Electronic Supplementary Material (ESI) for Chemical Science.

Metal-Free C-H Alkylation of Heteroarenes with Alkyltrifluoroborates: A General Protocol for 1°, 2°, and 3° Alkylation

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Supporting Information

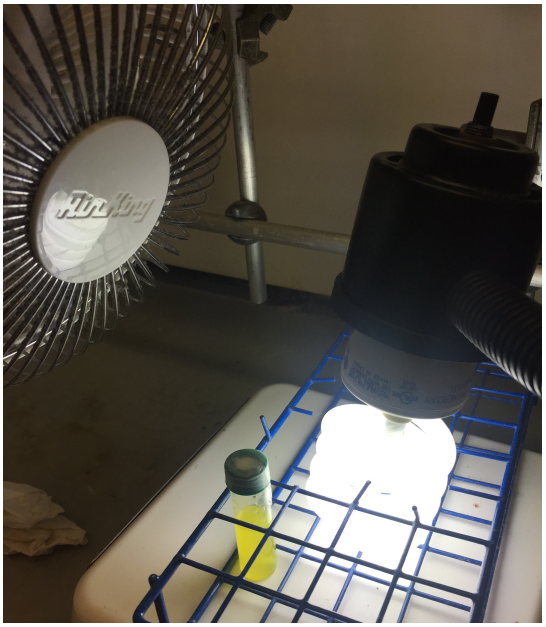
GENERAL CONSIDERATIONS:

NMR Spectra (^{1}H, ^{13}C, ^{19}F) were performed at 298 K. ^{1}H NMR spectra were referenced to residual non-deuterated chloroform (δ 7.26) in $CDCl_3$, residual DMSO-d_5 (δ 2.50) in DMSO-d_6, acetone-d_5 (δ 2.09) in acetone-d_6, and residual MeCN-d_2 (δ 1.94) in MeCN-d_3. ^{13}C NMR spectra were referenced to $CDCl_3$ (δ 77.2) and DMSO-d_6 (δ 39.5). Reactions were monitored by HPLC, GC/MS, ^{1}H NMR, and/or by TLC on silica gel plates (60 Å porosity, 250 μm thickness). TLC analysis was performed using hexanes/EtOAc as the eluant and visualized using UV light. Silica plugs utilized flash silica gel (60 Å porosity, 32–63 μm). Flash chromatography was accomplished using an automated system (visualizing at 254 nm, monitoring at 280 nm) with silica cartridges (60 Å porosity, 20–40 μm). Solvents were purified by use of drying cartridges through a solvent delivery system. Melting points (°C) are uncorrected.

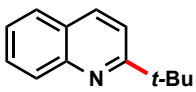
Deuterated NMR solvents were either used as purchased (DMSO-d_6) or were stored over 4Å molecular sieves and/or K_2CO_3 ($CDCl_3$). Na_2SO_4, $MgSO_4$, MeOH, CH_2Cl_2, MeCN, pentane, Et_2O, trifluoroacetic acid, and $K_2S_2O_8$ were used as purchased. Heteroarenes were purchased from commercial suppliers and used without further purification. MeCN/H_2O was degassed thoroughly with N_2 and stored under N_2. The photocatalyst *N*-Me-9-mesityl acridinium tetrafluoroborate was donated by Pfizer and used without further purification.

GENERAL PROCEDURE

To a 4.0 mL vial, alkyltrifluoroborate (0.30 mmol, 1.0 equiv), heteroarene (0.30 mmol, 1.0 equiv), photocatalyst (6.2 mg, 0.015 mmol, 0.05 equiv), and $K_2S_2O_8$ (162.2 mg, 0.60 mmol, 2.0 equiv) were added. Open to air, a mixture of 3.0 mL MeCN/H_2O (1:1) was added, followed by trifluoroacetic acid (34.2 mg, 0.30 mmol, 1.0 equiv). The mixture was stirred under 26 W CFLs (GE FLE26HT3/2/D) for 5–48 h under a fan. The reaction mixture was quenched with saturated $NaHCO_3$ and extracted with CH_2Cl_2 (3 x 20 mL). The organic extracts were combined and concentrated on Celite. The crude mixture was purified by silica gel column chromatography.



HETEROARENE SCOPE WITH *TERT*-BUTYLTRIFLUOROBORATE



2-(*tert*-Butyl)quinoline (**1a**)

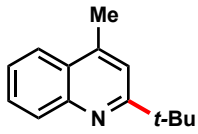
Physical state: 40 mg, 72% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.07 (d, J = 8.6 Hz, 2H), 7.77 – 7.75 (m, 1H), 7.68 – 7.64 (m, 1H), 7.54 – 7.52 (m, 1H), 7.49 – 7.46 (m, 1H), 1.48 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 169.4, 147.6, 136.0, 129.6, 129.1, 127.4, 126.6, 125.7, 118.3, 38.3, 30.3.

HRMS (ES+) m/z calc. for $C_{13}H_{16}N$ [M+H] 186.1283, found 186.1280.

FT-IR (cm^{-1}, neat, ATR) 2961, 1619, 1601, 1565, 1504, 1364, 1138, 1103, 829, 756, 478.



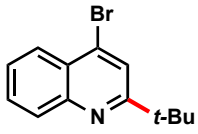
2-(*tert*-Butyl)-4-methylquinoline (**1b**)

Reference: Gabriele, B.; Mancuso, R; Salerno, G.; Ruffolo, G.; Plastina, P. *J. Org. Chem.* **2007**, *72*, 6873.

Physical state: 57 mg, 95% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.4 Hz, 1H), 7.93-7.90 (m, 1H), 7.66-7.64 (m, 1H), 7.49-7.27 (m, 1H), 7.34 (s, 1H), 2.67 (s, 3H), 1.47 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 169.1, 147.5, 143.7, 130.1, 128.8, 126.7, 125.5 123.5, 119.0, 38.1, 30.3, 19.1.



4-Bromo-2-(*tert*-butyl)quinoline (**1c**)

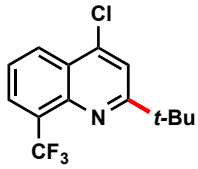
Physical state: 68 mg, 86% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.10 (d, *J* = 8.4 Hz, 1H), 8.06-8.02 (m, 1H), 7.79 (s, 1H), 7.69 (dd *J* = 7.7, 7.6 Hz, 1H), 7.54 (dd, *J* = 7.7, 7.6 Hz, 1H), 1.45 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 169.5, 148.3, 134.0, 130.1, 130.0, 127.0, 126.5, 126.2, 122.5, 38.3, 30.2.

HRMS (ES+) m/z calc. for $C_{13}H_{15}BrN$ [M+H] 264.0388, found 264.0397.

FT-IR (cm^{-1}, neat, ATR) 2957, 1585, 1488, 820, 756.



2-(*tert*-Butyl)-4-chloro-8-(trifluoromethyl)quinoline (**1d**)

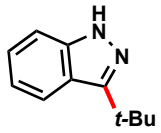
Physical state: 78 mg, 70% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.38 (d, *J* = 8.4 Hz, 1H), 8.08 (d, *J* = 7.2 Hz, 1H), 7.68 (s, 1H), 7.61-7.59 (m, 1H), 1.47 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 170.5, 144.9, 142.6, 128.5 (q, *J* = 5.5 Hz), 128.3 (q, *J* = 29.1 Hz), 128.2, 125.3, 125.2, 123.1, 119.3, 38.9, 29.9.

HRMS (ES+) m/z calc. for $C_{14}H_{14}ClF_3N$ [M+H] 288.0767, found 288.0762.

FT-IR (cm^{-1}, neat, ATR) 2965, 1592, 1489, 1463, 1293, 1145, 1118, 766.



3-(*tert*-Butyl)-1*H*-indazole (**1e**)

Reference: Li, P.; Wu, C.; Zhao, J.; Rogness, D. C.; Shi, F. *J. Org. Chem.* **2012**, *77*, 3149

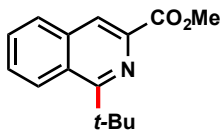
Physical state: 41 mg, 80% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 10.07 (bs, 1H), 7.91 (d, *J* = 8.2 Hz, 1H), 7.44 (d, *J* = 8.2 Hz, 1H), 7.36-7.33 (m, 1H), 7.14-7.11 (m, 1H), 1.55 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 154.8, 142.1, 126.3, 122.3, 120.7, 120.0, 110.1, 34.0, 30.2.

HRMS (ES+) m/z calc. for $C_{11}H_{15}N_2$ [M+H] 175.1235, found 175.1229.

FT-IR (cm^{-1}, neat, ATR) 3146, 3112, 3073, 2963, 2928, 2900, 1342, 739.



Methyl 1-(*tert*-Butyl)isoquinoline-3-carboxylate (**1g**)

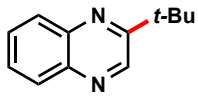
Physical state: 55 mg isolated, 77% yield, white solid (mp = 55 °C).

^{1}H NMR (500 MHz, $CDCl_3$) δ 11.64 (s, 1H), 8.50 – 8.45 (m, 2H), 7.72 – 7.70 (m, 2H), 4.06 (s, 3H), 1.64 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 171.8, 158.0, 155.4, 129.6, 129.3, 129.0, 128.8, 127.3, 124.3, 118.4, 52.9, 39.7, 31.2.

HRMS: submitted.

FT-IR (cm^{-1}, neat, ATR) 2953, 1661, 1450, 1337, 1242, 1164.



2-(*tert*-Butyl)quinoxaline (**1h**)

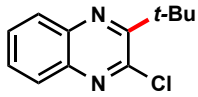
Physical state: 39 mg, 70% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.99 (s, 1H), 8.06 (dd, *J* = 8.0, 3.8 Hz, 2H), 7.71 (m, 2H), 1.52 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 163.8, 143.6, 141.8, 141.0, 129.8, 129.5, 129.1, 129.0, 37.4, 29.9.

HRMS (ES+) m/z calc. for $C_{12}H_{15}N_2$ [M+H] 186.1157, found 186.1158.

FT-IR (cm^{-1}, neat, ATR) 2963, 1558, 1492, 1464, 1365, 1237, 1155, 1128, 1097, 1014, 968, 761, 607.



2-(*tert*-Butyl)-3-chloroquinoxaline (**1i**)

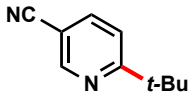
Physical state: 28 mg isolated, 43% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.99 (s, 1H), 8.07 – 8.05 (m, 2H), 7.74 – 7.68 (m, 2H), 1.52 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 163.8, 143.6, 141.8, 141.0, 129.8, 129.5, 129.1, 129.0, 37.4, 29.9.

HRMS (ES+) m/z calc. for $C_{12}H_{15}ClN_2$ [M+H] 221.0846, found 221.0844.

FT-IR (cm^{-1}, neat, ATR) 2977, 1167, 1104, 1008, 761.



6-(*tert*-Butyl)nicotinonitrile (**1j**)

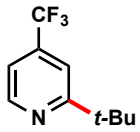
Physical state: 42 mg, 89% yield, yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.82 (s, 1H), 7.87 (d, *J* = 8.2 Hz, 1H), 7.46 (d, *J* = 8.2 Hz, 1H), 1.38 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 174.1, 151.7, 139.5, 119.3, 117.3, 106.9, 38.4, 30.0.

HRMS (ES+) m/z calc. for $C_{10}H_{13}N_2$ [M+H] 161.1079, found 161.1078.

FT-IR (cm^{-1}, neat, ATR) 2960, 2050, 1721, 1596.



2-(*tert*-Butyl)-4-(trifluoromethyl)pyridine (**1k**)

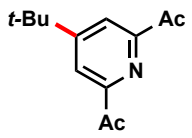
Reference: Stowers, K. J.; Fortner, K. C.; Sanford, M. S. *J. Am. Chem. Soc.* **2011**, *133*, 6541.

Physical state: 58 mg, 95% yield, light yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.74 (d, *J* = 4.9 Hz, 1H), 7.53 (s, 1H), 7.31 (d, *J* = 5.0 Hz, 1H), 1.40 (d, *J* = 1.9 Hz, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 171.2, 149.7, 138.7 (q, *J* = 34.0 Hz), 123.4 (q, *J* = 271.0), 116.4 (q, *J* = 4.0 Hz), 114.8, 114.81, 38.0, 30.2.

^{19}F NMR (477 MHz) δ -64.70.



1,1'-(4-(*tert*-Butyl)pyridine-2,6-diyl)bis(ethan-1-one) (**1l**)

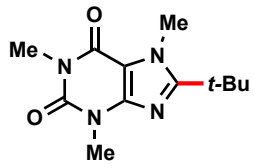
Physical state: 48 mg, 73% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.22 (s, 2H), 2.78 (s, 6H), 1.36 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 200.1, 162.9, 153.0, 122.0, 35.6, 30.6, 25.9.

HRMS (ES+) m/z calc. for $C_{13}H_{18}NO_2$ [M+H] 220.1338, found 220.1334.

FT-IR (cm^{-1}, neat, ATR) 2968, 2975, 1700, 1362, 1244, 1131, 610.



8-(*tert*-Butyl)-1,3,7-trimethyl-3,7-dihydro-1*H*-purine-2,6-dione (**1m**)

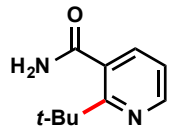
Physical state: 52 mg, 70% yield, white solid (173 °C).

^{1}H NMR (500 MHz, $CDCl_3$) δ 4.11 (s, 3H), 3.56 (s, 3H), 3.39 (s, 3H), 1.47 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 160.1, 155.8, 151.9, 147.1, 108.4, 34.3, 34.2, 29.7, 29.1, 28.0.

HRMS (ES+) m/z calc. for $C_{12}H_{19}N_4O_2$ [M+H] 251.1508, found 251.1505.

FT-IR (cm^{-1}, neat, ATR) 2974, 1699, 1656, 1543, 1492, 1428, 1364, 1240, 740.



2-(*tert*-Butyl)nicotinamide **(1n)**

Reference: Tada, M.; Yokoi, Y. *J. Heterocyclic Chem.* **1989**, *26*, 45.

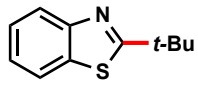
Physical state: 36 mg, 67% yield, light yellow solid (mp = 94 °C).

^{1}H NMR (500 MHz, DMSO-d_6) δ 8.95 (d, J = 2.3 Hz, 1H), 8.17 – 7.99 (m, 2H), 7.51 (d, J = 8.2 Hz, 2H), 1.31 (s, 9H).

^{13}C NMR (126 MHz, DMSO) δ 171.2, 166.5, 147.6, 135.6, 127.0, 118.5, 20.8, 14.1.

HRMS (ES+) m/z calc. for $C_{10}H_{15}N_2O$ [M+H] 179.1184, found 179.1190.

FT-IR (cm^{-1}, neat, ATR) 3433, 2253, 2127, 1667, 1394, 1051, 1023, 820, 760.



2-(*tert*-Butyl)benzo[*d*]thiazole (**1o**)

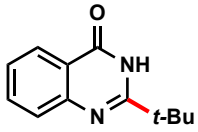
Physical state: 38 mg, 66% yield, yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.00 (d, *J* = 8.2 Hz, 1H), 7.85 (d, *J* = 7.9 Hz, 1H), 7.46 – 7.43 (m, 1H), 7.35 – 7.32 (m, 1H), 1.53 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 182.0, 153.4, 135.1, 125.9, 124.6, 122.8, 121.6, 38.5, 30.9.

HRMS (ES+) m/z calc. for $C_{11}H_{14}NS$ [M+H] 192.0847, found 192.0847.

FT-IR (cm^{-1}, neat, ATR) 2965, 1513, 1438, 1044, 1008, 758.



2-(*tert*-Butyl)quinazolin-4(3*H*)-one (**1p**)

Reference: Li, Z.; Dong, J.; Chen, X.; Li, Q.; Zhou, Y.; Yin, S. -F. *J. Org, Chem.* **2015**, *80*, 9392.

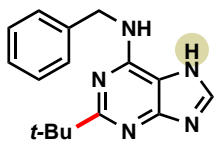
Physical state: 54 mg, 90% yield, white solid (mp = 110–113 °C).

^{1}H NMR (500 MHz, $CDCl_3$) δ 11.40 (s, 1H), 8.29 (d, *J* = 7.6 Hz, 1H), 7.74 (d, *J* = 9.8 Hz, 2H), 7.45 (t, *J* = 7.6 Hz, 1H), 1.50 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.1, 162.3, 149.4, 134.6, 127.8, 126.4, 126.3, 120.7, 100.1, 37.6, 28.4.

HRMS (ES+) m/z calc. for $C_{12}H_{15}N_2O$ [M+H] 203.1184, found 203.1183.

FT-IR (cm^{-1}, neat, ATR) 3189, 3079, 2968, 1667, 1611, 772.



N-Benzyl-2-(*tert*-butyl)-7*H*-purin-6-amine (**1q**)

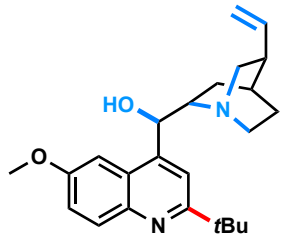
Physical state: 67 mg, 79% yield, yellow solid (mp = 125–127 °C).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.45 (s, 1H), 7.44 – 7.41 (m, 2H), (dd, *J* = 7.5, 7.5 Hz, 2H), 7.29 (d, *J* = 7.5 Hz, 1H), 6.12 (bs, 1H), 4.89 (s, 2H), 1.53 (s, 9H) (highlighted proton not observed).

^{13}C NMR (126 MHz, $CDCl_3$) δ 160.7, 154.2, 151.6, 138.7, 128.8, 128.7, 128.2, 127.6, 100.1, 33.9, 29.6, 27.8.

HRMS (ES+) m/z calc. for $C_{16}H_{20}N_5$ [M+H] 282.1719, found 282.1718.

FT-IR (cm^{-1}, neat, ATR) 2972, 1619, 1598, 1351, 1299.



(1*R*)-(2-(*tert*-Butyl)-6-methoxyquinolin-4-yl)(5-vinylquinuclidin-2-yl)methanol (**1r**)

Reference: Yardley, J. P.; Bright, R. E.; Rane, L.; Rees, R. W.; Russell, P. B.; Smith, H. *J. Med. Chem.* **1971**, *14*, 62.

Physical state: 62 mg, 54% yield, light yellow oil.

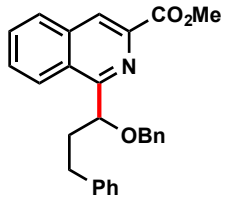
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.98 (d, *J* = 9.2 Hz, 1H), 7.67 (s, 1H), 7.30 (d, *J* = 9.2 Hz, 1H), 7.20 (s, 1H), 5.73 (dt, *J* = 17.6, 9.0 Hz, 1H), 5.58 (s, 1H), 4.97 – 4.90 (m, 2H), 3.89 (s, 3H), 3.50 – 3.45 (m, 1H), 3.20 – 3.08 (m, 2H), 2.71 – 2.65 (m, 2H), 2.29 – 2.25 (m, 1H), 1.81 (s, 1H), 1.79 – 1.65 (m, 2H), 1.52 – 1.43 (m, 11H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.6, 157.4, 146.9, 143.8, 142.0, 131.9, 124.7, 120.9, 115.5, 114.6, 101.3, 72.6, 60.1, 57.3, 55.8, 43.5, 40.1, 38.1, 30.3, 28.1, 27.8, 21.6.

HRMS (ES+) m/z calc. for $C_{24}H_{32}N_2O_2$ [M+H] 381.2536, found 381.2543.

FT-IR (cm^{-1}, neat, ATR)2954, 1621, 1601, 1561, 1505, 1471, 1363, 1343, 1263, 1231, 1106, 1034, 911, 832, 734, 645.

SECONDARY AND TERTIARY ALKYLTRIFLUOROBORATE SCOPE



Methyl 1-(1-(Benzyloxy)-3-phenylpropyl)isoquinoline-3-carboxylate (**2a**)

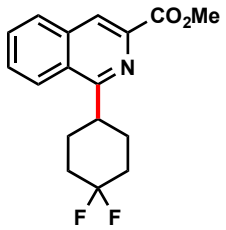
Physical state: 71 mg, 58% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.88 (d, *J* = 8.5 Hz, 1H), 8.52 (s, 1H), 7.98 (d, *J* = 8.0 Hz, 1H), 7.78 – 7.76 (m, 1H), 7.70 – 7.66 (m, 1H), 7.41 – 7.35 (m, 1H), 7.31 – 7.22 (m, 7H), 7.19 – 7.12 (m, 2H), 5.26 – 5.22 (m, 1H), 4.52 – 4.43 (m, 2H), 4.08 (s, 3H), 3.12 – 2.96 (m, 1H), 2.78 – 2.72 (m, 1H), 2.61 – 2.53 (m, 1H), 2.33 – 2.25 (m, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.4, 161.5, 141.7, 140.2, 138.1, 136.5, 130.6, 129.1, 128.8, 128.4, 128.2, 128.1(9), 127.8, 127.7, 127.5, 126.2, 125.7, 124.2, 85.1, 71.5, 52.8, 37.8, 32.5.

HRMS (ES+) m/z calc. for $C_{27}H_{25}NO_3Na$ [M+Na] 434.1732, found 434.1734.

FT-IR (cm^{-1}, neat, ATR) 3052, 2950, 1736, 1717, 1373, 1147, 1027, 908, 782, 490.



Methyl 1-(4,4-Difluorocyclohexyl)isoquinoline-3-carboxylate (**2b**)

Physical state: 32 mg, 35% yield, yellow oil.

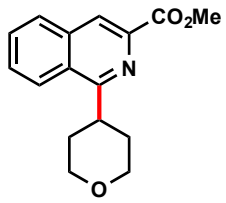
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.43 (s, 1H), 8.22 (d, *J* = 7.8 Hz, 1H), 7.98 – 7.95 (m, 1H), 7.77 – 7.72 (m, 2H), 4.02 (s, 3H), 3.72 – 3.58 (m, 1H), 2.40 – 2.27 (m, 4H), 2.16 – 1.90 (m, 4H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.7, 163.5, 163.5, 140.6, 136.1, 130.4, 129.4, 129.4, 129.3, 127.6, 125.2, 124.5, 123.3, 122.9, 121.4, 52.7, 39.7, 33.9, 33.7, 33.7, 33.5, 28.3, 28.2.

^{19}F NMR (471 MHz, C_6D6) δ 2.26 (d, *J* = 235.5 Hz), 6.03 (d, *J* = 235.5 Hz).

HRMS (ES+) m/z calc. for $C_{17}H_{17}F_2NO_3$ [M+Na] 328.1125, found 328.1124.

FT-IR (cm^{-1}, neat, ATR) 2951, 1736, 1450, 1374, 1236, 1205, 1101, 956, 784.



Methyl 1-(Tetrahydro-2H-pyran-4-yl)isoquinoline-3-carboxylate (**2c**)

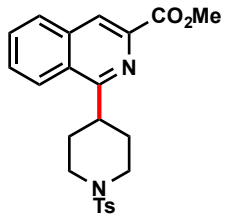
Physical state: 60 mg, 74% yield, white semi-solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ 8.45 (s, 1H), 8.35 – 8.22 (m, 1H), 8.07 – 7.90 (m, 1H), 7.76 (dt, *J* = 5.4, 3.2 Hz, 2H), 4.20 (dd, *J* = 11.4, 2.6 Hz, 2H), 4.05 (s, 3H), 3.93 – 3.56 (m, 3H), 2.51 – 2.23 (m, 2H), 1.91 (dd, *J* = 13.4, 1.5 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.9, 163.9, 141.0, 140.9, 136.3, 130.4, 129.4, 127.7, 124.6, 122.9, 68.3, 52.8, 39.4, 32.0.

HRMS (ES+) m/z calc. for $C_{16}H_{17}NO_3Na$ [M+Na] 294.1106, found 294.1111.

FT-IR (cm^{-1}, neat, ATR) 2962, 1589, 1489, 1387, 850.



Methyl 1-(1-Tosylpiperidin-4-yl)isoquinoline-3-carboxylate (**2d**)

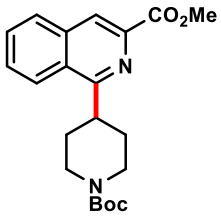
Physical state: 84 mg, 66% yield, pale yellow solid (mp = dec ~195 ^{O}C).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.42 (s, 1H), 8.11 (d, *J* = 8.5 Hz, 1H), 7.97 (d, *J* = 8.0 Hz, 1H), 7.74-7.66 (m, 4H), 7.37 (d, *J* = 8.0 Hz, 2H), 4.03 (s, 3H), 3.98 (d, *J* = 11.5 Hz, 2H), 3.53-3.48 (m, 1H), 2.62-2.52 (m, 2H), 2.48 (s, 3H), 2.45-2.32 (m, 2H), 2.05-2.03 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.5, 162.9, 143.3, 140.6, 133.3, 130.2, 129.5, 129.2, 129.1(9), 128.8, 127.8, 127.4, 124.1, 122.8, 52.6, 46.3, 39.1, 30.4, 21.5.

HRMS (ES+) m/z calc. for $C_{23}H_{25}N_2O_4S$ [M+H] 425.1535, found 425.1531.

FT-IR (cm^{-1}, neat, ATR) 2962, 1589, 1489, 1387, 850.



Methyl 1-(1-(*tert*-Butoxycarbonyl)piperidin-4-yl)isoquinoline-3-carboxylate (**2e**)

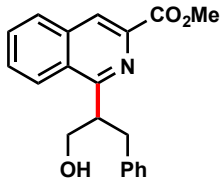
Physical state: 41 mg, 51% yield, white semi-solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.42 (s, 1H), 8.25 (d, *J* = 7.3 Hz, 1H), 8.06 – 7.89 (m, 1H), 7.84 – 7.64 (m, 2H), 4.32 (m, 2H), 4.02 (s, 3H), 3.72 (t, *J* = 11.4 Hz, 1H), 2.99 (m, 2H), 2.03 (m, 4H), 1.49 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.8, 164.1, 154.9, 140.8, 136.3, 130.5, 129.4, 127.8, 124.6, 122.9, 79.6, 58.5, 52.8, 40.2, 31.2, 28.7.

HRMS (ES+) m/z calc. for $C_{21}H_{27}N_2O_4$ [M+H] 371.1971, found 371.1984.

FT-IR (cm^{-1}, neat, ATR) 2962, 1589, 1489, 1387, 850.



Methyl 1-(1-Hydroxy-3-phenylpropan-2-yl)isoquinoline-3-carboxylate (**2f**)

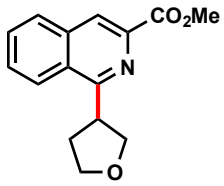
Physical state: 20 mg, 20% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.48 (s, 1H), 8.13 (d, *J* = 8.4 Hz, 1H), 7.98 (d, *J* = 8.1 Hz, 1H), 7.78 – 7.75 (m, 1H), 7.72 – 7.68 (m, 1H), 7.34 – 7.18 (m, 5H), 5.65 (d, *J* = 10.1 Hz, 1H), 4.19 (d, *J* = 11.3 Hz, 1H), 4.05 (s, 3H), 3.98 – 3.93 (m, 1H), 3.88 – 3.84 (m, 1H), 3.39 – 3.34 (m, 1H), 3.12 – 3.07 (m, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.2, 165.4, 140.1, 139.6, 136.3, 131.1, 129.9, 129.5, 129.4, 128.7, 128.0, 126.5, 125.0, 123.2, 63.1, 53.0, 44.4, 38.1.

HRMS (ES+) m/z calc. for $C_{20}H_{20}NO_2$ [M+H] 322.1443, found 322.1452.

FT-IR (cm^{-1}, neat, ATR) 1734, 1451, 1244, 1207, 749, 702.



Methyl 1-(Tetrahydrofuran-3-yl)isoquinoline-3-carboxylate (**2g**)

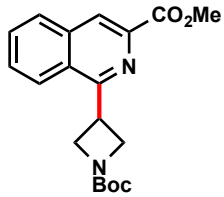
Physical state: 43.7 mg, 34% yield, colorless oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.45 (s, 1H), 8.27 (d, J = 7.2 Hz, 1H), 8.00 – 7.93 (m, 1H), 7.80 – 7.70 (m, 2H), 4.42 – 4.32 (m, 2H), 4.25 – 4.15 (m, 2H), 4.08 – 3.96 (m, 4H), 2.79 – 2.57 (m, 1H), 2.53 – 2.31 (m, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.5, 161.2, 136.0, 134.0, 130.4, 129.4, 129.0, 128.4, 124.8, 123.0, 112.7, 77.2, 68.8, 52.6, 43.4, 32.1.

HRMS (ES+) m/z calc. for $C_{15}H_{16}NO_3$ [M+H] 258.1130, found 258.1140.

FT-IR (cm^{-1}, neat, ATR) 2987, 2870, 1208, 1063, 861, 837.



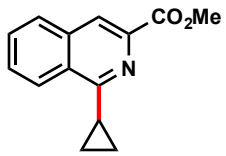
Methyl 1-(1-(*tert*-Butoxycarbonyl)azetidin-3-yl)isoquinoline-3-carboxylate (**2i**)

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.50 (s, 1H), 8.01 (d, J = 8.1 Hz, 1H), 7.89 (d, J = 8.2 Hz, 1H), 7.82 – 7.71 (m, 2H), 4.64 – 4.45 (m, 5H), 4.05 (s, 3H), 1.47 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.3, 159.7, 156.3, 140.3, 135.9, 130.7, 129.7, 129.2, 127.7, 124.3, 123.4, 79.4, 52.6, 33.0, 28.3.

HRMS (ES+) m/z calc. for $C_{19}H_{23}N_2O_4$ [M+H] 343.1658, found 343.1666.

FT-IR (cm^{-1}, neat, ATR) 2987, 2870, 1208, 1063, 861, 837.



Methyl 1-Cyclopropylisoquinoline-3-carboxylate (**2j**)

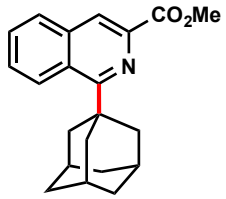
Physical state: 21 mg, 31% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.54 – 8.44 (m, 1H), 8.36 (s, 1H), 8.01 – 7.89 (m, 1H), 7.76 – 7.73 (m, 2H), 4.01 (s, 3H), 2.75 (tt, J = 8.5, 4.9 Hz, 1H), 1.37 – 1.34 (m, 2H), 1.17 – 1.13 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.9, 162.5, 140.7, 135.8, 130.6, 129.5, 129.4, 129.0, 125.6, 122.3, 52.9, 14.4, 9.3.

HRMS (ES+) m/z calc. for $C_{14}H_{13}NO_2$ [M+H] 228.1025, found 228.1019.

FT-IR (cm^{-1}, neat, ATR) 2951, 1737, 1321, 1269, 1244, 988.



Methyl 1-((3*r*,5*r*,7*r*)-Adamantan-1-yl)isoquinoline-3-carboxylate (**2k**)

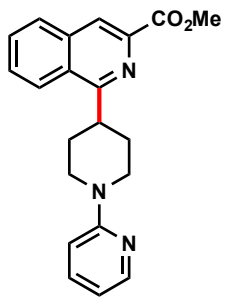
Physical state: 43.4 mg, 45% yield, off-white solid (mp = 210–212 ^{o}C)

^{1}H NMR (500 MHz, $CDCl_3$) δ 11.63 (s, 1H), 8.73 – 8.71 (m, 1H), 8.58 – 8.38 (m, 1H), 7.71 – 7.70 (m, 2H), 4.08 (s, 3H), 2.38 (s, 6H), 2.21 (s, 3H), 1.89 (m, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 171.6, 157.4, 155.1, 129.5, 129.1, 128.6, 128.4, 126.8, 124.2, 118.5, 52.7, 42.2, 41.9, 37.0, 29.1.

HRMS (ES+) m/z calc. for $C_{21}H_{24}NO_2$ [M+H] 322.1807, found 322.1797.

FT-IR (cm^{-1}, neat, ATR) 2951, 1737, 1321, 1269, 1244, 988.



Methyl 1-(1-(Pyridin-2-yl)piperidin-4-yl)isoquinoline-3-carboxylate (**2l**)

Physical state: 75 mg, 72% yield, yellow solid (mp = 154–157 °C).

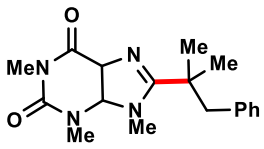
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.42 (s, 1H), 8.31 (s, 1H), 8.20 (s, 1H) 7.98 (d, *J* = 3.5 Hz, 1H), 7.76 – 7.74 (m, 2H), 7.49 – 7.45 (m, 1H), 6.74 (d, *J* = 8.5 Hz, 1H), 6.60-6.59 (m, 1H), 4.52 (d, *J* = 12.5 Hz, 2H), 4.00 (s, 3H), 3.82-3.80 (m, 1H), 3.12 (t, *J* = 12.5 Hz, 2H), 2.34-2.26 (m, 2H), 2.10-2.04 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.9, 164.3, 159.6, 148.1, 140.9, 137.5, 136.3, 130.4, 129.4, 129.4, 127.8, 124.8, 122.9, 112.8, 107.4, 52.8, 45.8, 40.7, 31.2.

HRMS (ES+) m/z calc. for $C_{21}H_{22}N_3O_2$ [M+H] 348.1712, found 348.1714.

FT-IR (cm^{-1}, neat, ATR) 2962, 1589, 1489, 1387, 850.

TERTIARY EXAMPLES



1,3,9-Trimethyl-8-(2-methyl-1-phenylpropan-2-yl)-3,9-dihydro-1H-purine-2,6-dione (**1v**)

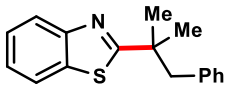
Physical state: 52 mg, 53% yield, pale yellow solid (mp = 101–103 °C).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.23-7.21 (m, 3H), 6.88-6.85 (m, 2H), 3.80 (s, 3H), 3.56 (s, 3H), 3.41 (s, 3H), 3.03 (s, 2H), 1.51 (s, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.7, 155.5, 146.9(4), 146.9(1), 137.4, 129.8, 128.1, 126.7, 107.7, 48.2, 39.4, 33.8, 29.5, 27.8, 27.2.

HRMS (ES+) m/z calc. for $C_{17}H_{23}N_4O_2$ [M+H] 327.1821, found 327.1820.

FT-IR (cm^{-1}, neat, ATR) 3055, 2987, 1758, 1699, 1656, 1422, 1040, 896, 733, 703.



2-(2-Methyl-1-phenylpropan-2-yl)benzo[d]thiazole (**1w**)

Physical state: 52 mg, 53% yield, pale yellow oil.

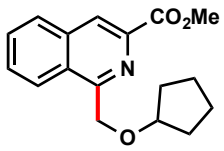
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.2 Hz, 1H), 7.86 (dd, *J* = 8.0, 0.5 Hz, 1H), 7.53 – 7.44 (m, 1H), 7.41 – 7.32 (m, 1H), 7.27 – 7.12 (m, 3H), 7.09 – 6.98 (m, 2H), 3.18 (s, 2H), 1.52 (s, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 180.7, 153.2, 137.6, 134.8, 130.4, 127.8, 126.3, 125.7, 124.5, 122.7, 121.4, 49.5, 42.2, 28.0.

HRMS (ES+) m/z calc. for $C_{17}H_{18}NS$ [M+H] 268.1160, found 268.1168.

FT-IR (cm^{-1}, neat, ATR) 3028, 2927, 1505, 1495, 1385, 1280, 1005, 743, 687.

PRIMARY ALKYLTRIFLUOROBORATE COUPLING



Methyl 1-((Cyclopentyloxy)methyl)isoquinoline-3-carboxylate (**3a**)

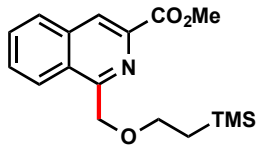
Physical state: 72 mg, 84% yield, clear viscous oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.52 (s, 1H), 8.45 (d, *J* = 7.7 Hz, 1H), 7.94 (d, *J* = 7.4 Hz, 1H), 7.74 (s, 2H), 5.10 (s, 2H), 4.13 (s, 1H), 4.04 (s, 3H), 1.52 (m, 8H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.5, 158.6, 140.3, 136.3, 130.9, 129.6, 129.1, 128.6, 126.7, 124.7, 82.3, 77.4, 77.2, 76.9, 72.5, 53.0, 32.4, 23.6.

HRMS (ES+) m/z calc. for $C_{17}H_{20}NO_3$ [M+H] 286.1443, found 286.1454.

FT-IR (cm^{-1}, neat, ATR) 2952, 1737, 1334, 1246, 1110, 1096, 791.



Methyl 1-((2-(Trimethylsilyl)ethoxy)methyl)isoquinoline-3-carboxylate (**3b**)

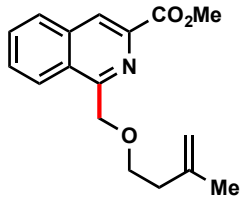
Physical state: 61 mg, 86% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.53 (s, 1H), 8.47 (d, *J* = 7.9 Hz, 1H), 7.96 (d, *J* = 7.9 Hz, 1H), 7.78 – 7.71 (m, 2H), 5.13 (s, 2H), 4.04 (s, 3H), 3.76 – 3.55 (m, 2H), 1.11 – 0.90 (m, 2H), -0.03 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.5, 158.4, 140.4, 136.3, 130.9, 129.6, 129.0, 128.6, 126.6, 124.7, 73.5, 68.5, 52.9, 18.5, -1.3.

HRMS (ES+) m/z calc. for $C_{17}H_{23}NO_3Si$ [M+Na] 340.1345, found 340.1347.

FT-IR (cm^{-1}, neat, ATR) 2951, 1740, 1719, 1247, 1208, 860.



Methyl 1-(((3-Methylbut-3-en-1-yl)oxy)methyl)isoquinoline-3-carboxylate (**3c**)

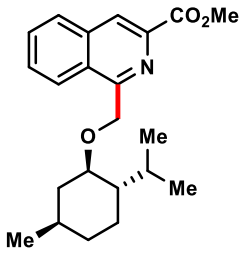
Physical state: 55 mg, 64% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.54 (s, 1H), 8.49 (d, *J* = 8.2 Hz, 1H), 7.96 (d, *J* = 7.9 Hz, 1H), 7.78 – 7.70 (m, 2H), 5.16 (s, 2H), 4.74 (s, 1H), 4.70 (s, 1H), 4.04 (s, 3H), 3.68 (t, *J* = 6.9 Hz, 2H), 2.32 (t, *J* = 6.9 Hz, 2H), 1.68 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.4, 158.2, 142.8, 140.3, 136.3, 131.0, 129.6, 129.0, 128.6, 126.6, 124.8, 111.7, 74.2, 69.4, 53.0, 37.9, 22.7.

HRMS (ES+) m/z calc. for $C_{17}H_{19}NO_3Na$ [M+Na] 308.1263, found 308.1263.

FT-IR (cm^{-1}, neat, ATR) 2950, 1738, 1450, 1295, 1209, 1109.



Methyl 1-((((1*R*,2*S*,5*R*)-2-Isopropyl-5-methylcyclohexyl)oxy)methyl)isoquinoline-3-carboxylate (**3d**)

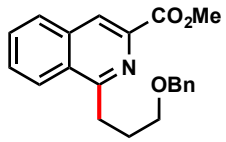
Physical state: 65 mg, 61% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.53 (s, 1H), 8.46 (d, *J* = 7.7 Hz, 1H), 7.95 (d, *J* = 8.2 Hz, 1H), 7.79 – 7.70 (m, 2H), 5.30 (d, *J* = 11.3 Hz, 1H), 5.04 (d, *J* = 11.3 Hz, 1H), 4.04 (s, 3H), 3.28 (td, *J* = 10.5, 4.1 Hz, 1H), 2.07 – 2.03 (m, 1H), 1.67 – 1.54 (m, 2H), 1.43 – 1.17 (m, 3H), 0.97 – 0.75 (m, 9H), 0.43 (d, *J* = 6.9 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.6, 158.9, 140.3, 136.3, 130.9, 129.4, 129.2, 128.6, 127.0, 124.8, 79.3, 71.3, 52.9, 48.5, 40.4, 34.6, 31.6, 25.3, 23.1, 22.5, 21.1, 15.7.

HRMS (ES+) m/z calc. for $C_{22}H_{29}NO_3Na$ [M+Na] 378.2047, found 378.2045.

FT-IR (cm^{-1}, neat, ATR) 2954, 2869, 1722, 1244, 1108, 984, 907, 688, 646.



Methyl 1-(3-(Benzyloxy)propyl)isoquinoline-3-carboxylate (**3e**)

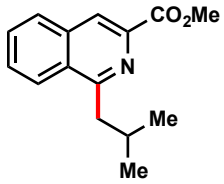
Physical state: 52 mg, 56% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.45 (s, 1H), 8.21 (d, *J* = 8.3 Hz, 1H), 8.03 (d, *J* = 7.4 Hz, 2H), 7.96 (d, *J* = 8.1 Hz, 1H), 7.74 (t, *J* = 7.5 Hz, 1H), 7.68 (t, *J* = 7.6 Hz, 1H), 7.54 (t, *J* = 7.0 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 2H), 4.41 (t, *J* = 6.4 Hz, 2H), 4.04 (s, 3H), 3.46 (t, *J* = 7.9 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.8, 166.8, 162.5, 140.8, 136.1, 133.0, 133.0, 130.7, 130.6, 129.7, 129.7, 129.52, 129.1, 128.5, 125.6, 123.1, 100.1, 77.4, 77.2, 76.9, 64.9, 64.8, 62.6, 53.0, 35.3, 29.4, 29.0, 26.4, 25.4.

HRMS (ES+) m/z calc. for $C_{19}H_{17}NO_3$ [M+Na] 308.1287, found 308.1283.

FT-IR (cm^{-1}, neat, ATR) 2951, 1716, 1315, 1275, 1246, 712.



Methyl 1-Isobutylisoquinoline-3-carboxylate (**3f**)

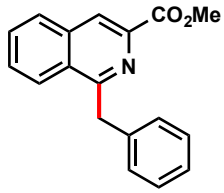
Physical state: 45 mg, 62% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.43 (s, 1H), 8.21 (d, *J* = 8.0 Hz, 1H), 7.94 (d, *J* = 7.8 Hz, 1H), 7.71 (m, 2H), 4.03 (s, 3H), 3.25 (d, *J* = 7.3 Hz, 2H), 2.32 (m, 1H), 0.98 (d, *J* = 6.7 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.9, 162.5, 140.8, 136.1, 130.5, 129.2, 129.0, 129.0, 125.9, 122.8, 52.9, 44.1, 29.8, 22.9.

HRMS (ES+) m/z calc. for $C_{15}H_{17}NO_2Na$ [M+Na] 266.1157, found 266.1161.

FT-IR (cm^{-1}, neat, ATR) 2955, 1737, 1718, 1294, 1242, 1205.



Methyl 1-Benzylisoquinoline-3-carboxylate (**3g**)

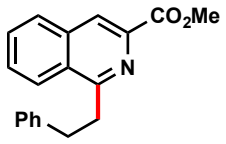
Physical state: 56 mg, 67% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.51 (s, 1H), 8.16 (d, *J* = 8.4 Hz, 1H), 7.95 (d, *J* = 8.1 Hz, 1H), 7.73 – 7.68 (m, 1H), 7.64 – 7.60 (m, 1H), 7.27 – 7.20 (m, 4H), 7.19 – 7.13 (t, *J* = 7.0 Hz, 1H), 4.78 (s, 2H), 4.07 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.7, 160.9, 140.8, 139.2, 136.4, 130.7, 129.6, 129.0, 128.8, 128.7 128.7, 126.5, 126.4, 123.7, 53.0, 42.6.

HRMS (ES+) m/z calc. for $C_{18}H_{16}NO_2$ [M+H] 278.1181, found 278.1171.

FT-IR (cm^{-1}, neat, ATR) 2949, 1736, 1568, 1438, 1242, 1208, 1150, 1106, 742, 692.



Methyl 1-Phenethylisoquinoline-3-carboxylate (**3h**)

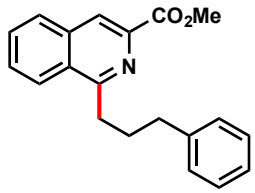
Physical state: 28 mg, 32% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.47 (s, 1H), 8.19 (d, *J* = 8.2 Hz, 1H), 7.96 (d, *J* = 7.9 Hz, 1H), 7.78 – 7.66 (m, 2H), 7.32 – 7.15 (m, 5H), 4.06 (s, 3H), 3.76 – 3.62 (m, 2H), 3.28 – 3.15 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.8, 166.8, 162.0, 141.8, 140.8, 136.1, 130.7, 129.5, 129.1, 128.6, 128.6, 126.2, 125.5, 123.2, 53.0, 37.4, 35.6 (one aryl carbon peak overlaps).

HRMS (ES+) m/z calc. for $C_{19}H_{18}NO_2$ [M+H] 314.1157, found 314.1157.

FT-IR (cm^{-1}, neat, ATR) 2949, 1737, 1716, 1240, 1208, 749.



Methyl 1-(3-Phenylpropyl)isoquinoline-3-carboxylate (**3i**)

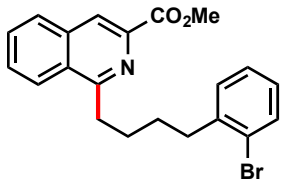
Physical state: 76% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.44 (s, 1H), 8.06 (d, *J* = 8.3 Hz, 1H), 7.94 (d, *J* = 8.0 Hz, 1H), 7.76 – 7.68 (m, 2H), 7.35 – 7.26 (m, 2H), 7.25 – 7.16 (m, 3H), 4.05 (s, 3H), 3.48 – 3.27 (m, 2H), 2.81 (t, *J* = 7.7 Hz, 2H), 2.26 – 2.19 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.8, 162.8, 142.1, 140.8, 136.1, 130.6 129.4, 129.0, 128.7, 128.5, 128.5, 126.0, 125.6, 123.1, 53.0, 36.1, 35.2, 31.6.

HRMS (ES+) m/z calc. for $C_{20}H_{20}NO_2$ [M+H] 306.1494, found 306.1492.

FT-IR (cm^{-1}, neat, ATR) 2949, 1736, 1716, 1242, 1209, 747.



Methyl 1-(4-(2-Bromophenyl)butyl)isoquinoline-3-carboxylate (**3j**)

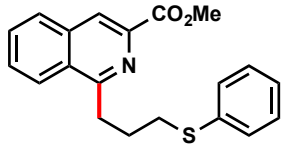
Physical state: 67 mg, 56% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.44 (s, 1H), 8.20 (d, *J* = 8.0 Hz, 1H), 7.95 (d, *J* = 7.8 Hz, 1H), 7.75 – 7.70 (m, 2H), 7.51 (d, *J* = 8.0 Hz, 1H), 7.24 – 7.19 (m, 2H), 7.03 (s, 1H), 4.04 (s, 3H), 3.42 (t, *J* = 8.1 Hz, 2H), 2.85 – 2.76 (m, 2H), 2.01 – 1.90 (m, 2H), 1.85 – 1.76 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.8, 162.9, 141.7, 140.8, 136.1, 132.9, 130.6, 130.5, 129.4, 129.0, 128.5, 127.6, 125.7, 124.6, 123.0, 53.0, 36.2, 35.7, 30.2, 29.8.

HRMS (ES+) m/z calc. for $C_{21}H_{20}BrNO_2$ [M+Na] 420.0575, found 420.0576.

FT-IR (cm^{-1}, neat, ATR) 2946, 1735, 1438, 1239, 1207, 1020, 748.



Methyl 1-(3-(Phenylthio)propyl)isoquinoline-3-carboxylate (**3k**)

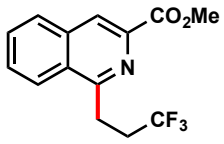
Physical state: 50 mg, 49% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.44 (s, 1H), 8.15 (d, *J* = 8.4 Hz, 1H), 7.95 (d, *J* = 8.1 Hz, 1H), 7.76 – 7.70 (m, 1H), 7.70 – 7.64 (m, 1H), 7.36 (d, *J* = 7.7 Hz, 2H), 7.31 – 7.21 (m, 2H), 7.19 – 7.14 (m, 1H), 4.04 (s, 3H), 3.58 – 3.46 (m, 2H), 3.11 (t, *J* = 7.0 Hz, 2H), 2.30 – 2.21 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.7, 161.9, 140.7, 136.5, 136.1, 130.7, 129.6, 129.4, 129.0, 128.5, 126.1 125.6, 123.2, 53.0, 34.4, 33.6, 29.0 (one aryl peak overlaps).

HRMS (ES+) m/z calc. for $C_{20}H_{20}NO_2S$ [M+H] 338.1215, found 338.1198.

FT-IR (cm^{-1}, neat, ATR) 2950, 1737, 1716, 1449, 1325, 1294, 1243, 1210.



Methyl 1-(3,3,3-Trifluoropropyl)isoquinoline-3-carboxylate (**3l**)

Physical state: 15 mg, 18% yield, viscous oil.

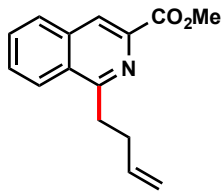
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.48 (s, 1H), 8.20 (d, *J* = 8.6 Hz, 1H), 8.06 – 7.93 (m, 1H), 7.86 – 7.74 (m, 2H), 4.05 (s, 3H), 3.68 – 3.57 (m, 2H), 2.96 – 2.77 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.5, 158.7, 140.6, 136.0, 131.1, 130.1, 129.3, 128.4, 124.8, 123.7, 53.1, 32.5 (q, *J* = 29.0 Hz), 29.0, 27.4.

^{19}F NMR (471 MHz, $CDCl_3$) δ -66.42.

HRMS (ES+) m/z calc. for $C_{14}H_{12}F_3NO_2Na$ [M+Na] 306.0718, found 306.0721.

FT-IR (cm^{-1}, neat, ATR) 3071, 1715, 1240, 1126.



Methyl 1-(But-3-en-1-yl)isoquinoline-3-carboxylate (**3p**)

Physical state: 40 mg, 55% yield, crystalline powder (mp = 54–57 °C).

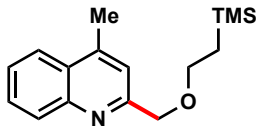
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.44 (s, 1H), 8.21 (d, *J* = 7.9 Hz, 1H), 7.95 (d, *J* = 7.9 Hz, 1H), 7.76 – 7.68 (m, 2H), 6.05 – 5.90 (m, 1H), 5.12 (d, *J* = 17.0 Hz, 1H), 5.01 (d, *J* = 10.2 Hz, 1H), 4.04 (s, 3H), 3.47 (t, *J* = 8.2 Hz, 2H), 2.70 – 2.60 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.7, 162.3, 140.8, 137.8, 136.1, 130.6, 129.5, 129.1, 128.5, 125.6, 123.1, 115.3, 53.0, 35.0, 33.8.

HRMS (ES+) m/z calc. for $C_{15}H_{15}NO_2$ [M+Na] 264.1000, found 264.0998.

FT-IR (cm^{-1}, neat, ATR) 1748, 1656, 1596, 1157.

DIVERSITY TABLE



4-Methyl-2-((2-(Trimethylsilyl)ethoxy)methyl)quinoline (**4a**)

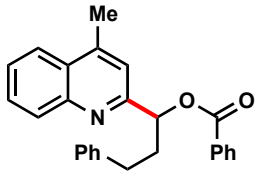
Reference: Molander, G. A.; Colombel, V.; Braz, V. *Org. Lett.* **2011**, *13*, 1852.

Physical state: 62 mg, 77% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.4 Hz, 1H), 7.98 (d, *J* = 8.3 Hz, 1H), 7.71 – 7.66 (m, 1H), 7.55 – 7.51 (m, 1H), 7.46 (s, 1H), 4.74 (s, 2H), 3.72 – 3.63 (m, 2H), 2.71 (s, 3H), 1.11 – 1.03 (m, 2H), -0.03 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 159.3, 147.5, 145.0, 129.7, 129.3, 127.7, 126.1, 123.8, 120.2, 74.1, 68.6, 19.0, 18.5, -1.2.

FT-IR (cm^{-1}, neat, ATR) 2953, 1603, 1249, 1101, 850, 836, 757.



1-(4-Methylquinolin-2-yl)-3-phenylpropyl benzoate (**4b**)

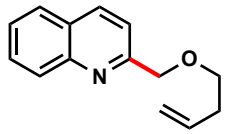
Physical state: 48 mg, 42% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.15 (d, *J* = 7.7 Hz, 2H), 8.10 (d, *J* = 8.4 Hz, 1H), 7.97 (d, *J* = 8.3 Hz, 1H), 7.72 – 7.69 (m, 1H), 7.62 – 7.59 (m, 1H), 7.56 – 7.52 (m, 1H), 7.51 – 7.47 (m, 2H), 7.34 (s, 1H), 7.30 – 7.12 (m, 5H), 6.20 (dd, *J* = 8.3, 5.1 Hz, 1H), 2.90 – 2.78 (m, 2H), 2.69 (s, 3H), 2.60 – 2.45 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.1, 159.7, 147.6, 145.3, 141.5 133.3, 130.3, 130.0, 129.4, 128.8, 128.6, 128.4, 127.8, 126.5, 126.4, 126.1, 123.8, 119.1, 36.9, 32.1, 19.1.

HRMS (ES+) m/z calc. for $C_{26}H_{23}NO_2$ [M+Na] 404.1626, found 404.1630.

FT-IR (cm^{-1}, neat, ATR) 1719, 1602, 1451, 1270, 1111, 1070, 1027, 713.



2-((But-3-en-1-yloxy)methyl)quinoline (**4c**)

Physical state: 24 mg, 38% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.18 (d, *J* = 8.4 Hz, 1H), 8.05 (d, *J* = 8.7 Hz, 1H), 7.82 (d, *J* = 8.4 Hz, 1H), 7.72 – 7.68 (m, 1H), 7.64 – 7.61 (m, 1H), 7.54 – 7.51 (m, 1H), 5.92 – 5.84 (m, 1H), 5.15 – 5.06 (m, 2H), 4.82 (s, 2H), 3.65 (t, *J* = 6.6 Hz, 2H), 2.45 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 159.6, 147.7, 136.9, 135.3, 129.7, 129.1, 127.8, 127.7, 126.4, 119.5, 116.7, 74.6, 70.5, 34.4.

HRMS (ES+) m/z calc. for $C_{14}H_{16}NO$ [M+H] 214.1232, found 214.1234.

FT-IR (cm^{-1}, neat, ATR) 2858, 1601, 1506, 1428, 1359, 1106, 996, 916, 829, 784, 755, 618.

2-Octylquinoline (**4d**)

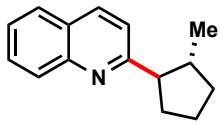
Physical state: 32 mg, 44% yield, yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.80 (d, *J* = 4.4 Hz, 1H), 8.11 (d, *J* = 8.4 Hz, 1H), 8.04 (d, *J* = 8.4 Hz, 1H), 7.71 – 7.68 (m, 1H), 7.57 – 7.54 (m, 1H), 7.23 (d, *J* = 4.3 Hz, 1H), 3.09 – 3.04 (m, 2H), 1.80 – 1.73 (m, 2H), 1.47 – 1.41 (m, 2H), 1.40 – 1.17 (m, 8H), 0.88 (t, *J* = 6.6 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 150.4, 148.9, 148.5, 130.4, 129.1, 127.8, 126.3, 123.8, 120.9, 32.3, 32.0, 30.3, 29.9, 29.6, 29.4, 22.8, 14.2.

HRMS (ES+) m/z calc. for $C_{17}H_{24}N$ [M+H] 242.1909, found 242.1904.

FT-IR (cm^{-1}, neat, ATR) 2924, 2855, 1592, 1508, 1463, 760.



2-((2*R*)-2-Methylcyclopentyl)quinoline (**4e**)

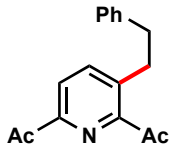
Physical state: 38 mg, 60% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.08 – 8.04 (m, 2H), 7.77 (d, *J* = 8.1 Hz, 1H), 7.69 – 7.65 (m, 1H), 7.49 – 7.45 (m, 1H), 7.31 (d, *J* = 8.6 Hz, 1H), 2.90 – 2.84 (m, 1H), 2.33 – 2.17 (m, 2H), 2.09 – 1.93 (m, 2H), 1.92 – 1.77 (m, 2H), 1.45 – 1.37 (m, 1H), 1.01 (d, *J* = 6.5 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 165.6, 148.1, 136.2, 129.3, 129.2, 127.6, 127.1, 125.7, 120.4, 57.3, 42.5, 35.2, 34.3, 24.5, 19.0.

HRMS (ES+) m/z calc. for $C_{15}H_{18}N$ [M+H] 212.1439, found 212.1444.

FT-IR (cm^{-1}, neat, ATR) 3050, 2946, 1601, 1255.



1,1'-(3-Phenethylpyridine-2,6-diyl)bis(ethan-1-one) (**4f**)

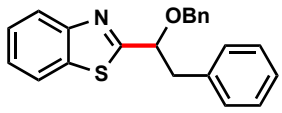
Physical state: 52 mg, 65% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.04 (d, *J* = 8.0 Hz, 1H), 7.62 (d, *J* = 8.0 Hz, 1H), 7.30 – 7.25 (m, 2H), 7.22 – 7.18 (m, 3H), 3.33 – 3.30 (m, 2H), 2.93 – 2.90 (m, 2H), 2.75 (s, 3H), 2.73 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 201.8, 199.4, 151.1, 150.6, 142.0, 141.0, 140.9, 128.8, 128.6, 126.4, 123.7, 37.4, 35.4, 28.4, 25.7.

HRMS (ES+) m/z calc. for $C_{17}H_{18}NO_2$ [M+H] 268.1338, found 268.1339.

FT-IR (cm^{-1}, neat, ATR) 1699, 1358, 1296, 700.



2-(1-(Benzyloxy)-2-phenylethyl)benzo[*d*]thiazole (**4g**)

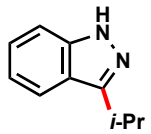
Physical state: 52 mg, 53% yield, colorless oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.07 – 8.00 (m, 1H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.52 – 7.47 (m, 1H), 7.43 – 7.36 (m, 5H), 7.35 – 7.31 (m, 1H), 7.28 – 7.24 (m, 2H), 7.17 (d, *J* = 7.8 Hz, 3H), 4.85 (dd, *J* = 8.3, 4.8 Hz, 1H), 4.70 (d, *J* = 11.4 Hz, 1H), 4.52 (d, *J* = 11.4 Hz, 1H), 2.93 – 2.82 (m, 1H), 2.82 – 2.71 (m, 1H), 2.41 – 2.29 (m, 1H), 2.29 – 2.19 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 175.4, 153.3, 141.3, 137.6, 135.1, 128.7, 128.6(5), 128.5(7), 128.3, 128.1, 126.1(5), 126.1(3), 125.3, 123.2, 122.1, 79.0, 72.3, 38.9, 31.7.

HRMS (ES+) m/z calc. for $C_{23}H_{23}NOS$ [M+H] 360.1422, found 360.1420.

FT-IR (cm^{-1}, neat, ATR) 3027, 2922, 2861, 1516, 1495, 1093, 1027, 1014, 758, 697.



3-Isopropyl-1*H*-indazole (**4h**)

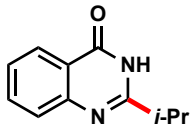
Physical state: 33 mg, 69% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 9.84 (bs, 1H), 7.78 (d, *J* = 8.1 Hz, 1H), 7.45 – 7.42 (m, 1H), 7.38 – 7.35 (m, 1H), 7.15 – 7.12 (m, 1H), 3.44 (sept, *J* = 7.0 Hz, 1H), 1.48 (d, *J* = 7.0 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 152.8, 141.6, 126.7, 121.4, 120.8, 120.2, 109.9, 27.9, 22.3.

HRMS (ES+) m/z calc. for $C_{10}H_{12}N_2$ [M+] 160.1000, found 160.1001.

FT-IR (cm^{-1}, neat, ATR) 3189, 2968, 1623, 1501, 1349, 742.



2-Isopropylquinazolin-4(3*H*)-one (**4i**)

Reference: Shen, G.; Zhou, H.; Sui, Y.; Liu, Q.; Zou, K. *Tetrahedron Lett.* **2016**, *57*, 587

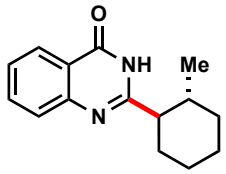
Physical state: 45 mg, 79% yield, white solid (mp = 123 °C).

^{1}H NMR (500 MHz, $CDCl_3$) δ 11.64 (s, 1H), 8.30 (d, *J* = 7.9 Hz, 1H), 7.79 – 7.72 (m, 2H), 7.47 – 7.45 (m, 1H), 3.06 (sept, *J* = 7.0 Hz, 1H), 1.45 (d, *J* = 7.0 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.4, 161.0, 149.6, 134.8, 127.5, 126.4, 126.4, 120.9, 35.1, 20.6.

HRMS (ES+) m/z calc. for $C_{11}H_{12}N_2ONa$ [M+Na] 211.0847, found 211.0851.

FT-IR (cm^{-1}, neat, ATR) 2970, 2932, 1622, 1609, 1472, 1384, 1252, 772.



2-((1*R*,2*R*)-2-Methylcyclohexyl)quinazolin-4(3*H*)-one (**4j**)

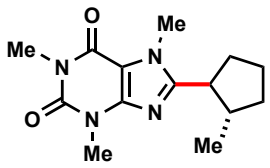
Physical state: 30 mg, 41% yield, white powder (mp = 89–93 °C).

^{1}H NMR (500 MHz, $CDCl_3$) δ 11.48 (s, 1H), 8.29 (d, *J* = 7.9 Hz, 1H), 7.80 – 7.71 (m, 2H), 7.48 – 7.46 (m, 1H), 2.39 – 2.33 (m, 1H), 2.05 – 1.96 (m, 2H), 1.92 – 1.73 (m, 4H), 1.57 – 1.49 (m, 1H), 1.43 – 1.35 (m, 1H), 1.26 – 1.12 (m, 1H), 0.88 (d, *J* = 6.5 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.1, 159.9, 149.6, 134.8, 127.5, 126.4, 120.9, 100.1, 52.9, 35.2, 35.2, 31.5, 26.2, 26.1, 20.6.

HRMS (ES+) m/z calc. for $C_{15}H_{19}N_2O$ [M+H] 243.1497, found 243.1500.

FT-IR (cm^{-1}, neat, ATR) 2926, 1668, 1471, 773.



1,3,7-Trimethyl-8-((2*S*)-2-methylcyclopentyl)-3,7-dihydro-1*H*-purine-2,6-dione (**4k**)

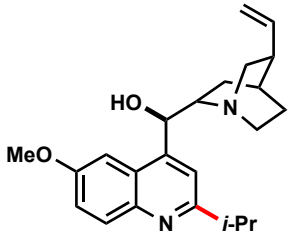
Physical state: 31 mg, 37%, light yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 3.93 (s, 3H), 3.56 (s, 3H), 3.40 (s, 3H), 2.67 – 2.63 (m, 1H), 2.50 - 2.40 (m, 1H), 2.14 – 2.01 (m, 2H), 1.96 – 1.76 (m, 4H), 1.02 (d, *J* = 6.5 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 157.6, 155.5, 152.0, 148.4, 107.4, 44.8, 41.3, 34.6, 32.4, 31.7, 29.9, 28.0, 24.2, 19.2.

HRMS (ES+) m/z calc. for $C_{14}H_{21}N_4O_2$ [M+H] 277.1658, found 277.1661.

FT-IR (cm^{-1}, neat, ATR) 2954, 1703, 1661, 1543, 1436, 1221, 1041, 981, 747.



(1*R*)-(2-Isopropyl-6-methoxyquinolin-4-yl)(5-vinylquinuclidin-2-yl)methanol (**4l**)

Physical state: 82 mg, 75% yield, light yellow solid (mp = 145 °C).

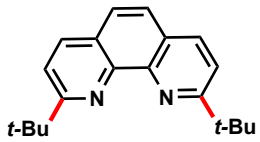
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 (d, *J* = 9.1 Hz, 1H), 7.52 (s, 1H), 7.22 (d, *J* = 9.1 Hz, 1H), 7.07 (s, 1H), 5.80 (s, 1H), 5.73 – 5.60 (m, 1H), 5.00 – 4.92 (m, 2H), 3.81 – 3.73 (m, 4H), 3.26 – 3.08 (m, 3H), 2.85 – 2.75 (m, 3H), 2.42 – 2.35 (m, 1H), 1.90 – 1.80 (m, 2H), 1.65 – 1.60 (m, 1H), 1.49 – 1.39 (m, 1H), 1.34 (d, *J* = 6.9 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.7, 157.6, 146.3, 143.8, 140.1, 131.3, 124.7, 121.5, 116.5, 115.8, 100.6, 60.2, 60.1, 56.2, 55.9, 43.7, 39.0, 37.2, 27.7, 26.4, 22.7, 20.2.

HRMS (ES+) m/z calc. for $C_{23}H_{30}N_2O_2$ [M+H] 367.2361, found 367.2394.

FT-IR (cm^{-1}, neat, ATR) 2962, 1674, 1620, 1236.

LIGAND FUCNTIONALIZATION



2,9-Di-*tert*-butyl-1,10-phenanthroline (**5b**)

Reference: Xu, C.; Zhang, L.; Dong, C.; Xu, J.; Pan, Y.; Li, Y.; Zhang, H.; Li, H.; Yu, Z.; Xu, L. *Adv. Synth. Catal.* **2016**, *358*, 567.

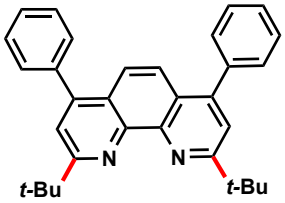
Physical state: 38 mg, 42% yield, white semi-solid.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.13 (d, *J* = 8.4 Hz, 2H), 7.84 – 7.48 (m, 4H), 1.60 (s, 18H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 169.4, 145.0, 136.0, 127.0, 125.5, 119.7, 38.8, 30.4.

HRMS (ES+) m/z calc. for $C_{20}H_{25}N$ [M+H] 293.2018, found 293.2020.

FT-IR (cm^{-1}, neat, ATR) 2962, 1589, 1489, 1387, 850.



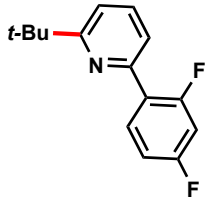
2,9-Di-*tert*-butyl-4,7-diphenyl-1,10-phenanthroline (**5d**)

Reference: Sugihara, S.; Okada, T.; Hiratani, K. *Anal. Sci.* **1993**, *9*, 593.

Physical state: 152 mg, 68% yield, yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.72 (s, 2H), 7.63 (s, 2H), 7.56 – 7.43 (m, 10H), 1.64 (s, 18H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.8, 148.4, 145.7, 139.2, 129.9, 128.6, 128.2, 124.9, 123.1, 120.1, 38.9, 30.5.



2-(*tert*-Butyl)-6-(2,4-difluorophenyl)pyridine (**5f**)

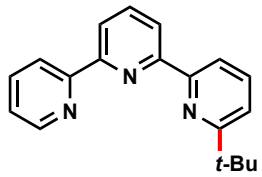
Physical state: 61 mg, 82% yield, light yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.61 (d, J = 5.1 Hz, 1H), 7.96 (m, 1H), 7.72 (s, 1H), 7.28 – 7.22 (m, 1H), 6.99 (t, J = 8.4 Hz, 1H), 6.91 (m, 1H), 1.36 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 163.2 (dd, J = 250.5, 12.1 Hz), 160.6 (dd, J = 252.0, 11.9 Hz), 160.6, 149.8, 132.4 (dd, J = 9.7, 4.6 Hz), 124.5 (dd, J = 12.0, 3.9 Hz), 122.6, 121.5 (d, J = 8.9 Hz), 119.7, 111.9 (dd, J = 21.0, 3.8 Hz), 104.4 (m), 35.0, 30.7.

HRMS (ES+) m/z calc. for $C_{15}H_{16}F_2N$ [M+H] 248.1251, found 248.1241.

FT-IR (cm^{-1}, neat, ATR) 2949, 1736, 1716, 1242, 1209, 747, 700.



6-(*tert*-Butyl)-2,2':6',2''-terpyridine (**5h**)

Physical state: 64 mg, 74% yield, yellow oil.

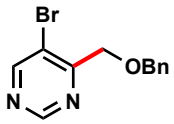
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.75 (s, 1H), 8.71 – 8.60 (m, 3H), 8.45 (m, 2H), 7.94 (m, 1H), 7.86 (m, 1H), 7.33 (dt, *J* = 6.7, 3.5 Hz, 2H), 1.43 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 160.9, 156.3, 155.6, 149.3, 149.3, 138.1, 137.0, 137.0, 123.9, 121.3, 121.1, 121.1, 121.0, 120.9, 118.2, 35.1, 30.7.

HRMS (ES+) m/z calc. for: submitted.

FT-IR (cm^{-1}, neat, ATR) 2963, 1602, 1579, 1548, 1456, 1391, 820, 770.

HETEROARENE WITH FUNCTION HANDLES



4-((Benzyloxy)methyl)-5-bromopyrimidine (**6a**)

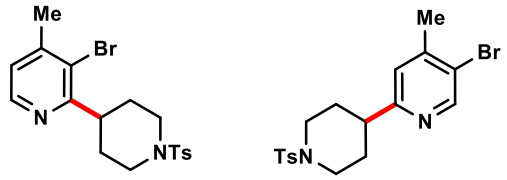
Physical state: 42 mg, 50% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 9.13 (s, 1H), 8.77 (s, 1H), 7.43 – 7.30 (m, 5H), 4.73 (s, 2H), 4.71 (s, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 164.1, 158.9, 157.1, 137.4, 128.7, 128.2, 128.2, 120.3, 73.7, 71.1.

HRMS (ES+) m/z calc. for $C_{12}H_{12}BrN_3O$ [M+H] 279.0133, found 279.0135.

FT-IR (cm^{-1}, neat, ATR) 2860, 1560, 1454, 1388, 1360, 1216, 1097, 1036, 738, 698.



ratio = ~ 3.53 : 1

3-Bromo-4-methyl-2-(1-tosylpiperidin-4-yl)pyridine and 5-bromo-4-methyl-2-(1-tosylpiperidin-4-yl)pyridine (**6b**)

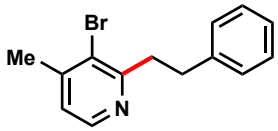
Physical state: 69 mg, 57% yield, white amorphous solid (mp = 120–122 °C).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.52 (s, 1H – minor isomer), 8.31 (d, *J* = 4.8 Hz, 1H – major isomer), 7.72 – 7.67 (m, 3H – both isomers), 7.38 – 7.33 (m, 2H - both isomers), 7.01 (d, *J* = 4.8 Hz, 1H – major isomer), 6.99 (s, 2H – minor isomer), 3.94 (m, 2H – both isomers), 3.16 (m, 1H – both isomers), 2.61 – 2.34 (m, 8H – both isomers), 2.12 – 1.79 (m, 4H – both isomers).

^{13}C NMR (126 MHz, $CDCl_3$) δ 161.0, 147.6, 147.1, 129.5, 127.7, 127.6, 123.94, 122.91, 121.68, 46.37, 41.60, 29.77, 23.46, 21.44. (major peaks)

HRMS (ES+) m/z calc. for $C_{18}H_{22}BrN_2O_2S$ [M+H] 408.0585, found 409.0586.

FT-IR (cm^{-1}, neat, ATR) 3052, 2915, 2801, 1351, 1331, 1160, 927, 726, 648, 548.



3-Bromo-4-methyl-2-phenethylpyridine (**6c**)

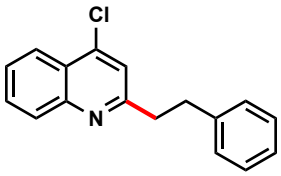
Physical state: 50 mg, 60% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33 (d, *J* = 4.8 Hz, 1H), 7.30 (d, *J* = 4.4 Hz, 4H), 7.21 (p, *J* = 4.1 Hz, 1H), 7.03 (d, *J* = 4.8 Hz, 1H), 3.37 – 3.22 (m, 2H), 3.05 (dd, *J* = 10.2, 6.7 Hz, 2H), 2.43 (s, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 159.9, 147.9, 147.2, 141.9, 128.6, 128.5, 126.1, 124.3, 123.9, 40.4, 34.8, 23.6.

HRMS (ES+) m/z calc. for $C_{14}H_{14}BrN$ [M+H] 276.0388, found 276.0388.

FT-IR (cm^{-1}, neat, ATR) 1727, 1591, 1435, 1281, 1258, 1084, 738, 698.



4-Chloro-2-phenethylquinoline (**6d**)

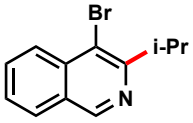
Physical state: 38 mg, 47% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.20 (d, *J* = 8.3 Hz, 1H), 8.08 (d, *J* = 8.4 Hz, 1H), 7.76 (t, *J* = 7.7 Hz, 1H), 7.60 (t, *J* = 7.6 Hz, 1H), 7.35 (s, 1H), 7.30 (t, *J* = 7.5 Hz, 2H), 7.22 (dd, *J* = 15.9, 8.7 Hz, 2H), 3.29 – 3.23 (m, 2H), 3.16 (dd, *J* = 9.7, 6.3 Hz, 2H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 161.9, 149.0, 142.7, 141.3, 130.5, 129.4, 128.6, 126.9, 126.3, 125.2, 124.1, 121.7, 40.9, 35.8.

HRMS (ES+) m/z calc. for $C_{17}H_{15}ClN$ [M+H] 268.0893, found 268.0896.

FT-IR (cm^{-1}, neat, ATR) 3062, 3027, 1589, 1493, 1149, 866, 759, 698.



4-Bromo-3-isopropylisoquinoline (**6e**)

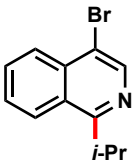
Physical state: 30 mg, 40% yield, clear oil.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.67 (s, 1H), 8.24 – 8.18 (m, 2H), 7.79 – 7.76 (m, 1H), 7.67 – 7.64 (m, 1H), 3.91 (sept, *J* = 6.8 Hz, 1H), 1.43 (d, *J* = 6.8 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.1, 143.8, 135.0, 130.9, 127.9, 127.7, 127.0, 125.2, 117.7, 31.2, 22.3.

HRMS (ES+) m/z calc. for $C_{12}H_{13}BrN$ [M+H] 250.0231, found 250.0224.

FT-IR (cm^{-1}, neat, ATR) 2965, 2929, 1565, 1387, 1240, 1009, 928.



4-Bromo-1-isopropylisoquinoline (**6f**)

Physical state: 22 mg, 29% yield, clear oil.

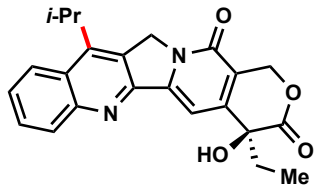
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.51 (s, 1H), 8.35 (d, *J* = 8.5 Hz, 1H), 7.62 – 7.59 (m, 1H), 7.52 – 7.49 (m, 1H), 7.43 (d, *J* = 8.5 Hz, 1H), 4.08 (sept, *J* = 6.8 Hz, 1H), 1.55 (d, *J* = 6.8 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 166.8, 143.2, 136.3, 129.9, 127.1, 126.9, 126.3, 125.9, 125.1, 31.3, 22.4.

HRMS (ES+) m/z calc. for $C_{12}H_{14}BrN$ [M+H] 250.0231, found 250.0224.

FT-IR (cm^{-1}, neat, ATR) 2965, 1556, 1502, 1388, 1246, 765.

CAMPTOTHECIN ANALOGUES



(*S*)-4-Ethyl-4-hydroxy-11-isopropyl-1,12-dihydro-14*H*-pyrano[3',4':6,7]indolizino[1,2-*b*]quinoline-3,14(4*H*)-dione (**7a**)

Reference: Miao, Z. *et al. J. Med. Chem.* **2013**, *56*, 7902.

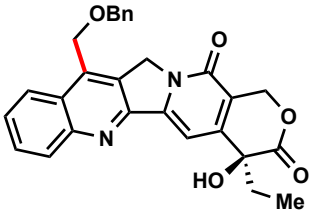
Physical state: 67 mg, 57% yield, light yellow solid (mp = 192 °C).

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.25 – 8.20 (m, 2H), 7.79 – 7.76 (m, 1H), 7.70 – 7.61 (m, 2H), 5.74 (d, *J* = 16.1 Hz, 1H), 5.38 (s, 2H), 5.30 (d, *J* = 16.1 Hz, 1H), 4.05 – 3.92 (m, 1H), 3.90 (bs, 1H), 1.94 – 1.84 (m, 2H), 1.56 (d, *J* = 8.3 Hz, 6H), 1.03 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 174.1, 157.7, 152.5, 150.4, 149.9, 149.5, 146.6, 130.9, 130.1, 127.8, 126.9, 125.5, 123.9, 118.5, 98.0, 72.9, 66.5, 50.4, 31.8, 21.7, 21.6, 8.0.

HRMS (ES+) m/z calc. for $C_{23}H_{22}N_2O_4$ [M+Na] 413.1477, found 413.1460.

FT-IR (cm^{-1}, neat, ATR) 3320, 2971, 1748, 1657, 1157, 727.



(*S*)-11-((Benzyloxy)methyl)-4-ethyl-4-hydroxy-1,12-dihydro-14*H*-pyrano[3',4':6,7]indolizino[1,2-*b*]quinoline-3,14(4*H*)-dione (**7b**)

Physical state: 23 mg, 33% yield, yellow oil.

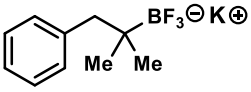
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.22 (d, *J* = 8.5 Hz, 1H), 7.96 (d, *J* = 8.5 Hz, 1H), 7.80 -7.76 (m, 1H), 7.69 – 7.59 (m, 2H), 7.42 – 7.34 (m, 5H), 5.75 (d, *J* = 16.2 Hz, 1H), 5.42 (s, 2H), 5.31 (d, *J* = 16.2 Hz, 1H), 5.18 (s, 2H), 4.78 (s, 2H), 3.78 (s, 1H), 1.95 – 1.86 (m, 2H), 1.04 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 174.1, 157.8, 152.8, 150.1, 149.1, 146.5, 139.4, 137.1, 130.7, 130.3, 128.9, 128.5, 128.1, 128.1, 127.2, 126.0, 123.5, 118.8, 97.9, 73.9, 72.9, 67.2, 66.6, 51.0, 31.8, 8.0.

HRMS (ES+) m/z calc. for $C_{28}H_{25}N_2O_5$ [M+H] 469.1763, found 469.1774.

FT-IR (cm^{-1}, neat, ATR) 2987, 2870, 1208, 1063, 861, 837.

SYNTHESIS OF TERTIARY ALKYLTRIFLUOROBORATE



Potassium Trifluoro(2-methyl-1-phenylpropan-2-yl)borate (**1u**)

Synthesized using Silas' procedure from (2-bromo-2-methylpropyl)benzene (*J. Am. Chem. Soc.* **2016**, *138*, 6139) in 70% yield (~85% purity by mass), 840 mg white crystalline solid (mp = 170 – 172 °C).

^{1}H NMR (500 MHz, acetone-d_6) δ 7.16 – 7.13 (m, 2H), 7.08 – 7.05 (m, 3H), 2.52 (s, 2H), 0.63 (s, 6H). Peaks at 0.75 and 0.13 correspond to $EtBF_3K$ generated during borylation procedure.

^{13}C NMR (126 MHz, acetone-d_6) δ 142.1, 130.5, 126.6, 124.2, 44.5, 22.5 (carbon α to boron not observed due to quadrupolar relaxation).

^{19}F NMR (470.7 MHz, acetone-d_6) δ -153.1 (product), -142.7 ($EtBF_3K$).

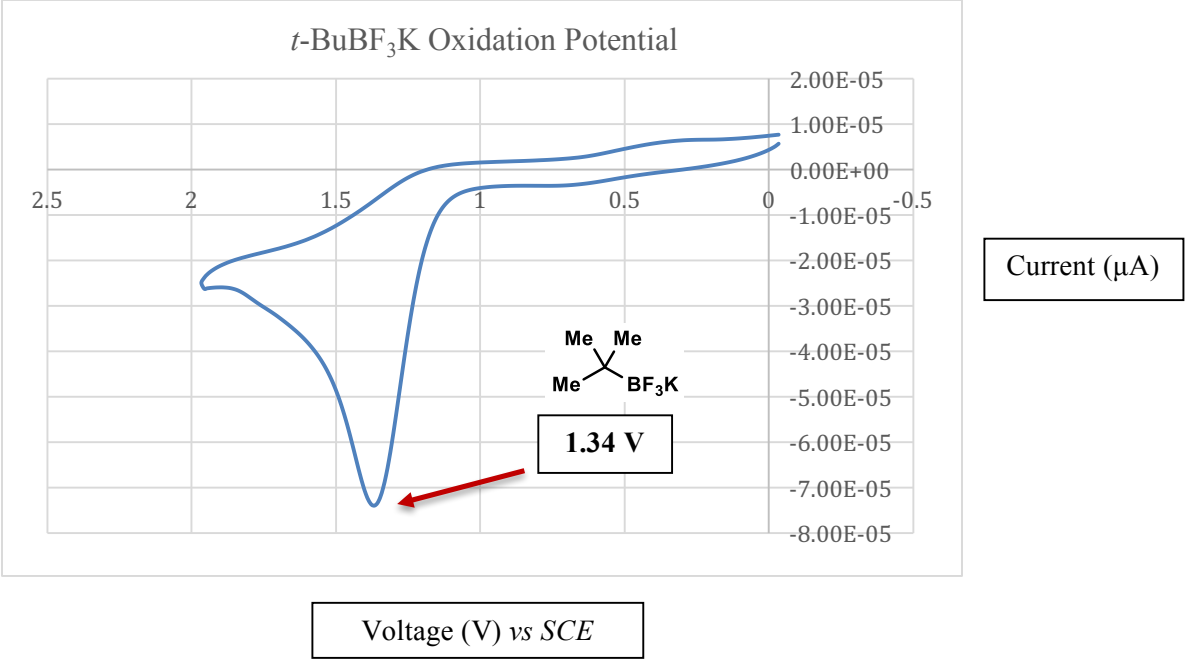
^{11}B NMR (128.4 MHz, acetone-d_6) δ -6.43.

