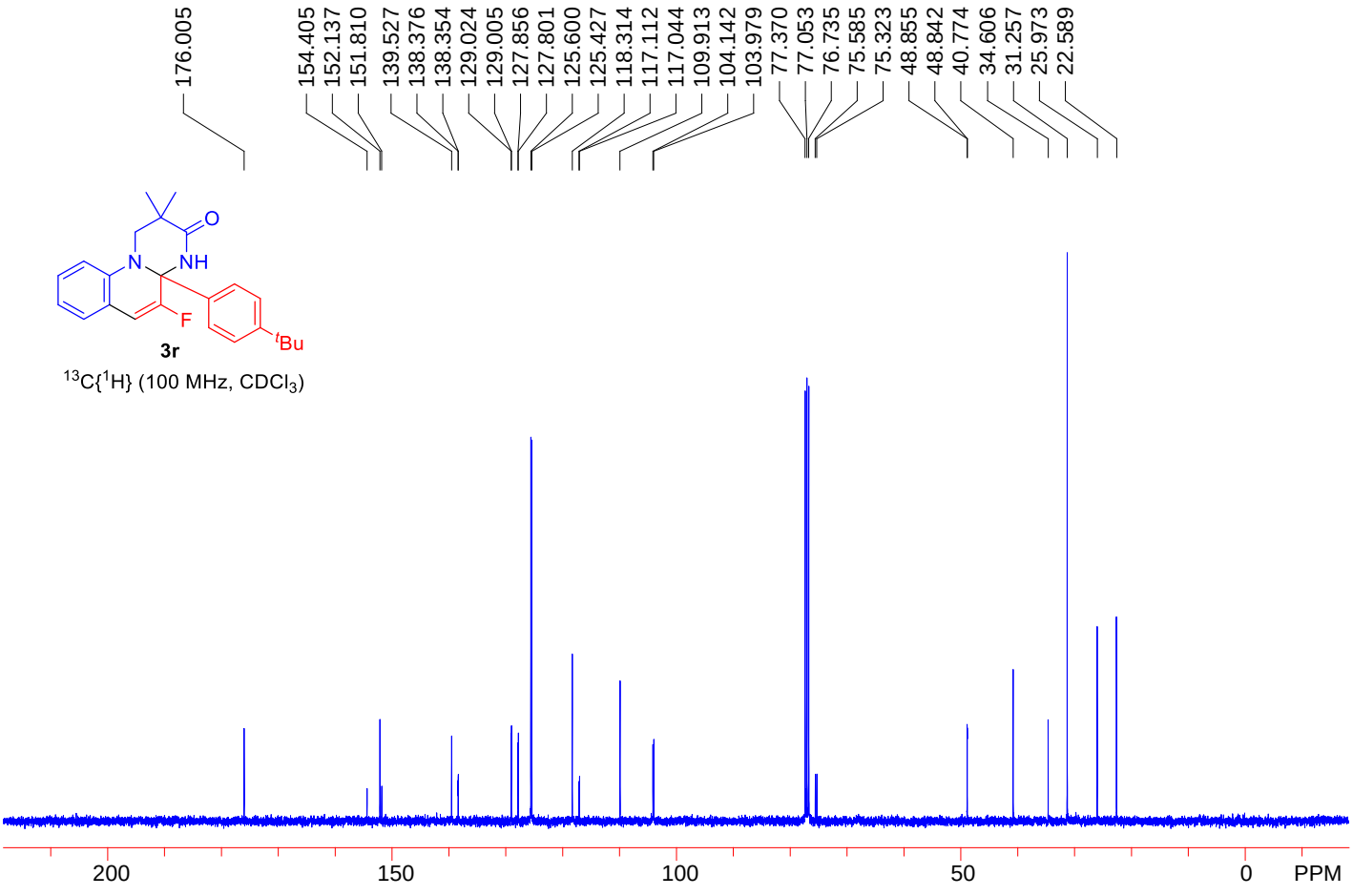

176.018
153.853
152.135
139.450
139.083
138.605
129.384
129.072
129.058
127.908
127.861
125.721
118.334
116.994
116.943
109.885
104.203
104.096
77.281
77.070
76.858
75.603
75.421
48.744
40.809
26.067
22.609
21.091
O
NH
N
F
Me
3q
13C{1H} (150 MHz, CDCl3)
200
150
100
50
0
PPM

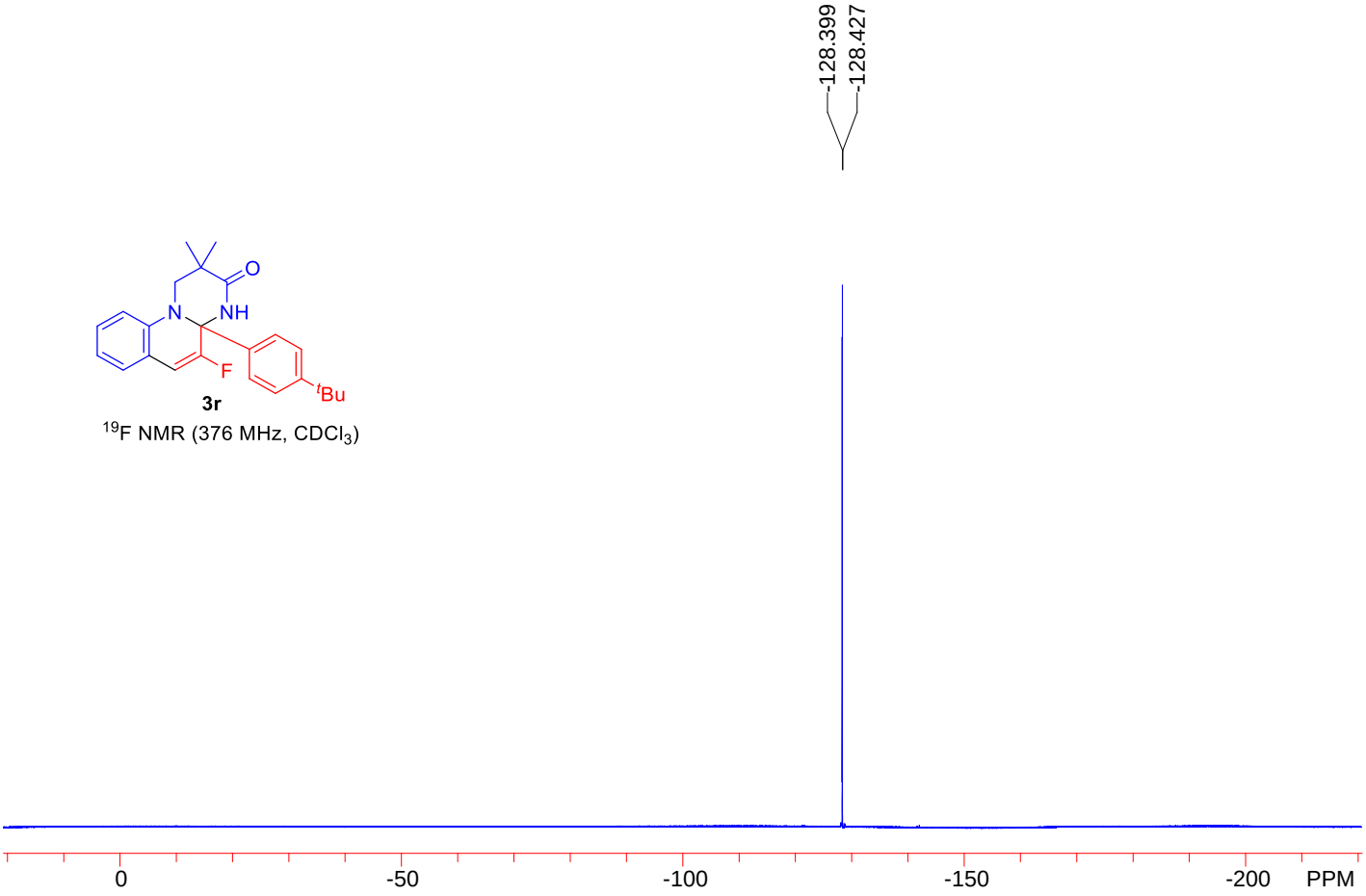


3q

^{19}F NMR (565 MHz, $CDCl_3$)

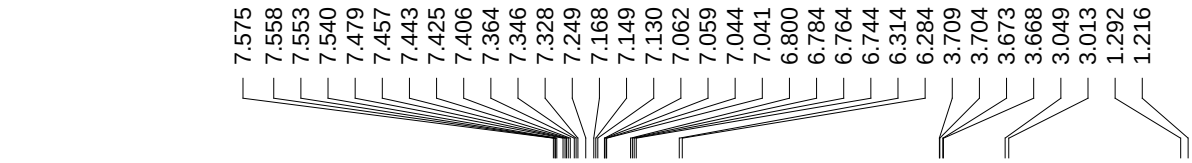

7.356
7.335
7.311
7.289
7.254
7.143
7.124
7.107
7.034
7.031
7.016
7.012
6.758
6.739
6.726
6.705
6.663
6.269
6.239
3.657
3.652
3.622
3.617
3.020
2.985
1.288
1.271
1.202
O
NH
N
F
tBu
3r
1H NMR (400 MHz, CDCl3)
9.06
4.03
1.03
1.01
2.02
1.00
1.00
1.01
1.01
3.03
3.02
10
8
6
4
2
0
PPM

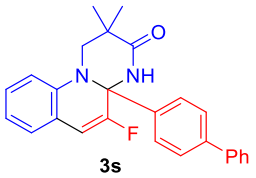

176.005
154.405
152.137
151.810
139.527
138.376
138.354
129.024
129.005
127.856
127.801
125.600
125.427
118.314
117.112
117.044
109.913
104.142
103.979
77.370
77.053
76.735
75.585
75.323
48.855
48.842
40.774
34.606
31.257
25.973
22.589
O
NH
N
F
tBu
3r
13C{1H} (100 MHz, CDCl3)
200
150
100
50
0
PPM



3r

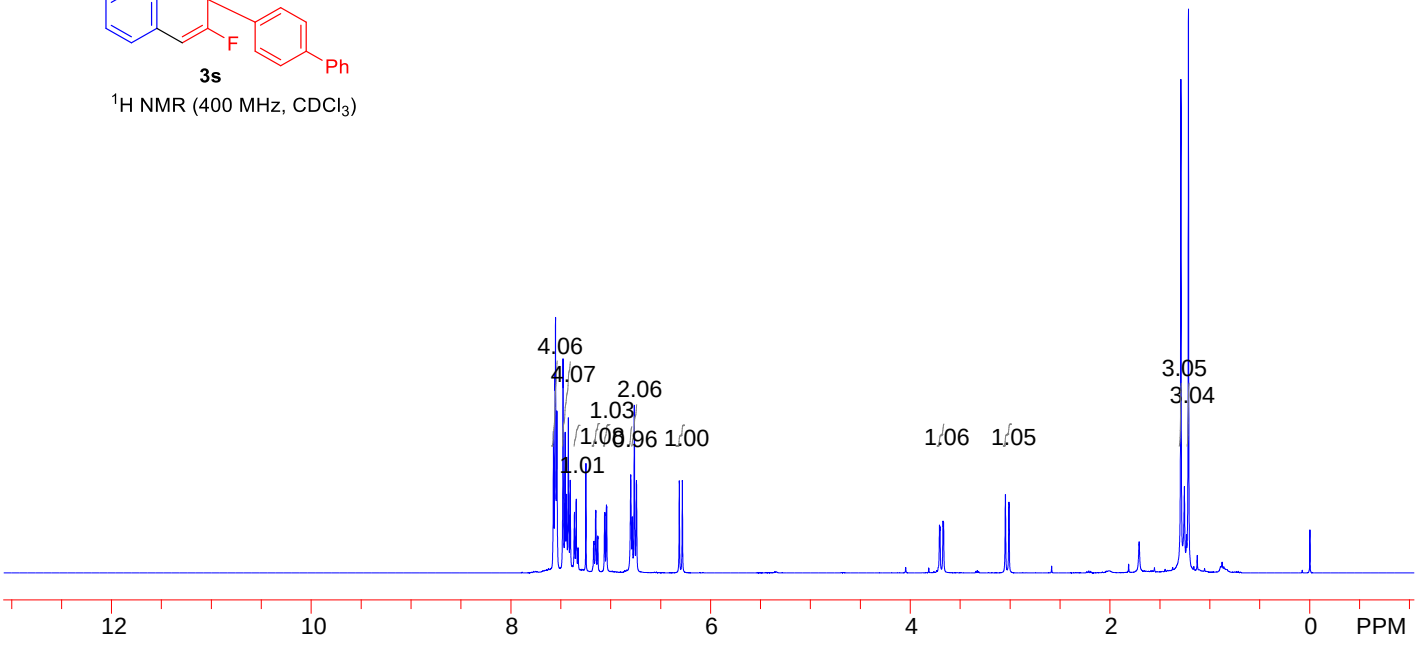
^{19}F NMR (376 MHz, $CDCl_3$)

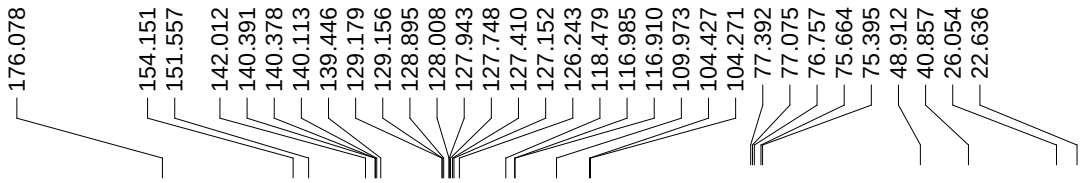


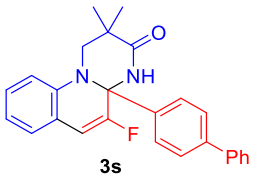


3s

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

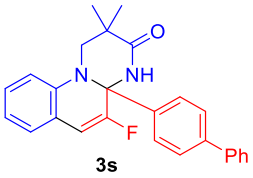






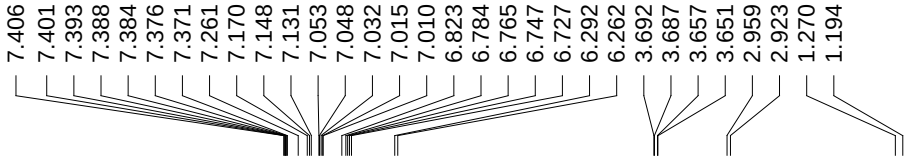
3s

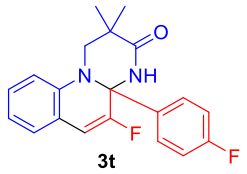
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)



3s

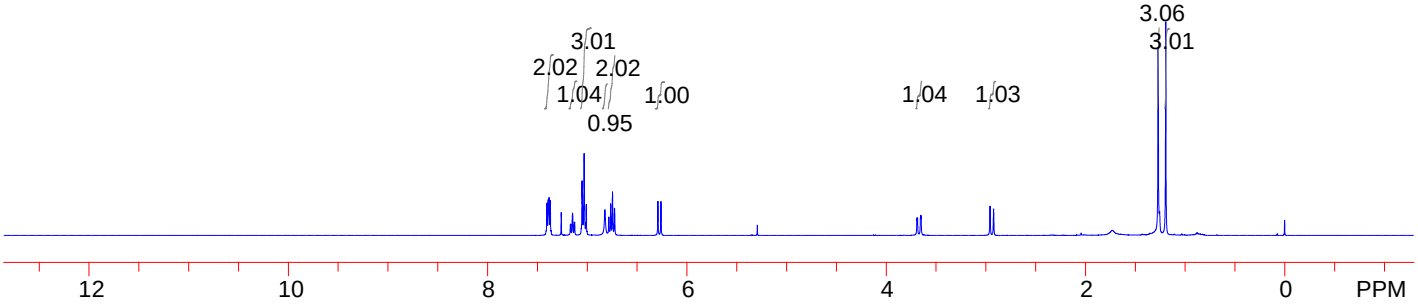
^{19}F NMR (565 MHz, $CDCl_3$)

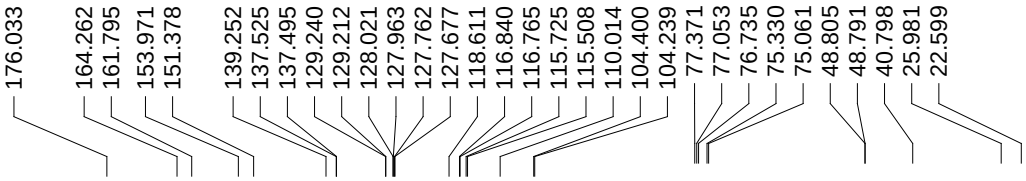


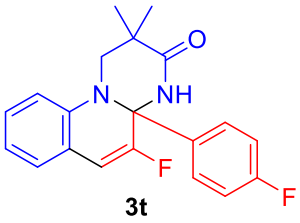


3t

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

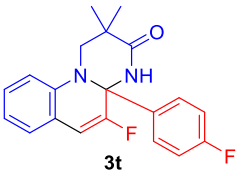






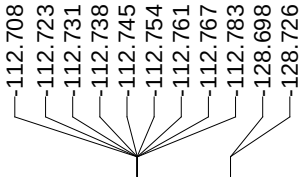
3t

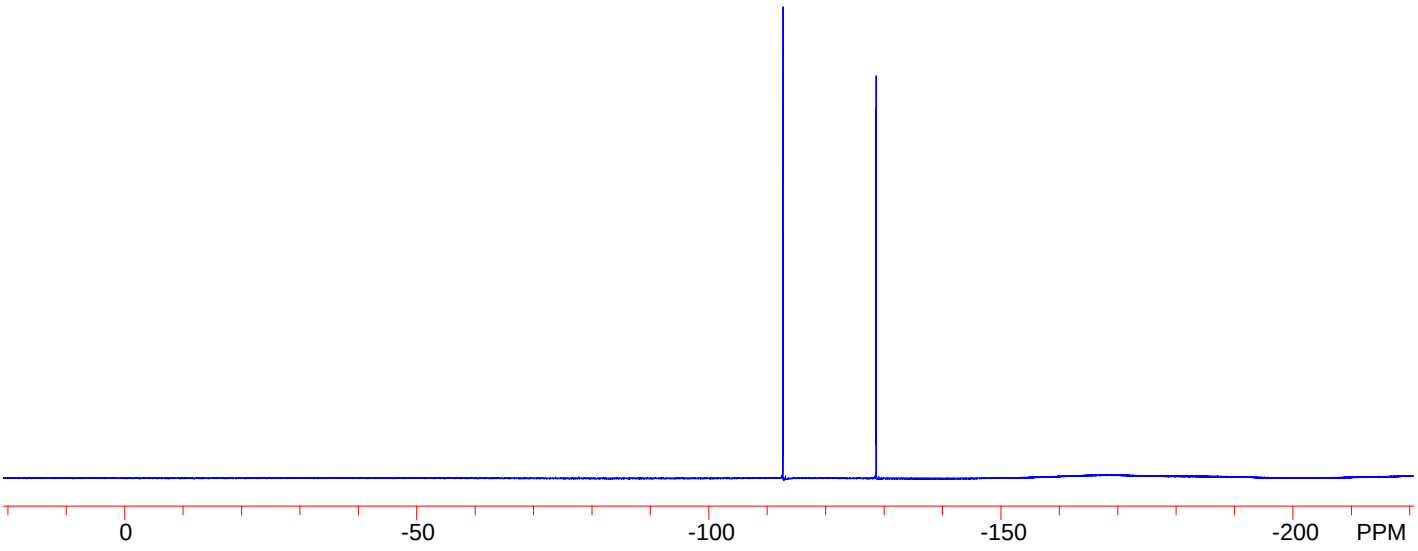
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)

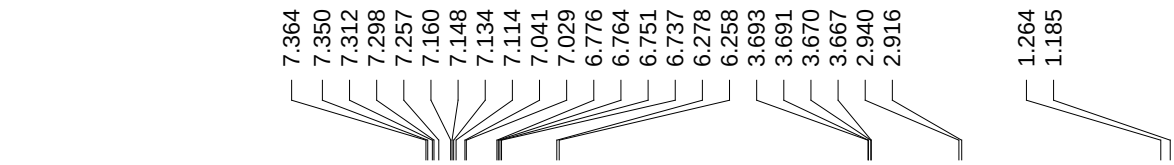


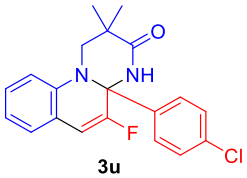
3t

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



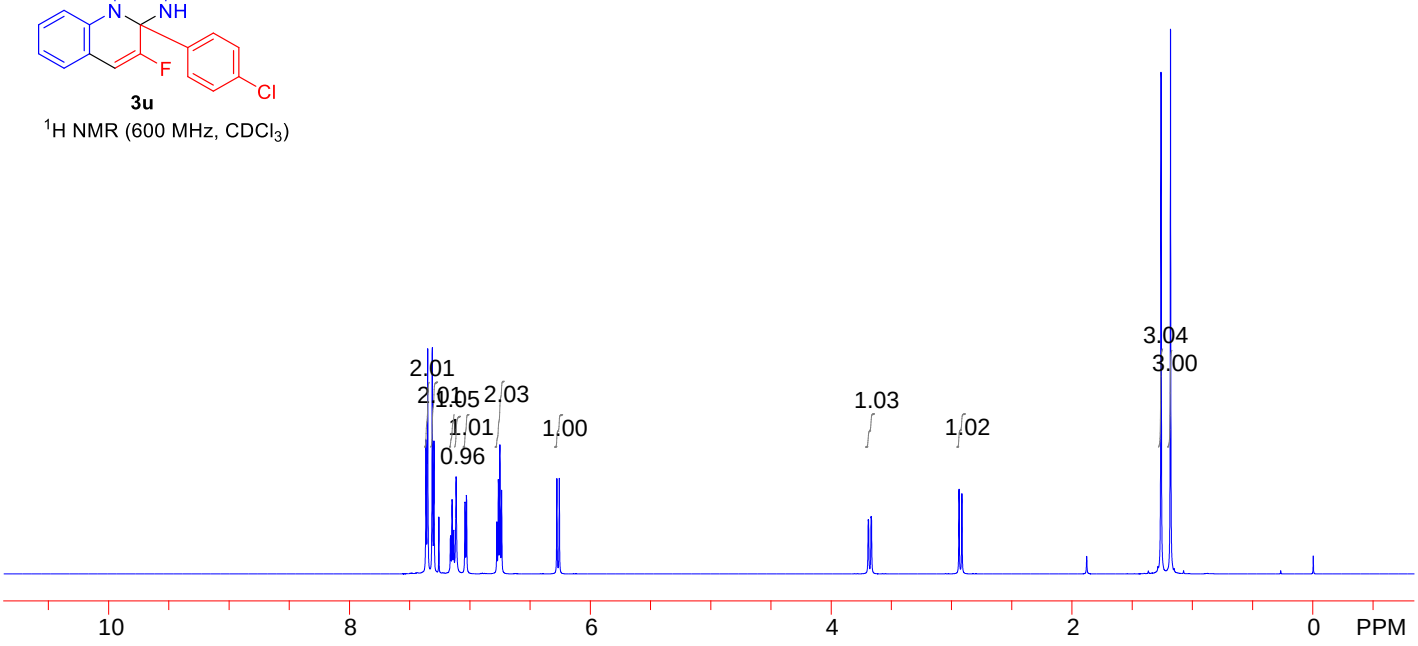


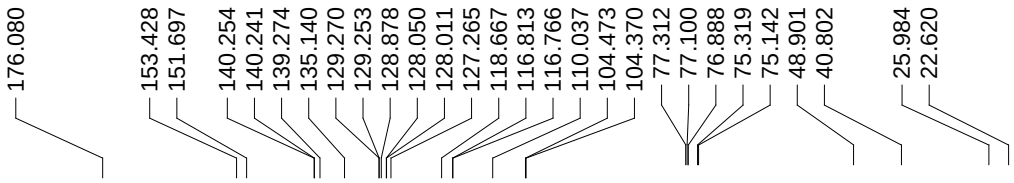


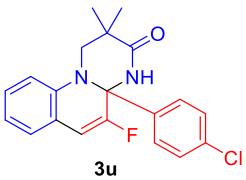


3u

^{1}H NMR (600 MHz, $CDCl_3$)

