Supporting Information

Copper-mediated regioselective C-H Etherification of naphthylamides with arylboronic acids using water as oxygen Source

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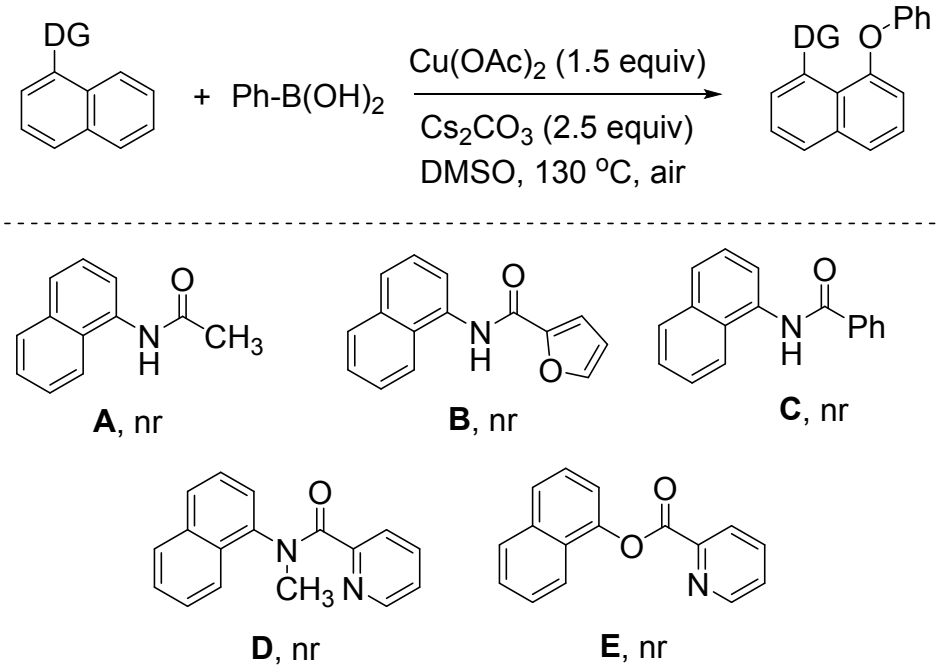
General Information. $Cu(OAc)_2$ (98%), $Cu(OAc)_2•H_2O$ (98%), CuO (99.9%), CuI (99.9%), $CuCl_2$ (99.9%), $CuSO_4$ (98%) and Cs_2CO_3 (99.9%) were purchased from Aldrich and used as received. The solvents were purchased from commercial sources and dried according to standard procedure. Naphthylamides were prepared according to literature.[1] Purification of the reaction products was carried out on column chromatography using Merck silica gel (60-120 mesh). Analytical TLC was performed on Merck silica gel G/GF 254 plate. NMR spectra were recorded on Bruker Avance III 600 MHz and Varian 400 MHz using $CDCl_3$ as solvent and Me_4Si as an internal standard. Chemical shifts (δ) were reported in ppm and spin-spin coupling constants (J) were given in Hz. Melting points were determined using Buchi B-540 melting point apparatus and are uncorrected. FT-IR spectra were recorded using Thermo Fisher Scientific spectrometer. Mass spectra were recorded on a Q-TOF ESI-MS instrument (model HAB 273). Single crystal X-ray data were collected on a Bruker SMART APEX equipped with a CCD area detector using Mo/Kα radiation and the structure was solved by direct method using *SHELXL-14* (Göttingen, Germany).

Procedure for the Synthesis of Naphthylamides.[1] To a stirred solution of picolinic acid (1 mmol) in 5 mL dichloromethane at 0 °C under nitrogen atmosphere, was added oxalyl chloride (1.1 mmol, 0.1 mL), followed by catalytic amount of *N*,*N*-dimethylformamide (10 μL). The resultant mixture was stirred at 0 °C for 0.5 h and then at room temperature for 1 h. The reaction mixture was then cooled to 0 °C and triethylamine (2 mmol, 0.28 mL) was added. Then, (i.e. 0 °C), naphthylamine (1.1 mmol) was added portion wise and the resultant mixture was allowed to warm up to room temperature and the stirring was continued for 24 h. Progress of the reaction was monitored by TLC using ethyl acetate and hexane as an eluent. After completion, the reaction mixture was diluted with dichloromethane (45 mL), and washed with brine (3 × 5 mL)

and water (1 x 5 mL). Drying (Na_2SO_4) and evaporation of the solvent gave a residue that was purified on silica gel column chromatography using *n*-hexane and ethyl acetate as an eluent.

Screening of Directing Groups



Reaction conditions: substrates **A-E** (0.1 mmol), boronic acid (0.2 mmol), $Cu(OAc)_2$ (0.15 mmol), Cs_2CO_3 (0.25 mmol), DMSO (1.0 mL), 130 °C, air, 10 h. nr = no reaction.

General Procedure for Copper-Mediated Etherification. *N*-Naphthalenyl picolinamide **1** (0.2 mmol), boronic acid **2** (0.4 mmol), Cs_2CO_3 (0.5 mmol, 163 mg), $Cu(OAc)_2$ (0.3 mmol, 55 mg) and DMSO (1.5 mL) were stirred in a preheated oil bath at 130 °C under air for an appropriate time. The progress of the reaction was monitored by TLC using ethyl acetate and hexane as an eluent. After completion, the reaction mixture was cooled to room temperature, diluted with ethyl acetate (45 mL). The mixture was washed with 3 mL of aqueous ammonia, brine (5 mL)

and water (5 mL). Drying (Na_2SO_4) and evaporation of the solvent gave a residue that was purified on silica gel column chromatography using *n*-hexane and ethyl acetate as an eluent.