HRMS (ES+) m/z calc. for $C_{10}H_{13}BF_3^-$ [M-] calc. 201.0198, found: submitted.

FT-IR (cm^{-1}, neat, ATR) 2970, 2928, 2861, 1467, 1225, 1019, 945, 749, 702.

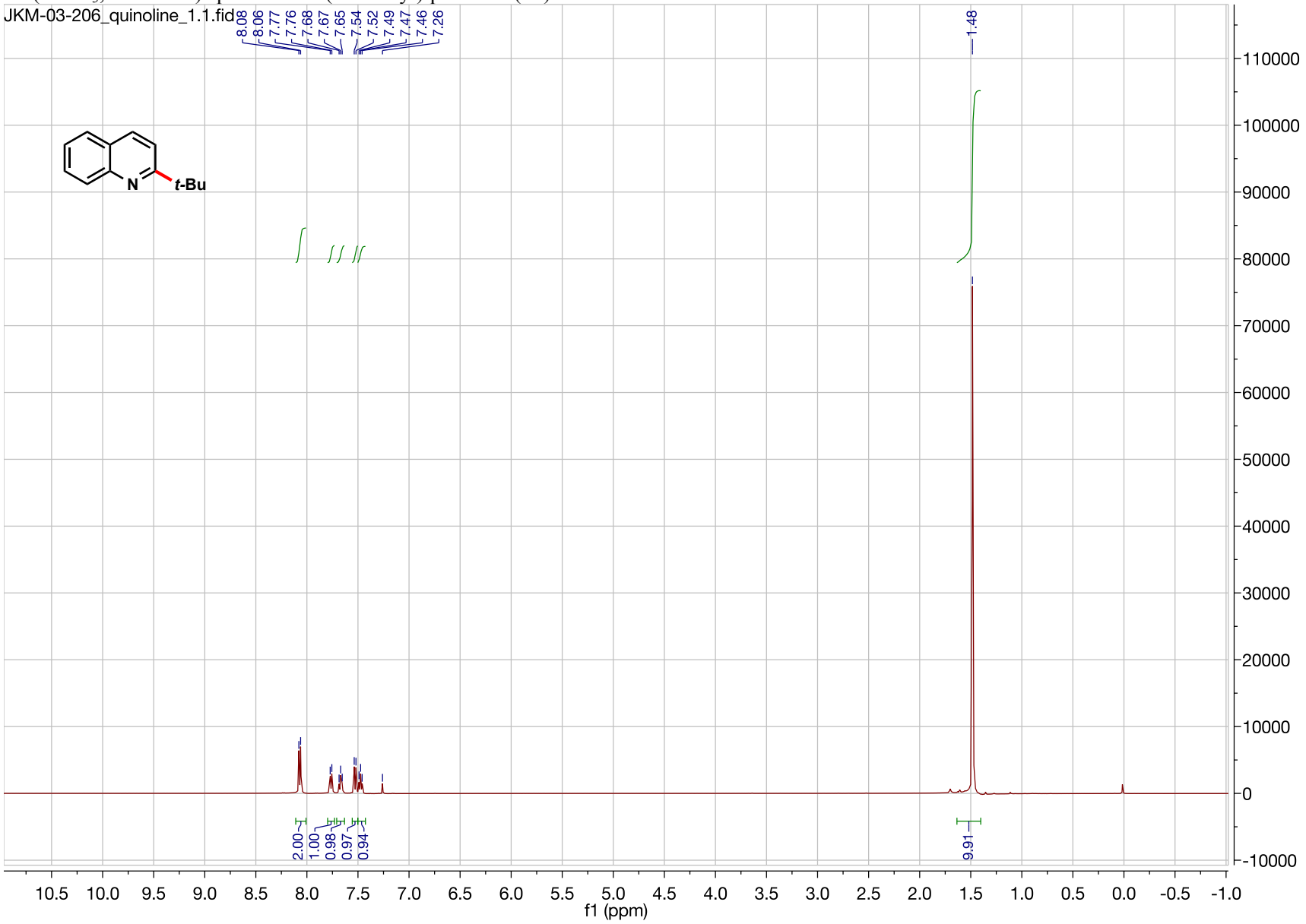
CYCLIC VOLTAMMETRY OF ORGANOBORON REAGENTS

Electrochemical measurements were recorded on a CH Instruments: Model 600E Series Electrochemical Analyzer (observed in 0.002 M MeCN; $[N(Bu)_4](PF_6)$ = 0.1 M; Ag/AgCl = electrode; reported in SCE based on a ferrocene internal standard).

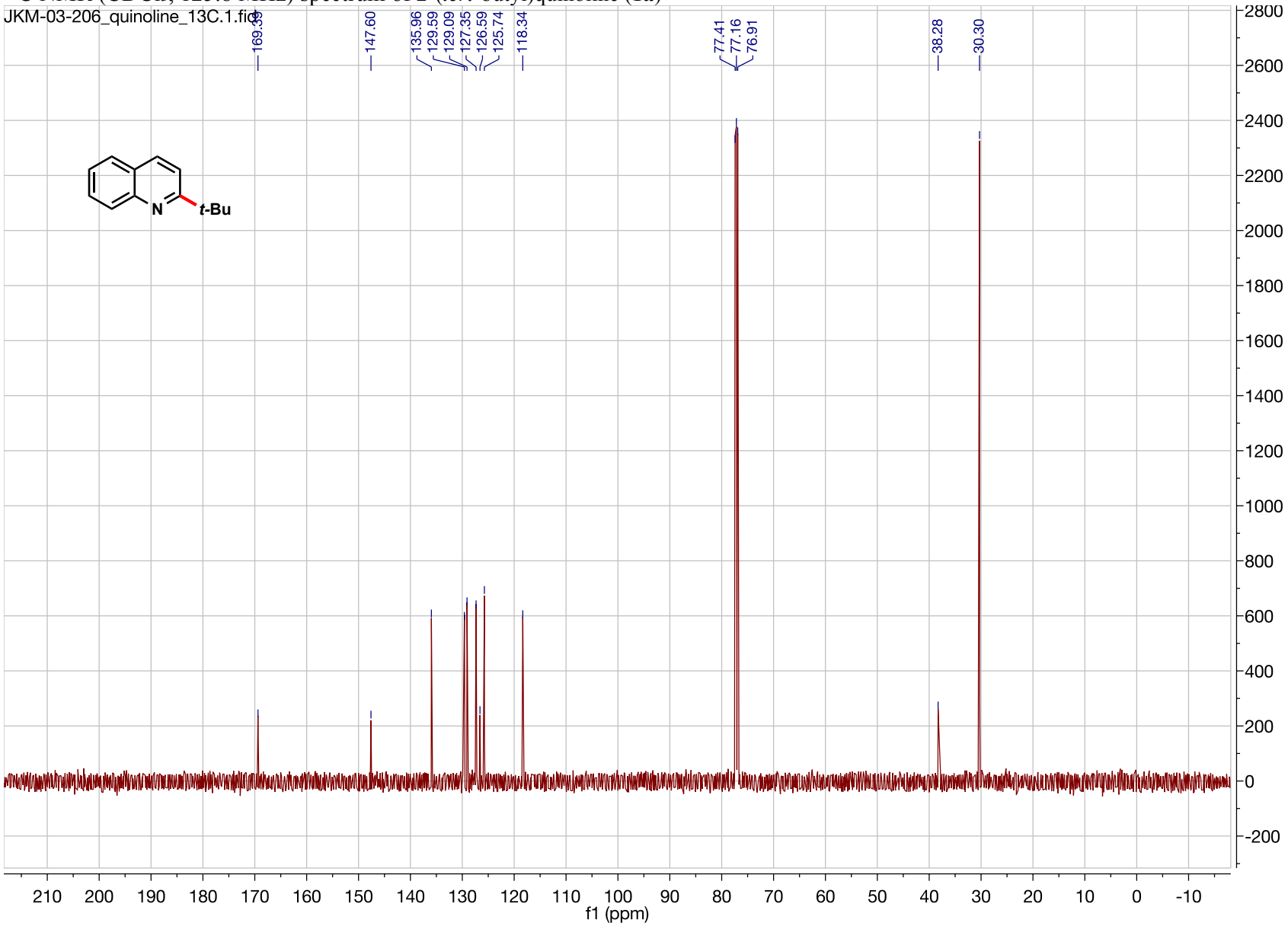


Of the organoboron reagents examined, only the potassium cyclohexyltriolborate XX (~1.1 V *vs SCE*) and potassium cyclohexyltrifluoroborate (~1.5 V *vs SCE*) exhibited oxidations within the solvent window of MeCN. These potentials have been reported previously by Akita and coworkers (*Adv. Synth. Cat.* **2012**, *354 (18)*, 3414). No features were observed for oxidation of the cyclohexyl boronic acid, MIDA, and pincaol boronates.

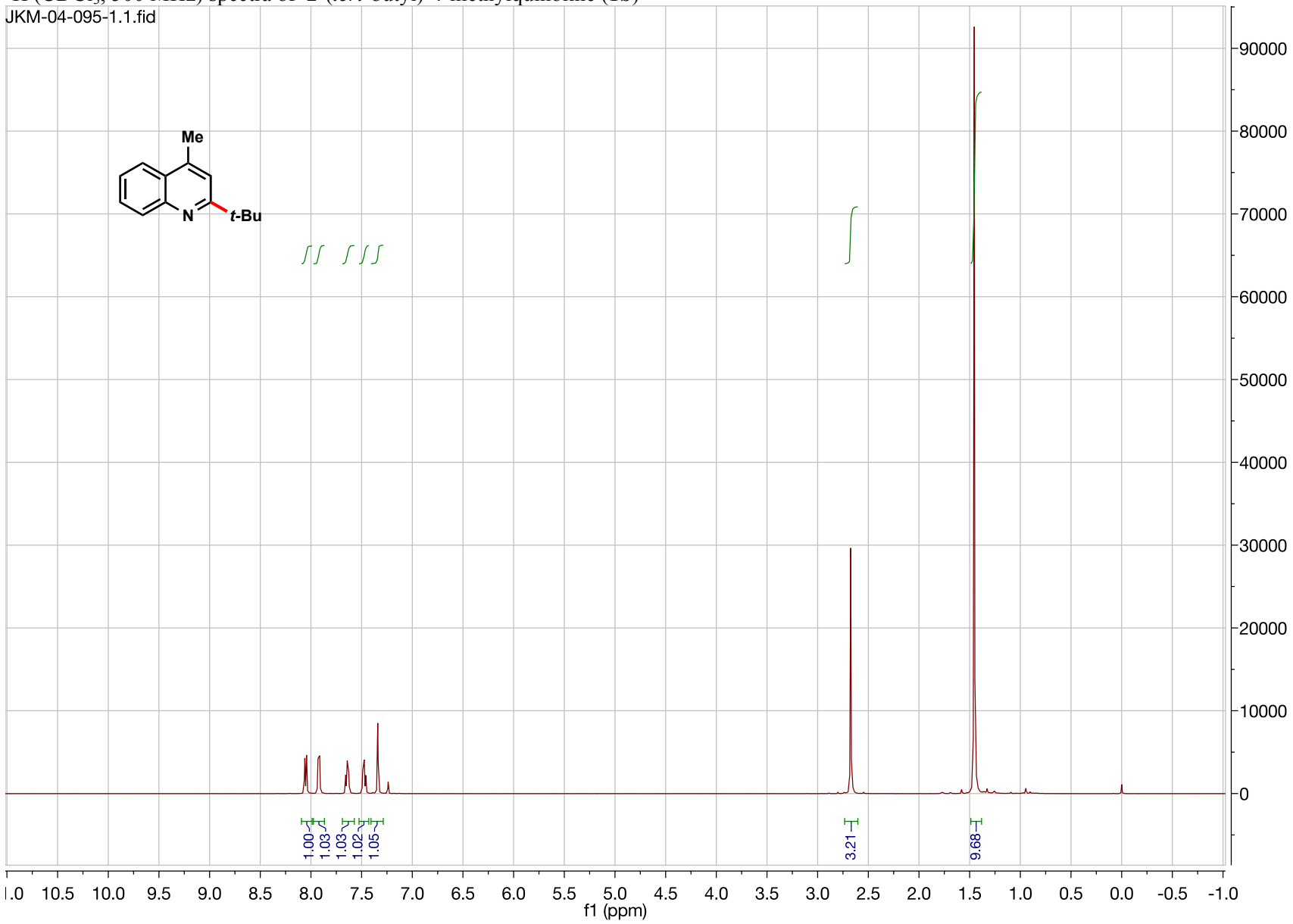
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(*tert*-butyl)quinoline (**1a**)



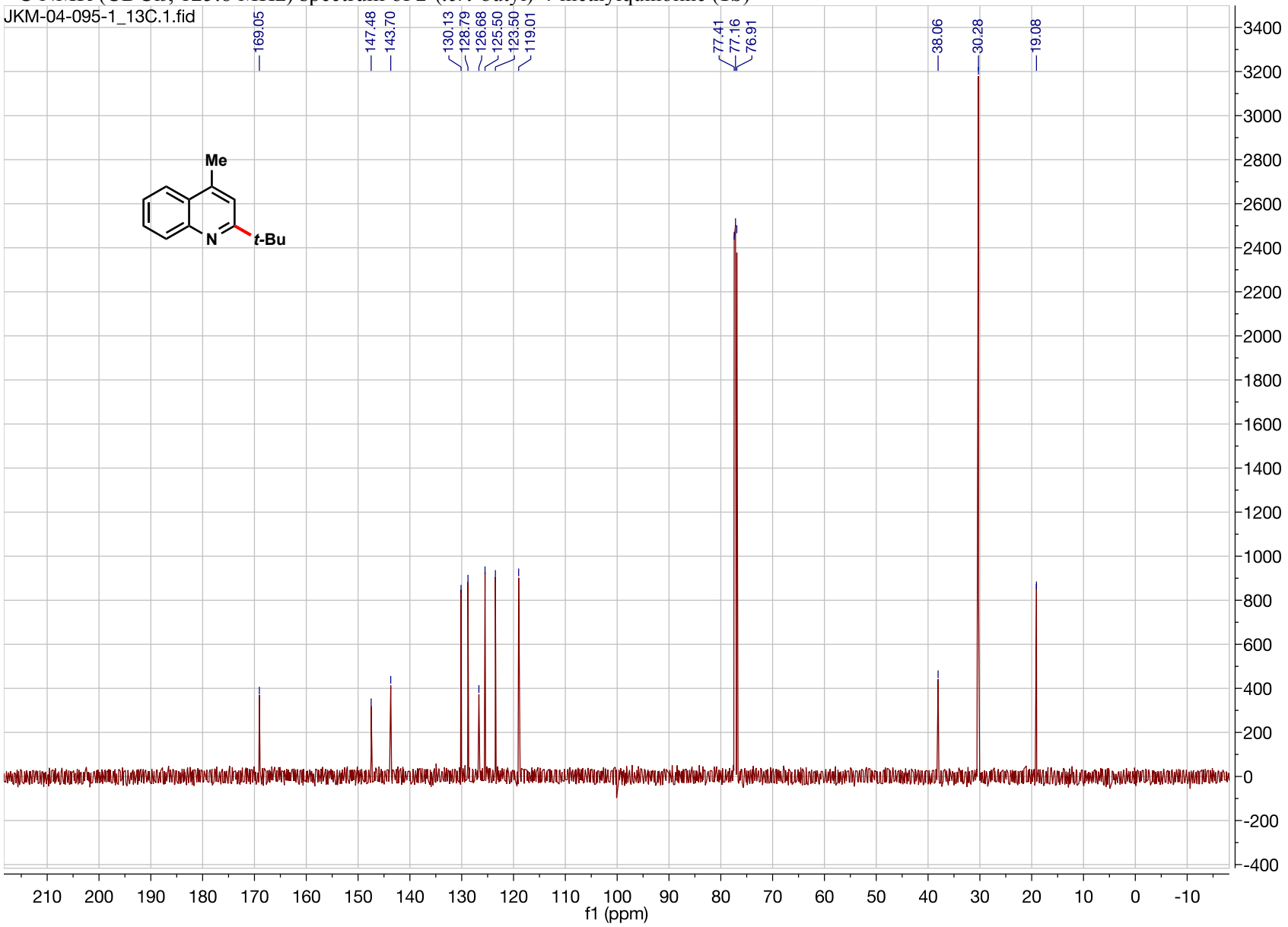
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(*tert*-butyl)quinoline (**1a**)



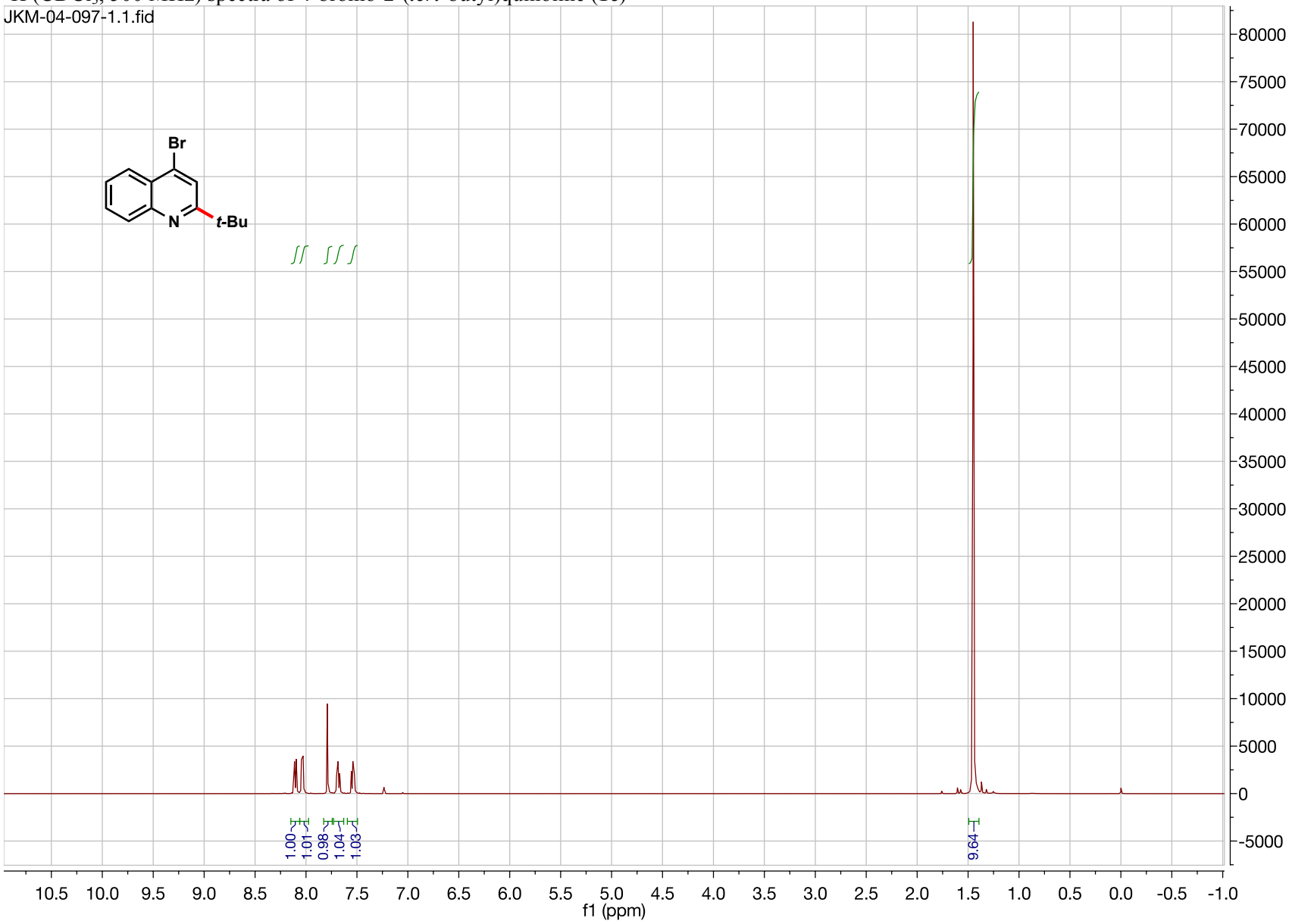
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(*tert*-butyl)-4-methylquinoline (**1b**)



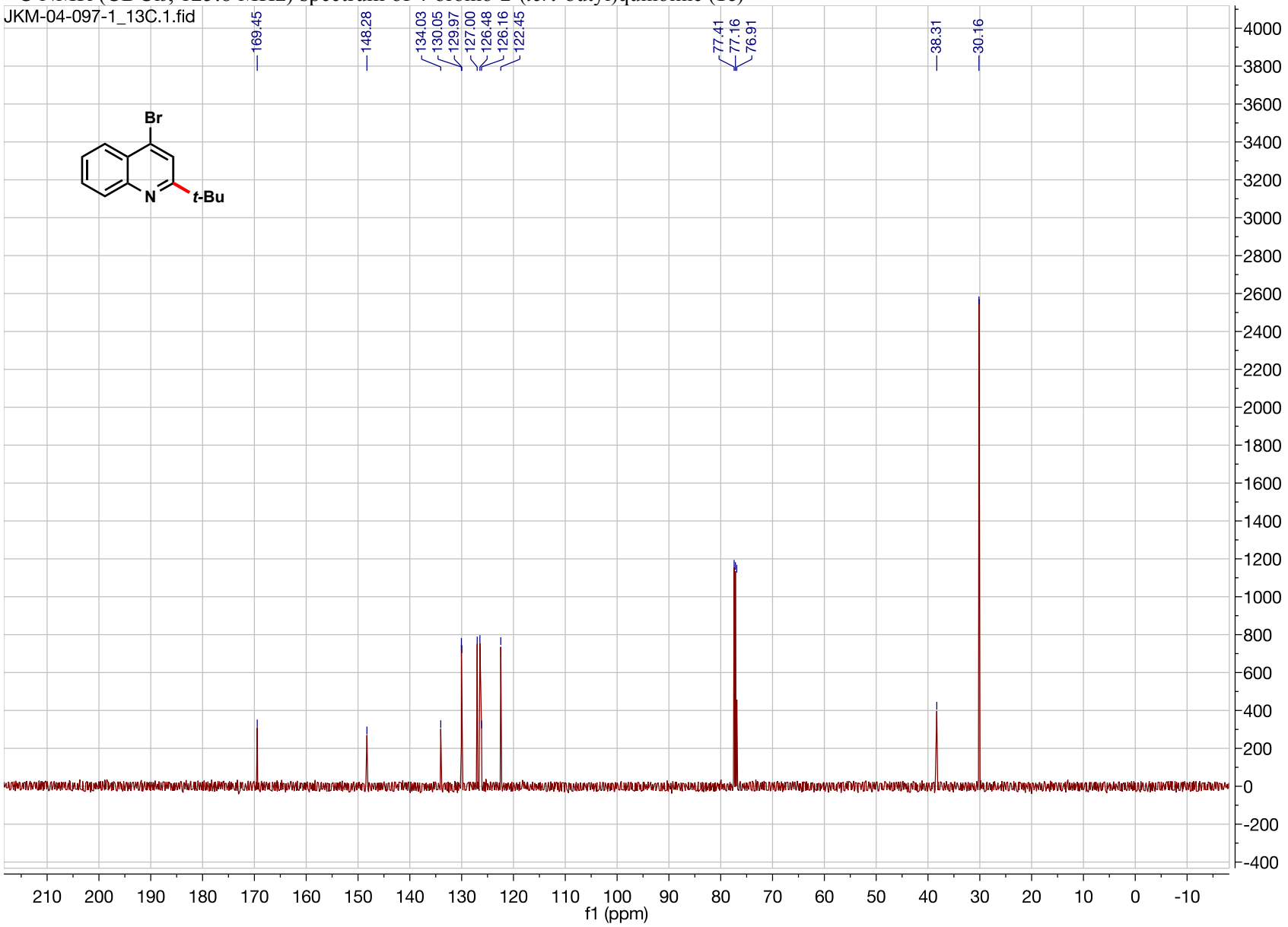
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(*tert*-butyl)-4-methylquinoline (**1b**)



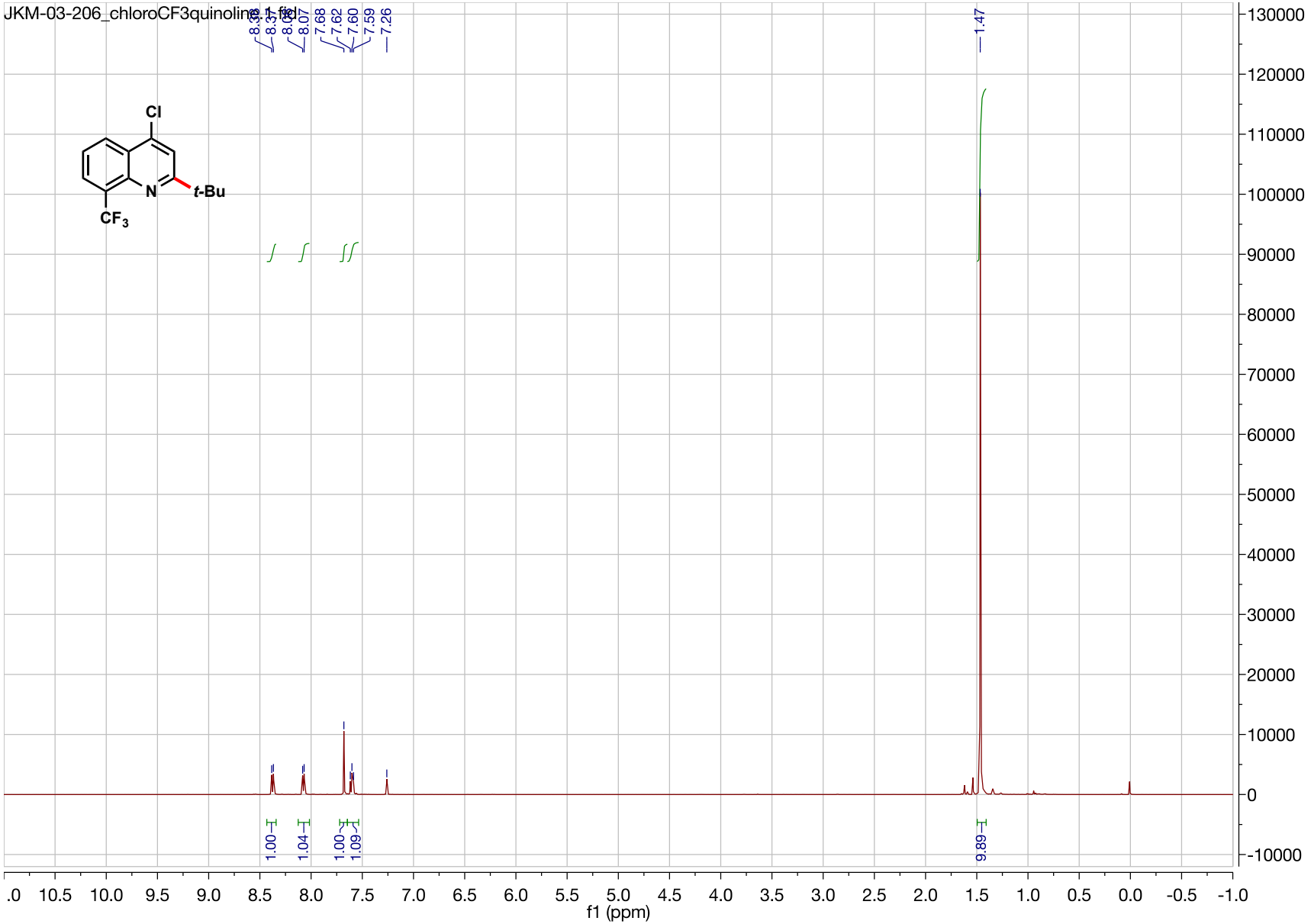
^{1}H ($CDCl_3$, 500 MHz) spectra of 4-bromo-2-(*tert*-butyl)quinoline (**1c**)



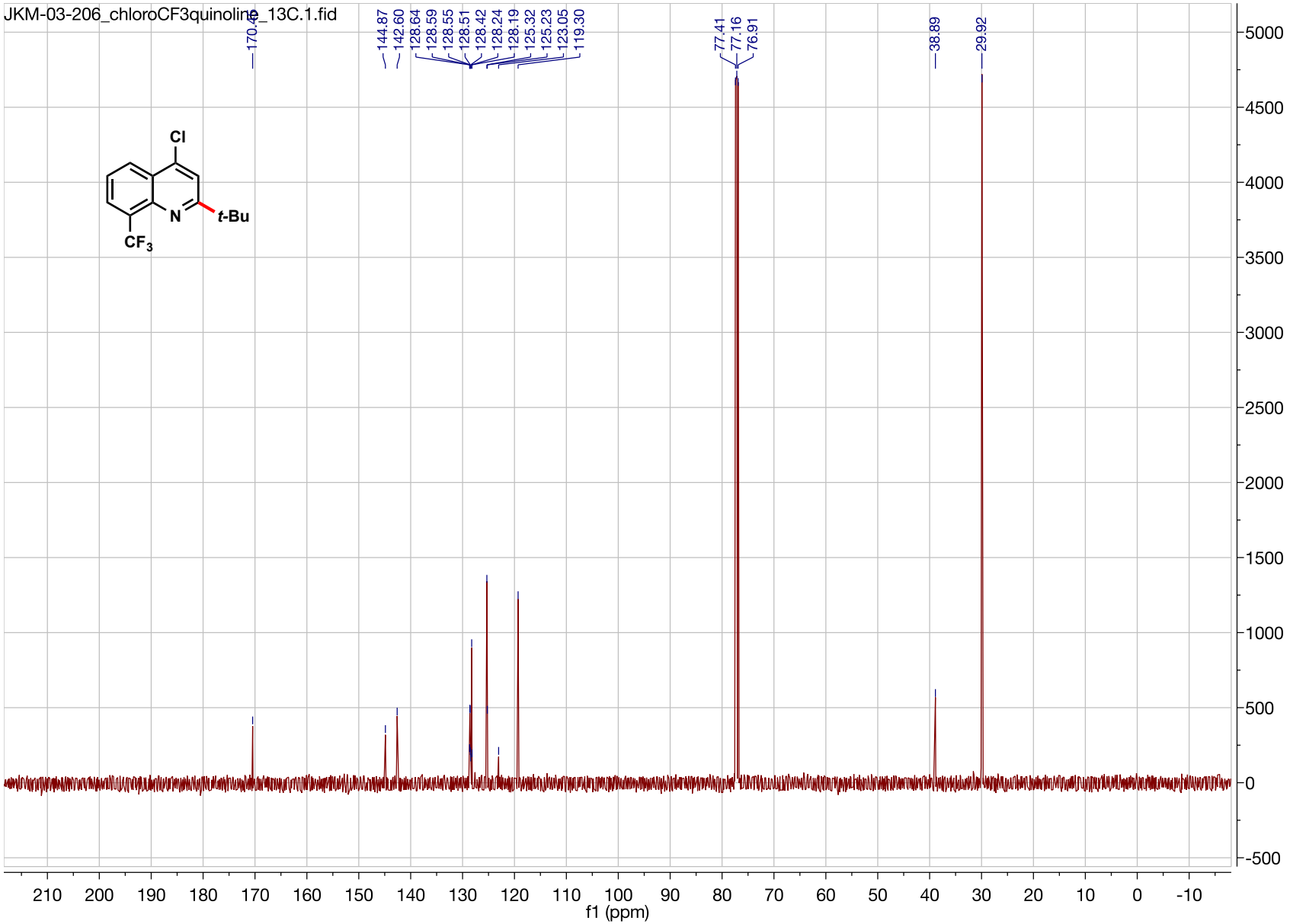
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 4-bromo-2-(*tert*-butyl)quinoline (**1c**)



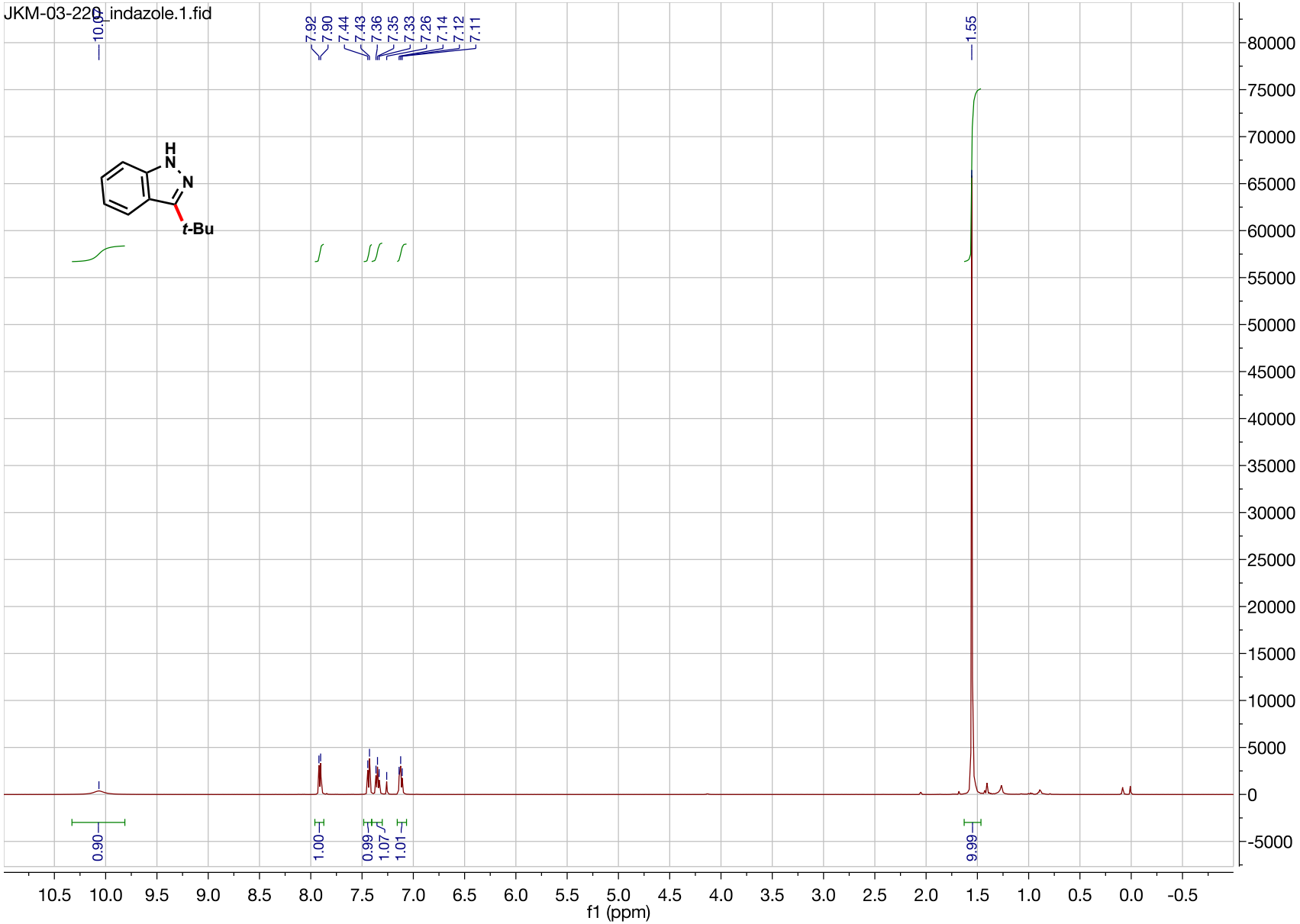
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(*tert*-butyl)-4-chloro-8-(trifluoromethyl)quinoline (**1d**)



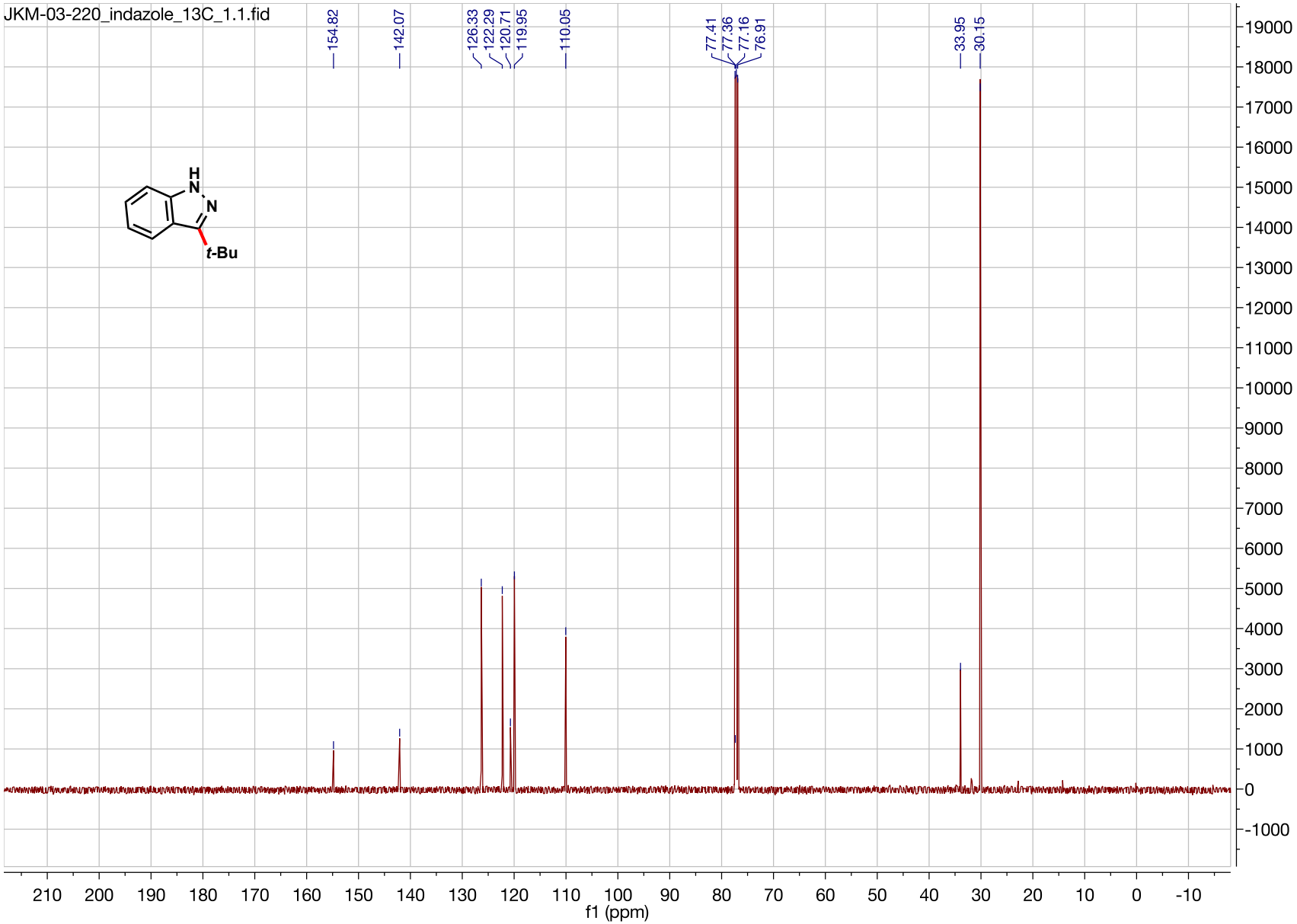
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(*tert*-butyl)-4-chloro-8-(trifluoromethyl)quinoline (**1d**)



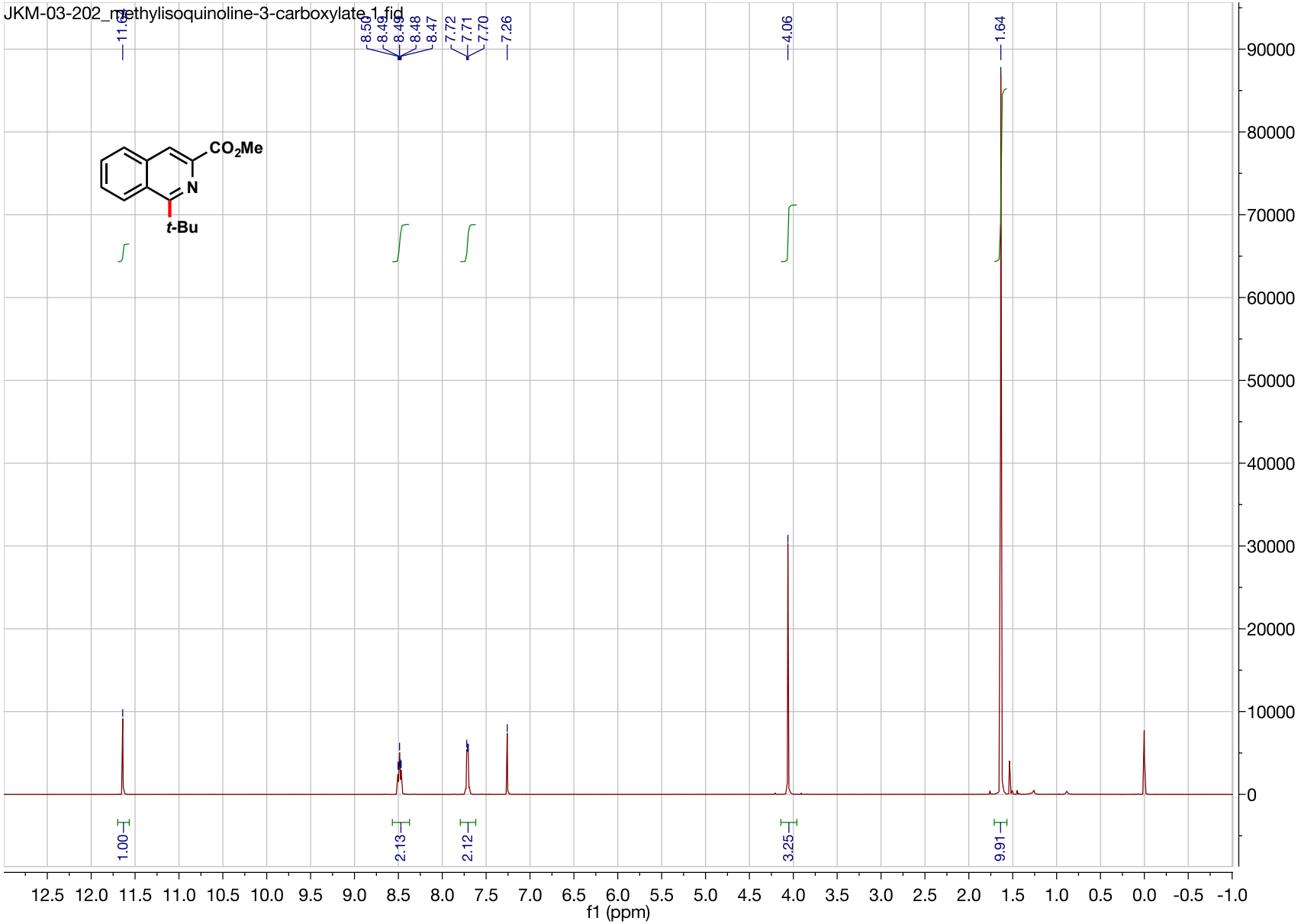
^{1}H ($CDCl_3$, 500 MHz) spectra of 3-(*tert*-butyl)-1*H*-indazole (**1e**)



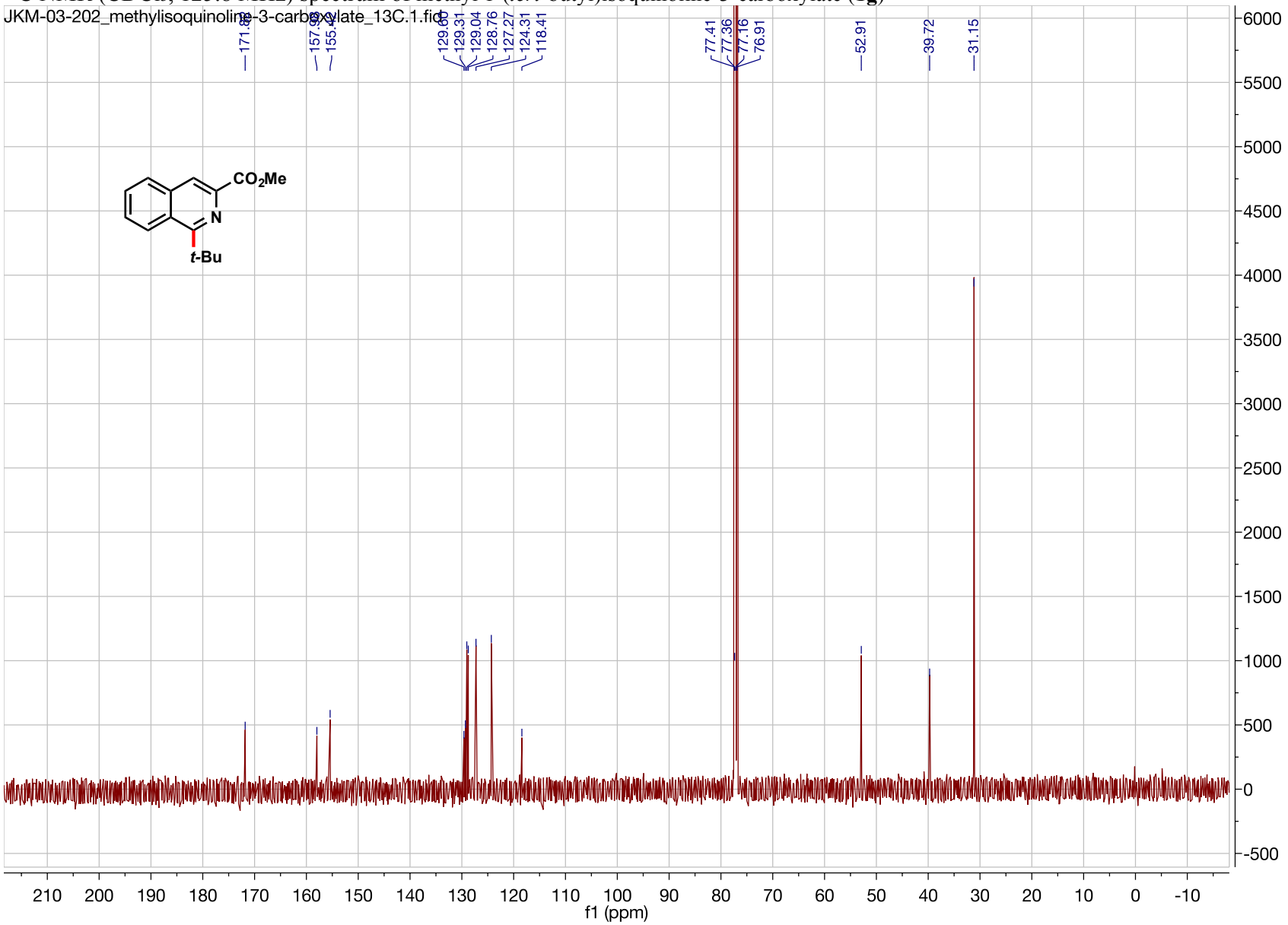
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 3-(*tert*-butyl)-1*H*-indazole (**1e**)



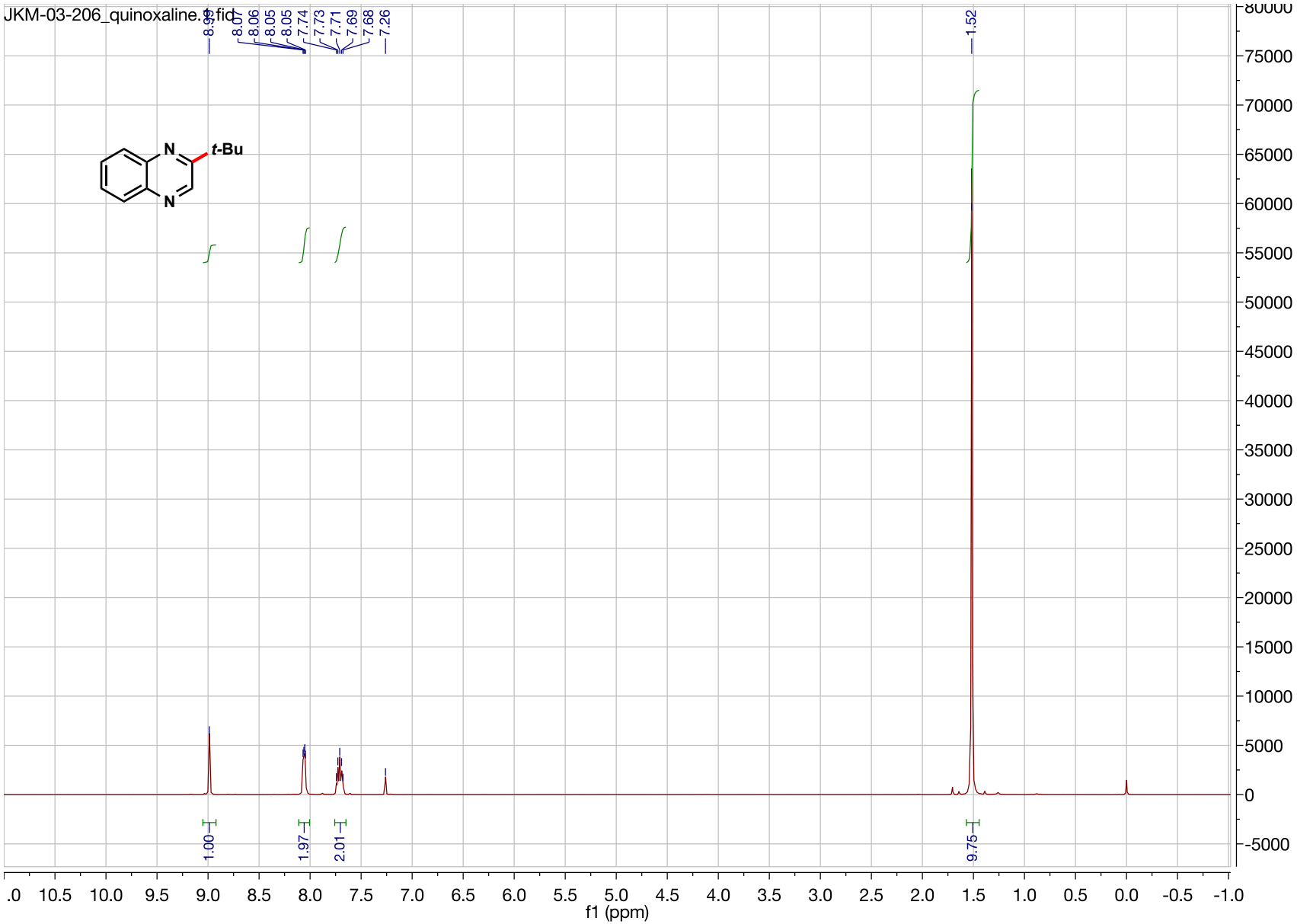
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(*tert*-butyl)isoquinoline-3-carboxylate (**1g**)



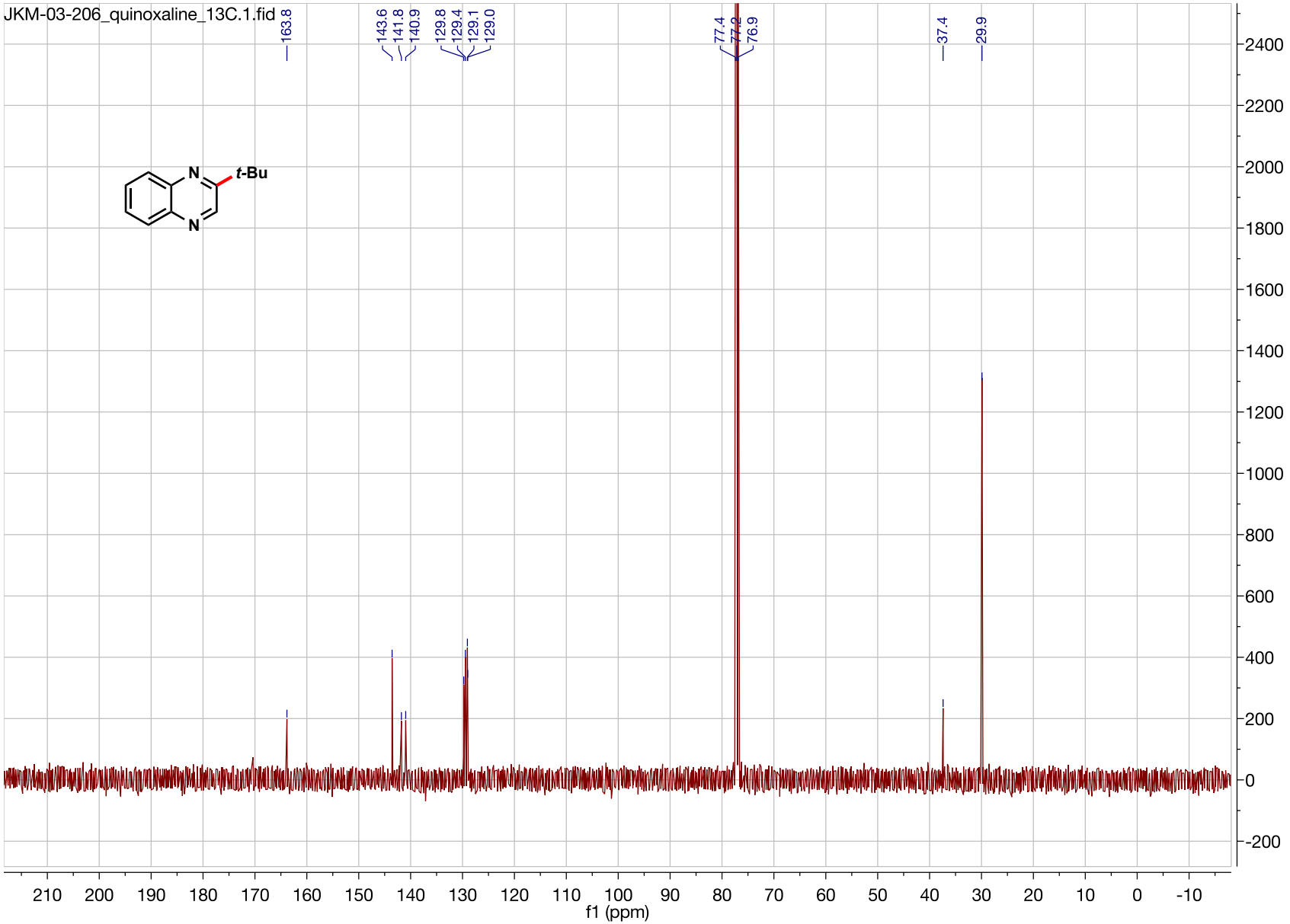
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(*tert*-butyl)isoquinoline-3-carboxylate (**1g**)



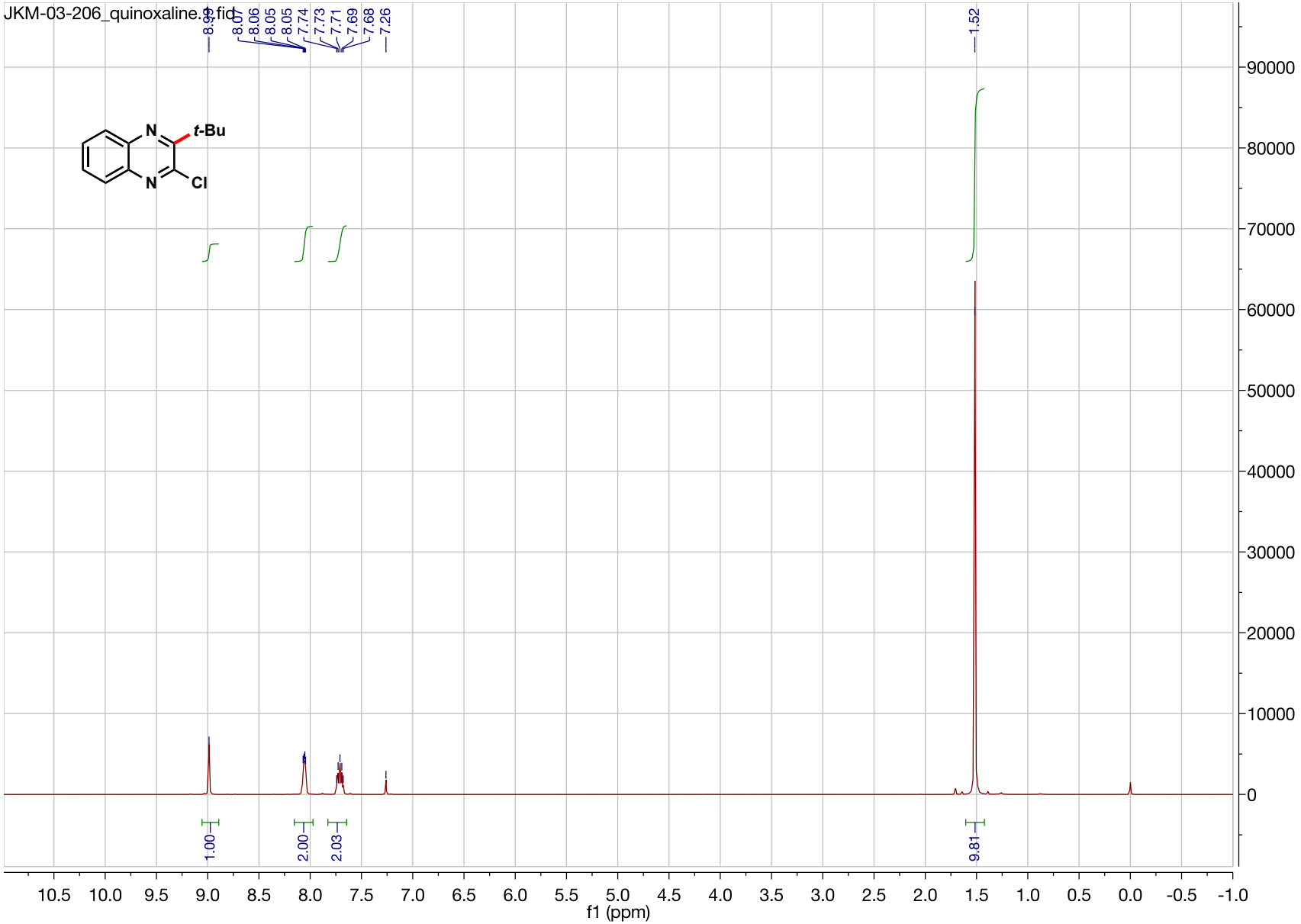
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(*tert*-butyl)quinoxaline (**1h**)



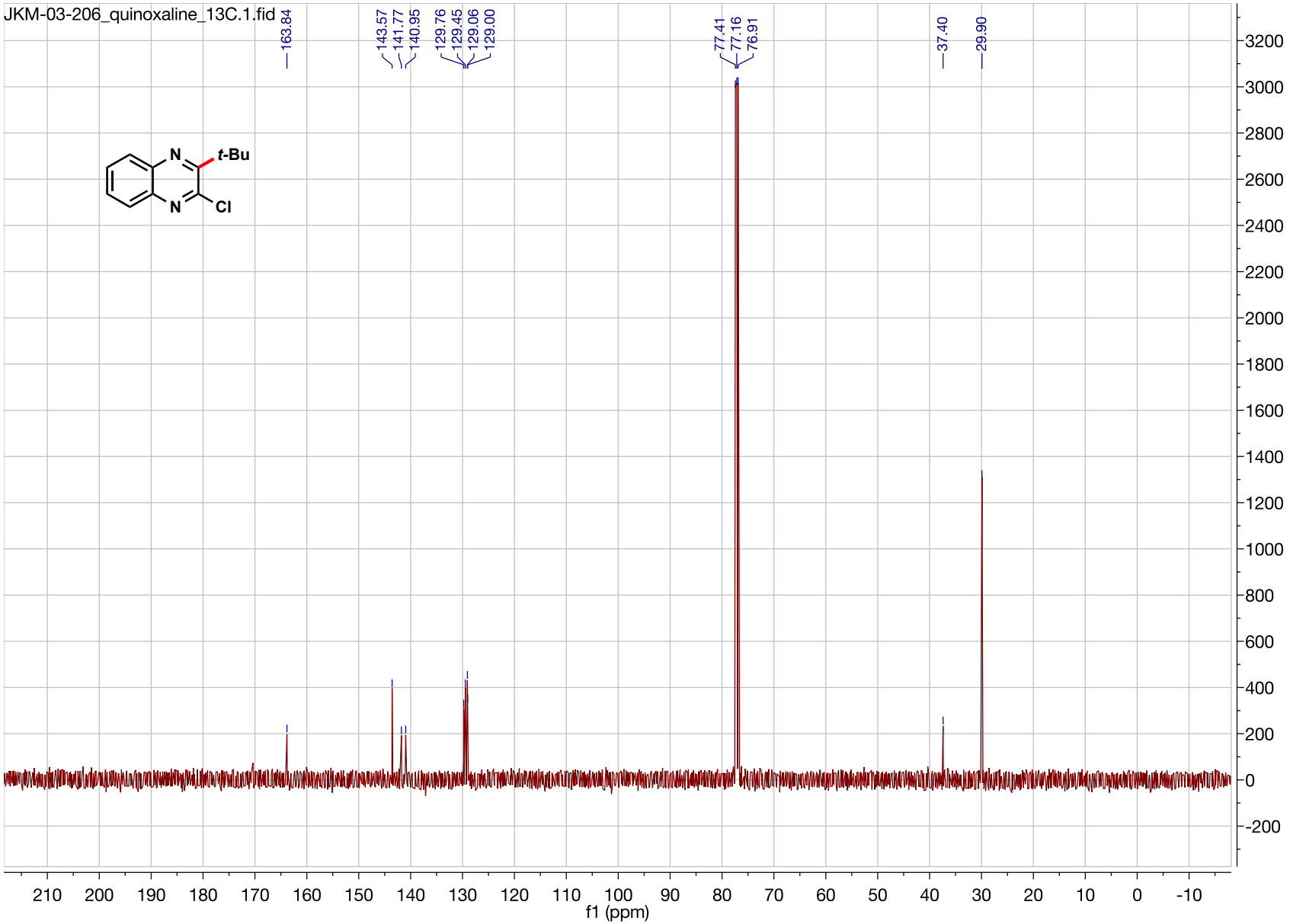
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(*tert*-butyl)quinoxaline (**1h**)



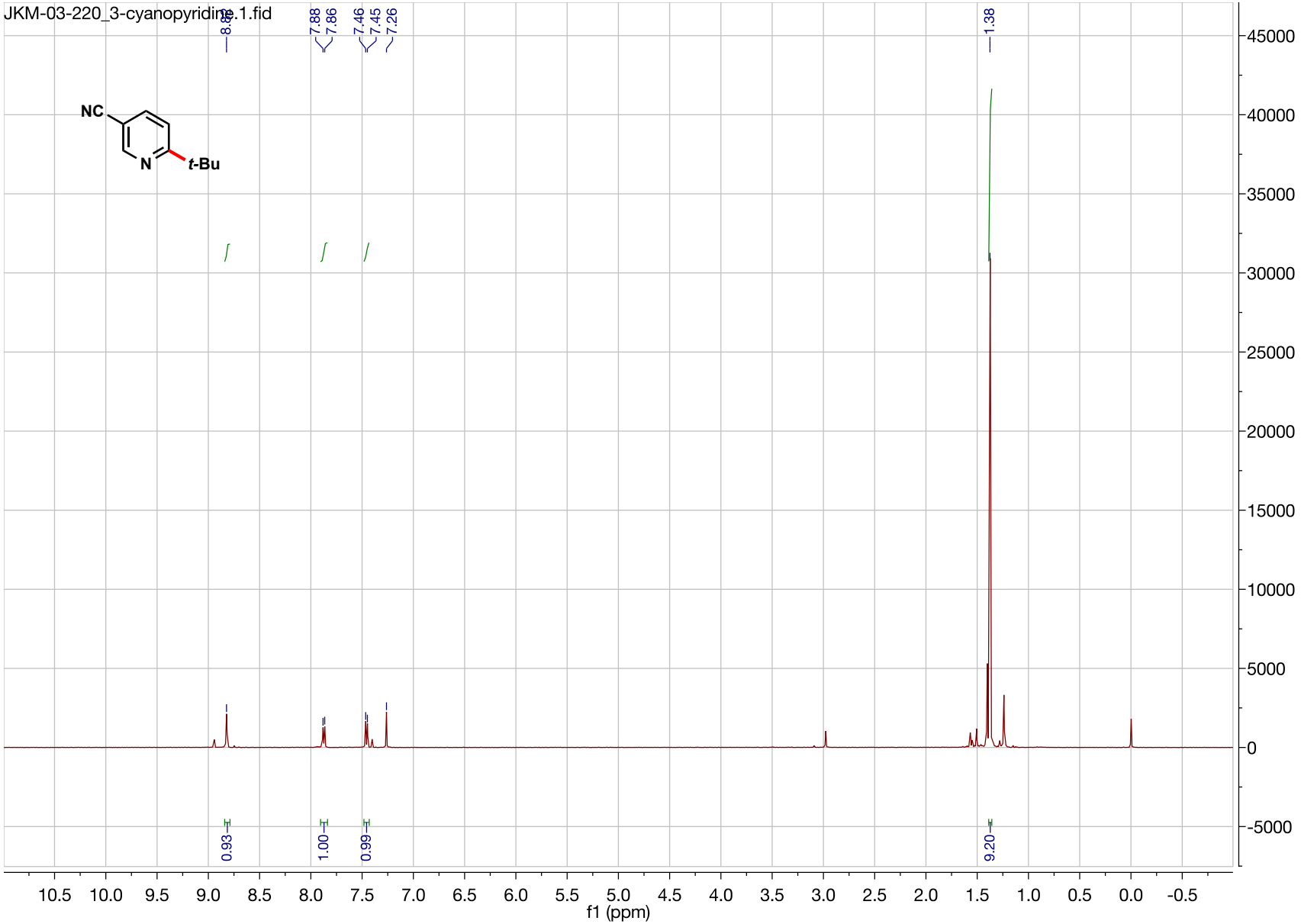
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(*tert*-butyl)-3-chloroquinoxaline (**1i**)



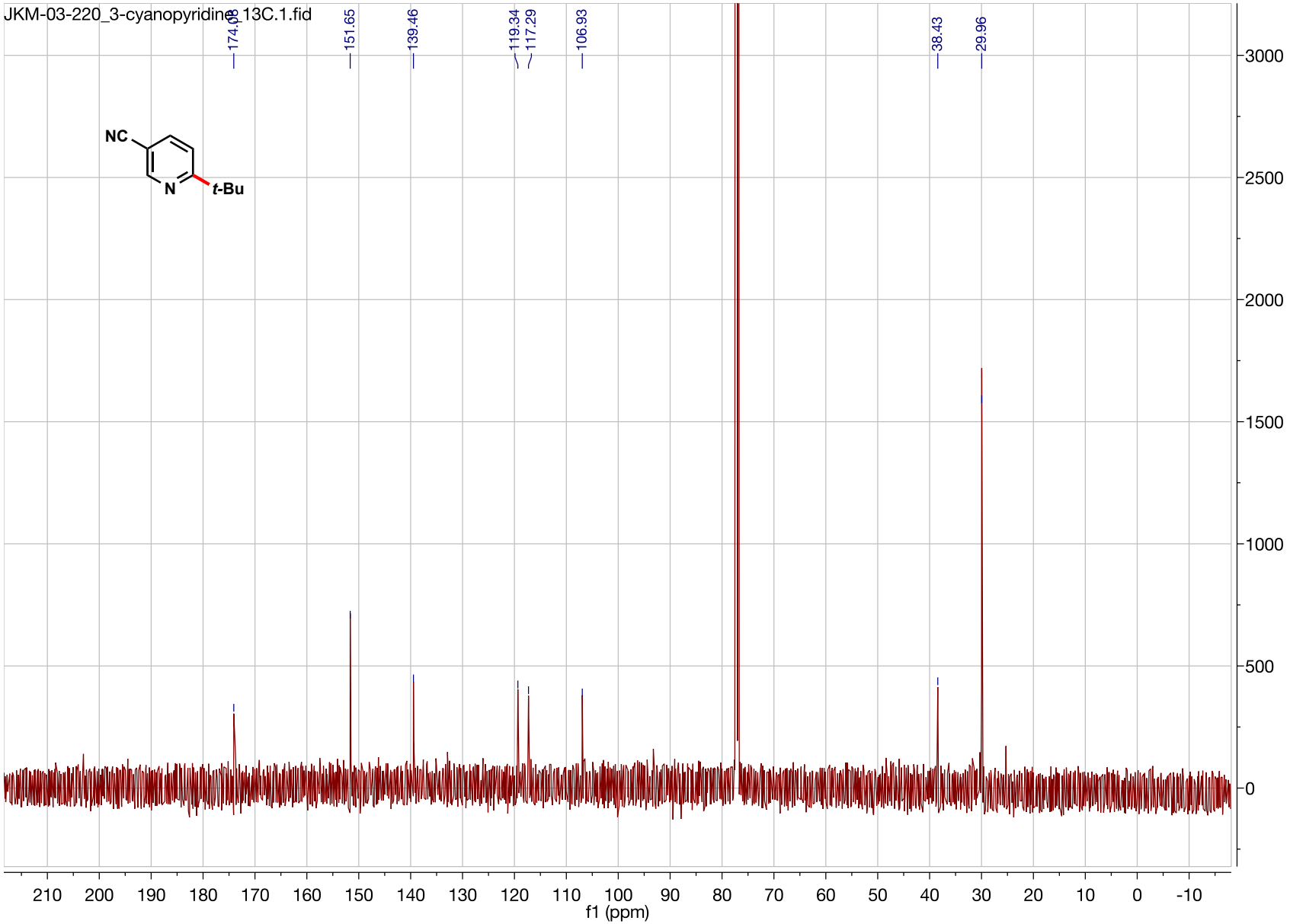
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(*tert*-butyl)-3-chloroquinoxaline (**1i**)



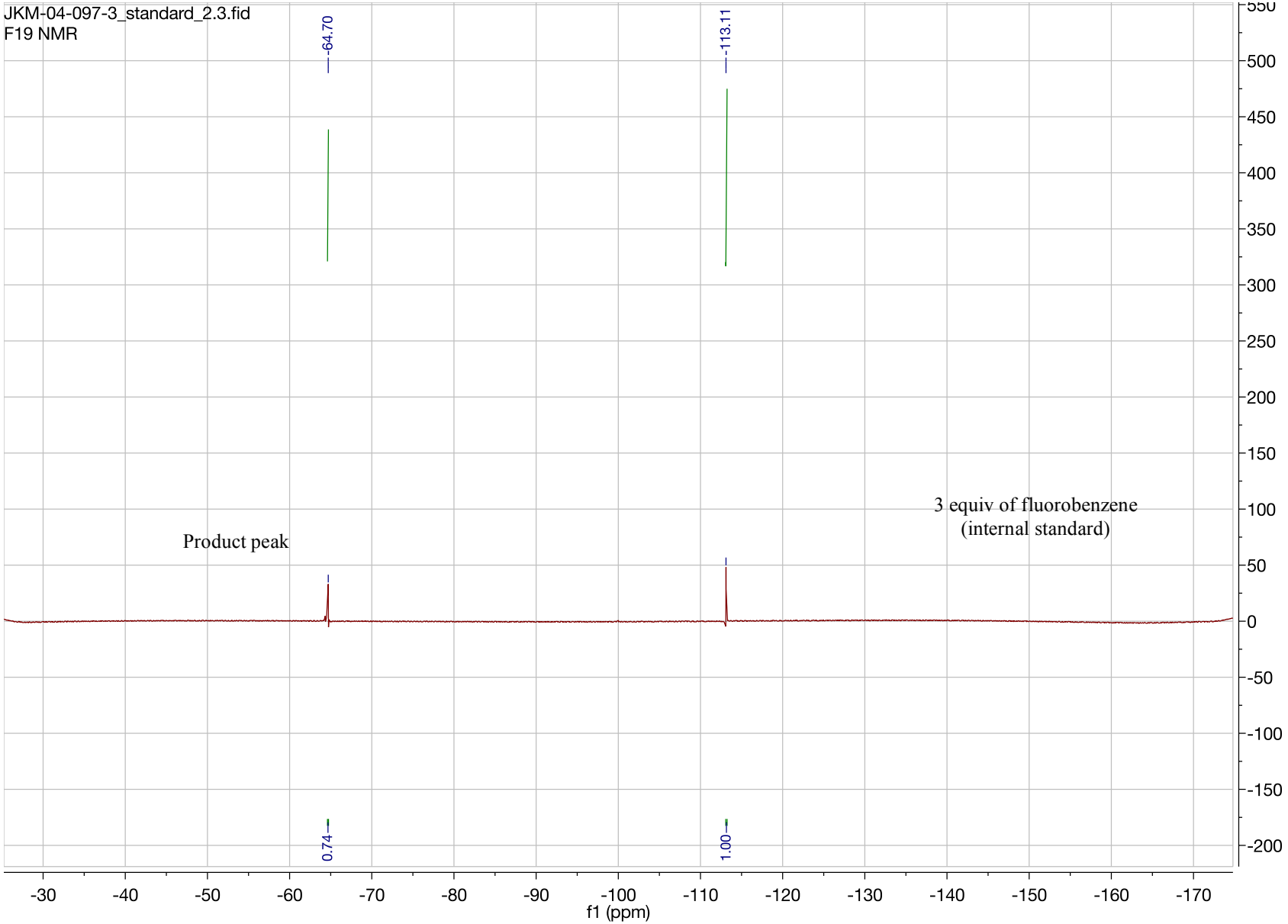
^{1}H ($CDCl_3$, 500 MHz) spectra of 6-(*tert*-butyl)nicotinonitrile (**1j**)



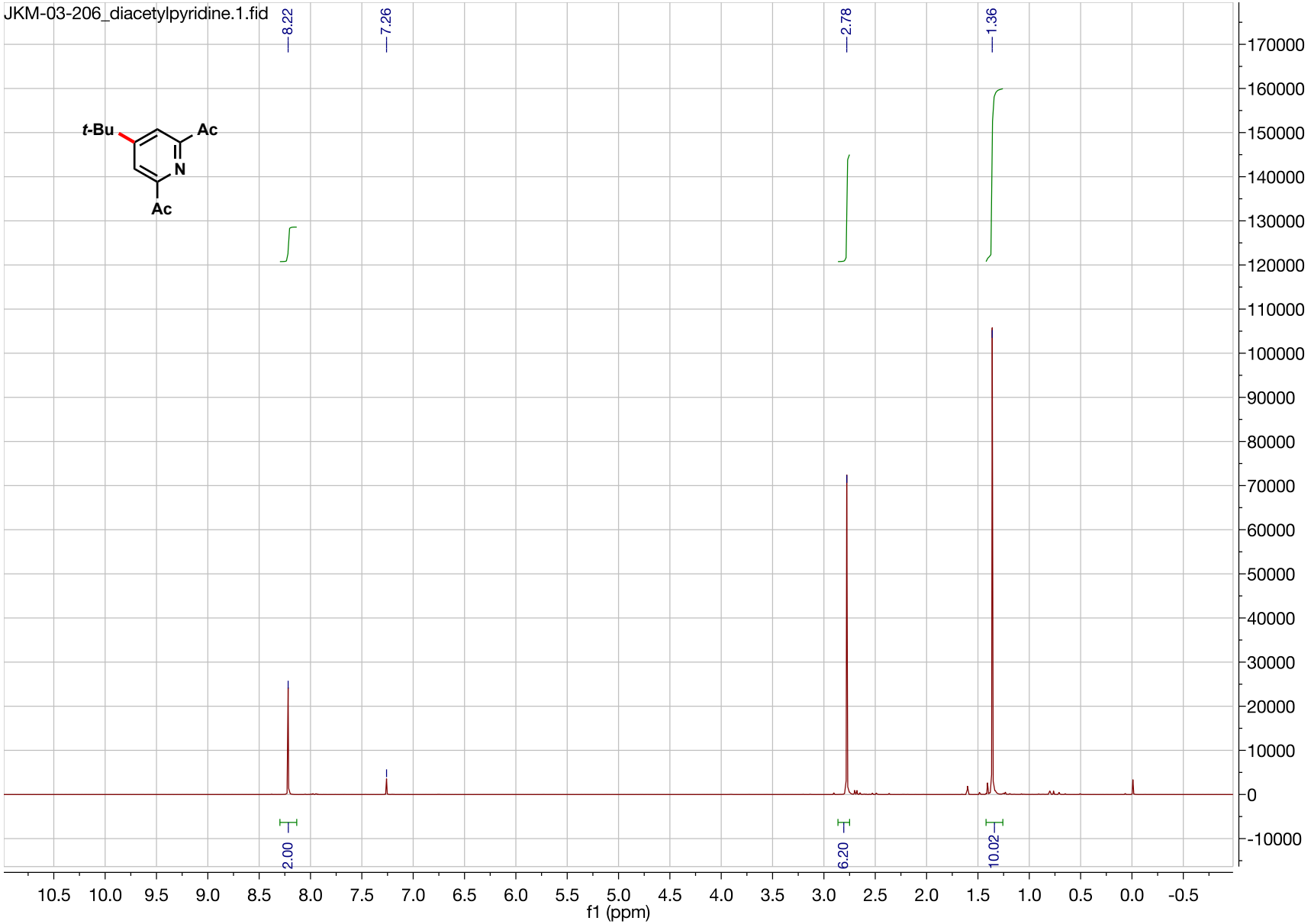
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 6-(*tert*-butyl)nicotinonitrile (**1j**)



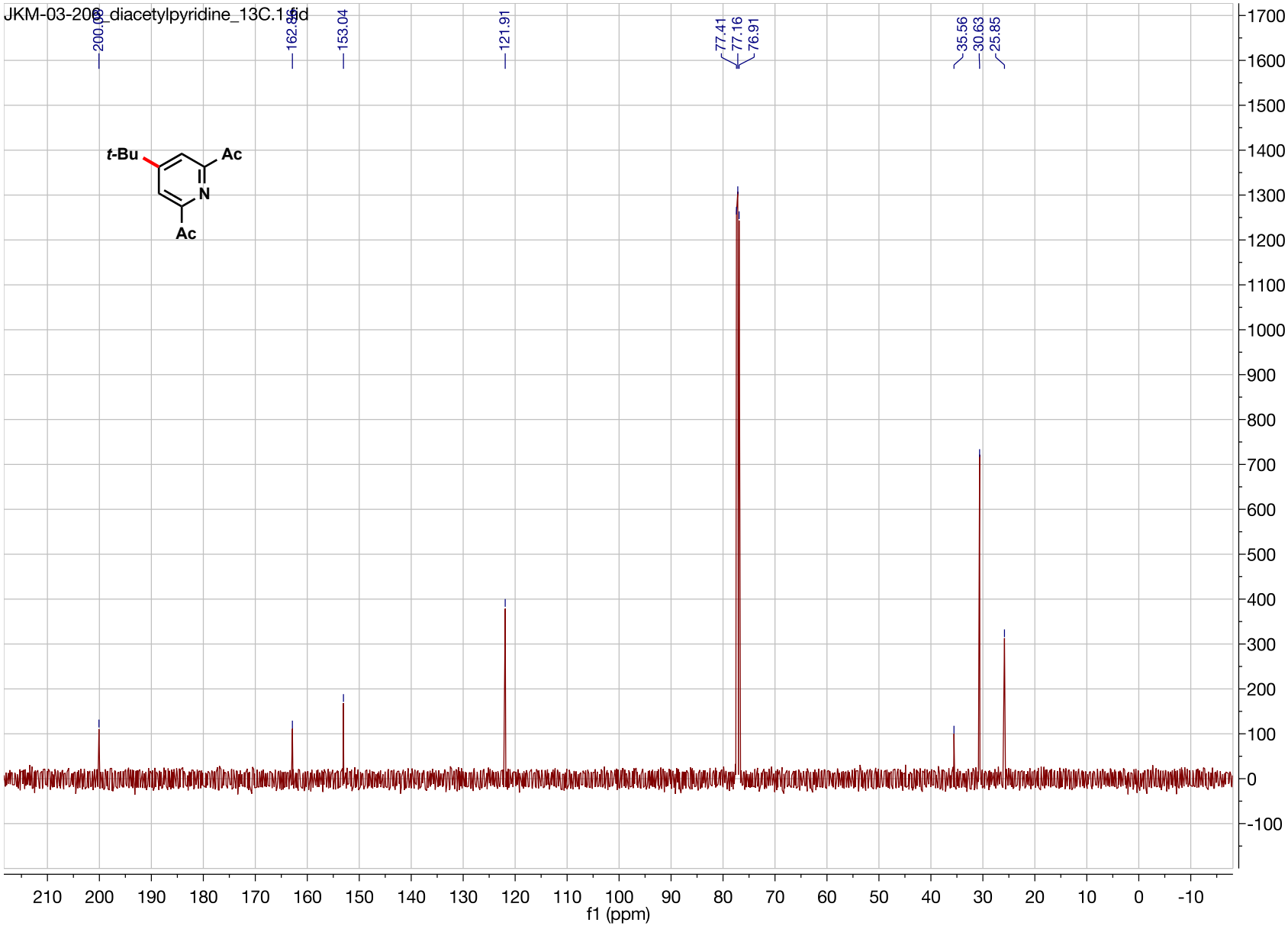
^{19}F ($CDCl_3$, 477 MHz) spectra of 2-(*tert*-Butyl)-4-(trifluoromethyl)pyridine (**1k**) with fluorobenzene