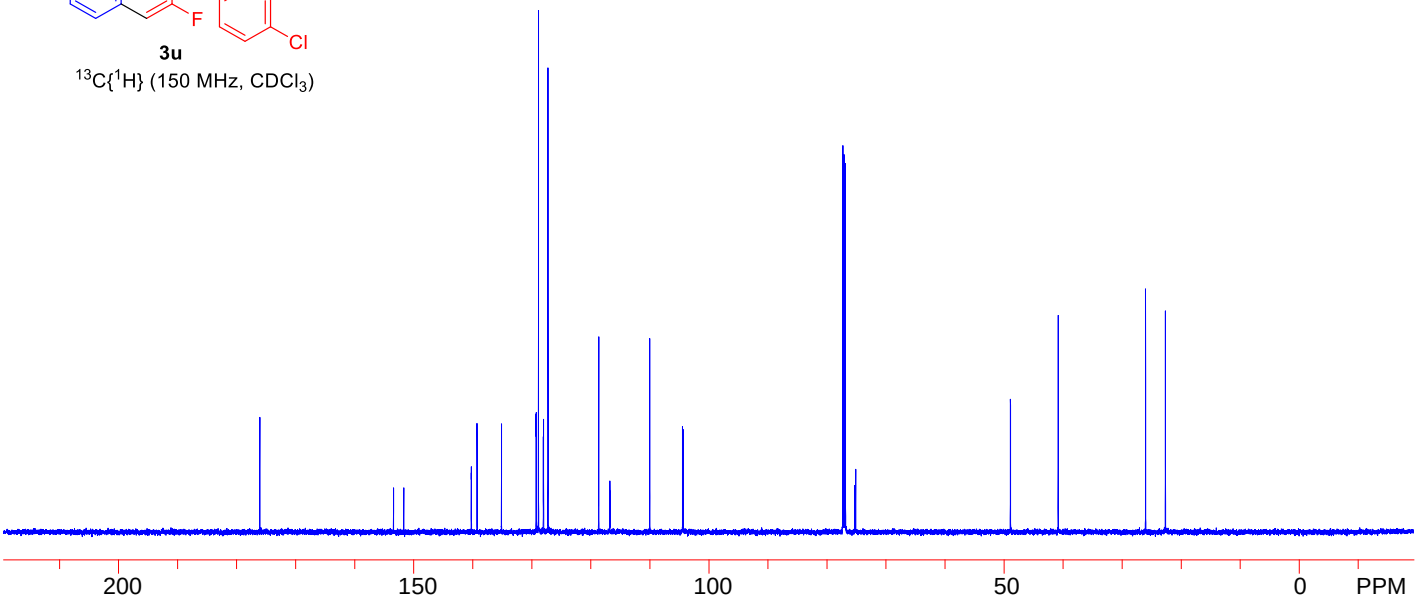


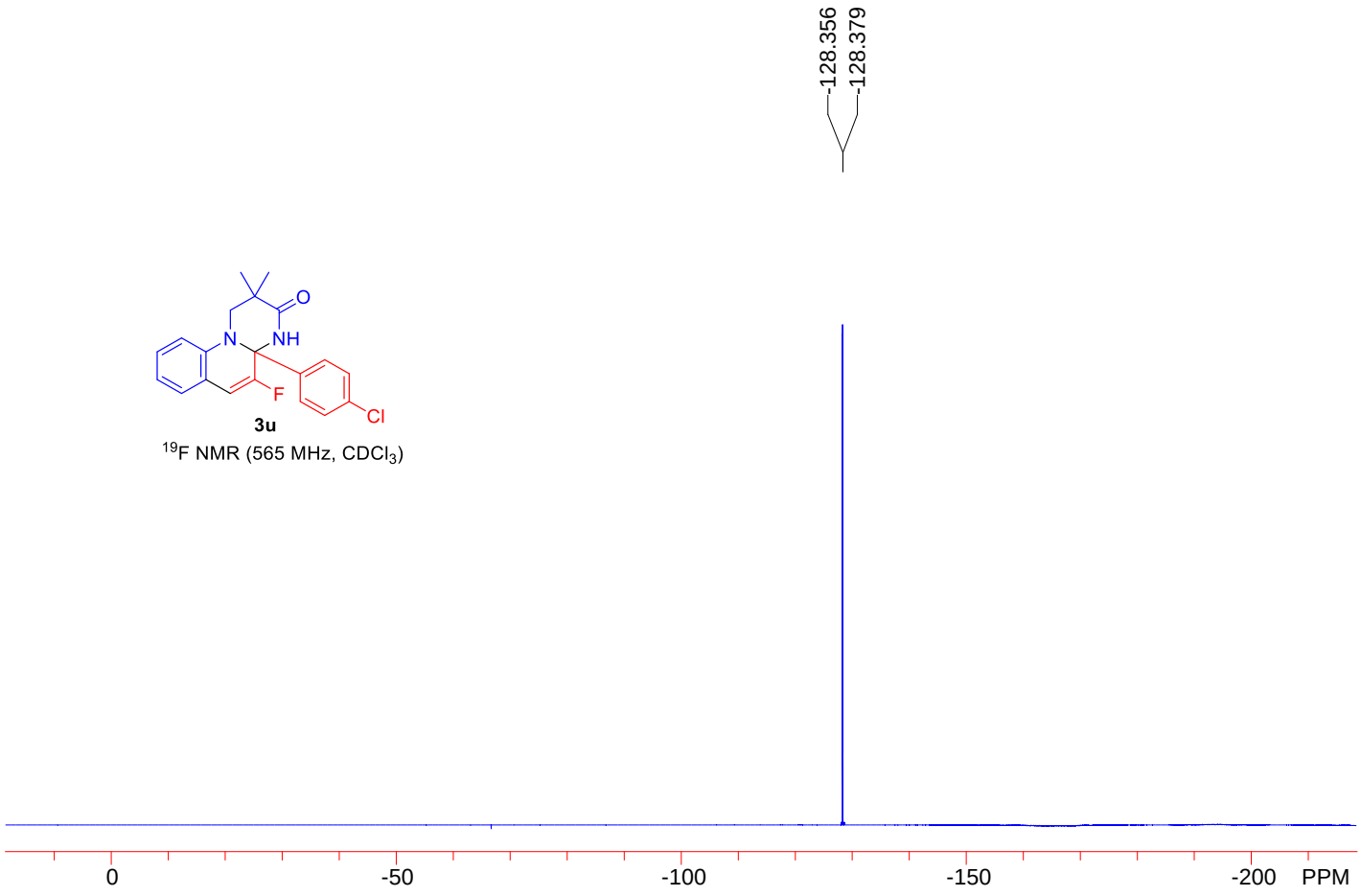




3u

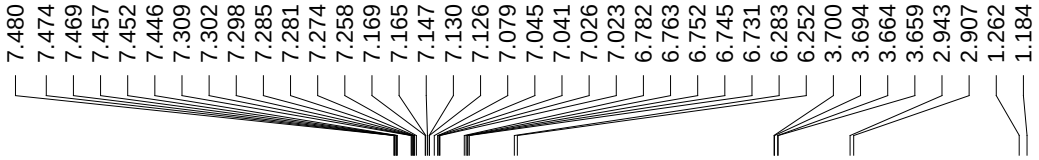
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)

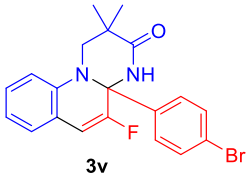




3u

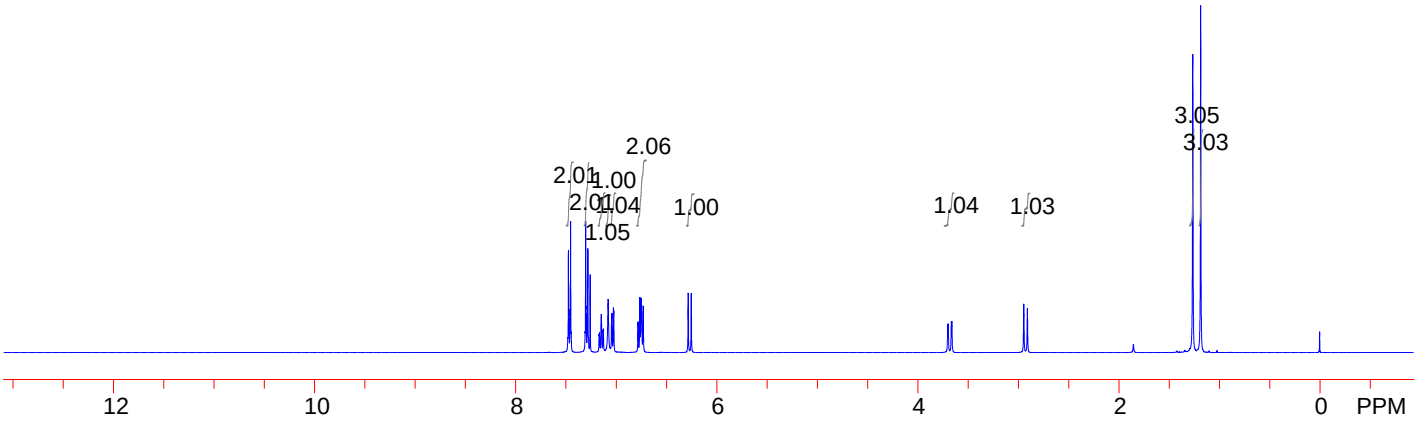
^{19}F NMR (565 MHz, $CDCl_3$)

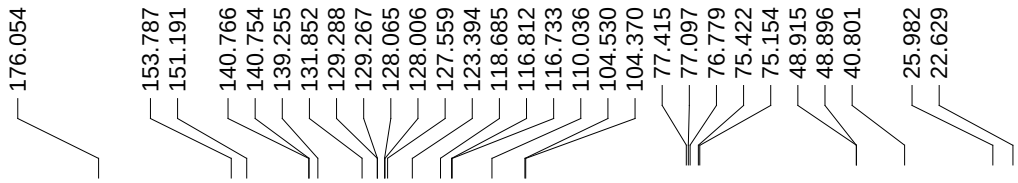


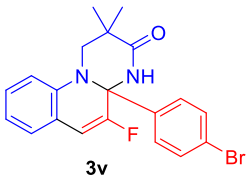


3v

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

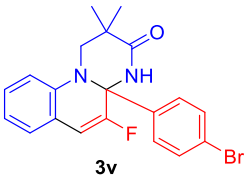






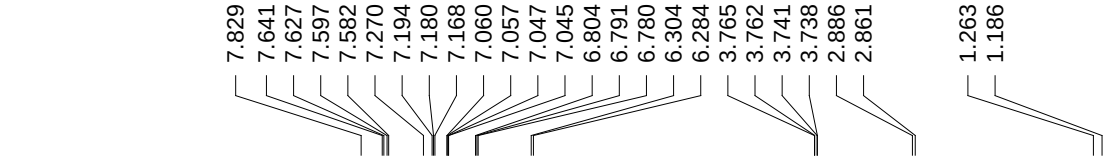
3v

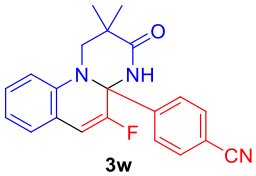
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)



3v

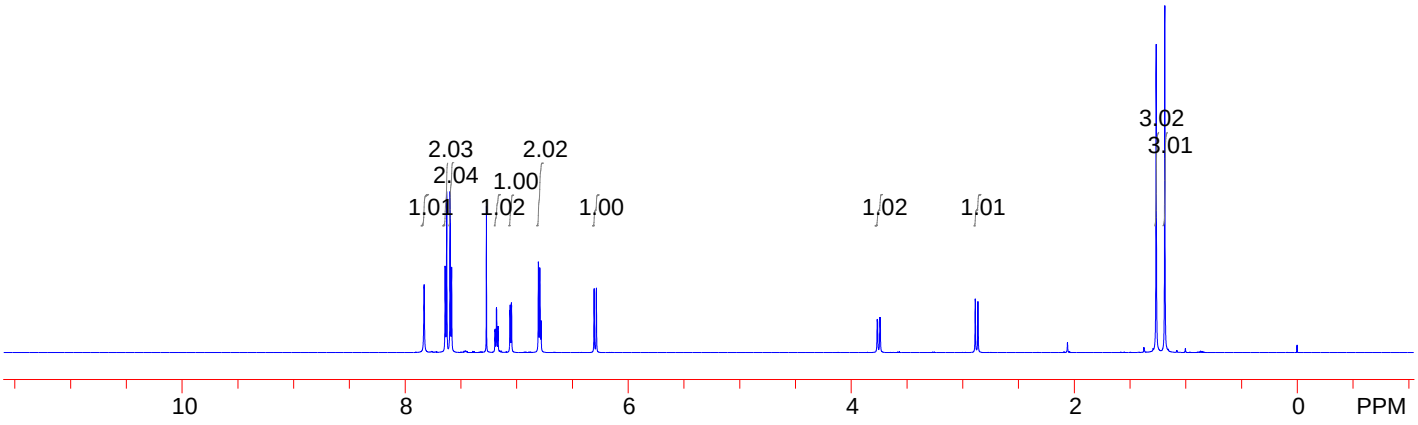
^{19}F NMR (376 MHz, $CDCl_3$)

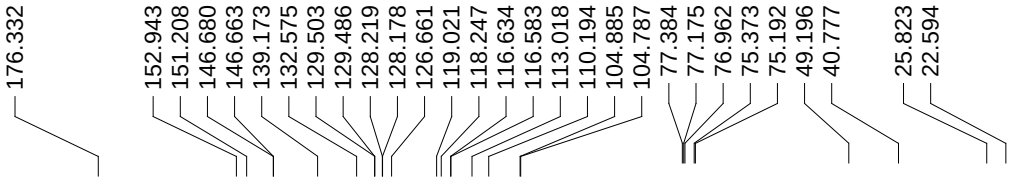


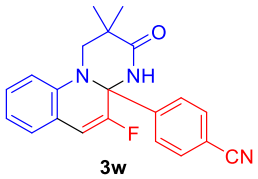


3w

^{1}H NMR (600 MHz, $CDCl_3$)

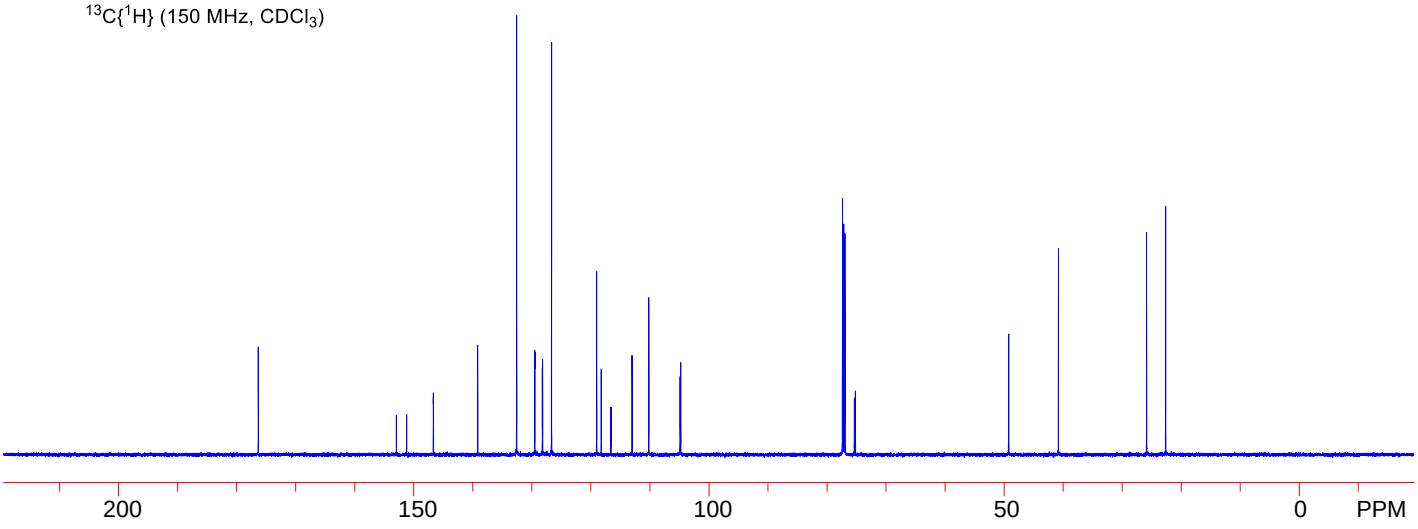


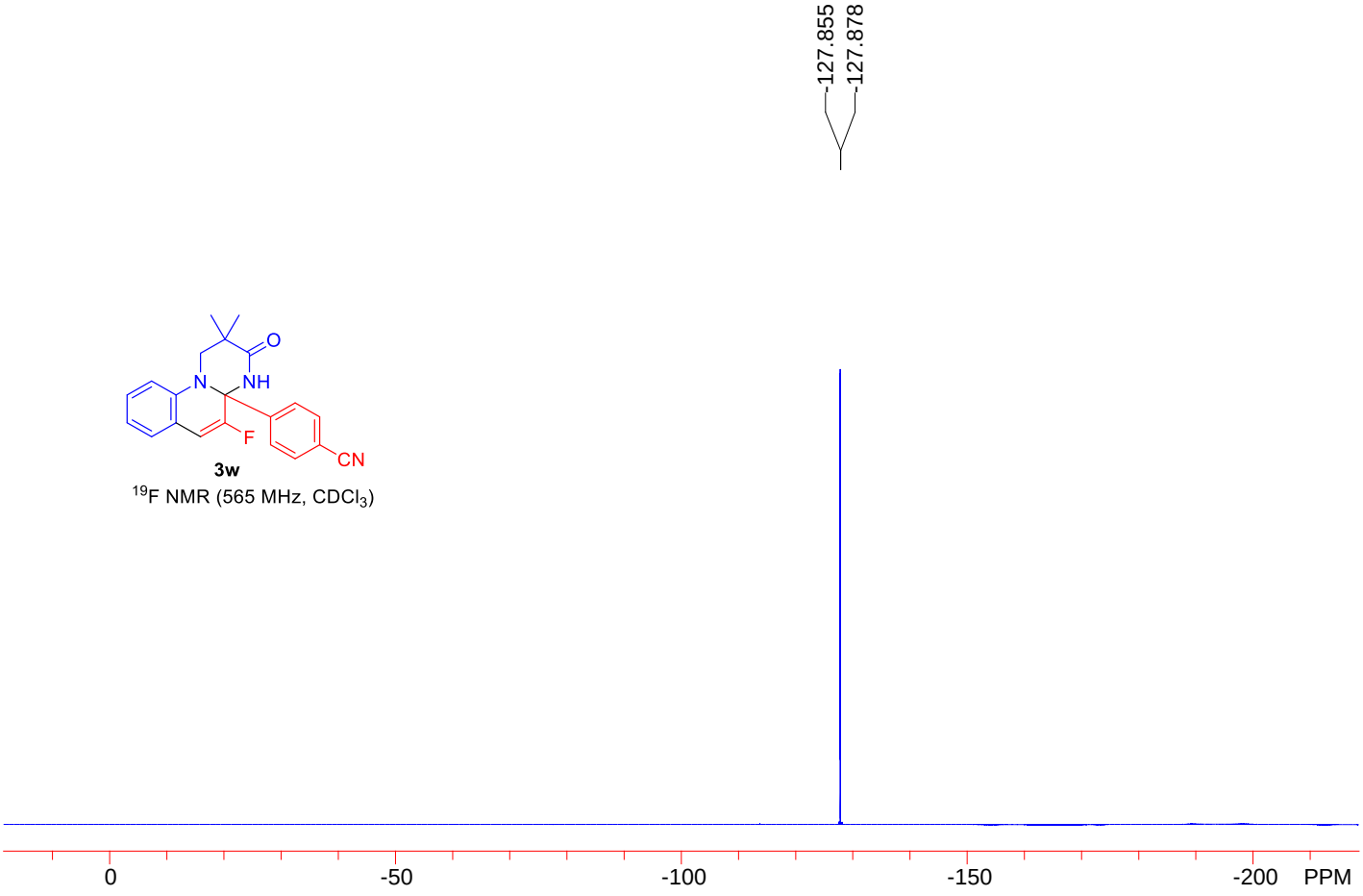




3w

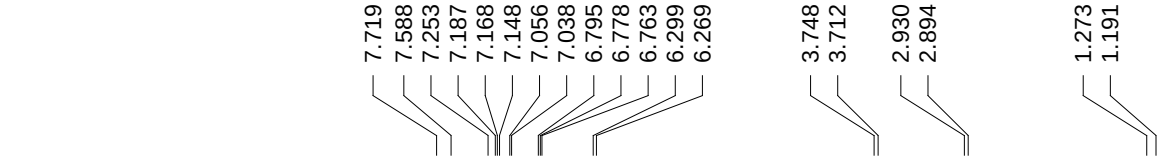
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)