Crystal Data and Structure Refinement for 3k

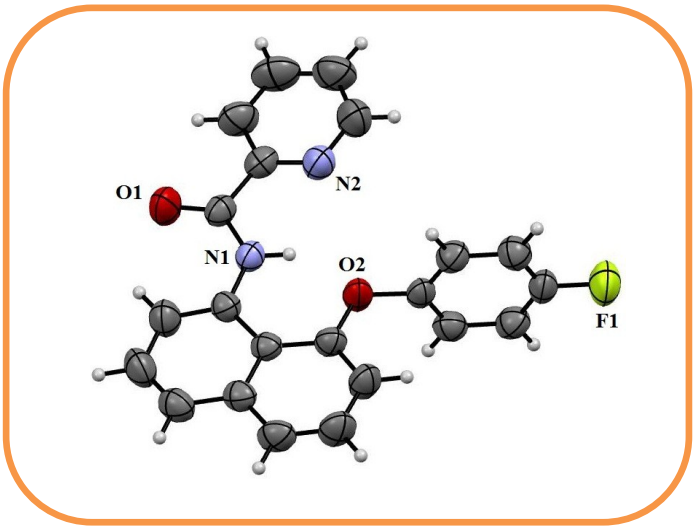
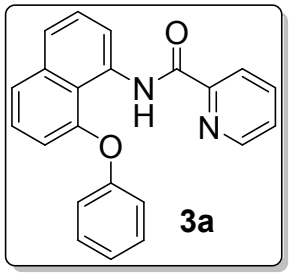


Figure S1. ORTEP diagram of [*N*-(1-(4-fluorophenoxy)naphthalen-8-yl)picolinamide] **3k** with 50% ellipsoid. H-Atoms are omitted for clarity (CCDC 1528745).

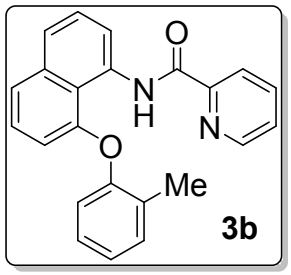
Identification code	**3k**
Empirical formula	$C_{22}\ H_{15}\ F\ N_2\ O_2$
Formula weight	358.36
Crystal habit, color	block , yellow
Crystal size, mm^3	0. 35 x 0.28 x 0.21
Temperature, *T*/K	296(2)
Wavelength, λ/Å	0.71073
Crystal system	Triclinic
Space group	'P -1
Unit cell dimensions	a = 9.1885(7)Å b = 9.6792(9) Å c = 11.0350(9)Å α = 64.897(5) β = 78.682(5) γ = 89.685(5)
Volume, *V*/$Å^3$	868.09(13)

Z	2
Calculated density, $Mg \cdot m^{-3}$	1.371
Absorption coefficient, μ/mm^{-1}	0.096
F(000)	372
θ range for data collection	2.09 to 28.69°
Limiting indices	$-10 \le h \le 11$, $-8 \le k \le 11$, $-12 \le l \le 12$
Reflection collected / unique	2872/ 2157
Completeness to θ	96.40 % (θ = 24.75°)
Max. and min. transmission	0.968 and 0.967
Refinement method	'SHELXL-2014/7'
Data / restraints / parameters	2872/0/ 244
Goodness–of–fit on F^2	1.030
Final R indices [I>2sigma(I)]	$R1$ = 0.0443, $wR2$ = 0.1325
R indices (all data)	$R1$ = 0.0588, $wR2$ = 0.1470

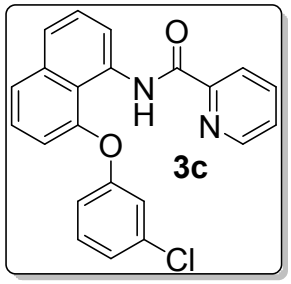
Characterization Data



***N*-(1-Phenoxynaphthalen-8-yl)picolinamide 3a**. Brown solid; yield 82% (55.8 mg); analytical TLC on silica gel R_f 0.35 in 15% ethyl acetate/hexane; mp 110-114 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 13.0 (s, 1H), 9.02 (d, *J*=7.8 Hz, 1H), 8.25 (d, *J*=7.2 Hz, 2H), 7.84-7.81 (m, 1H), 7.65-7.55 (m, 3H), 7.39 (t, *J*=7.8 Hz, 2H), 7.35-7.32 (m, 2H), 7.22 (d, *J*=7.8 Hz, 2H), 7.18-7.16 (m, 1H), 6.96 (d, *J*=7.8 Hz, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.8, 156.8, 154.4, 150.7, 148, 137.5, 136.8, 134.7, 129.9, 127.1, 126.2, 125.8, 124.4, 124.2, 124.1, 122.4, 120.3, 118.1, 117.3, 114.2; IR (KBr): 3436, 2924, 1682, 1534, 1359, 1490, 1228, 1037, 748 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{22}H_{16}N_2O_2$, 341.1285; found 341.1301.