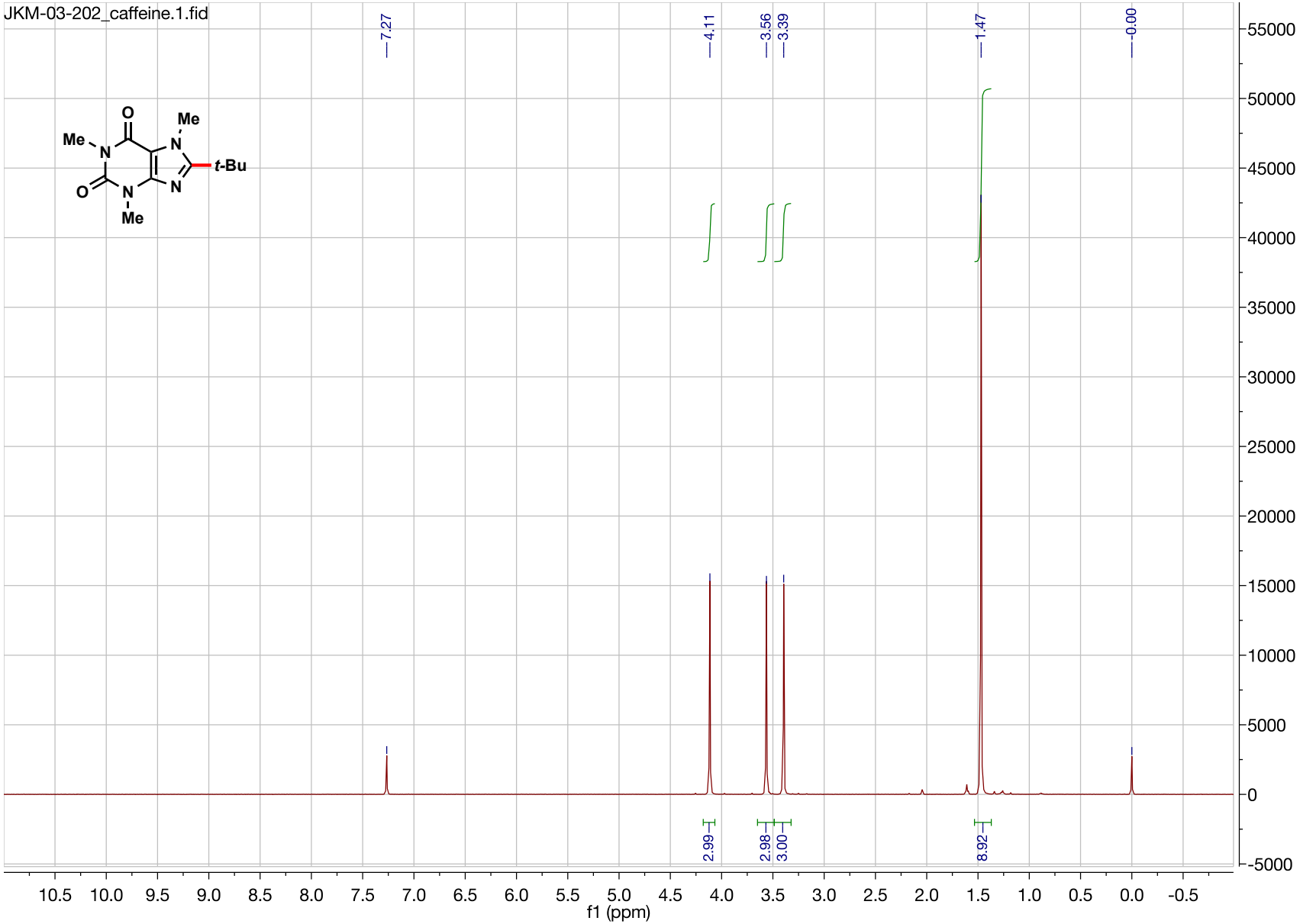
^{1}H ($CDCl_3$, 500 MHz) spectra of 1,1'-(4-(*tert*-butyl)pyridine-2,6-diyl)bis(ethan-1-one) (**1l**)



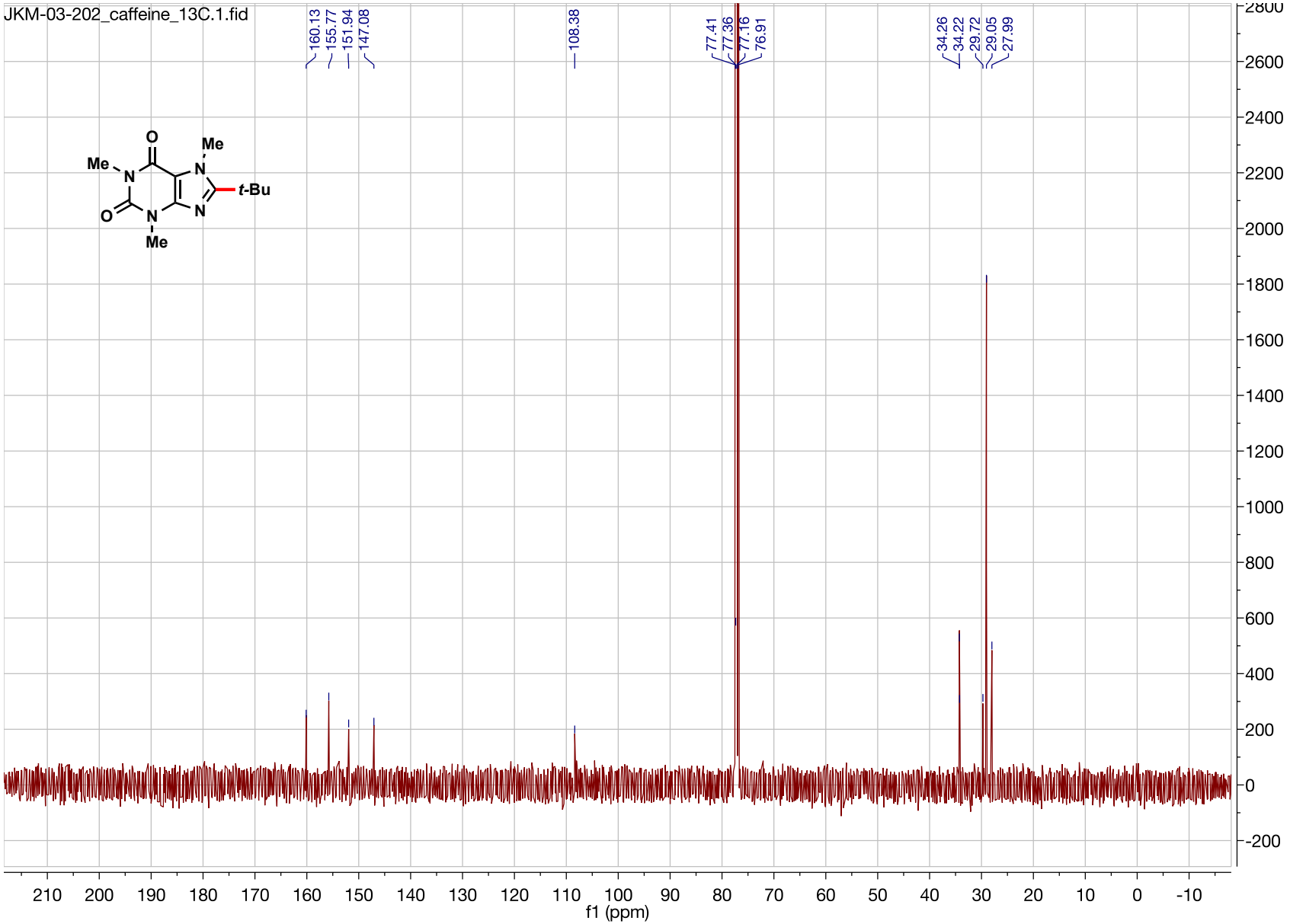
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 1,1'-(4-(*tert*-butyl)pyridine-2,6-diyl)bis(ethan-1-one) (**1l**)



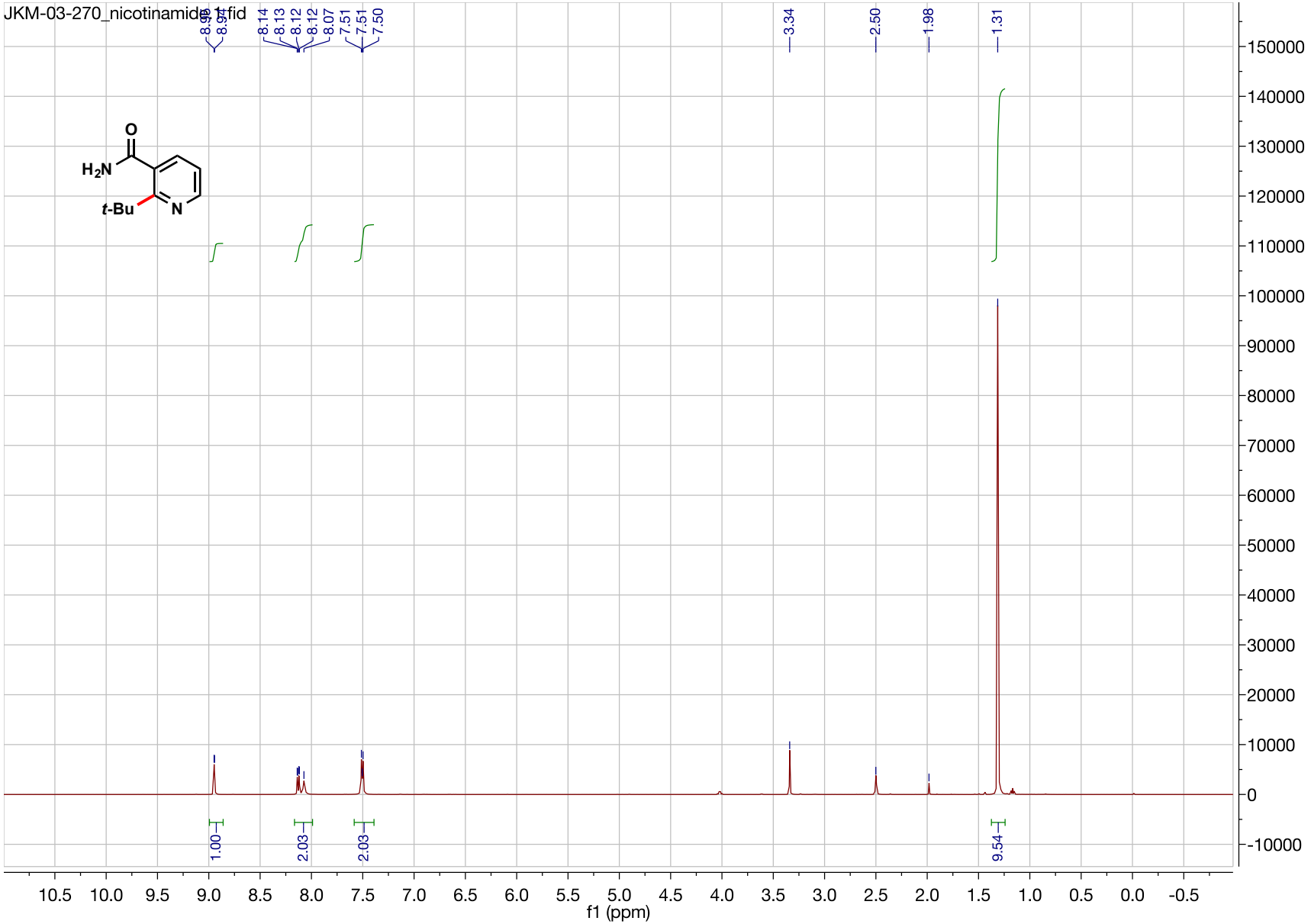
^{1}H ($CDCl_3$, 500 MHz) spectra of 8-(*tert*-butyl)-1,3,7-trimethyl-3,7-dihydro-1*H*-purine-2,6-dione (**1m**)



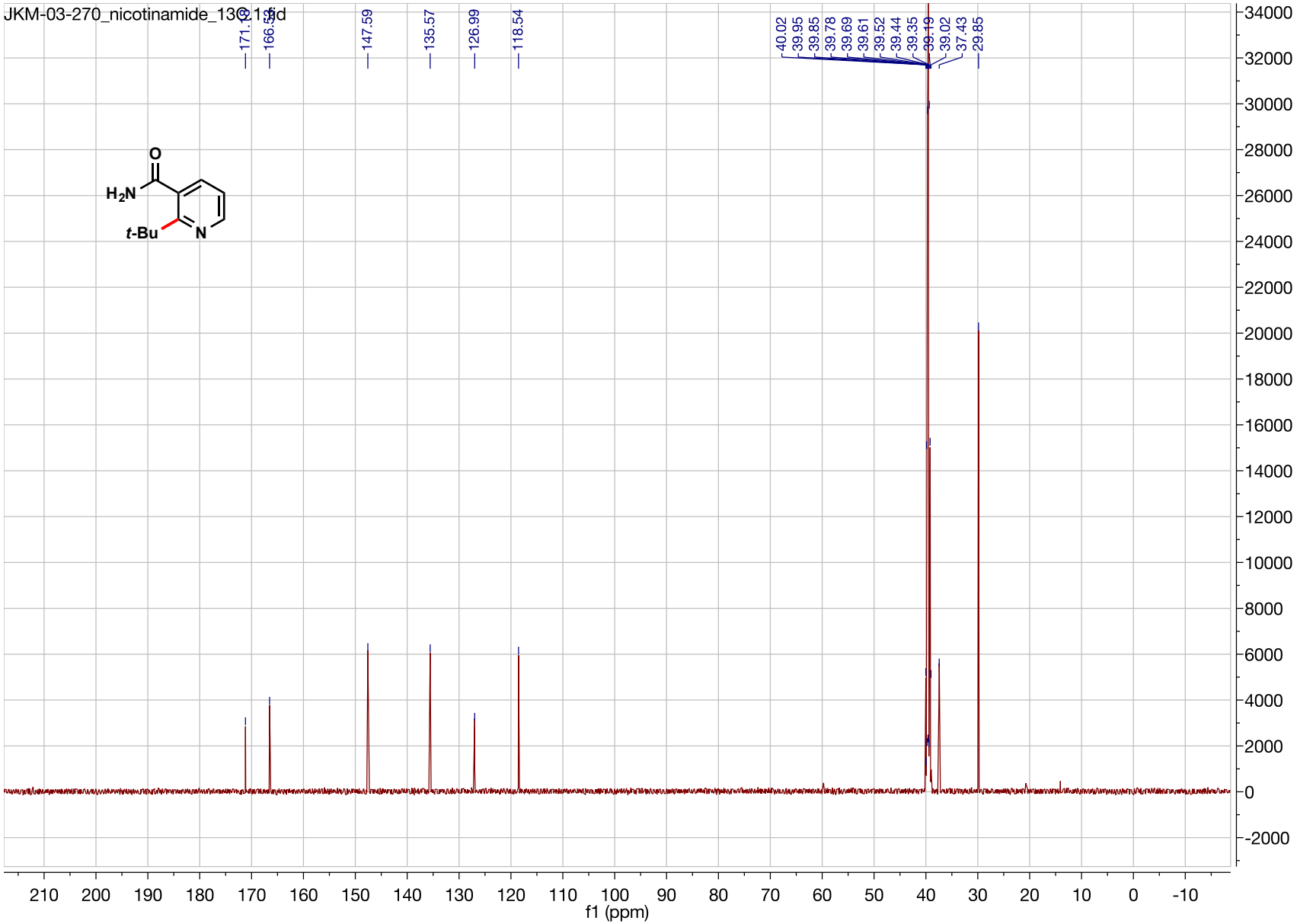
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 8-(*tert*-butyl)-1,3,7-trimethyl-3,7-dihydro-1*H*-purine-2,6-dione (**1m**)



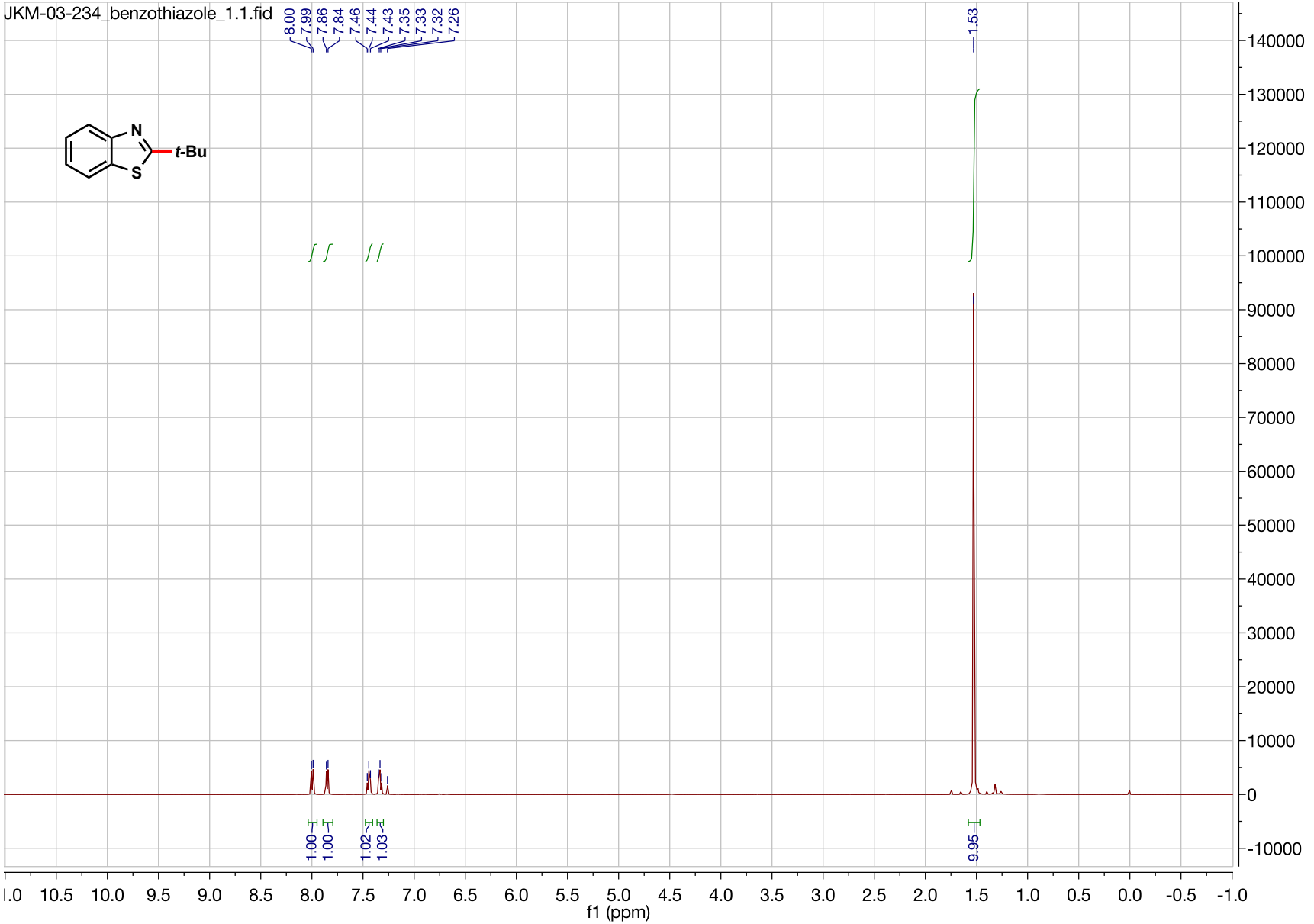
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(*tert*-butyl)nicotinamide **(1n)**



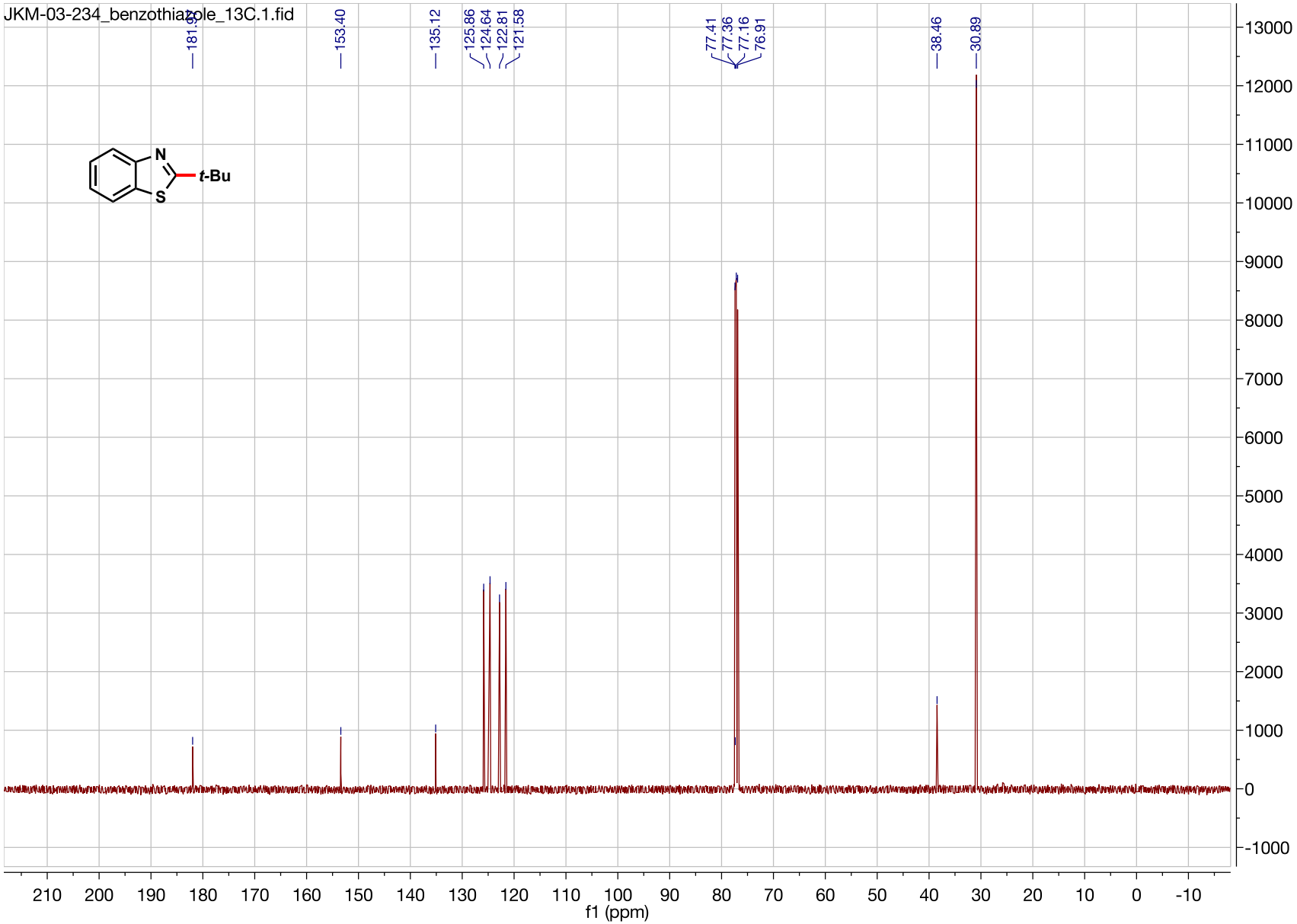
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(*tert*-butyl)nicotinamide **(1n)**



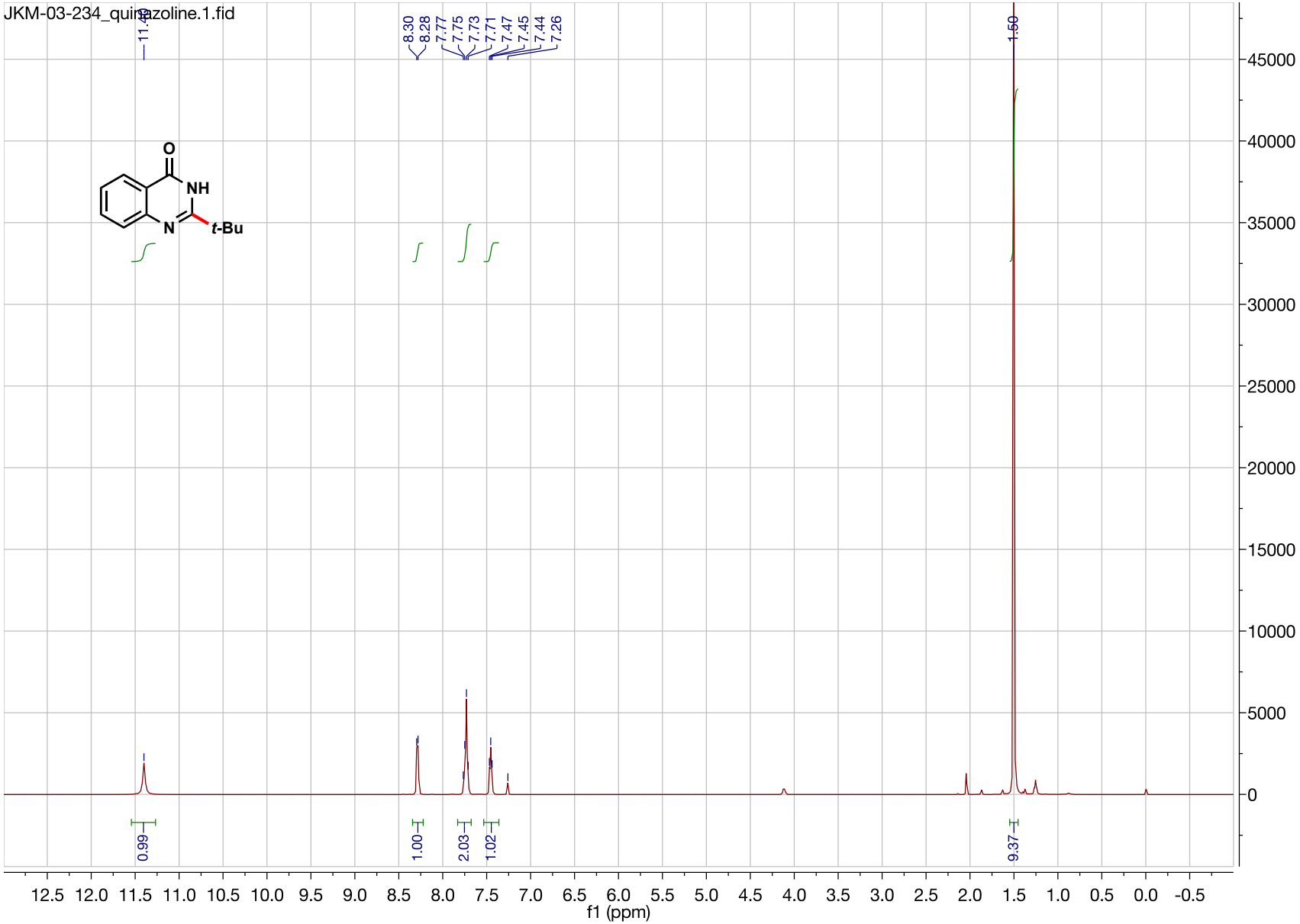
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(*tert*-butyl)benzo[*d*]thiazole (**1o**)



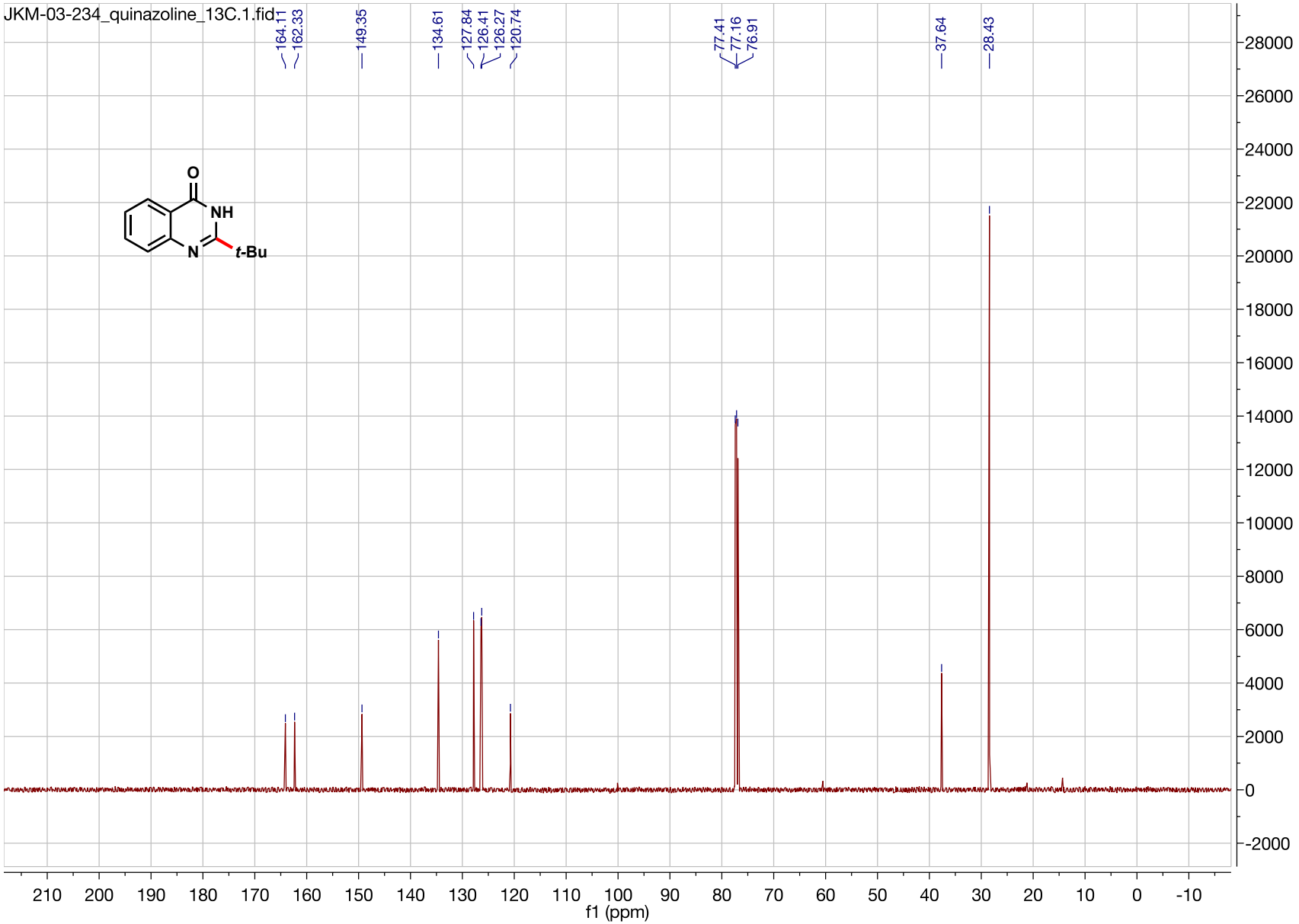
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(*tert*-butyl)benzo[*d*]thiazole (**1o**)



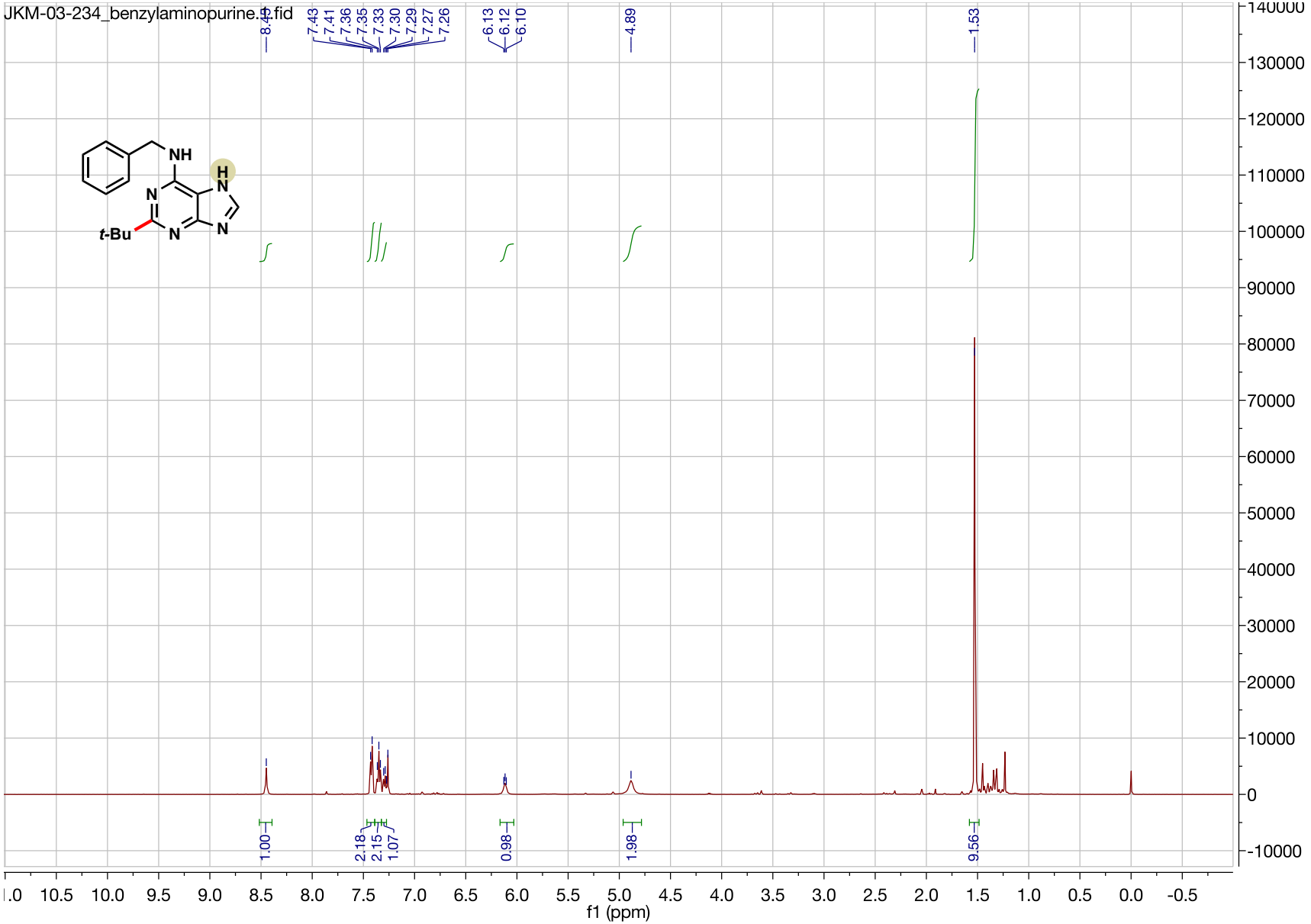
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(*tert*-butyl)quinazolin-4(3*H*)-one (**1p**)



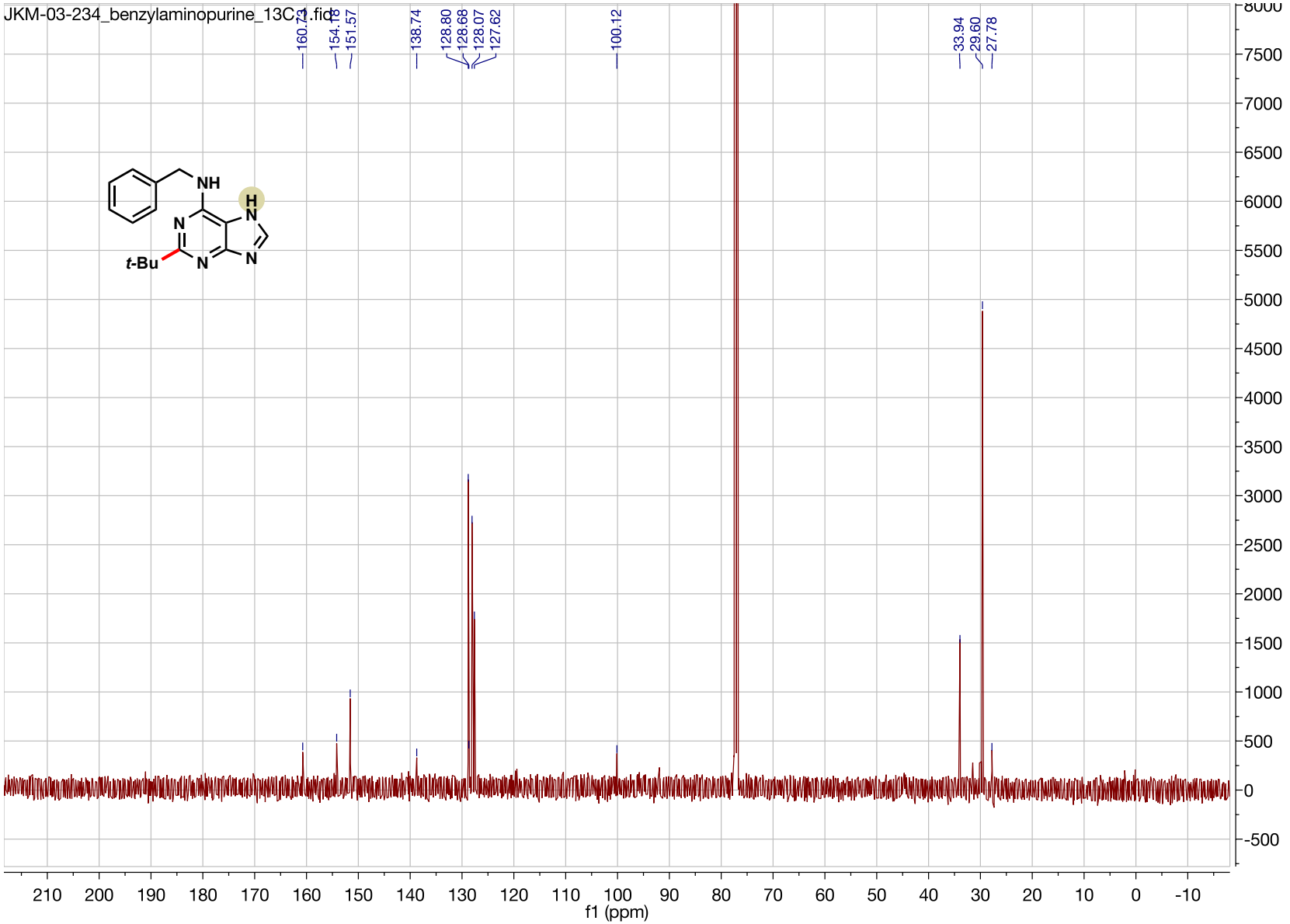
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(*tert*-butyl)quinazolin-4(3*H*)-one (**1p**)



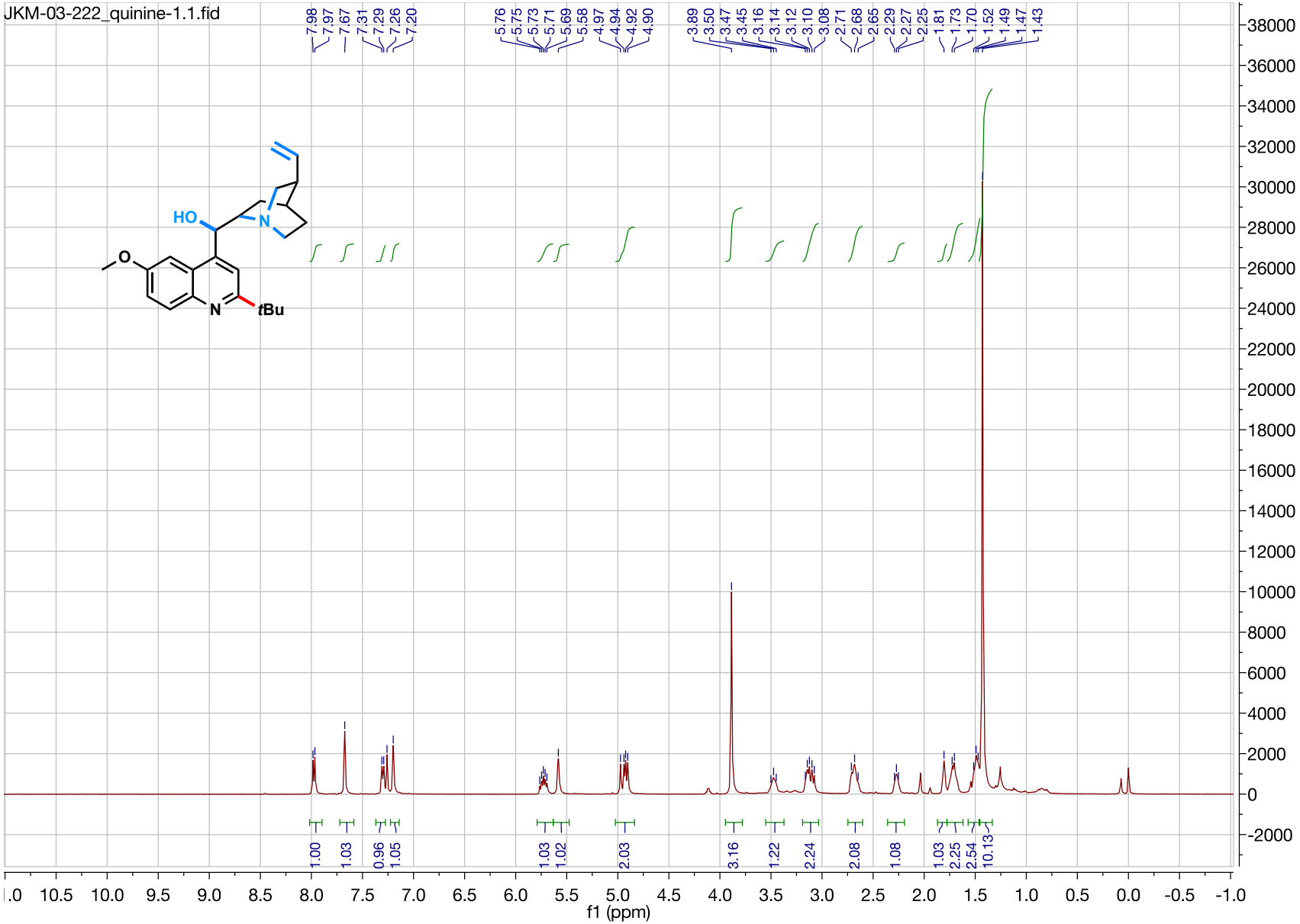
^{1}H ($CDCl_3$, 500 MHz) spectra of *N*-benzyl-2-(*tert*-butyl)-7*H*-purin-6-amine (**1q**)



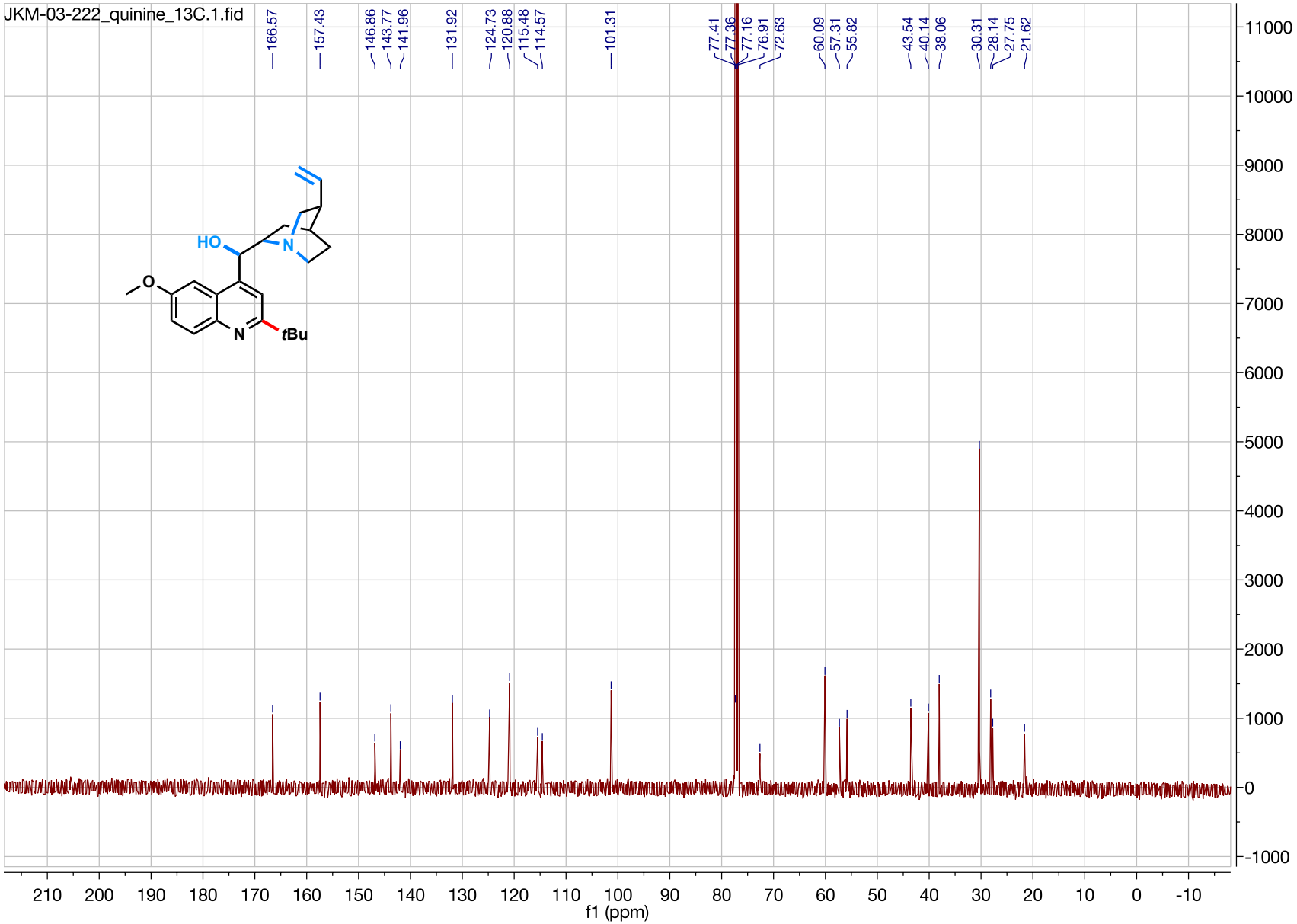
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of *N*-benzyl-2-(*tert*-butyl)-7*H*-purin-6-amine (**1q**)



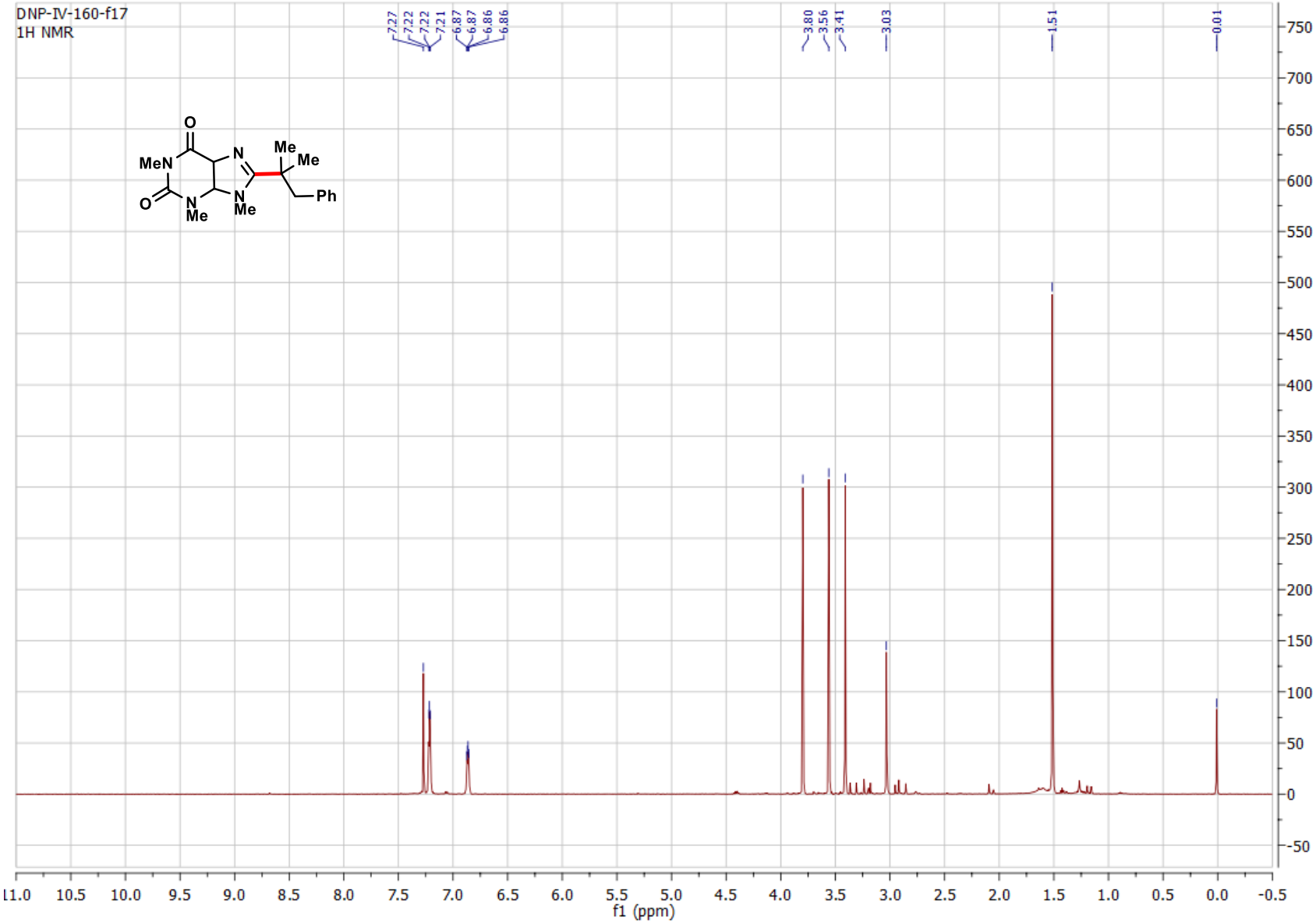
^{1}H ($CDCl_3$, 500 MHz) spectra of (1*R*)-(2-(*tert*-butyl)-6-methoxyquinolin-4-yl)(5-vinylquinuclidin-2-yl)methanol (**1r**)



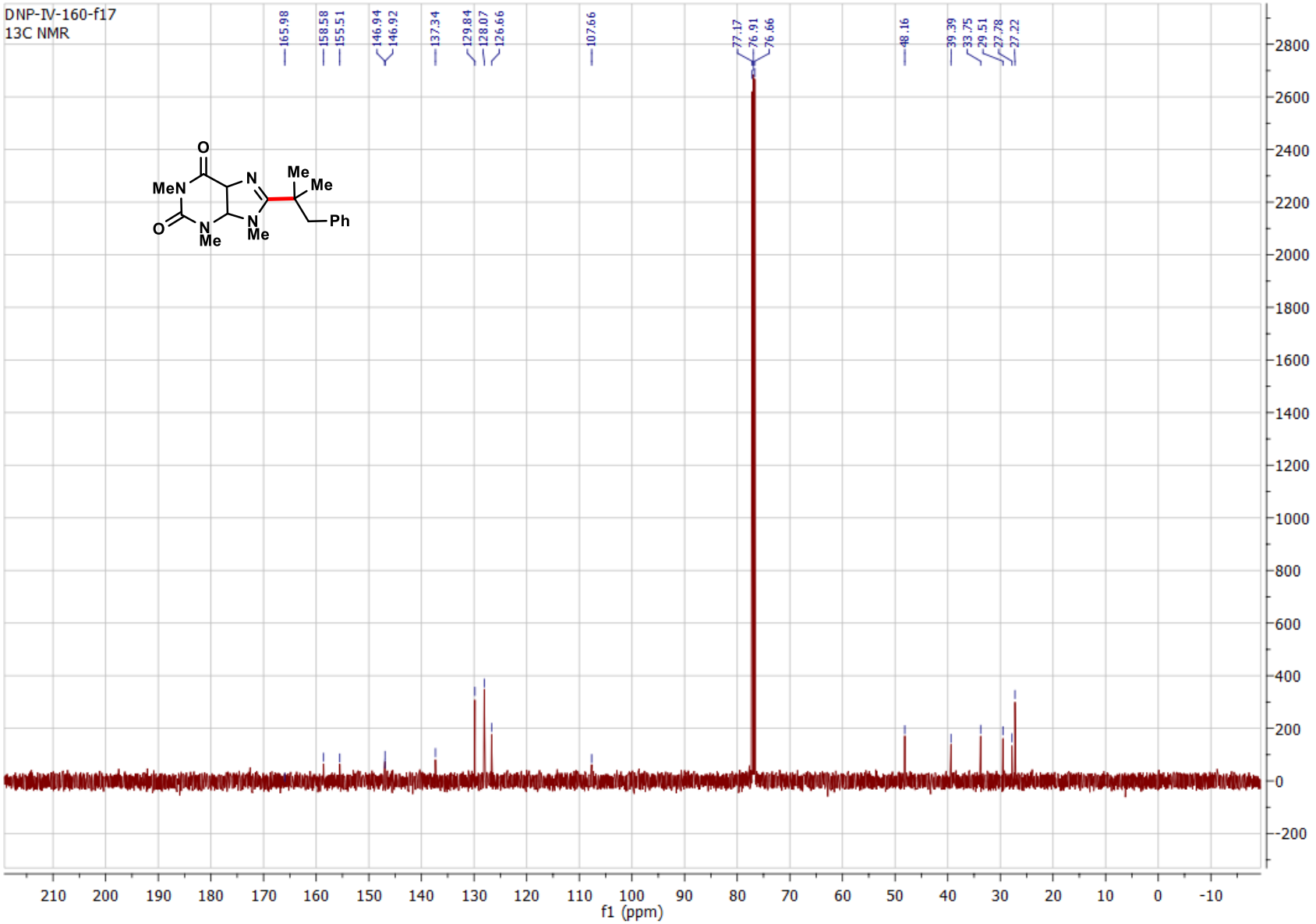
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of (1*R*)-(2-(*tert*-butyl)-6-methoxyquinolin-4-yl)(5-vinylquinuclidin-2-yl)methanol (**1r**)



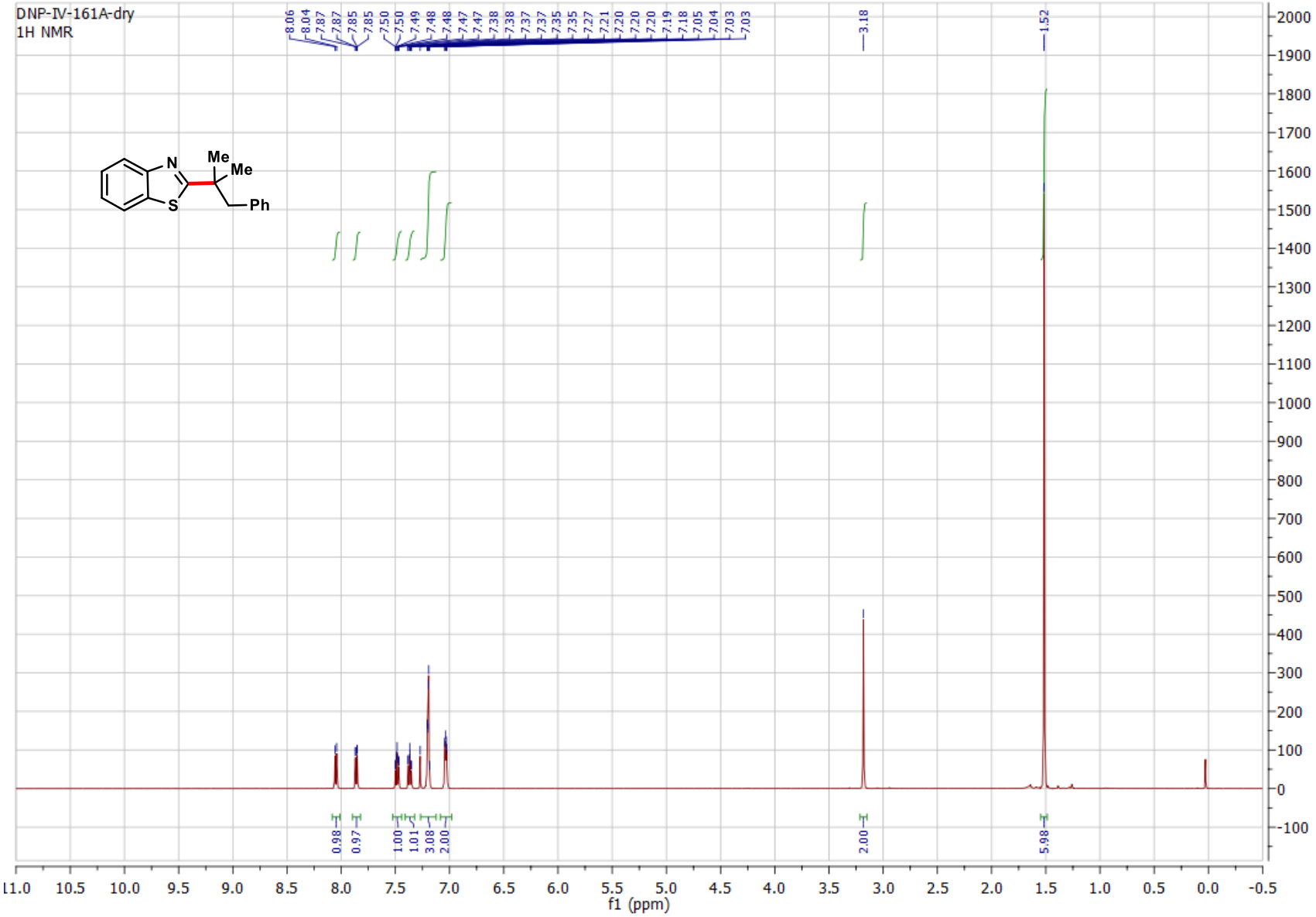
^{1}H ($CDCl_3$, 500 MHz) spectra of 1,3,9-trimethyl-8-(2-methyl-1-phenylpropan-2-yl)-3,9-dihydro-1H-purine-2,6-dione (**1v**)



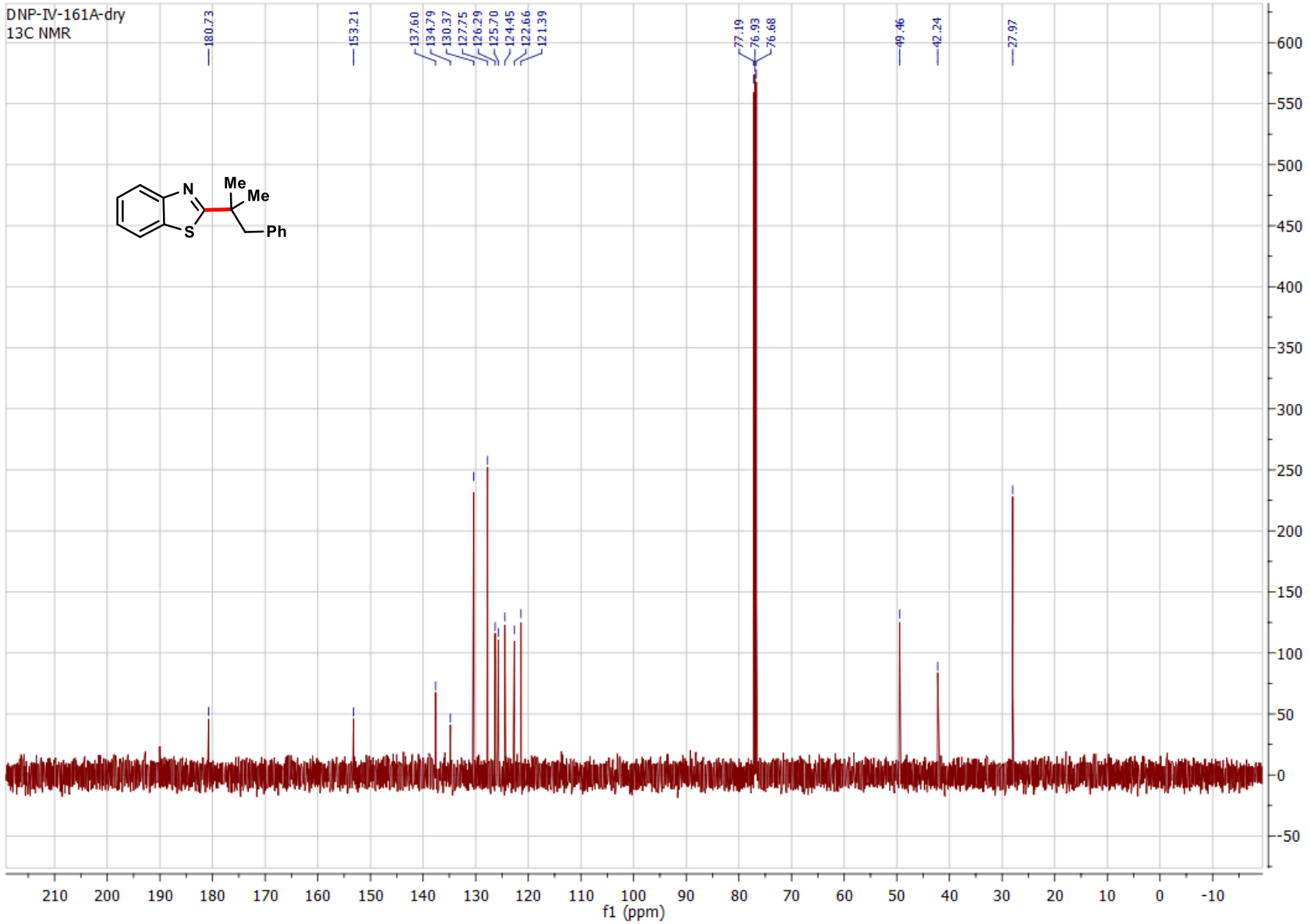
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 1,3,9-trimethyl-8-(2-methyl-1-phenylpropan-2-yl)-3,9-dihydro-1H-purine-2,6-dione (**1v**)



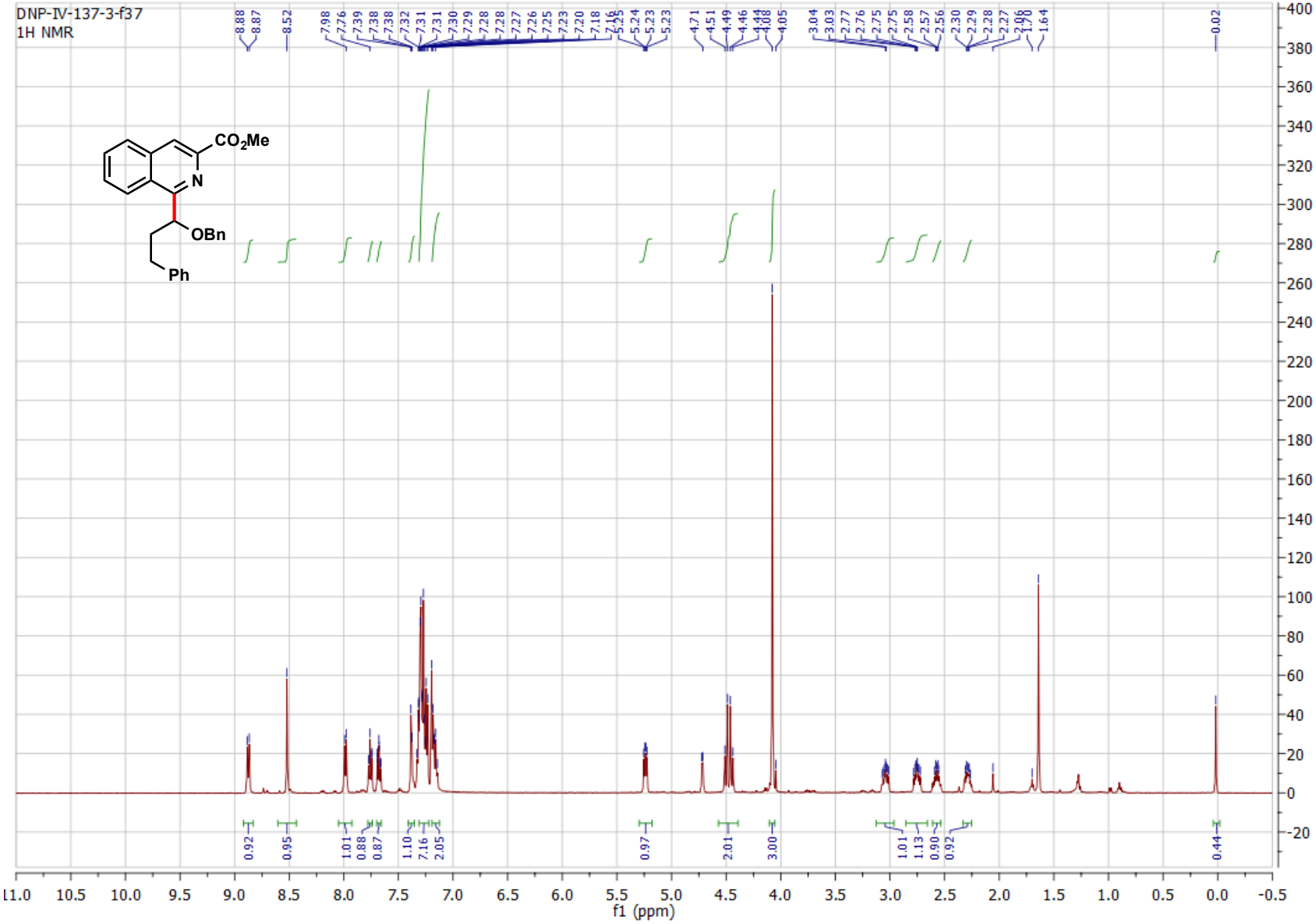
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(2-methyl-1-phenylpropan-2-yl)benzo[d]thiazole (**1w**)



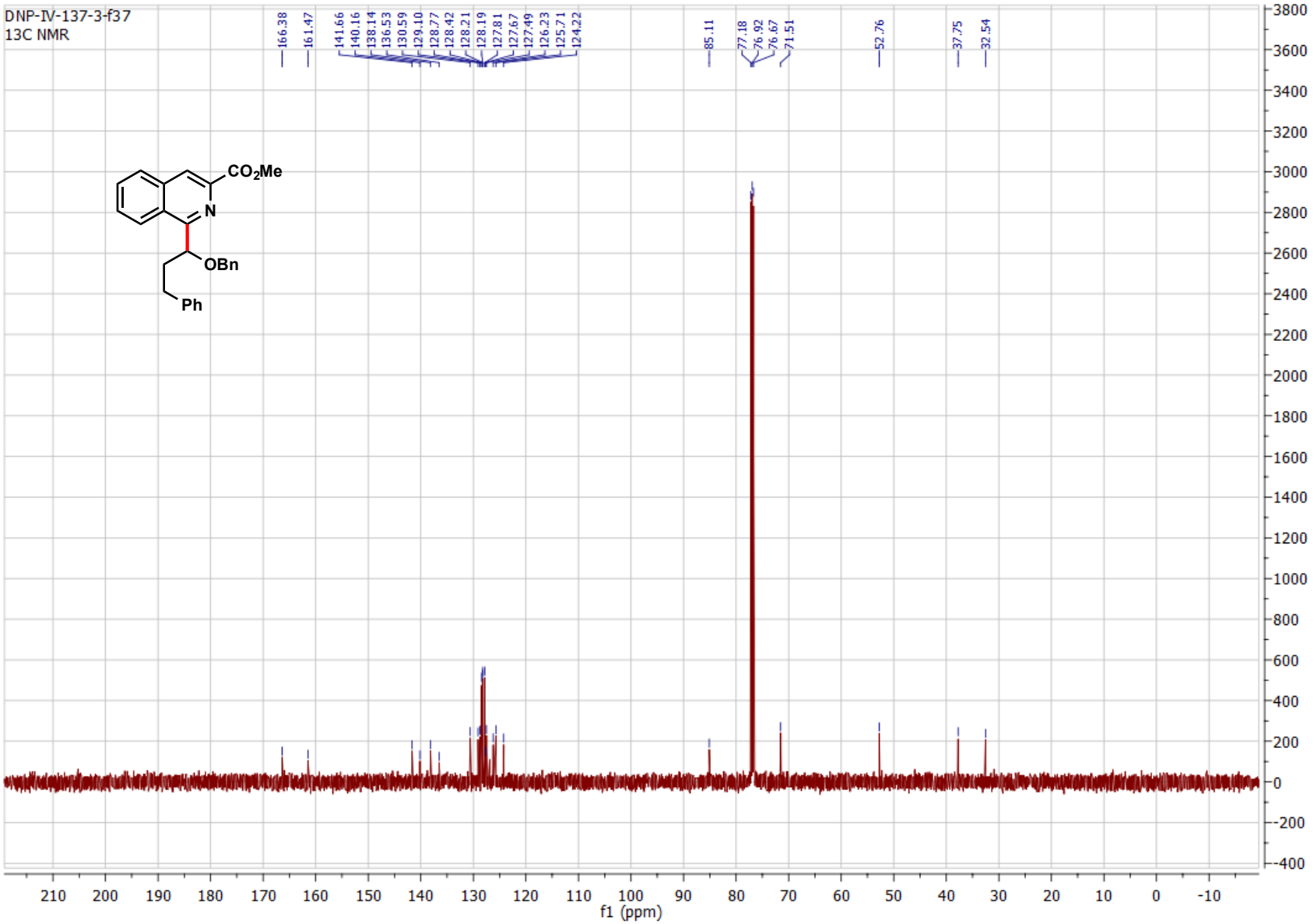
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(2-methyl-1-phenylpropan-2-yl)benzo[d]thiazole (**1w**)



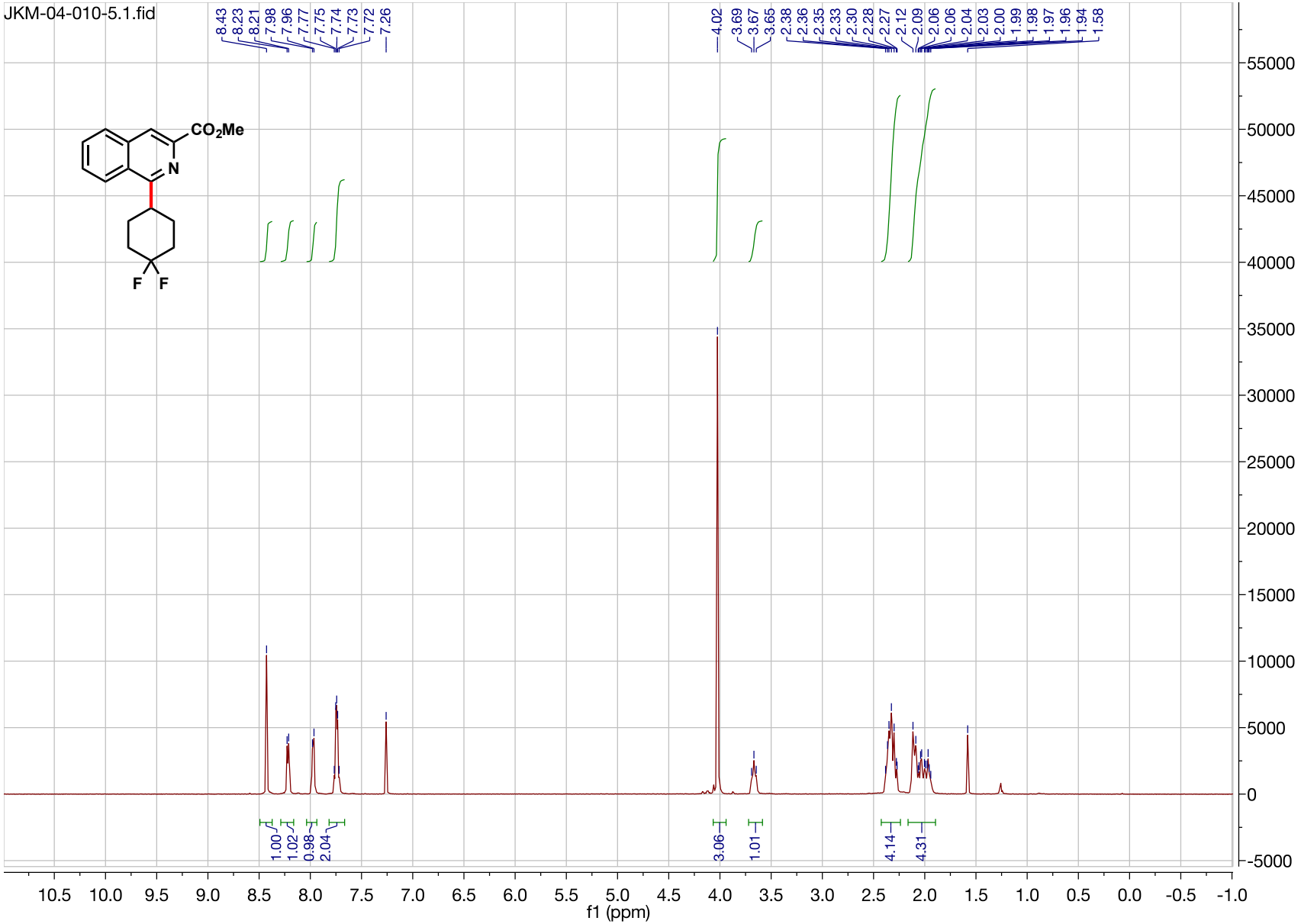
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(1-(benzyloxy)-3-phenylpropyl)isoquinoline-3-carboxylate (**2a**)



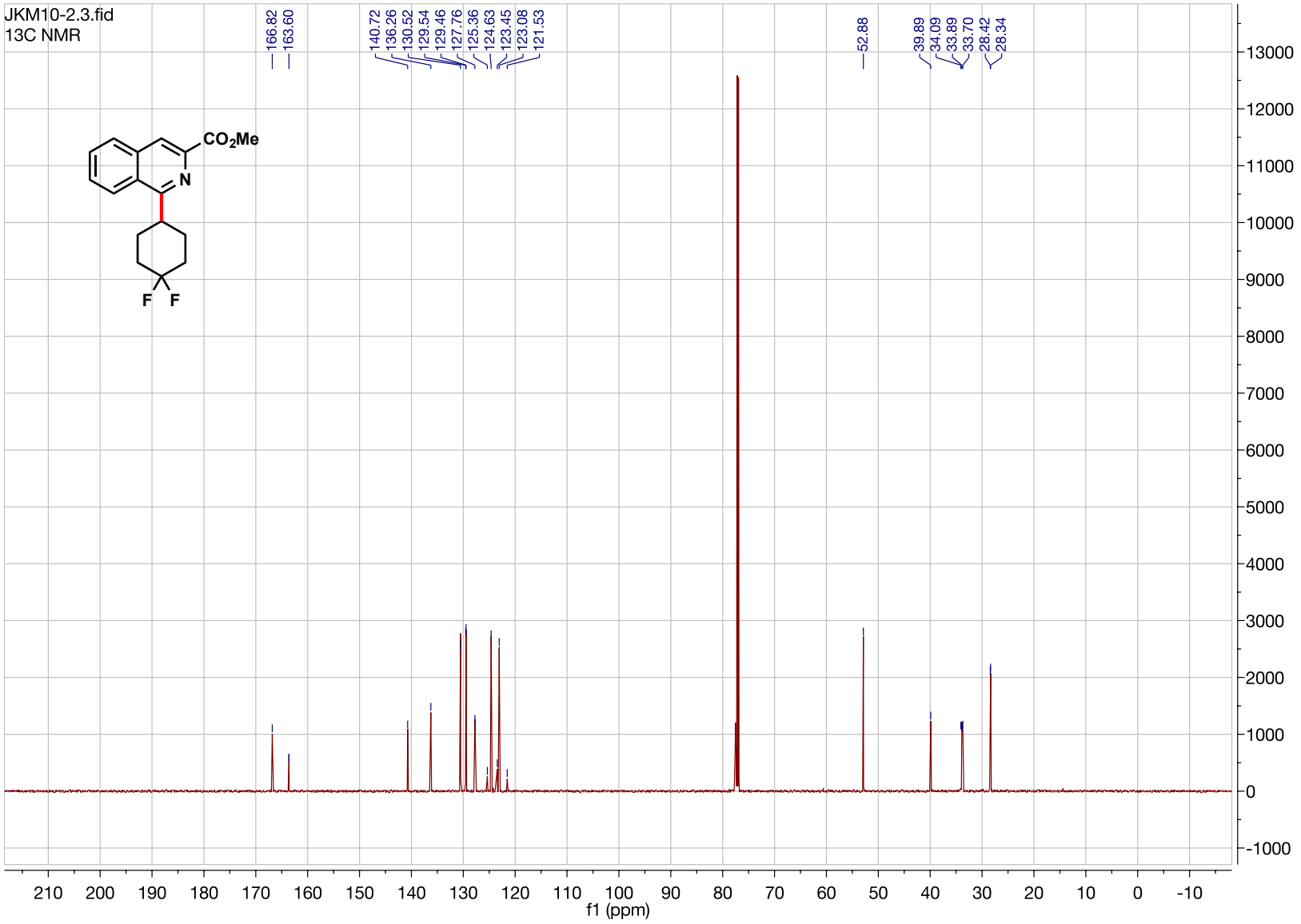
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(1-(benzyloxy)-3-phenylpropyl)isoquinoline-3-carboxylate (**2a**)



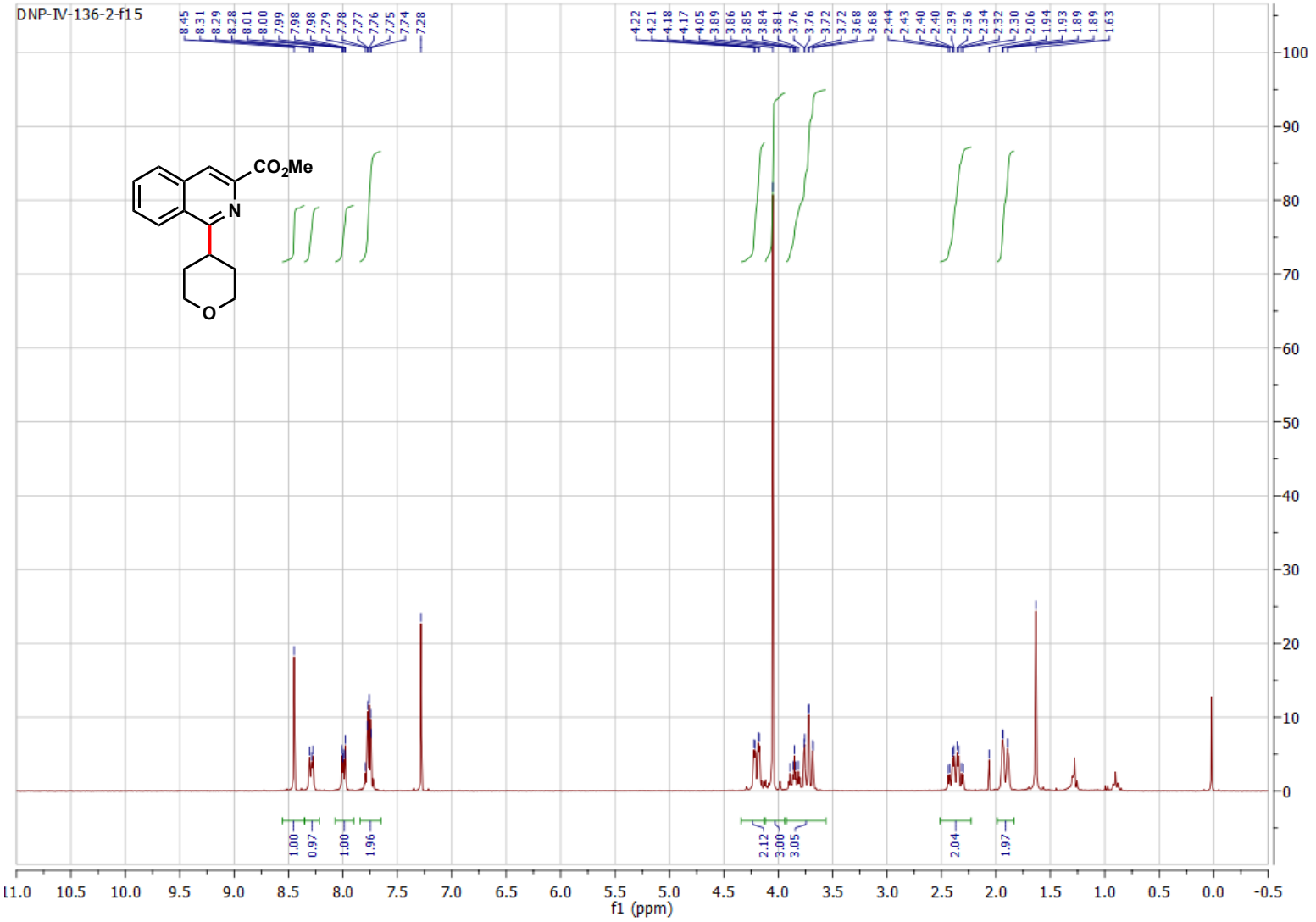
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(4,4-difluorocyclohexyl)isoquinoline-3-carboxylate (**2b**)