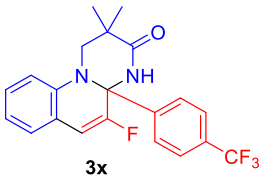




3w

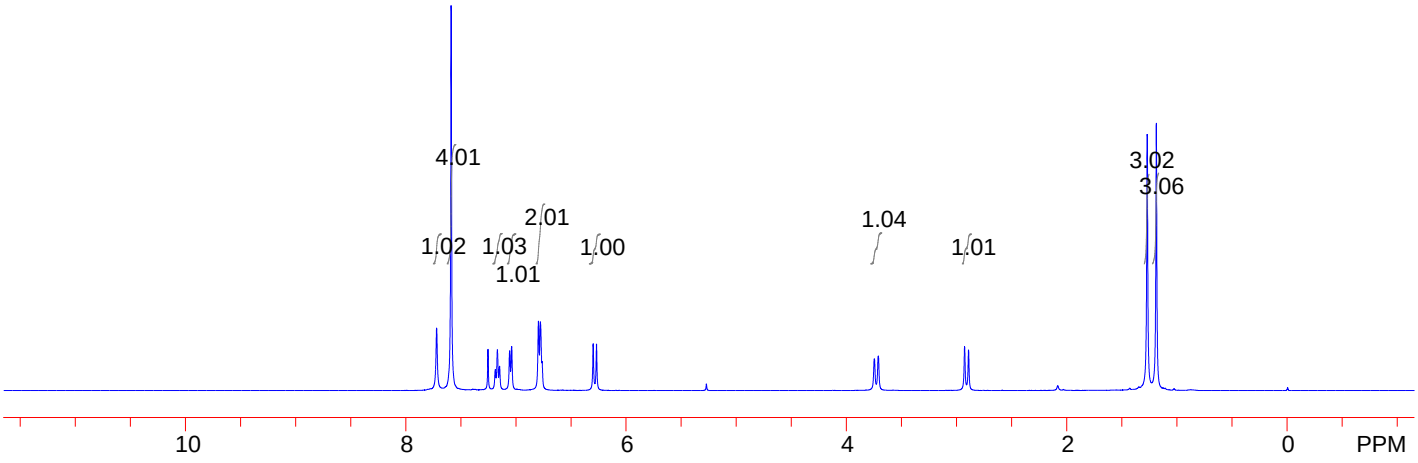
^{19}F NMR (565 MHz, $CDCl_3$)

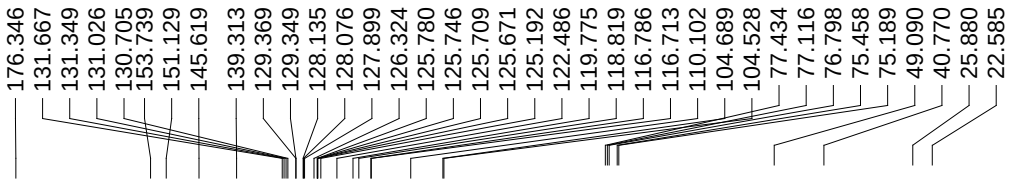


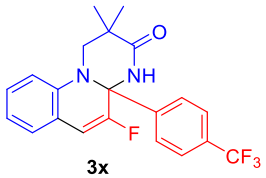


3x

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

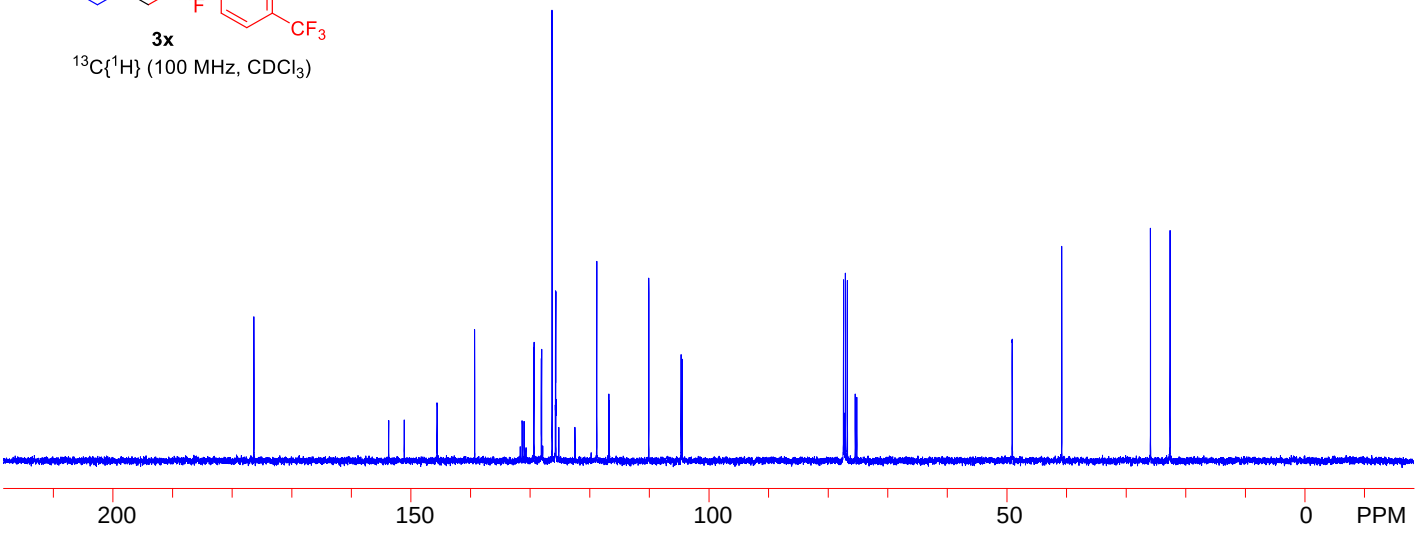


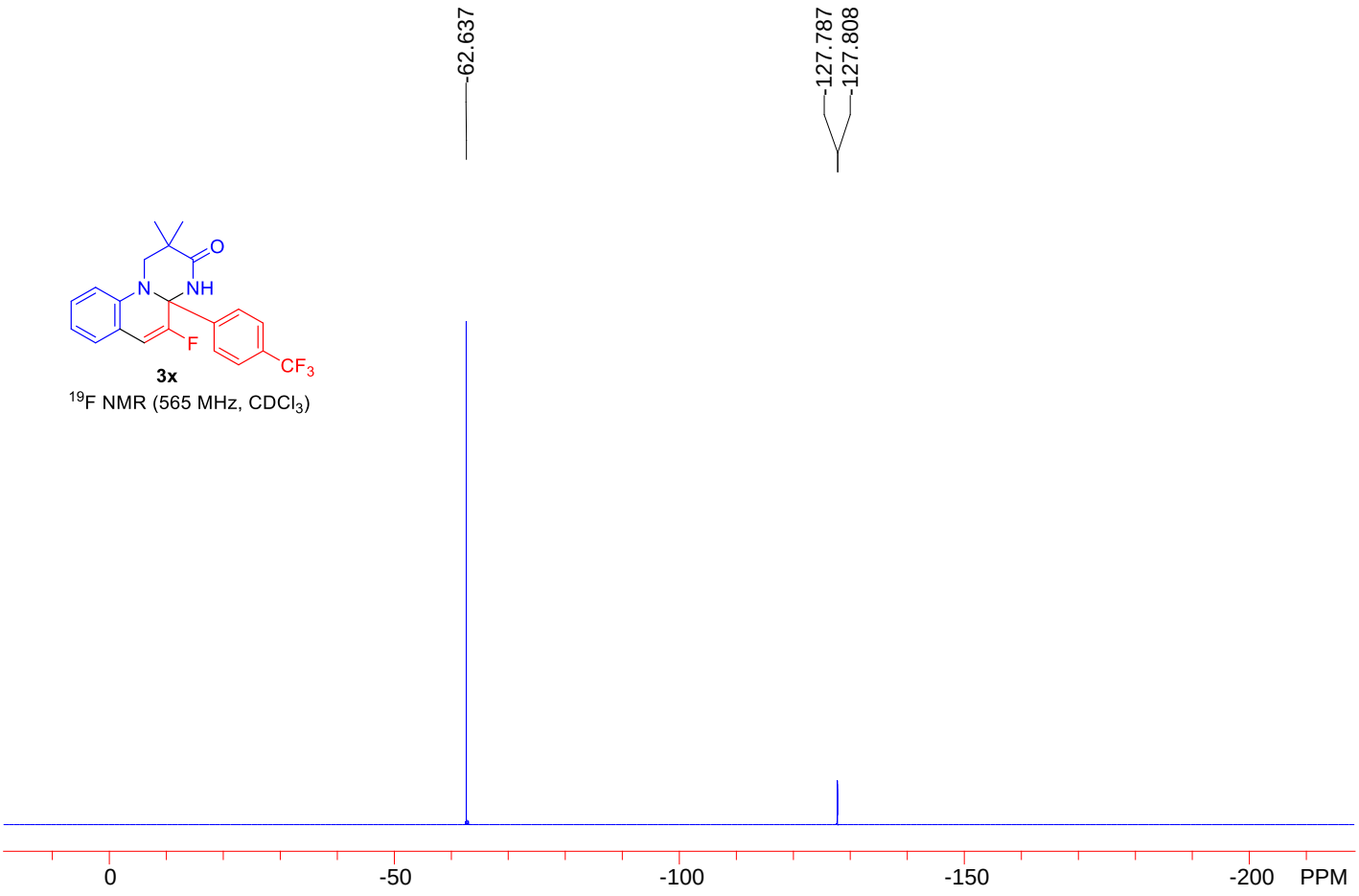




3x

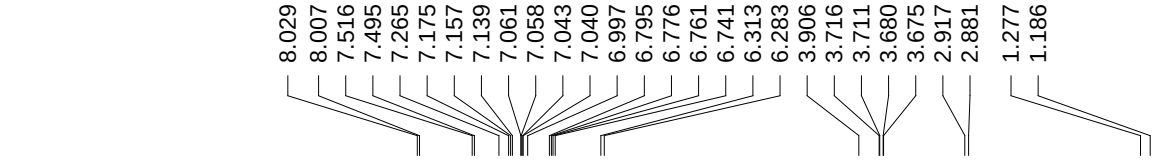
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)

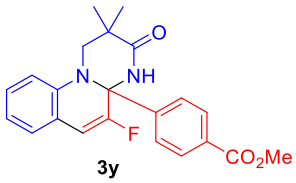




3x

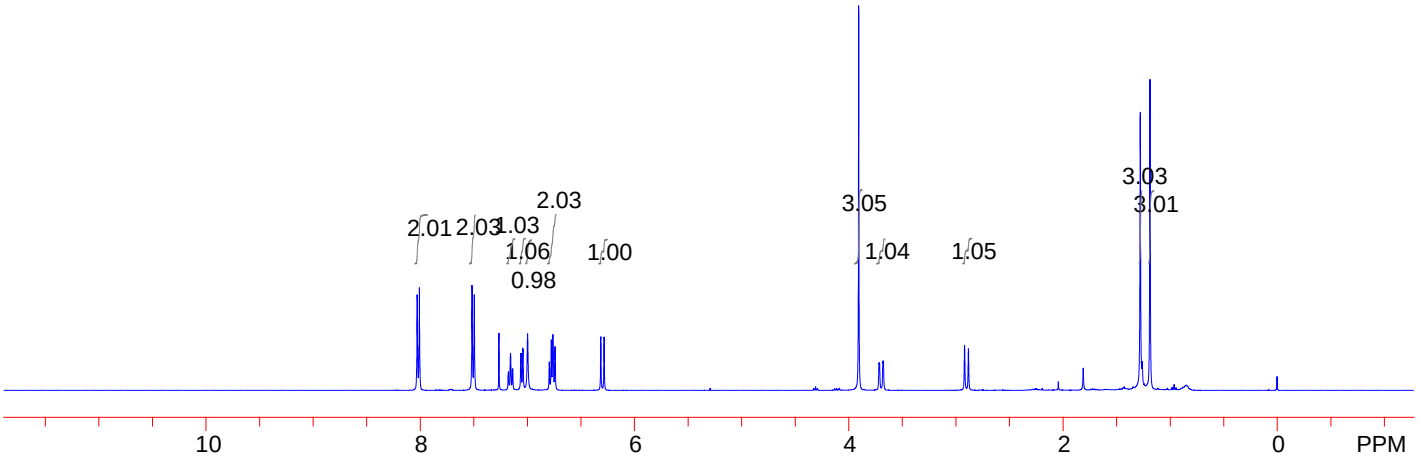
^{19}F NMR (565 MHz, $CDCl_3$)

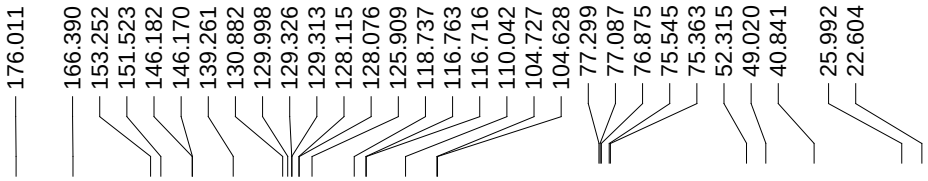


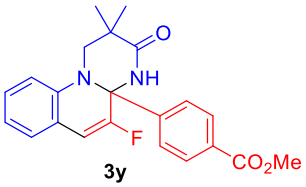


3y

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

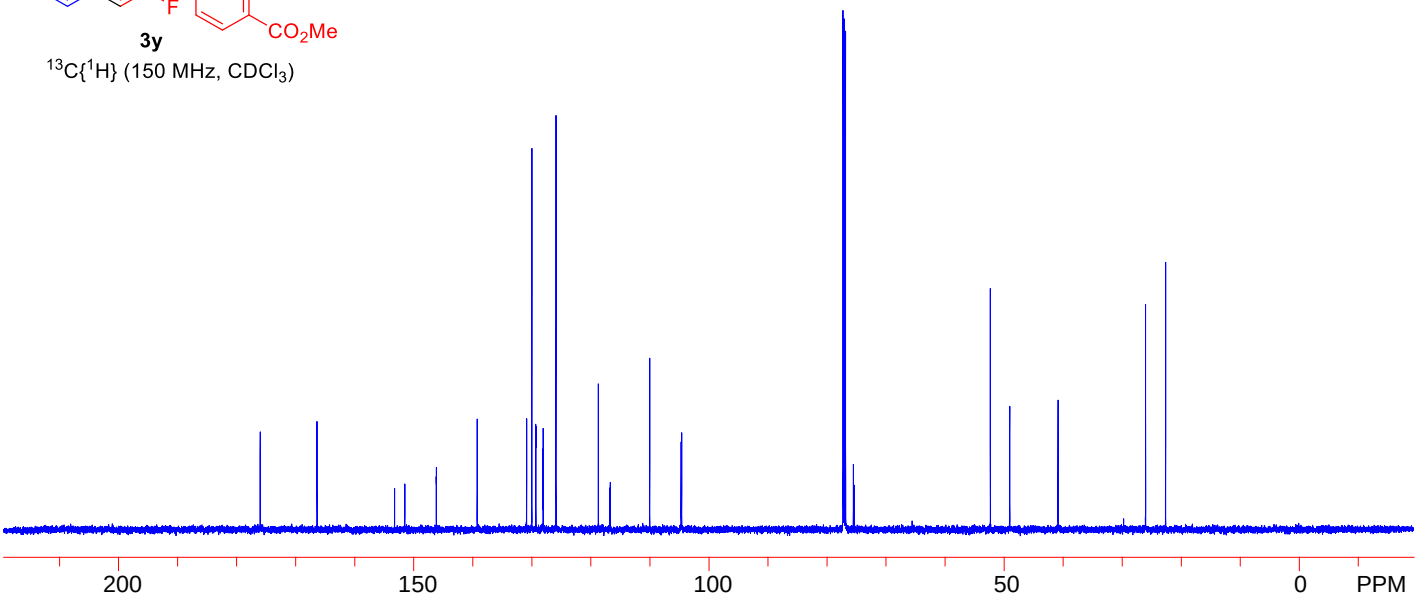


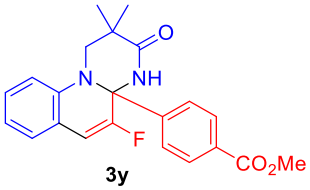




3y

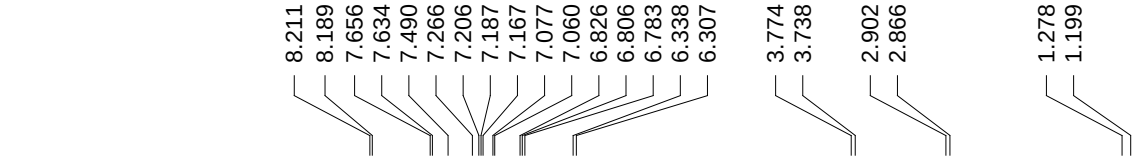
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)

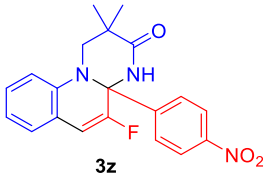




3y

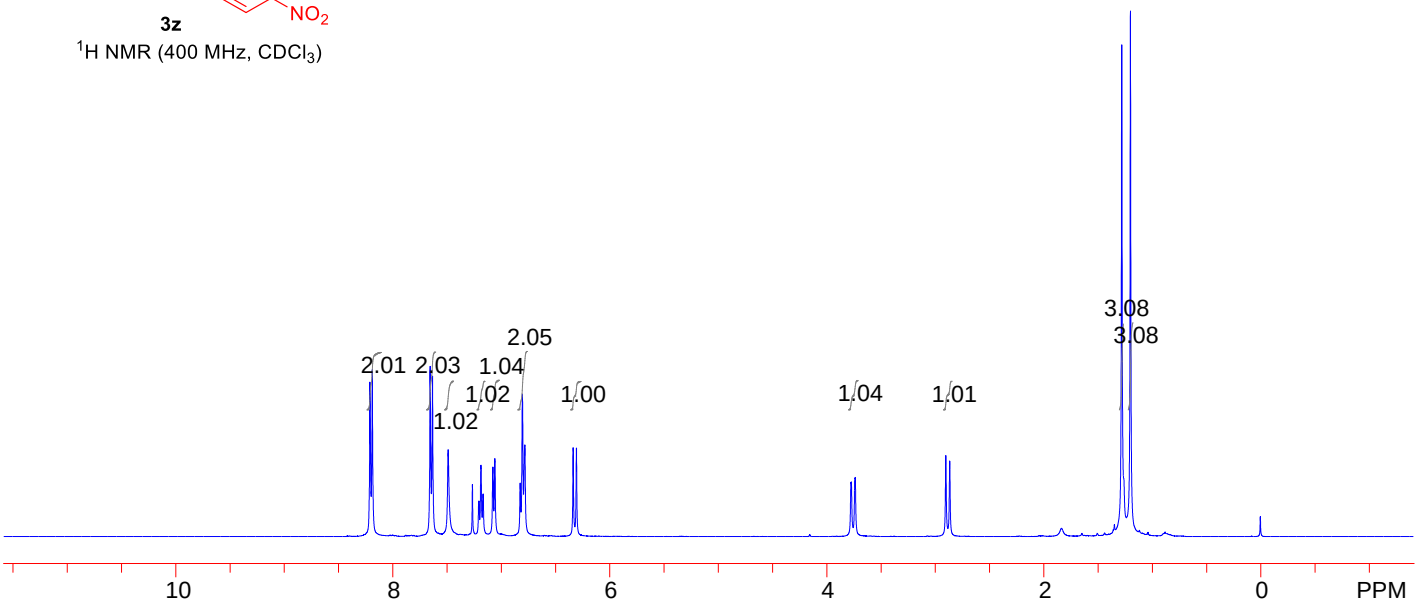
^{19}F NMR (376 MHz, $CDCl_3$)