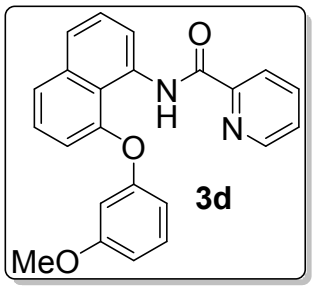


***N*-(1-(*o*-Tolyloxy)naphthalen-8-yl)picolinamide 3b**. Yellow solid; yield 71% (50.3 mg); analytical TLC on silica gel R_f 0.4 in 15% ethyl acetate/hexane; mp 135-138 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 13.26 (s, 1H), 9.08-9.06 (m, 1H), 8.3 (d, *J*=8 Hz, 1H), 8.09-8.08 (m, 1H), 7.86-7.82 (m, 1H), 7.64-7.54 (m, 3H), 7.38 (d, *J*=7.2 Hz, 1H), 7.33-7.28 (m, 3H), 7.22-7.18 (m, 1H), 7.14 (d, *J*=8 Hz, 1H), 6.72-6.7 (m, 1H), 2.36 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.9, 155.2, 153.9, 150.8, 147.8, 137.6, 137, 135.1, 131.7, 130.9, 127.6, 127.1, 126.2, 125.8, 125.2, 124, 123.5, 122.3, 121.5, 117.3, 117, 111.2, 16.87; IR (KBr): 3437, 2925, 1683, 1539, 1496, 1231, 1116, 1032, 746 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{23}H_{18}N_2O_2$, 355.1441; found 355.1458.

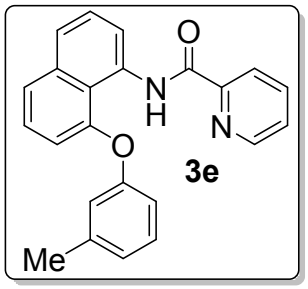


***N*-(1-(3-Chlorophenoxy)naphthalen-8-yl)picolinamide 3c**. Yellow solid; yield 65% (48.7 mg); analytical TLC on silica gel R_f 0.37 in 15% ethyl acetate/hexane; mp 130-132 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 12.7 (s, 1H), 8.98 (d, *J*=7.2 Hz, 1H), 8.36-8.35 (m, 1H), 8.25 (d, *J*=7.8 Hz, 1H), 7.86-7.83 (m, 1H), 7.66 (d, *J*=7.8 Hz, 2H), 7.57 (t, *J*=7.8 Hz, 1H), 7.41-7.36 (m, 2H), 7.27-

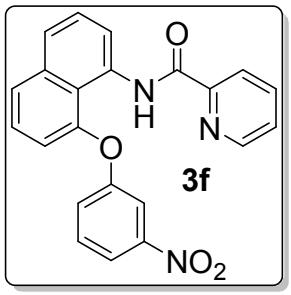
7.24 (m, 2H), 7.11 (d, *J*=8.4 Hz, 1H), 7.03-7.01(m, 2H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.8, 157.9, 153.1, 150.6, 147.89, 137.71, 136.98, 135.22, 134.23, 130.65, 127.18, 126.40, 125.87, 125.41, 124.32, 124.14, 122.5, 120.5, 118.2, 117.8, 117.5, 115.3; IR (KBr): 3274, 2925, 1675, 1544, 1496, 1286, 1040, 821 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{22}H_{15}ClN_2O_2$, 375.0895; found 375.0902.



***N*-(1-(3-Methoxyphenoxy)naphthalen-8-yl)picolinamide 3d**. Brown solid; yield 70% (51.9 mg); analytical TLC on silica gel R_f 0.36 in 25% ethyl acetate/hexane, mp 112-115 °C ; ^{1}H NMR (400 MHz, $CDCl_3$): 12.94 (s, 1H), 9.0 (d, *J*=8 Hz, 1H), 8.32-8.25 (m, 2H), 7.86-7.83 (m, 1H), 7.65-7.54 (m, 3H), 7.38-7.27 (m, 3H), 6.99 (d, *J*=8 Hz, 1H), 6.79-6.70 (m, 3H), 3.77 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.9, 161.1, 157.9, 154.0, 150.7, 148.1, 137.5, 136.8, 134.6, 130.2, 127.0, 126.2, 125.9, 124.6, 124.1, 122.3, 118.1, 117.3, 114.4, 112.3, 109.9, 106.6, 55.6; IR (KBr): 3274, 2925, 1675, 1544, 1496, 1286, 1040, 821 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{23}H_{18}N_2O_3$, 371.1390; found 371.1390.

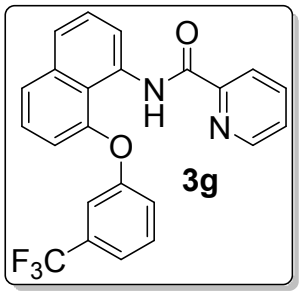


***N*-(1-(*m*-Tolyloxy)naphthalen-8-yl)picolinamide 3e**. Yellow solid; yield 73% (51.7 mg); analytical TLC on silica gel R_f 0.33 in 15% ethyl acetate/hexane; mp 99-103°C; ^{1}H NMR (400 MHz, $CDCl_3$) : δ 12.99 (s, 1H), 8.98 (d, *J*=7.6 Hz, 1H), 8.25-8.21 (m, 2H), 7.82-7.78 (m, 1H), 7.62-7.51 (m, 3H), 7.34-7.29 (m, 2H), 7.24-7.22 (m, 1H), 7.0-6.92 (m, 4H), 2.32 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.9, 156.8, 154.4, 150.8, 148, 140.1, 137.5, 136.8, 134.7, 129.6, 127.1, 126.2, 125.8, 125, 124.3, 124.1, 122.4, 121.2, 120.8, 118.1, 117.2, 114.2, 21.6; IR (KBr): 3437, 2924, 1684, 1536, 1431, 1341, 1229, 1032, 817 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{23}H_{18}N_2O_2$, 355.1441; found 355.1458.