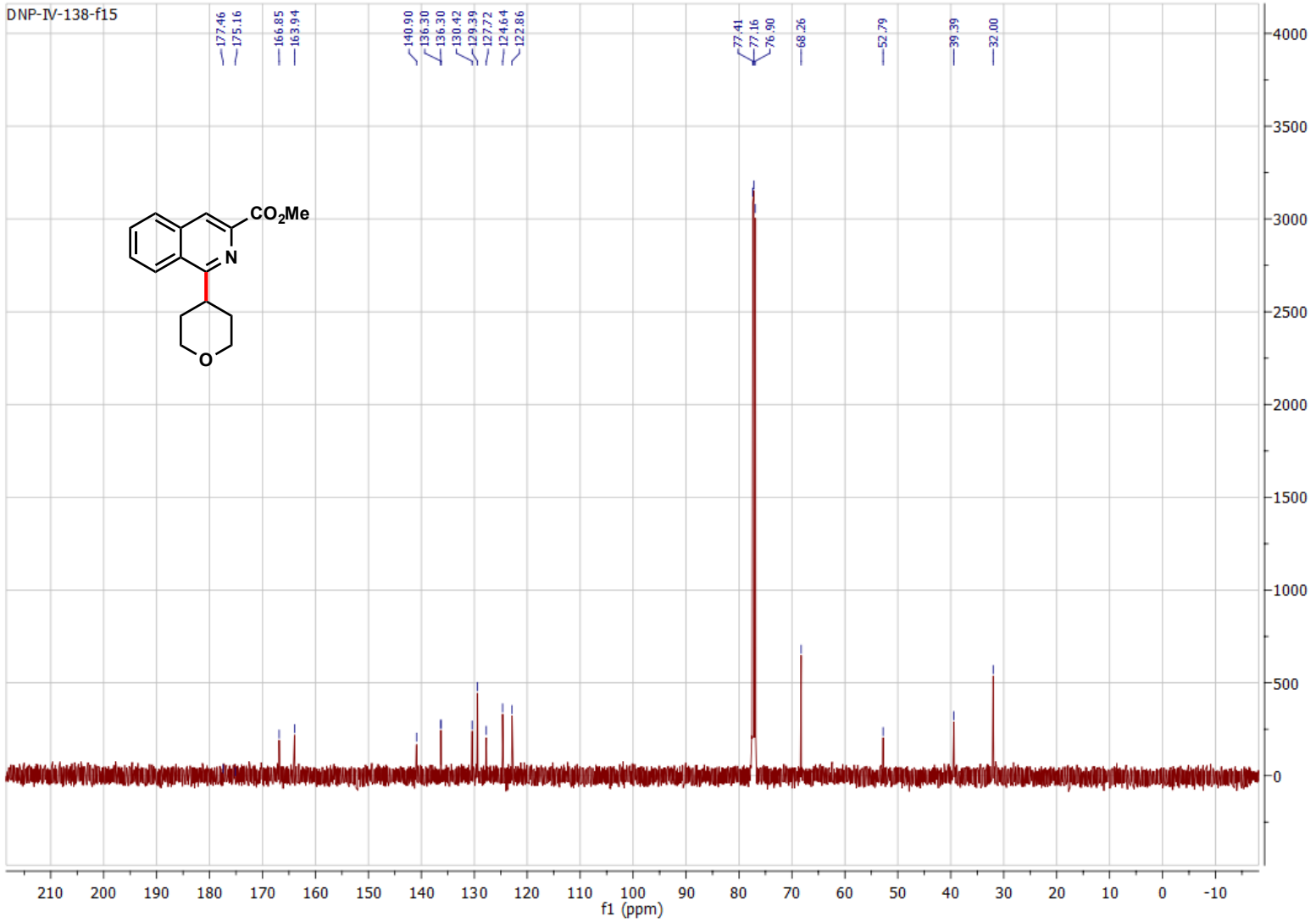
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(4,4-difluorocyclohexyl)isoquinoline-3-carboxylate (**2b**)



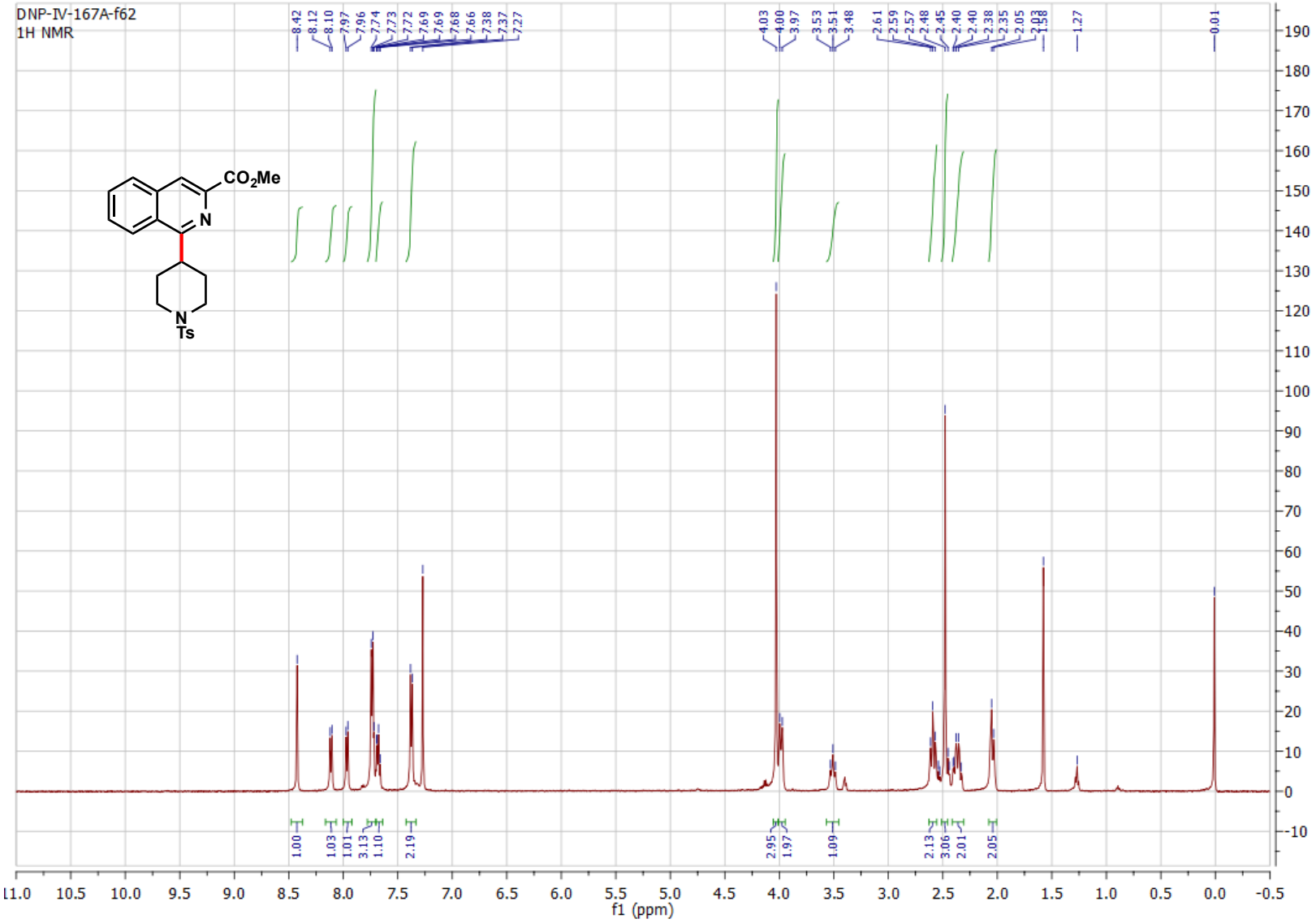
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(tetrahydro-2H-pyran-4-yl)isoquinoline-3-carboxylate (**2c**)



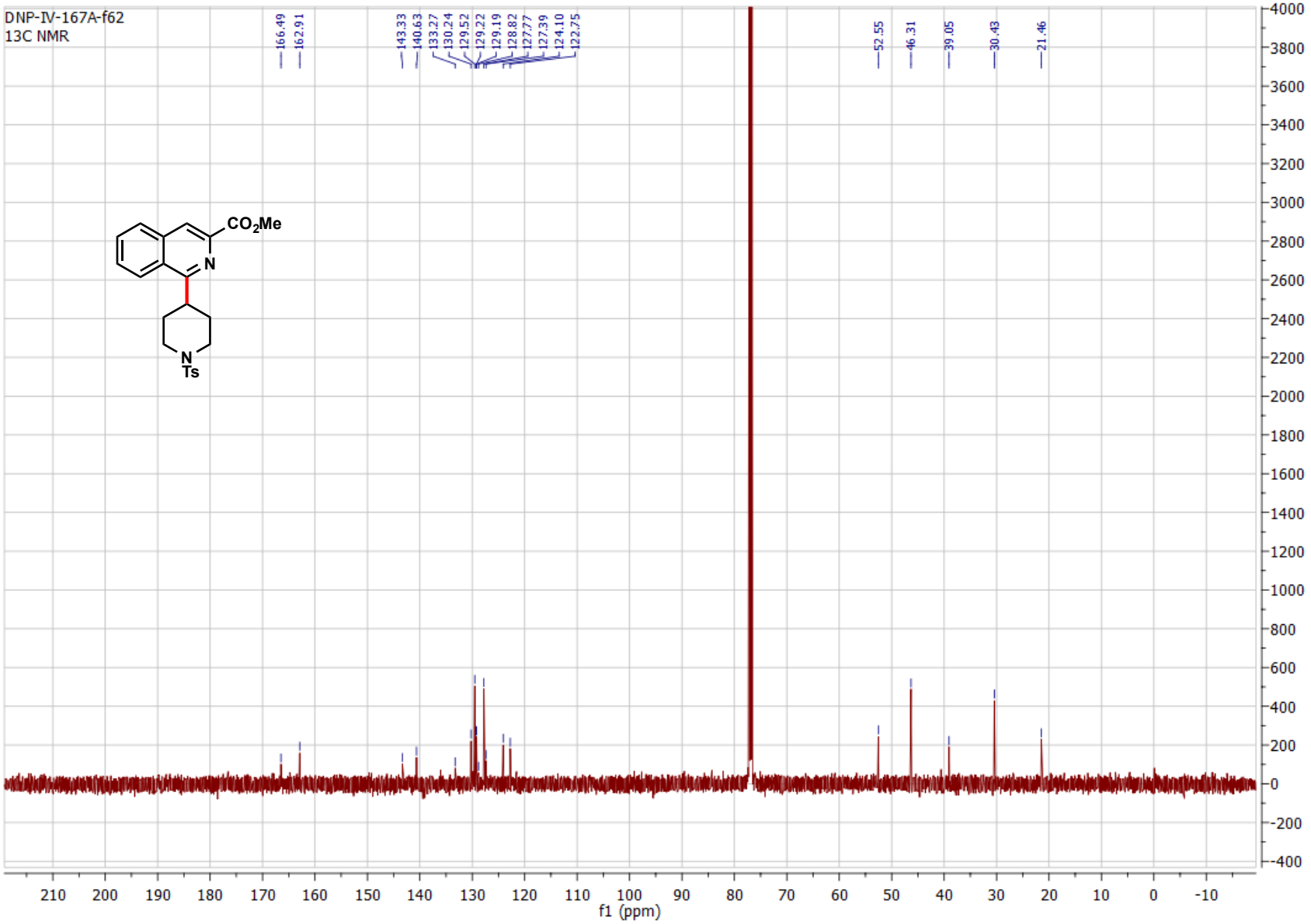
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(tetrahydro-2H-pyran-4-yl)isoquinoline-3-carboxylate (**2c**)



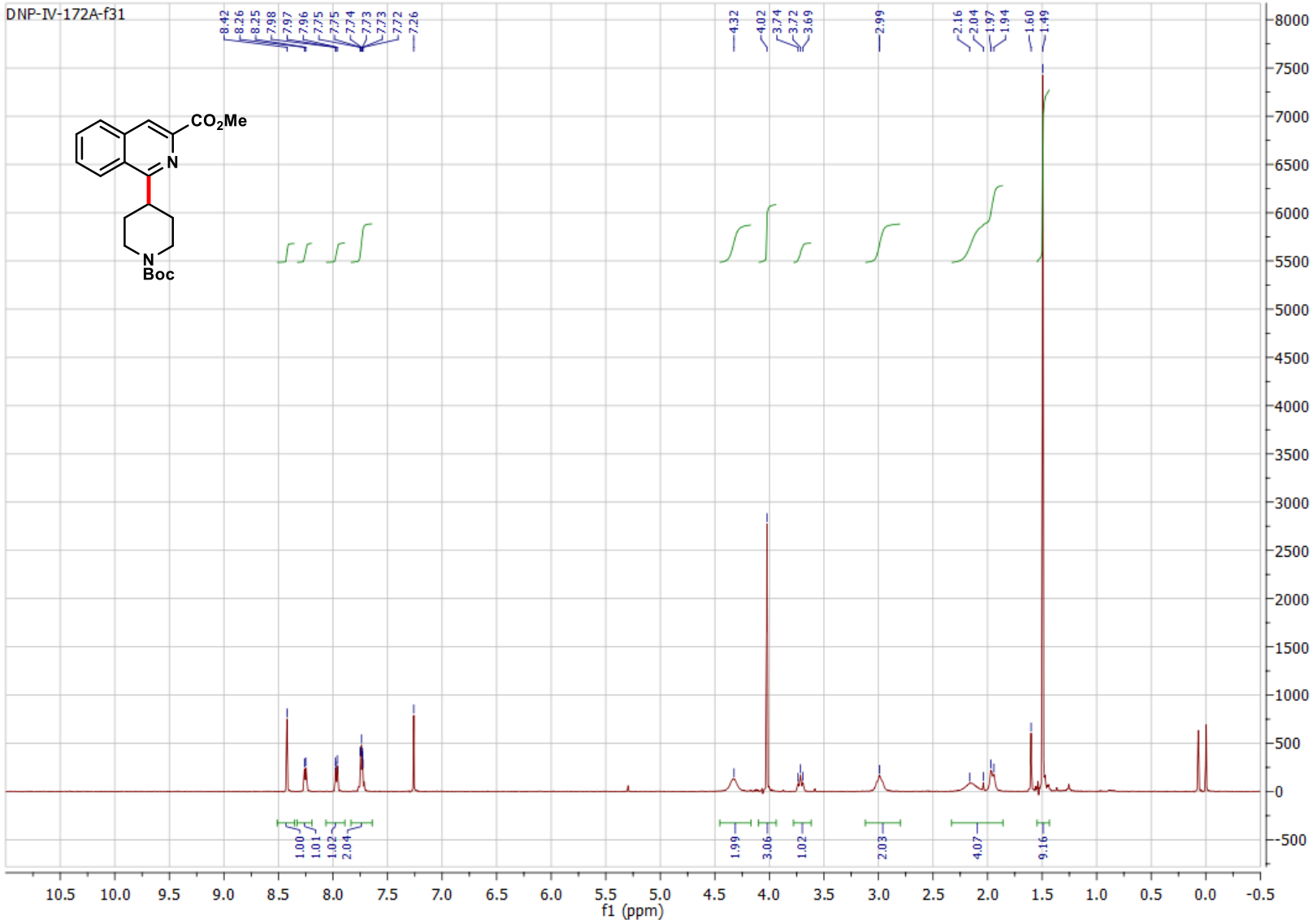
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(1-tosylpiperidin-4-yl)isoquinoline-3-carboxylate (**2d**)



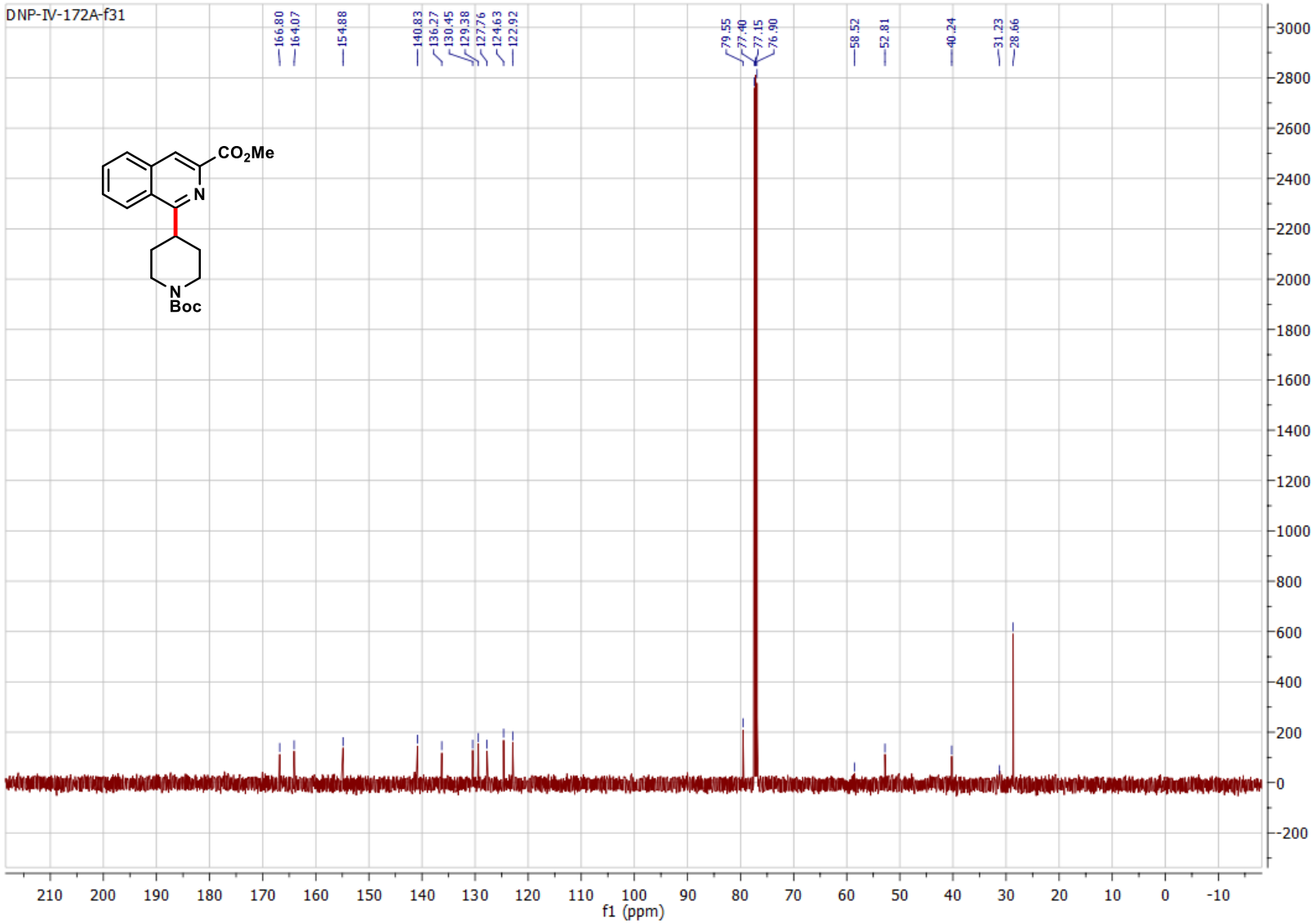
^{13}C ($CDCl_3$, 125.8 MHz) spectra of methyl 1-(1-tosylpiperidin-4-yl)isoquinoline-3-carboxylate (**2d**)



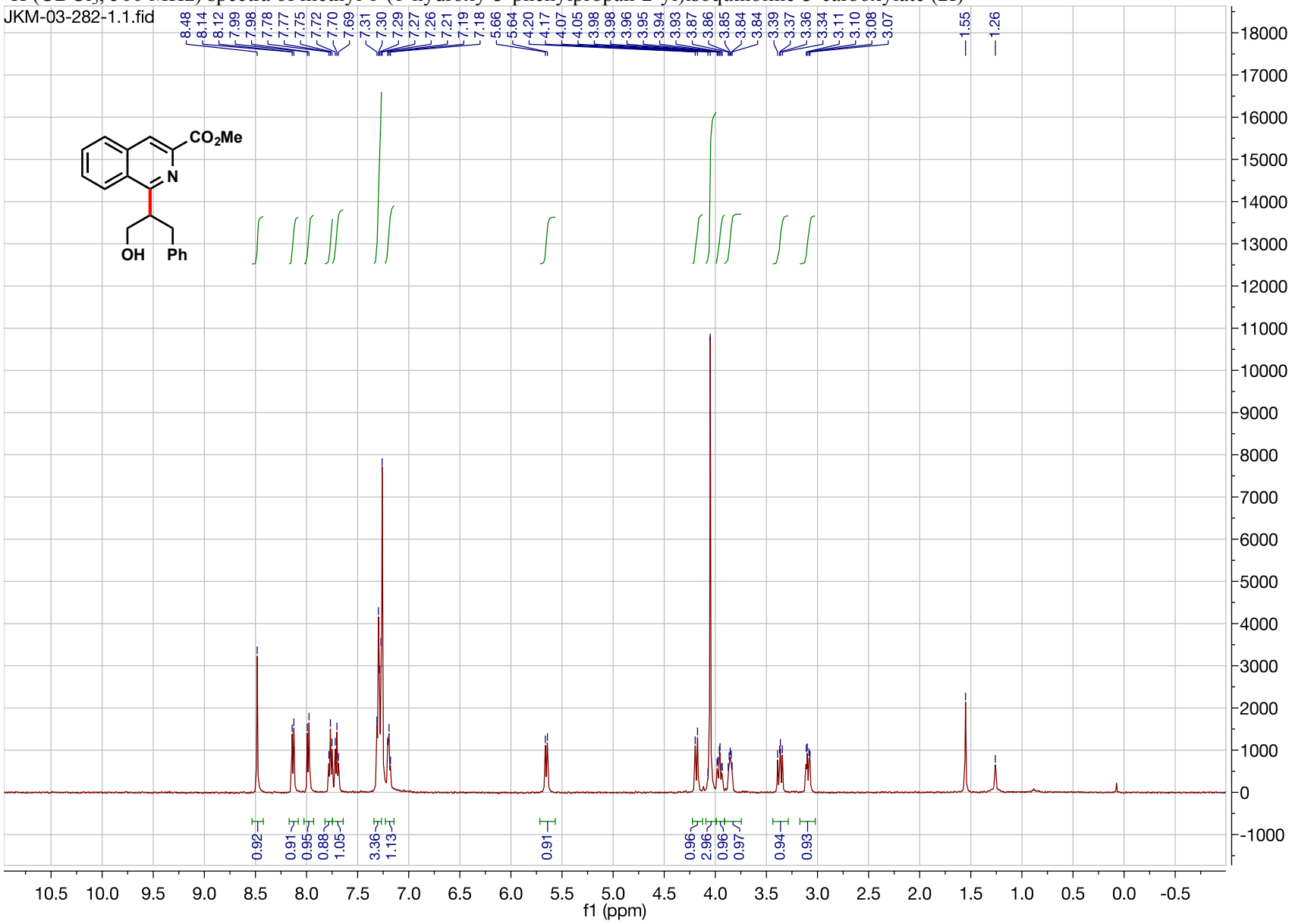
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(1-(*tert*-butoxycarbonyl)piperidin-4-yl)isoquinoline-3-carboxylate (**2e**)



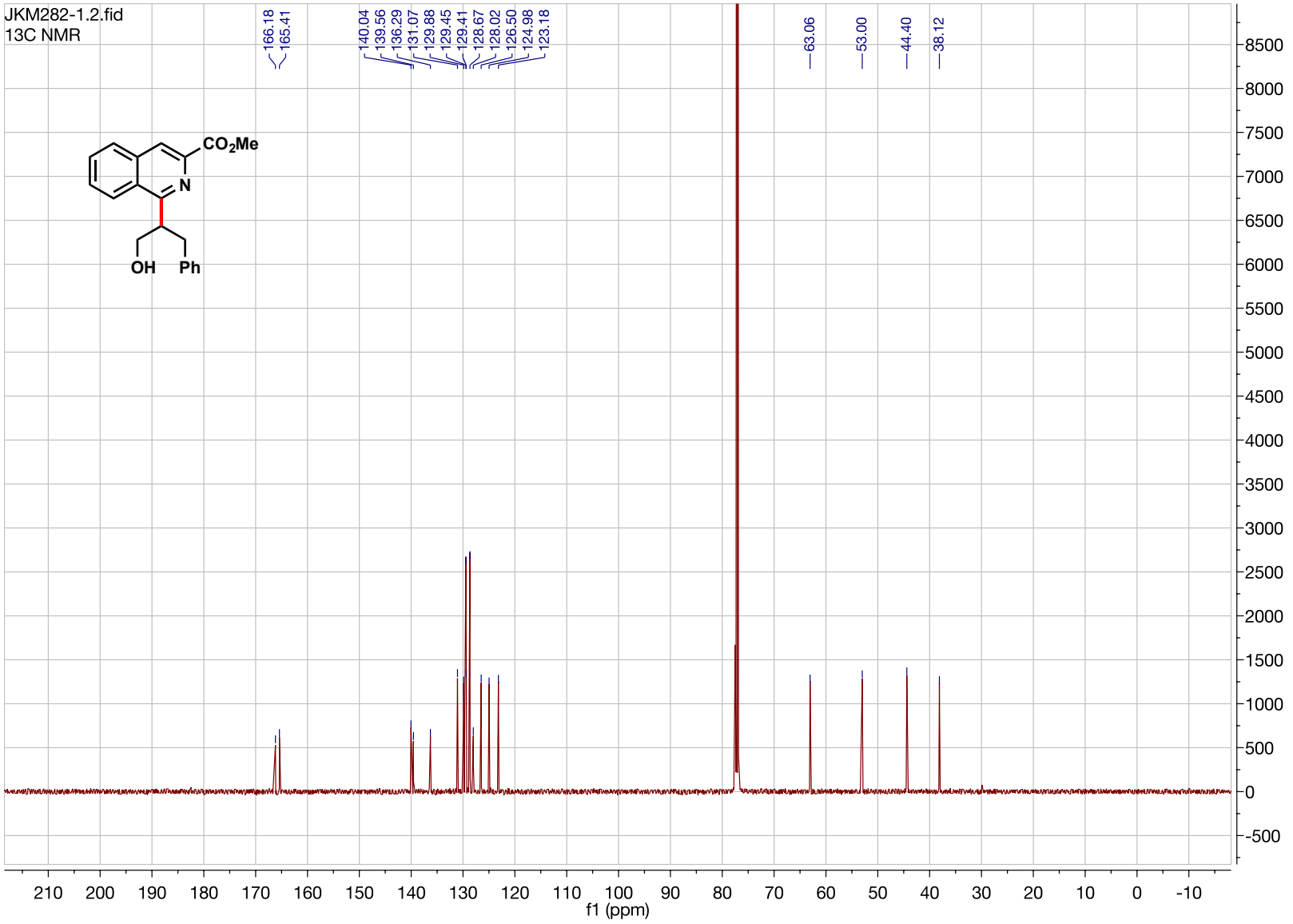
^{13}C ($CDCl_3$, 125.8 MHz) spectra of methyl 1-(1-(*tert*-butoxycarbonyl)piperidin-4-yl)isoquinoline-3-carboxylate (**2e**)



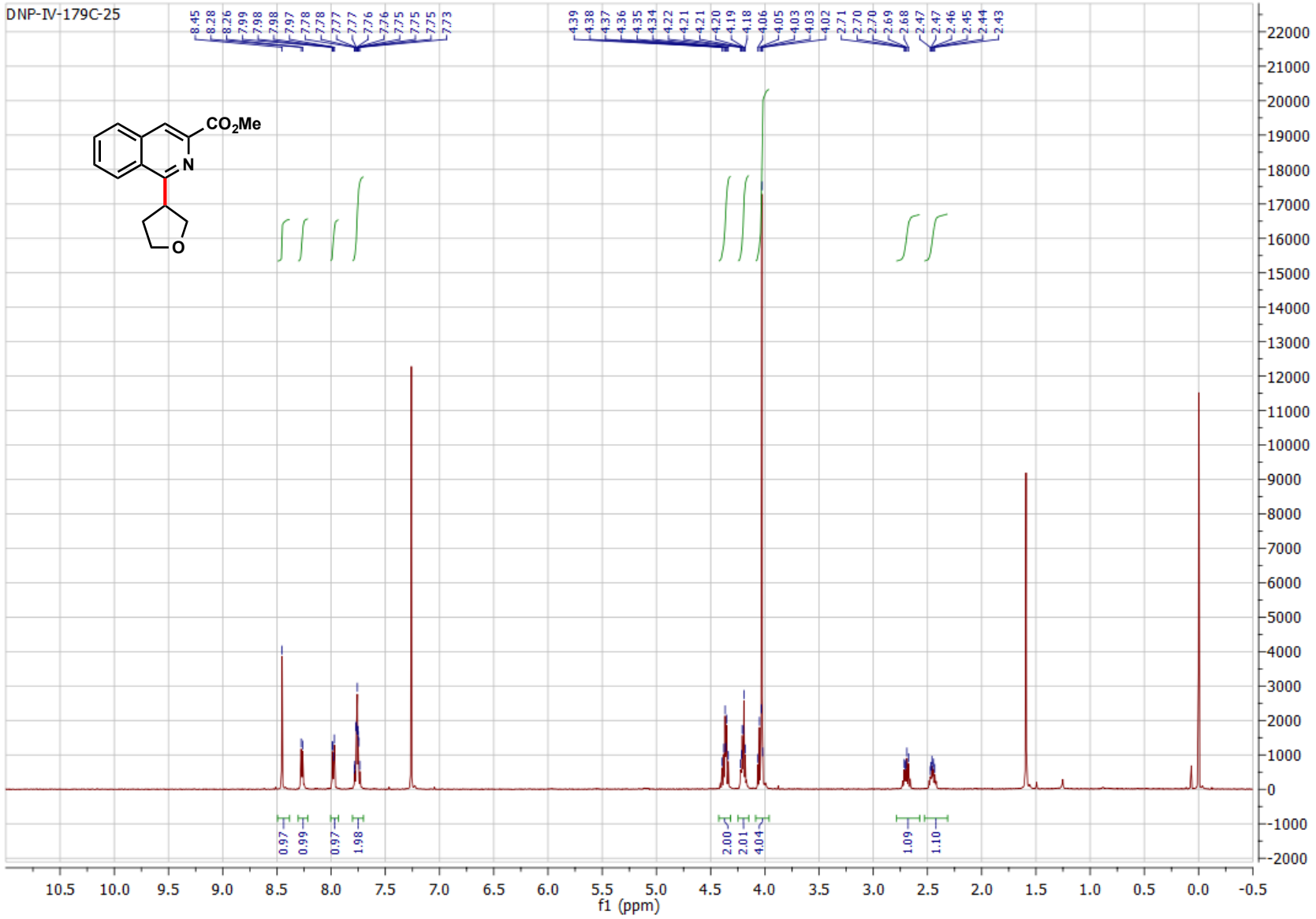
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(1-hydroxy-3-phenylpropan-2-yl)isoquinoline-3-carboxylate (**2f**)



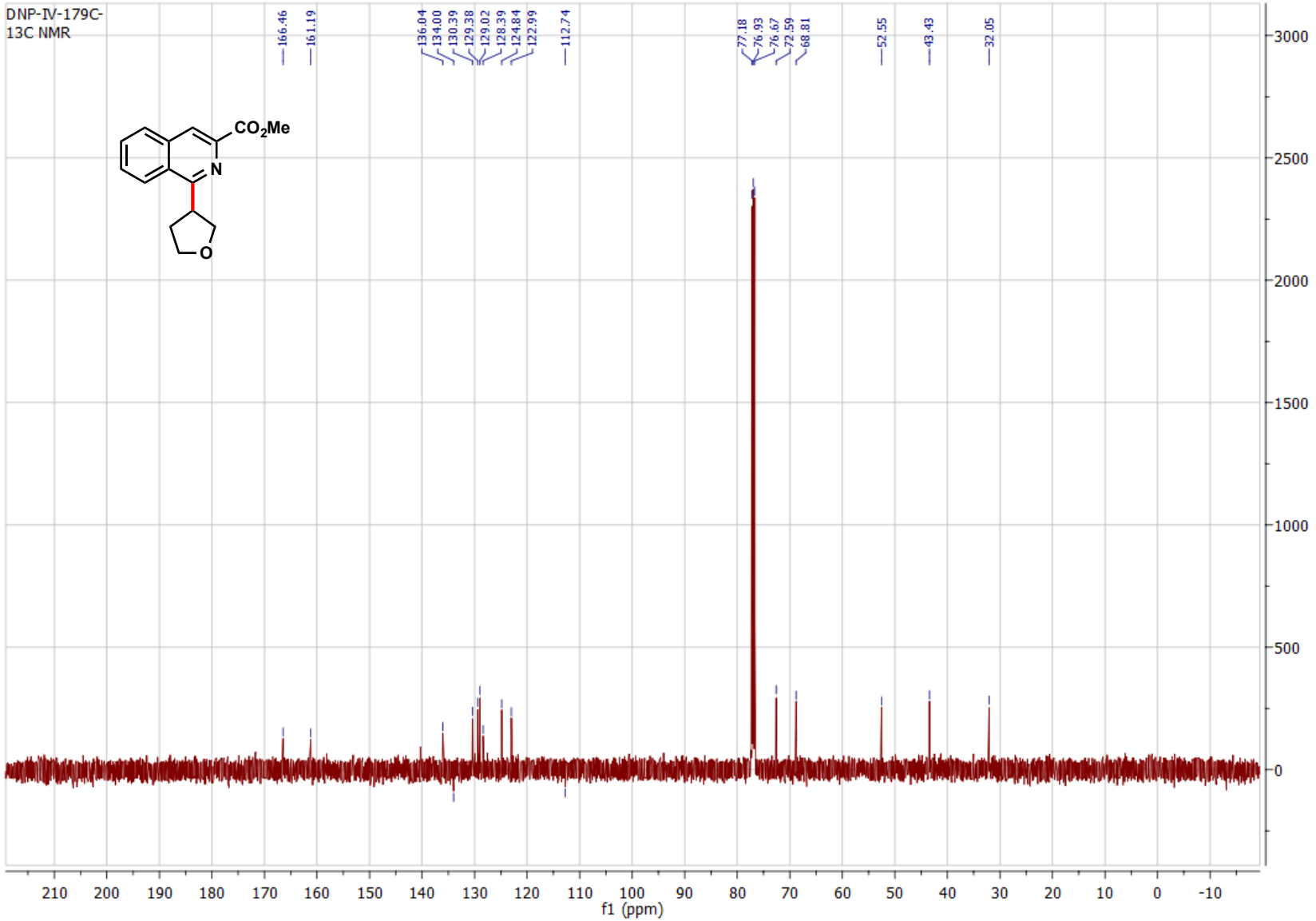
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(1-hydroxy-3-phenylpropan-2-yl)isoquinoline-3-carboxylate (**2f**)



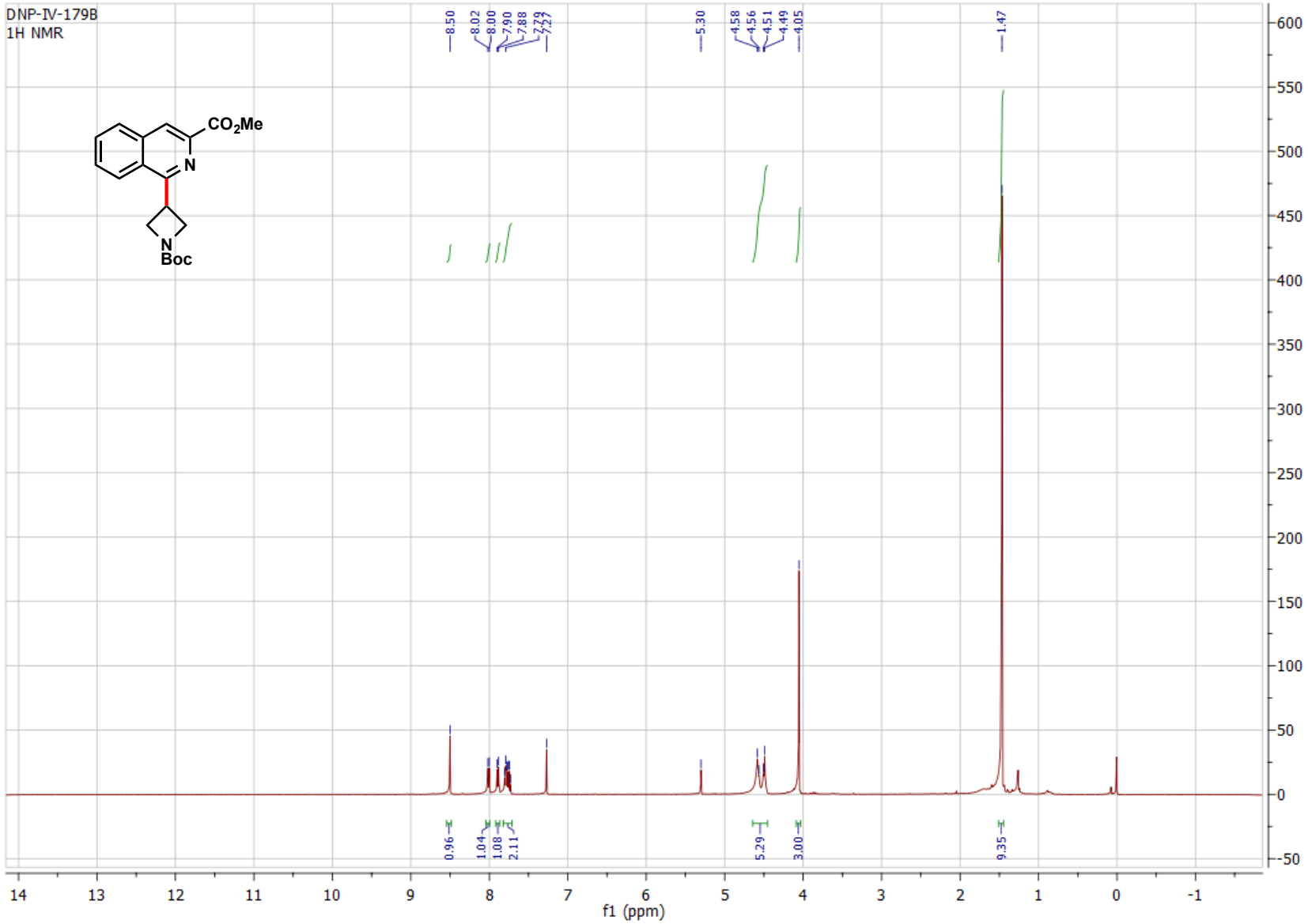
^{1}H NMR ($CDCl_3$, 500 MHz) spectrum of methyl 1-(tetrahydrofuran-3-yl)isoquinoline-3-carboxylate (**2g**)



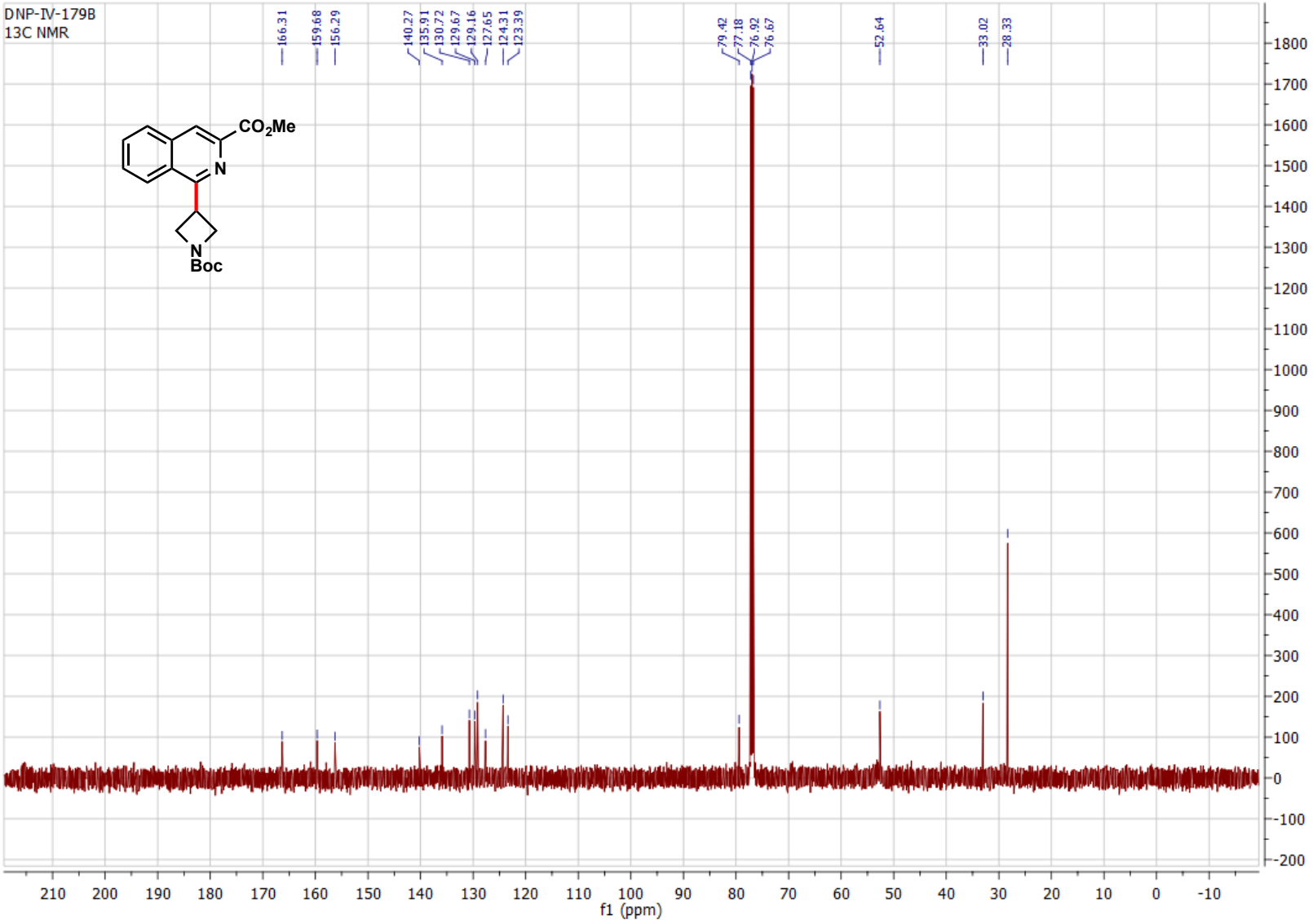
^{1}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(tetrahydrofuran-3-yl)isoquinoline-3-carboxylate (**2g**)



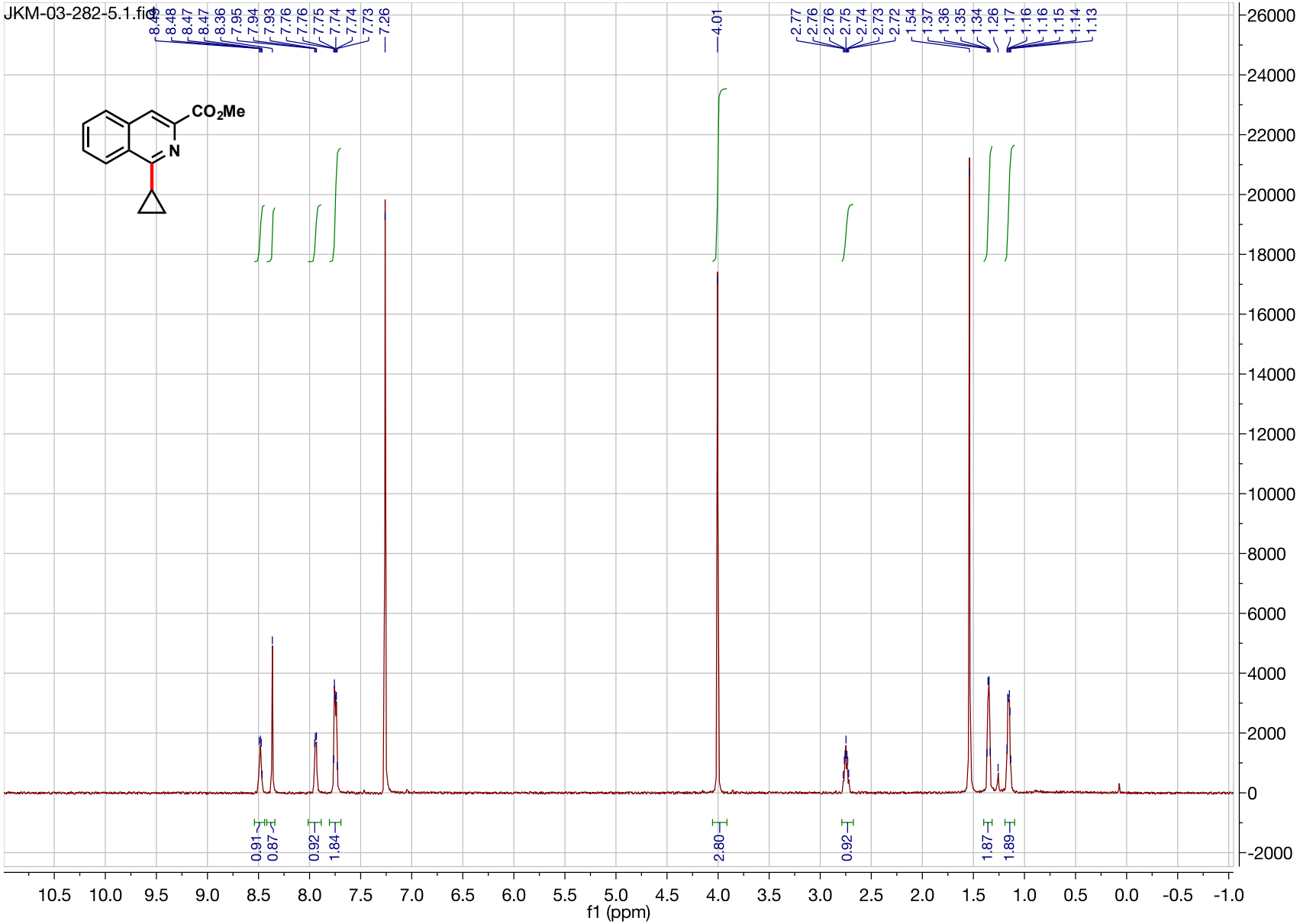
^{1}H NMR ($CDCl_3$, 500 MHz) spectrum of methyl 1-(1-(*tert*-butoxycarbonyl)azetidin-3-yl)isoquinoline-3-carboxylate (**2i**)



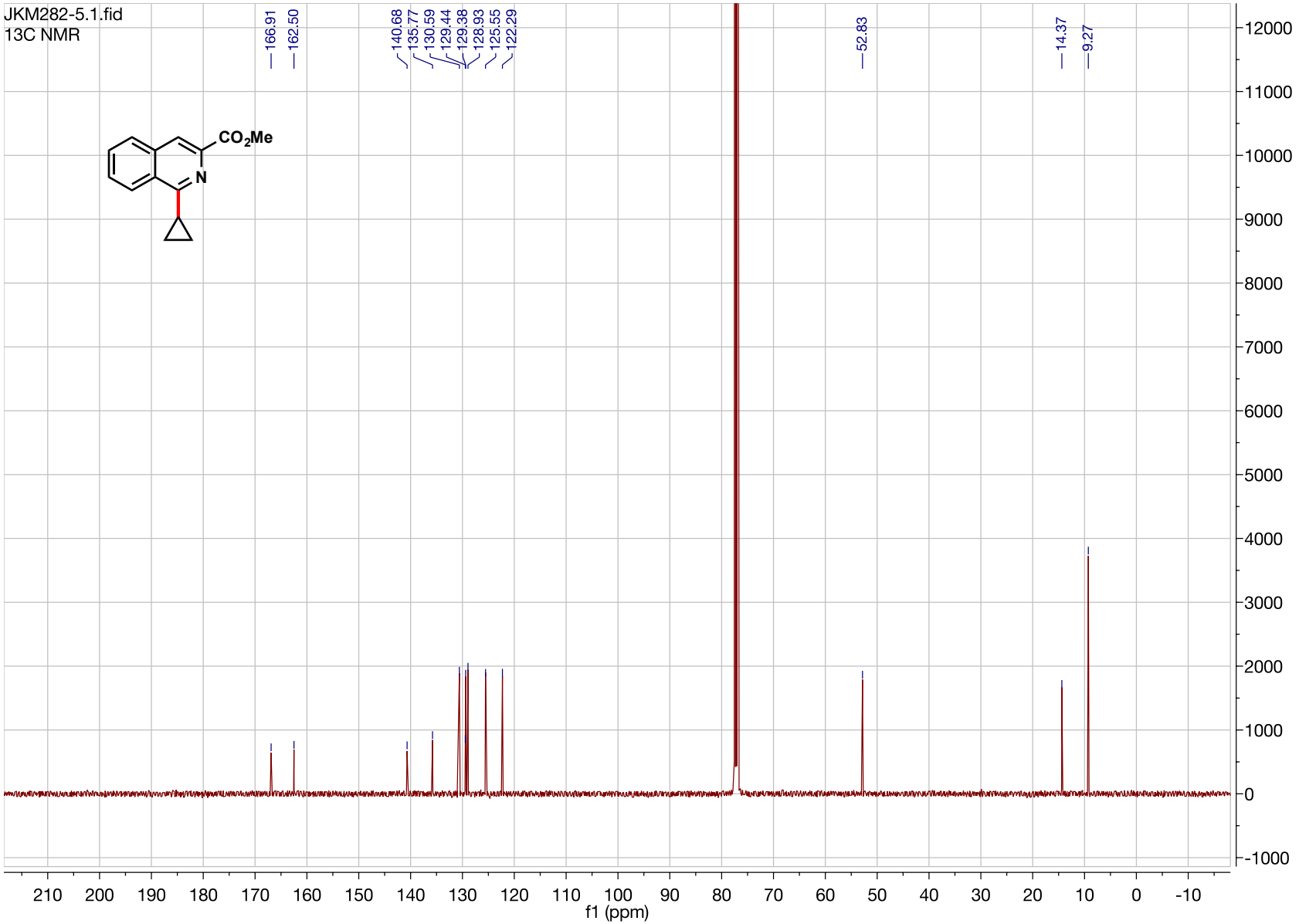
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(1-(*tert*-butoxycarbonyl)azetidin-3-yl)isoquinoline-3-carboxylate (**2i**)



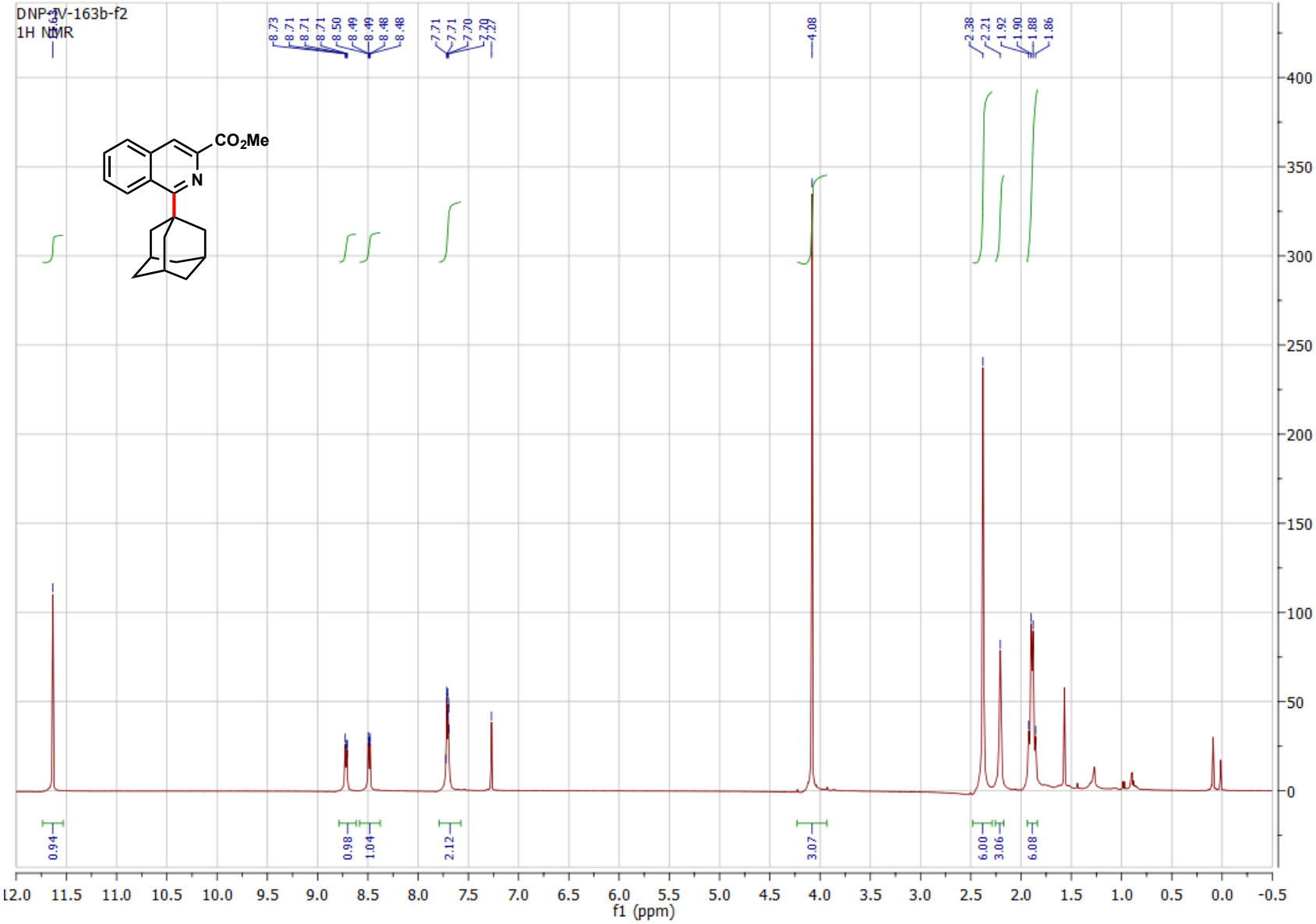
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-cyclopropylisoquinoline-3-carboxylate (**2j**)



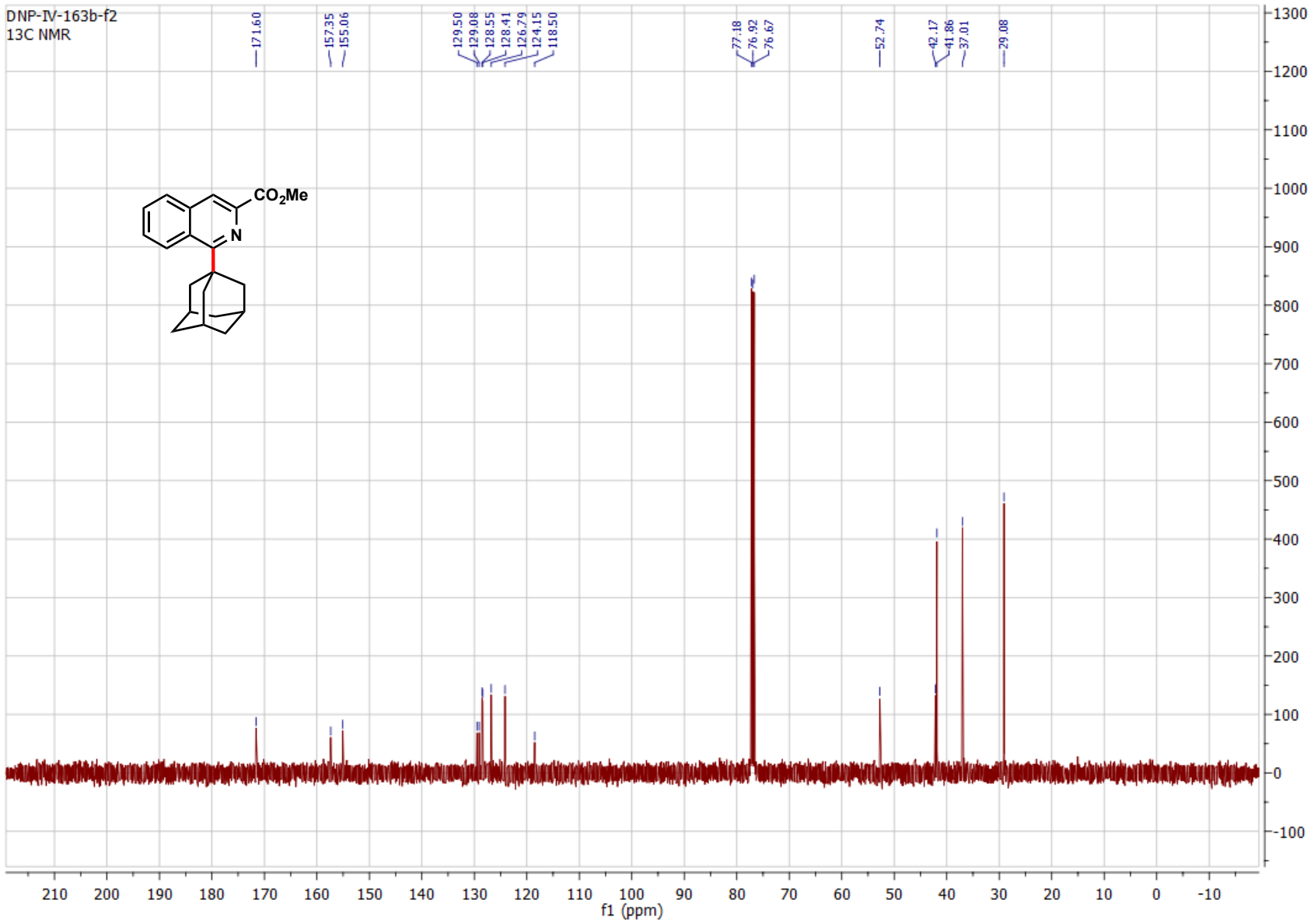
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-cyclopropylisoquinoline-3-carboxylate (**2j**)



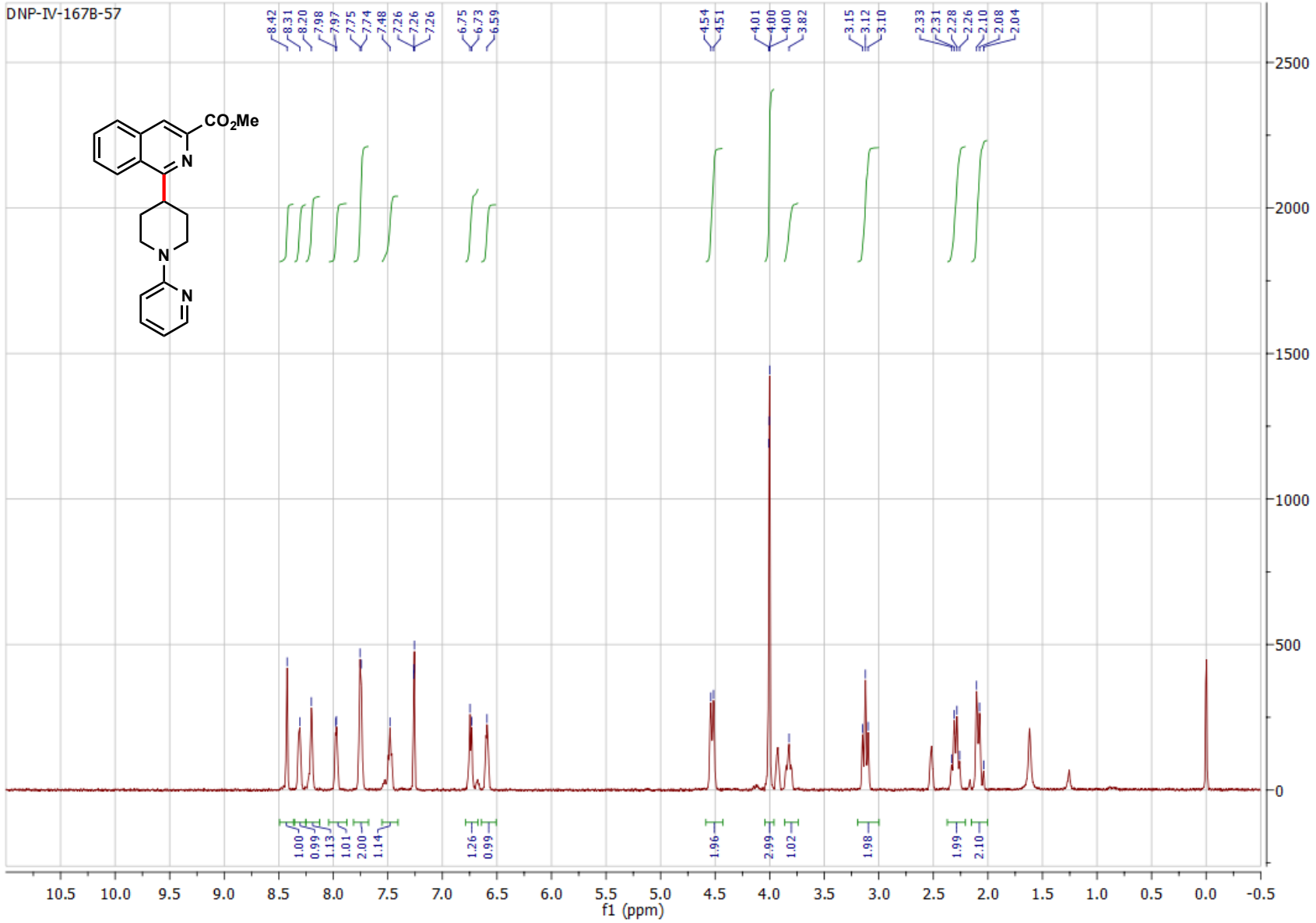
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-((3*r*,5*r*,7*r*)-adamantan-1-yl)isoquinoline-3-carboxylate (**2k**)



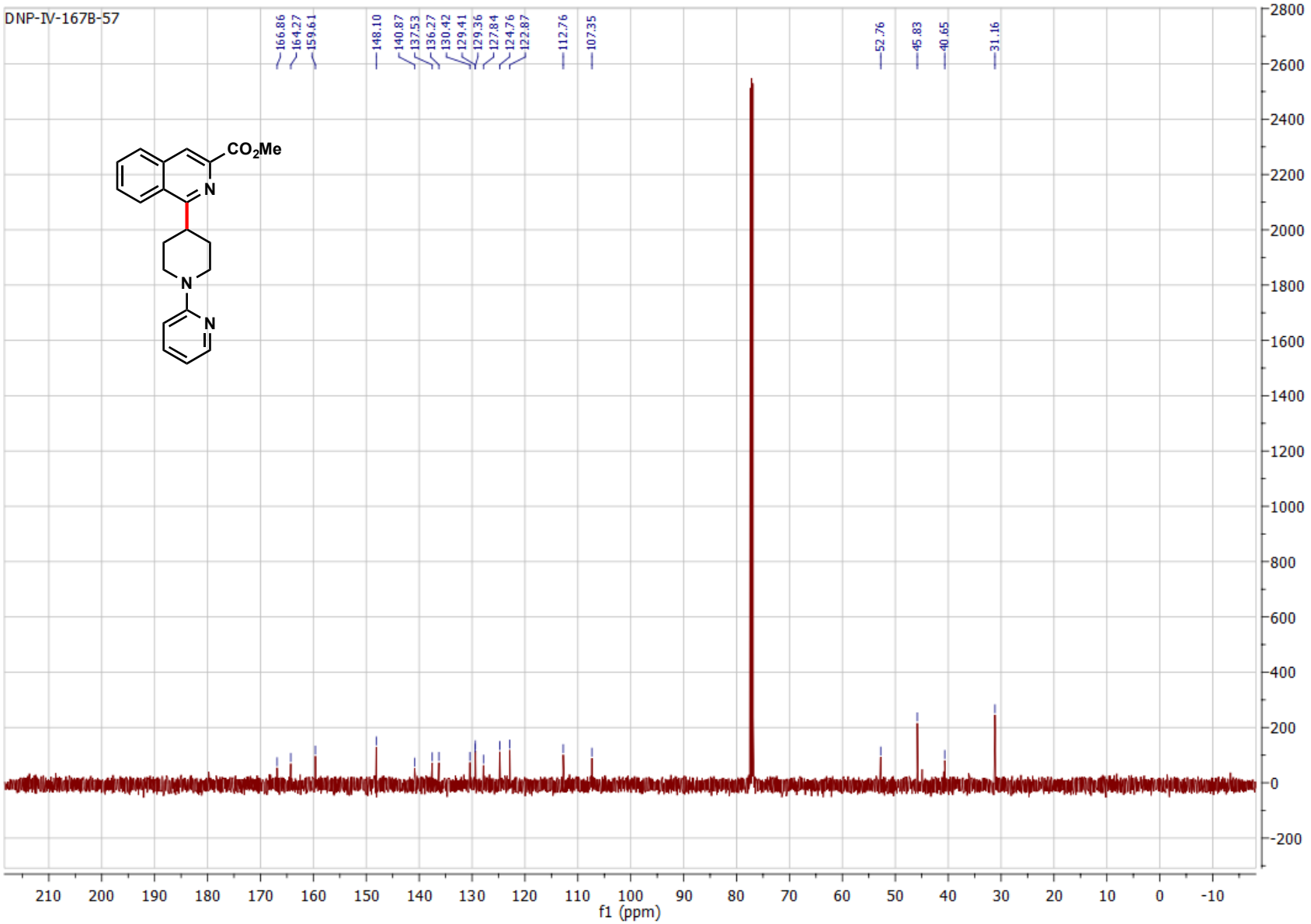
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-((3*r*,5*r*,7*r*)-adamantan-1-yl)isoquinoline-3-carboxylate (**2k**)



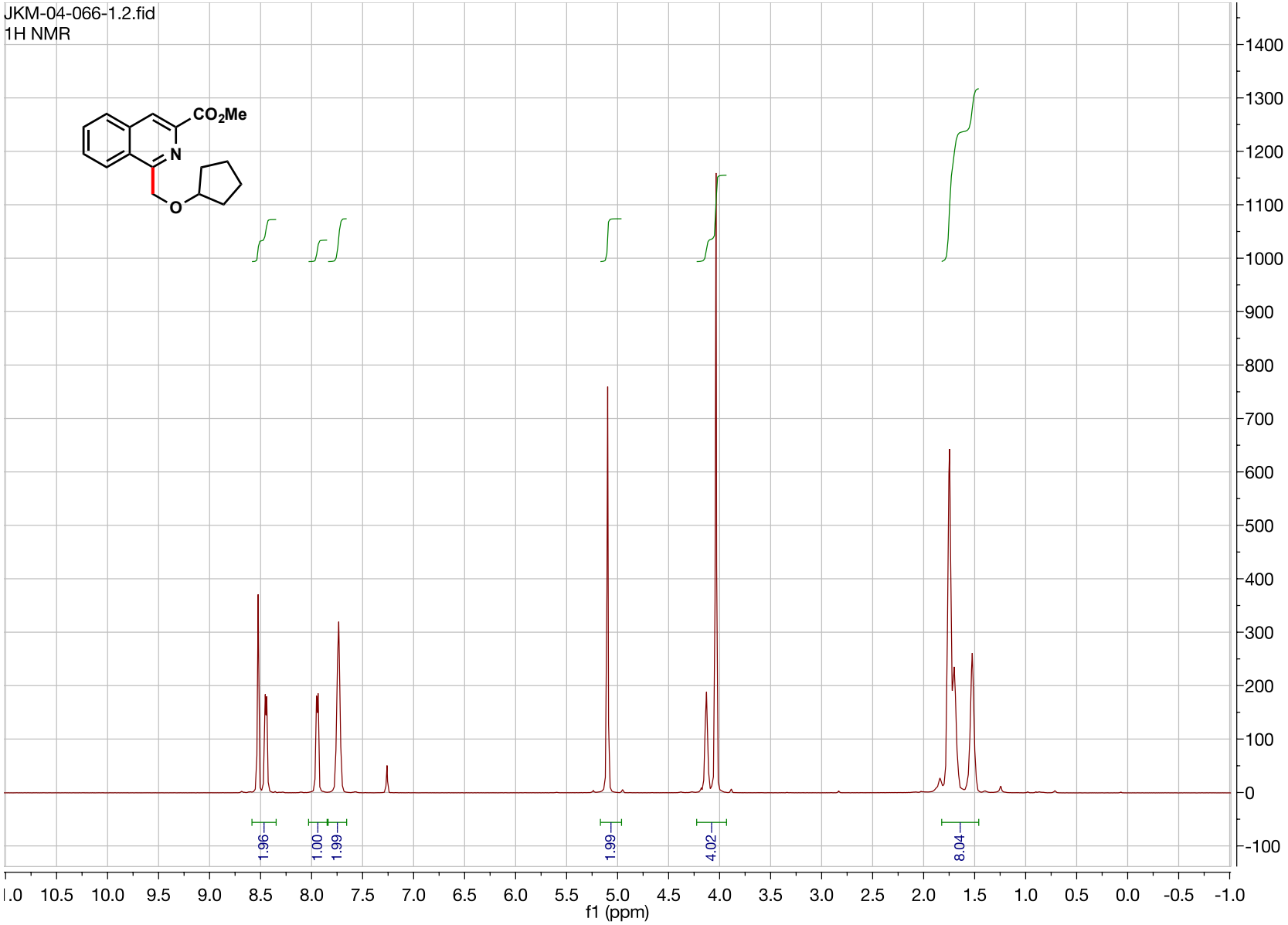
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(1-(pyridin-2-yl)piperidin-4-yl)isoquinoline-3-carboxylate (**2l**)



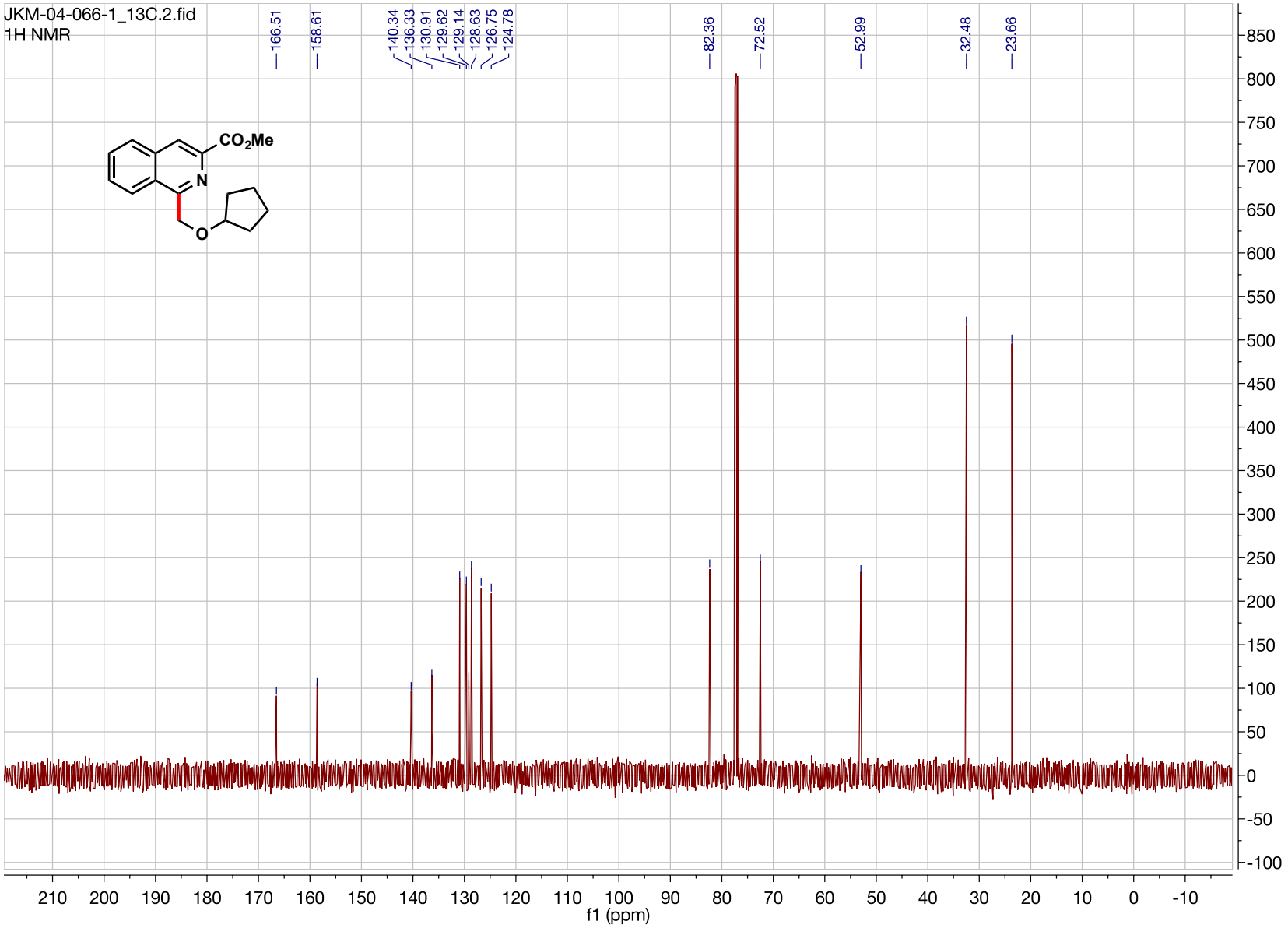
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(1-(pyridin-2-yl)piperidin-4-yl)isoquinoline-3-carboxylate (**2l**)



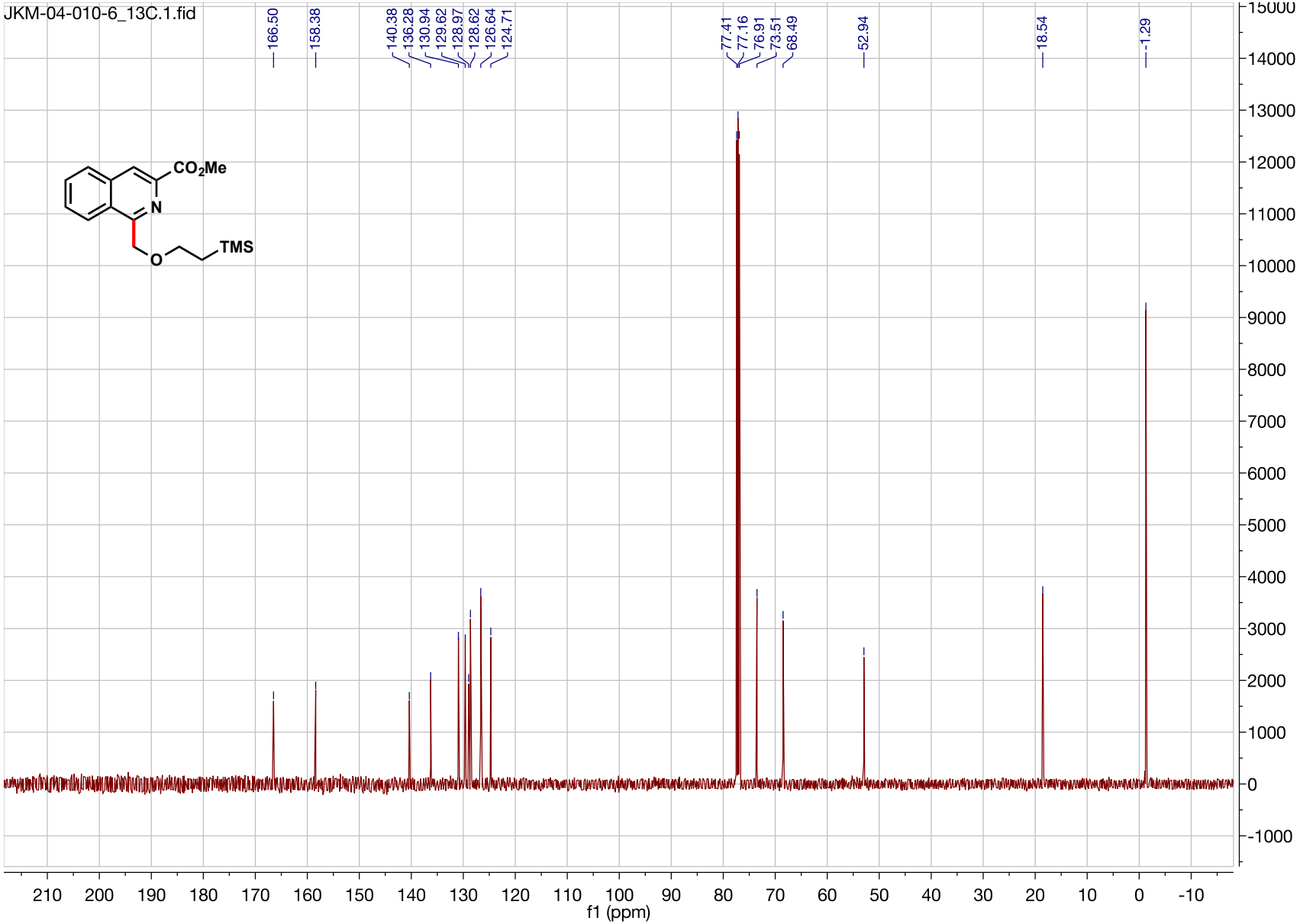
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-((cyclopentyloxy)methyl)isoquinoline-3-carboxylate (**3a**)



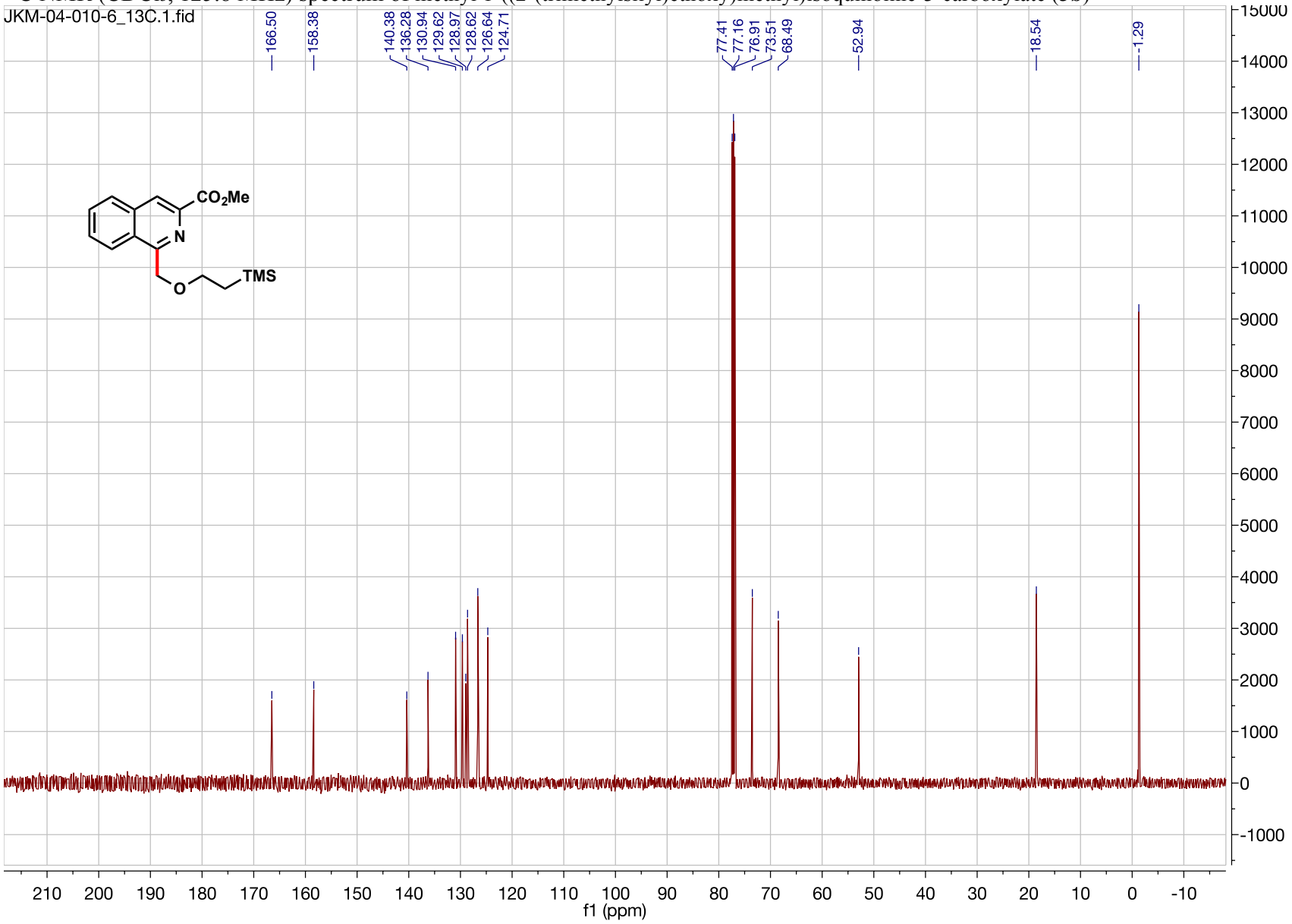
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-((cyclopentyloxy)methyl)isoquinoline-3-carboxylate (**3a**)