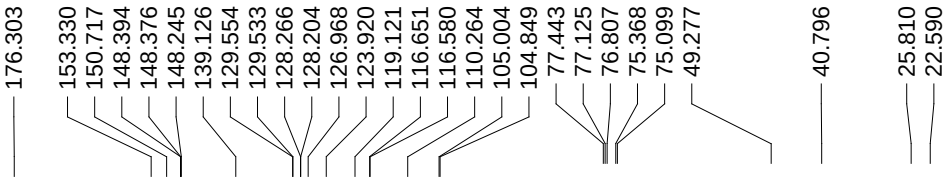


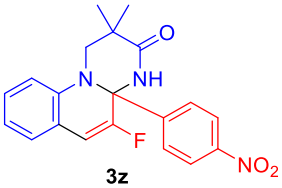


3z

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

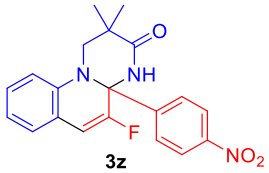






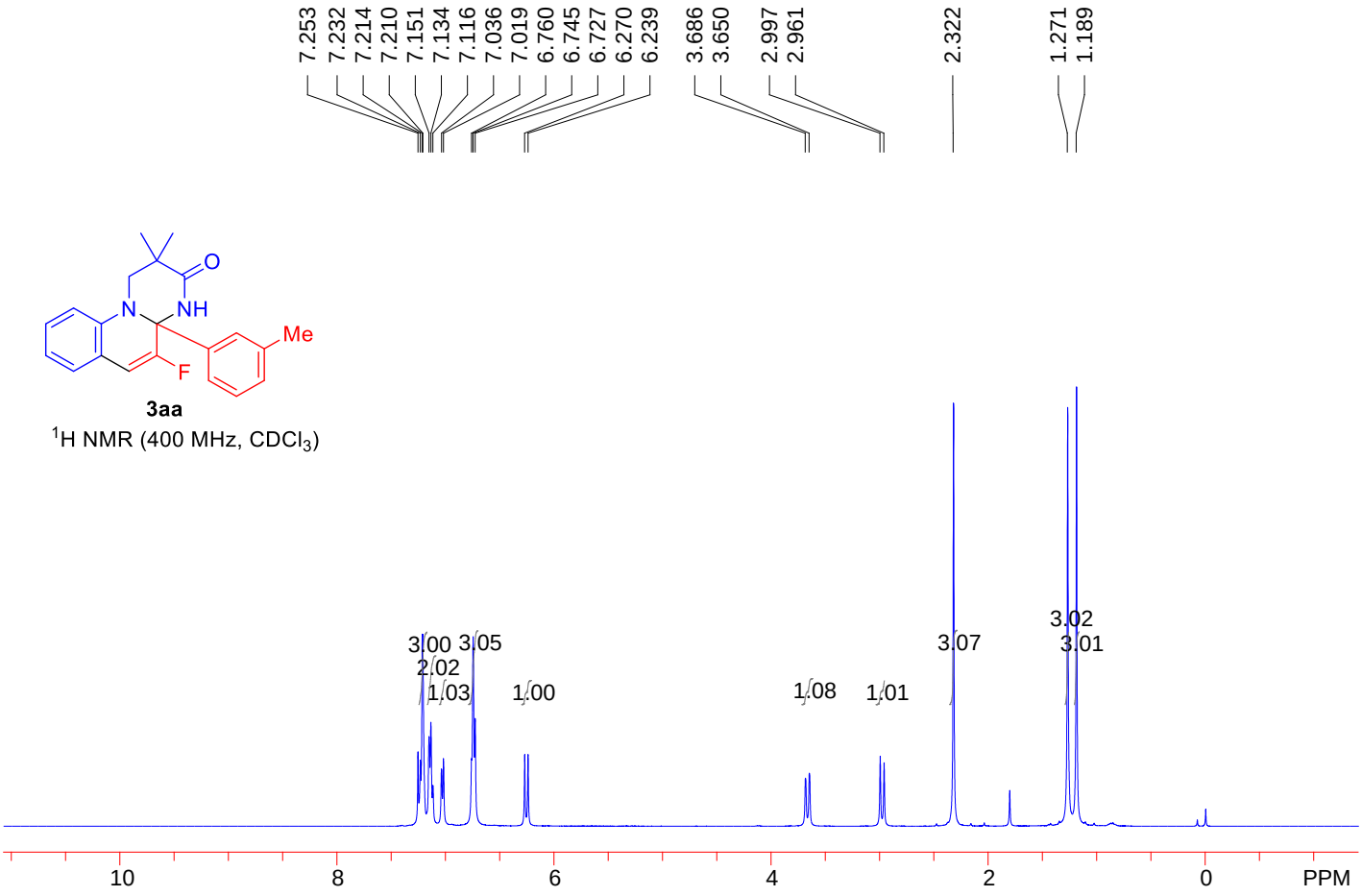
3z

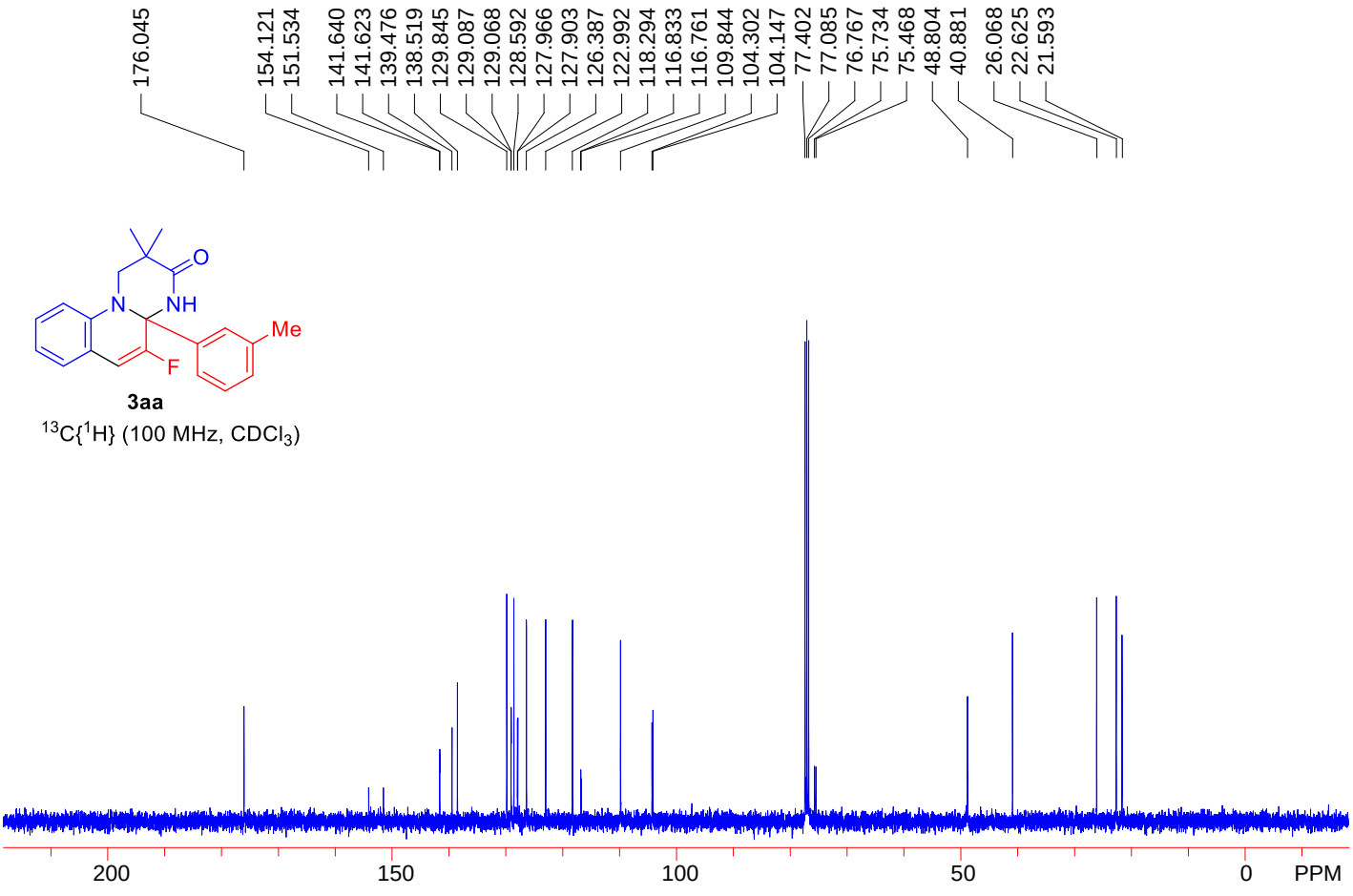
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)

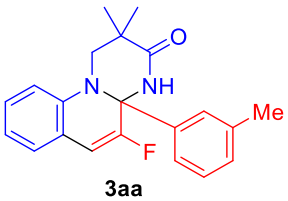


3z

^{19}F NMR (565 MHz, $CDCl_3$)

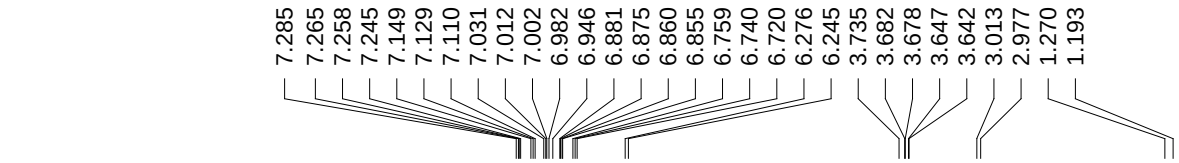

7.253
7.232
7.214
7.210
7.151
7.134
7.116
7.036
7.019
6.760
6.745
6.727
6.270
6.239
3.686
3.650
2.997
2.961
2.322
1.271
1.189
O
NH
N
Me
F
3aa
1H NMR (400 MHz, CDCl3)
3.00
2.02
1.03
3.05
1.00
1.08
1.01
3.07
3.02
3.01
10
8
6
4
2
0
PPM

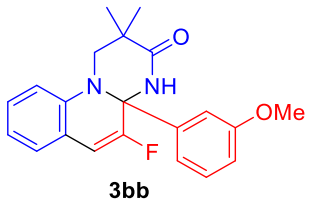

176.045
154.121
151.534
141.640
141.623
139.476
138.519
129.845
129.087
129.068
128.592
127.966
127.903
126.387
122.992
118.294
116.833
116.761
109.844
104.302
104.147
77.402
77.085
76.767
75.734
75.468
48.804
40.881
26.068
22.625
21.593
O
NH
N
Me
F
3aa
13C{1H} (100 MHz, CDCl3)
200
150
100
50
0
PPM



3aa

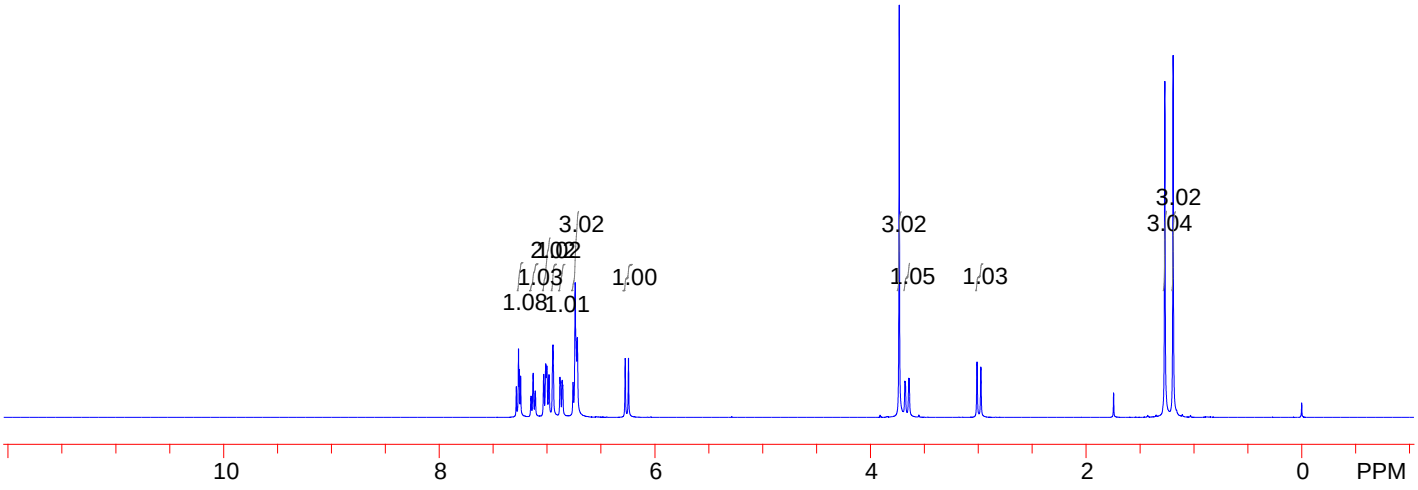
^{19}F NMR (565 MHz, $CDCl_3$)

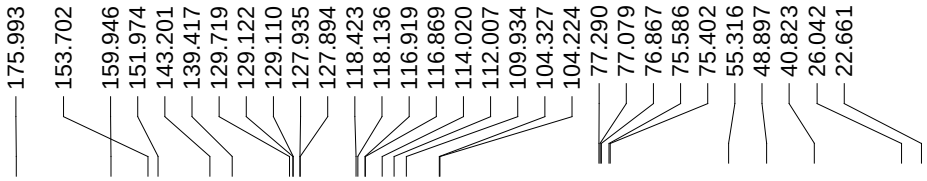


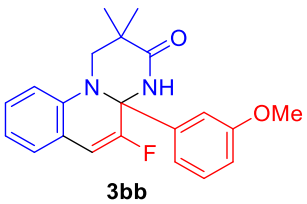


3bb

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

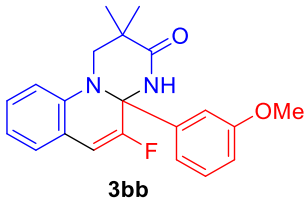






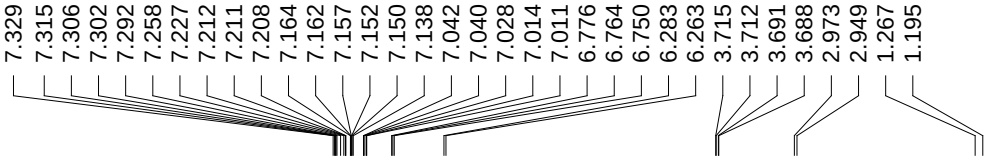
3bb

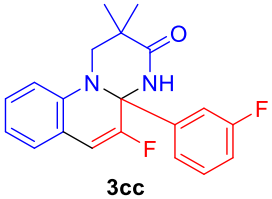
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)



3bb

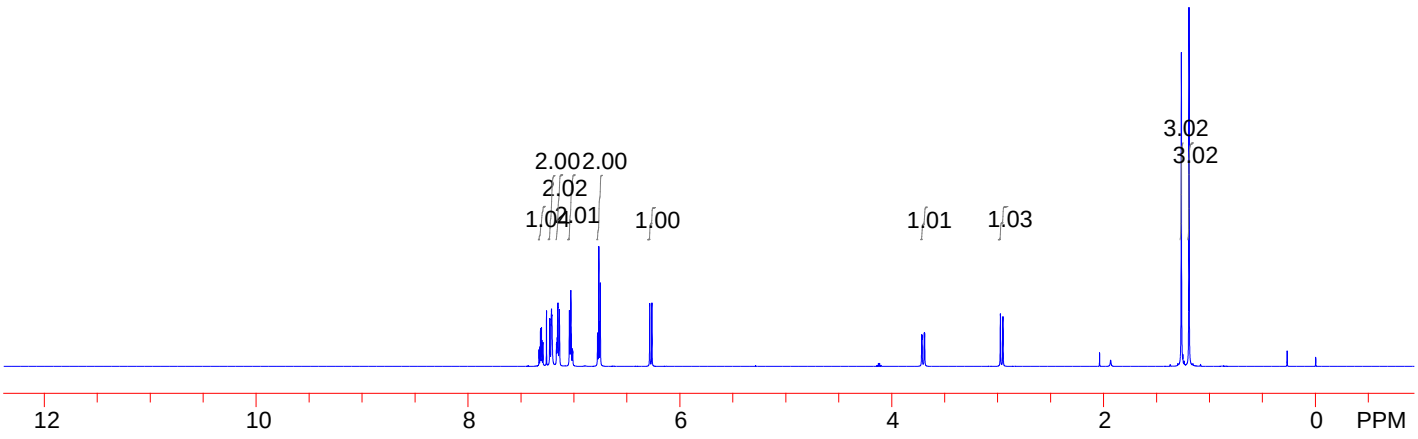
^{19}F NMR (565 MHz, $CDCl_3$)

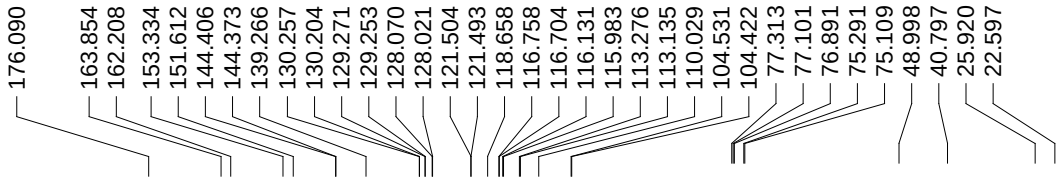


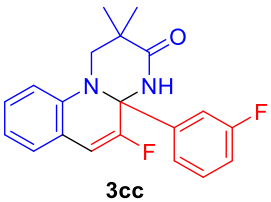


3cc

^{1}H NMR (600 MHz, $CDCl_3$)

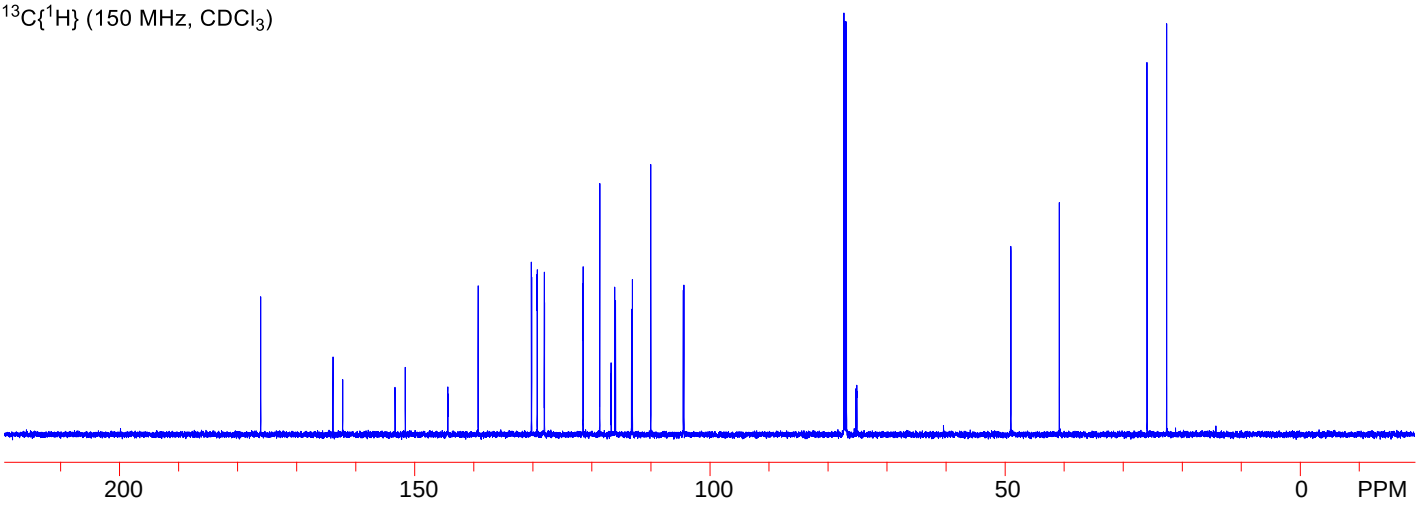


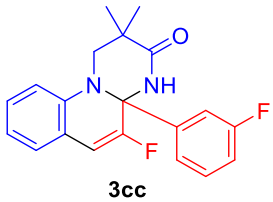




3cc

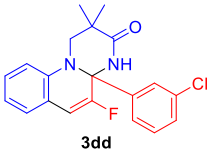
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)





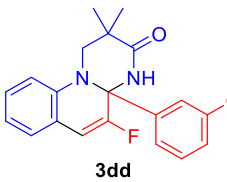
3cc

^{19}F NMR (565 MHz, $CDCl_3$)



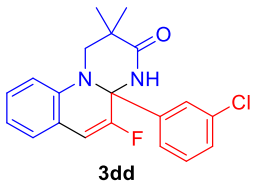
3dd

^{1}H NMR (600 MHz, $CDCl_3$)



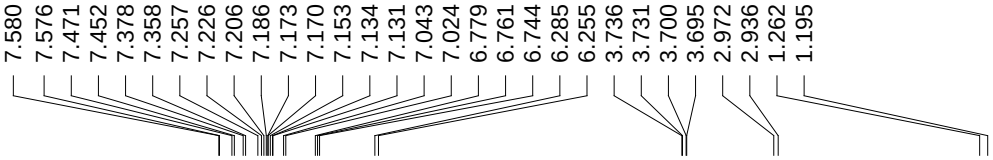
3dd

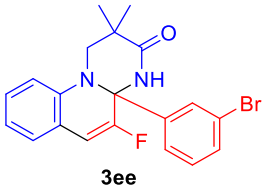
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)



3dd

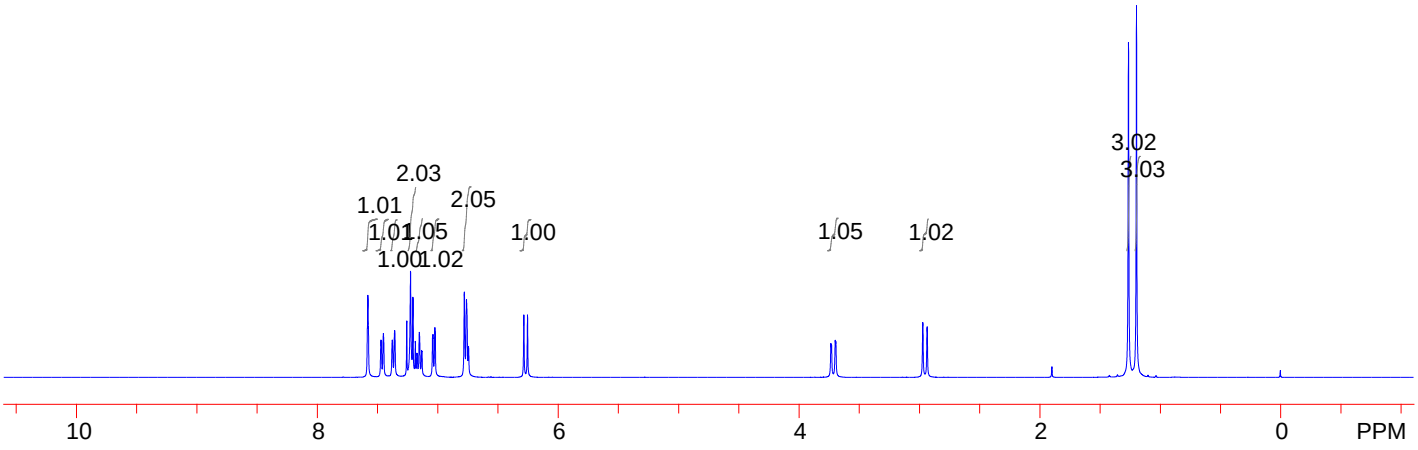
^{19}F NMR (565 MHz, $CDCl_3$)