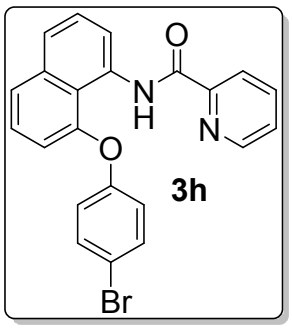


3f

***N*-(1-(3-Nitrophenoxy)naphthalen-8-yl)picolinamide 3f**. Yellow solid; yield 51% (39.3 mg); analytical TLC on silica gel R_f 0.32 in 20% ethyl acetate/hexane; mp 151-153 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 12.43 (s, 1H), 8.95 (d, *J*=7.2 Hz, 1H), 8.47-8.46 (m, 1H), 8.24 (d, *J*=7.8 Hz, 1H), 8.15-8.14 (m, 1H), 7.94-7.93 (m, 1H), 7.86-7.83 (m, 1H), 7.75 (d, *J*=8.4 Hz, 1H), 7.7 (d, *J*=8.4 Hz, 1H), 7.6 (t, *J*=7.8 Hz, 1H), 7.46-7.41(m, 3H), 7.34-7.32 (m, 1H), 7.08 (d, *J*=7.2 Hz, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.8, 158.5, 151.9, 150.3, 149.3, 148.1, 137.7, 137.1, 134.0, 130.4, 127.5, 126.7, 126.4, 125.9, 124.6, 124.2, 122.6, 118.6, 118.5, 118.4, 116.5, 114.8; (KBr): 3429, 2924, 1673, 1524, 1498, 1351, 1240, 1032, 803 cm^{-1}. HRMS (ESI): calcd for $[M+Na]^+$ $C_{22}H_{15}N_3O_4$, 408.0955; found 408.0971.

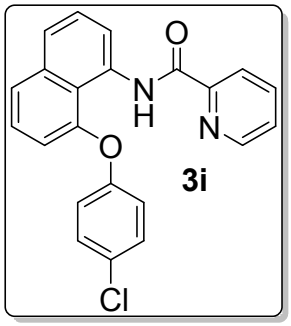


***N*-(1-(3-(Trifluoromethyl)phenoxy)naphthalen-8-yl)picolinamide 3g**. Yellow solid; yield 72% (58.8 mg); analytical TLC on silica gel R_f 0.35 in 15% ethyl acetate/hexane; mp 127-130 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 12.56 (s, 1H), 8.87 (d, *J*=7.6 Hz, 1H), 8.23-8.22 (m, 1H), 8.15 (d, *J*=7.6 Hz, 1H), 7.74 (t, *J*=7.6 Hz, 1H), 7.58 (d, *J*=9.2 Hz, 2H), 7.5-7.45 (m, 2H), 7.35-7.27 (m, 4H), 7.16-7.12 (m, 1H), 6.91 (d, *J*=7.6 Hz, 1H); ^{13}C NMR ($CDCl_3$, 150 MHz): δ 162.8, 157.5, 152.9, 150.6, 147.9, 137.6, 137, 134.2, 132.3 (J_{C-F}=32.5 Hz), 130.5, 127.3, 126.4, 125.8, 125.6, 124.4, 123.8 (J_{C-F}=270.9 Hz), 122.5, 122.2, 120.5 (J_{C-F}=3.7 Hz), 118.4, 118, 117.07 (J_{C-F}=3.7 Hz), 115.5; IR (KBr): 3293, 3071, 1673, 1547, 1327, 1169, 1287, 1093, 798 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{23}H_{15}F_3N_2O_2$, 409.1158; found 409.1174.



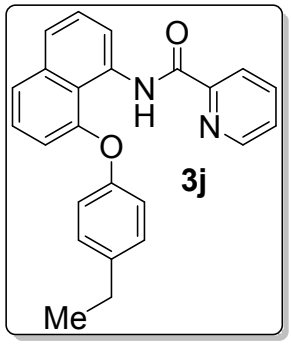
***N*-(1-(4-Bromophenoxy)naphthalen-8-yl)picolinamide 3h**. Yellow solid; yield 63% (52.8 mg); analytical TLC on silica gel R_f 0.35 in 15% ethyl acetate/hexane; mp 110-112 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 13.01 (s, 1H), 9.01 (d, *J*=7.6 Hz, 1H), 8.25 (d, *J*=7.2 Hz, 2H), 7.85-7.8 (m, 1H),

7.65-7.54 (m, 3H), 7.41-7.31(m, 3H), 7.23-7.15 (m, 3H), 6.96 (d, *J*=7.6 Hz, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163, 156.8, 154.5, 150.8, 148.1, 137.4, 136.7, 134.7, 130.1, 127.1, 126.2, 125.8, 124.4, 124.2, 124.1, 122.4, 120.3, 118.1, 117.3, 114.2; ; IR (KBr): 3443, 2924, 1682, 1536, 1431, 1341, 1230, 1029, 818 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{22}H_{15}BrN_2O_2$, 419.0390; found 419.0363.