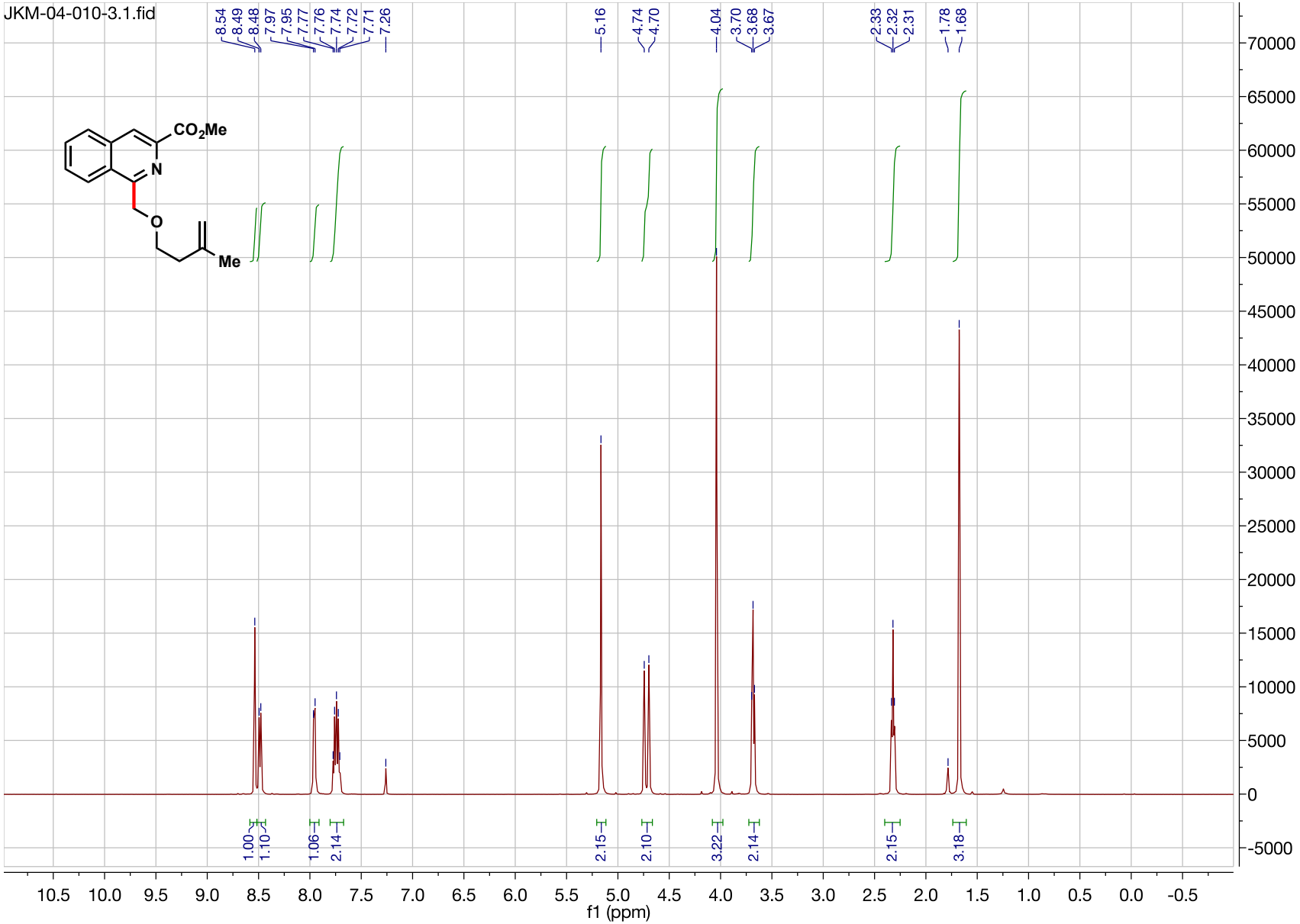
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-((2-(trimethylsilyl)ethoxy)methyl)isoquinoline-3-carboxylate (**3b**)



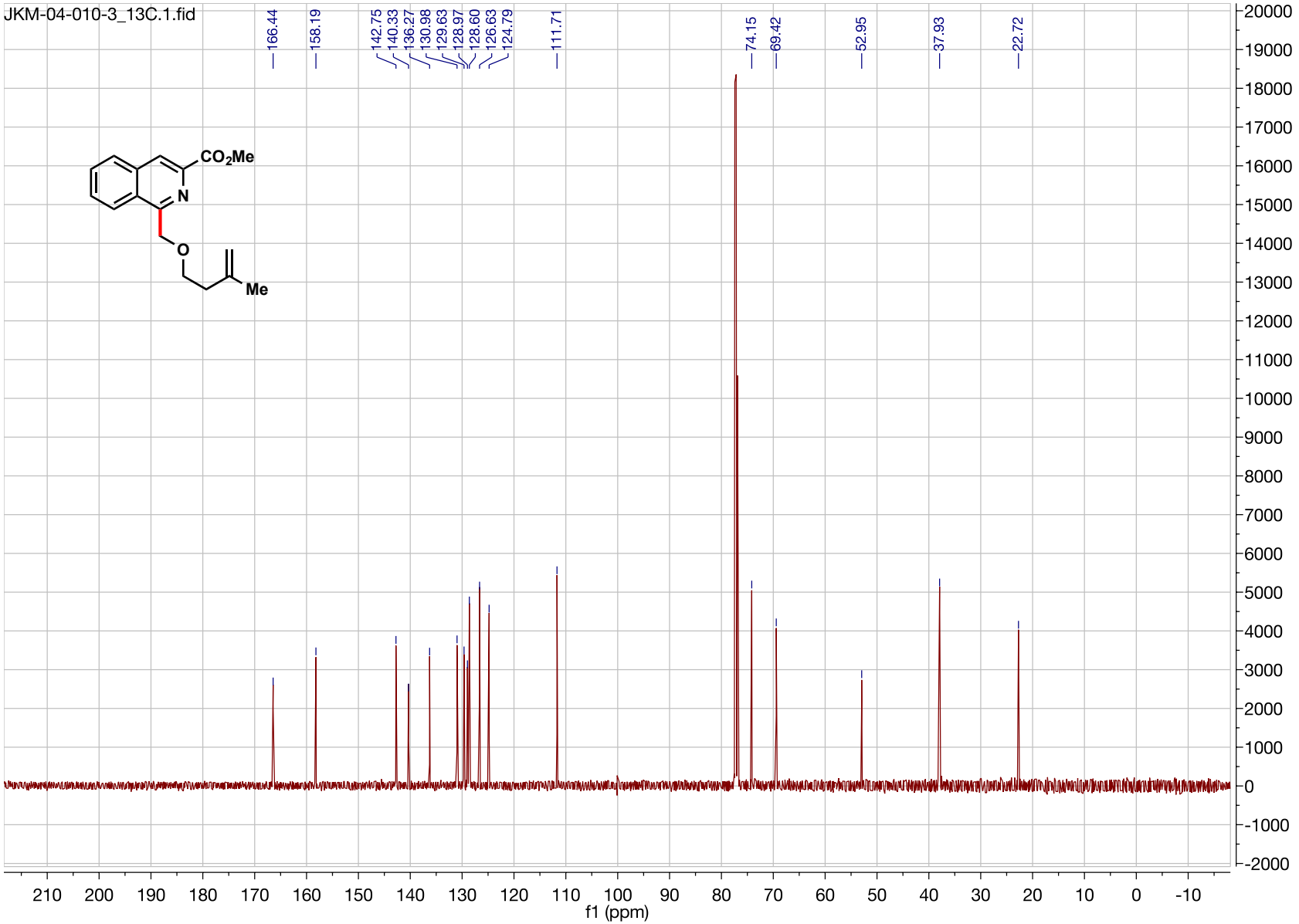
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-((2-(trimethylsilyl)ethoxy)methyl)isoquinoline-3-carboxylate (**3b**)



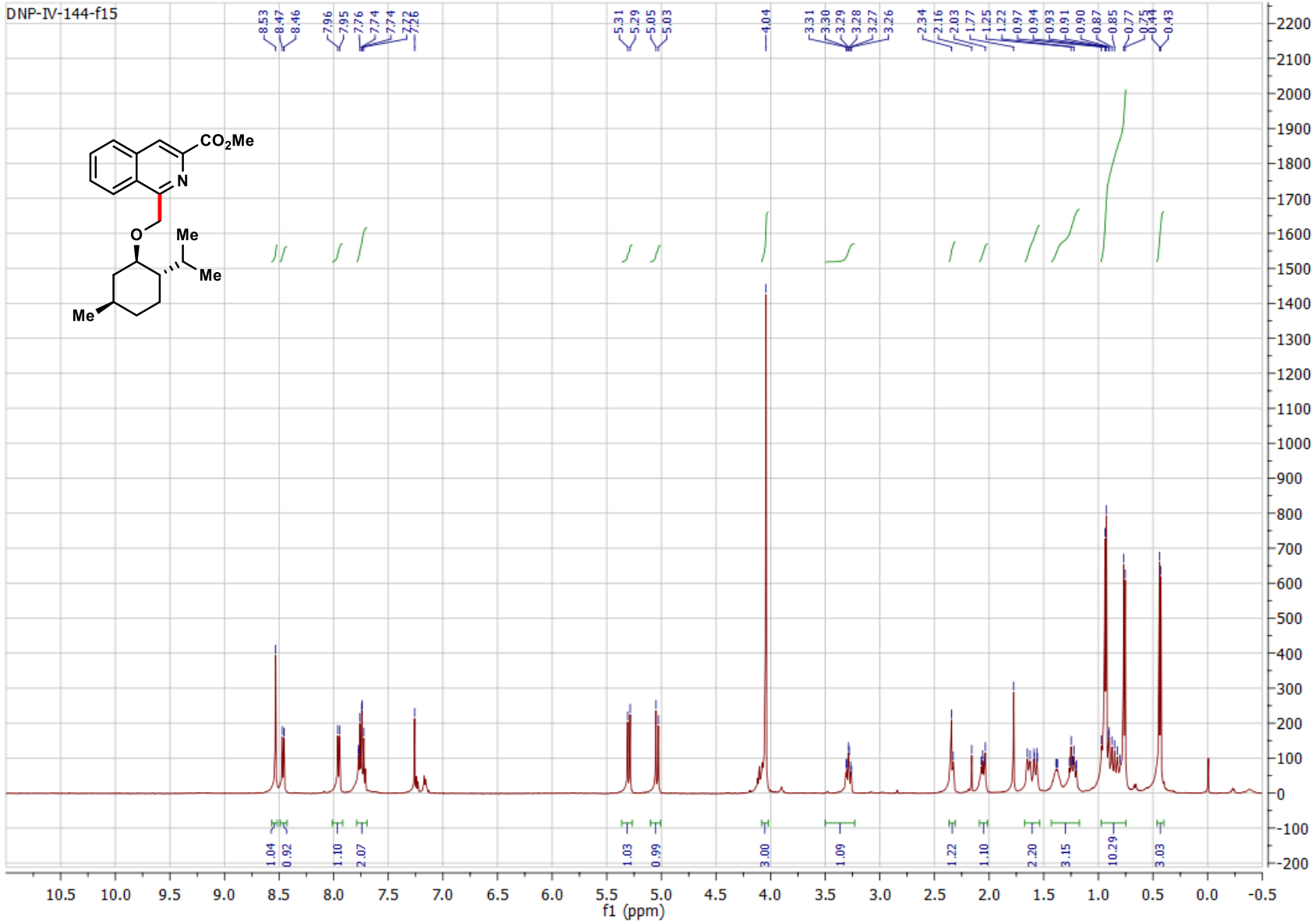
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(((3-methylbut-3-en-1-yl)oxy)methyl)isoquinoline-3-carboxylate (**3c**)



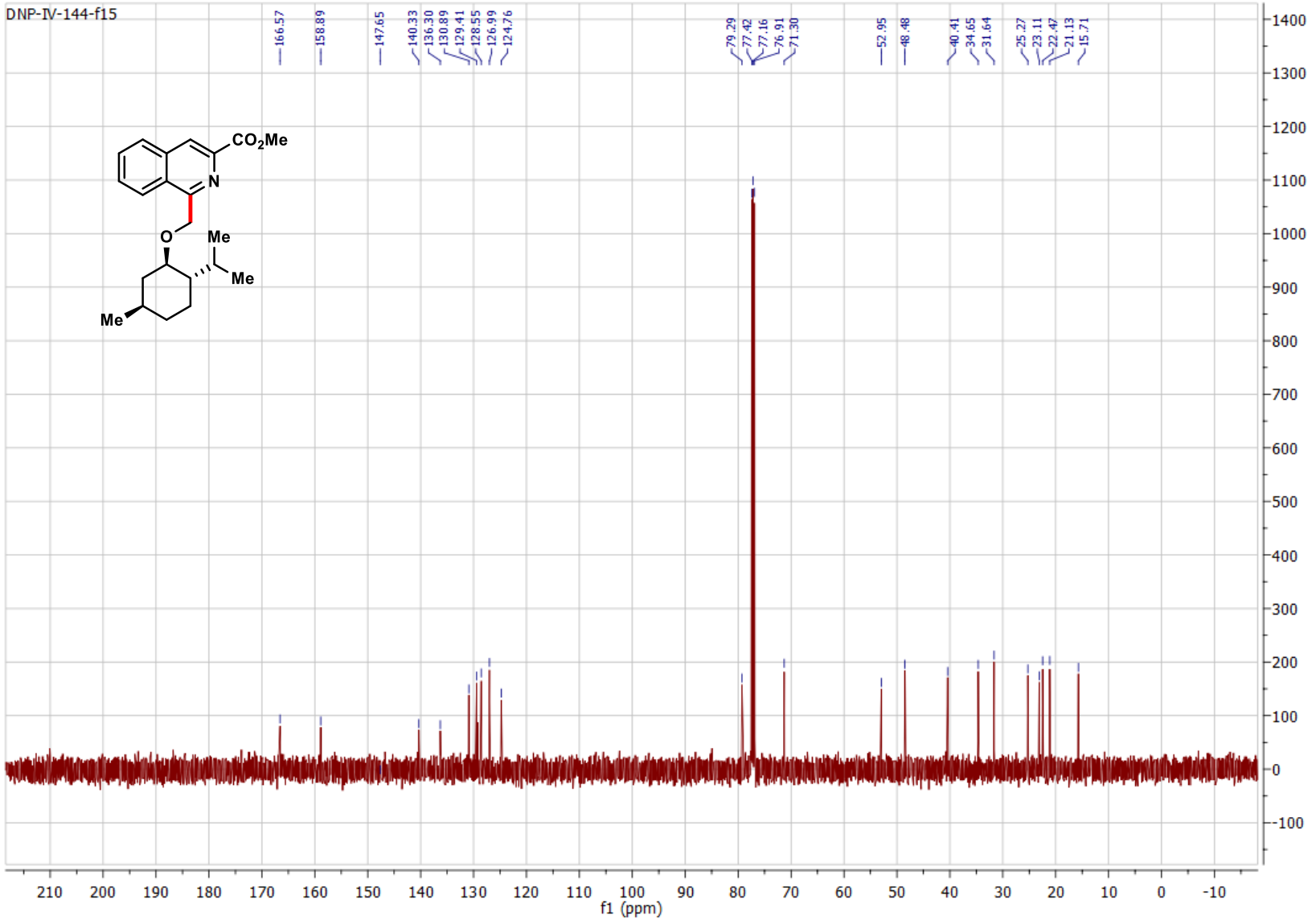
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(((3-methylbut-3-en-1-yl)oxy)methyl)isoquinoline-3-carboxylate (**3c**)



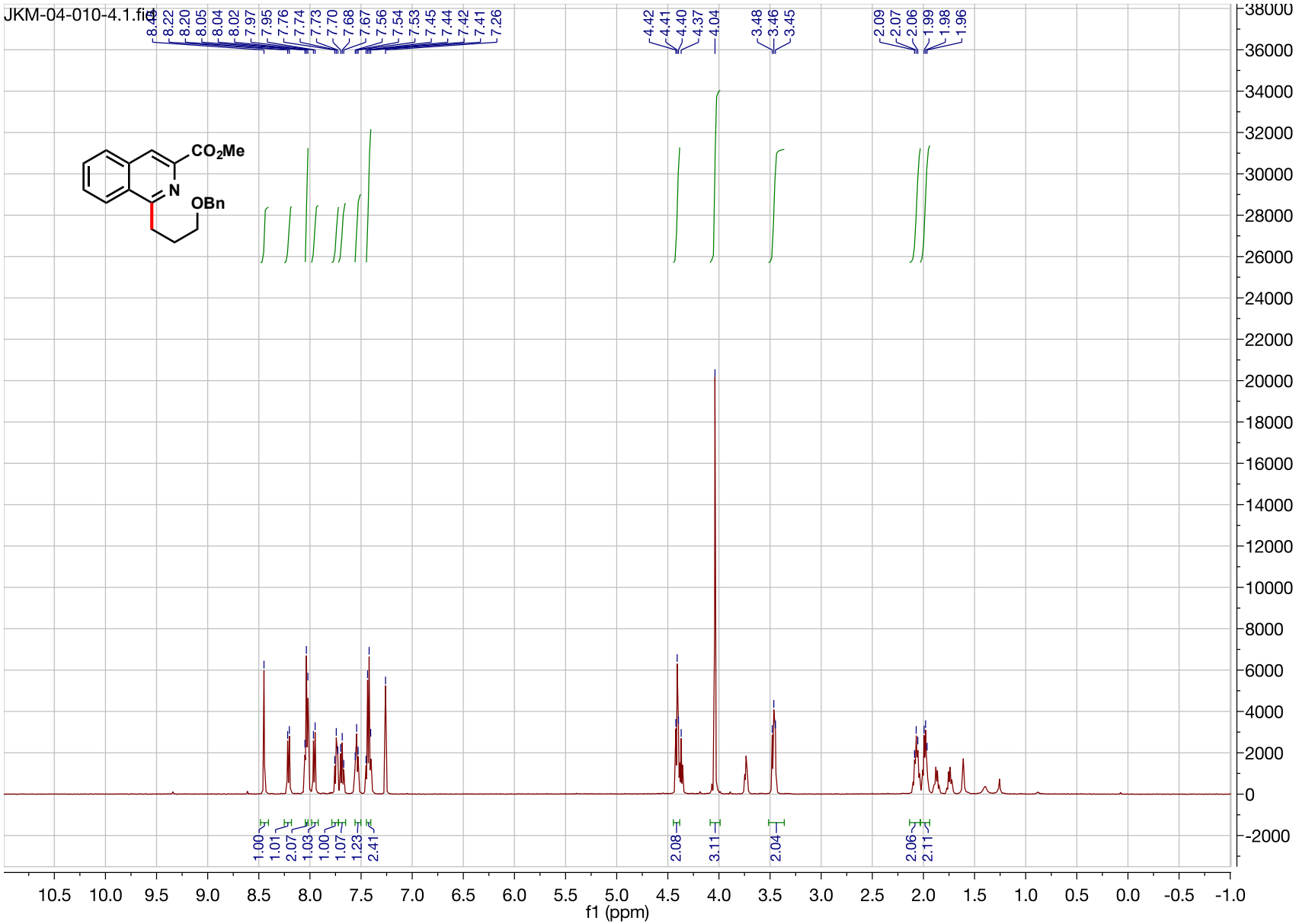
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-((((1*R*,2*S*,5*R*)-2-isopropyl-5-methylcyclohexyl)oxy)methyl)isoquinoline-3-carboxylate (**3d**)



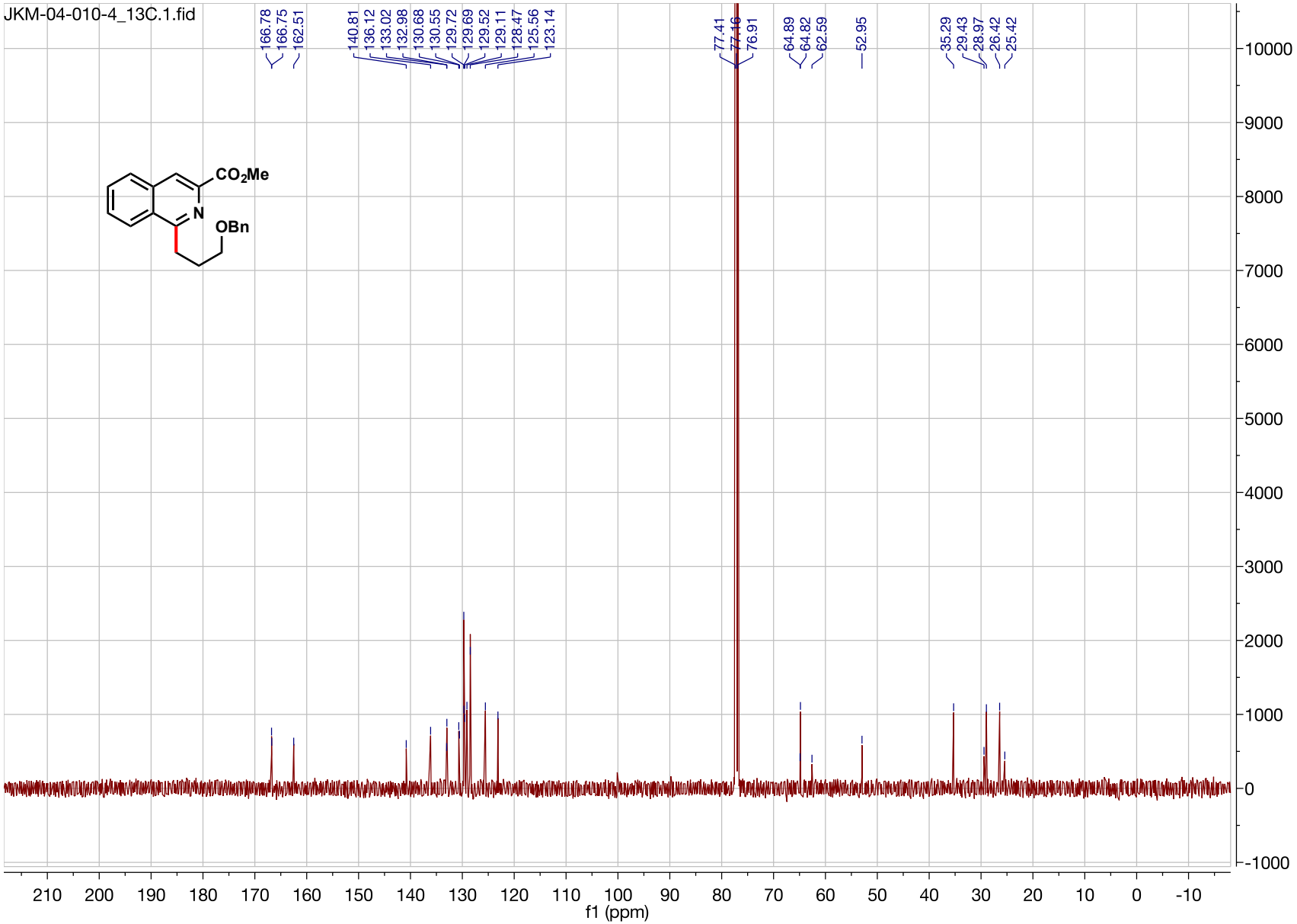
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-((((1*R*,2*S*,5*R*)-2-isopropyl-5-methylcyclohexyl)oxy)methyl)isoquinoline-3-carboxylate (**3d**)



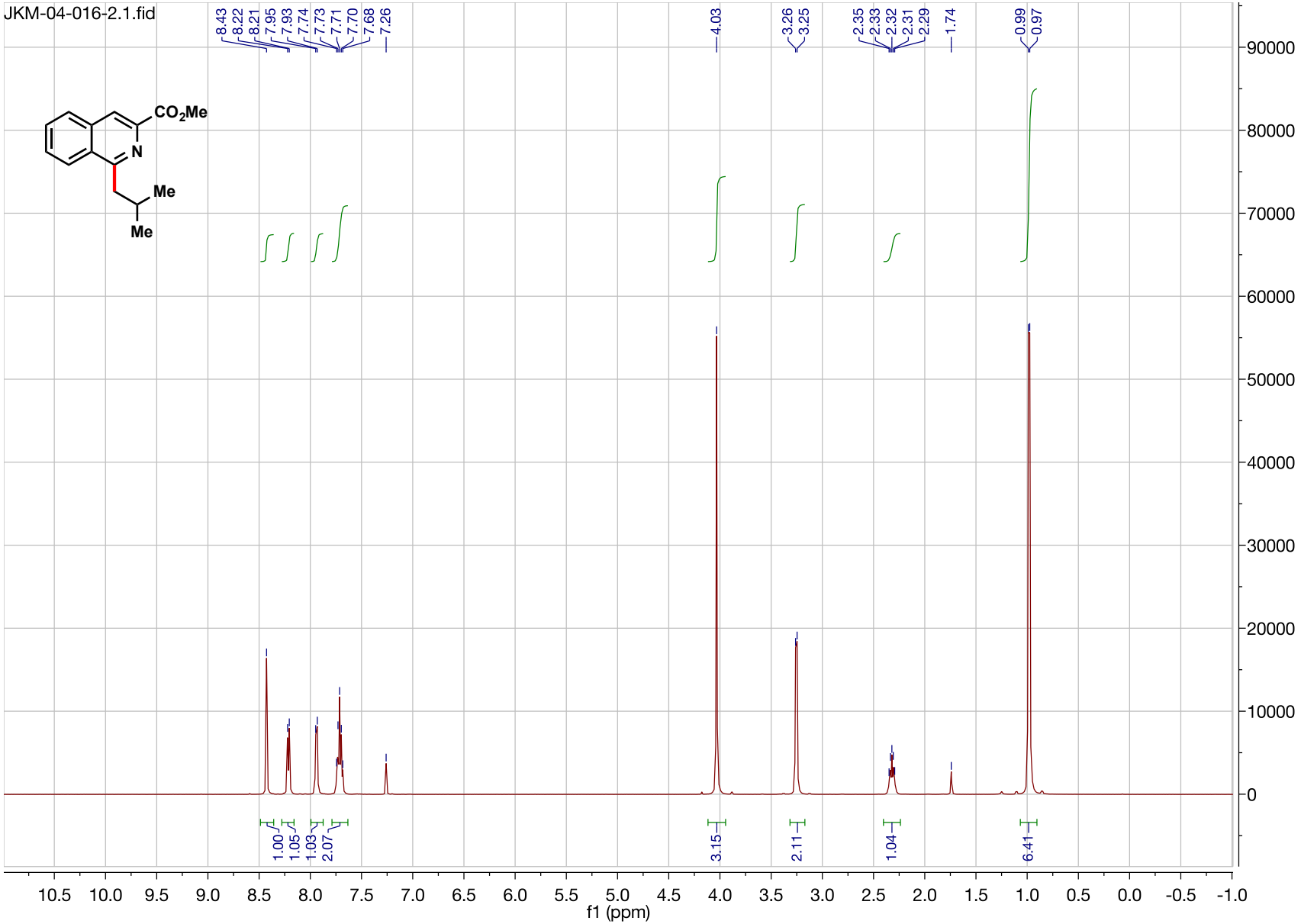
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(3-(benzyloxy)propyl)isoquinoline-3-carboxylate (**3e**)



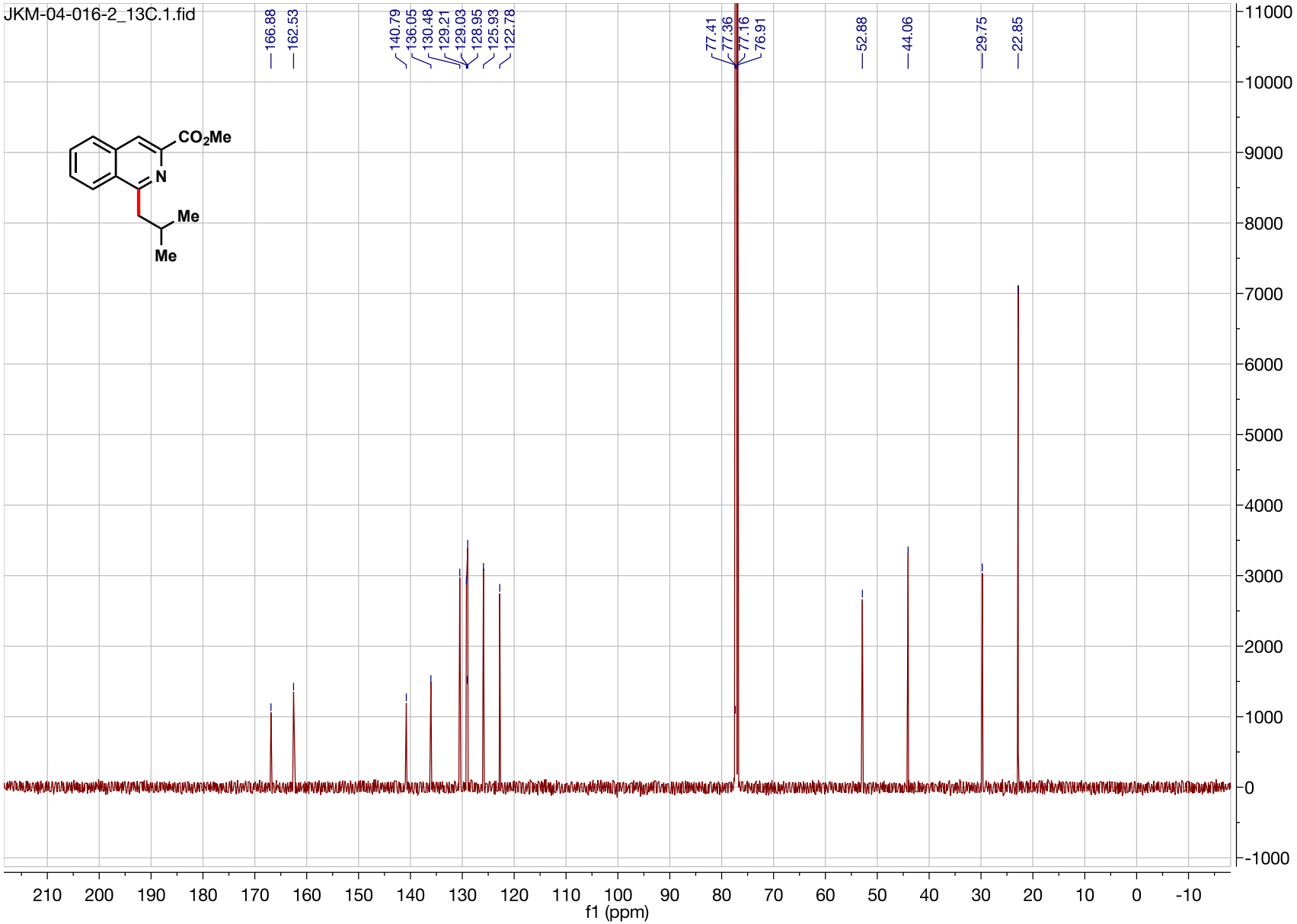
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(3-(benzyloxy)propyl)isoquinoline-3-carboxylate (**3e**)



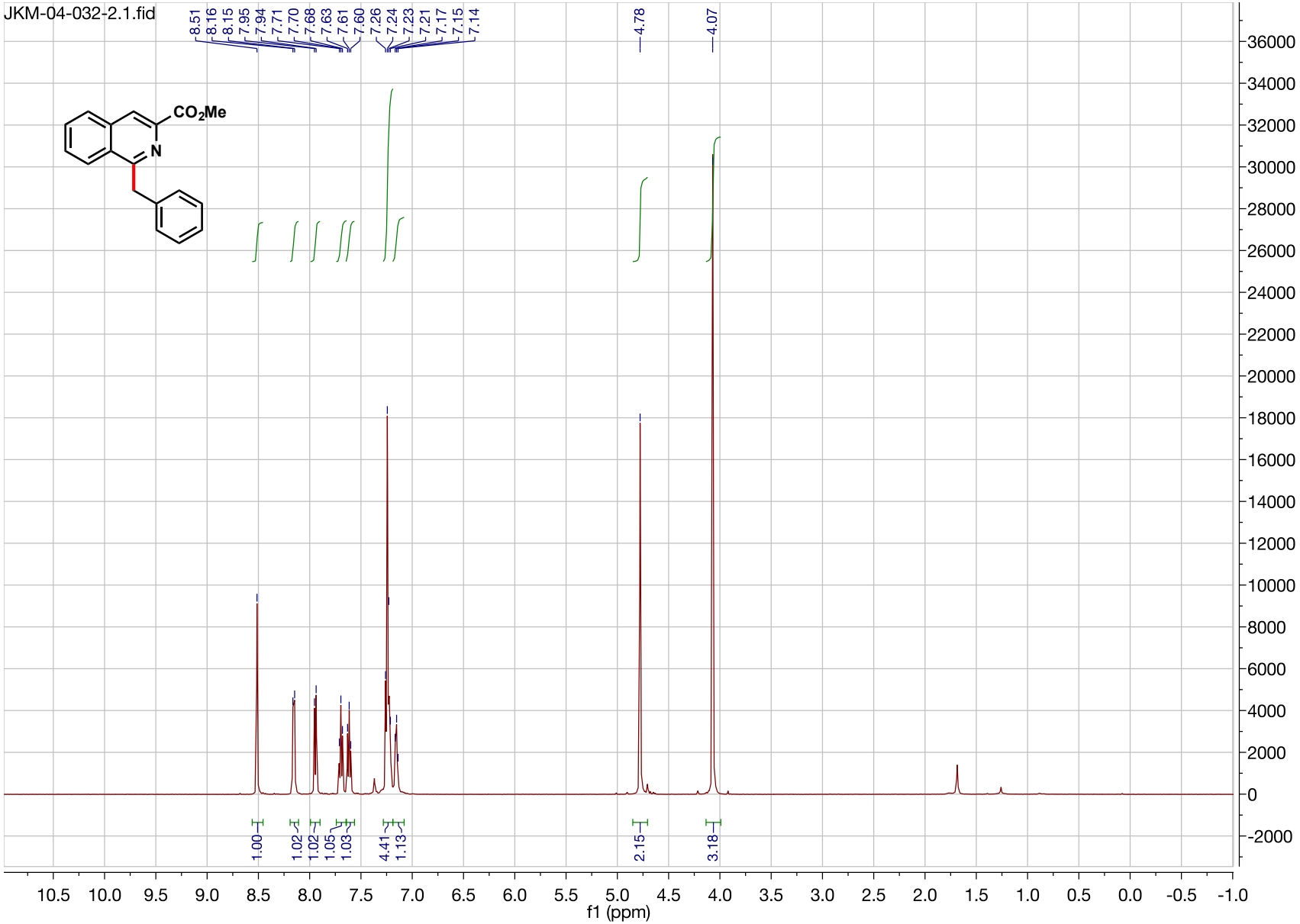
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-isobutylisoquinoline-3-carboxylate (**3f**)



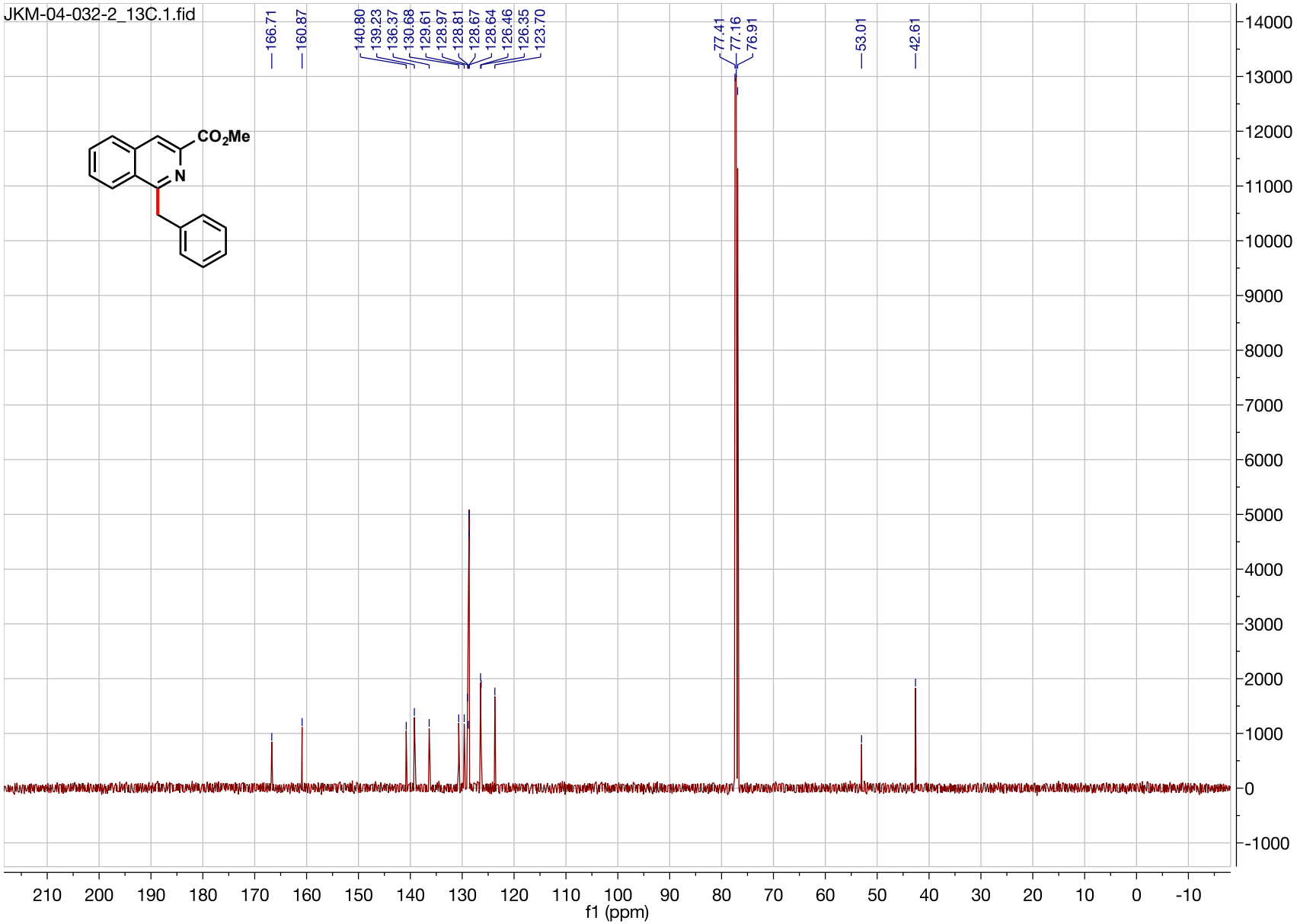
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-isobutylisoquinoline-3-carboxylate (**3f**)



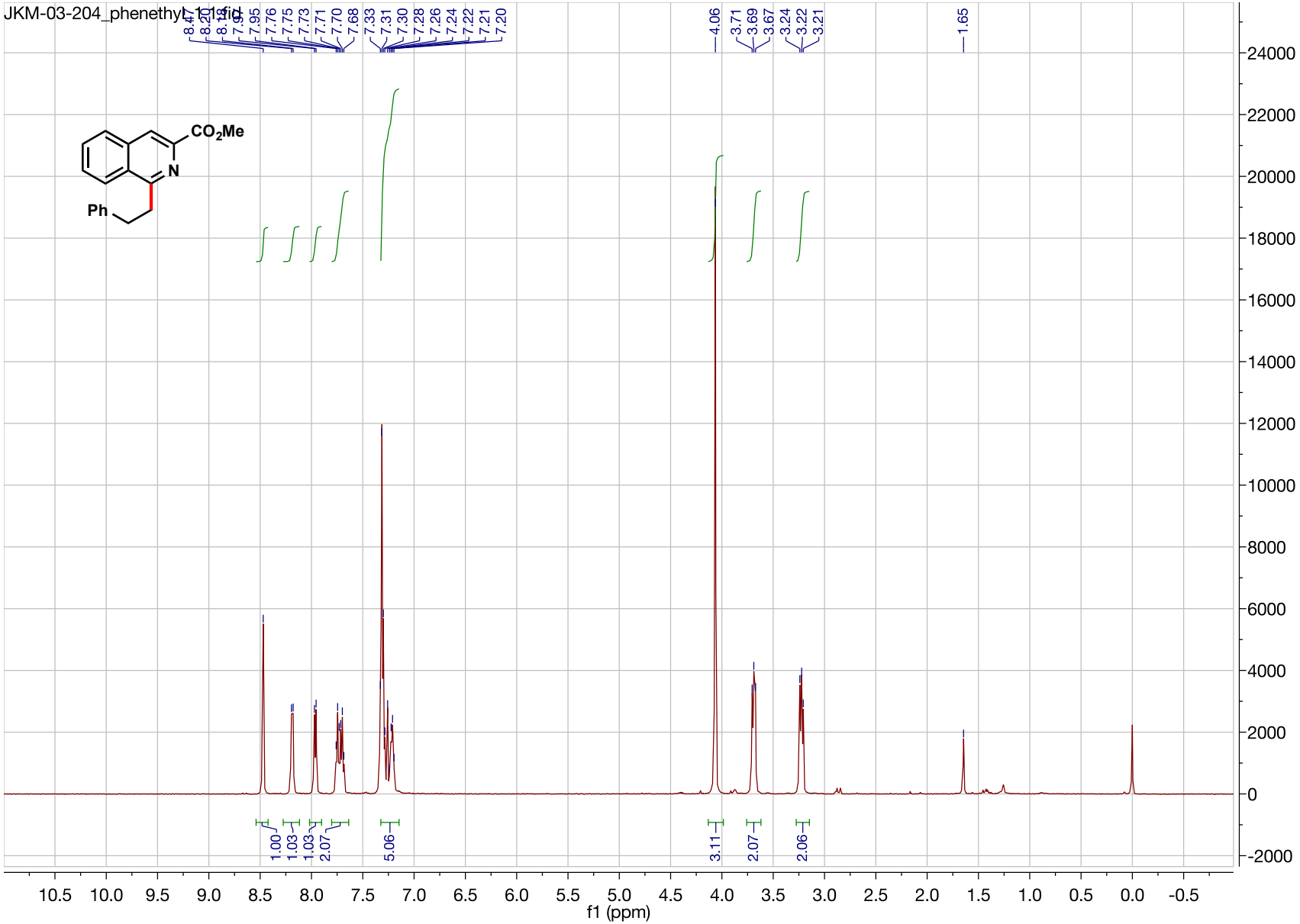
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-benzylisoquinoline-3-carboxylate (**3g**)



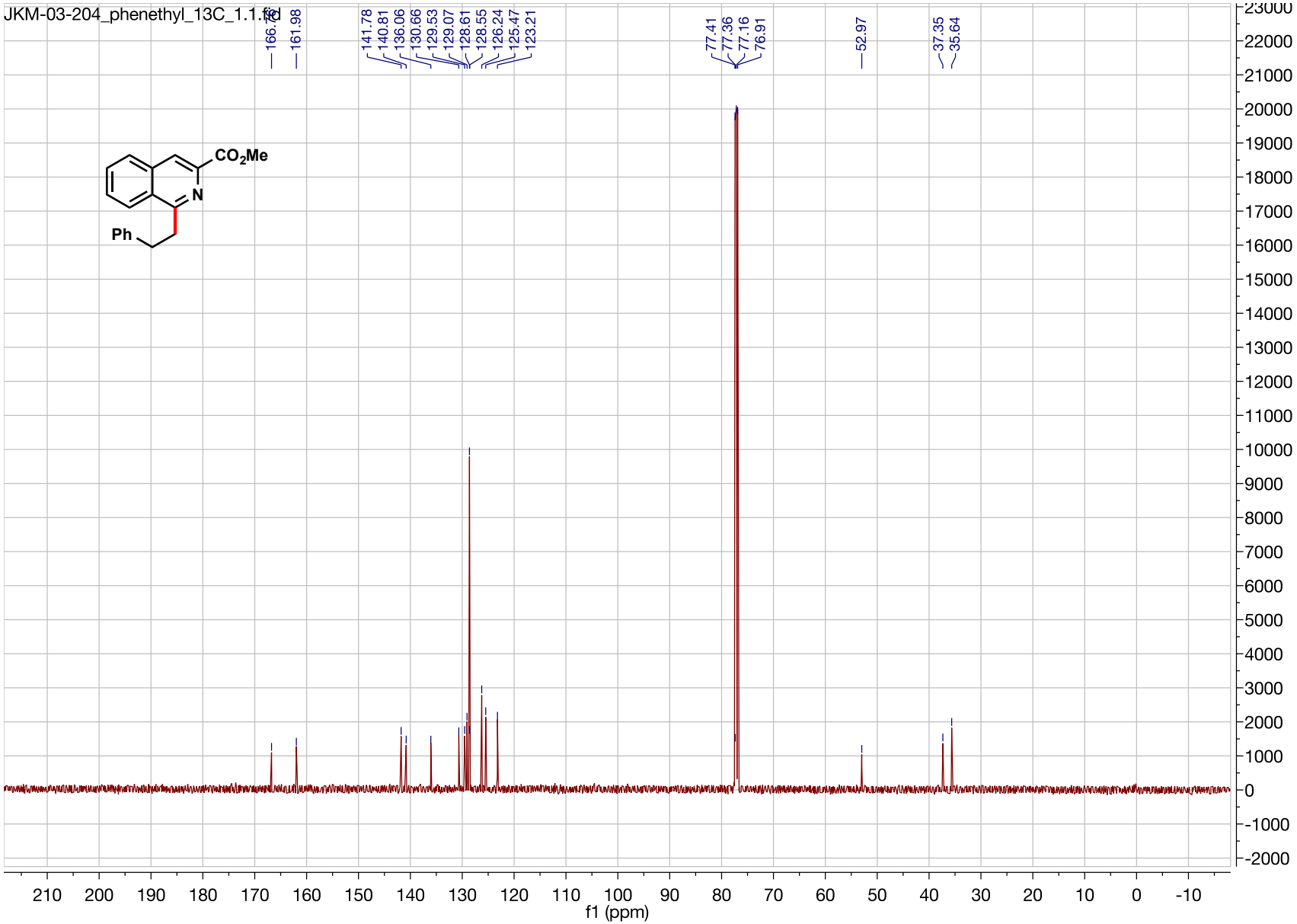
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-benzylisoquinoline-3-carboxylate (**3g**)



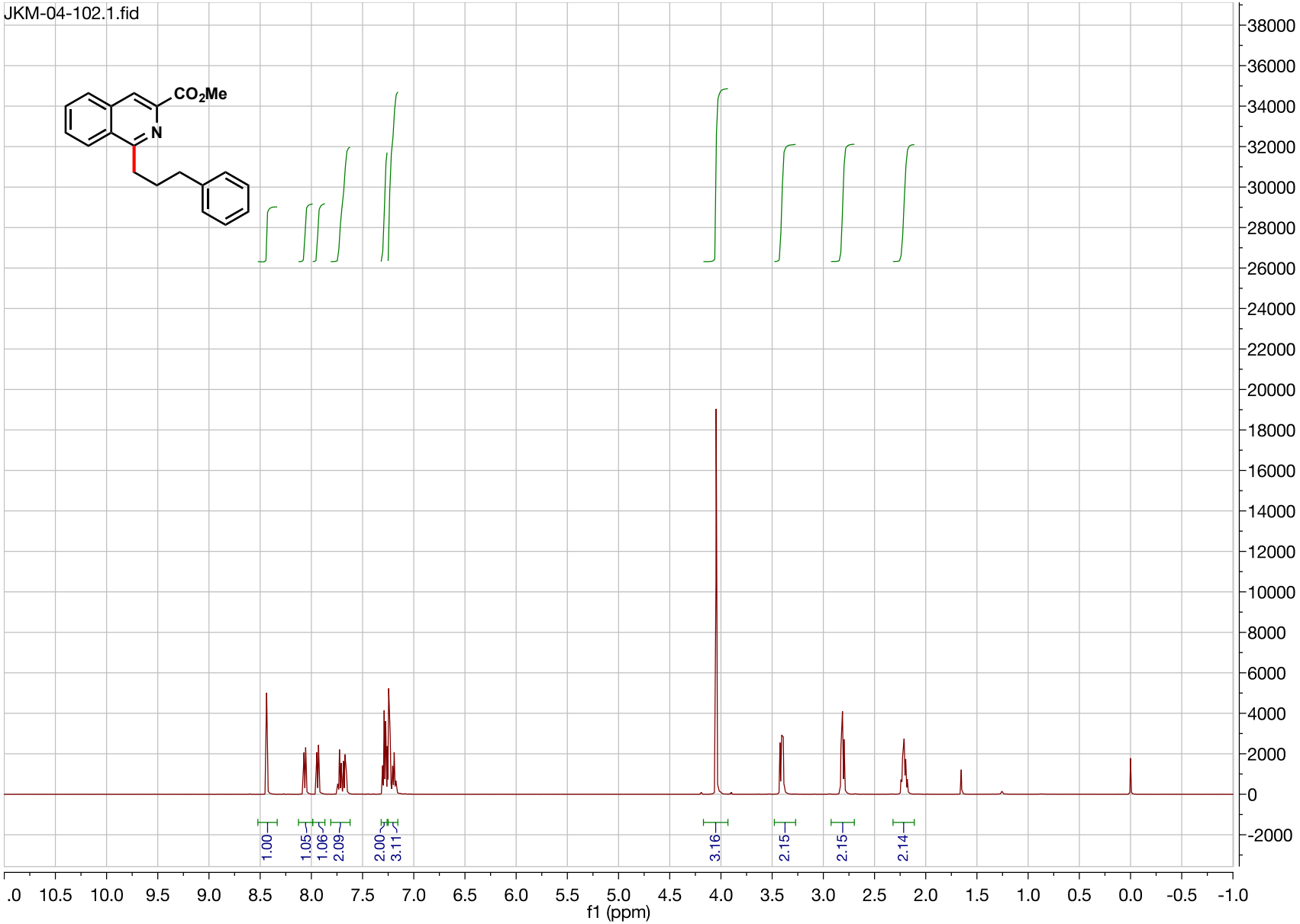
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-phenethylisoquinoline-3-carboxylate (**3h**)



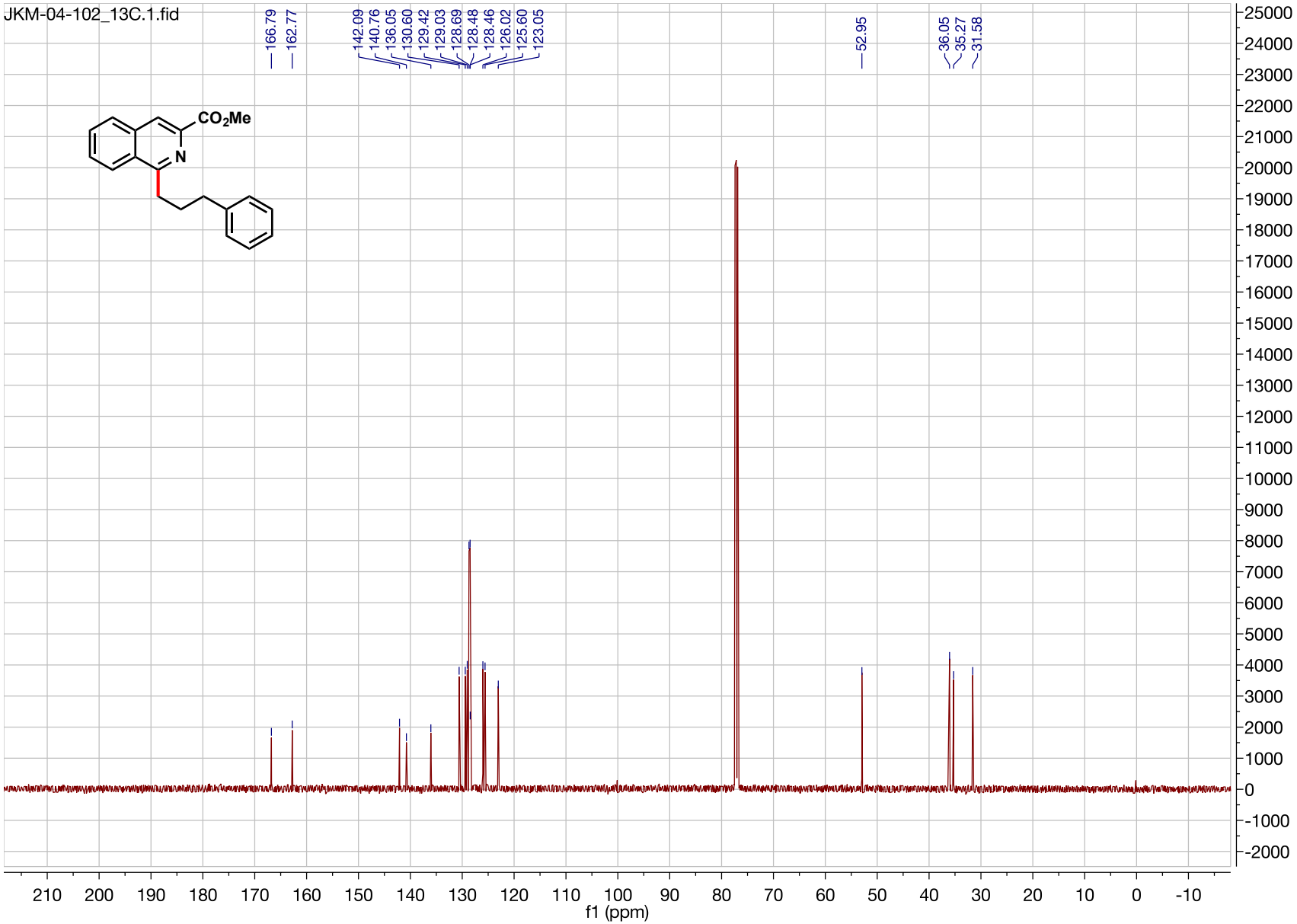
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-phenethylisoquinoline-3-carboxylate (**3h**)



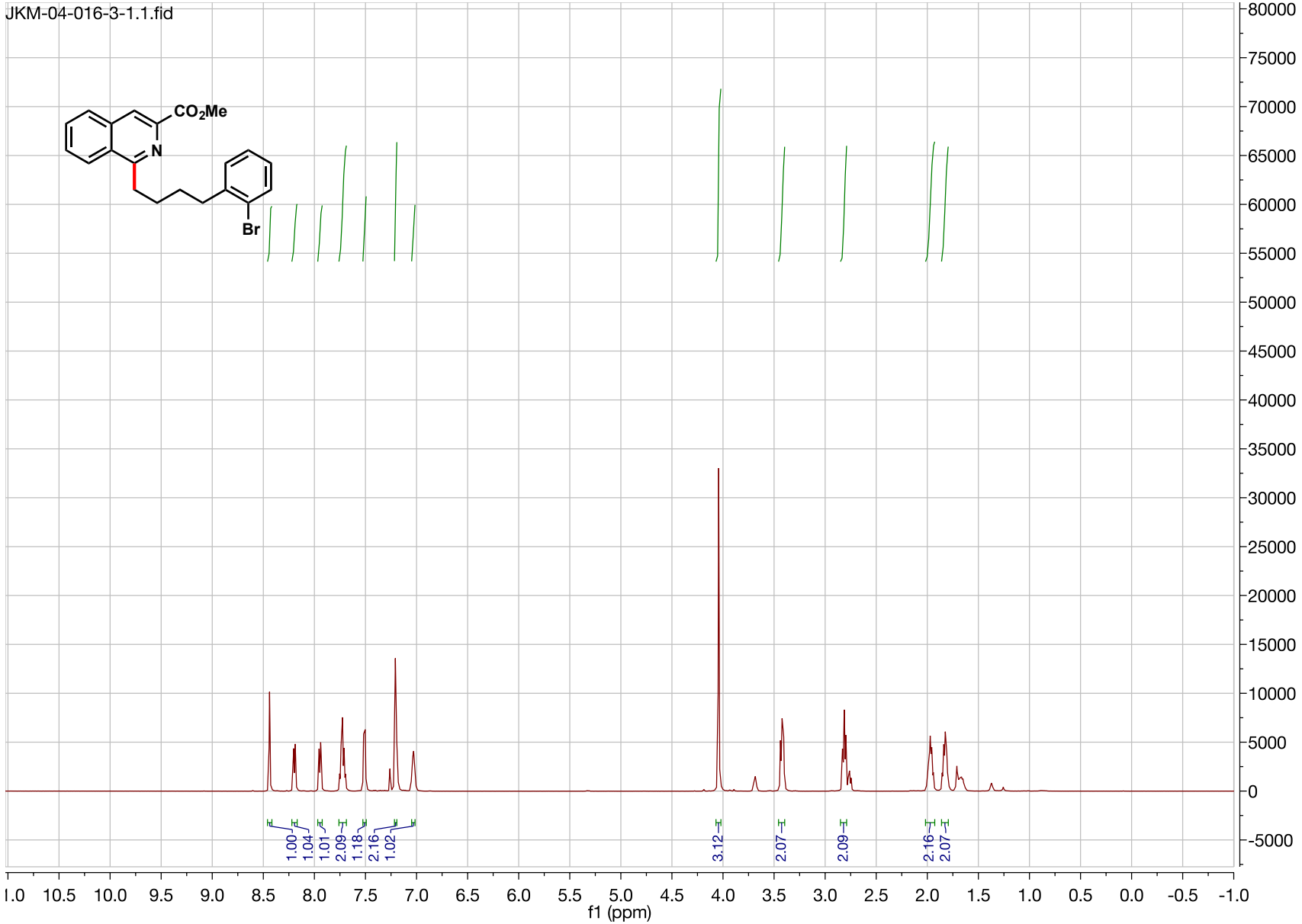
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(3-phenylpropyl)isoquinoline-3-carboxylate (**3i**)



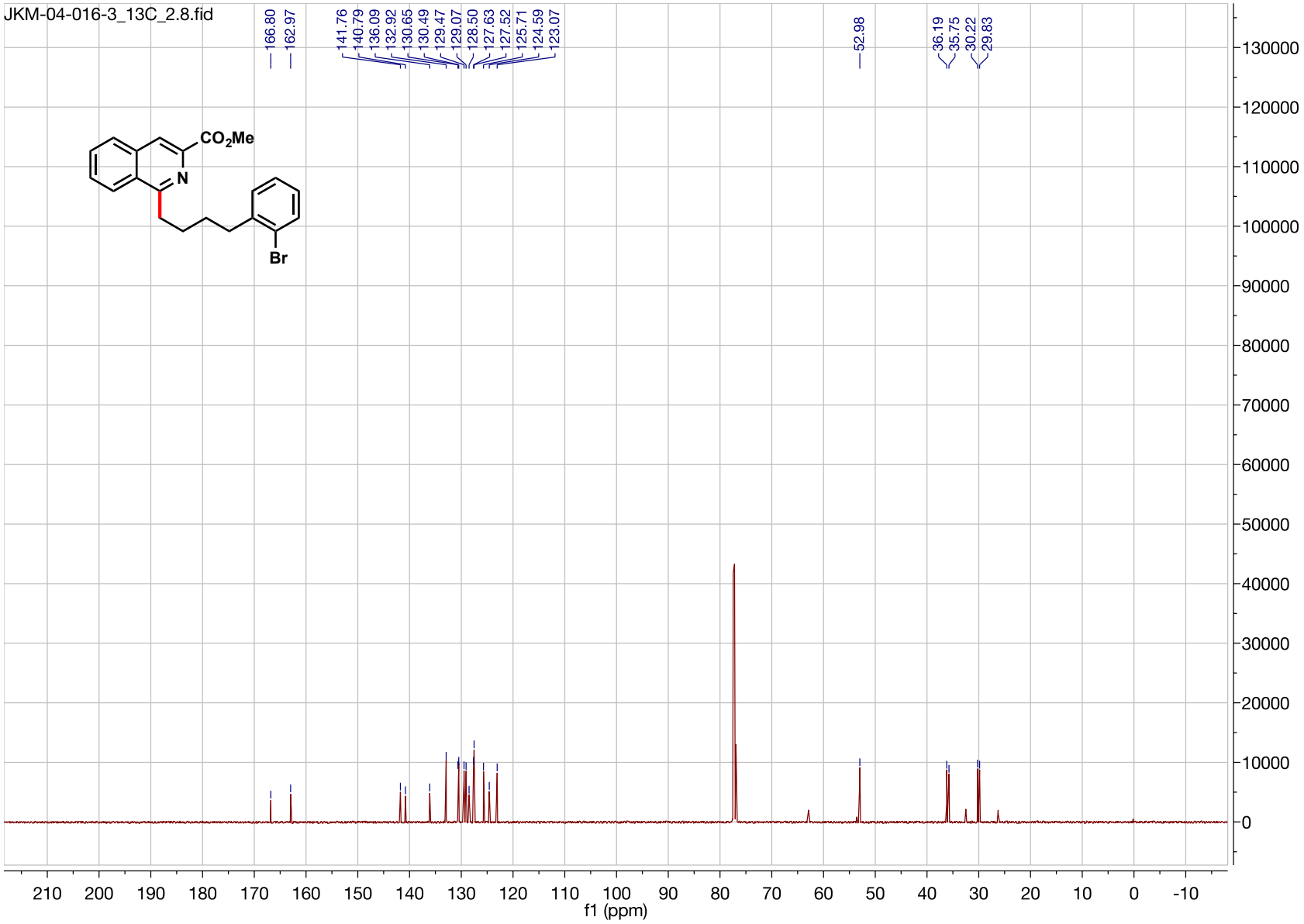
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(3-phenylpropyl)isoquinoline-3-carboxylate (**3i**)



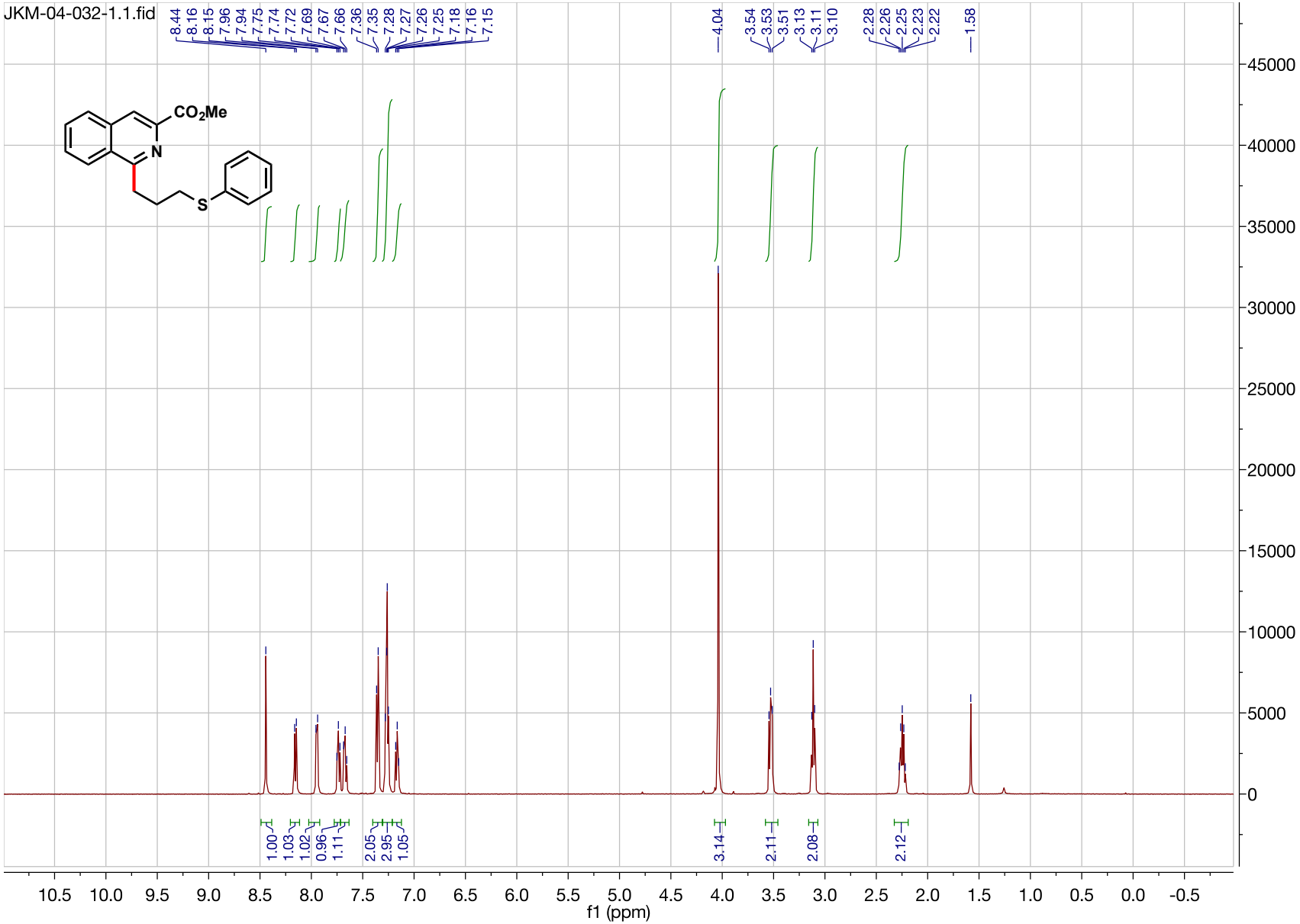
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(4-(2-bromophenyl)butyl)isoquinoline-3-carboxylate (**3j**)



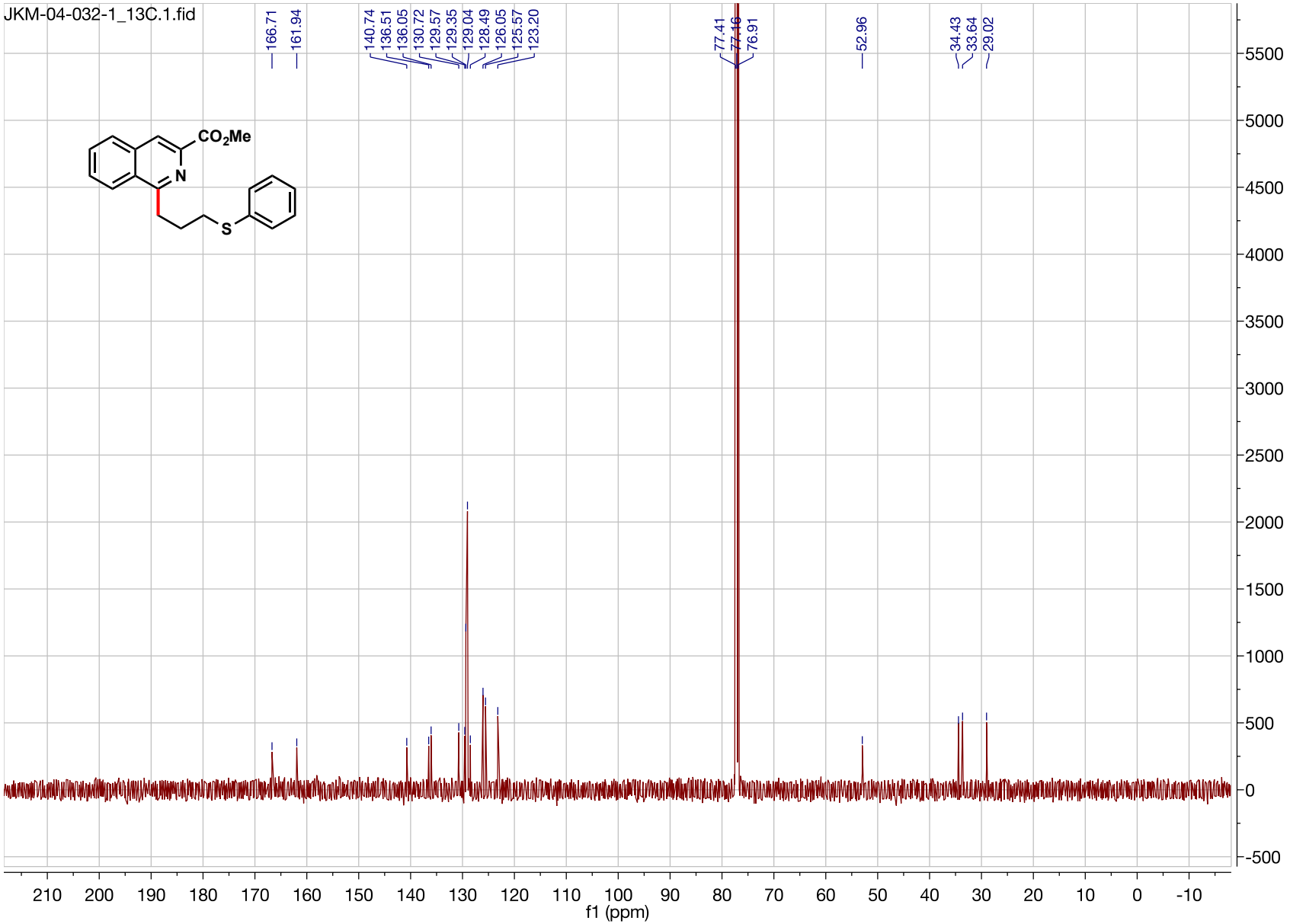
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(4-(2-bromophenyl)butyl)isoquinoline-3-carboxylate (**3j**)



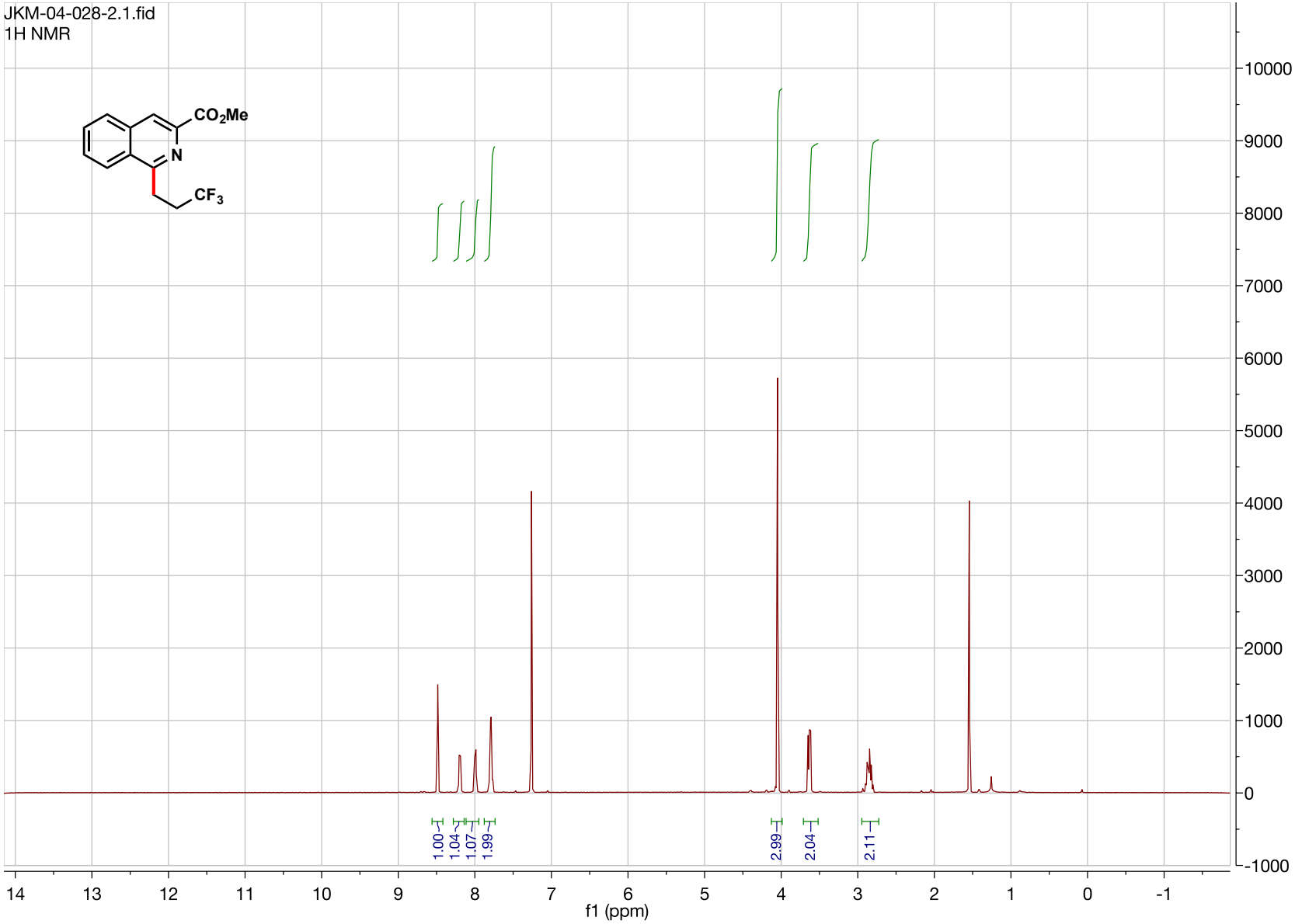
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(3-(phenylthio)propyl)isoquinoline-3-carboxylate (**3k**)



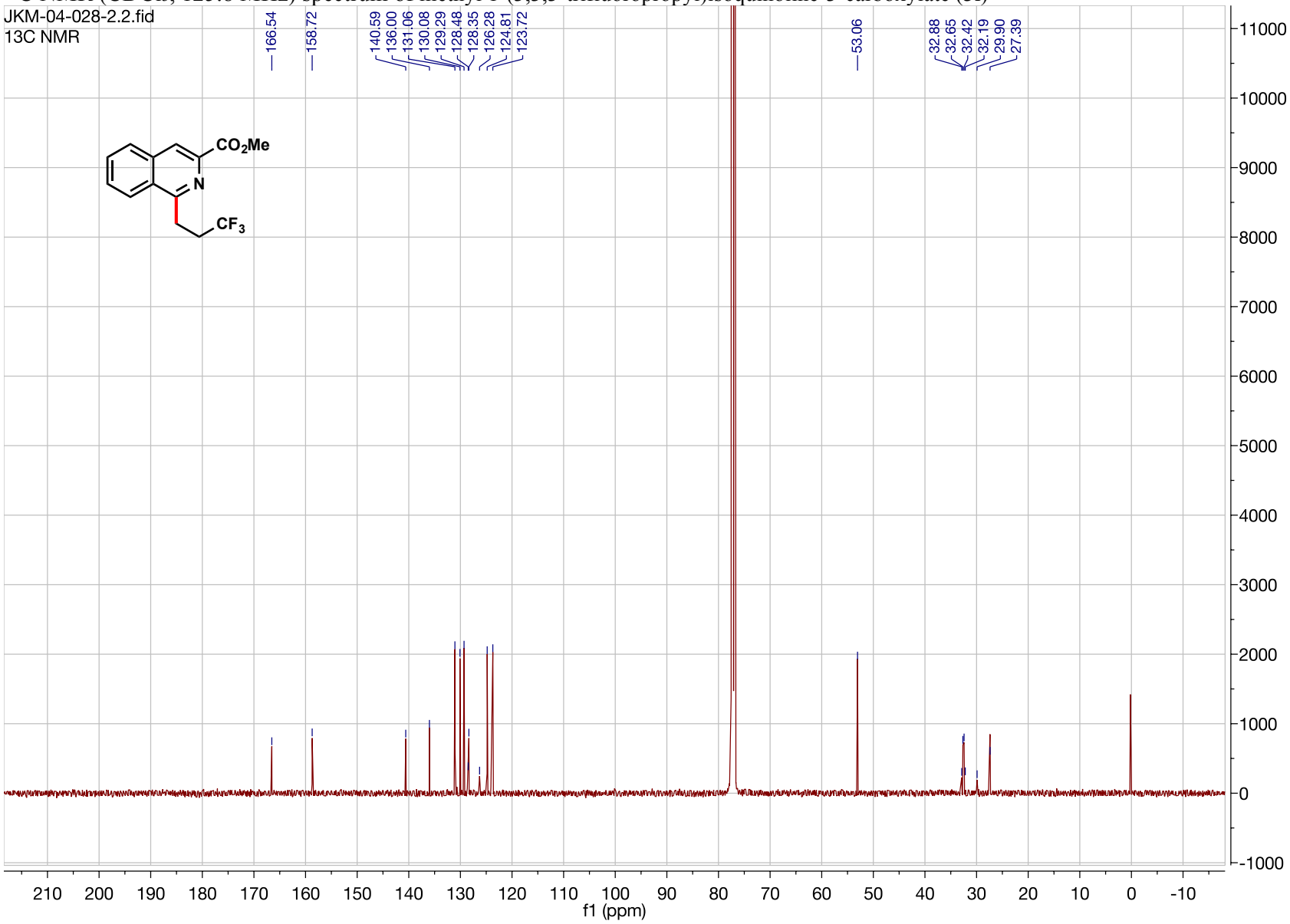
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(3-(phenylthio)propyl)isoquinoline-3-carboxylate (**3k**)



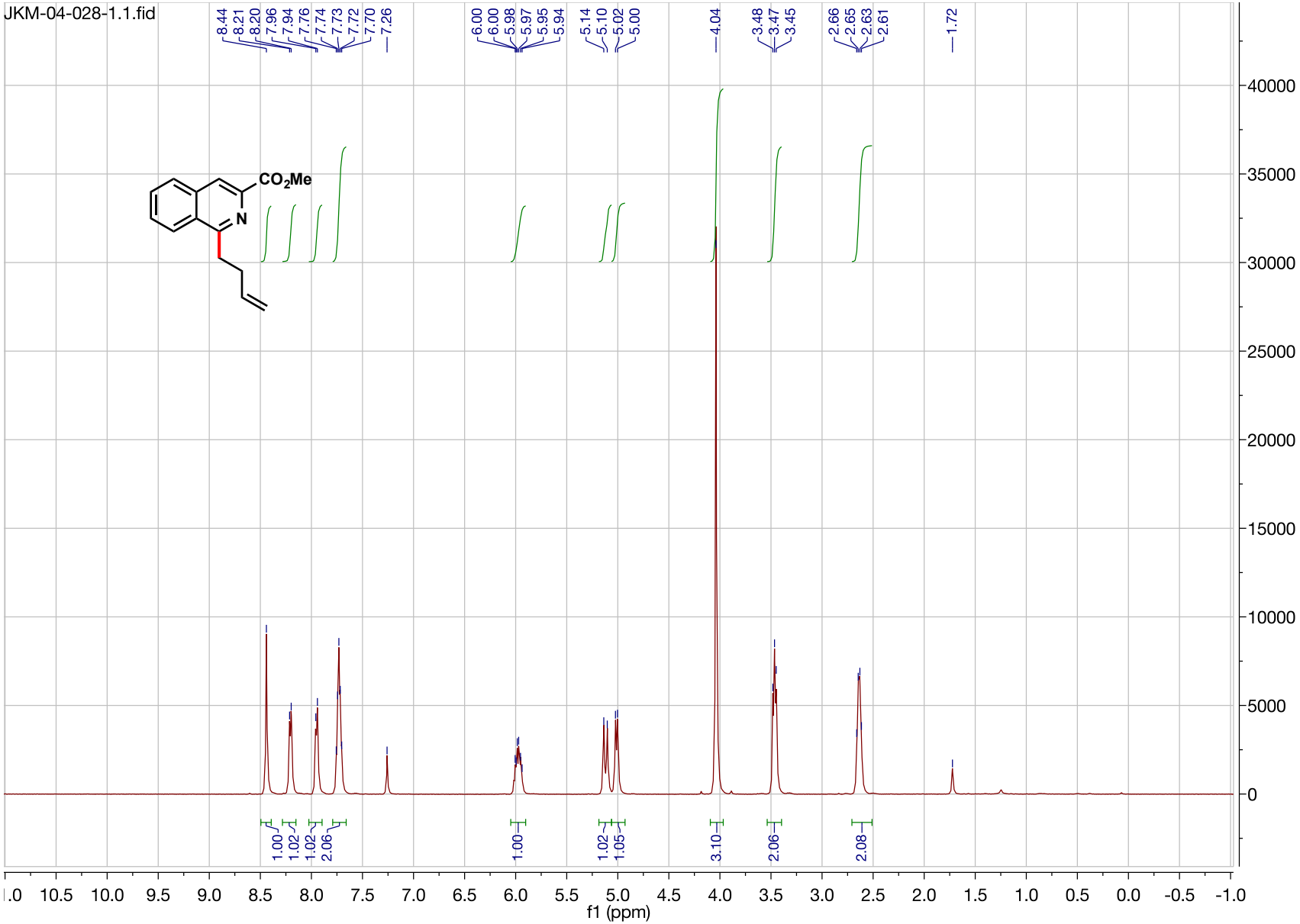
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(3,3,3-trifluoropropyl)isoquinoline-3-carboxylate (**3l**)