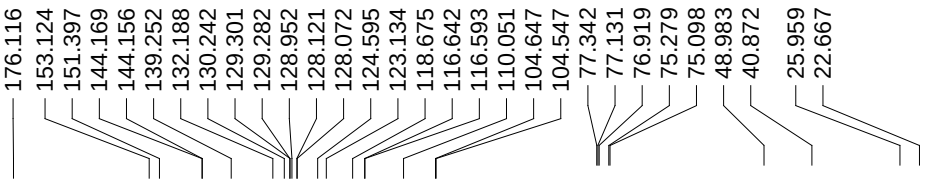


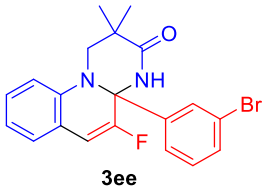


3ee

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

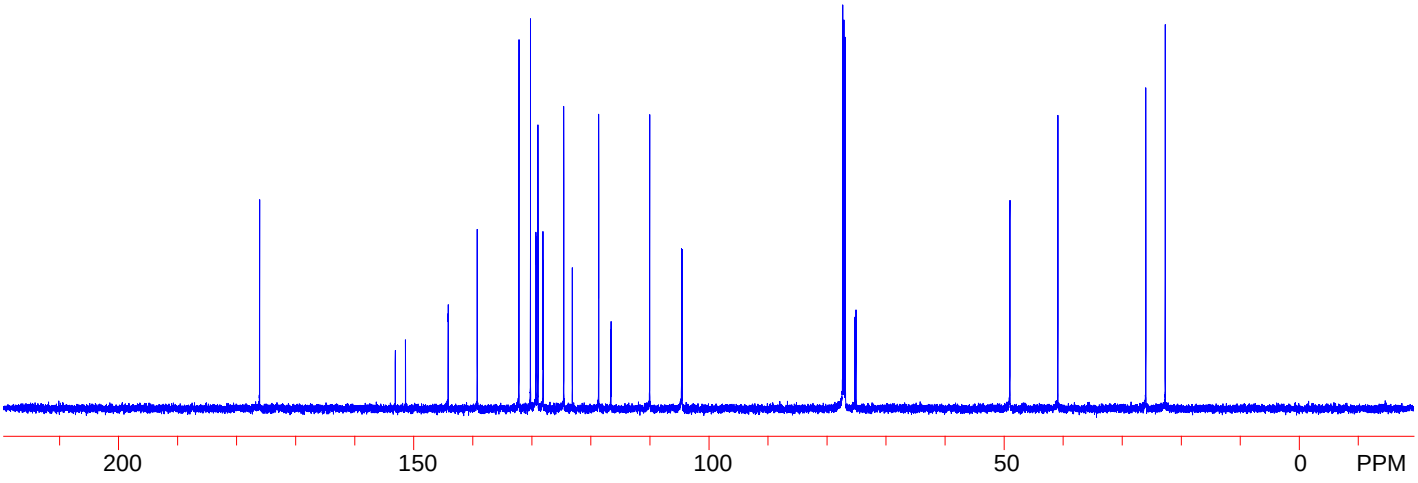


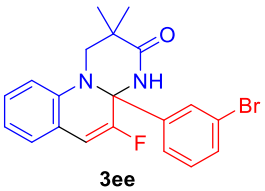




3ee

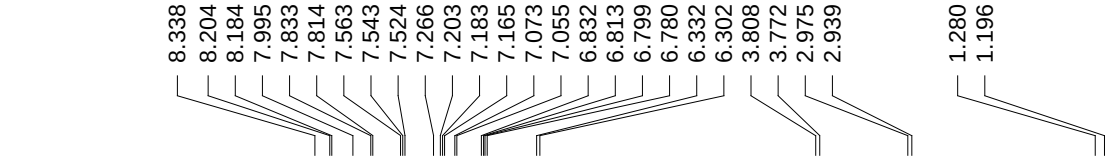
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)

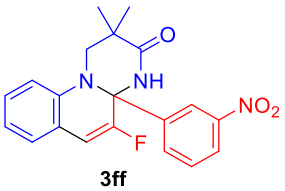




3ee

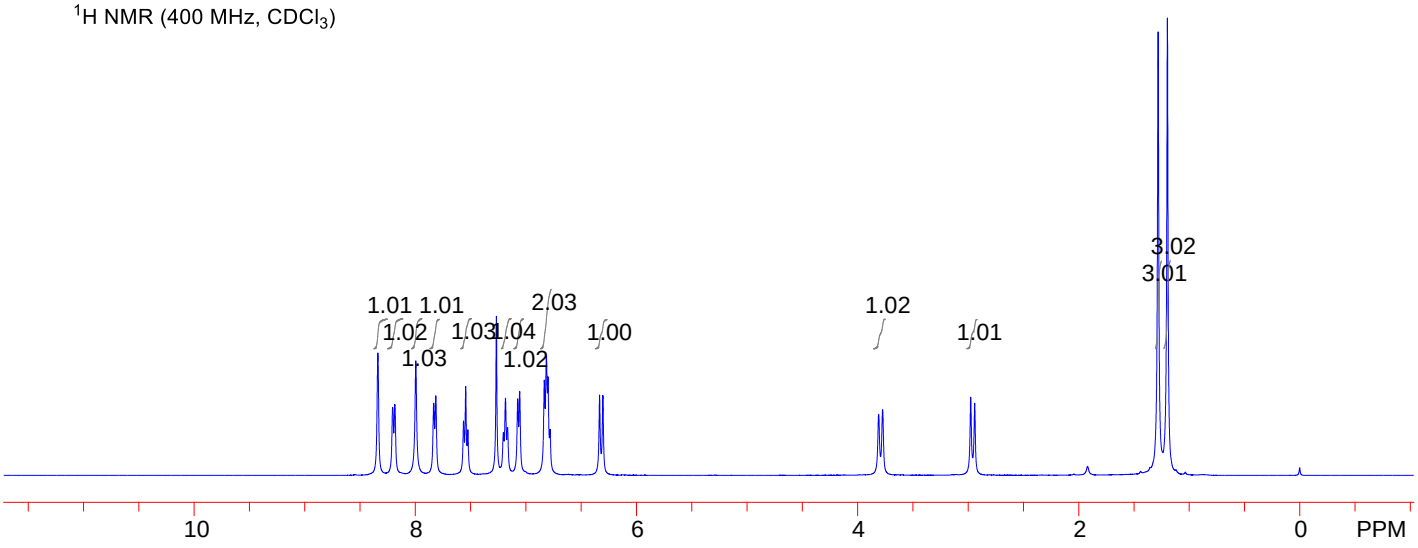
^{19}F NMR (565 MHz, $CDCl_3$)

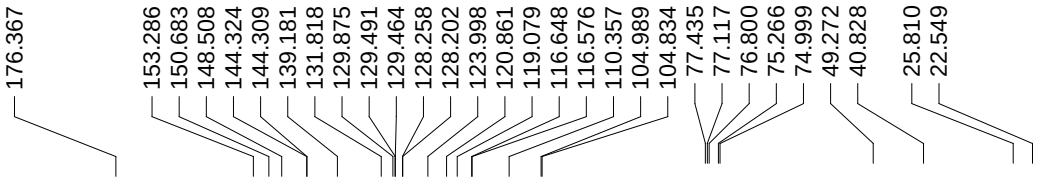


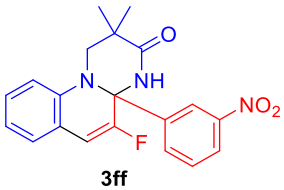


3ff

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

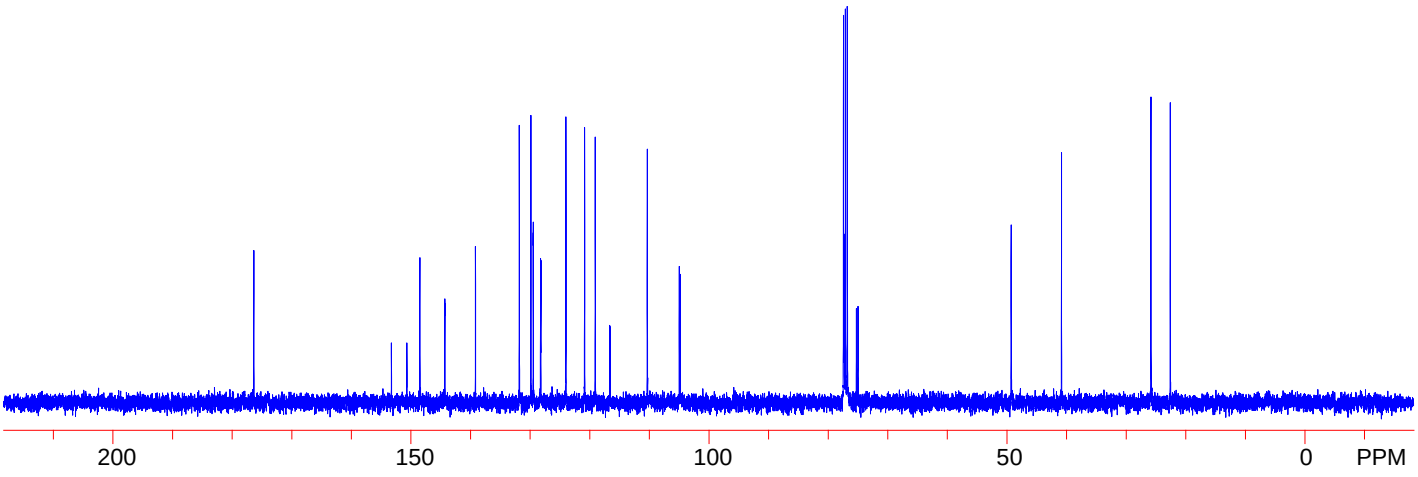


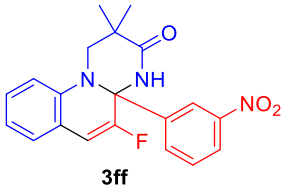




3ff

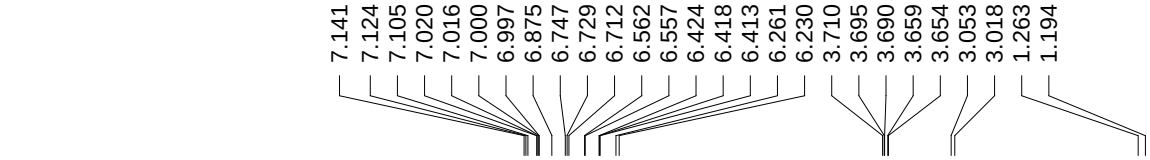
^{13}C{^{1}H} (100 MHz, $CDCl_3$)

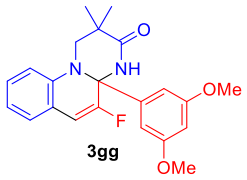




3ff

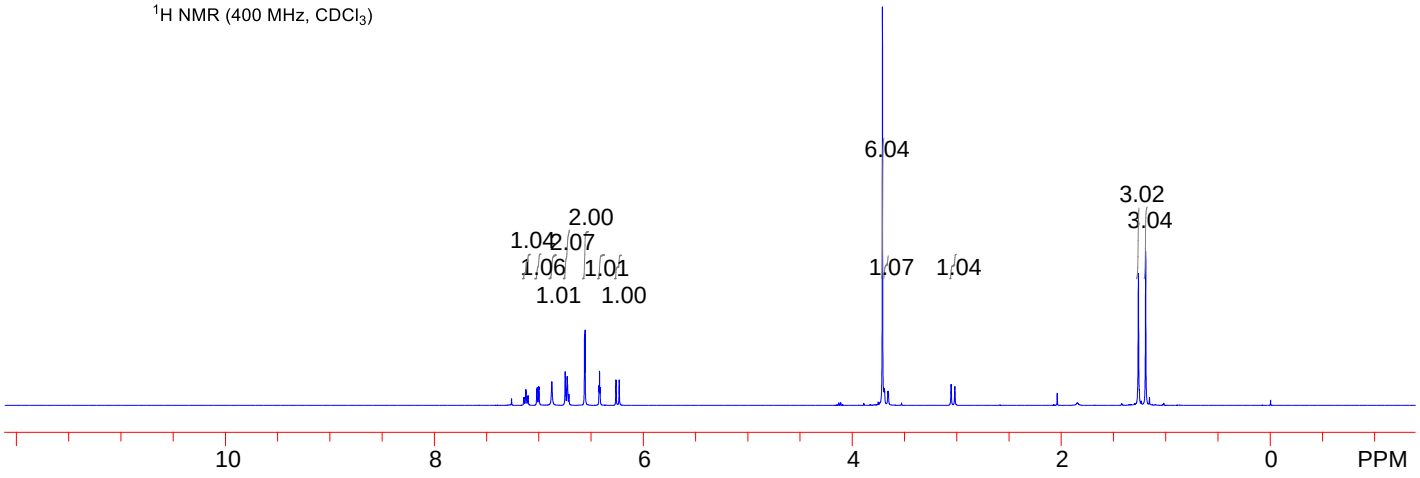
^{19}F NMR (565 MHz, $CDCl_3$)

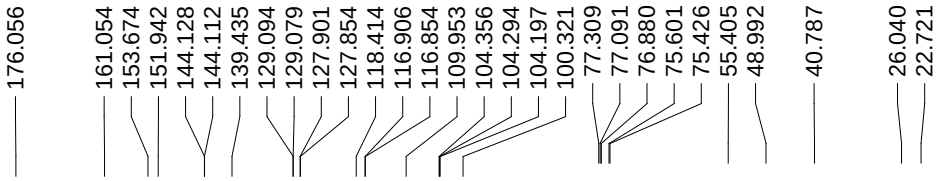


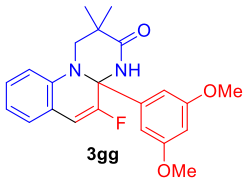


3gg

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



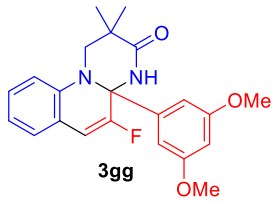




3gg

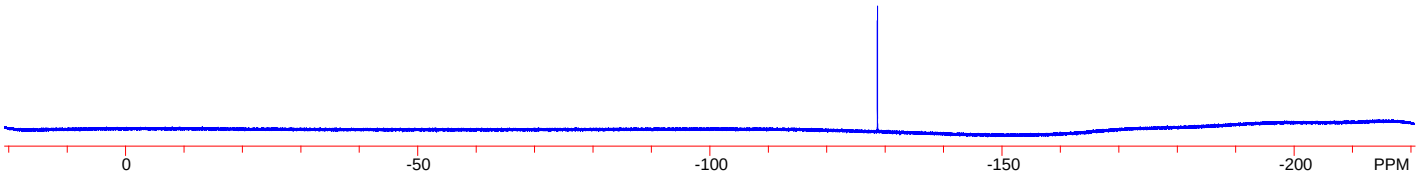
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)

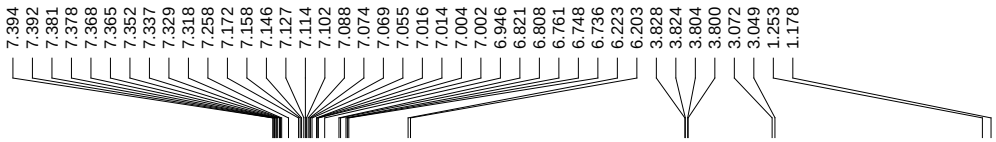
128.752
128.781

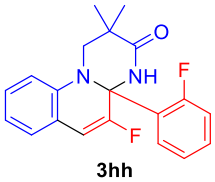


3gg

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

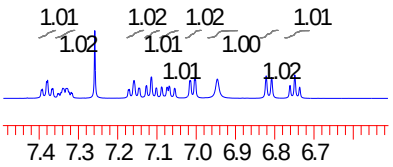


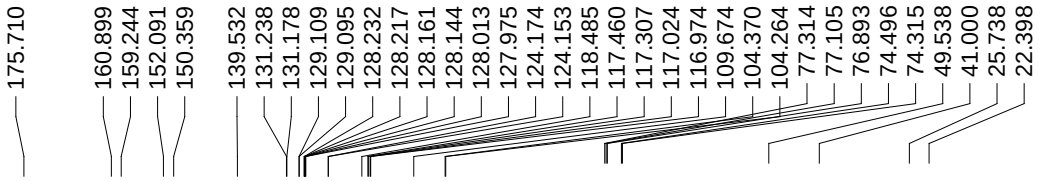


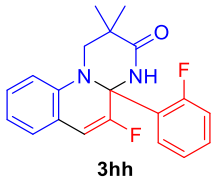


3hh

^{1}H NMR (600 MHz, $CDCl_3$)

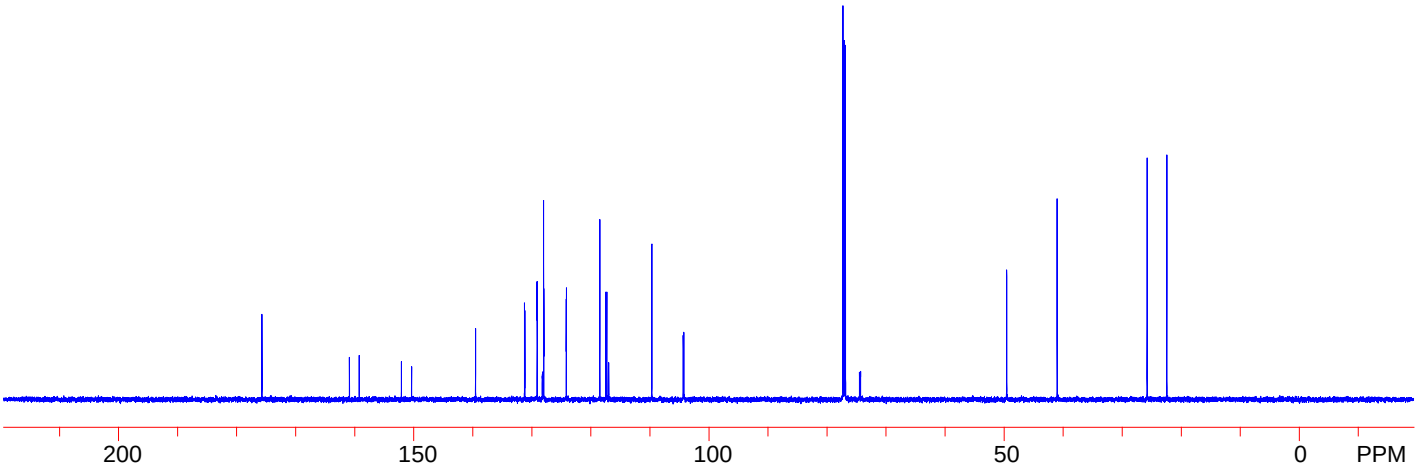


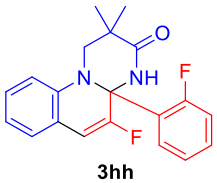




3hh

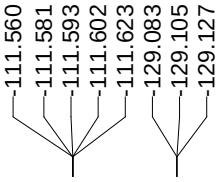
^{13}C{^{1}H} (150 MHz, $CDCl_3$)

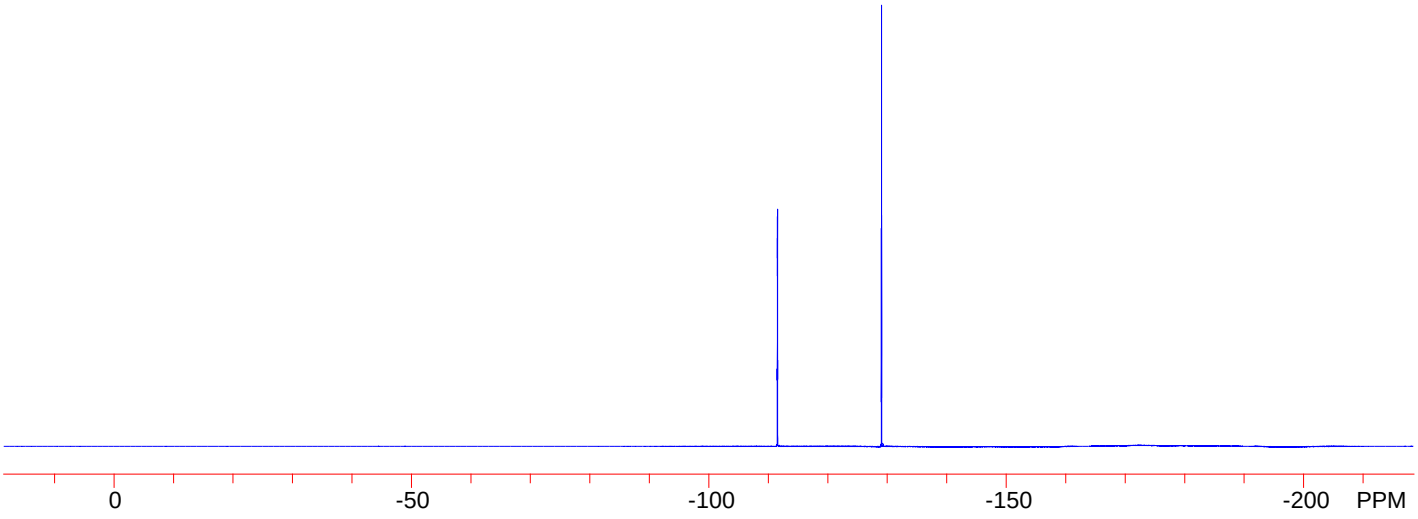


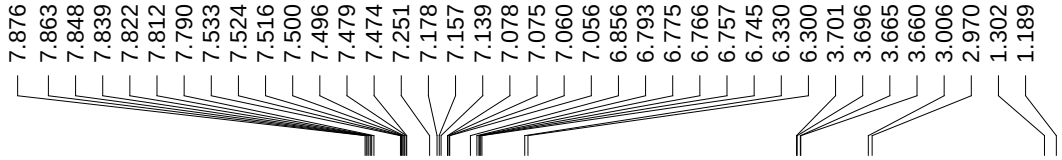


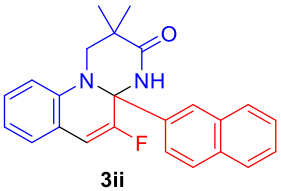
3hh

^{19}F NMR (565 MHz, $CDCl_3$)



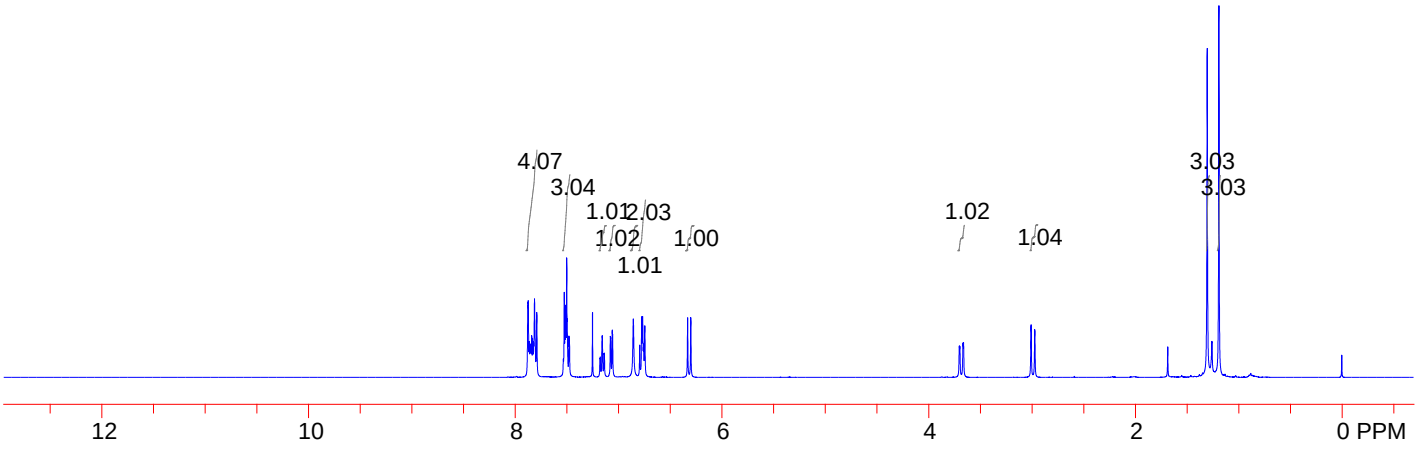


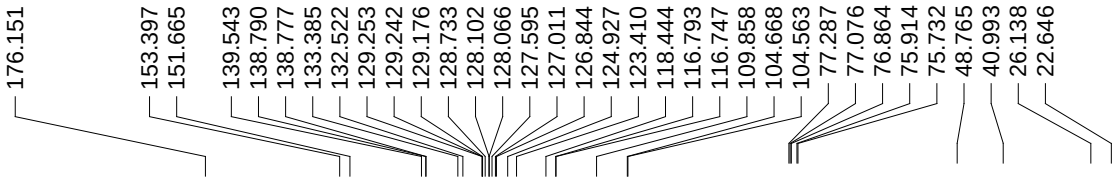


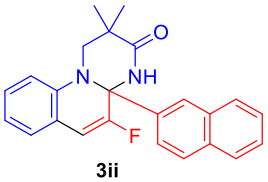


3ii

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

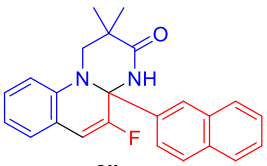






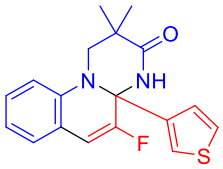
3ii

$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)