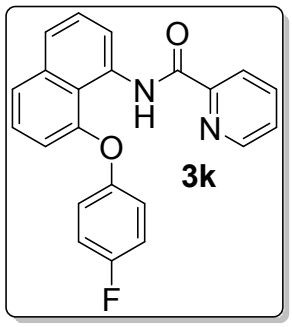


3i

***N*-(1-(4-Chlorophenoxy)naphthalen-8-yl)picolinamide 3i**. Pale yellow solid; yield 70% (52.5 mg); analytical TLC on silica gel R_f 0.34 in 15% ethyl acetate/hexane; mp 142-143 ° C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 12.81(s, 1H), 8.99 (d, *J* = 8.4 Hz, 1H), 8.29-8.25 (m, 2H), 7.86-7.83 (m, 1H), 7.66-7.62 (m, 2H), 7.58-7.56 (m, 1H), 7.39-7.33 (m, 4H), 7.15-7.27 (m, 2H), 6.95-6.94 (m, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.9, 155.5, 153.9, 150.7, 147.9, 137.5, 136.9, 134.5, 130, 129.3, 127.3, 126.3, 125.8, 125, 124.2, 122.5, 121.3, 118.1, 117.6, 114.6; IR (KBr): 3285, 2924, 1669, 1541, 1487, 1228, 1091, 848 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{22}H_{15}ClN_2O_2$, 375.0895; found 375.0901.

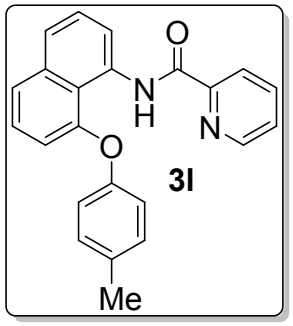


***N*-(1-(4-Ethylphenoxy)naphthalen-8-yl)picolinamide 3j**. Yellow solid; yield 77% (56.7 mg); analytical TLC on silica gel R_f 0.35 in 15% ethyl acetate/hexane; mp 99-104 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 13.0 (s, 1H), 8.92 (d, *J*=7.6 Hz, 1H), 8.16 (d, *J*=7.2 Hz, 2H), 7.75-7.71 (m, 1H), 7.54-7.43 (m, 3H), 7.22 (t, *J*=8 Hz, 2H), 7.16-7.11 (m, 2H), 7.05 (d, *J*=8.4 Hz, 2H), 6.85 (d, *J*=7.6 Hz, 1H), 2.57 (q, *J*=7.6 Hz, 2H), 1.16 (t, *J*=7.6 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.9, 154.8, 154.5, 150.8, 148.0, 140.2, 137.5, 136.8, 134.8, 129.2, 127.1, 126.2, 125.8, 124.1, 122.3, 120.2, 117.9, 117.1, 113.7, 28.4, 15.9; IR (KBr): υ 3274, 2925, 1677, 1542, 1498, 1230, 1030, 820 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{24}H_{20}N_2O_2$, 369.1598; found 369.1603.



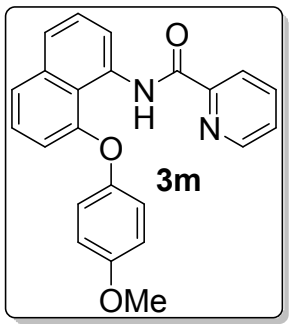
***N*-(1-(4-Fluorophenoxy)naphthalen-8-yl)picolinamide 3k**. Pale yellow solid; yield 78% (55.9 mg); analytical TLC on silica gel R_f 0.37 in 15% ethyl acetate/hexane; mp 120-123 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 13.0 (s, 1H), 9.02-8.99 (m, 1H), 8.27-8.23 (m, 2H), 7.86-7.81 (m, 1H), 7.64-7.54 (m, 3H), 7.36-7.31 (m, 2H), 7.21-7.17 (m, 2H), 7.11-7.07 (m, 2H), 6.9 (d, *J*=7.2 Hz,

1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.7 ($^1J_{C\text{-}F}$=221 Hz), 158.6, 154.6, 152.3, 150.8, 148.1, 137.6, 136.7, 134.6, 127.2, 126.2, 125.8, 124.5, 124.1, 122.4, 121.7 ($^3J_{C\text{-}F}$=8 Hz), 117.8, 117.4, 116.6 ($^2J_{C\text{-}F}$=23 Hz), 113.5; IR (KBr): υ 3438, 2924, 1671, 1540, 1432, 1223, 1032, 852 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{22}H_{15}FN_2O_2$, 359.1190; found 359.1204.



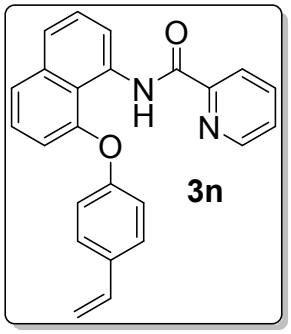
3l

***N*-(1-(*p*-Tolyloxy)naphthalen-8-yl)picolinamide 3l**. Yellow solid; yield 71% (50.3 mg); analytical TLC on silica gel R_f 0.32 in 10% ethyl acetate/hexane; mp 157-160 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 13.11 (s, 1H), 9.05-9.03 (m, 1H), 8.29-8.27 (m, 2H), 7.87-7.84 (m, 1H), 7.66-7.64 (m, 1H), 7.6-7.57 (m, 2H), 7.38-7.37 (m, 1H), 7.35-7.32 (m, 1H), 7.22 (d, *J*=8.4 Hz, 2H), 7.15-7.14 (m, 2H), 6.96-6.94 (m, 1H), 2.39 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.9, 154.8, 154.3, 150.8, 148, 137.5, 136.8, 134.8, 133.8, 130.4, 127.1, 126.2, 125.8, 124.1, 122.4, 120.3, 117.9, 117.1, 113.5, 21; IR (KBr):3538, 2925, 1682, 1537, 1430, 1378, 1031, 750 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{23}H_{18}N_2O_2$, 355.1441; found 355.1457.