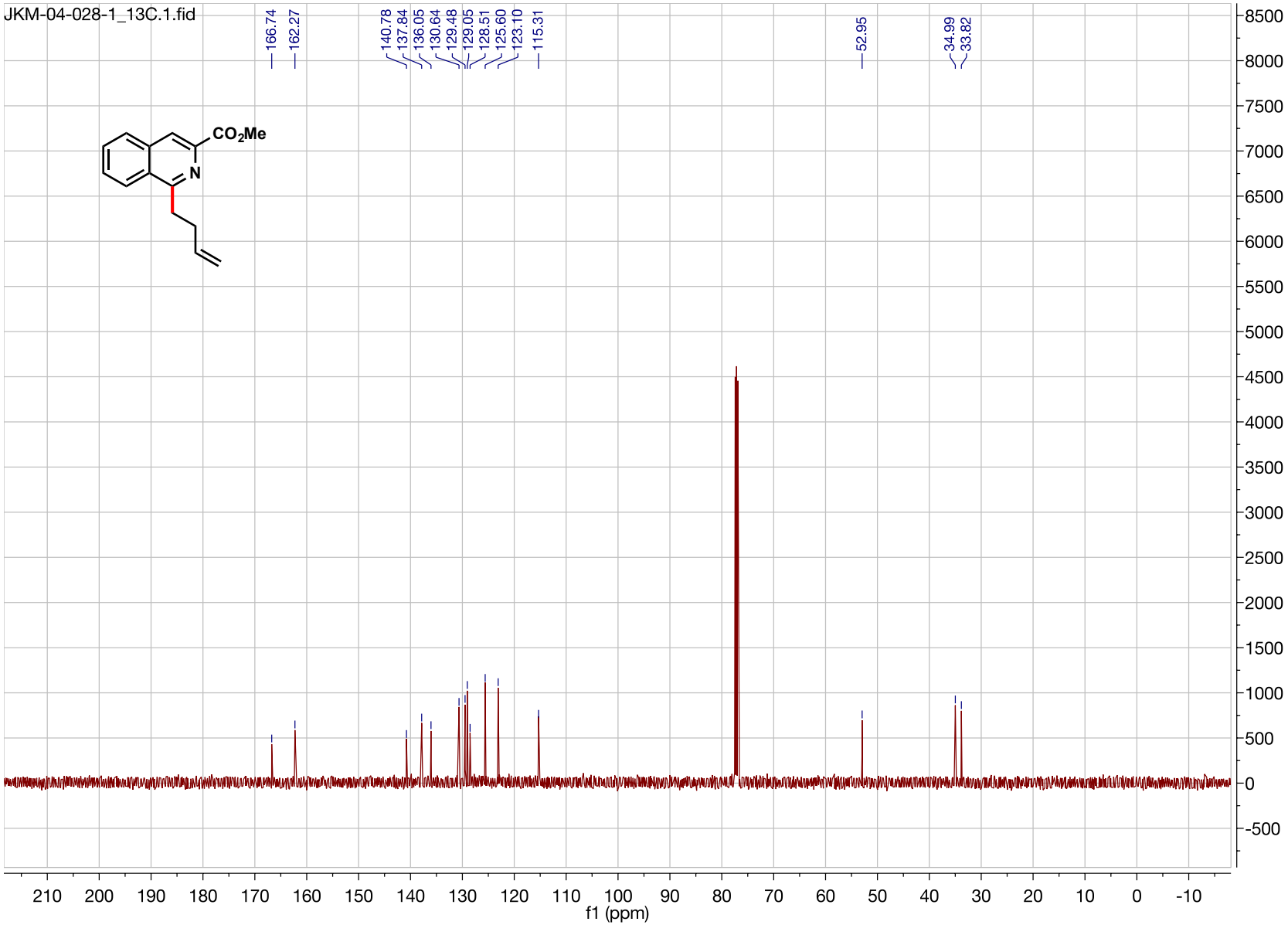
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(3,3,3-trifluoropropyl)isoquinoline-3-carboxylate (**3l**)



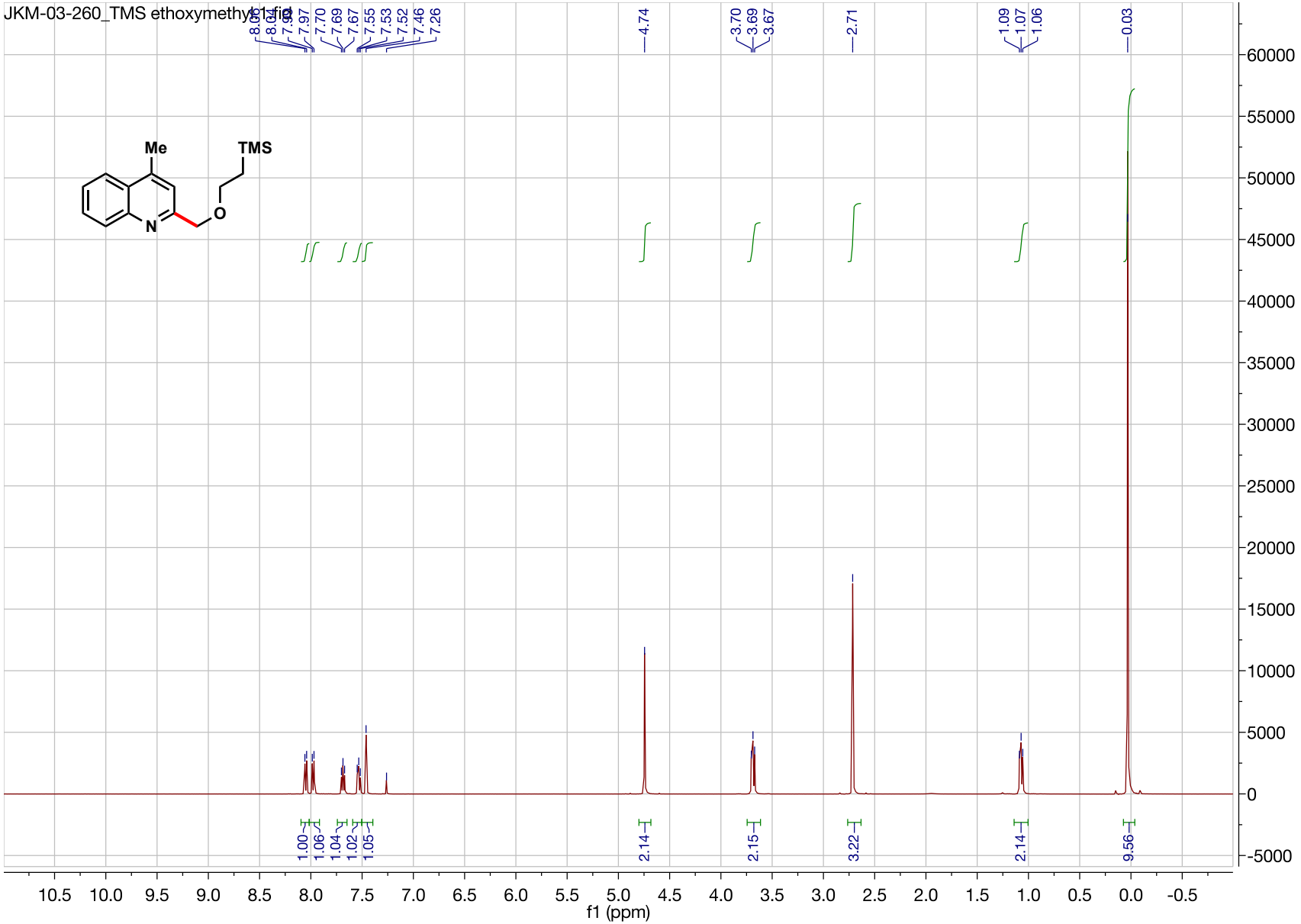
^{1}H ($CDCl_3$, 500 MHz) spectra of methyl 1-(but-3-en-1-yl)isoquinoline-3-carboxylate (**3p**)



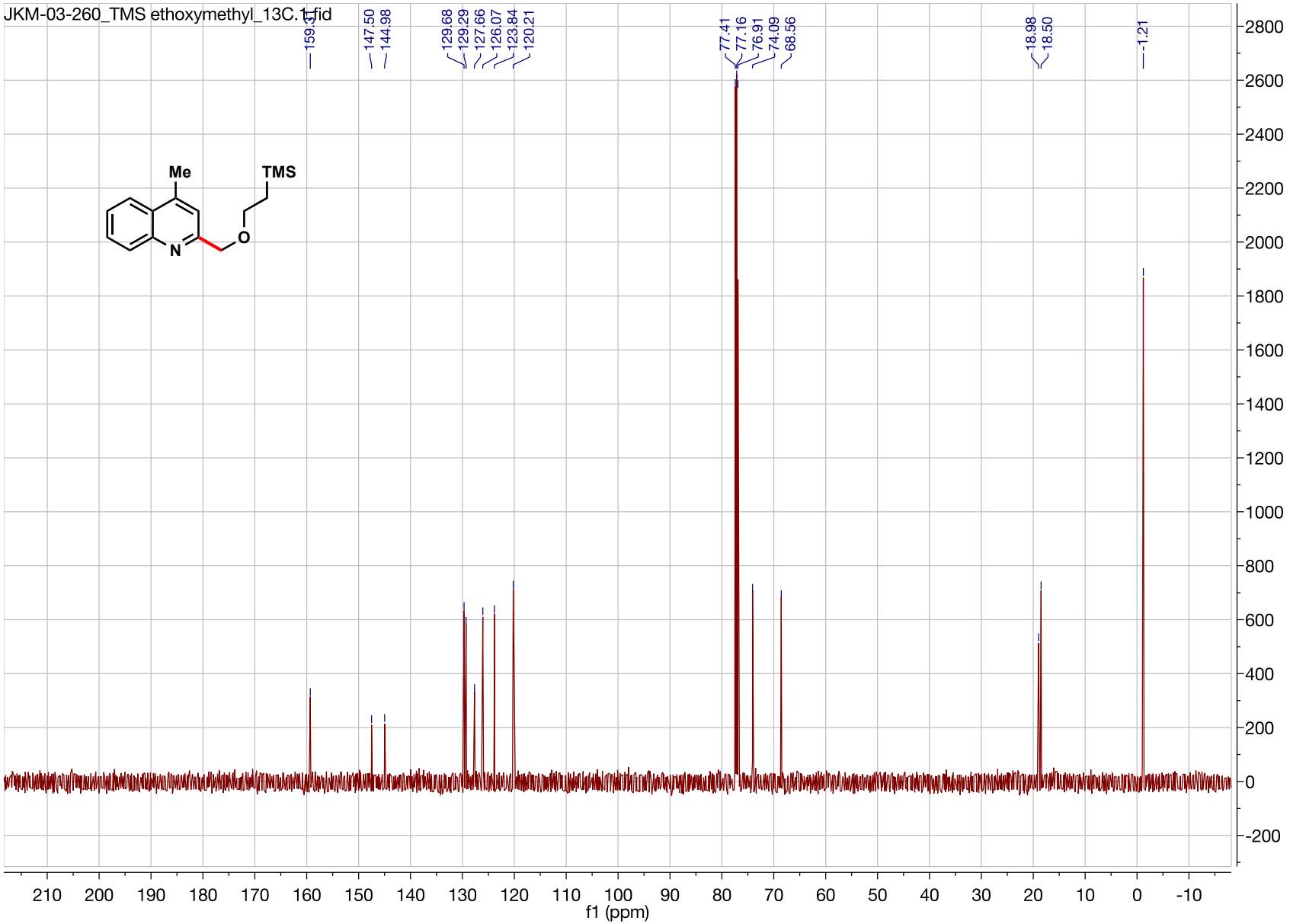
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of methyl 1-(but-3-en-1-yl)isoquinoline-3-carboxylate (**3p**)



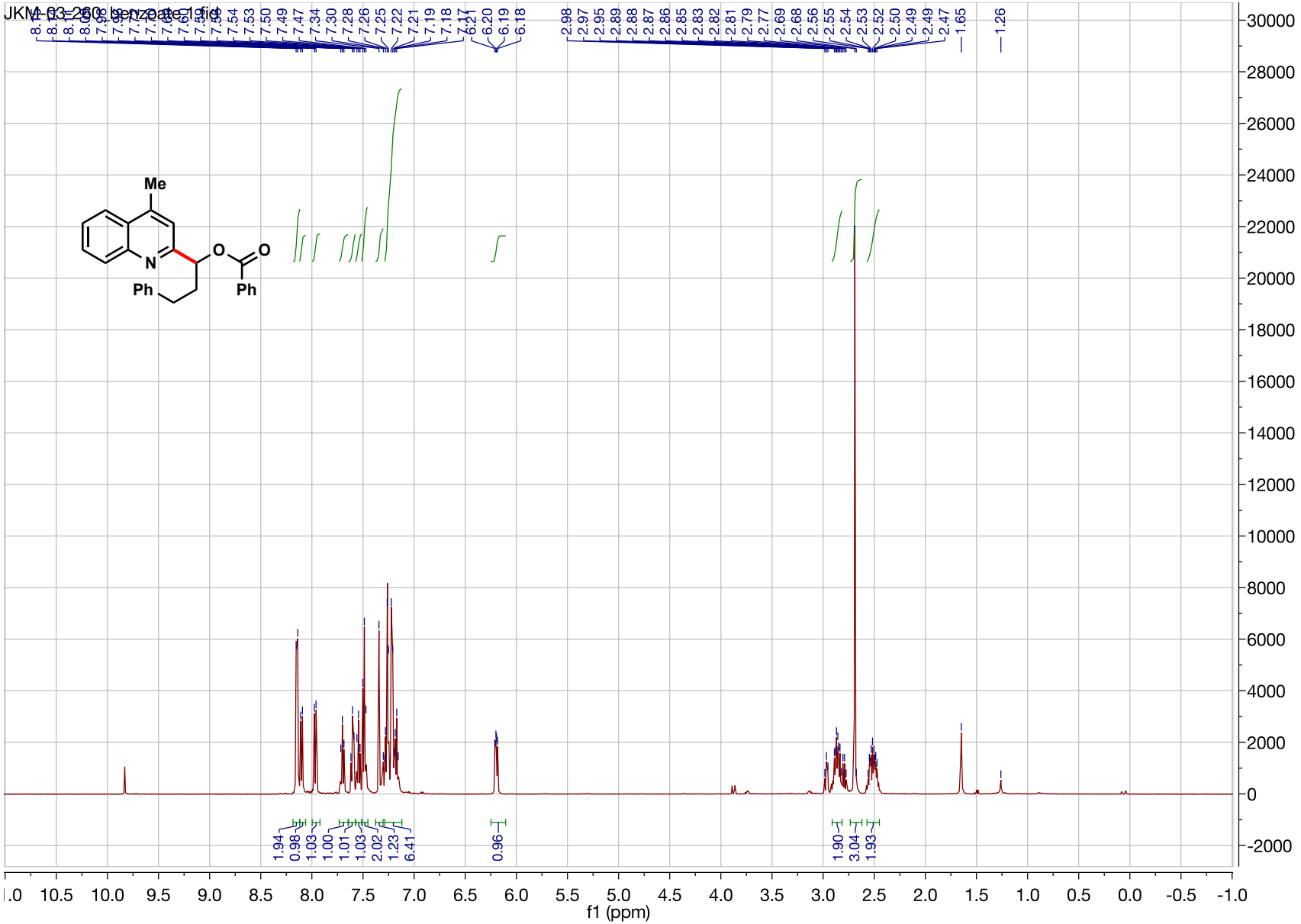
^{1}H ($CDCl_3$, 500 MHz) spectra of 4-methyl-2-((2-(trimethylsilyl)ethoxy)methyl)quinoline (**4a**)



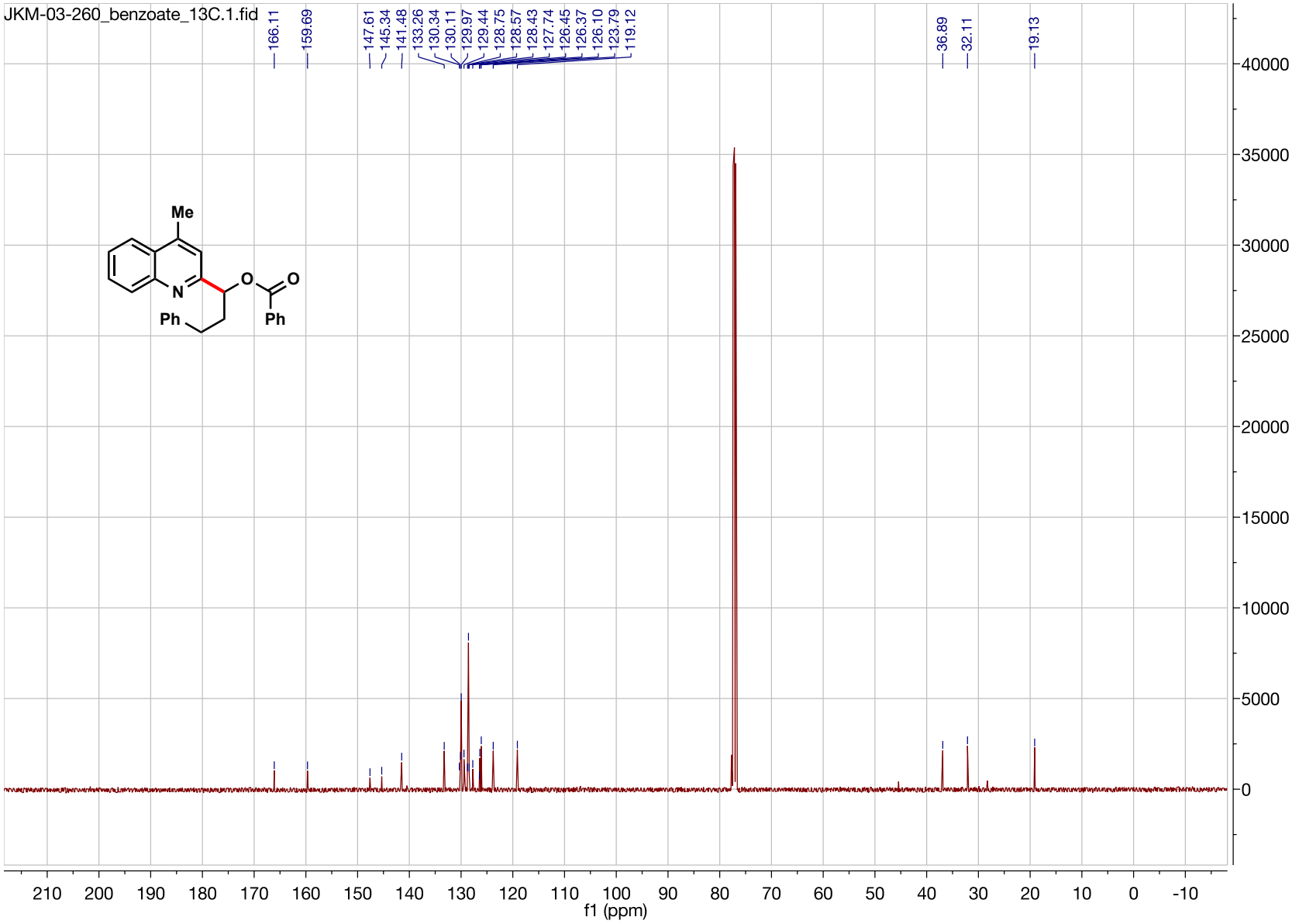
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 4-methyl-2-((2-(trimethylsilyl)ethoxy)methyl)quinoline (**4a**)



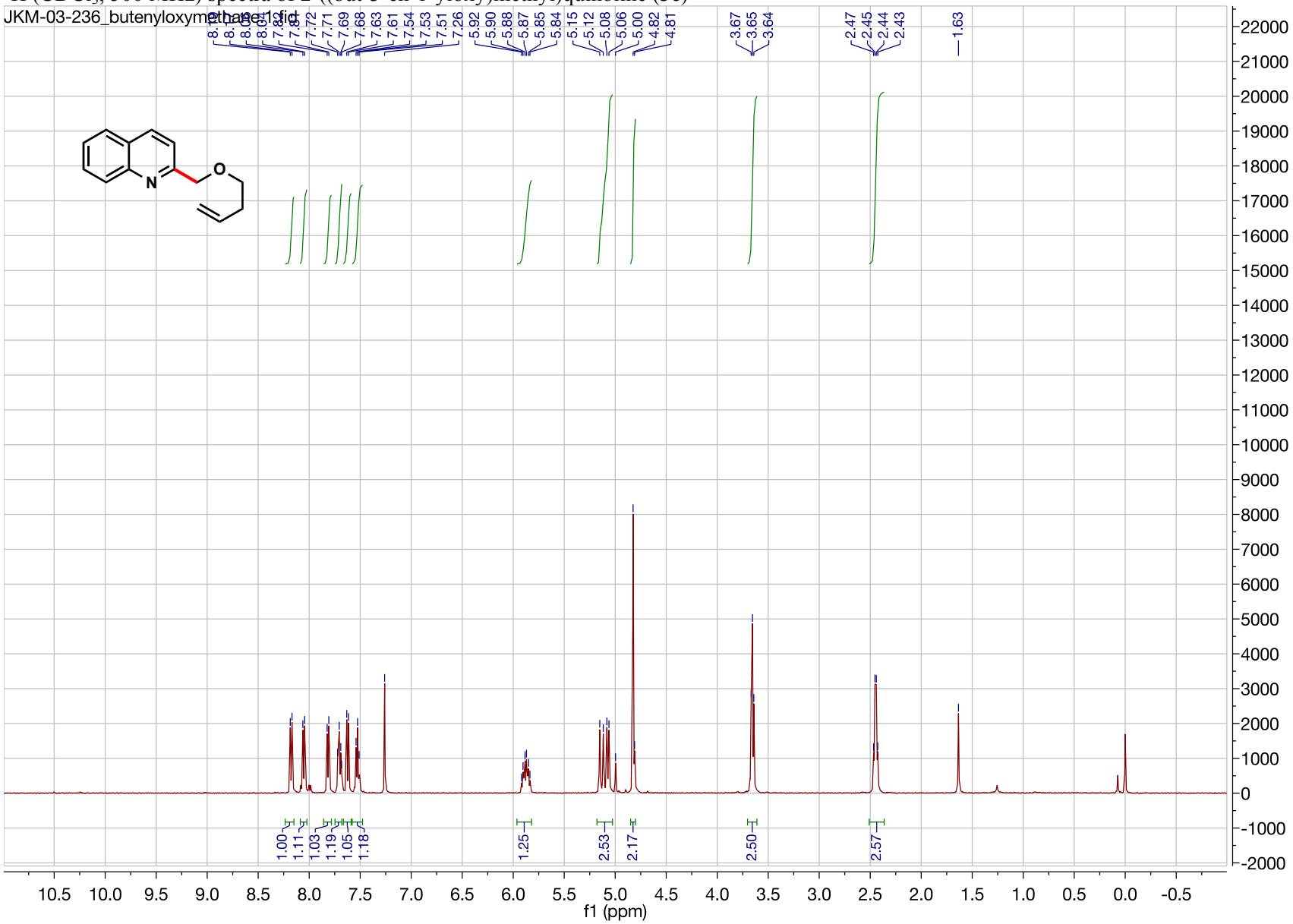
^{1}H ($CDCl_3$, 500 MHz) spectra of 1-(4-methylquinolin-2-yl)-3-phenylpropyl benzoate (**4b**)



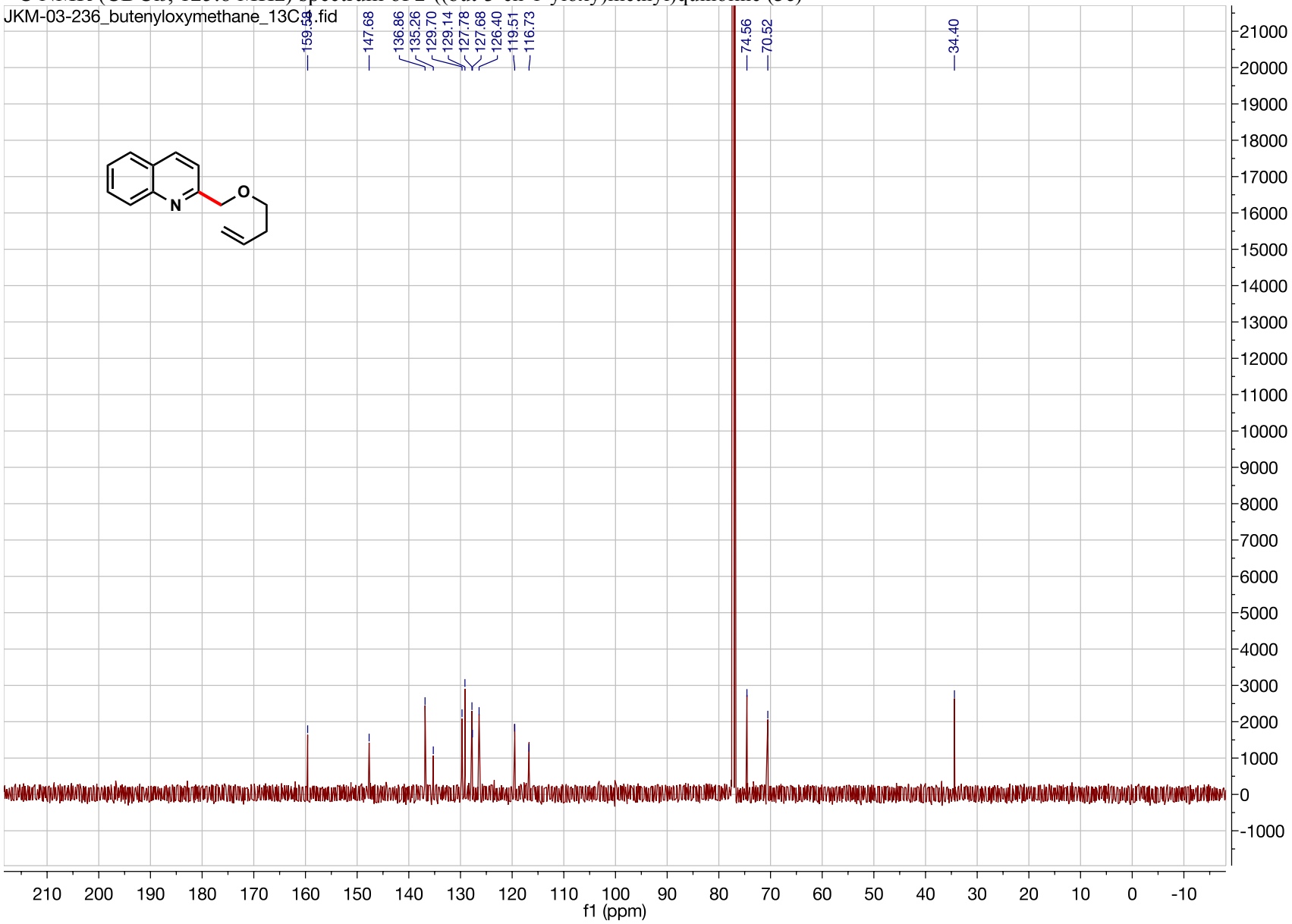
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 1-(4-methylquinolin-2-yl)-3-phenylpropyl benzoate (**4b**)



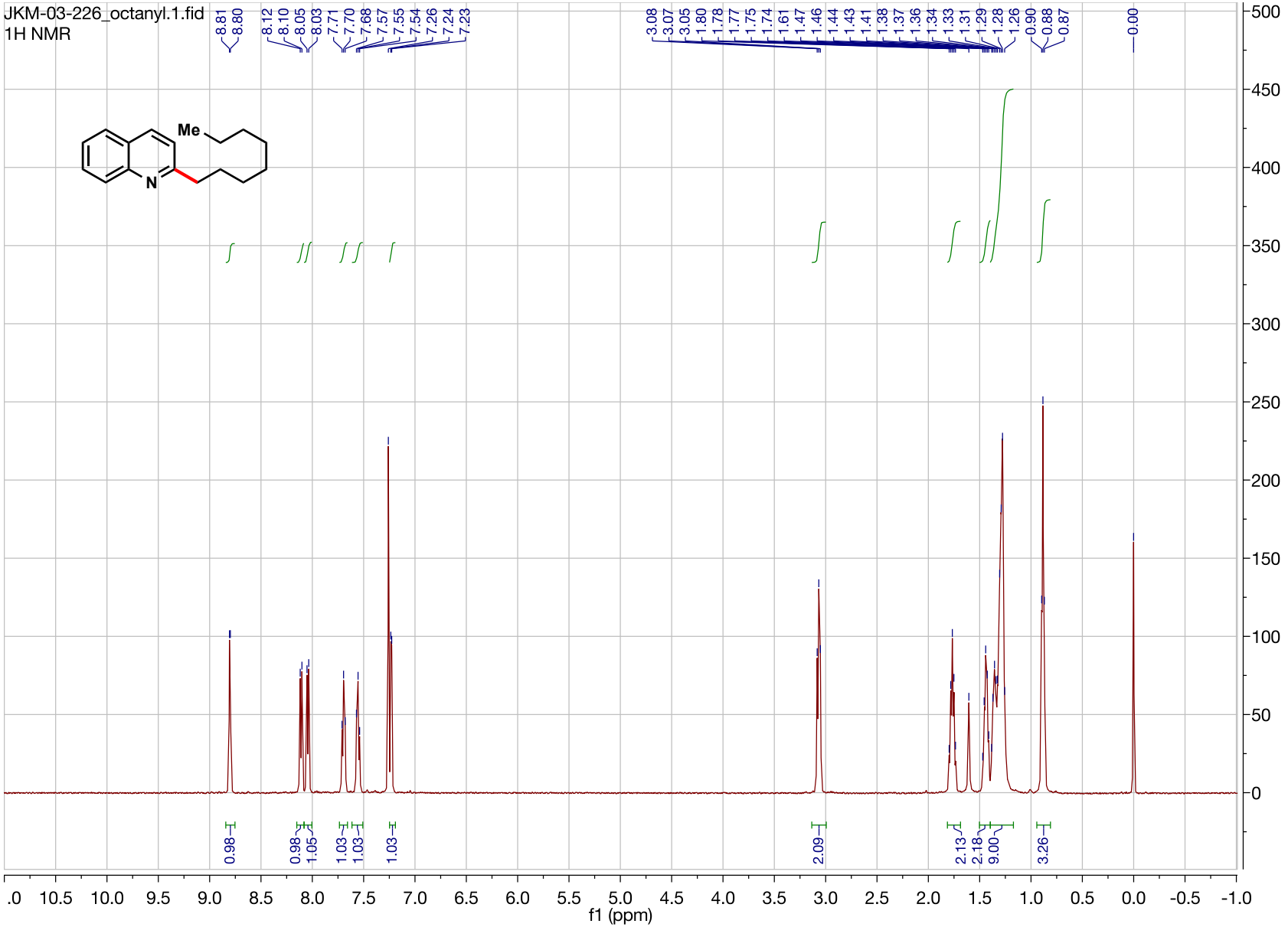
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-((but-3-en-1-yloxy)methyl)quinoline (**3c**)



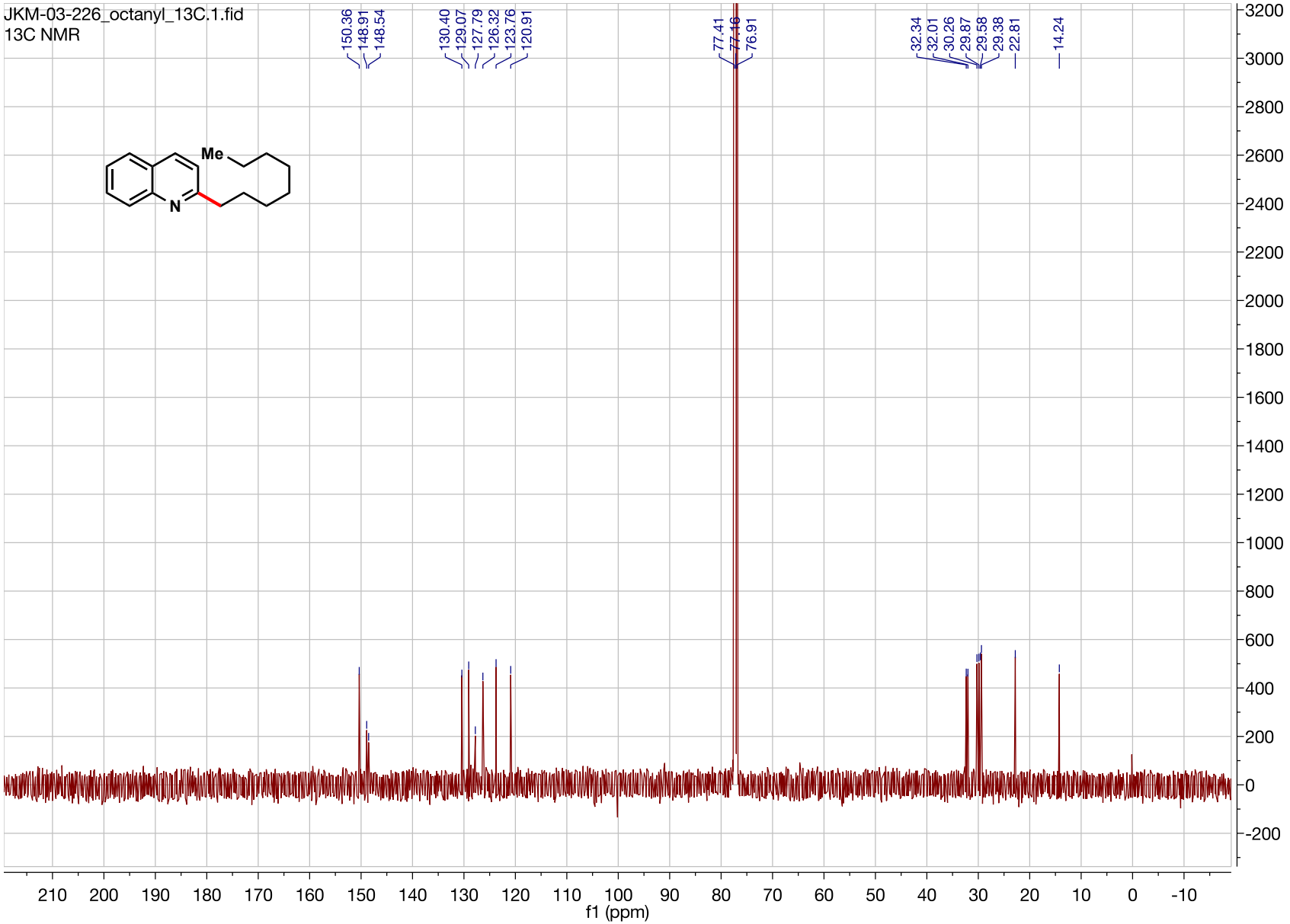
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-((but-3-en-1-yloxy)methyl)quinoline (**3c**)



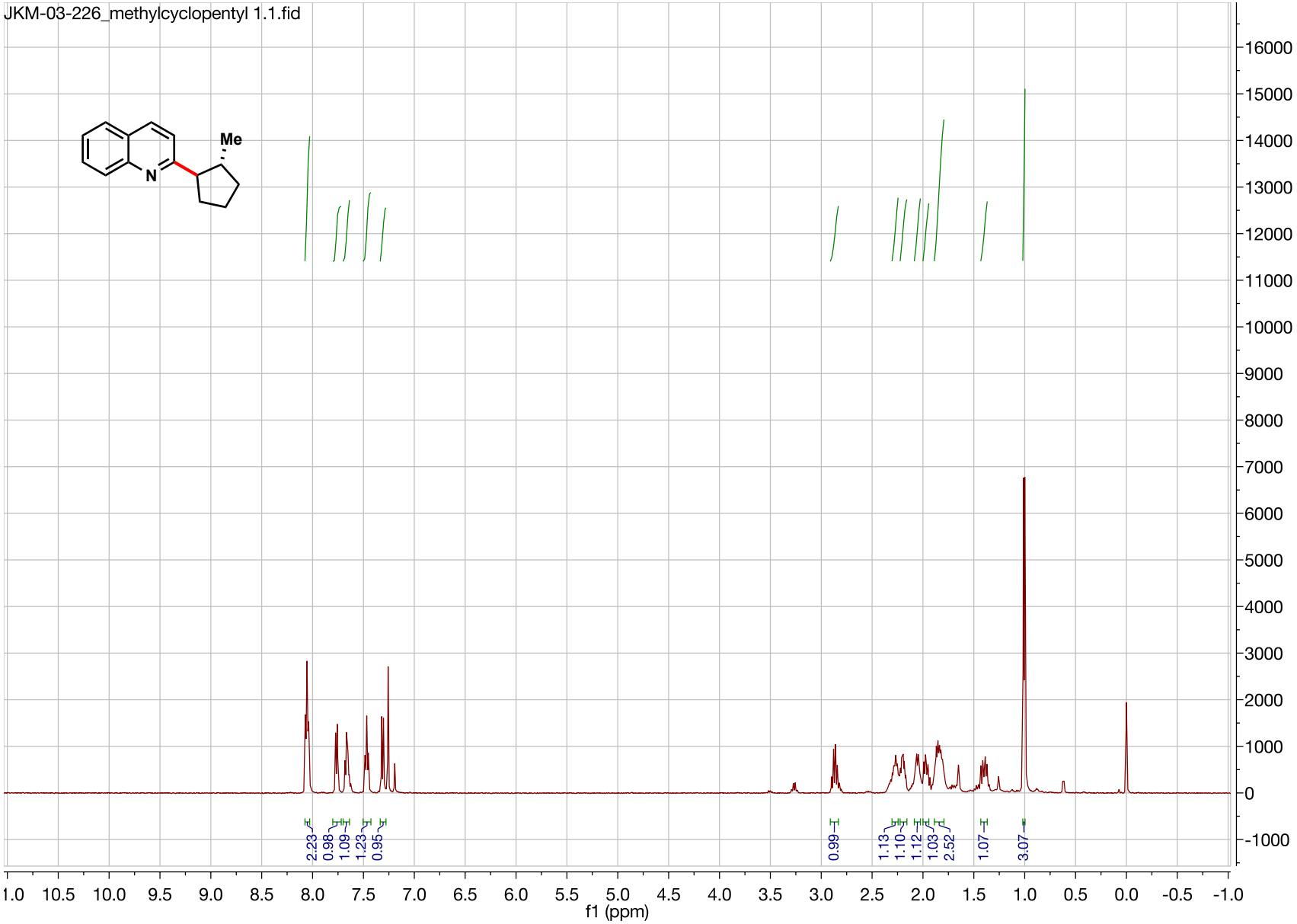
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-octylquinoline (**3d**)



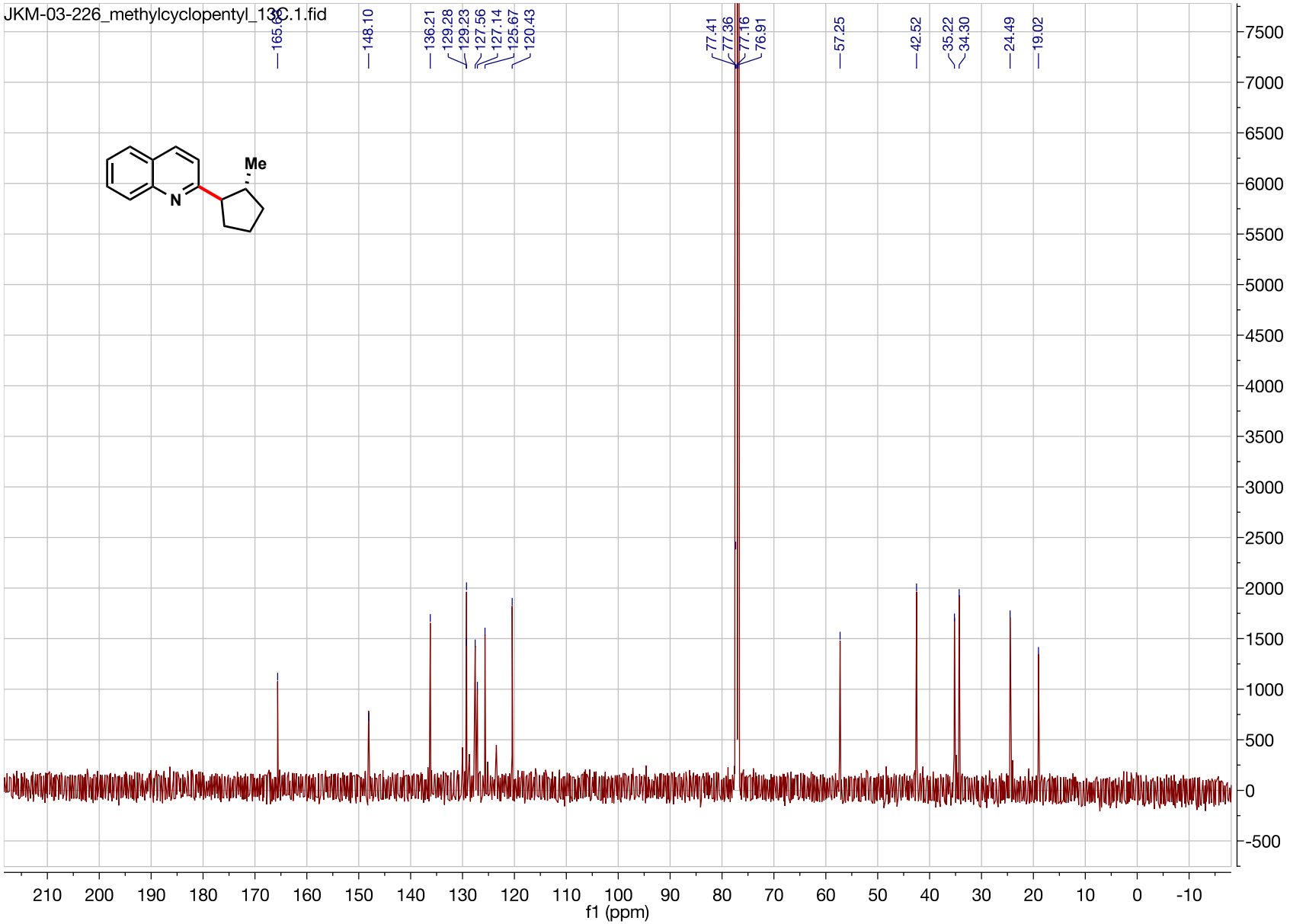
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-octylquinoline (**3d**)



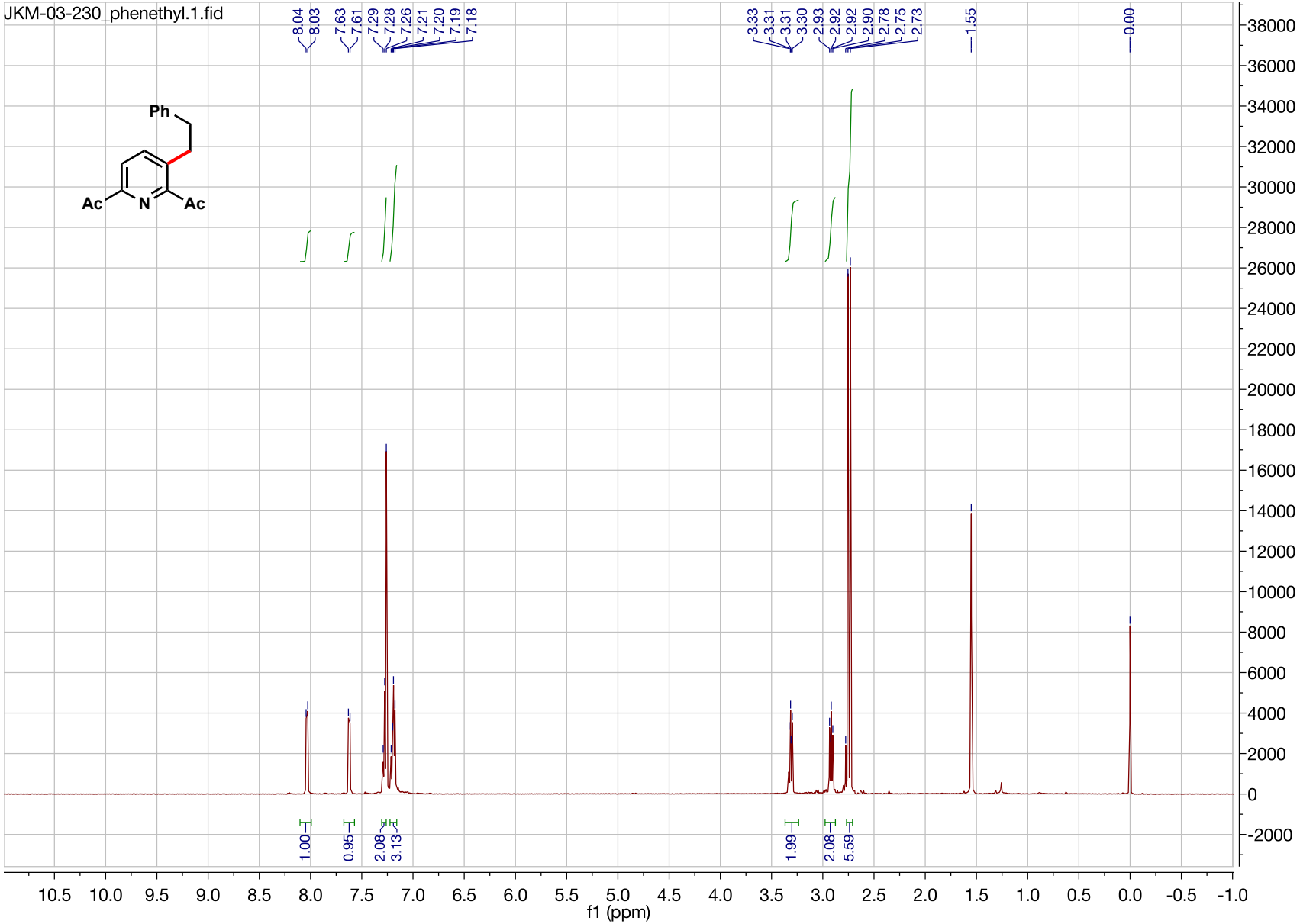
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-((2*R*)-2-methylcyclopentyl)quinoline (**3e**)



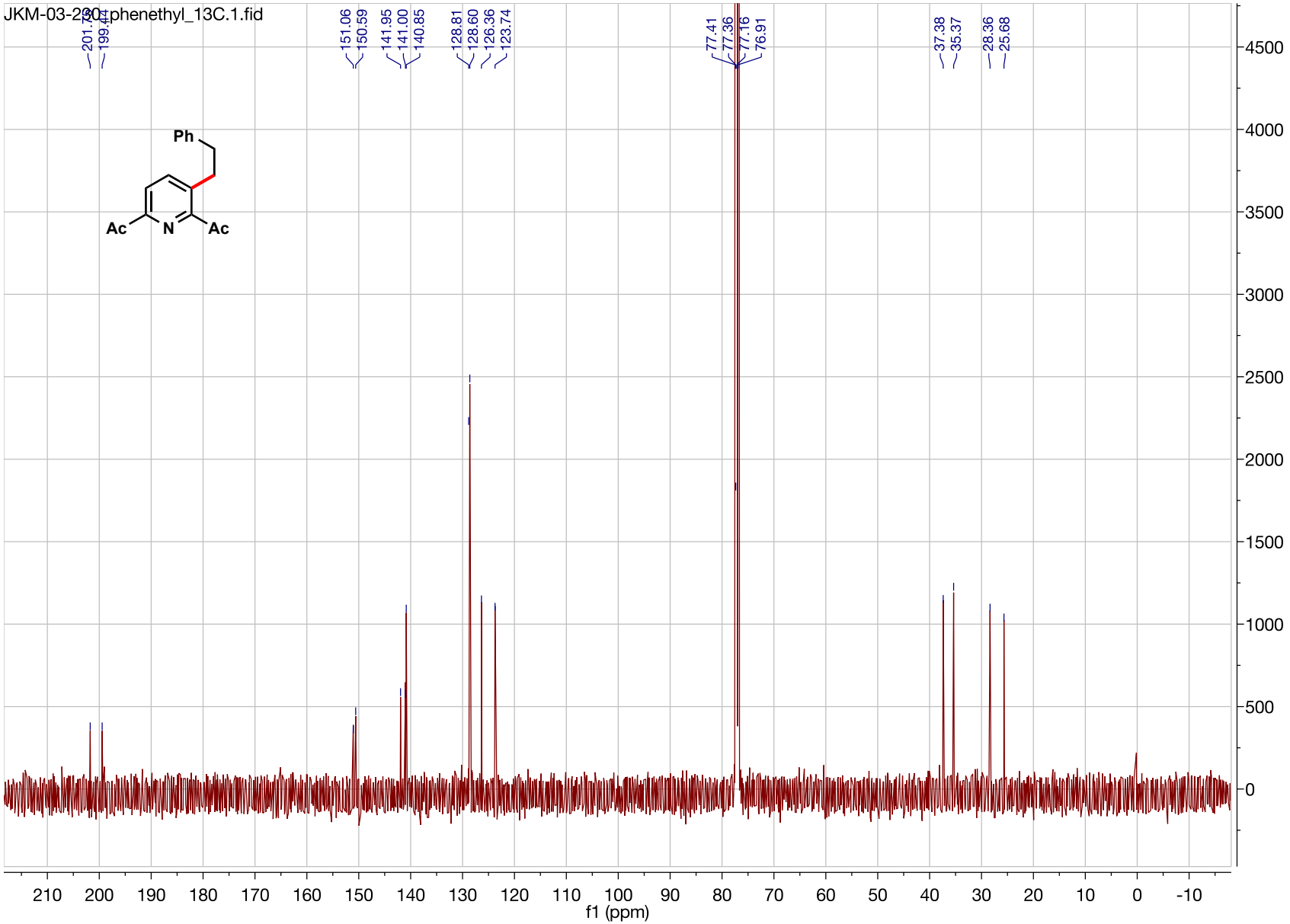
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-((2*R*)-2-methylcyclopentyl)quinoline (**3e**)



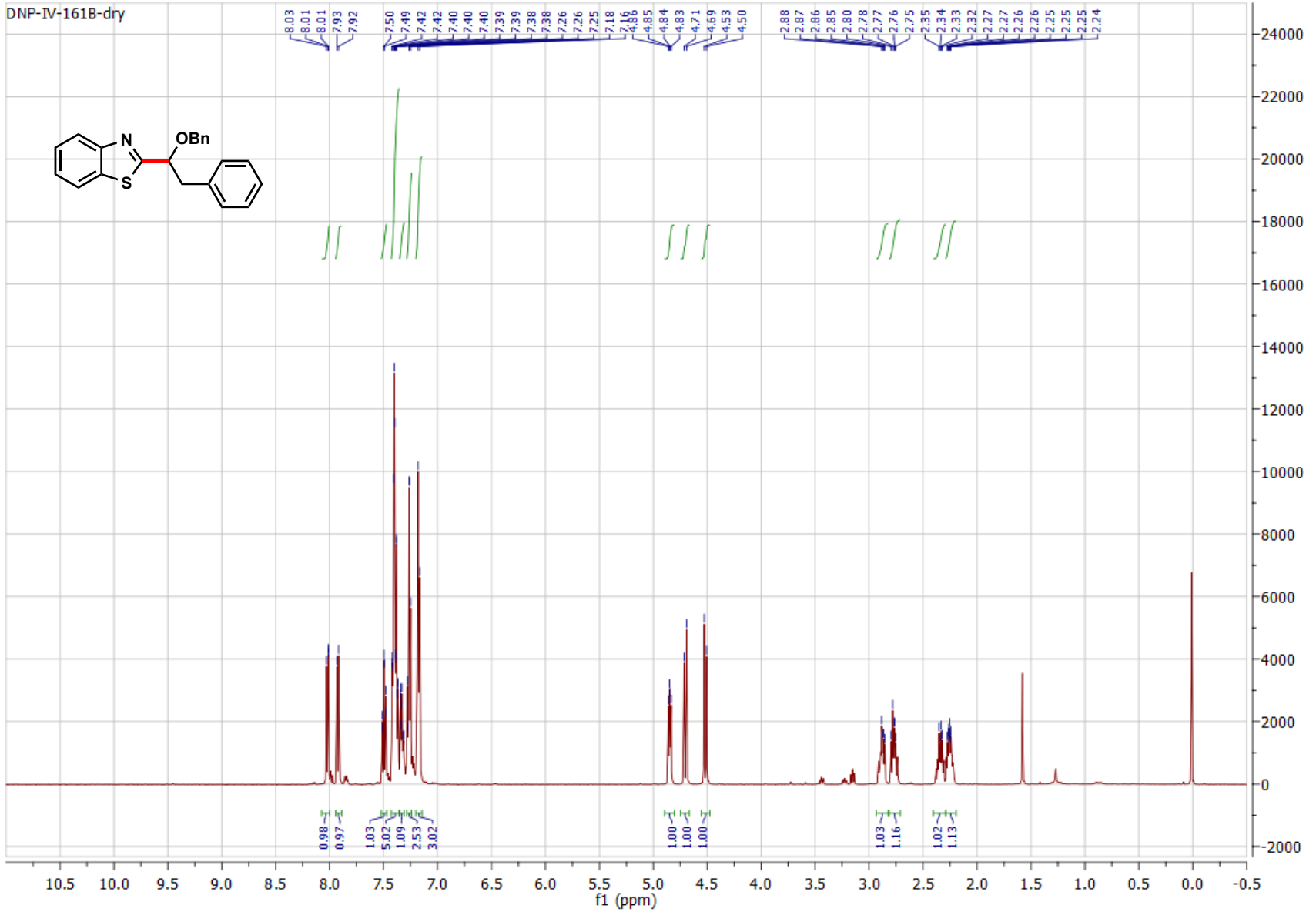
^{1}H ($CDCl_3$, 500 MHz) spectra of 1,1'-(3-phenethylpyridine-2,6-diyl)bis(ethan-1-one) (**3f**)



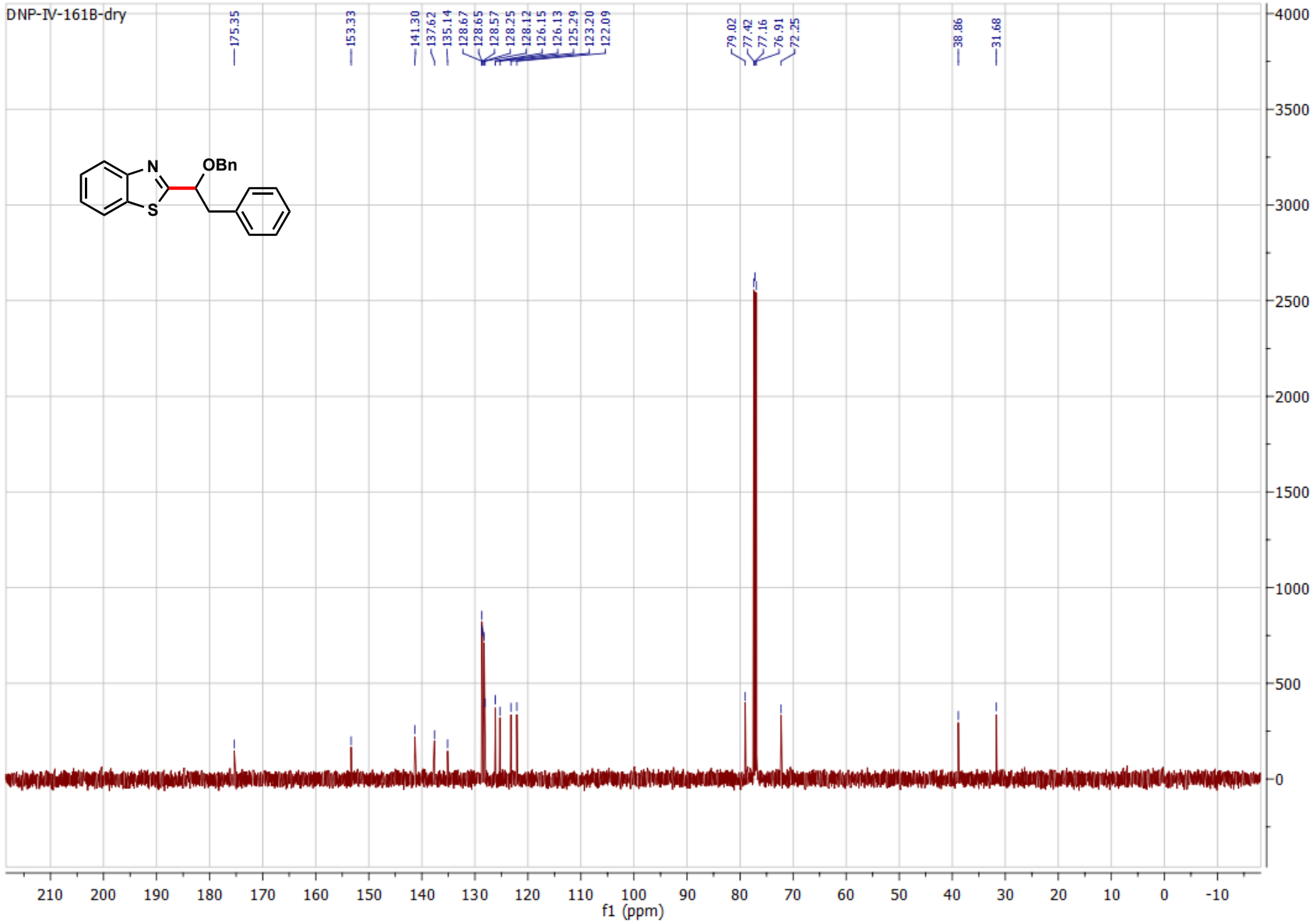
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 1,1'-(3-phenethylpyridine-2,6-diyl)bis(ethan-1-one) (**3f**)



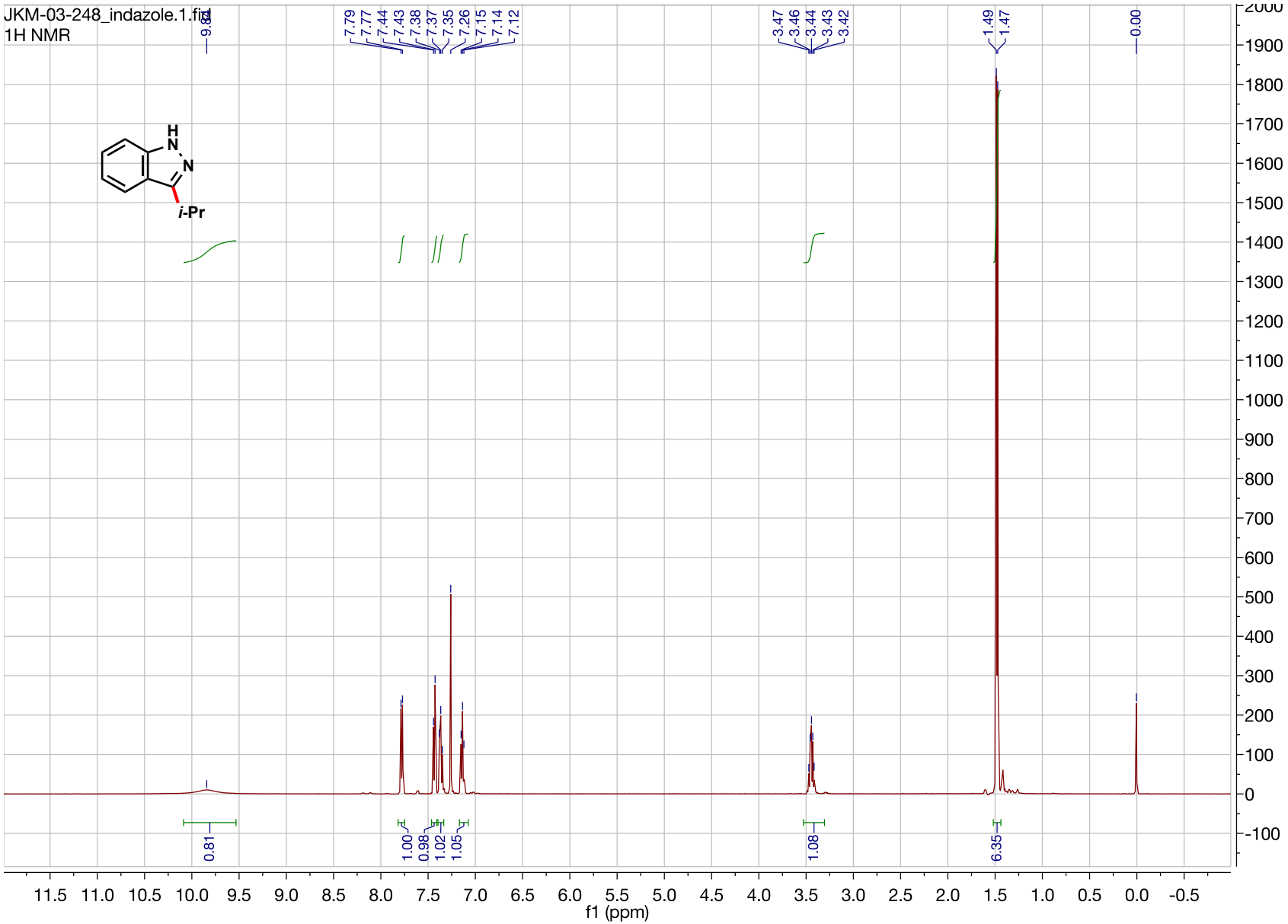
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(1-(benzyloxy)-2-phenylethyl)benzo[*d*]thiazole (**3g**)



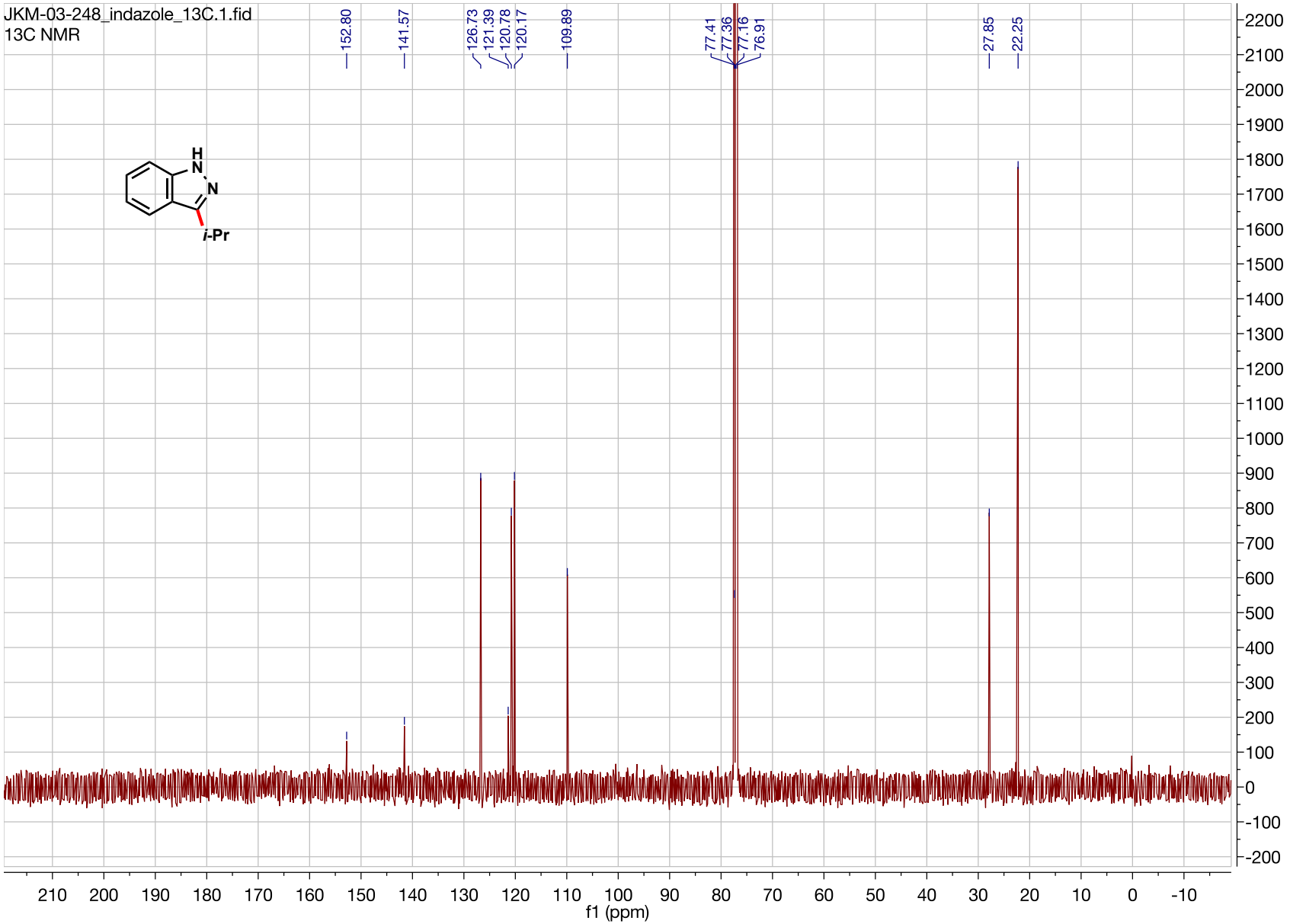
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(1-(benzyloxy)-2-phenylethyl)benzo[*d*]thiazole (**3g**)



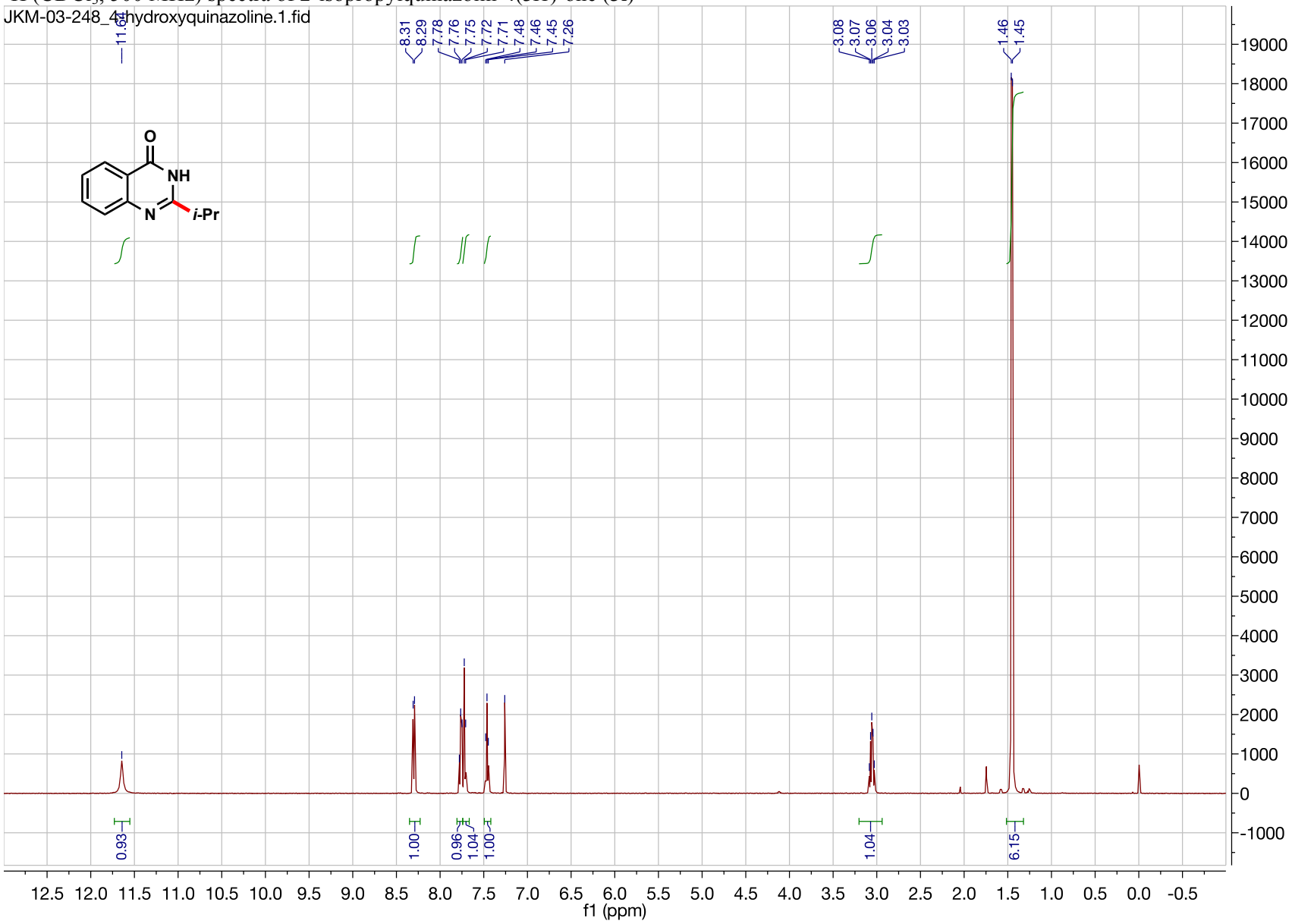
^{1}H ($CDCl_3$, 500 MHz) spectra of 3-Isopropyl-1*H*-indazole (**3h**)



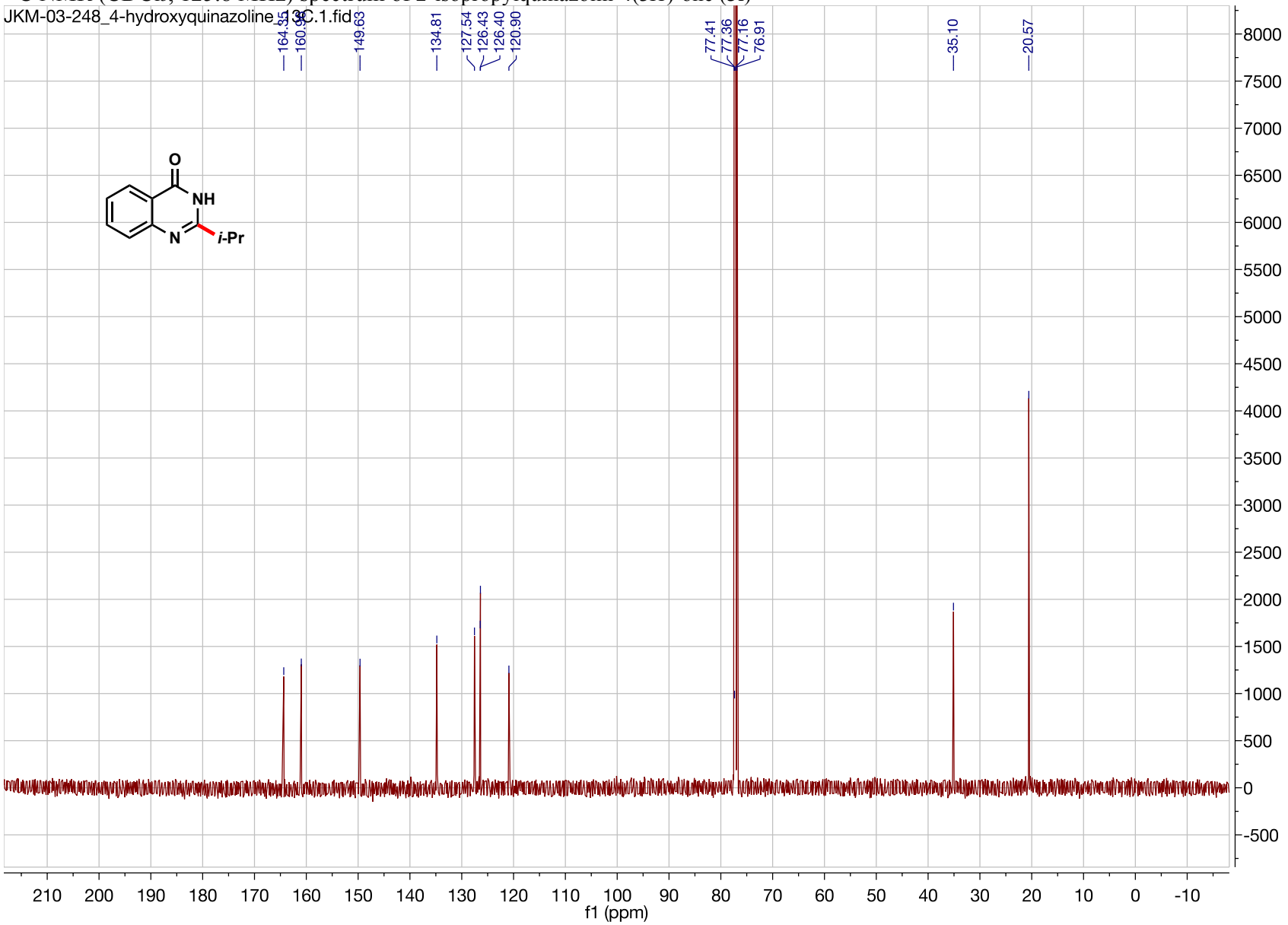
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 3-isopropyl-1*H*-indazole (**3h**)



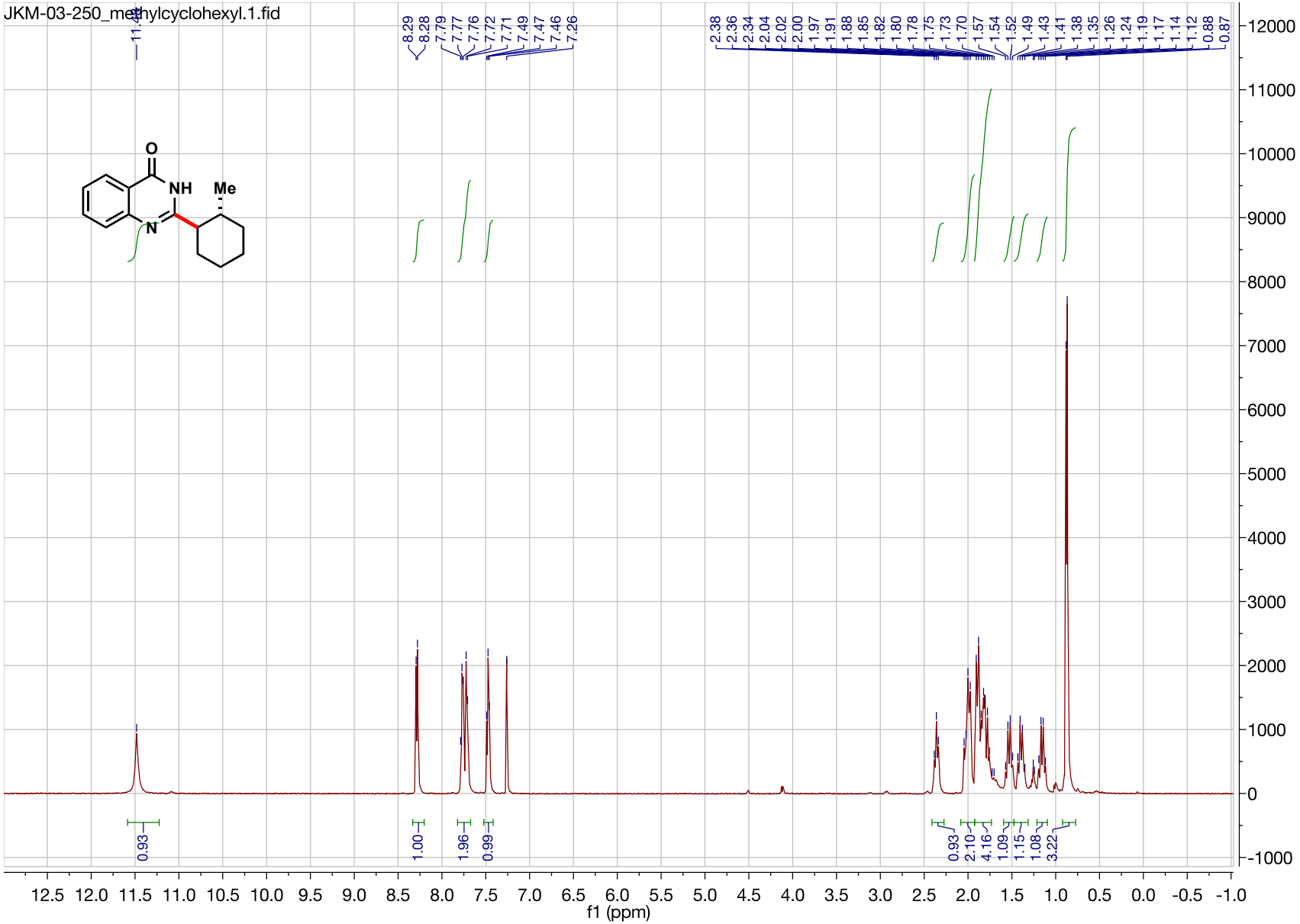
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-isopropylquinazolin-4(3*H*)-one (**3i**)



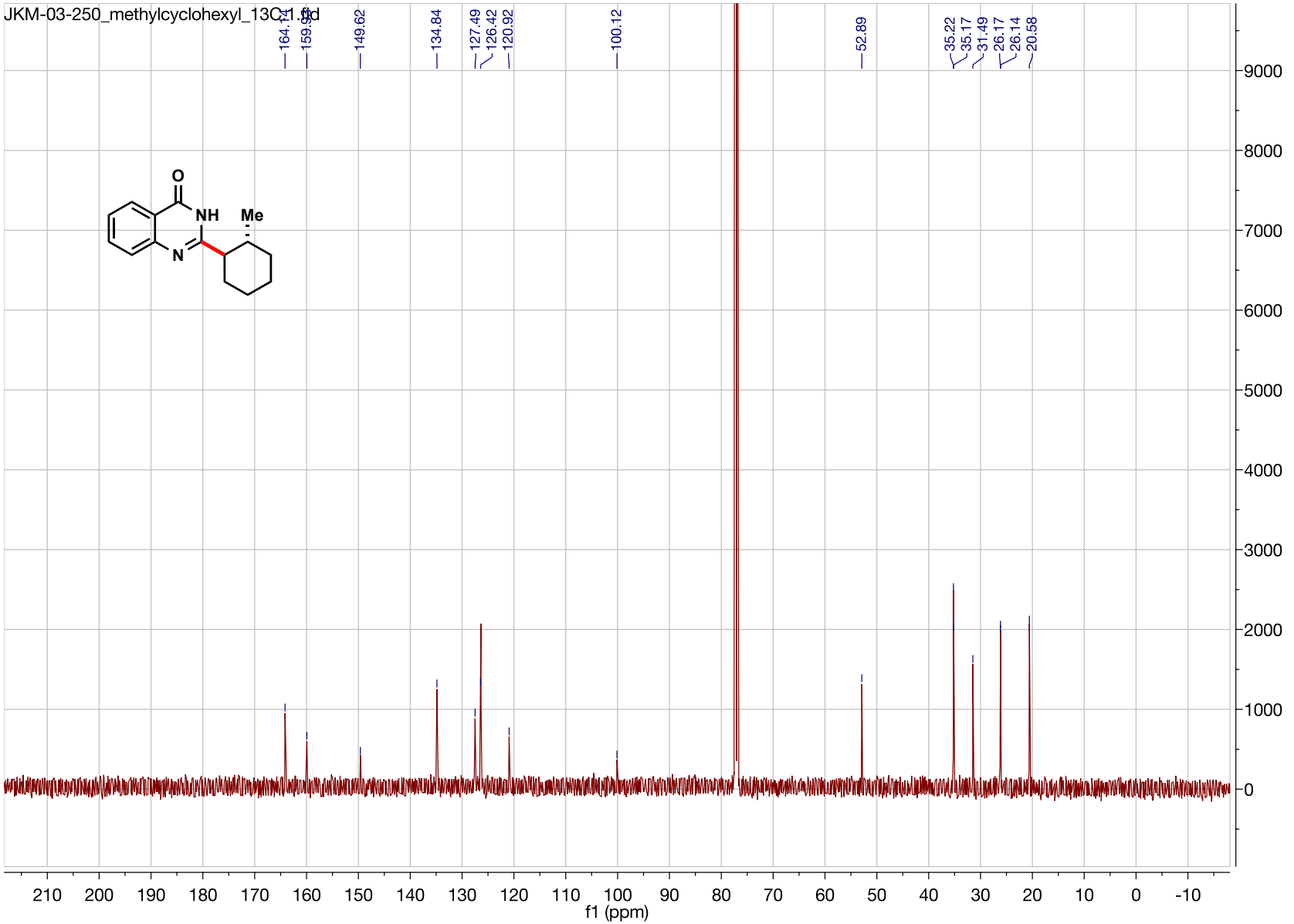
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-isopropylquinazolin-4(3*H*)-one (**3i**)