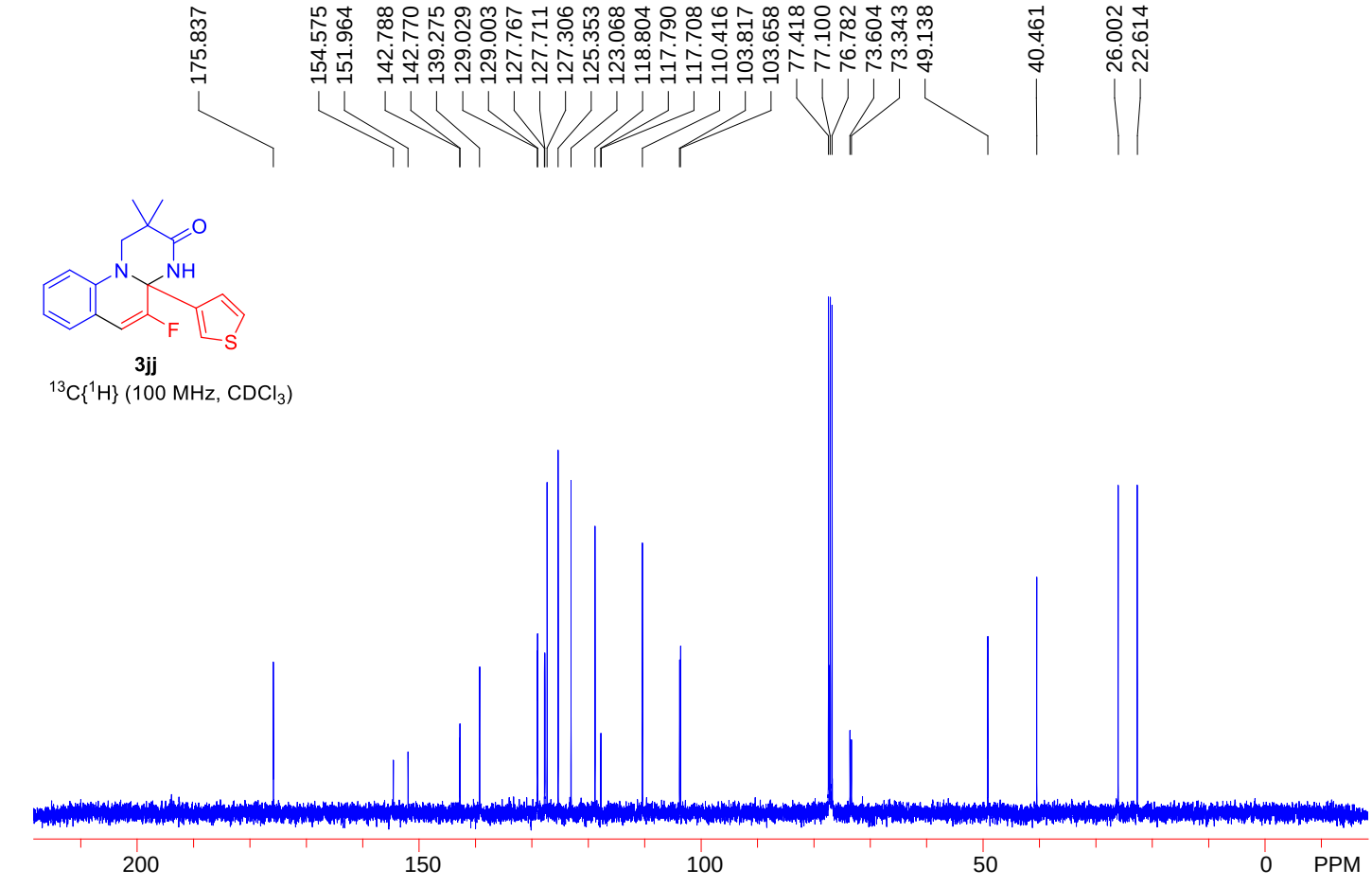
3ii

^{19}F NMR (565 MHz, $CDCl_3$)



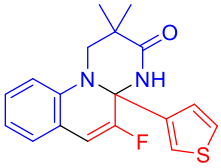
3jj

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



3jj

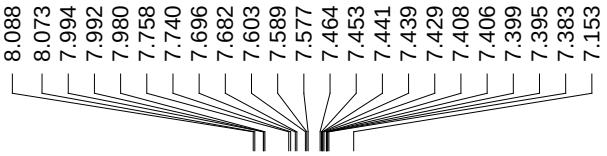
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)

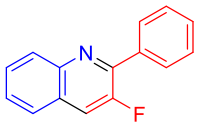


3jj

^{19}F NMR (565 MHz, $CDCl_3$)

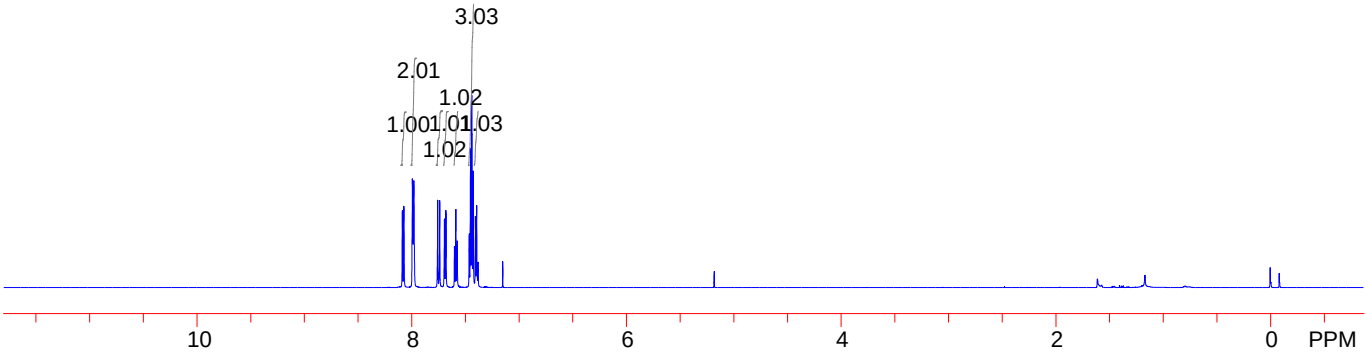
V. Copies of NMR spectra of 4a-4h

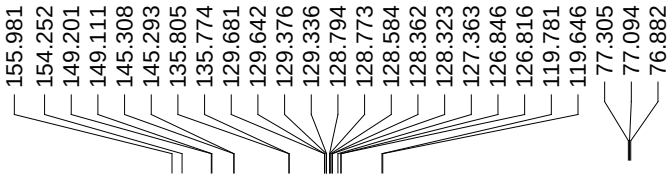


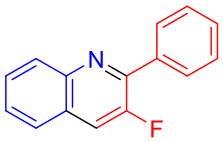


4a

^{1}H NMR (600 MHz, $CDCl_3$)

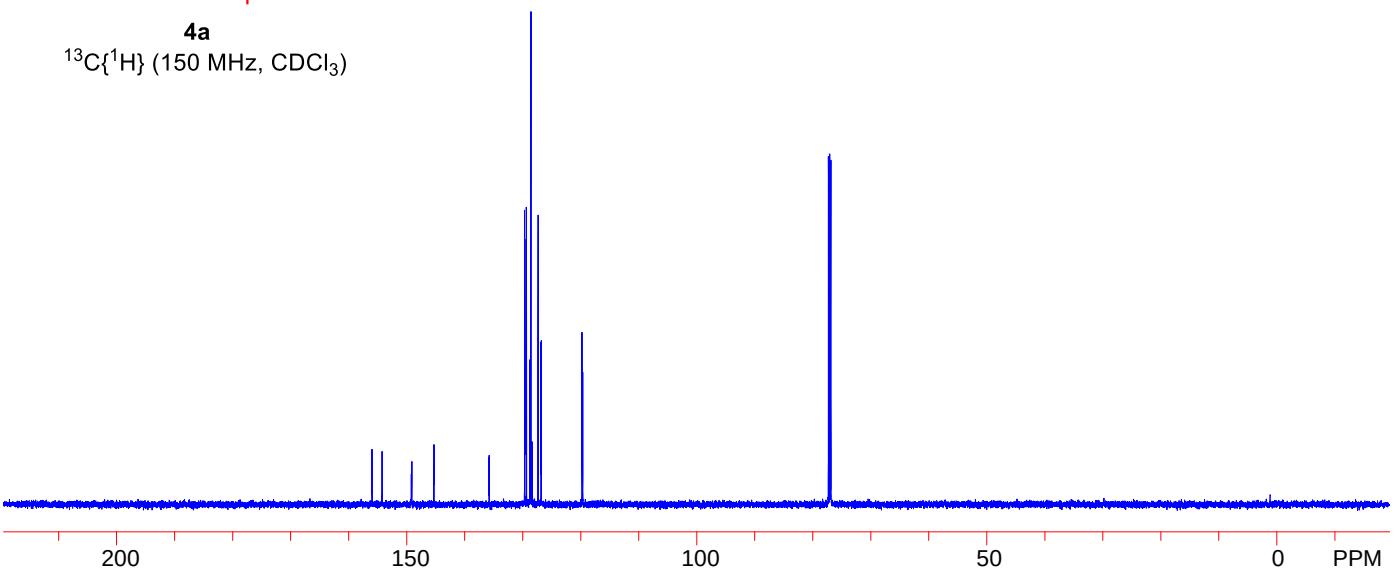


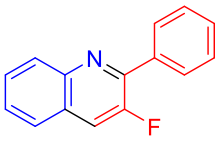




4a

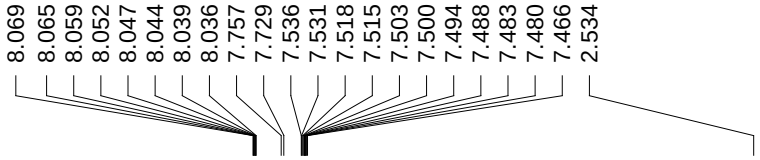
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)

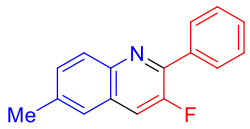




4a

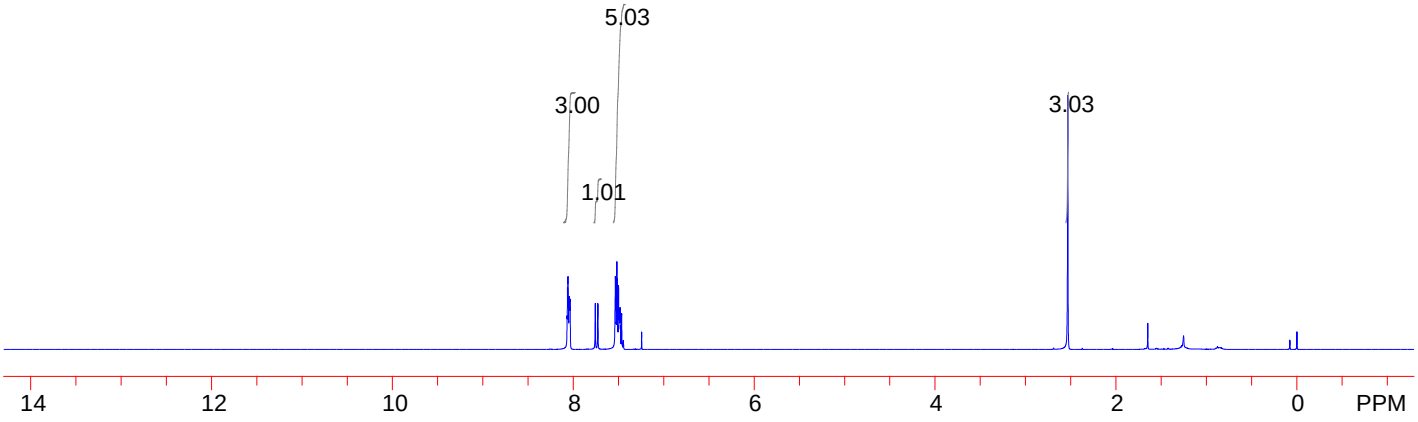
^{19}F NMR (565 MHz, $CDCl_3$)

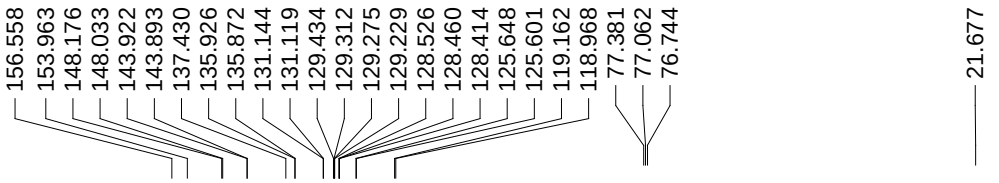


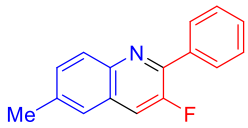


4b

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

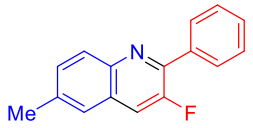






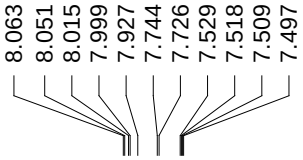
4b

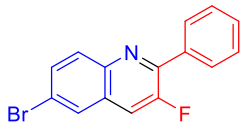
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)



4b

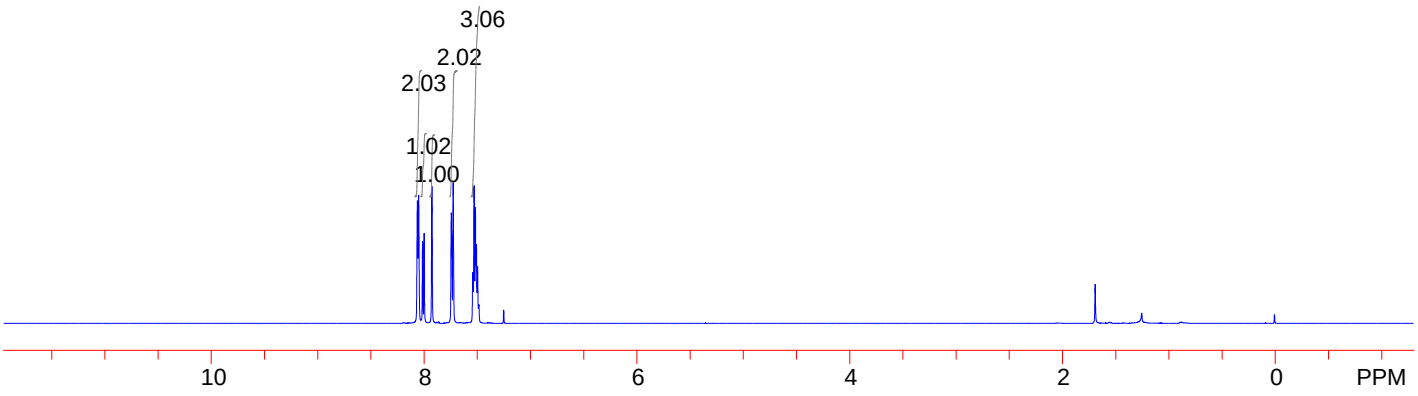
^{19}F NMR (376 MHz, $CDCl_3$)

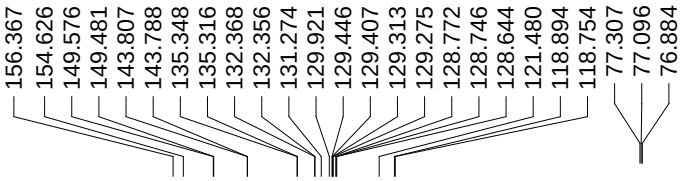


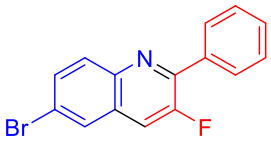


4c

^{1}H NMR (600 MHz, $CDCl_3$)

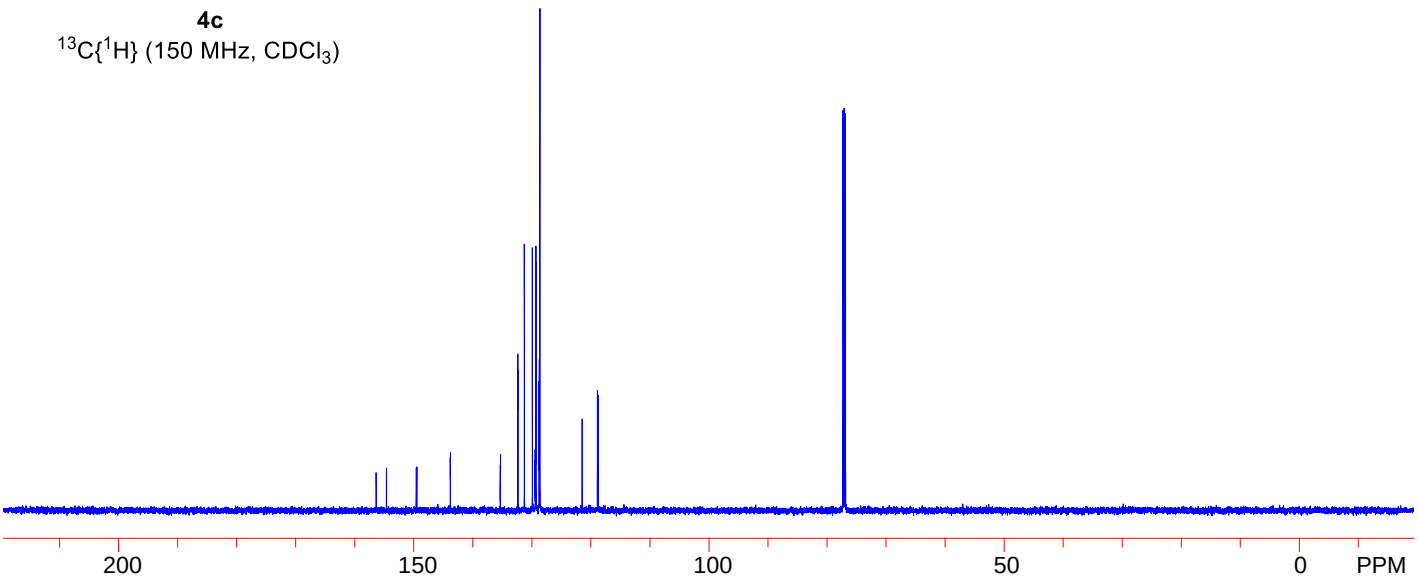


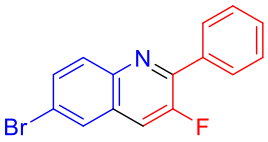




4c

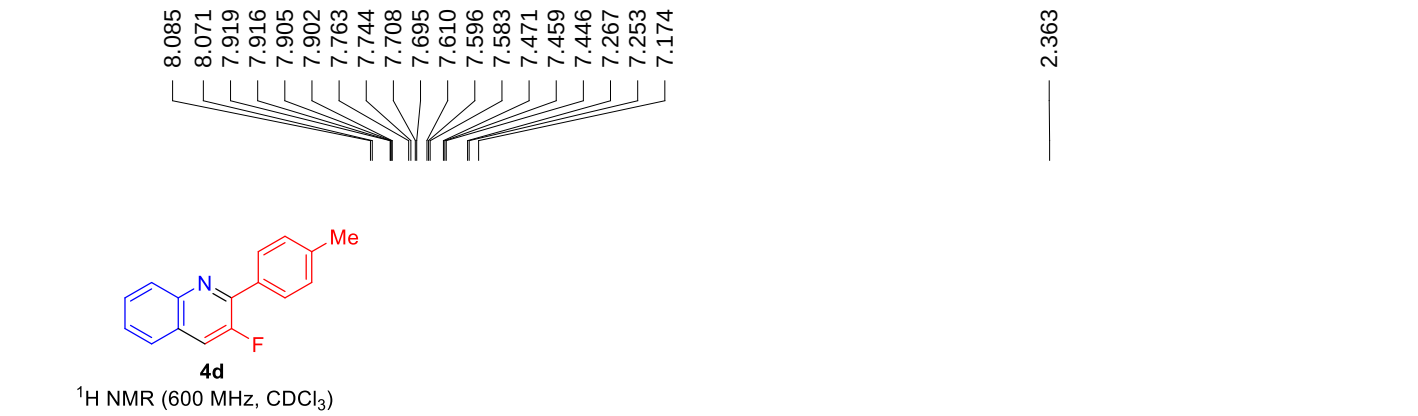
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)