3m

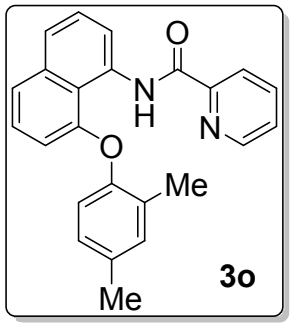
***N*-(1-(4-Methoxyphenoxy)naphthalen-8-yl)picolinamide 3m**. Yellow solid; yield 82% (60.7 mg); analytical TLC on silica gel R_f 0.35 in 25% ethyl acetate/hexane; mp 115-118 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 13.16 (s, 1H), 9.033-9.02 (m, 1H), 8.27-8.24 (m, 2H), 7.85-7.82 (m, 1H), 7.62 (d, *J*=7.8 Hz, 1H), 7.57-7.54 (m, 2H), 7.35-7.34 (m, 1H), 7.3 (t, *J*=7.8 Hz, 1H), 7.19-7.17 (m, 2H), 6.96-6.94 (m, 2H), 6.88 (d, *J*=7.8 Hz, 1H), 3.84(s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163, 156.6, 155.5, 150.8, 149.8, 148.0, 137.5, 136.8, 134.9, 127.2, 126.2, 125.8, 124.0, 123.8, 122.4, 121.8, 117.6, 117.0, 115.0, 112.6, 56.3; IR (KBr): 3265, 3054, 1686, 1540, 1429, 1343, 1285, 1033, 850 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+C_{23}H_{18}N_2O_3$, 371.1390; found 371.1405.



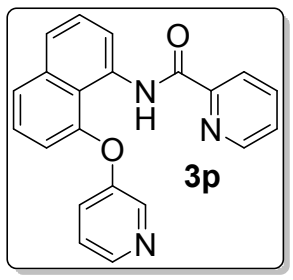
3n

***N*-(1-(4-Vinylphenoxy)naphthalen-8-yl)picolinamide 3n**. Yellow solid; yield 79 % (57.9 mg); analytical TLC on silica gel R_f 0.32 in 10% ethyl acetate/hexane; mp 128-131°C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 12.95 (s, 1H), 9.02-9.00 (m, 1H), 8.29-8.25 (m, 2H), 7.85-7.82 (m, 1H), 7.65-7.55 (m, 3H), 7.44 (d, *J*=8.4 Hz, 2H), 7.37-7.32 (m, 2H), 7.18-7.17 (m, 2H), 6.98-6.96 (m, 1H), 6.74-6.69 (m, 1H), 5.70 (d, *J*=17.4 Hz, 1H), 5.23 (d, *J*=10.8 Hz, 1H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 163, 156.5, 154.3, 150.7, 148.0, 137.5, 136.8, 136.1, 134.7, 133.8, 127.7, 127.2, 126.2, 125.8, 124.6, 124.2, 122.4, 120.3, 118.1, 117.3, 114.3, 113.5; IR (KBr): 3432, 2924, 1677, 1543,

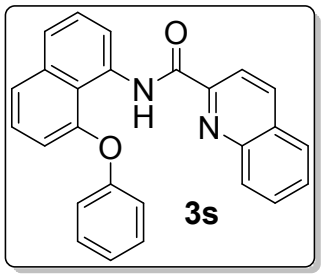
1429, 1287, 1114, 853 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+C_{24}H_{18}N_2O_2$, 367.1441; found 367.1438.



***N*-(1-(2,4-Dimethylphenoxy)naphthalen-8-yl)picolinamide 3o**. Thick oil, yield 55% (40.5 mg); analytical TLC on silica gel R_f 0.4 in 10% ethyl acetate/hexane; ^1H NMR (600 MHz, $CDCl_3$): δ 13.3 (s, 1H), 9.05 (d, *J*=7.8 Hz, 1H), 8.29-8.28 (m, 1H), 8.12-8.11 (m, 1H), 7.85-7.82 (m, 1H), 7.62 (m, 1H), 7.58-7.55 (m, 1H), 7.33-7.31 (m, 1H), 7.27-7.25 (m, 1H), 7.17 (s, 1H), 7.07-7.06 (m, 1H), 7.02-7.01 (m, 1H), 6.68-6.66 (m, 1H), 2.39 (s, 3H), 2.29 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.9, 155.4, 151.5, 150.9, 147.9, 137.4, 136.8, 135.2, 134.6, 132.4, 130.6, 128.2, 127.1, 126.2, 125.9, 123.9, 123.2, 122.4, 121.5, 117.2, 116.8, 110.8, 21.1, 16.5; IR (KBr, cm^{-1}): υ 3283, 2923, 1684, 1538, 1497,1342, 1205, 1032, 816 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{24}H_{20}N_2O_2$, 369.1598; found 369.1606.

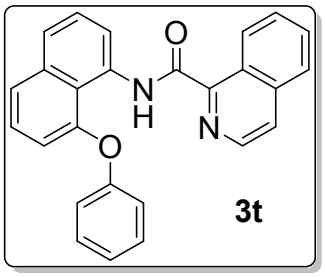


***N*-(1-(Pyridin-3-yloxy)naphthalen-8-yl)picolinamide 3p**. Colorless solid, yield 59% (40.3 mg); analytical TLC on silica gel R_f 0.34 in 35% ethyl acetate/hexane; mp 108-110 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 12.65 (s, 1H), 8.92 (d, *J*=7.6 Hz, 1H), 8.65 (s, 1H), 8.35 (s, 1H), 8.3-8.29 (m, 1H), 8.18 (d, *J*=7.2 Hz, 1H), 7.77-7.75 (m, 1H), 7.61-7.59 (m, 2H), 7.53-7.5 (m, 1H), 7.2-7.19 (m, 4H), 6.92 (d, *J*=7.2 Hz, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.8, 153.1, 150.5, 148.0, 144.9, 142.4, 137.7, 136.9, 134.3, 127.4, 126.5, 126.1, 125.8, 125.6, 124.4, 122.5, 118.3, 117.9, 115; IR (KBr): 3269, 2915, 1667, 1535, 1486, 1238, 1036, 829 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{21}H_{16}N_3O_2$, 342.1237; found 342.1244.