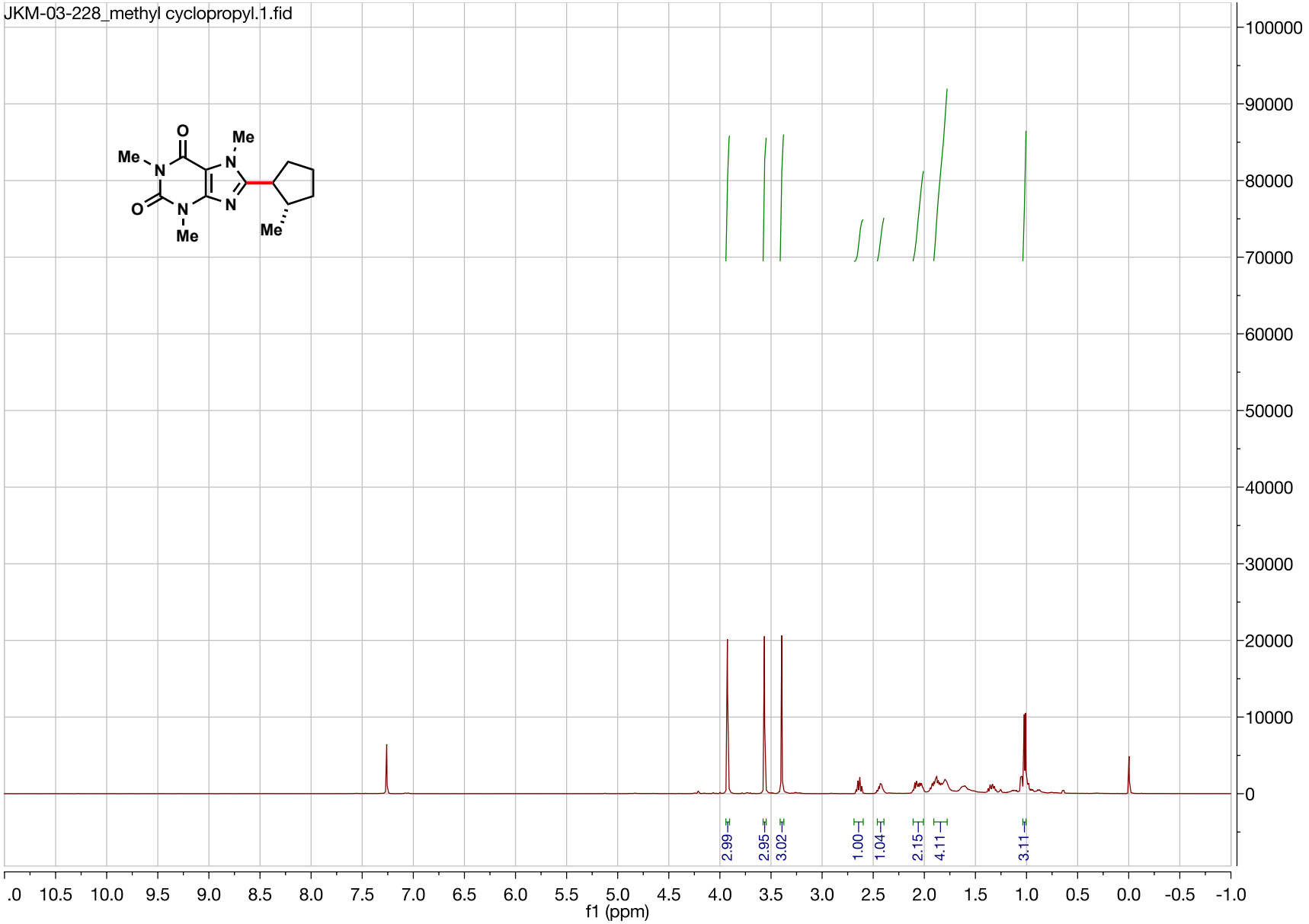
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-((1*R*,2*R*)-2-methylcyclohexyl)quinazolin-4(3*H*)-one (**3j**)



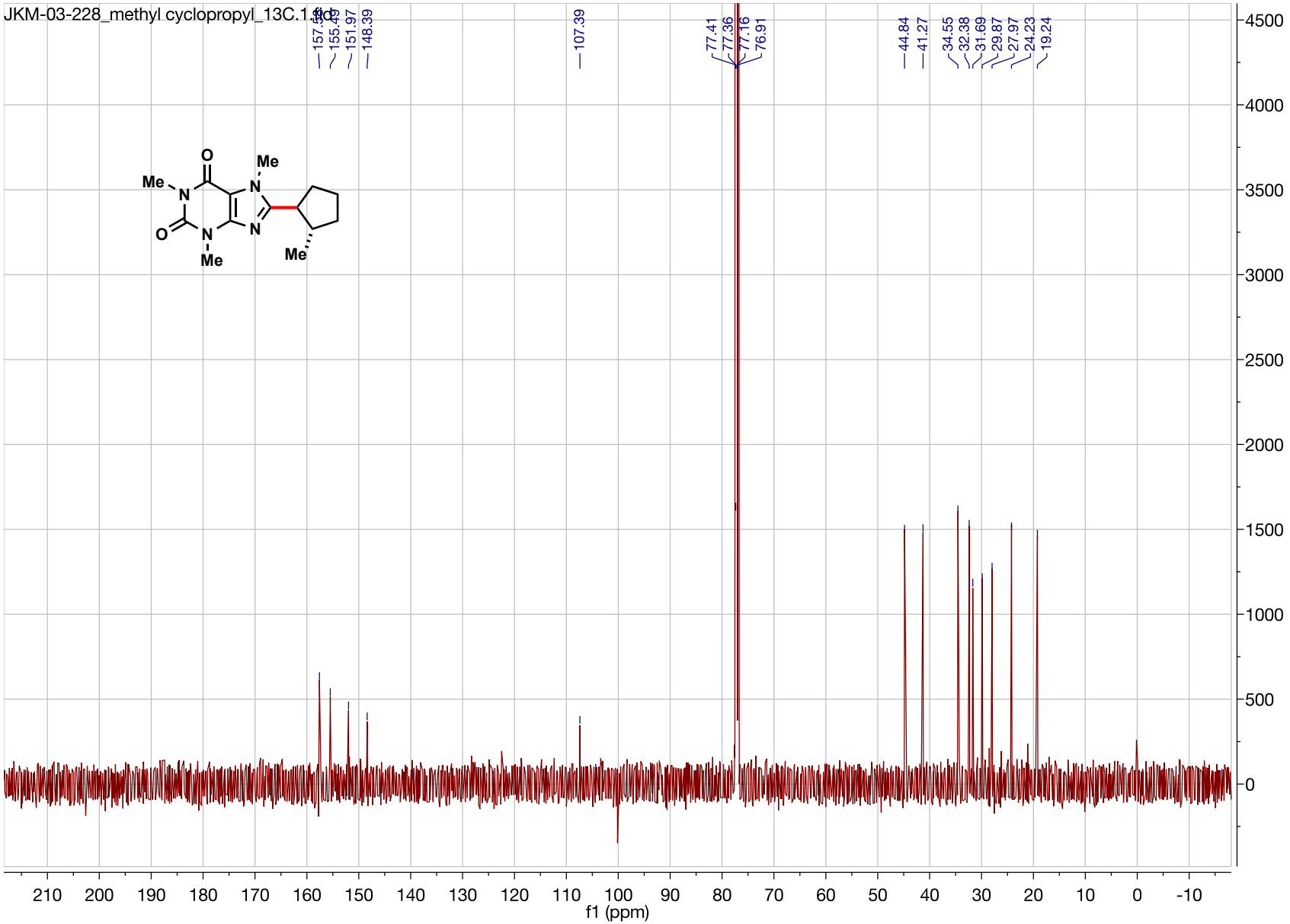
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-((1*R*,2*R*)-2-methylcyclohexyl)quinazolin-4(3*H*)-one (**3j**)



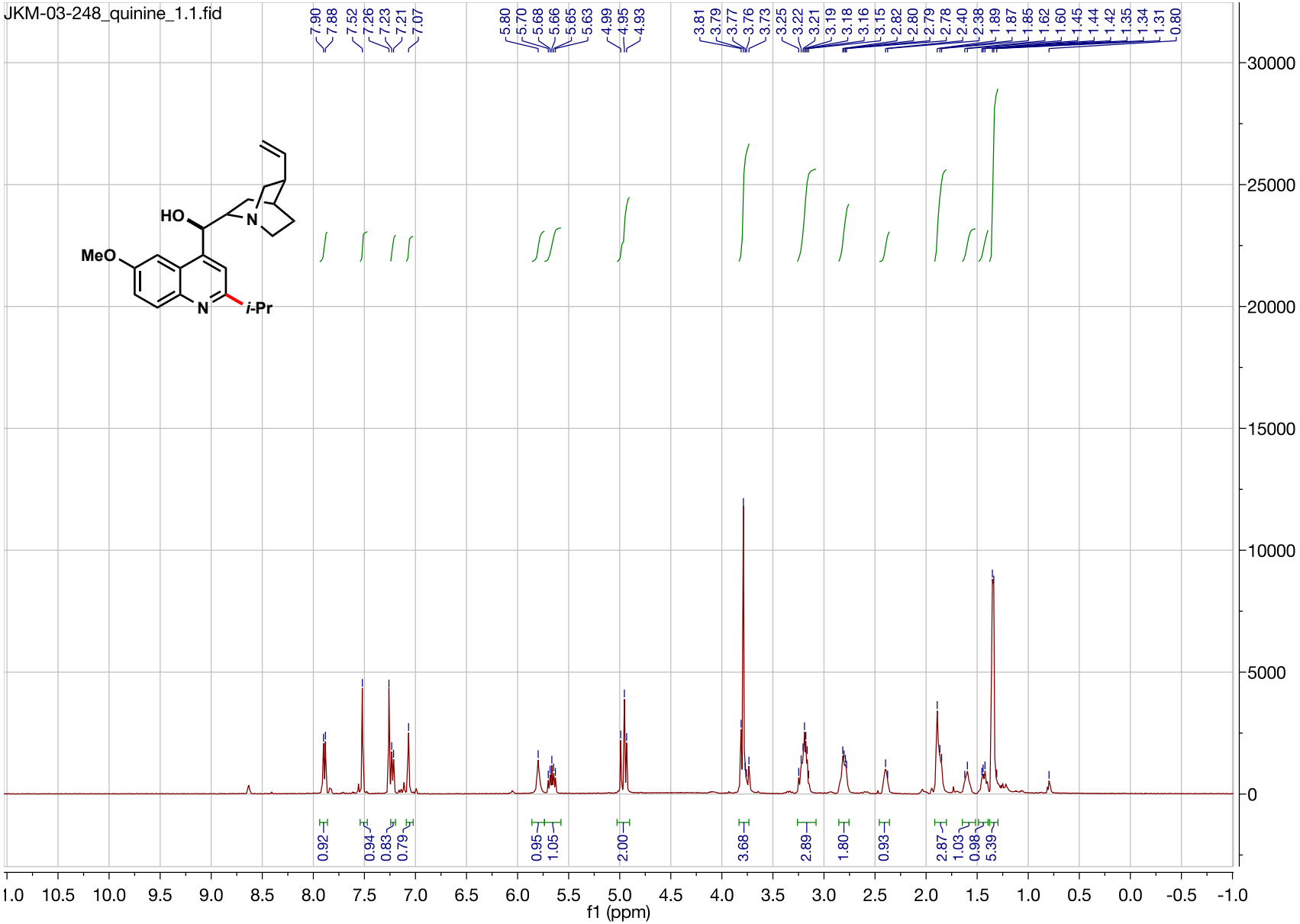
^{1}H ($CDCl_3$, 500 MHz) spectra of 1,3,7-trimethyl-8-((2*S*)-2-methylcyclopentyl)-3,7-dihydro-1*H*-purine-2,6-dione (**3k**)



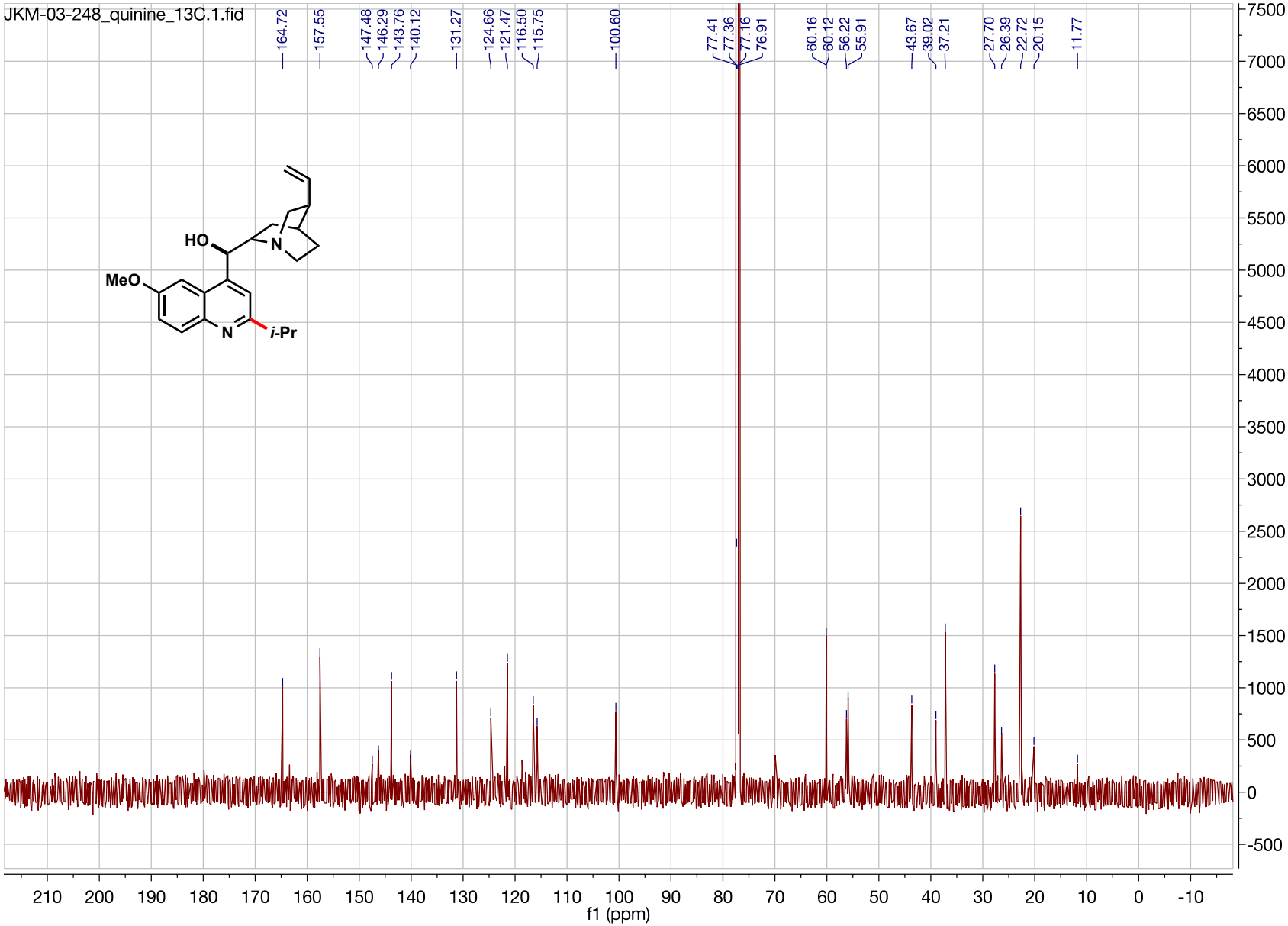
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 1,3,7-trimethyl-8-((2*S*)-2-methylcyclopentyl)-3,7-dihydro-1*H*-purine-2,6-dione (**3k**)



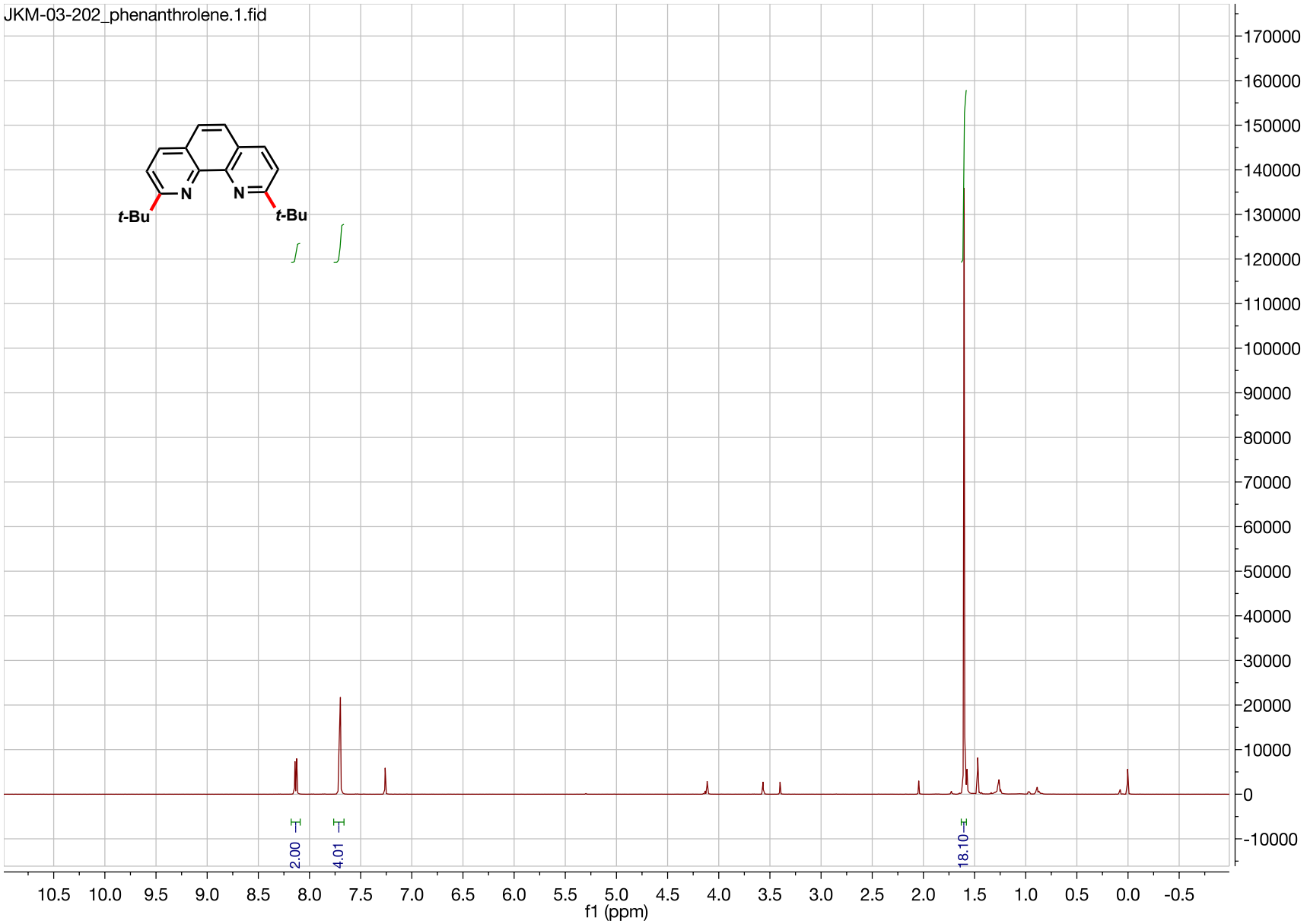
^{1}H ($CDCl_3$, 500 MHz) spectra of (1*R*)-(2-isopropyl-6-methoxyquinolin-4-yl)(5-vinylquinuclidin-2-yl)methanol (**4l**)



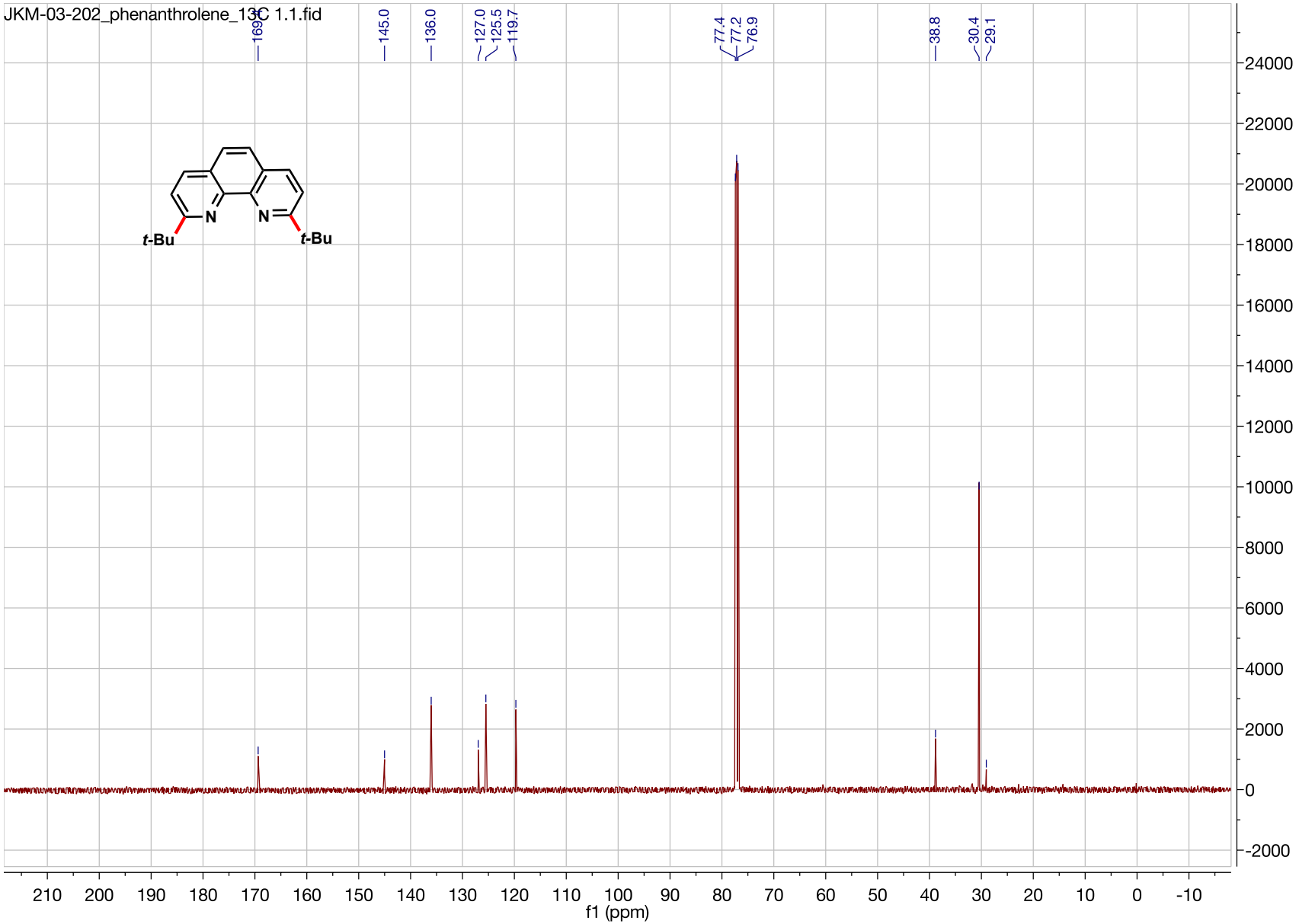
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of (1*R*)-(2-isopropyl-6-methoxyquinolin-4-yl)(5-vinylquinuclidin-2-yl)methanol (**4l**)



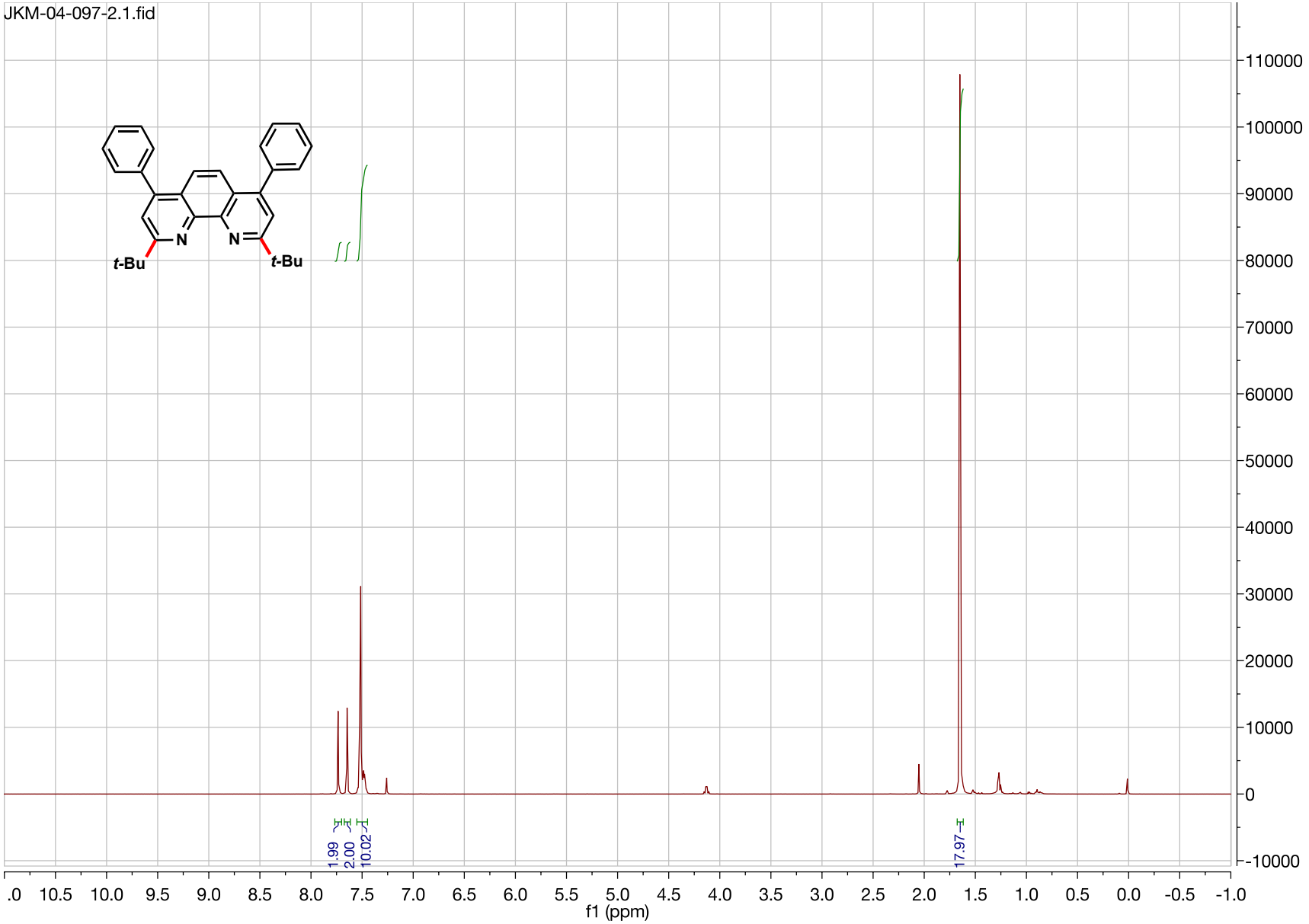
^{1}H ($CDCl_3$, 500 MHz) spectra of 2,9-di-*tert*-butyl-1,10-phenanthroline (**5b**)



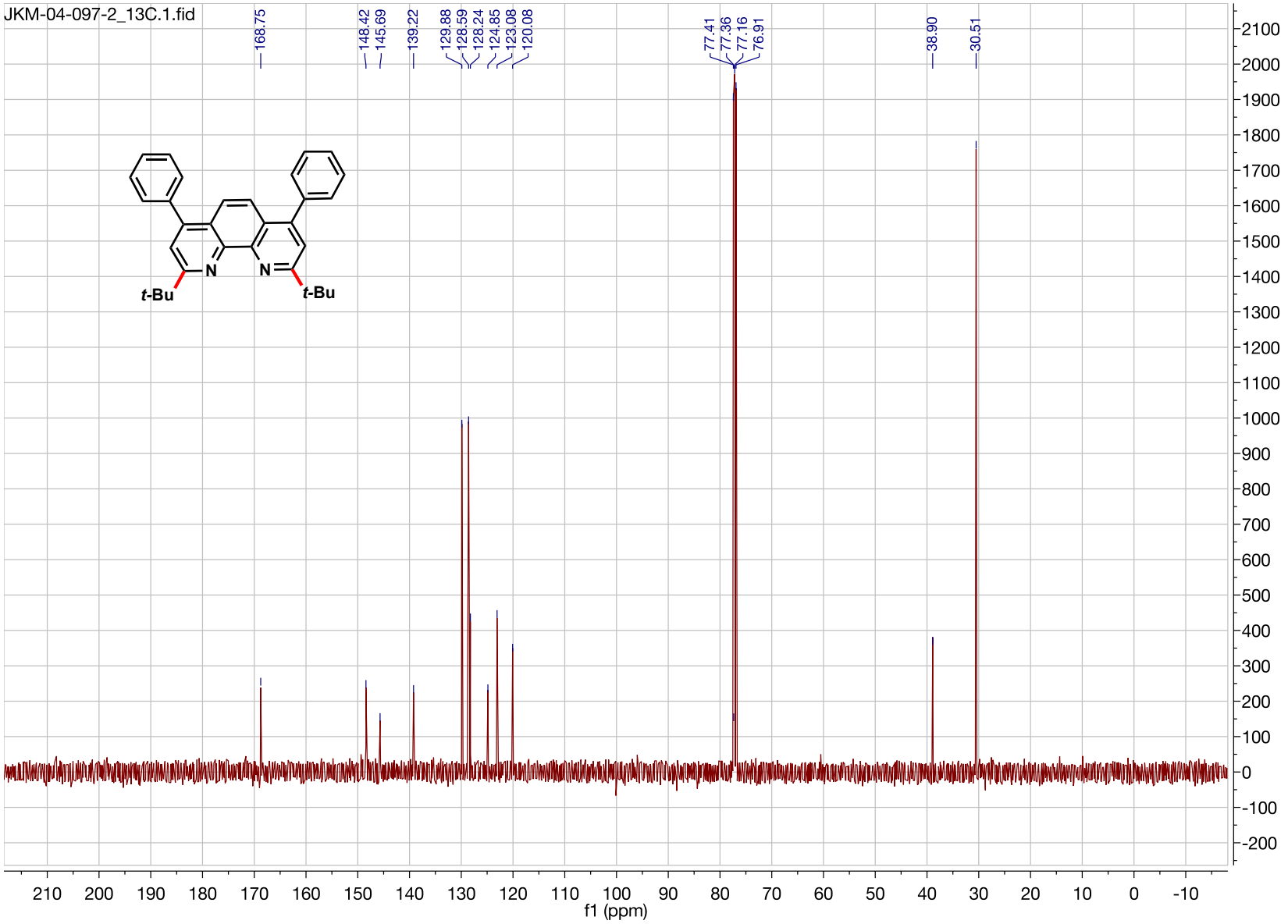
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2,9-di-*tert*-butyl-1,10-phenanthroline (**5b**)



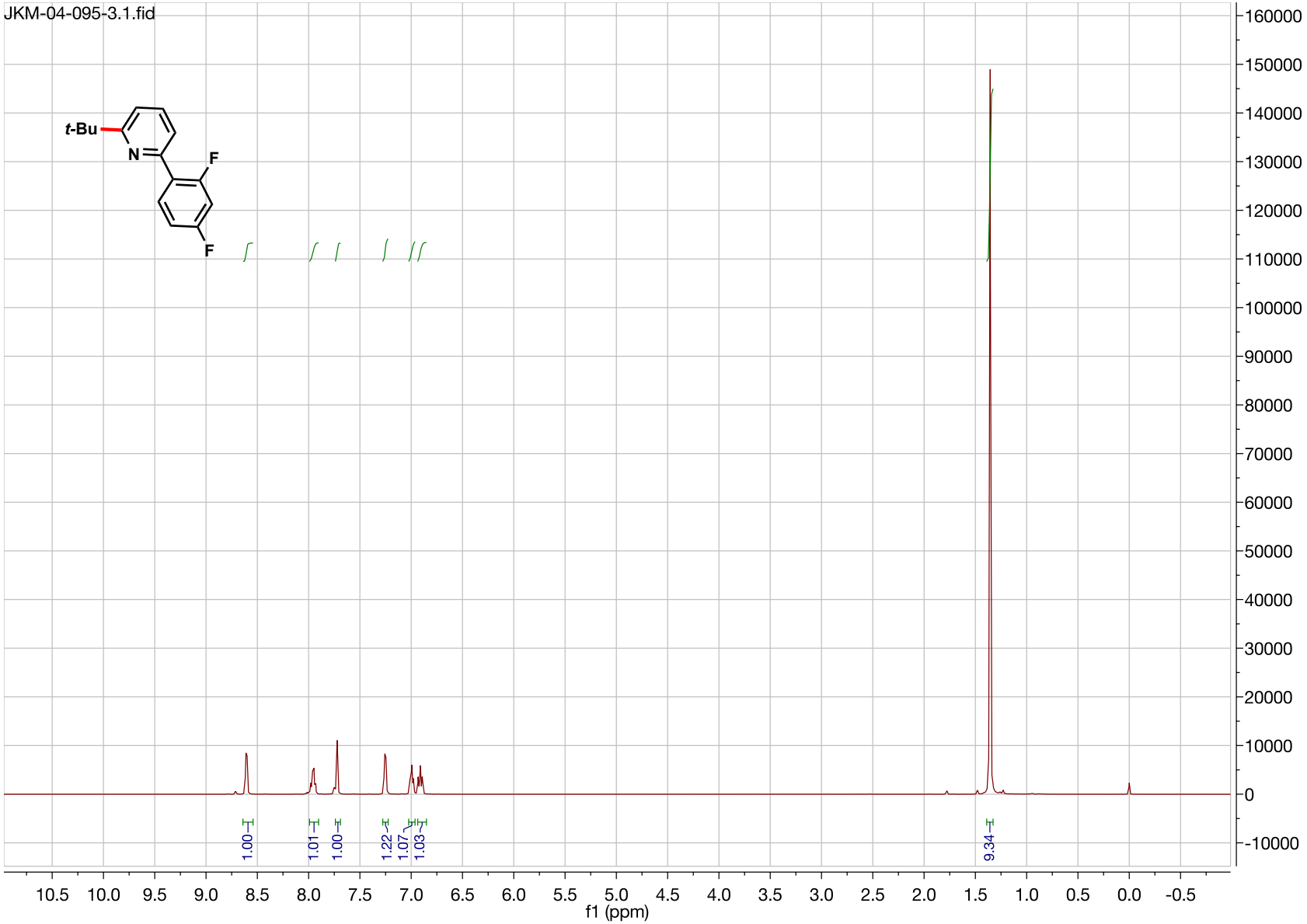
^{1}H ($CDCl_3$, 500 MHz) spectra of 2,9-di-*tert*-butyl-4,7-diphenyl-1,10-phenanthroline (**5d**)



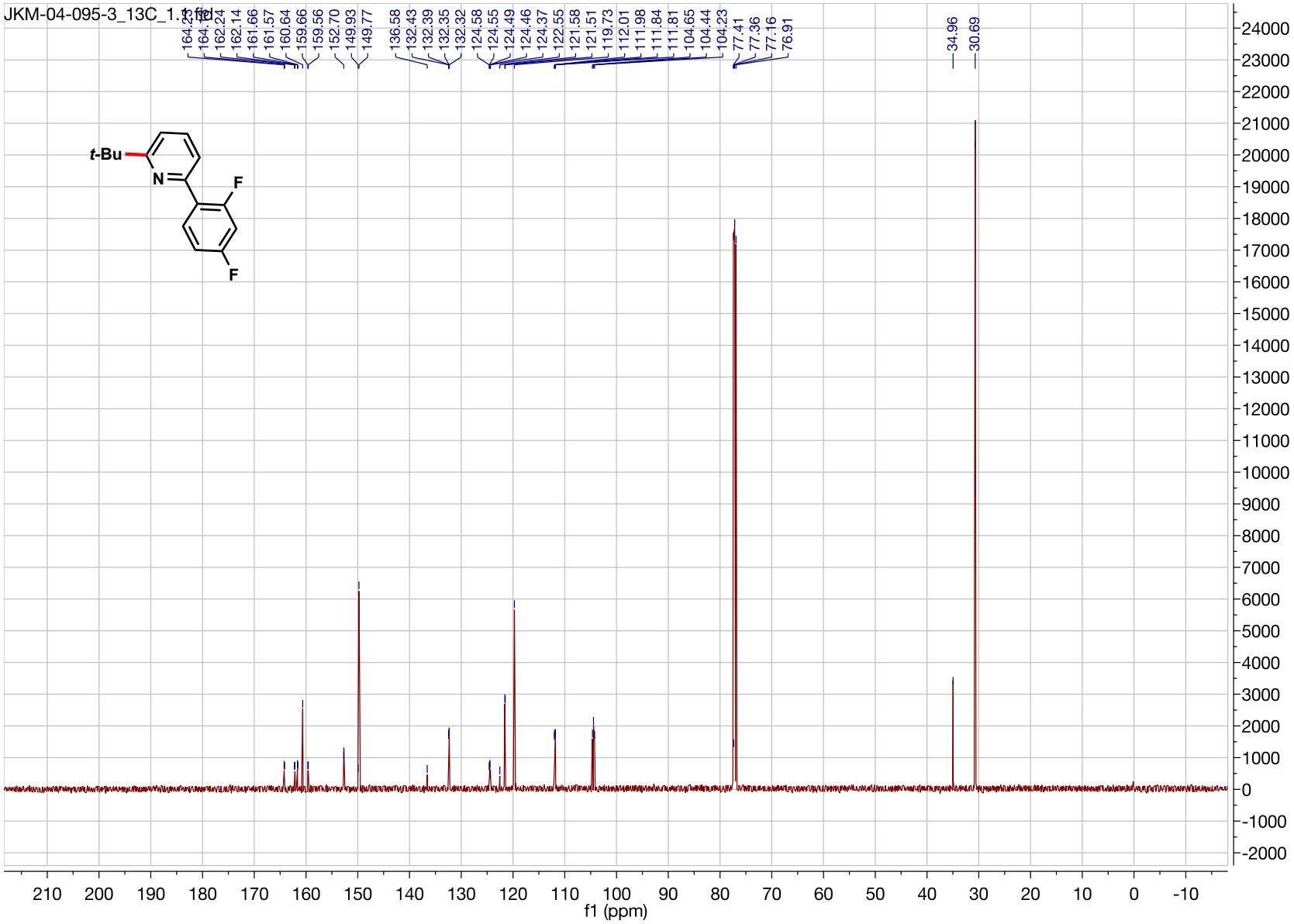
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2,9-di-*tert*-butyl-4,7-diphenyl-1,10-phenanthroline (**5d**)



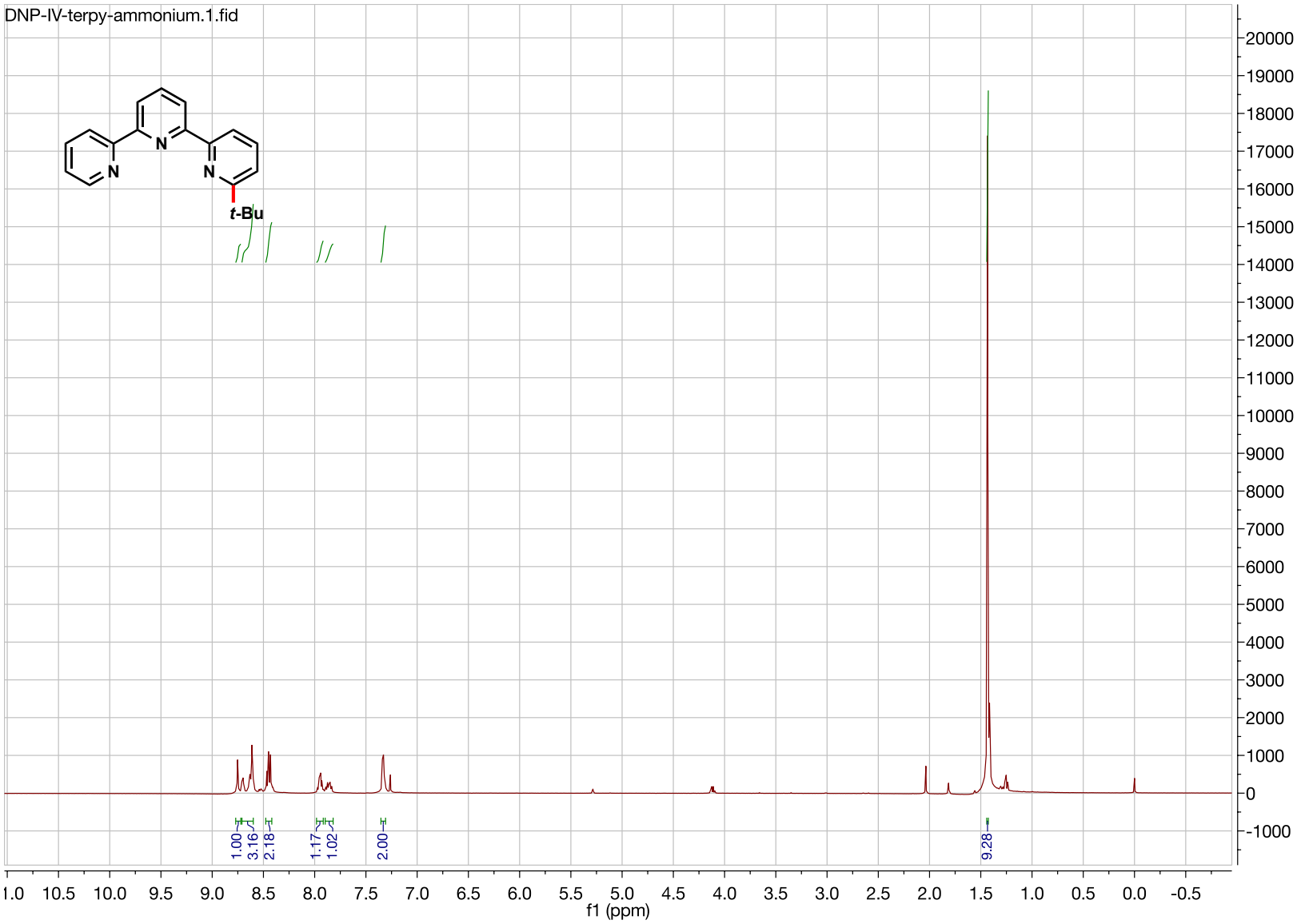
^{1}H ($CDCl_3$, 500 MHz) spectra of 2-(*tert*-butyl)-6-(2,4-difluorophenyl)pyridine (**5f**)



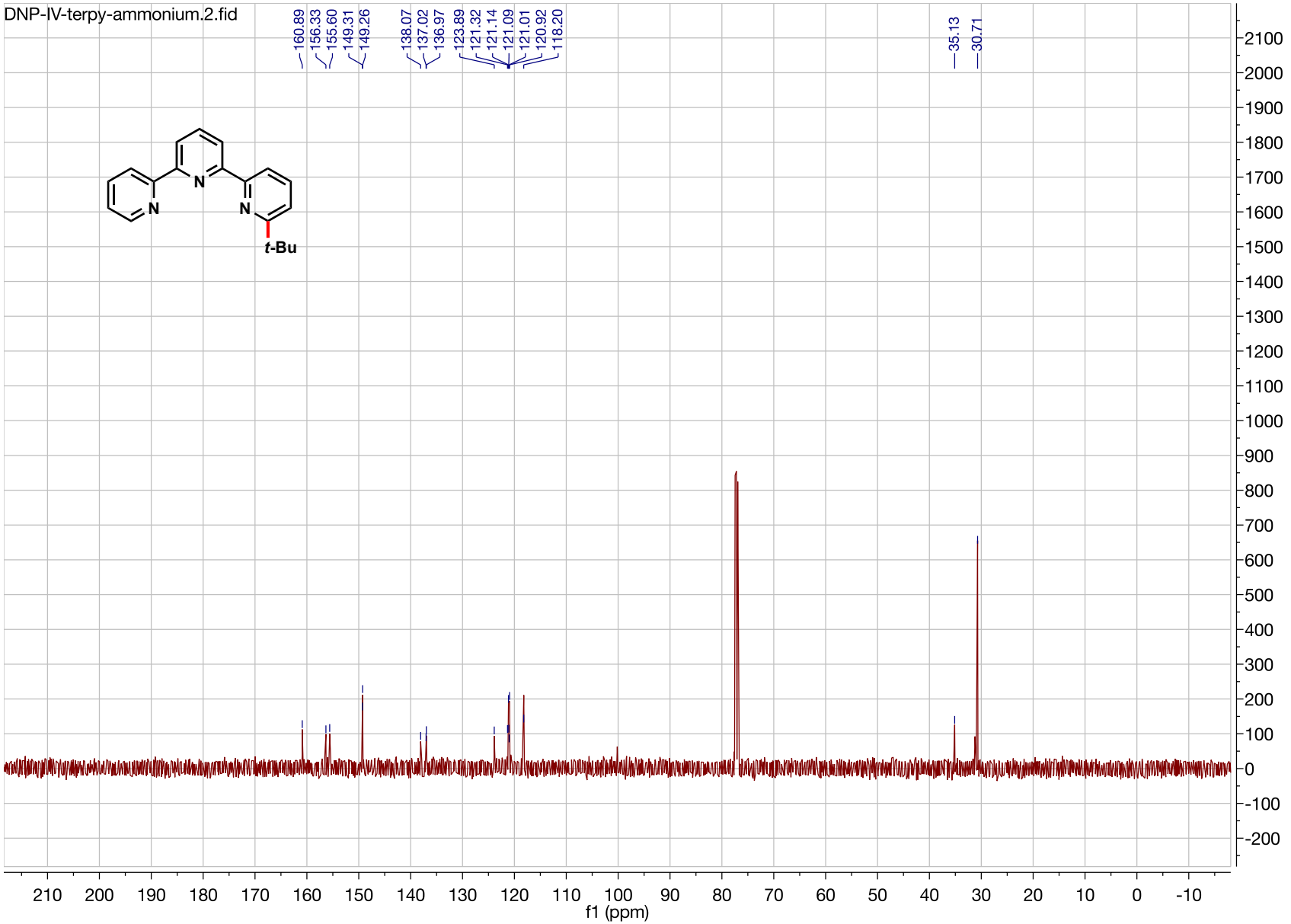
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 2-(*tert*-butyl)-6-(2,4-difluorophenyl)pyridine (**5f**)



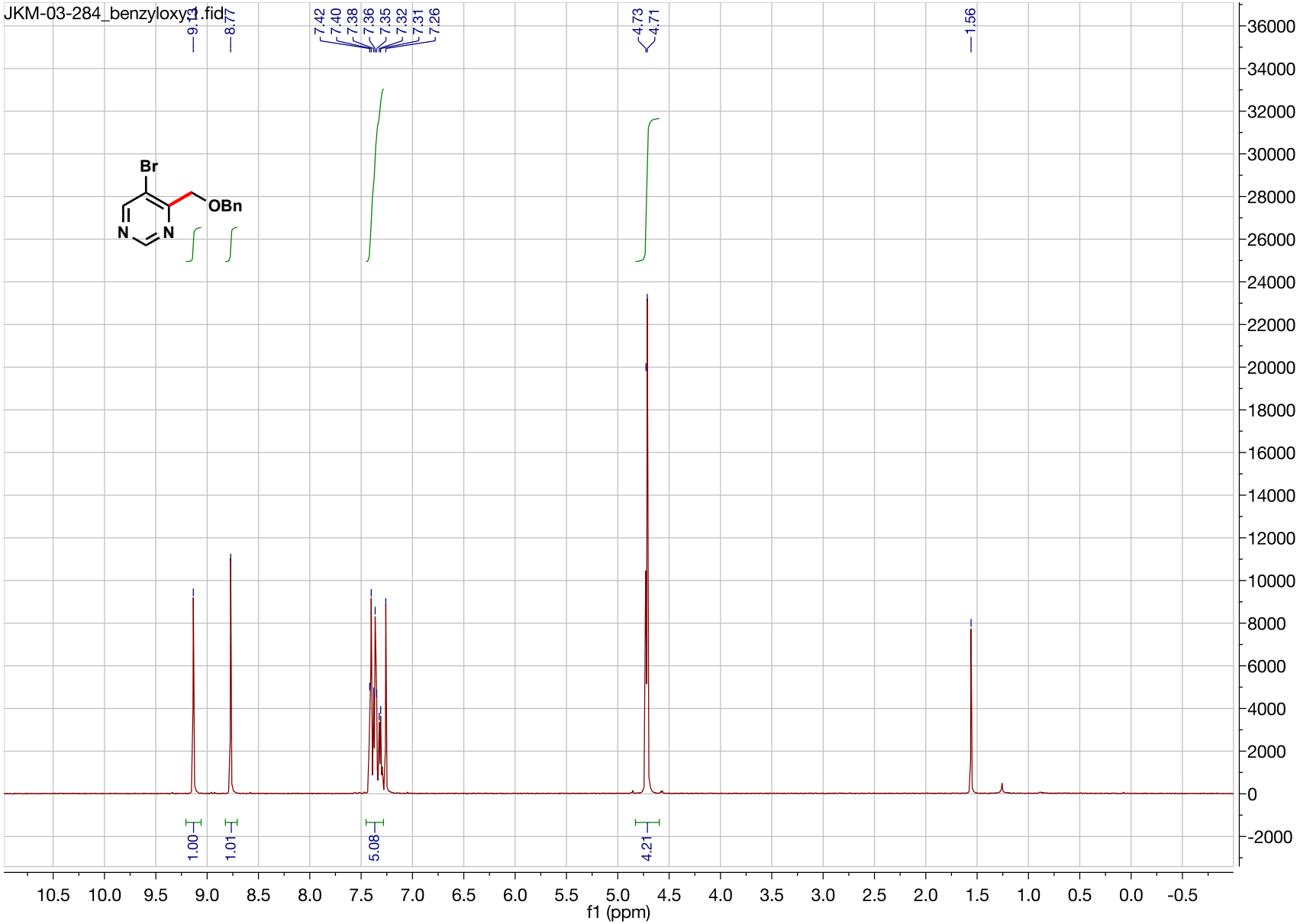
^{1}H ($CDCl_3$, 500 MHz) spectra of 6-(*tert*-butyl)-2,2':6',2''-terpyridine (**5h**)



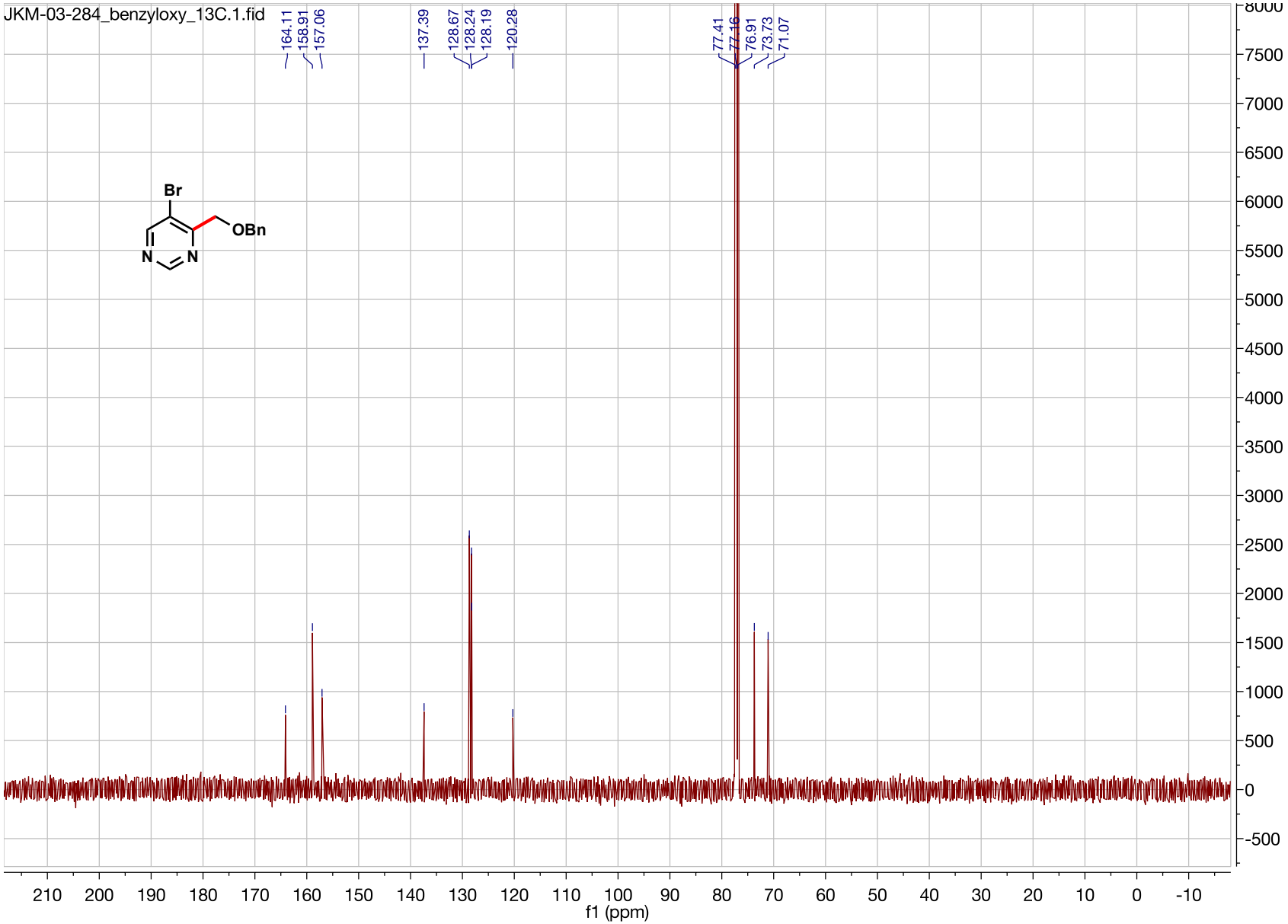
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 6-(*tert*-butyl)-2,2':6',2''-terpyridine (**5h**)



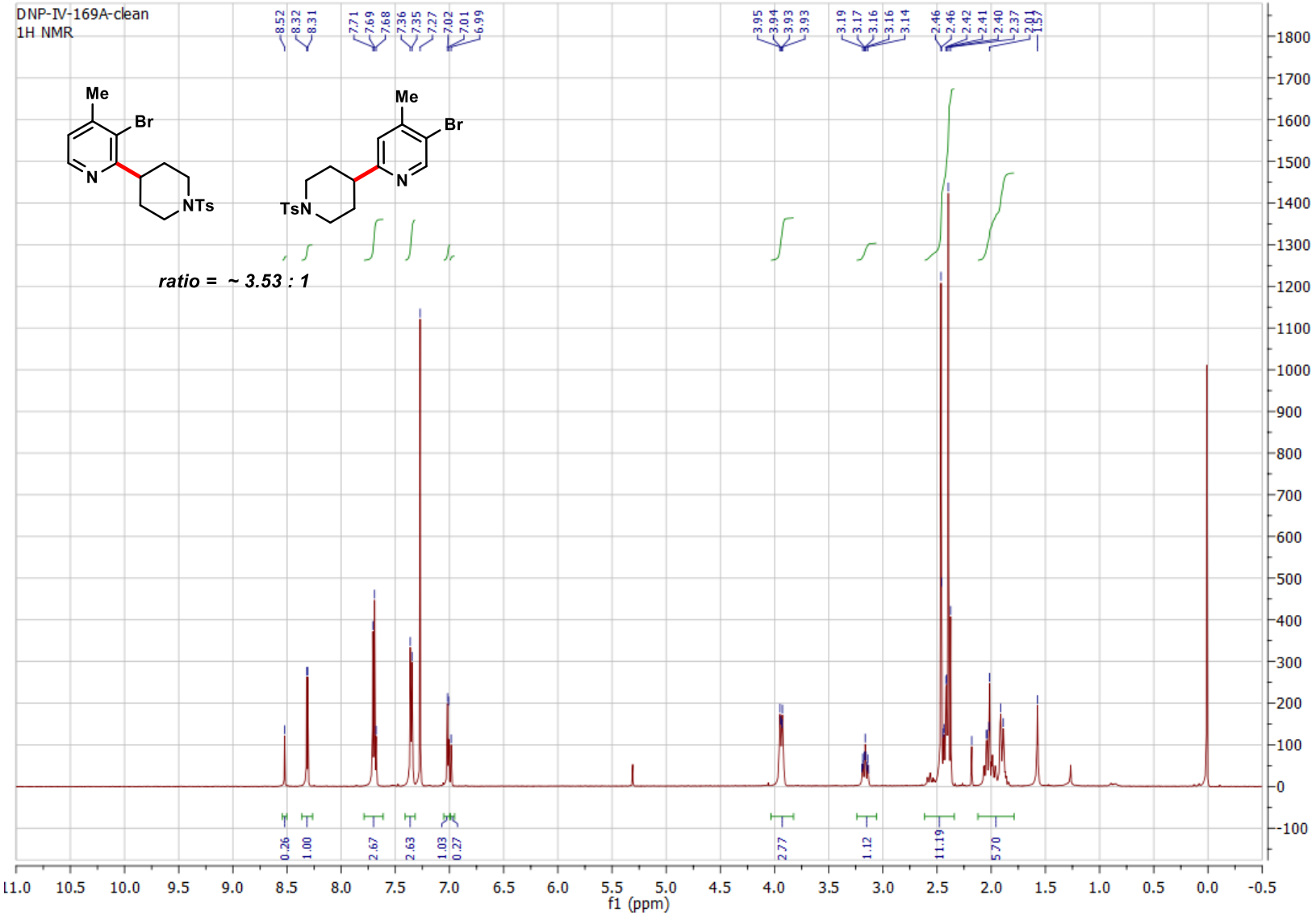
^{1}H ($CDCl_3$, 500 MHz) spectra of 4-((benzyloxy)methyl)-5-bromopyrimidine (**6a**)



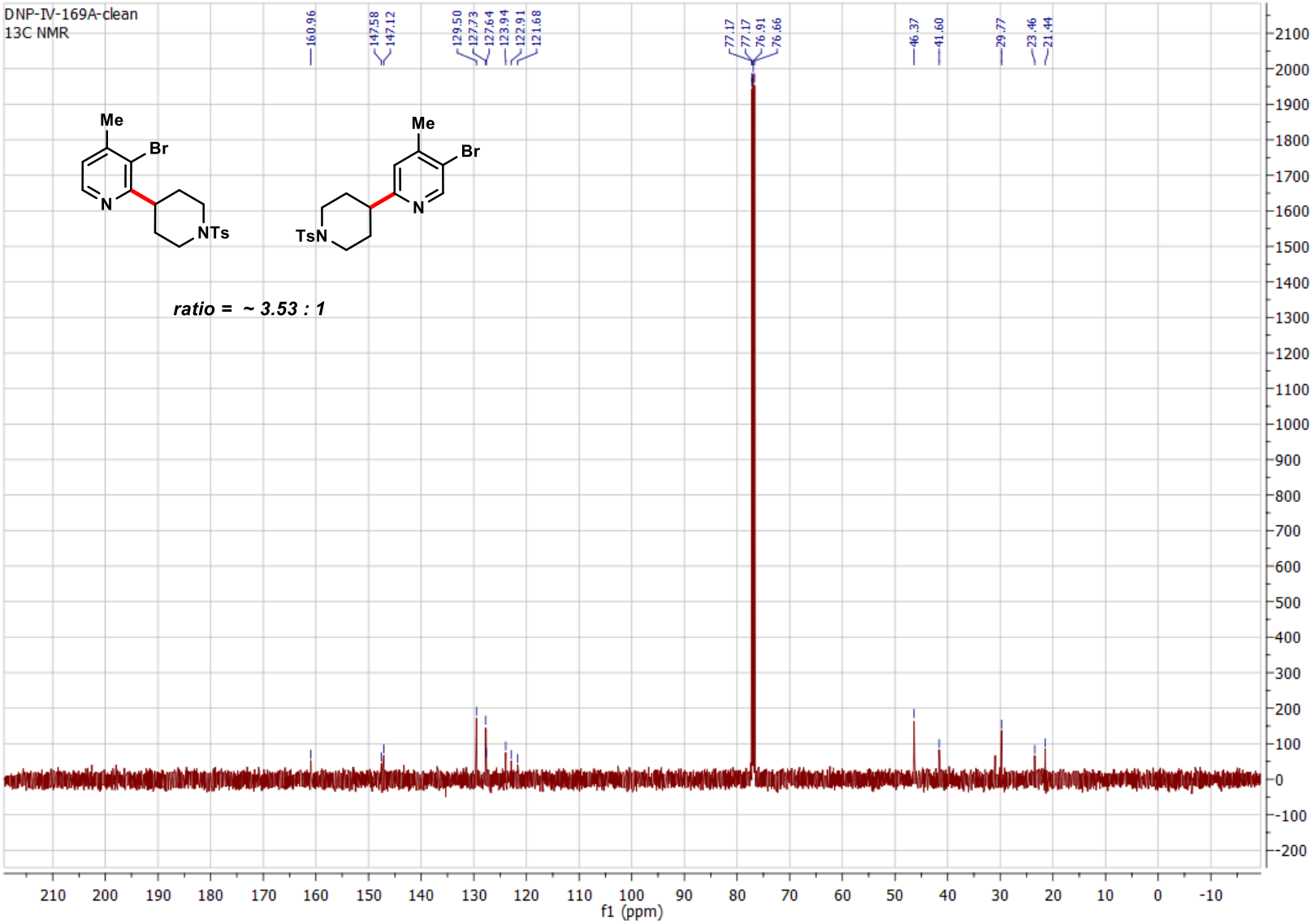
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 4-((benzyloxy)methyl)-5-bromopyrimidine (**6a**)



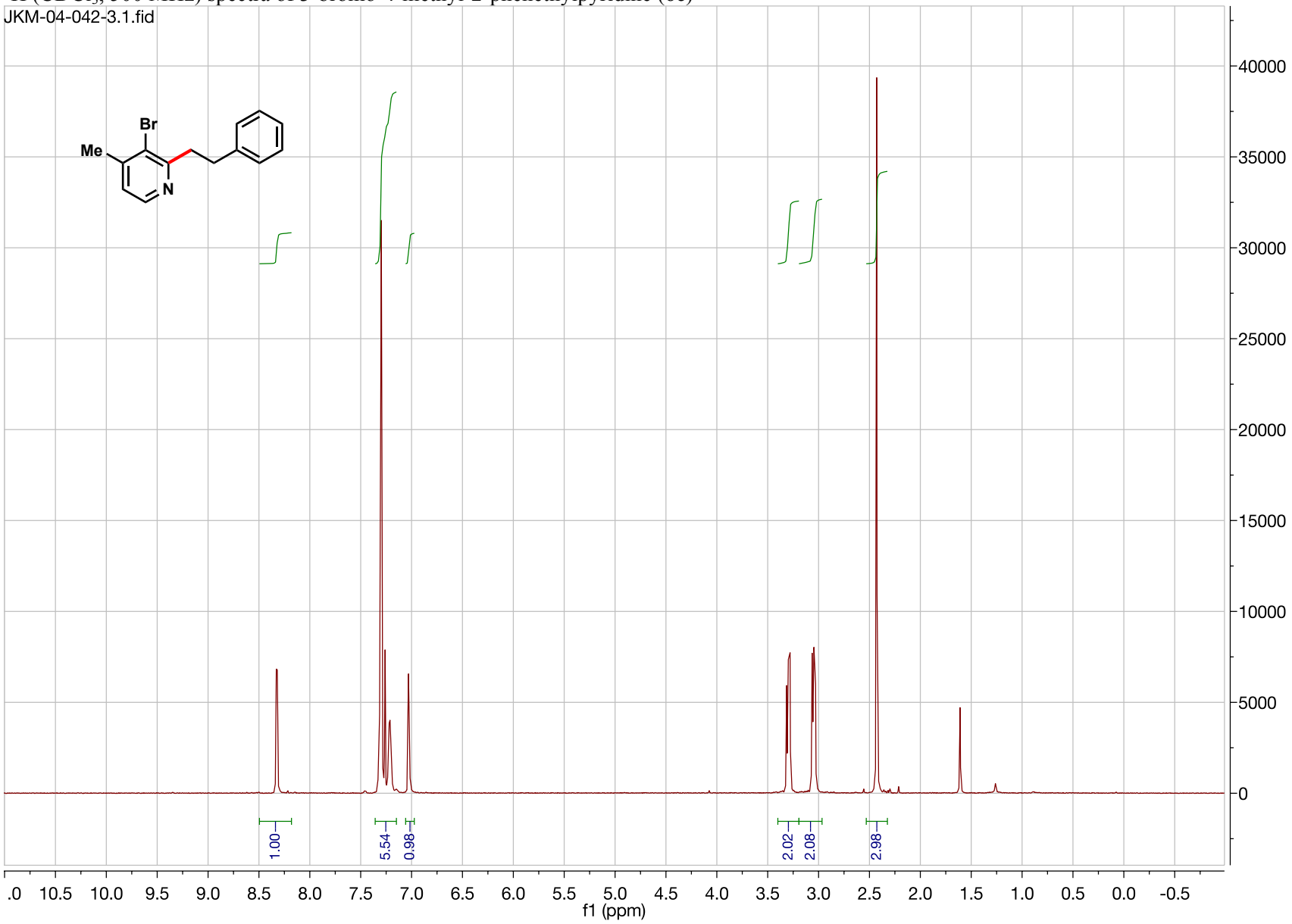
^{1}H NMR ($CDCl_3$, 500 MHz) spectrum 3-bromo-4-methyl-2-(1-tosylpiperidin-4-yl)pyridine and 5-bromo-4-methyl-2-(1-tosylpiperidin-4-yl)pyridine (**6b**)



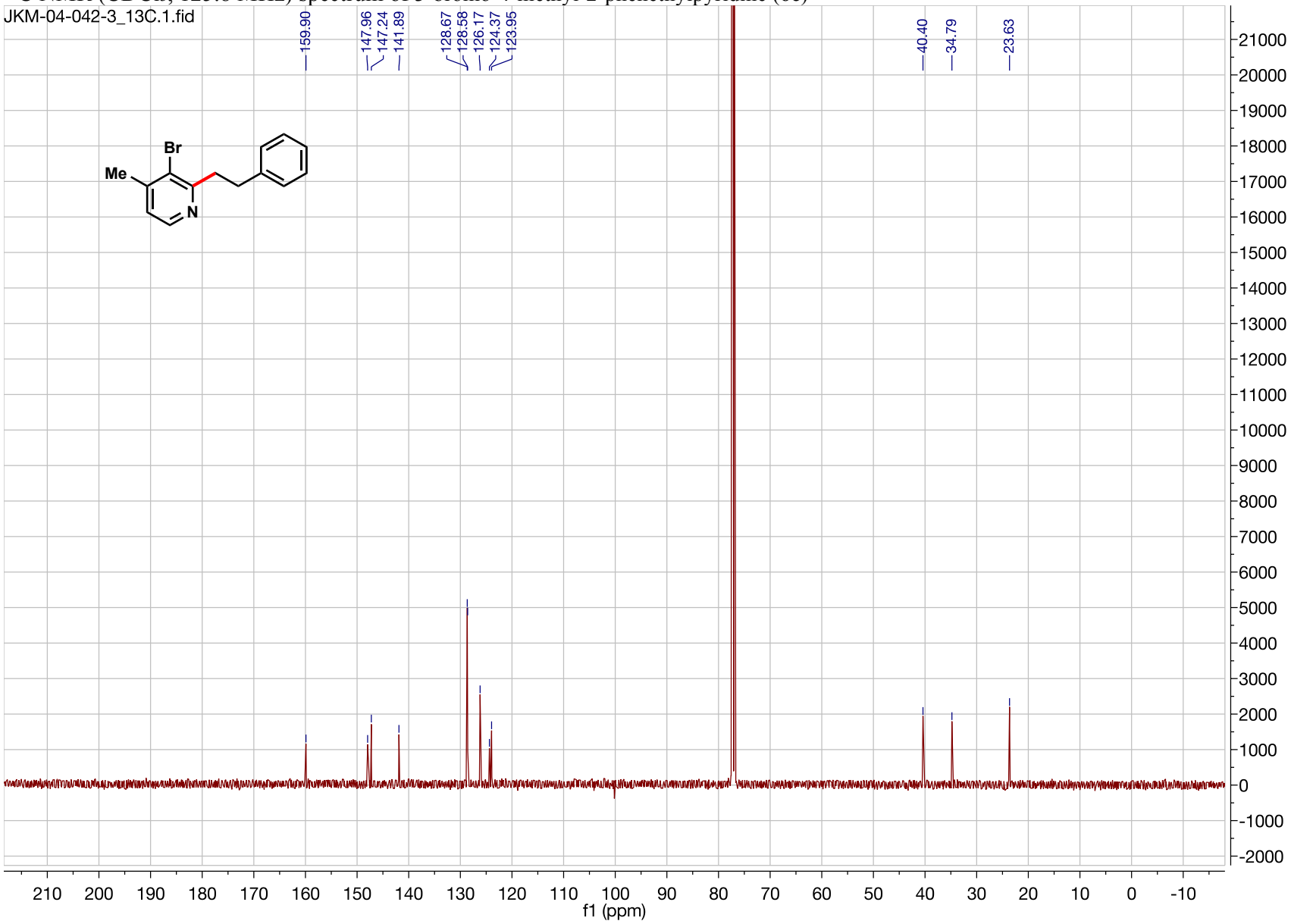
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 3-bromo-4-methyl-2-(1-tosylpiperidin-4-yl)pyridine and 5-bromo-4-methyl-2-(1-tosylpiperidin-4-yl)pyridine (**6b**)



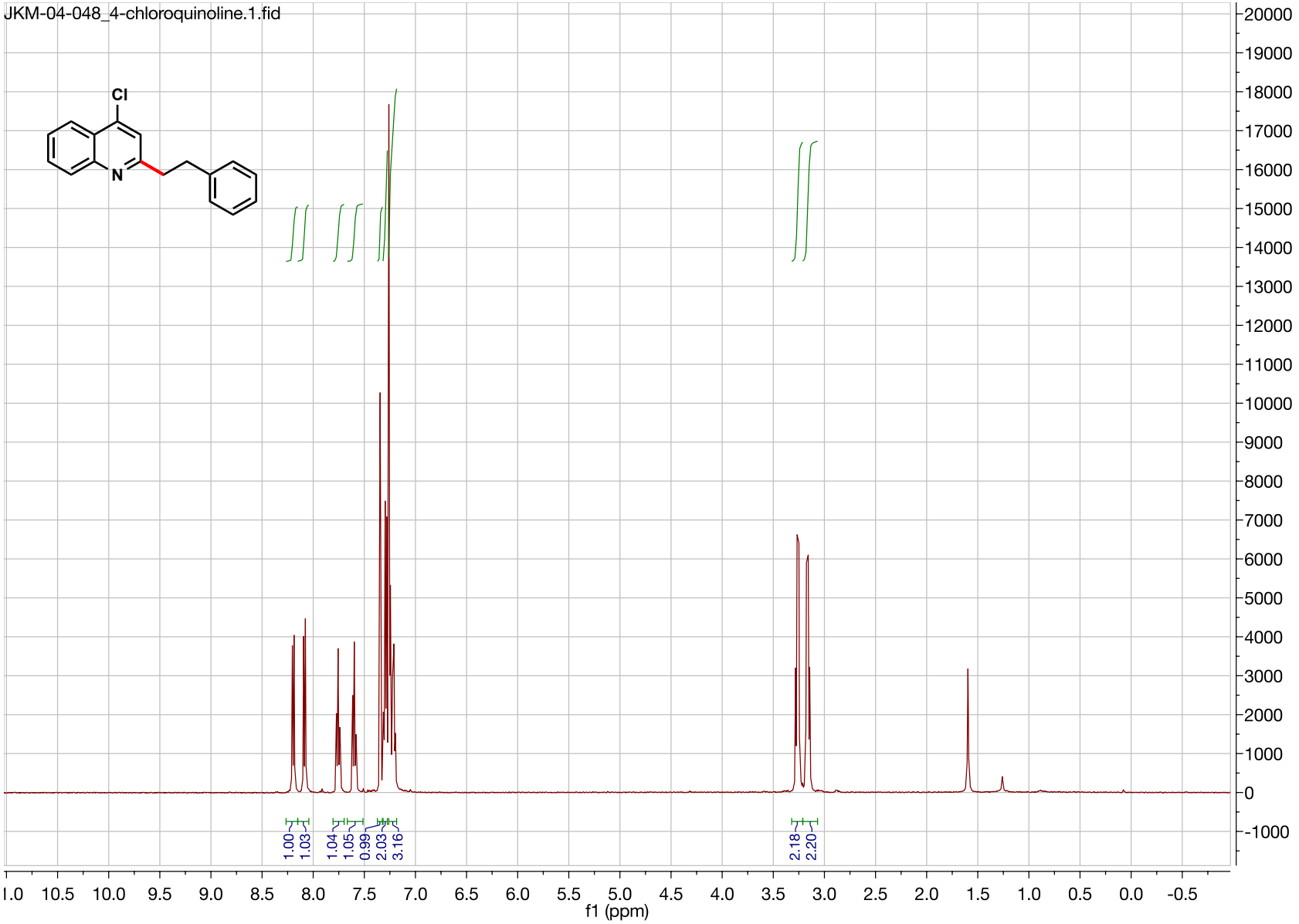
^{1}H ($CDCl_3$, 500 MHz) spectra of 3-bromo-4-methyl-2-phenethylpyridine (**6c**)



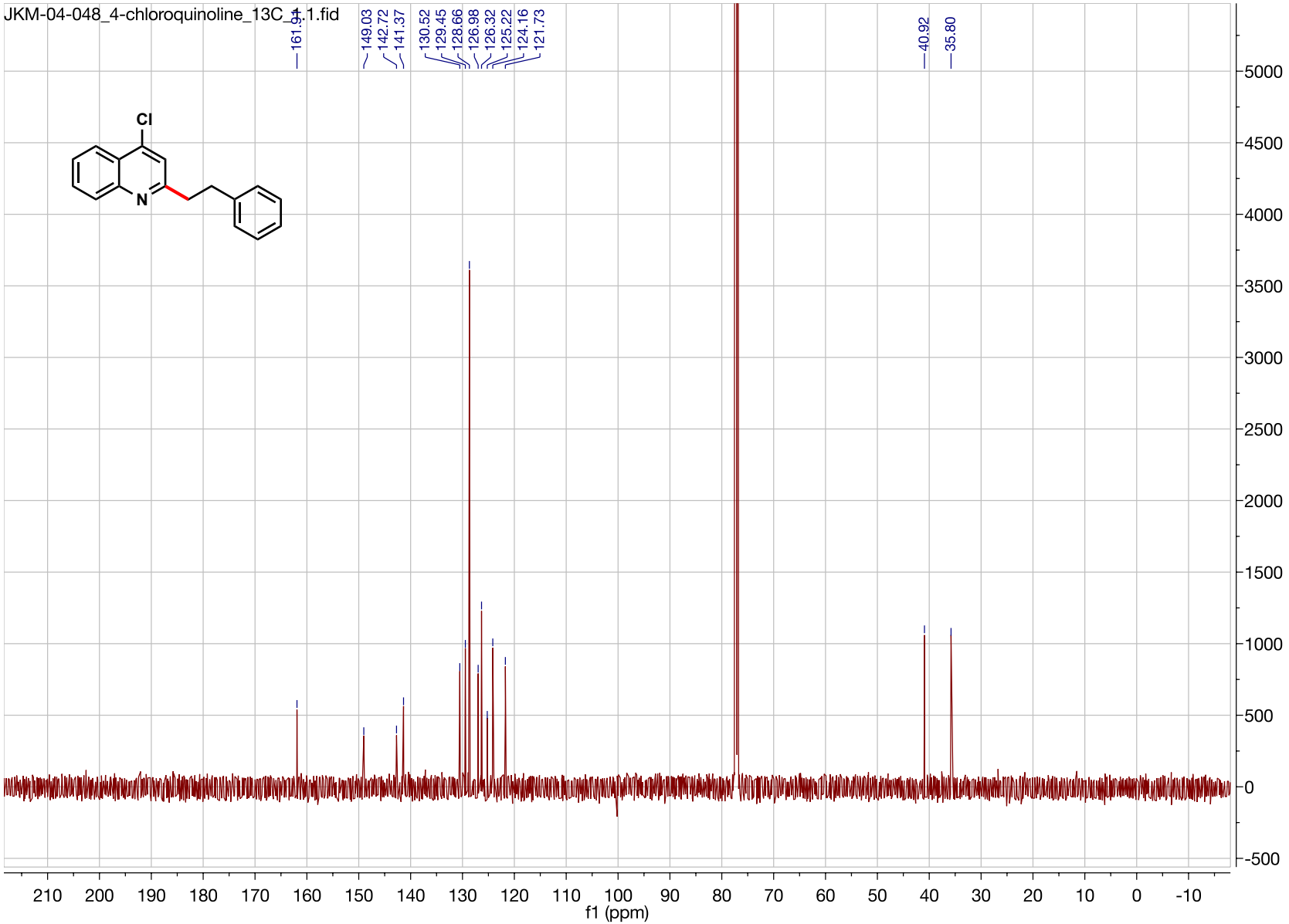
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 3-bromo-4-methyl-2-phenethylpyridine (**6c**)



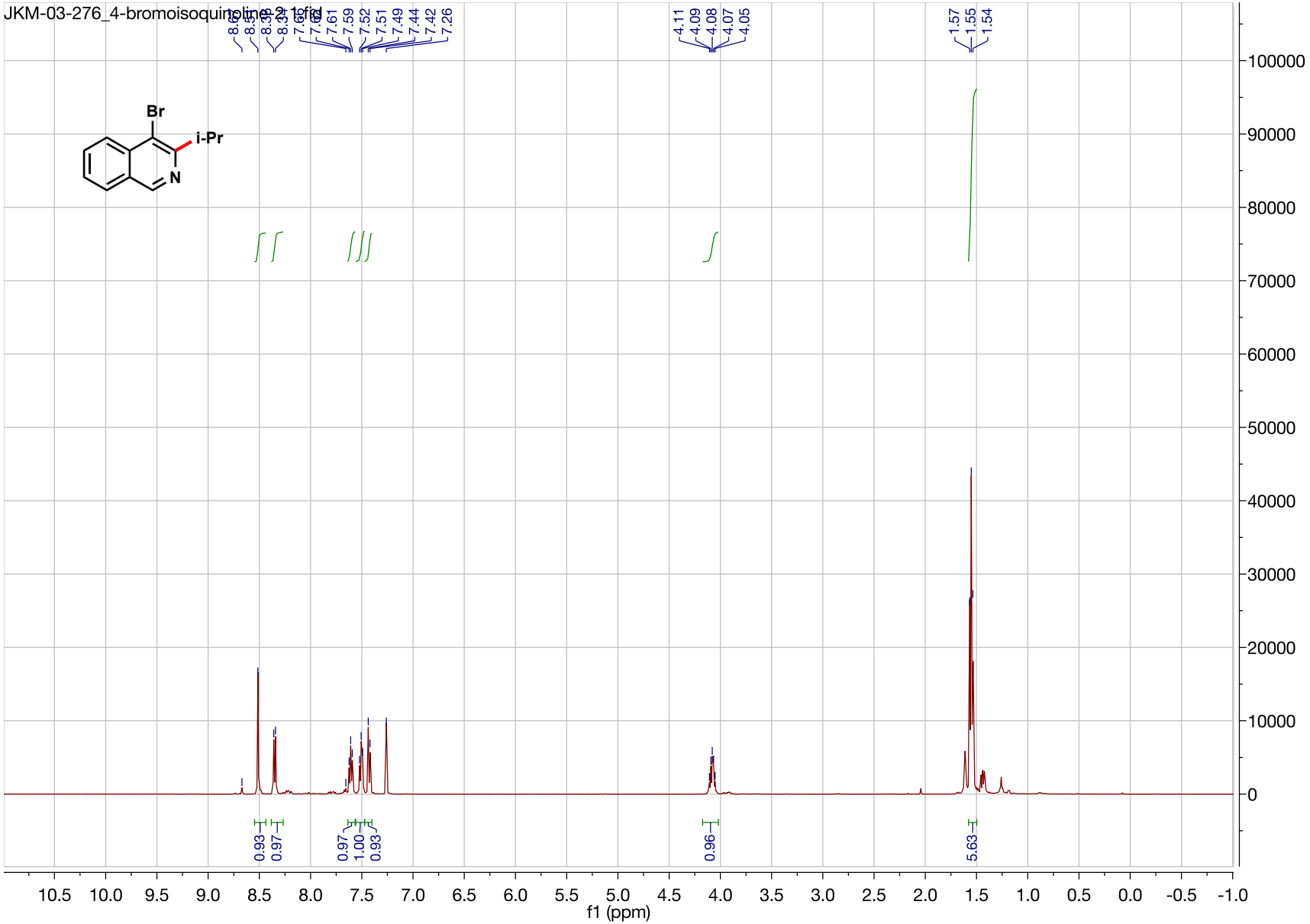
^{1}H ($CDCl_3$, 500 MHz) spectra of 4-chloro-2-phenethylquinoline (**6d**)