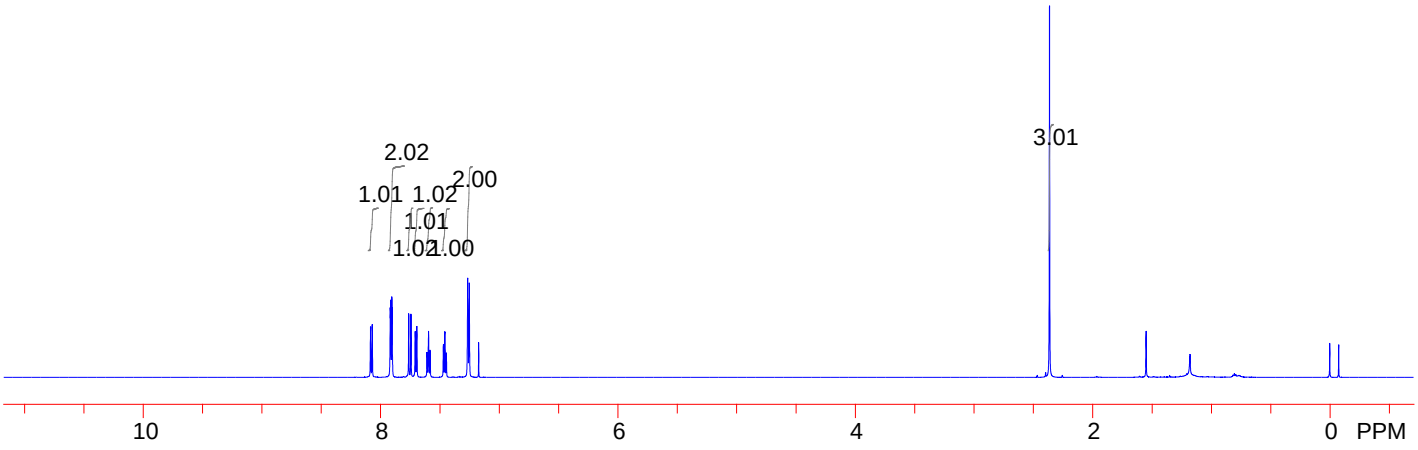
4c

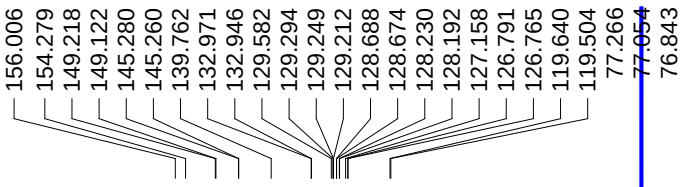
^{19}F NMR (565 MHz, $CDCl_3$)

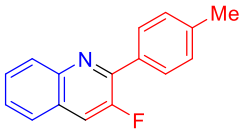


4d

^{1}H NMR (600 MHz, $CDCl_3$)

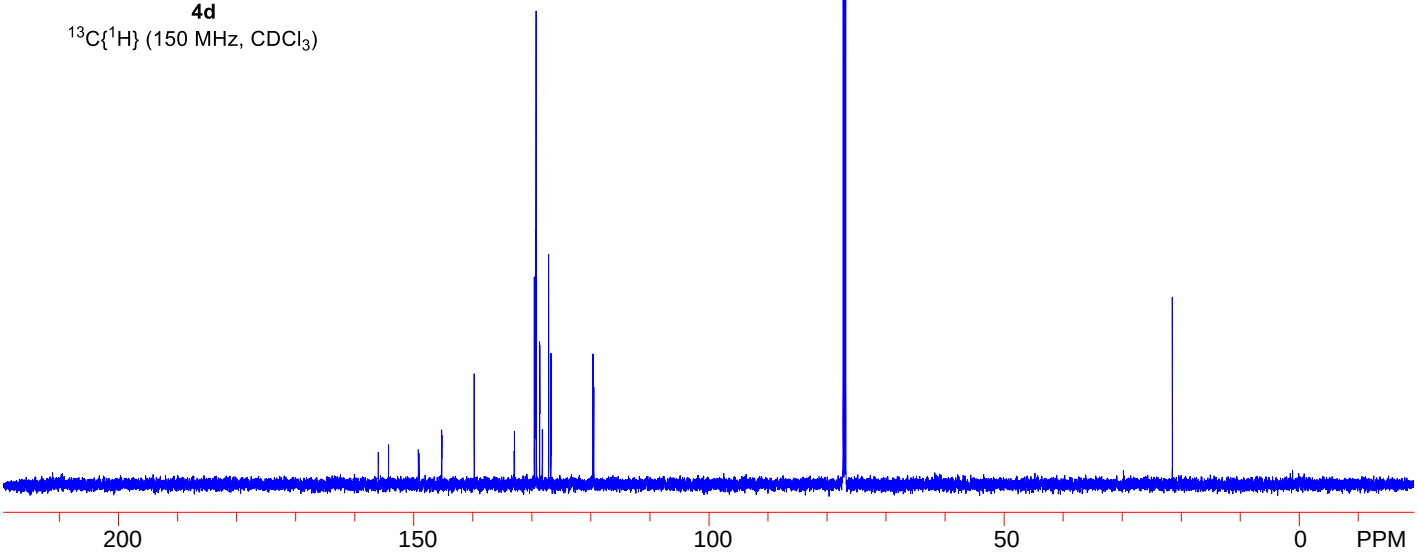


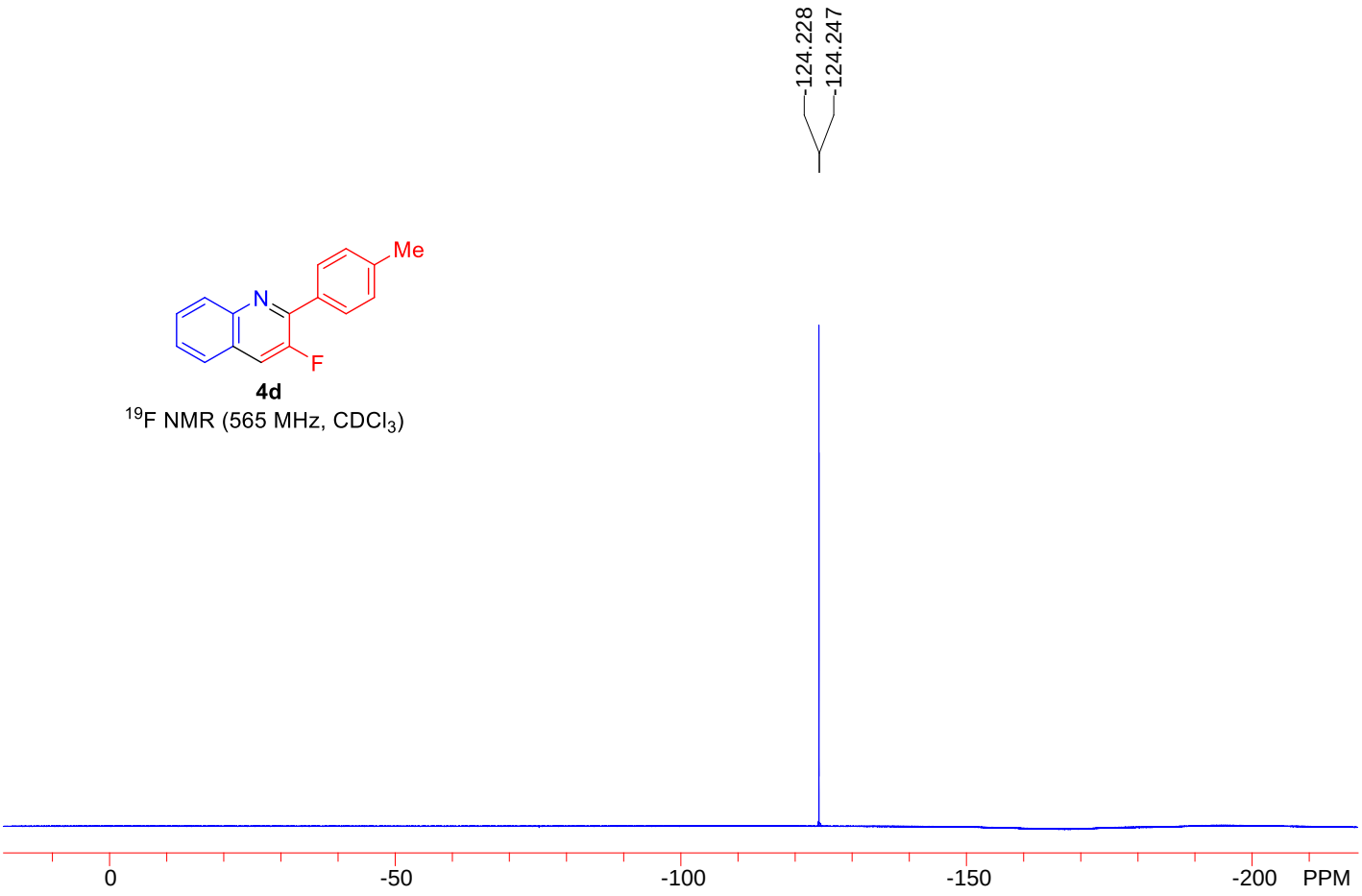




4d

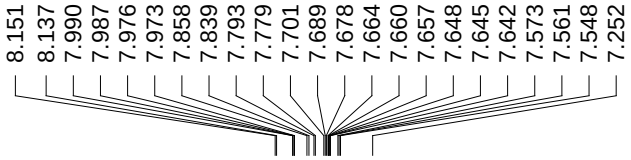
^{13}C{^{1}H} (150 MHz, $CDCl_3$)

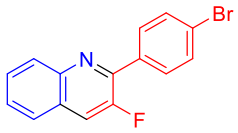




4d

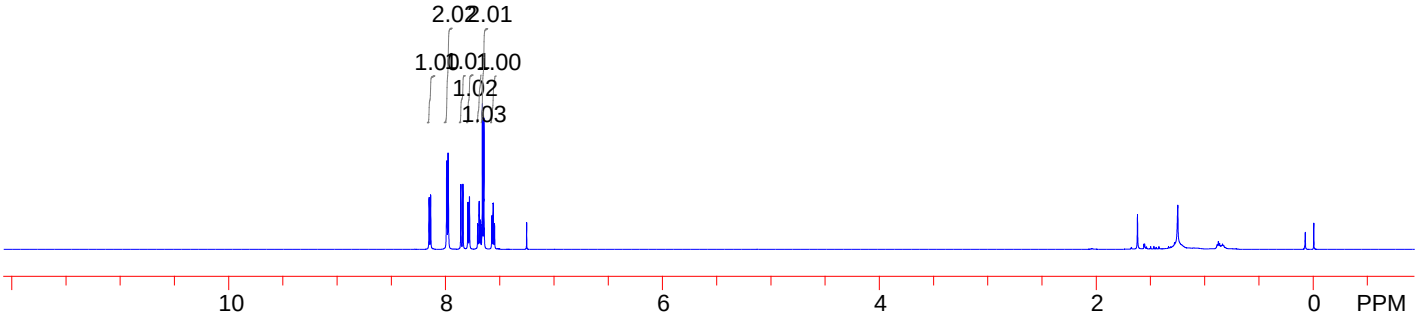
^{19}F NMR (565 MHz, $CDCl_3$)

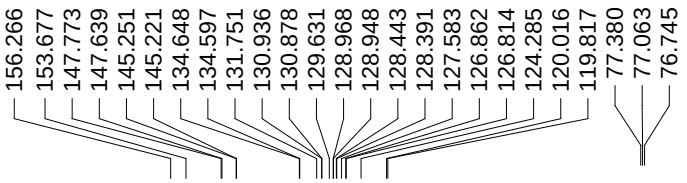


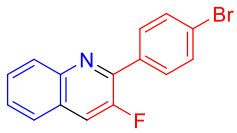


4e

^{1}H NMR (600 MHz, $CDCl_3$)

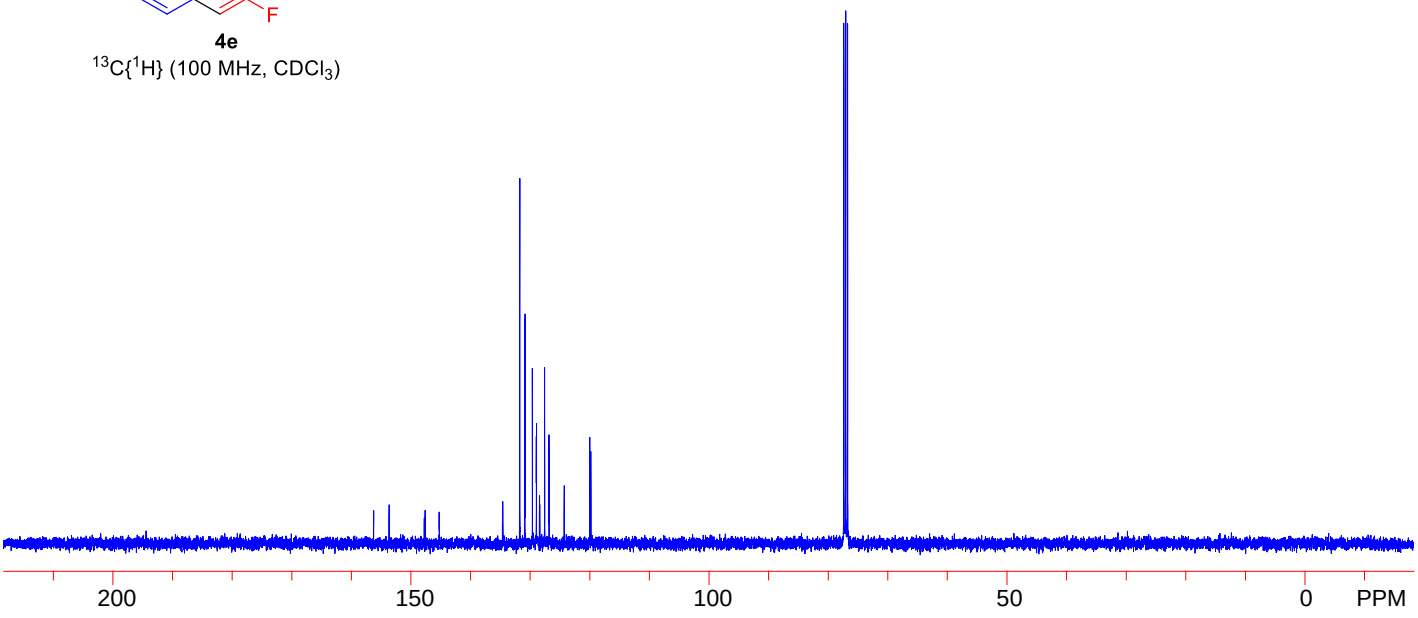


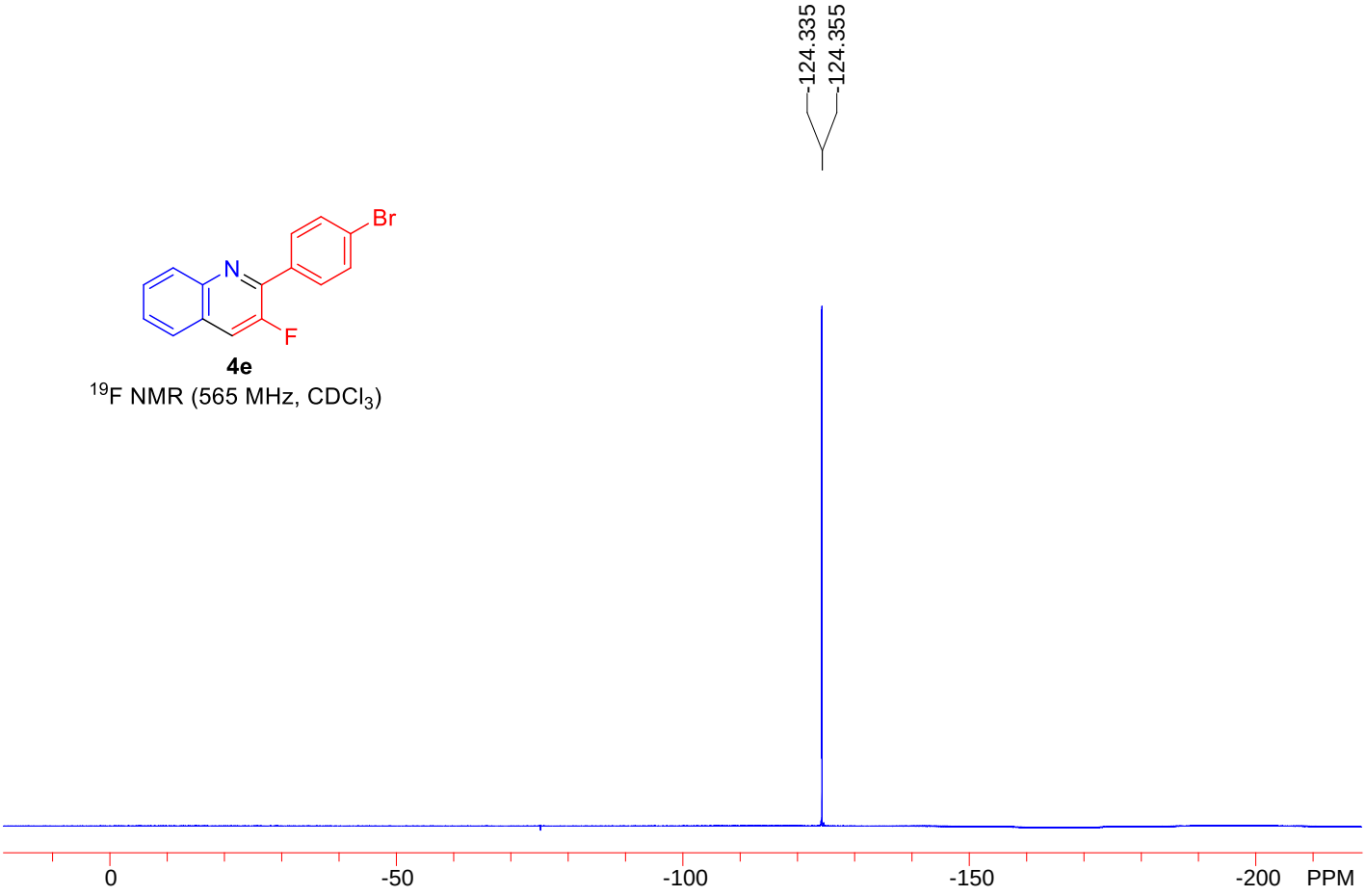




4e

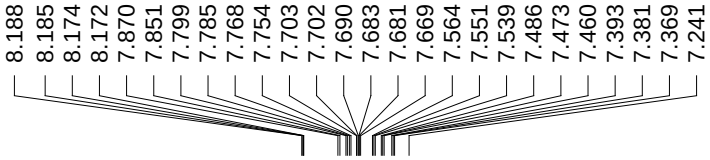
^{13}C{^{1}H} (100 MHz, $CDCl_3$)

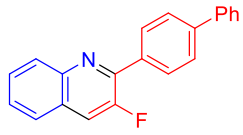




4e

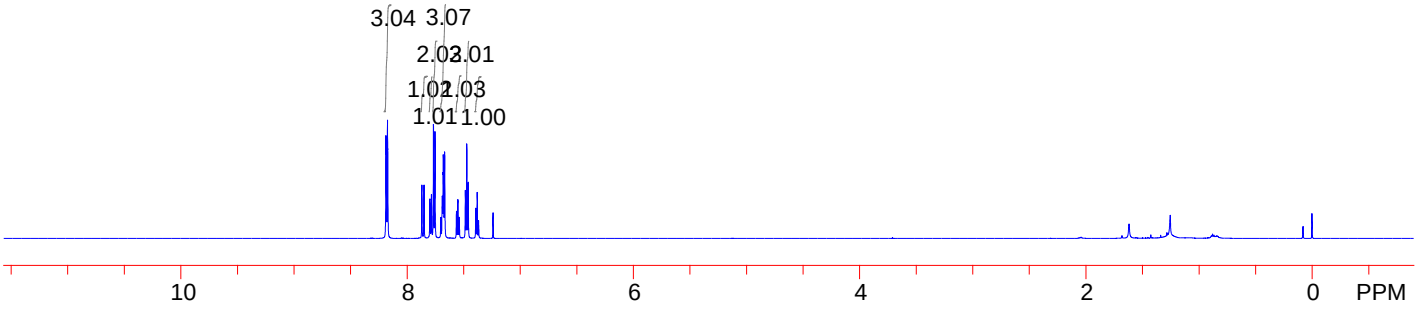
^{19}F NMR (565 MHz, $CDCl_3$)

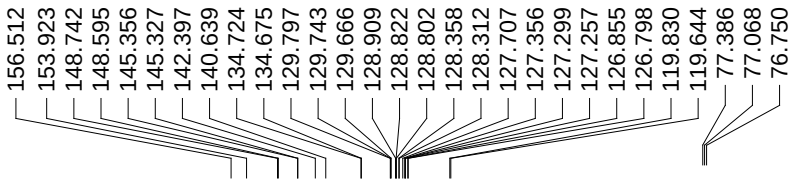


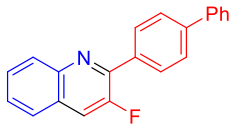


4f

^{1}H NMR (600 MHz, $CDCl_3$)