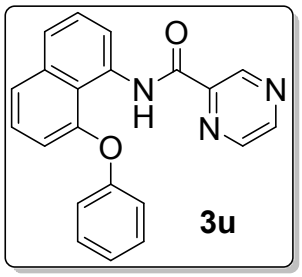


3s

***N*-(1-Phenoxynaphthalen-8-yl)quinoline-2-carboxamide 3s**. Yellow solid; yield 61% (47.63 mg); analytical TLC on silica gel R_f 0.32 in 10% ethyl acetate/hexane; mp 140-142 °C, ^{1}H NMR (600 MHz, $CDCl_3$): δ 13.21 (s, 1H), 9.11-9.10 (m, 1H), 8.4 (d, *J*=8.4 Hz, 1H), 8.29 (d, *J*=9 Hz, 1H), 7.82 (d, *J*=8.4 Hz, 1H), 7.66-7.65 (m, 1H), 7.61-7.56 (m, 2H), 7.53-7.5 (m, 4H), 7.35-7.31 (m, 4H), 7.01 (d, *J*=8.4 Hz, 1H), 6.82-6.81 (m, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163.1, 155.9, 150.7, 146.7, 137.7, 136.8, 135, 130.5, 129.9, 129.8, 129.4, 127.9, 127.7, 127.2, 125.8, 125.3, 124.2, 123.8, 122.2, 119.0, 117.4, 117.3, 112.2; IR (KBr):3232, 2925, 1674, 1538, 1493, 1228, 1142, 816 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{26}H_{18}N_2O_2$ 391.1441, found 391.1451.

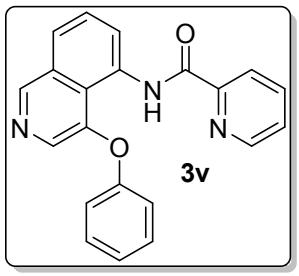


***N*-(1-Phenoxynaphthalen-8-yl)isoquinoline-1-carboxamide 3t**. Yellow solid; yield 67% (52.3 mg); analytical TLC on silica gel R_f 0.36 in 15% ethyl acetate/hexane; mp 145-148 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 13.17 (s, 1H), 9.73 (d, *J*=10 Hz, 1H), 9.05 (d, *J*=6.8 Hz, 1H), 8.11 (d, *J*=5.6 Hz, 1H), 7.84-7.81 (m, 1H), 7.71-7.6 (m, 6H), 7.4-7.34 (m, 3H), 7.22-7.16 (m, 3H), 6.95 (d, *J*=8 Hz, 1H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 164.5, 157.6, 156.8, 154.5, 148.5, 141.4, 140.1, 137.7, 136.9, 134.9, 130.5, 130.0, 128.8, 128, 127.4, 127.1, 127.1, 125.8, 124.6, 124.5, 124.3, 124.1, 120.3, 118.3, 117.2, 114.2; IR (KBr): 3436, 2924, 1669, 1533, 1434, 1233, 1140, 1033, 815 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{26}H_{18}N_2O_2$, 391.1441; found 391.1450.

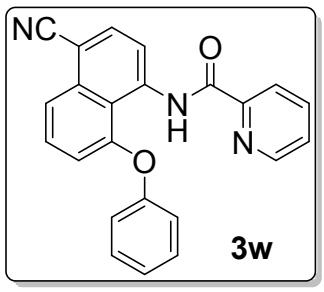


***N*-(1-Phenoxynaphthalen-8-yl)pyrazine-2-carboxamide 3u**. Yellow solid, yield 71% (48.5 mg); analytical TLC on silica gel R_f 0.36 in 25% ethyl acetate/hexane; mp 149-152 °C ; ^{1}H NMR (600 MHz, $CDCl_3$): δ 12.79 (s, 1H), 9.5 (s, 1H), 8.97 (d, *J*=7.8 Hz, 1H), 8.66-8.65 (m, 1H), 8.22 (s, 1H), 7.66 (d, *J*=7.8 Hz, 1H), 7.61(d, *J*=8.4 Hz, 1H), 7.58-7.56 (m, 1H), 7.41-7.38 (m, 2H), 7.35-7.33 (m, 1H), 7.2-7.17 (m, 3H), 6.95 (d, *J*=7.8 Hz, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 161.3, 156.6, 154.2, 147.2, 145.4, 144.6, 142.4, 136.8, 134.2, 130.0, 127.1, 126, 124.7,

124.6, 124.4, 120.1, 117.9, 117.5, 114.4; IR (KBr): 3467, 2900, 1641, 1541, 1491, 1342, 1031, 822 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{21}H_{15}N_3O_2$, 342.1237; found 342.1243.