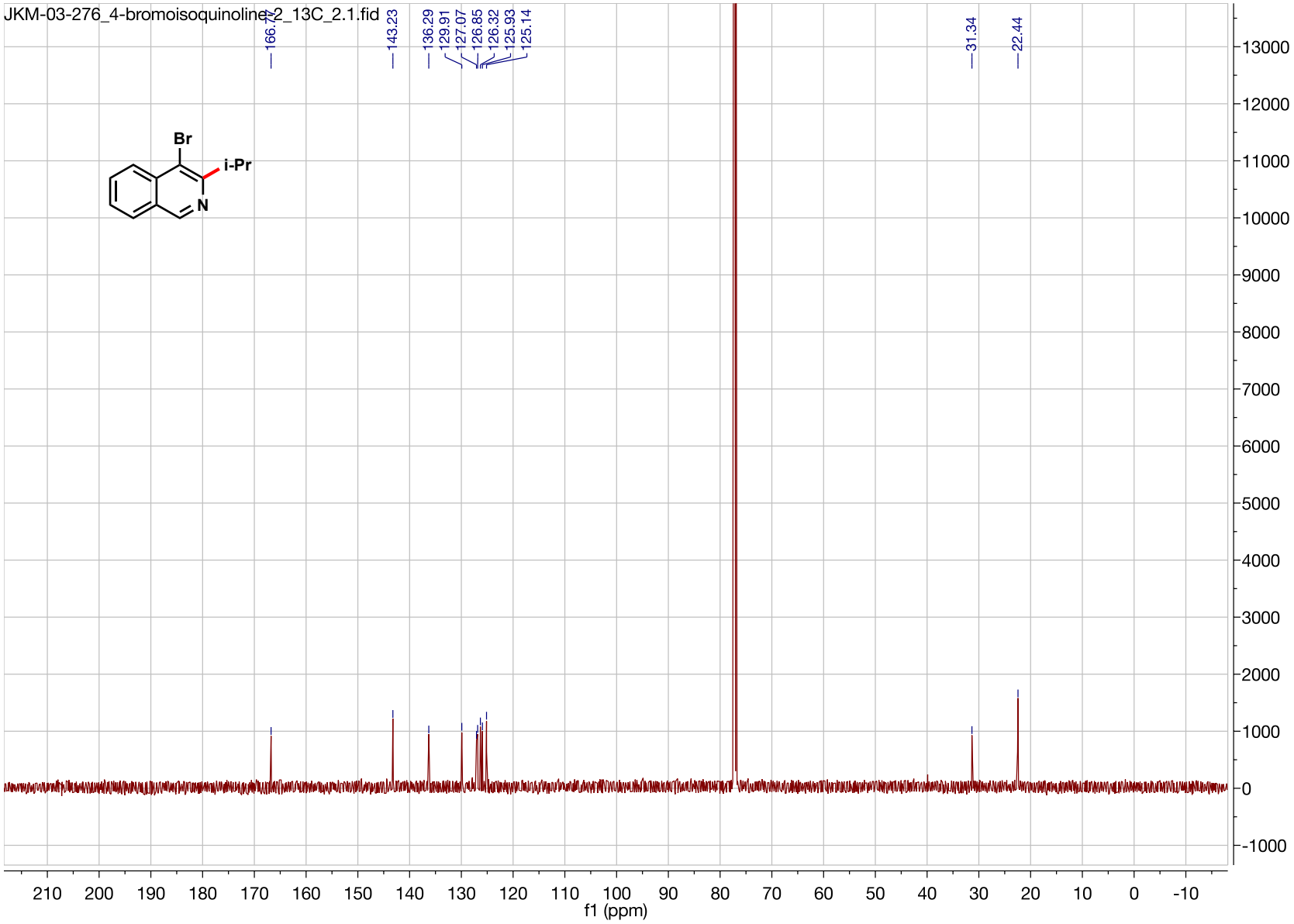
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 4-chloro-2-phenethylquinoline (**6d**)



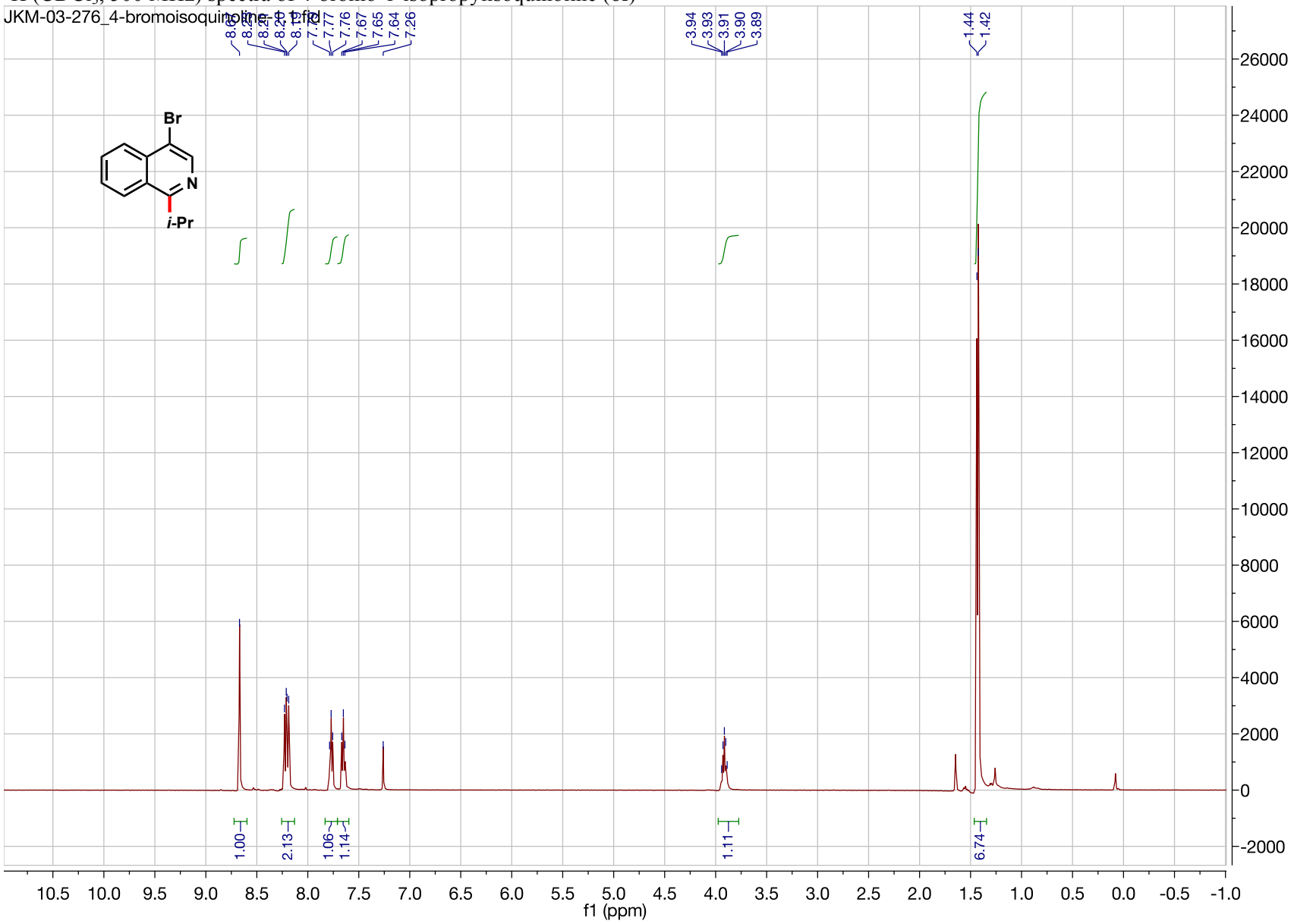
^{1}H ($CDCl_3$, 500 MHz) spectra of 4-bromo-3-isopropylisoquinoline (**6e**)



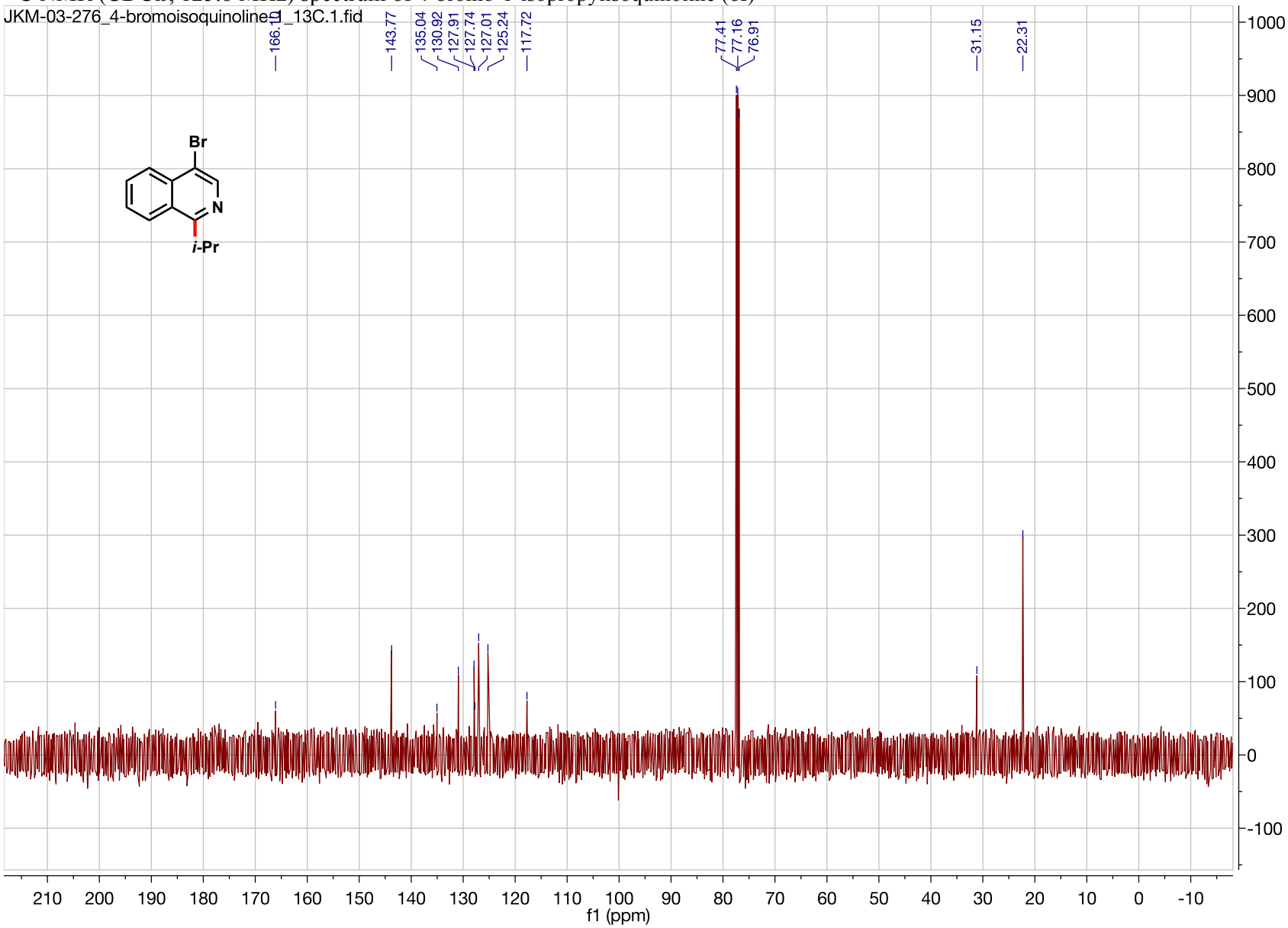
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 4-bromo-3-isopropylisoquinoline (**6e**)



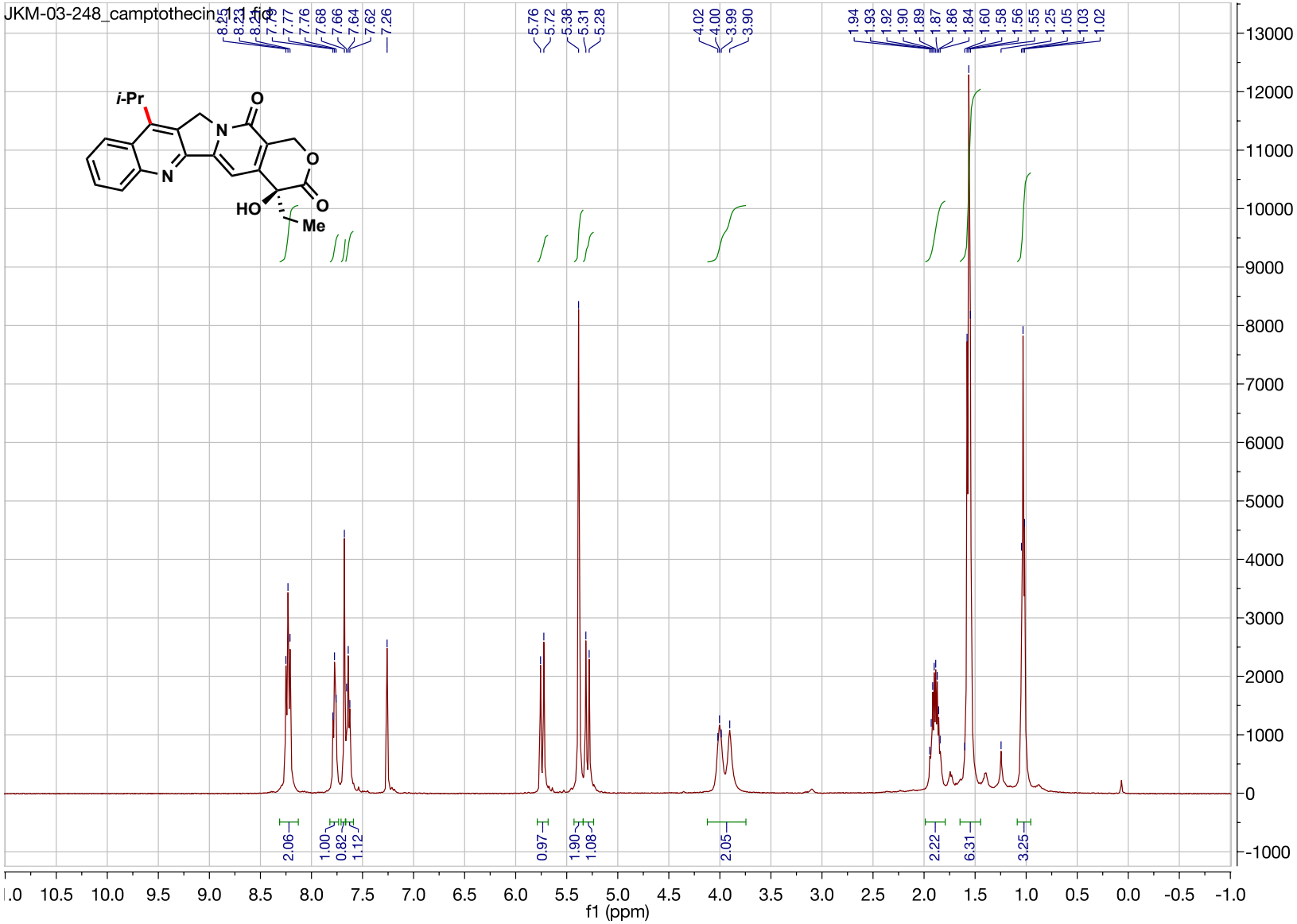
^{1}H ($CDCl_3$, 500 MHz) spectra of 4-bromo-1-isopropylisoquinoline (**6f**)



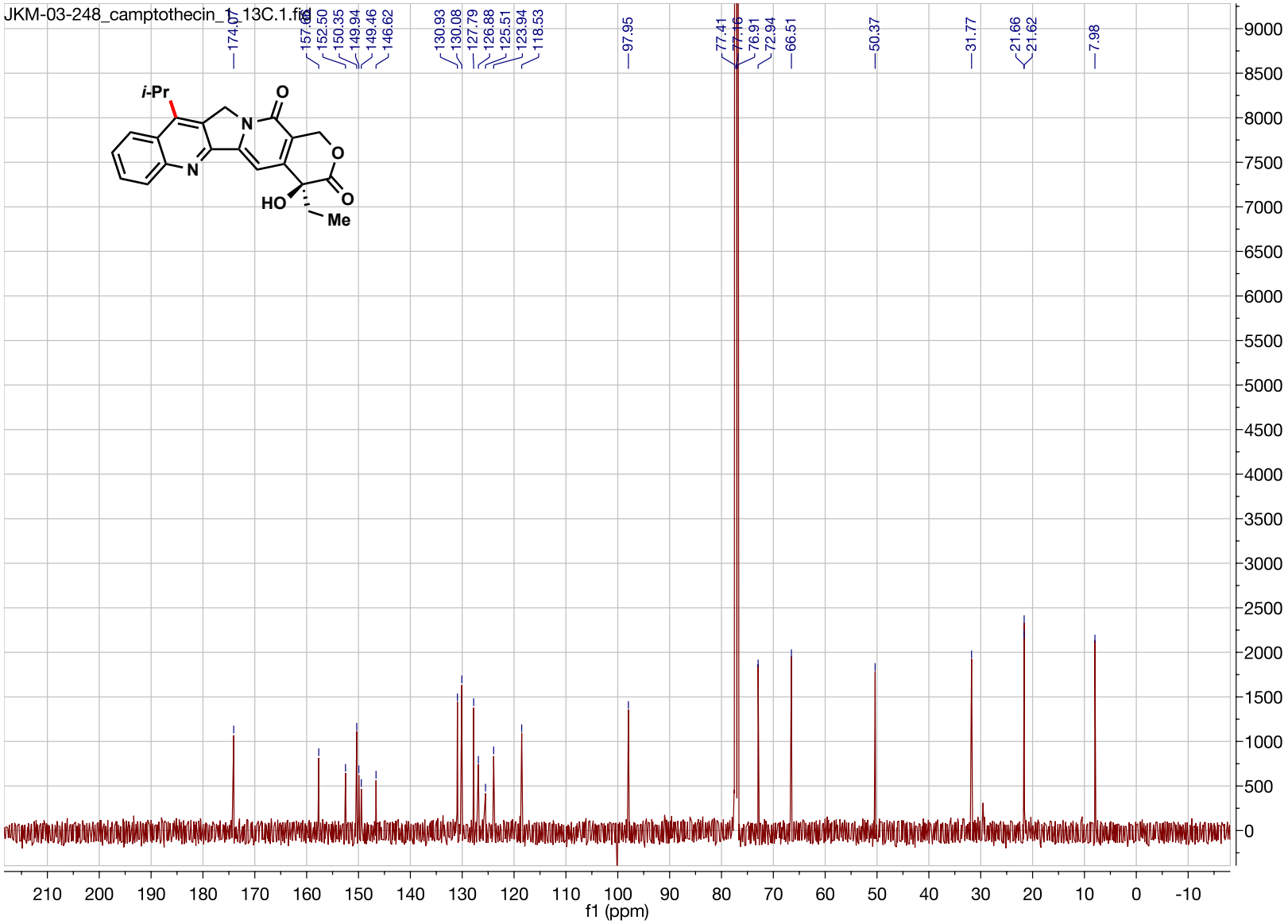
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of 4-bromo-1-isopropylisoquinoline (**6f**)



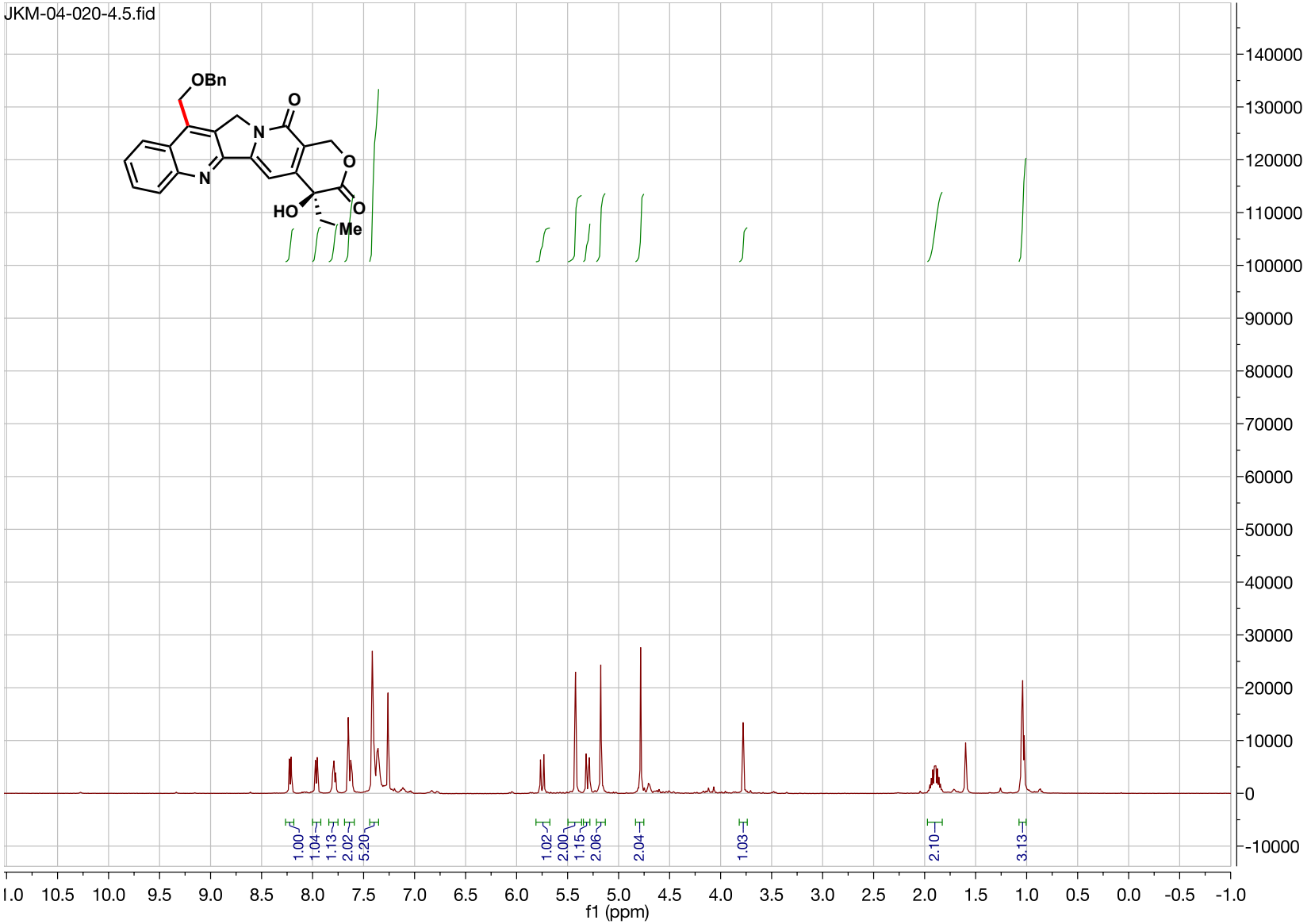
^{1}H ($CDCl_3$, 500 MHz) spectra of (*S*)-4-ethyl-4-hydroxy-11-isopropyl-1,12-dihydro-14*H*-pyrano[3',4':6,7]indolizino[1,2-*b*]quinoline-3,14(4*H*)-dione (**7a**)



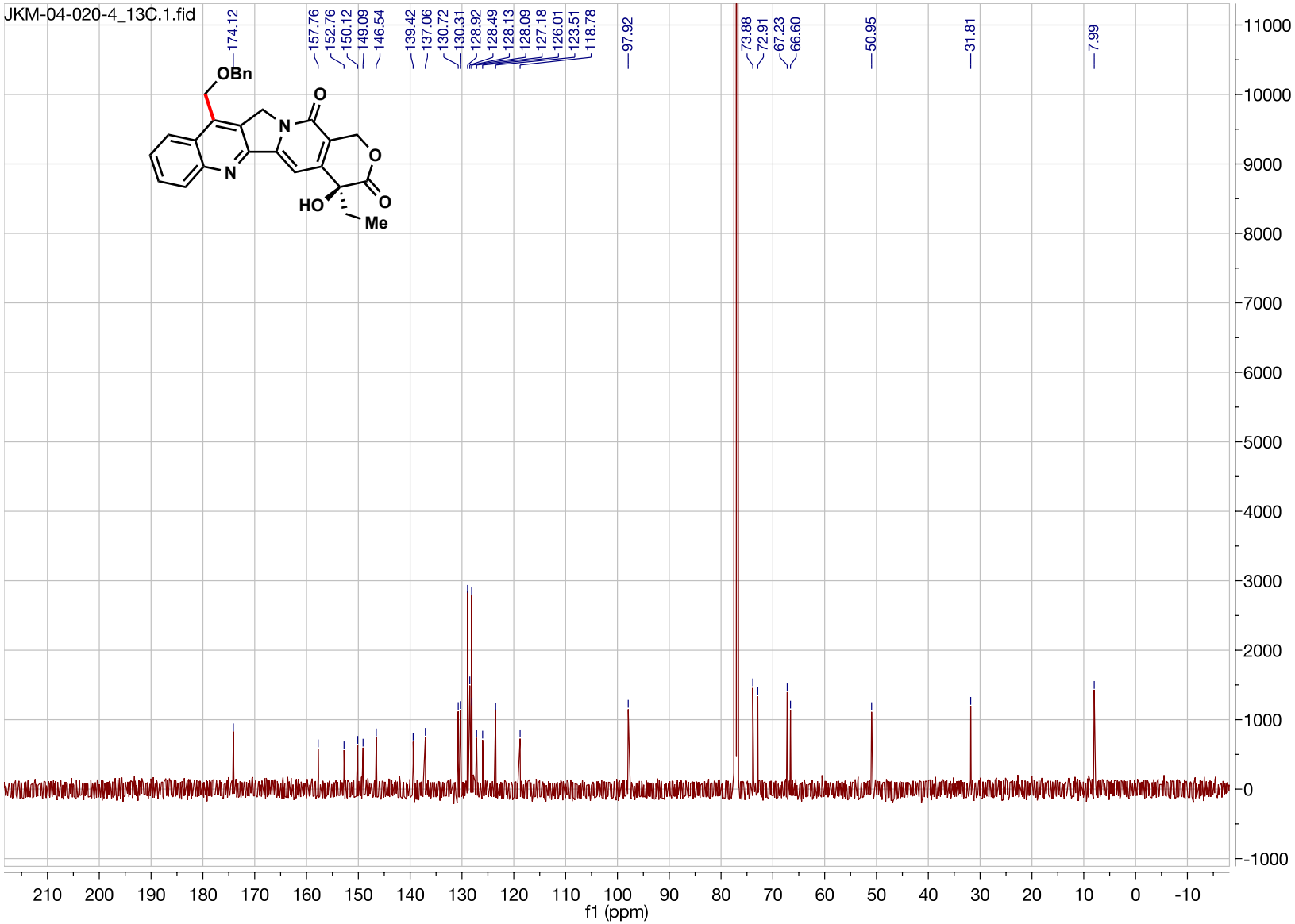
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of (*S*)-4-ethyl-4-hydroxy-11-isopropyl-1,12-dihydro-14*H*-pyrano[3',4':6,7]indolizino[1,2-*b*]quinoline-3,14(4*H*)-dione (**7a**)



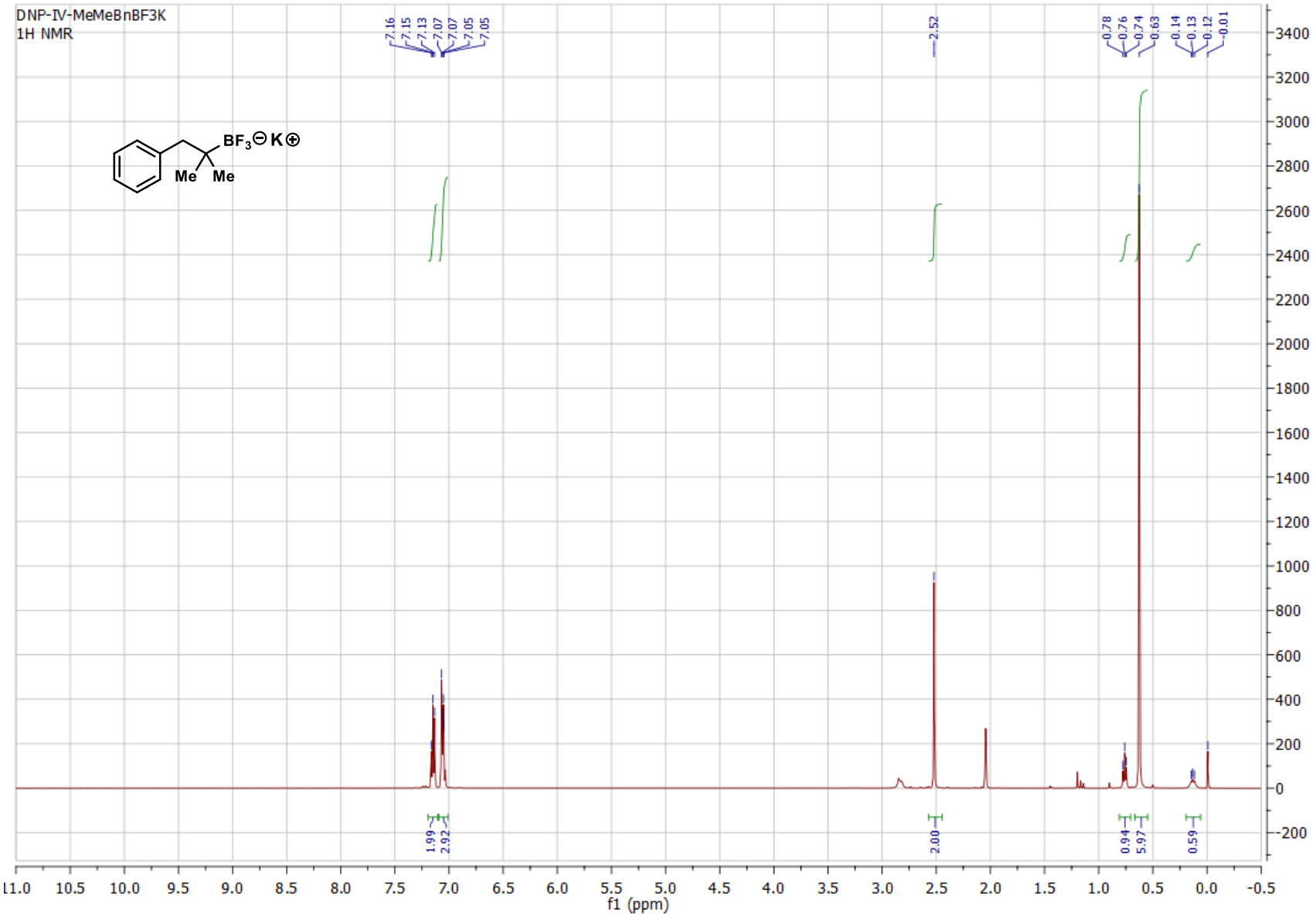
^{1}H ($CDCl_3$, 500 MHz) spectra of (*S*)-11-((benzyloxy)methyl)-4-ethyl-4-hydroxy-1,12-dihydro-14*H*-pyrano[3',4':6,7]indolizino[1,2-*b*]quinoline-3,14(4*H*)-dione (**7b**)



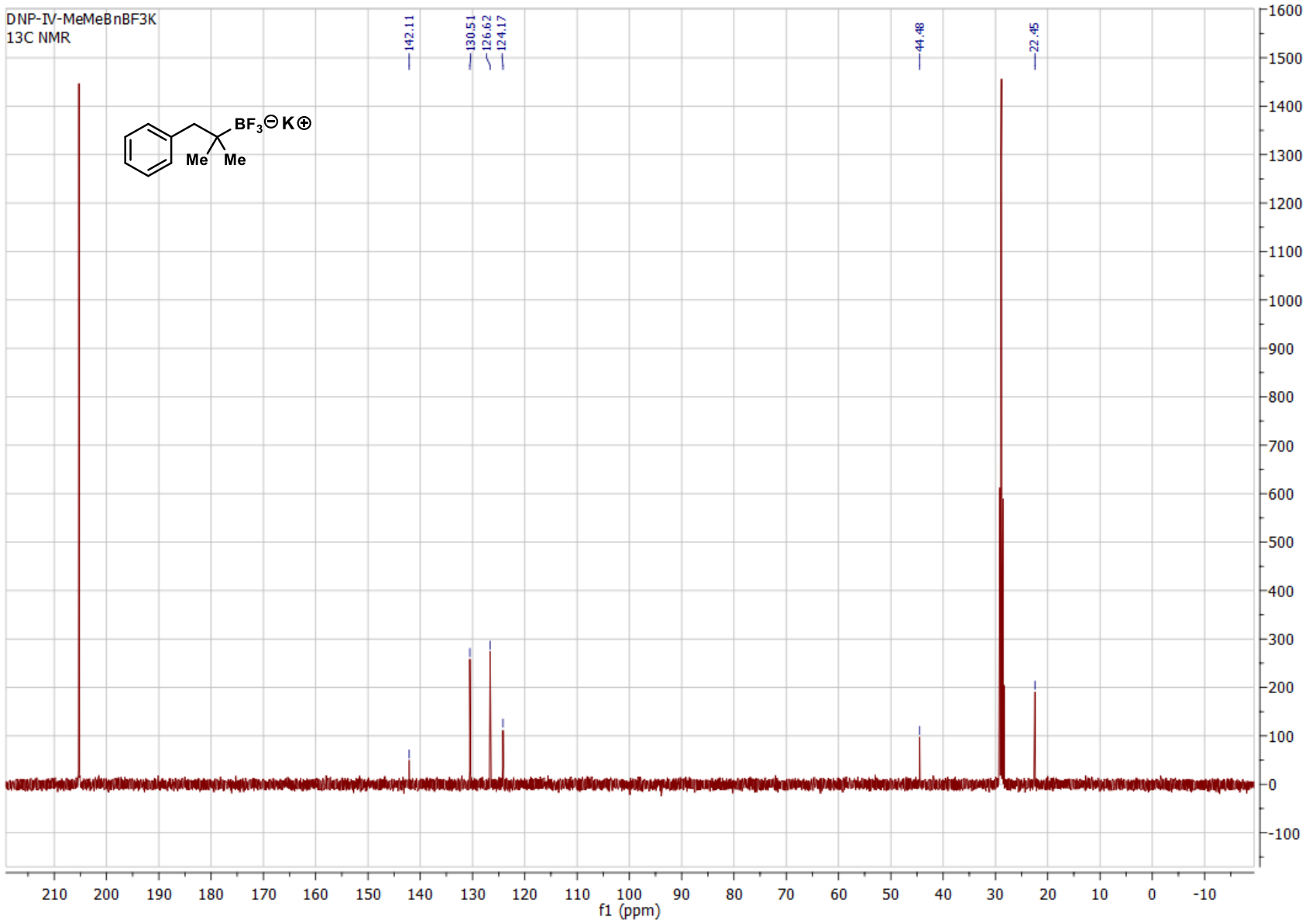
^{13}C NMR ($CDCl_3$, 125.8 MHz) spectrum of (*S*)-11-((benzyloxy)methyl)-4-ethyl-4-hydroxy-1,12-dihydro-14*H*-pyrano[3',4':6,7]indolizino[1,2-*b*]quinoline-3,14(4*H*)-dione (**7b**)



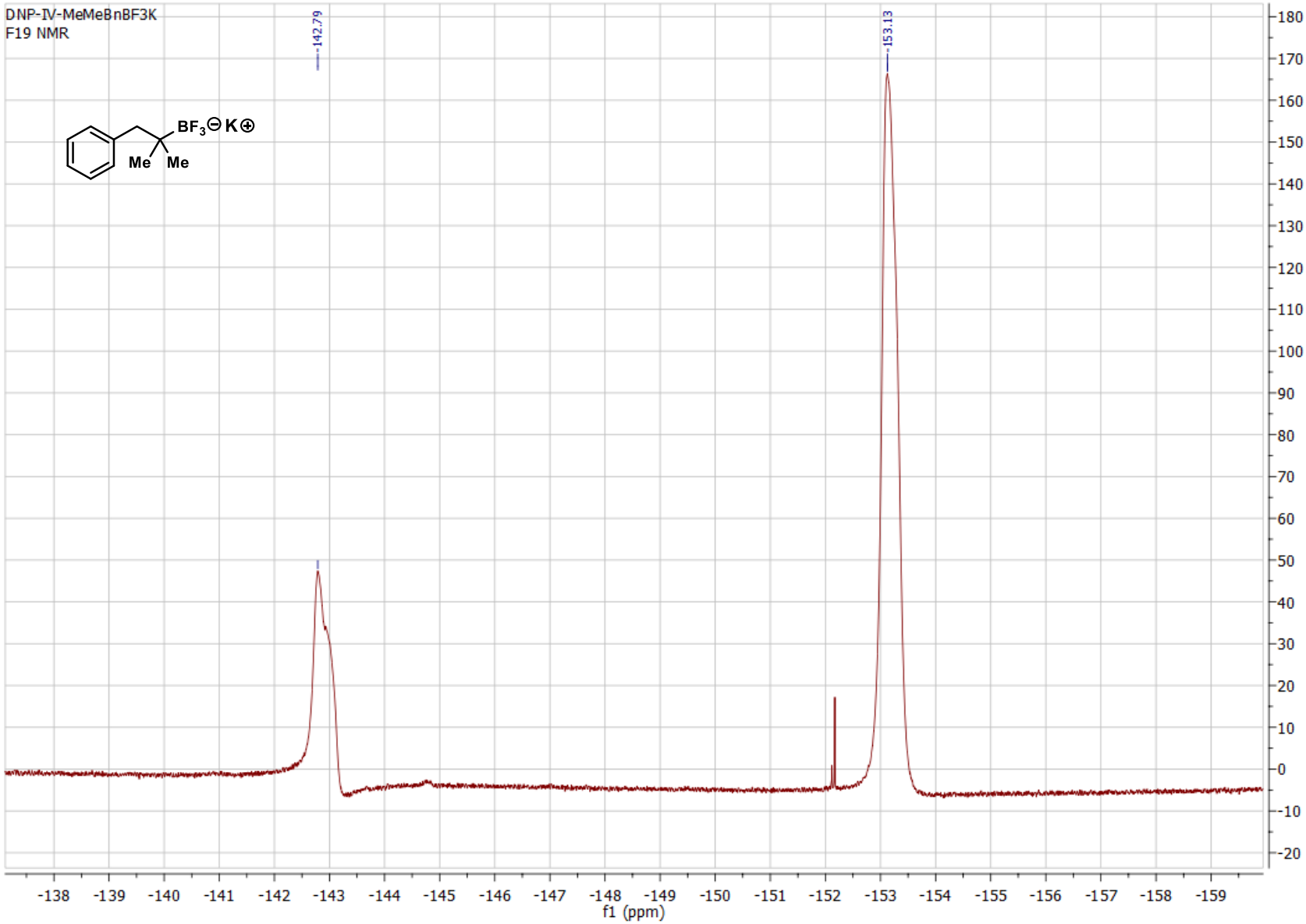
^{1}H NMR (acetone-d_6, 500 MHz) spectrum of Potassium trifluoro(2-methyl-1-phenylpropan-2-yl)borate (**1u**)



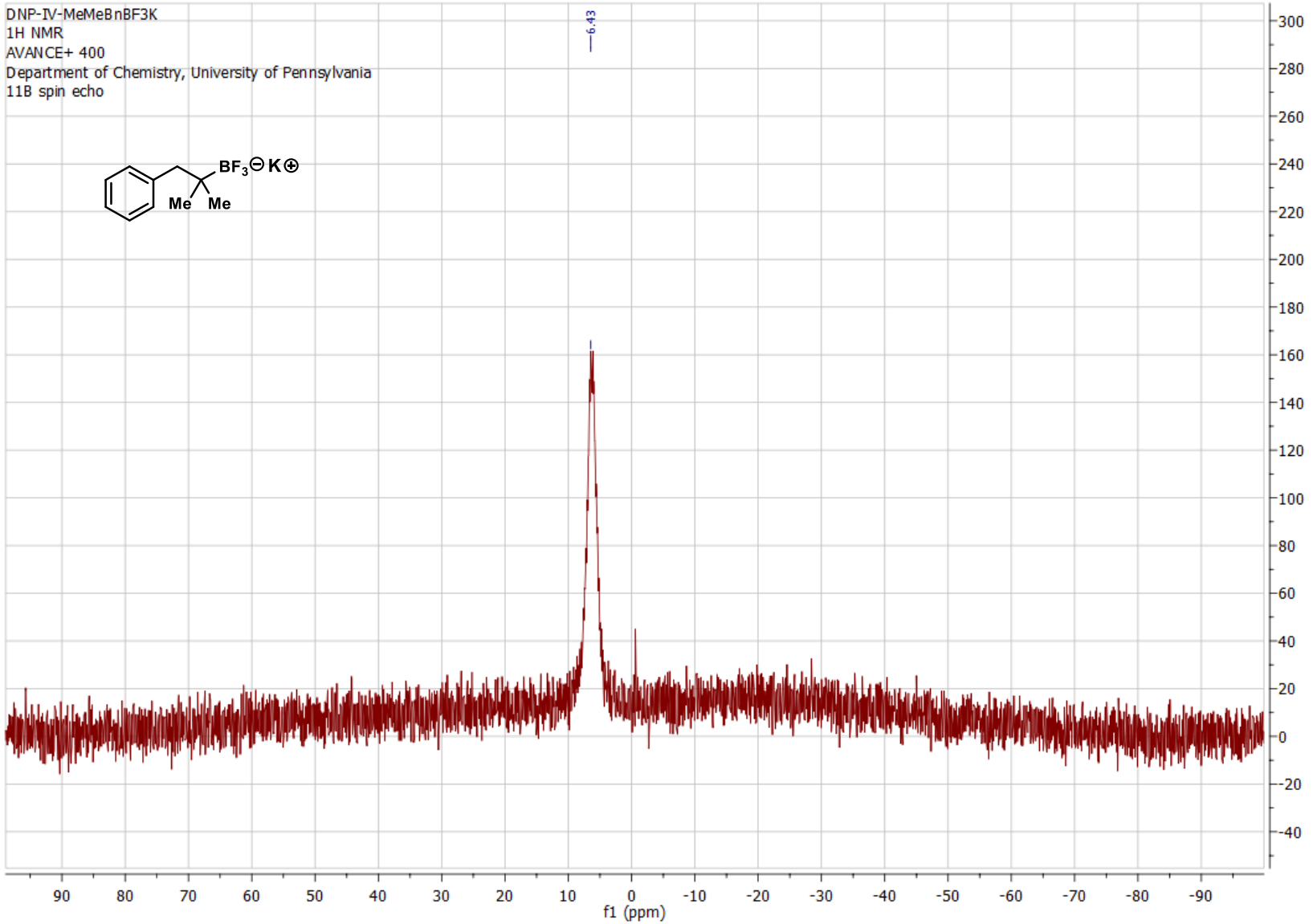
^{13}C NMR (acetone-d_6, 125.8 MHz) spectrum of Potassium trifluoro(2-methyl-1-phenylpropan-2-yl)borate (**1u**)



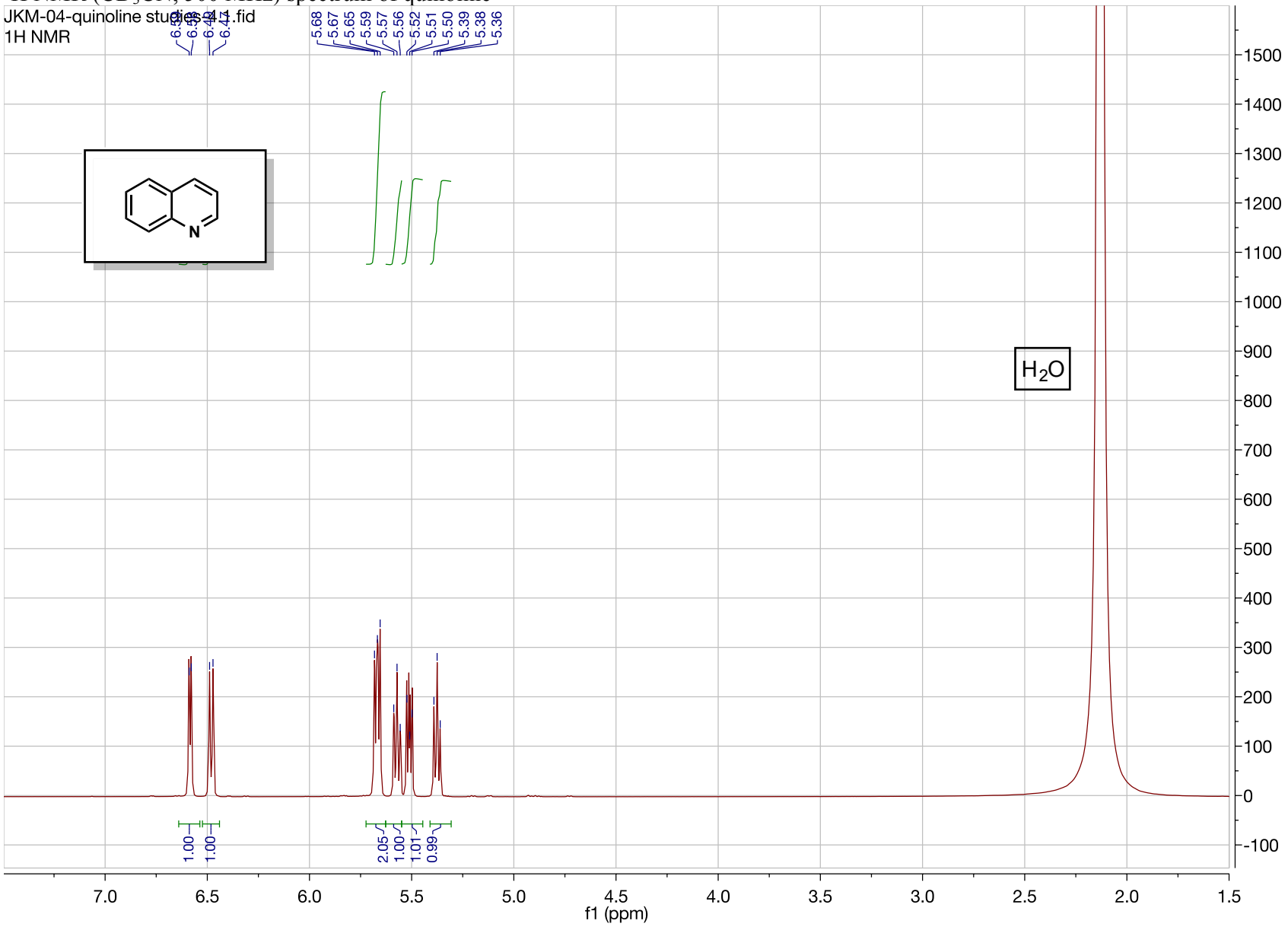
^{19}F NMR (acetone-d_6, 470.7 MHz) spectrum of Potassium trifluoro(2-methyl-1-phenylpropan-2-yl)borate (**1u**)



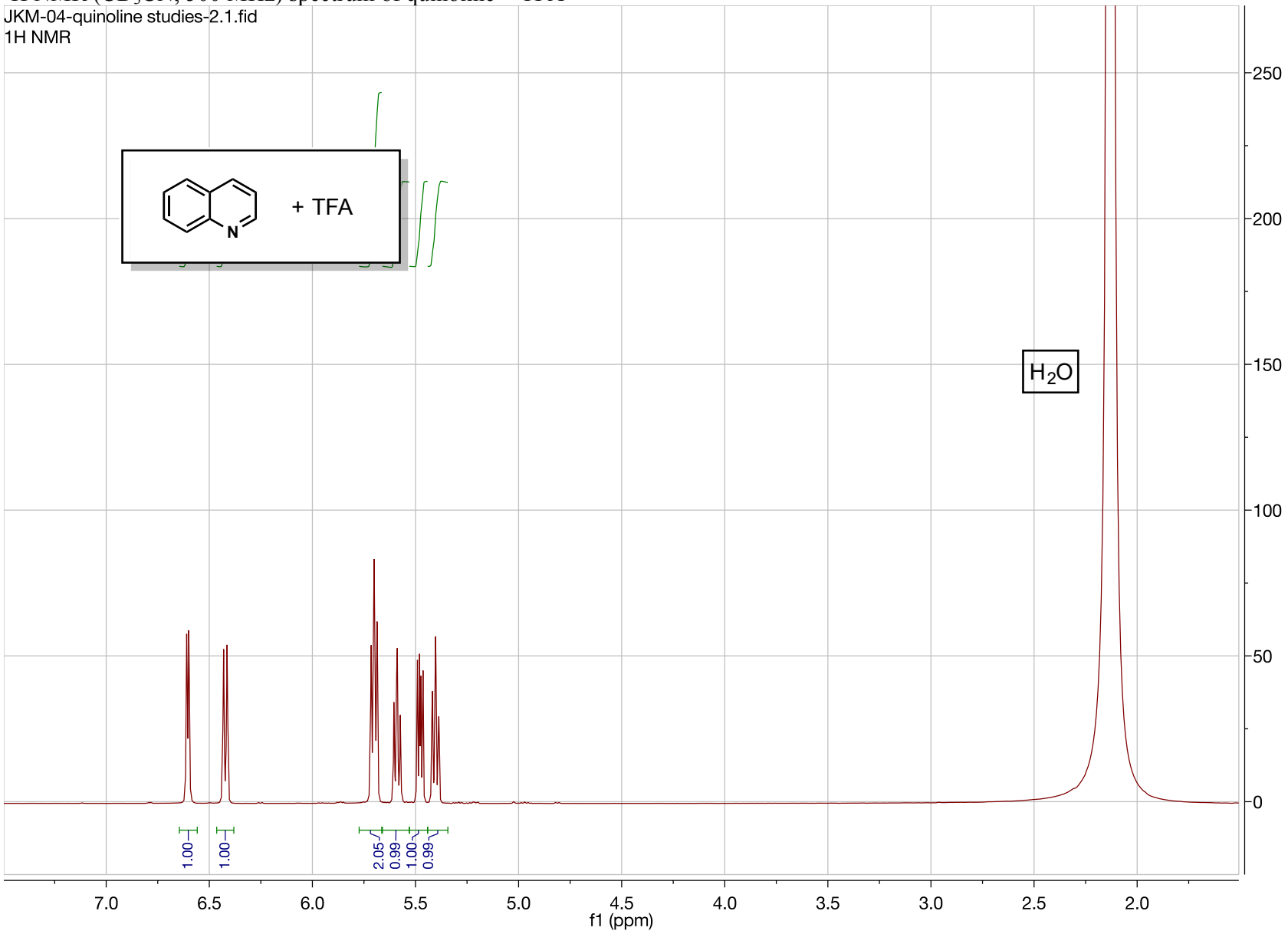
^{11}B NMR (acetone-d_6, 128.4 MHz) spectrum of Potassium trifluoro(2-methyl-1-phenylpropan-2-yl)borate (**1u**)



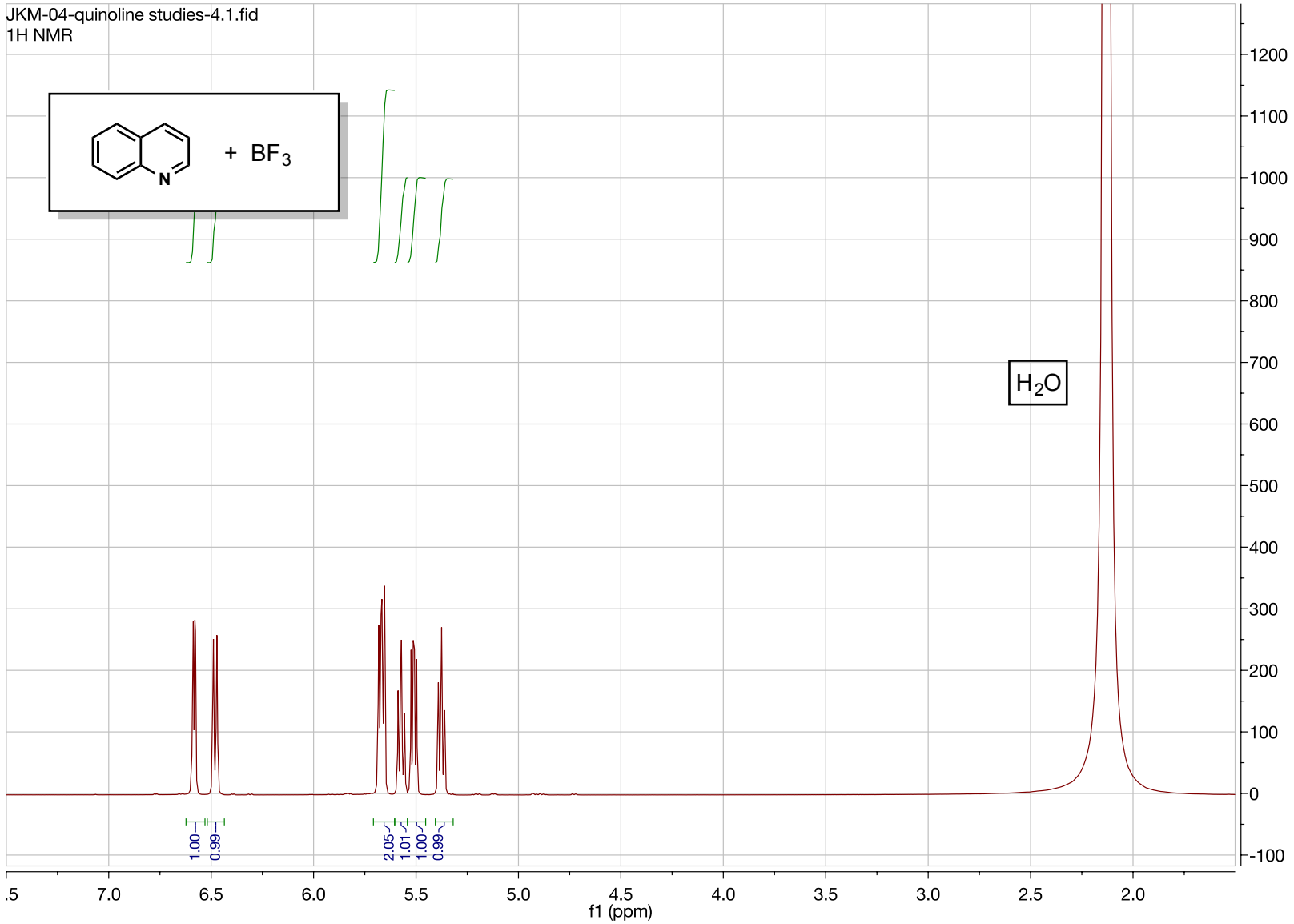
^{1}H NMR (CD_3CN, 500 MHz) spectrum of quinoline



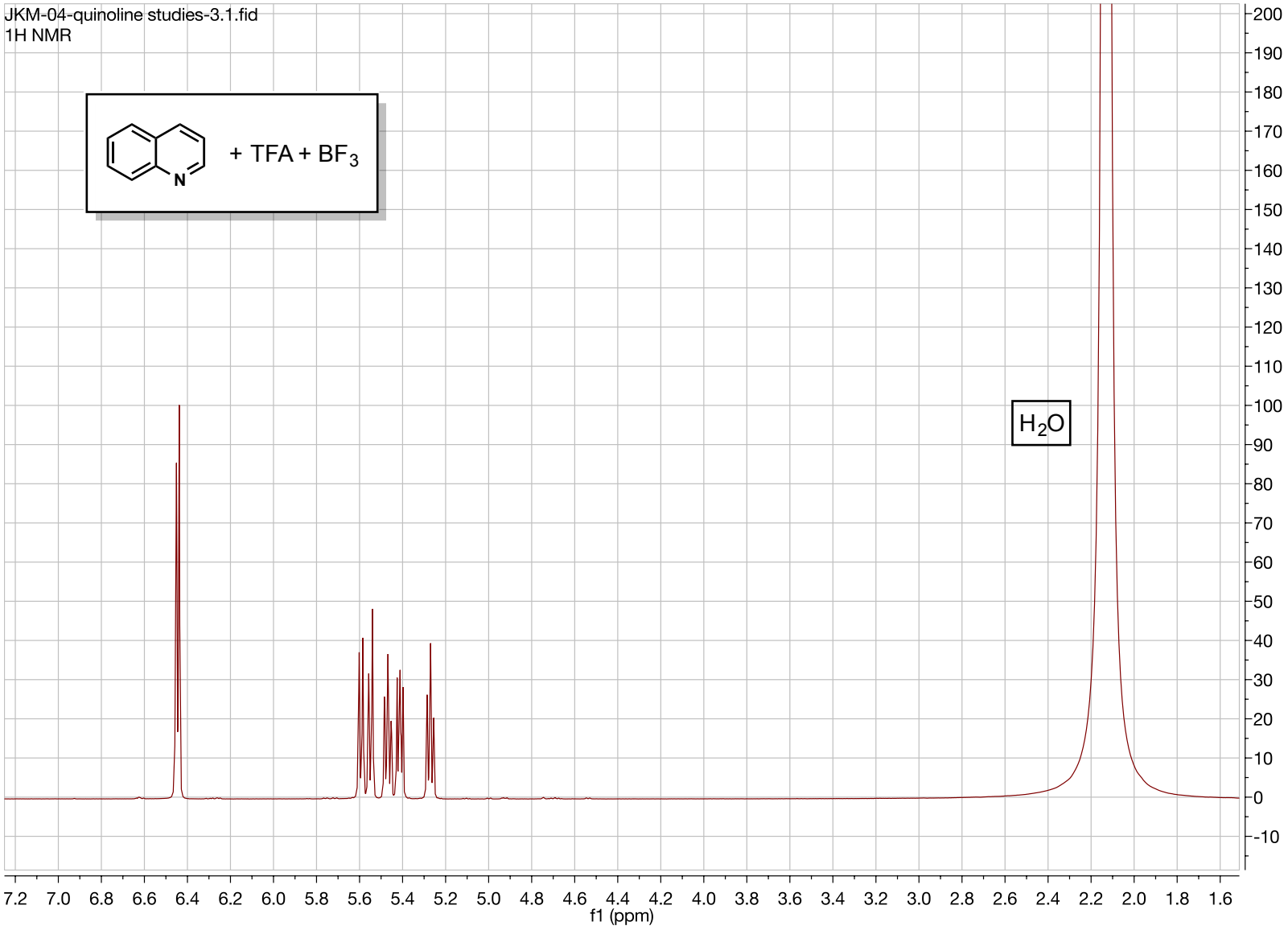
^{1}H NMR (CD_3CN, 500 MHz) spectrum of quinoline + TFA



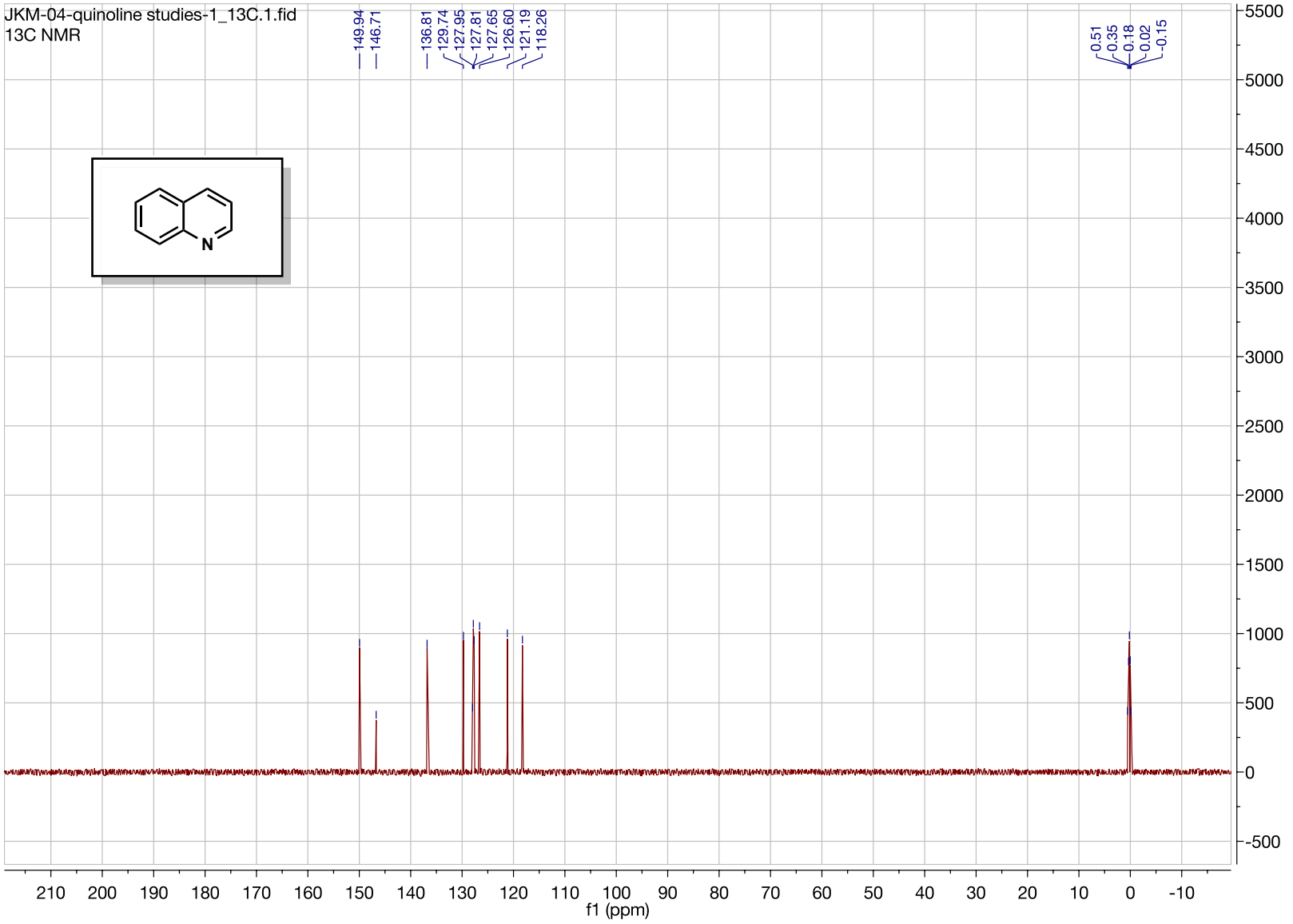
^{1}H NMR (CD_3CN, 500 MHz) spectrum of quinoline + BF_3



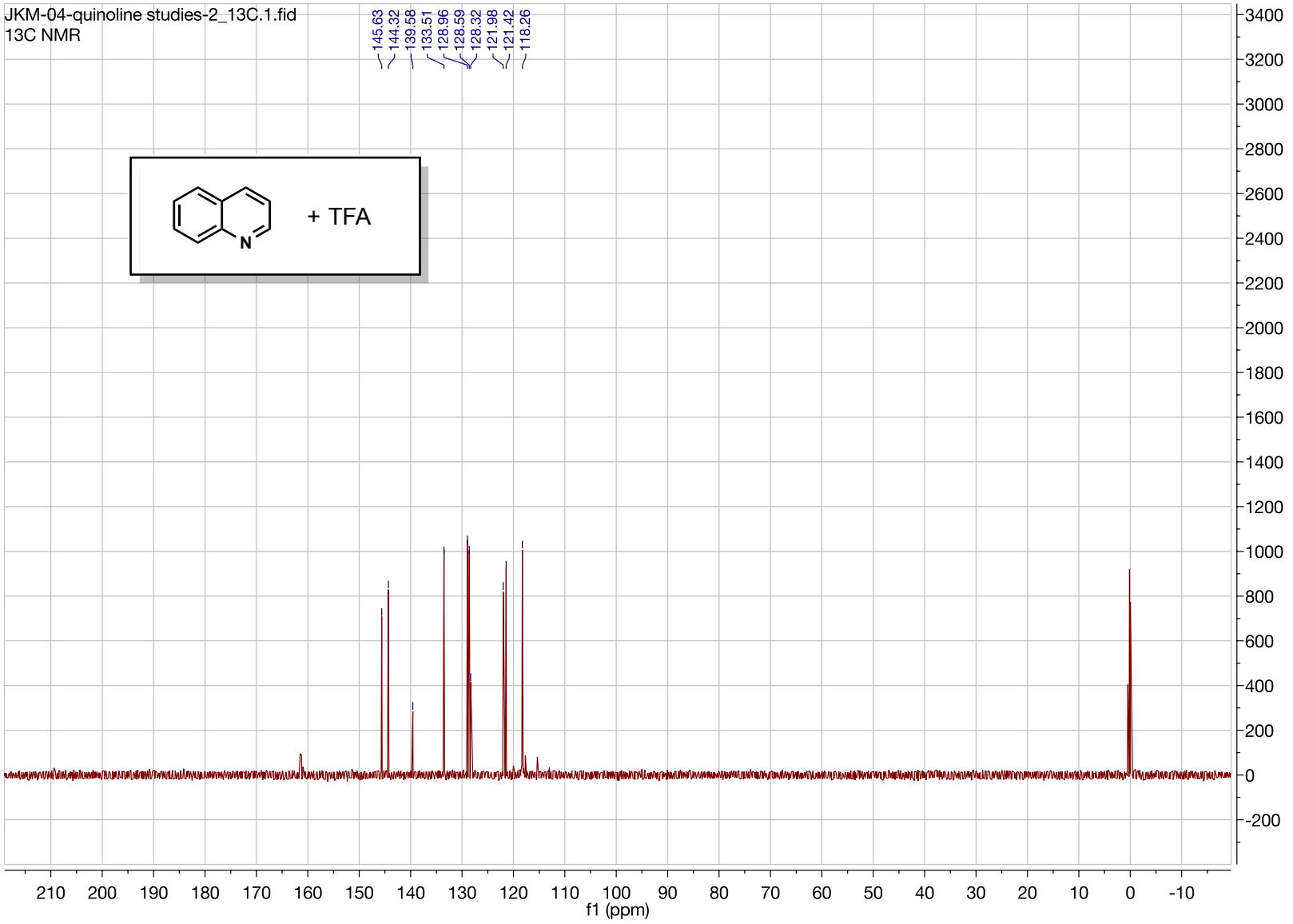
^{1}H NMR (CD_3CN, 500 MHz) spectrum of quinoline + TFA + BF_3



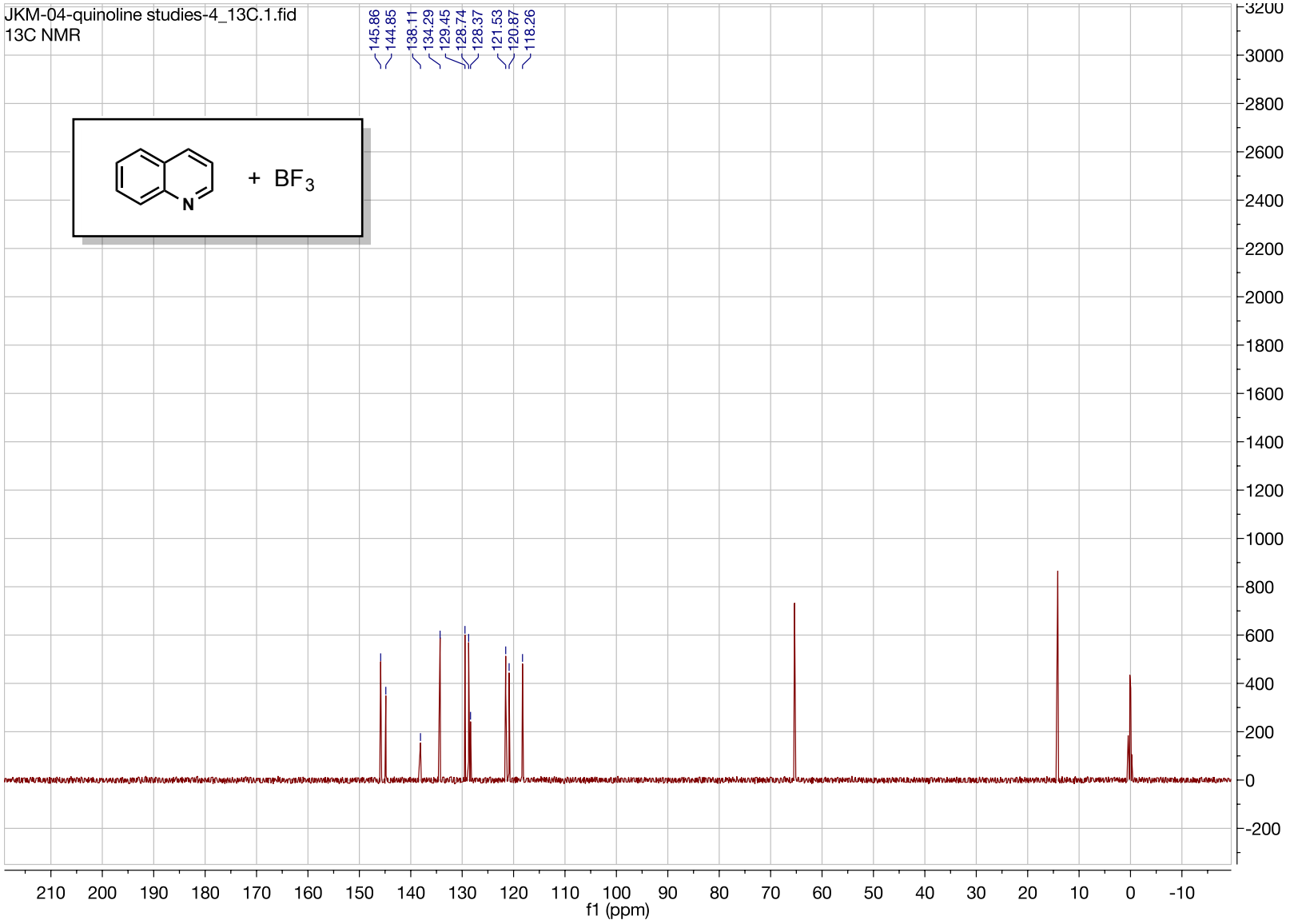
^{13}C NMR (CD_3CN, 125.8 MHz) spectrum of quinoline



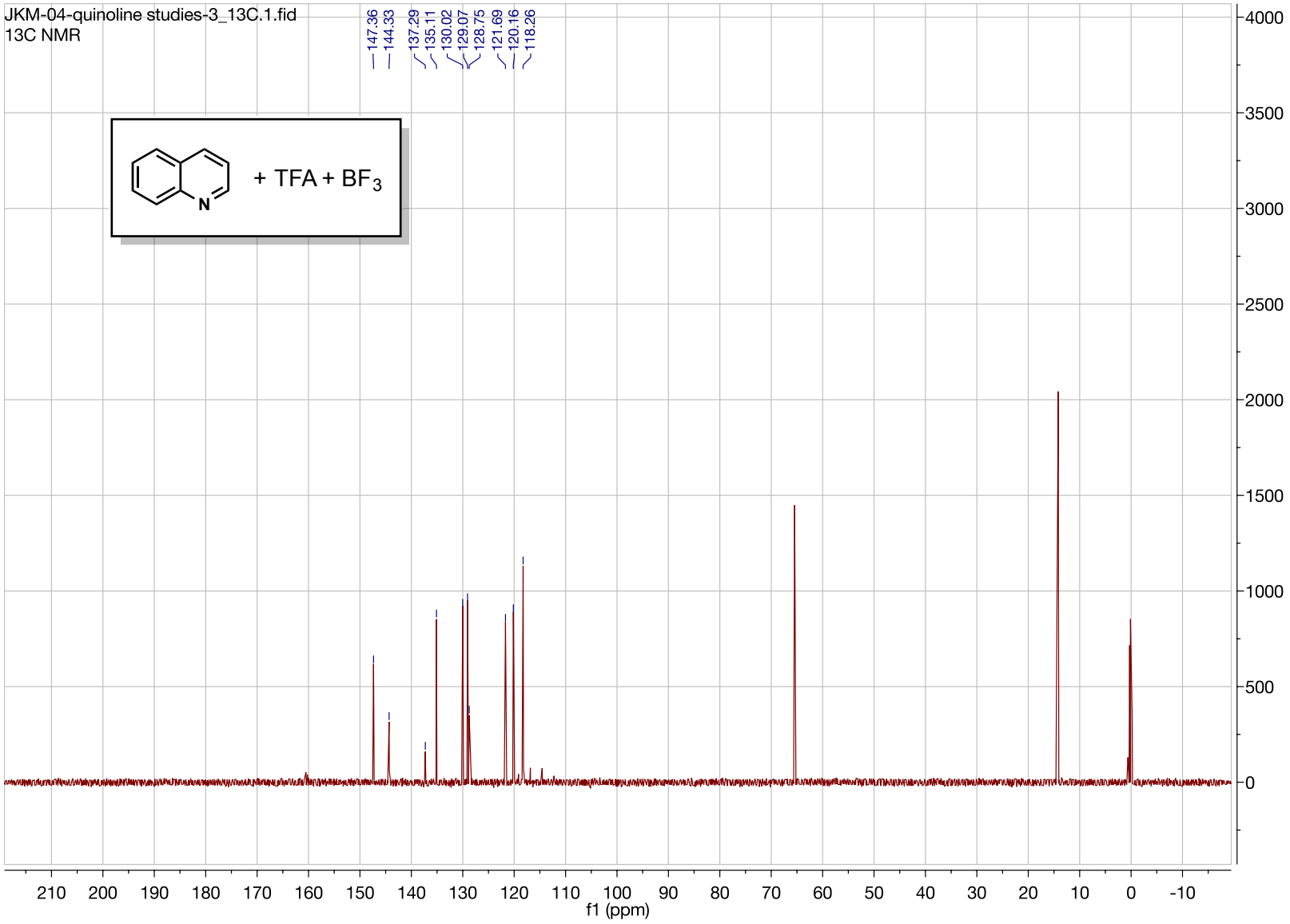
^{13}C NMR (CD_3CN, 125.8 MHz) spectrum of quinoline + TFA



^{13}C NMR (CD_3CN, 125.8 MHz) spectrum of quinoline + BF_3



^{13}C NMR (CD_3CN, 125.8 MHz) spectrum of quinoline + TFA + BF_3

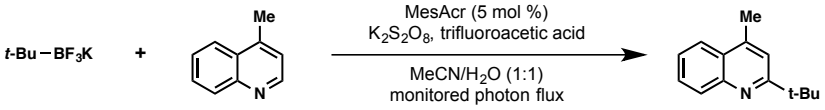


Determination of Quantum Yield

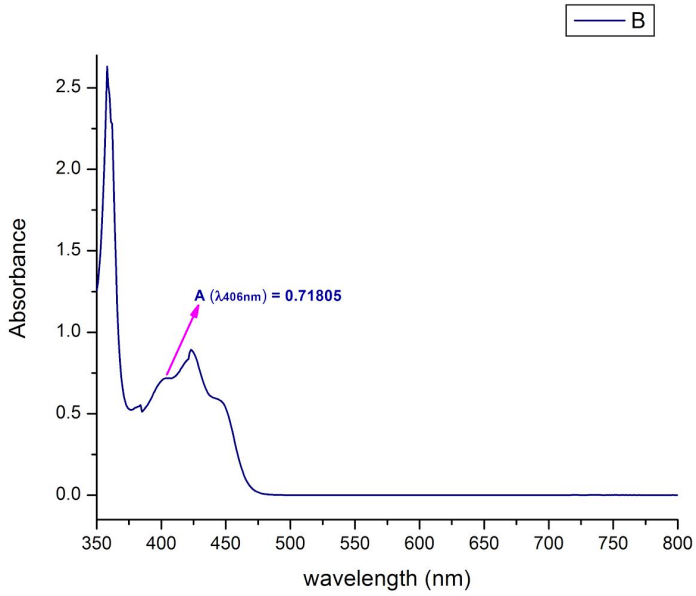
The quantum yield was determined using the following equation (reference: El Khatib, M.; Serafim, R. A. M.; Molander, G. A. *Angew. Chem. Int. Ed.* **2016**, *55*, 254):

$$\phi = \frac{mmol\ of\ product}{(photon\ flux)(t)(f)}$$

The following reaction was used to determine quantum yield:



The absorbance of 9-mesityl-10-methylacridinium perchlorate was measured in MeCN/H_2O (1:1). Subsequently, the reaction (with remaining reagents) was irradiated at a wavelength where the photocatalyst absorbs and the ϕ_{Fe2+} has been reported (reference: Demas, J. N.; Bowman, W. D.; Zalewski, E. F.; Velapoidl, R. A. *J. Phys. Chem.* **1981**, *85*, 2766). At 407 nm, the absorbance (A) was 0.71805:



$f = 1 - 10^{-A}$

$f = 1 - 10^{-0.71805} = 0.8086$

The lights of the laboratory were shut off, and photocatalyst, heteroarene, persulfate, and MeCN/H_2O were added to the cuvette. Trifluoroacetic acid and trifluoroborate were added last and then the cuvette was capped with a PTFE stopper. Ar was bubbled through the reaction for 300 s, and under Ar, the sample was stirred and irradiated (406 nm, slit width = 10.0 cm) for 3600 s. After irradiation, the crude mixture was diluted with EtOAc and passed through a silica plug. The filtrate was concentrated. ^{1}H NMR was used to determine the yield (3.160 x 10^{-6} mol after 3600 s).

Standard ferrioxalate actinometry was used to determine the photon flux of the spectrophotometer. Potassium ferrioxalate hydrate was used to determine formation of Fe^{2+} by observing formation of $[Fe(phen)_3]^{2+}$ after addition of 1,10-phenanthroline. A 0.15 M solution of ferrioxalate was prepared by dissolving 501 mg of potassium ferrioxalate hydrate in 6.8 mL of 0.05 M H_2SO_4, and this solution was stored in the dark. A buffered solution of phen was prepared by dissolving 11.1 mg phen and 2.5 g NaOAc in 11.1 mL of 0.5 M H_2SO_4, and this solution was also stored in the dark.

Absorbance of non-irradiated sample: A solution of phen (0.35 mL) was added to ferrioxalate solution (2.0 mL) in a vial that was covered with foil. The vial was capped and allowed to rest for 1 h before being transferred to a cuvette. The absorbance of the non-irradiated solution was measured to be 0.5875.

Absorbance of irradiated sample: The solution of ferrioxalate (2.0 mL) was stirred and irradiated for 90 s at 406 nm with a slit width of 10.0 nm. After irradiation, the buffered solution of phen (0.35 mL) was added to the cuvette and allowed to rest for 1 h in the dark. The absorbance was then found to be 2.3697.

Calculations:

$$\text{mol } Fe^{2+} = \frac{(V)(\Delta A)}{(1)(\varepsilon)} = \frac{(0.00235\ L)(2.3607-0.58752)}{(1\ cm)(11{,}110\ mol^{-1}cm^{-1})} = 3.751 \text{ x } 10^{-7}$$

$$\text{photon flux} = \frac{mol\ Fe^{2+}}{\phi(Fe^{2+})(t)(f)} = \frac{3.751 \text{ x } 10-7}{(1.188)(90\ s)(1.00)} = 3.508 \text{ x } 10^{-9} \text{ einstein/s}$$

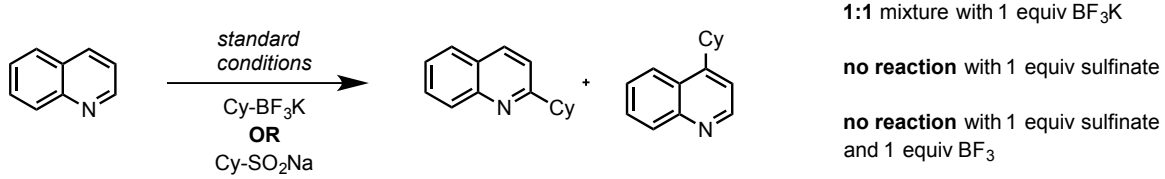
$$\phi = \frac{mmol\ of\ product}{(photon\ flux)(t)(f)} = \frac{3.160 \times 10^{-6}\ mol}{(3.508 \times 10^{-9}\frac{\varepsilon}{s})(3600\ s)(0.8086)} = 0.31$$

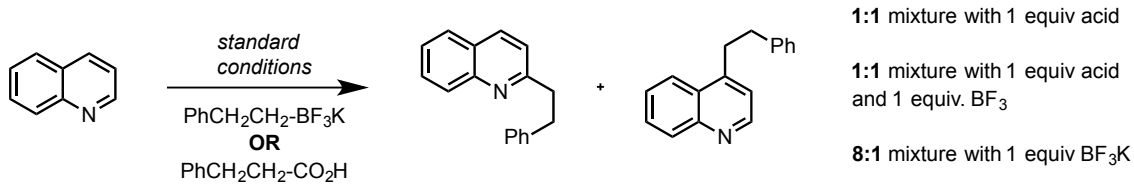
The quantum yield supports a *closed catalytic pathway*.

BF_3 Studies with Alternate Radical Precursors

Reactions were performed on 0.1 mmol scale under standard conditions (containing 10% internal standard, 4,4'-di-*tert*-butylbiphenyl) where the alkylation partner was replaced by the respective sulfinate or carboxylic acid precursors. For the reactions with added BF_3, an etherate solution (48% by weight) was added to the reaction mixture after addition of all the other reagents. After 24 hours, the reaction was quenched by addition of equal volume of 1.0 M K_2CO_3. The resultant mixture was extracted 3 times with CH_2Cl_2. The aqueous layer was inspected by TLC to confirm full extraction. An aliquot of the CH_2Cl_2 layer was then placed on the GCMS, and the ratio of C2/C4 alkylation was determined by integration.

Comparison to other radical precursors





DFT Calculations: Radical Association with BF_3

Calculations were performed using: um06/6-311+G(d,p), smd:water //ub3lyp/6-31g(d) [ub3lyp/6-31g(d)].