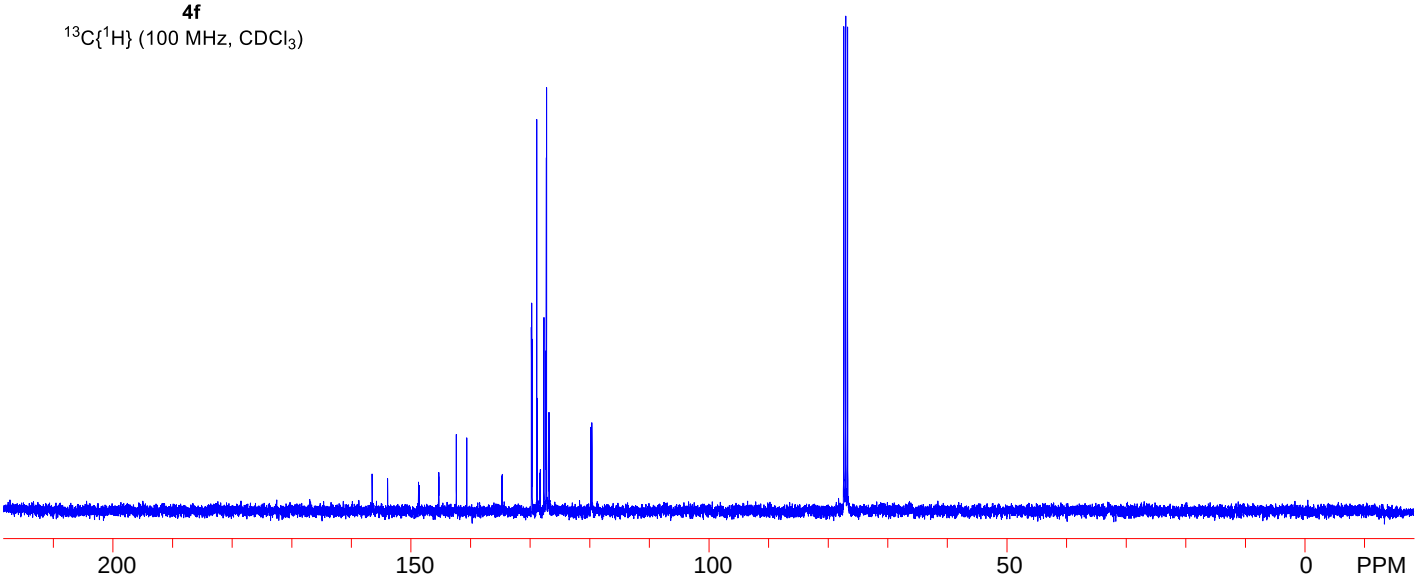


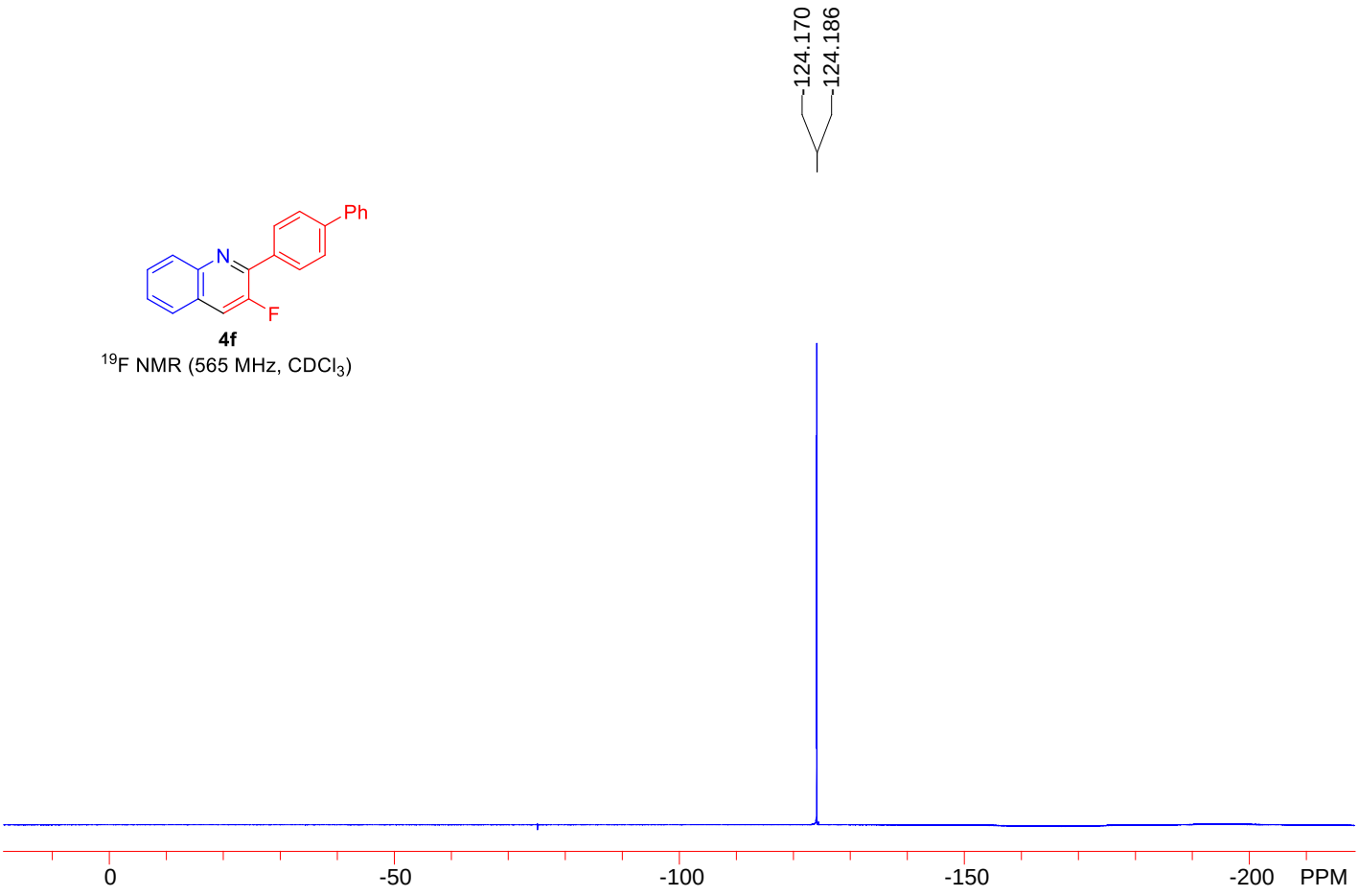




4f

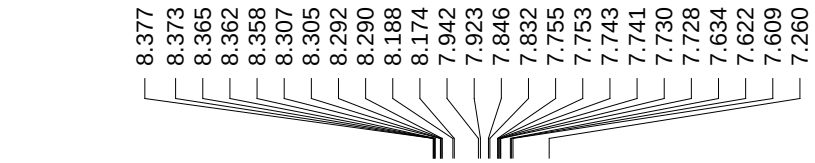
$^{13}C\{^{1}H\}$ (100 MHz, $CDCl_3$)

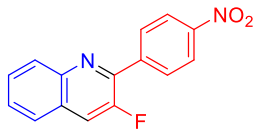




4f

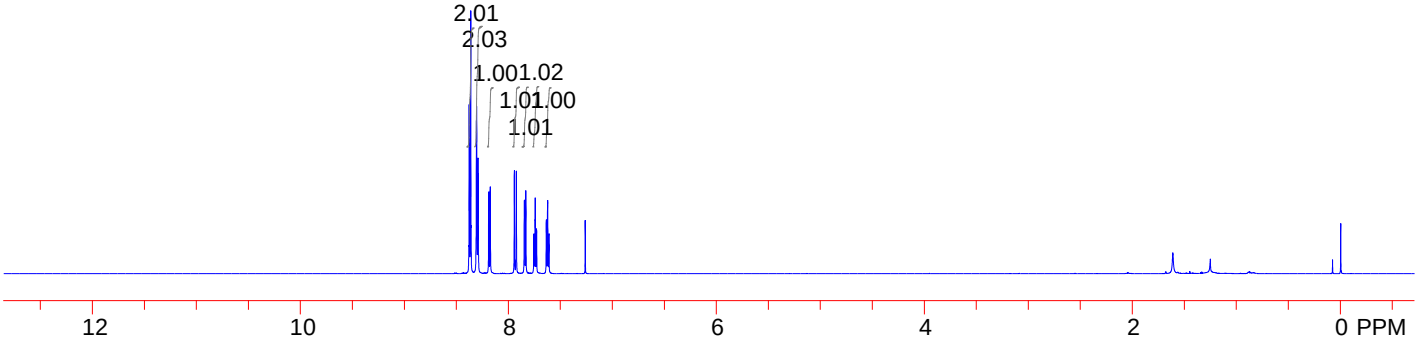
^{19}F NMR (565 MHz, $CDCl_3$)

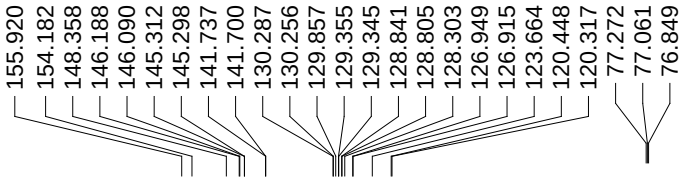


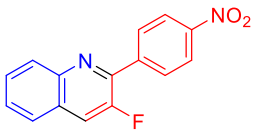


4g

^{1}H NMR (600 MHz, $CDCl_3$)

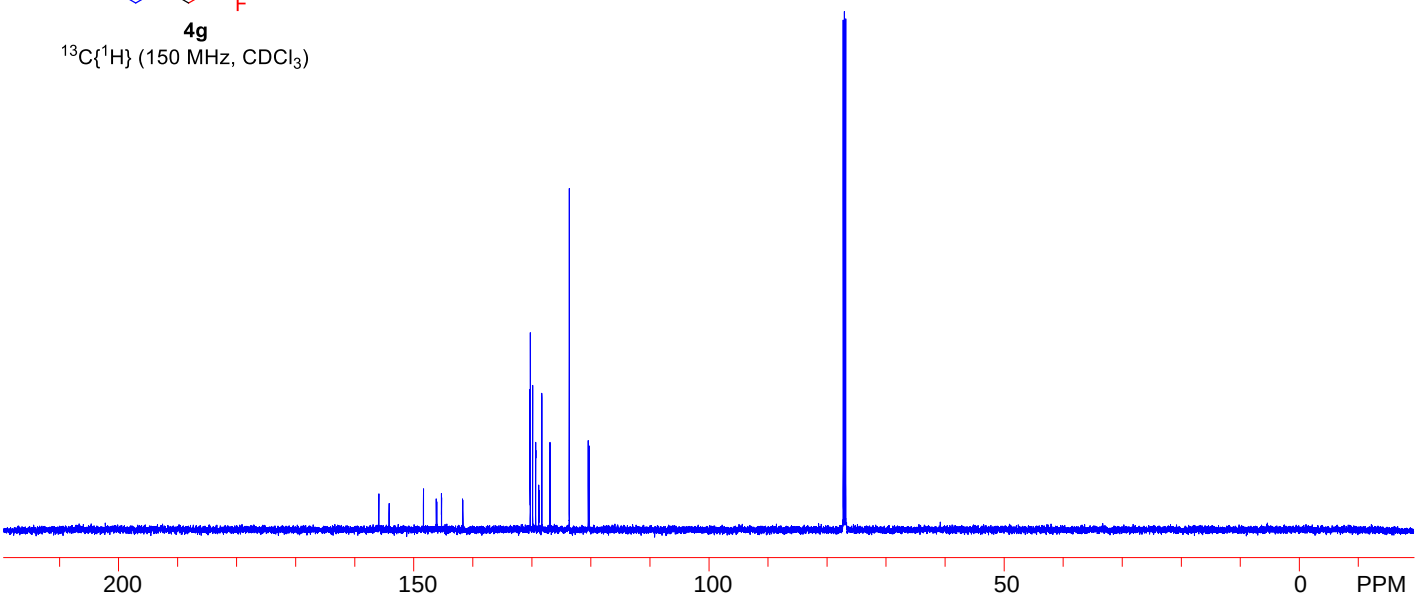


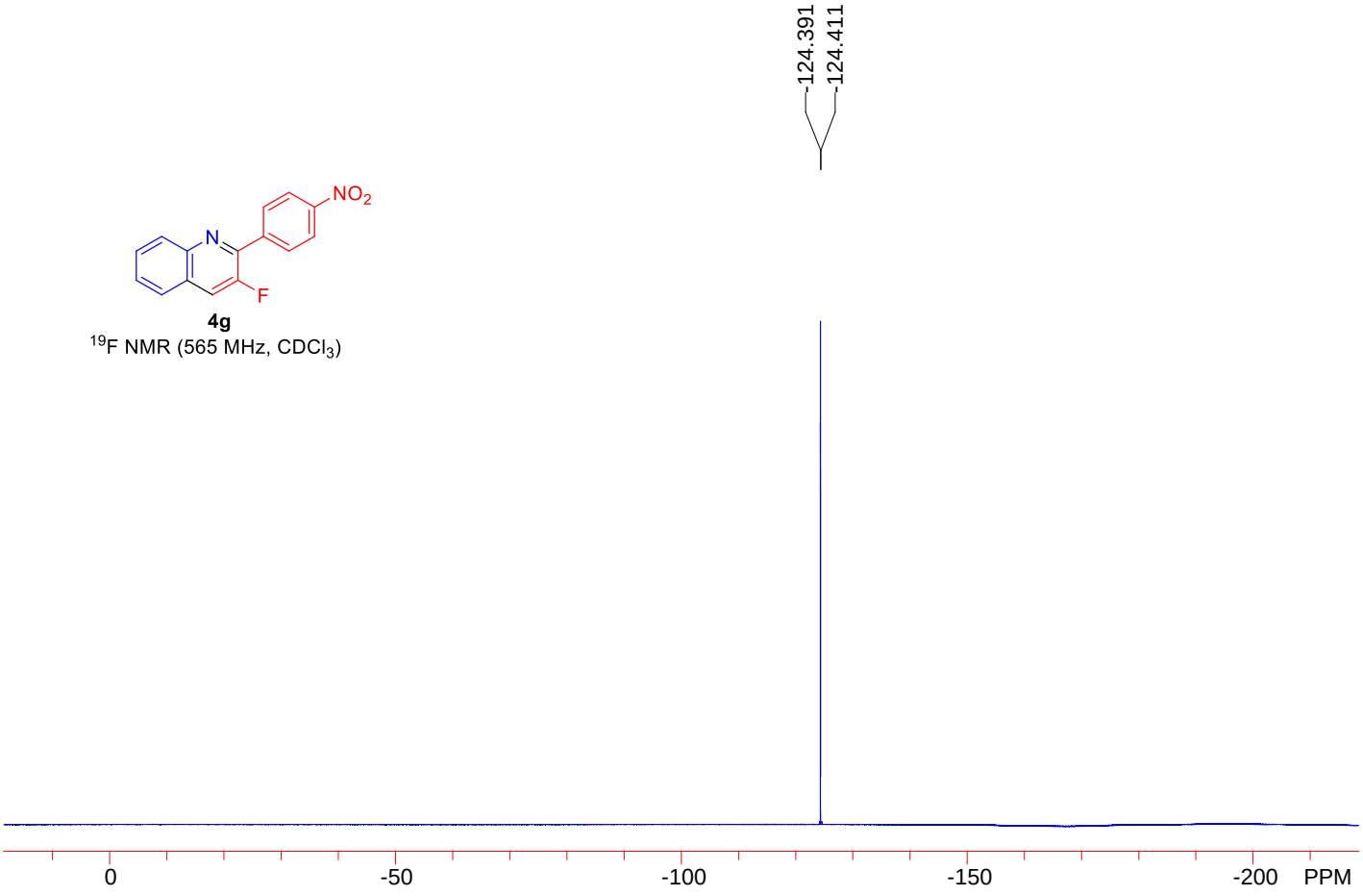




4g

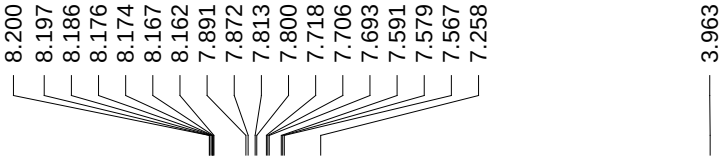
$^{13}C\{^{1}H\}$ (150 MHz, $CDCl_3$)

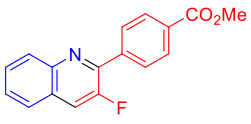




4g

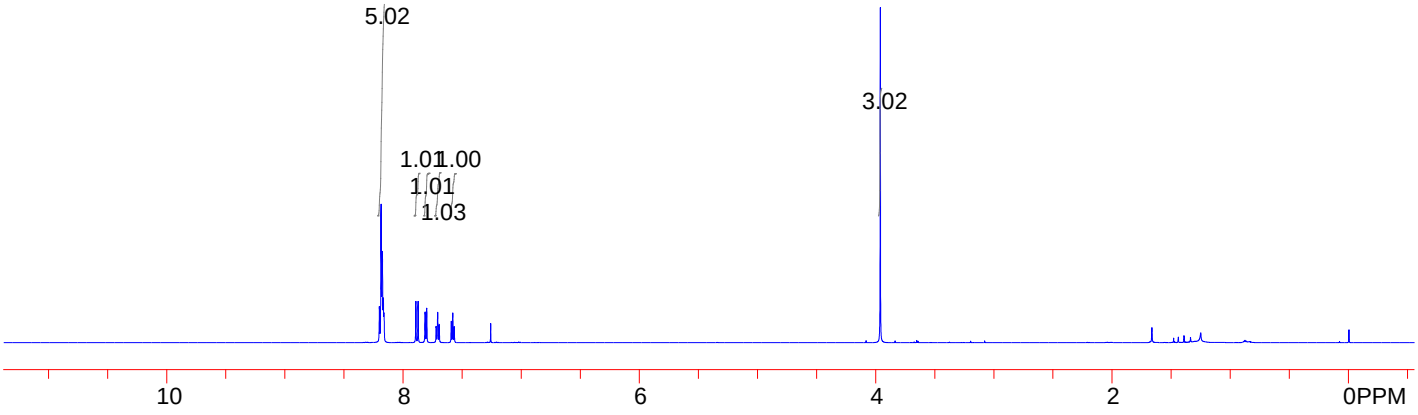
^{19}F NMR (565 MHz, $CDCl_3$)

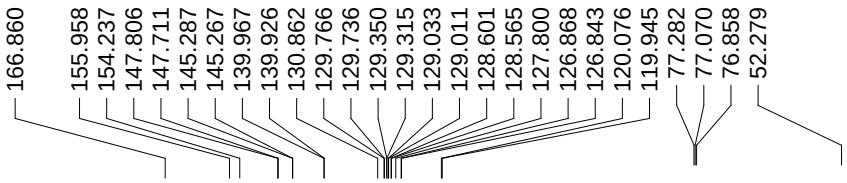


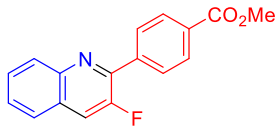


4h

^{1}H NMR (600 MHz, $CDCl_3$)

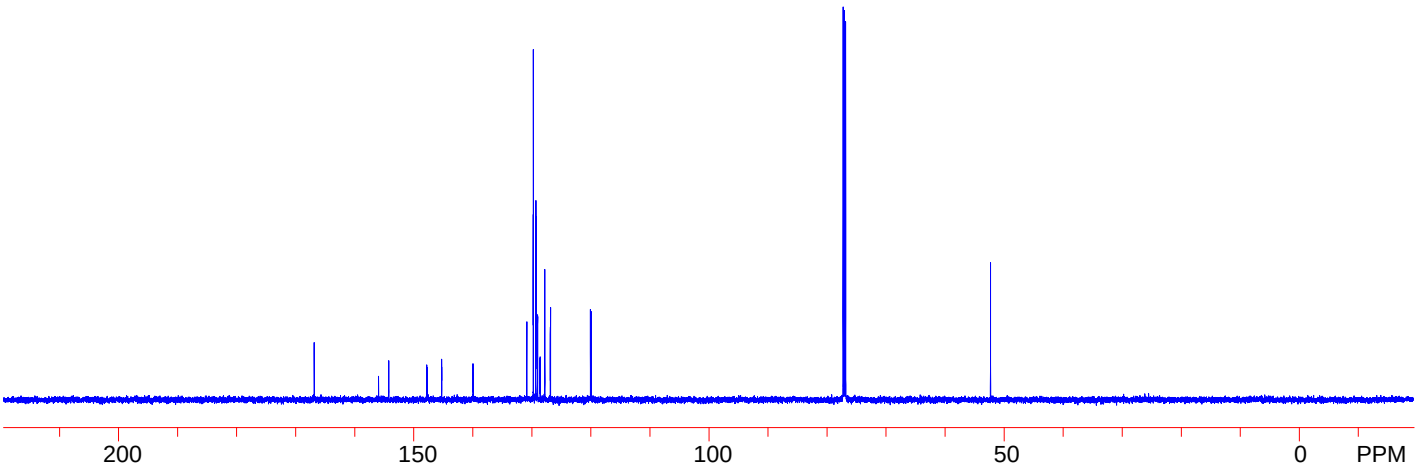


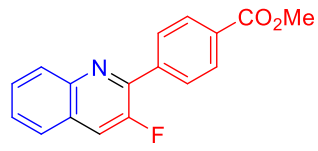




4h

^{13}C{^{1}H} (150 MHz, $CDCl_3$)





4h

^{19}F NMR (565 MHz, $CDCl_3$)

VI. X-ray crystal structure and data of 3a

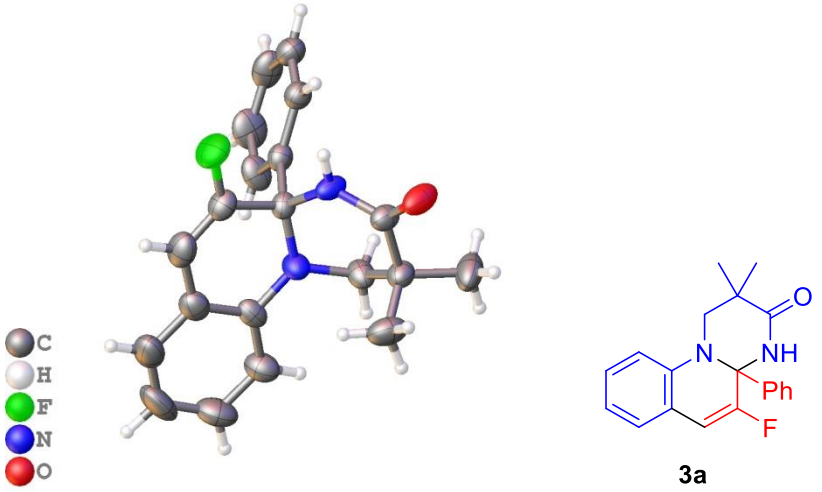


Figure S3. X-ray crystal structure of **3a** with 50% ellipsoid probability

X-ray structure determination. Single crystals suitable for X-ray diffraction were obtained by slow evaporation of the solvent from a petroleum ether/ethyl acetate (3:1) solution of **3a**. Crystal data collection and refinement parameters of **3a** are summarized in Table S1. Intensity data were collected at 293 K on a SuperNova Dual diffractometer using mirror-monochromated Cu Kα radiation, λ = 1.54184 Å. The data were corrected for decay, Lorentz, and polarization effects as well as absorption and beam corrections based on the multi-scan technique. Using Olex2, the structure was solved with the SHELXS structure solution program using Direct Methods and refined with the SHELXL refinement package using Least Squares minimisation. Nonhydrogen atoms were refined with anisotropic displacement parameters. The H-atoms were either located or calculated and subsequently treated with a riding model.

Table S1. Crystallographic data and structure refinement results of **3a**

Empirical formula	4 ($C_{20}H_{19}FN_2O$)
Formula weight	1289.48
Temp, K	293 (2)
Crystal system	monoclinic
Space group	$P2_1$
a, Å	10.8075(2)
b, Å	27.0003(4)
c, Å	11.6524(2)

α (°)	90
β (°)	91.7370(10)
γ (°)	90
Volume, Å^3	3398.67(10)
Z	2
d_{calc}, g cm^{-3}	1.260
λ, Å	1.54184
μ, mm^{-1}	0.696
No. of data collected	14783
No. of unique data	9237
R_{int}	0.0210
Goodness-of-fit on F^2	1.043
R_1, wR_2 ($I > 2\sigma(I)$)	0.0580, 0.1516
R_1, wR_2 (all data)	0.0628, 0.1594

VII. References

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