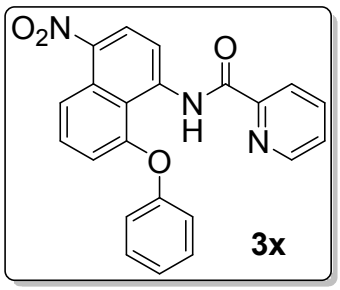


***N*-(4-Phenoxyisoquinolin-5-yl)picolinamide 3v**. Thick liquid, yield 65% (44.4 mg); analytical TLC on silica gel R_f 0.35 in 35% ethyl acetate/hexane; ^1H NMR (600 MHz, $CDCl_3$): δ 12.86 (s, 1H), 9.24-9.22 (m, 1H), 9.0 (s, 1H), 8.31-8.27 (m, 2H), 8.14 (s, 1H), 7.88-7.86 (m, 1H), 7.79 (d, *J*=7.8 Hz, 1H), 7.75-7.72 (m, 1H), 7.46-7.43 (m, 2H), 7.41-7.39 (m, 1H), 7.29-7.28 (m, 2H), 7.25-7.22 (m, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163.1, 156.4, 150.2, 149.6, 148.3, 148.1, 137.6, 134.1, 132.3, 131.1, 130.1, 128.9, 126.5, 124.8, 123.0, 122.5, 120.7, 120.6, 119.8; IR (KBr): 3433, 2925, 1634, 1534, 1463, 1284, 1014, 745 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{21}H_{15}N_3O_2$, 342.1237; found 342.1252.



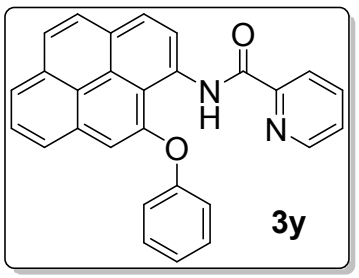
***N*-(1-Cyano-5-phenoxynaphthalen-4-yl)picolinamide 3w**. Yellow oil; yield 65% (47.5 mg); analytical TLC on silica gel R_f 0.35 in 30% ethyl acetate/hexane; ^1H NMR (600 MHz, $CDCl_3$): δ 13.44 (s, 1H), 9.16 (d, *J*=8.4 Hz, 1H), 8.28 (d, *J*=7.8 Hz, 1H), 8.21 (m, 1H), 8.05-8.1 (m, 2H),

7.9-7.87 (m, 1H), 7.57-7.54 (m, 1H), 7.54-7.48 (m, 2H), 7.41-7.39 (m, 1H), 7.29-7.28 (m, 3H), 7.07-7.06 (m, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163.5, 155.8, 155.5, 150.0, 148.1, 139.9, 137.8, 135.9, 134.7, 130.3, 128.6, 126.8, 125.1, 122.7, 121.2, 120.7, 118.6, 117.2, 115.3, 114.6, 104.9; IR (KBr): 3435, 2924, 1745, 1636, 1526, 1460, 1241, 1050, 740. HRMS (ESI): calcd for $[M+H]^+$ $C_{23}H_{15}N_3O_2$, 366.1237; found 366.1249.



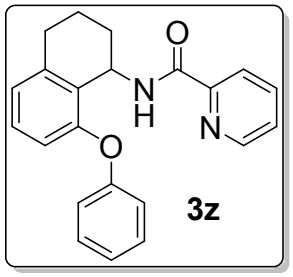
3x

***N*-(1-Nitro-5-phenoxynaphthalen-4-yl)picolinamide 3x**. Yellow solid; yield 68% (52.4 mg); analytical TLC on silica gel R_f 0.35 in 35% ethyl acetate/hexane; mp 218-220 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 13.57 (s, 1H), 9.18 (d, *J*=9 Hz, 1H), 8.41-8.45 (m, 2H), 8.28 (d, *J*=7.8 Hz, 1H), 8.21-8.19 (m, 2H), 7.59-7.56 (m, 1H), 7.51-7.48 (m, 2H), 7.42-7.4 (m, 1H), 7.3-7.28 (m, 3H), 7.09-7.04 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 163.5, 155.8, 155.4, 150, 148.1, 142.2, 140.9, 137.8, 130.3, 129.2, 128.9, 126.8, 126.7, 125.2, 122.7, 120.8, 118.8, 117.9, 114.7, 114.2; IR (KBr): 3447, 2924, 2854, 1636, 1537, 1499, 1499, 1117, 742 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{22}H_{15}N_3O_4$, 386.1135; found 386.1148.



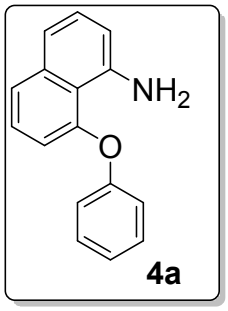
3y

***N*-(4-Phenoxypyren-3-yl)picolinamide 3y**. Yellow solid; yield 70% (58.1 mg); analytical TLC on silica gel R_f 0.39 in 15% ethyl acetate/hexane; mp 174-177 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 13.2 (s, 1H), 9.45 (d, *J*=8.4 Hz, 1H), 8.16-8.12 (m, 3H), 7.89-7.86 (m, 2H), 7.81(d, *J*=9 Hz, 1H), 7.74-7.68 (m, 3H), 7.32-7.21(m, 6H), 7.12-7.1(m, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 162.8, 156.3, 154.0, 150. 8, 148, 137.6, 133.8, 131.9, 131.5, 130.1, 128.0, 127.8, 127.5, 127.4, 126.6, 126.37, 126.3, 124.6, 124.1, 123.4, 122.7, 122.4, 120.8, 119.2, 114.8, 112.33; IR (KBr): 3430, 2924, 1689, 1522, 1490, 1327, 1257, 1045, 847 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{28}H_{18}N_2O_2$, 415.1441; found 415.1456.



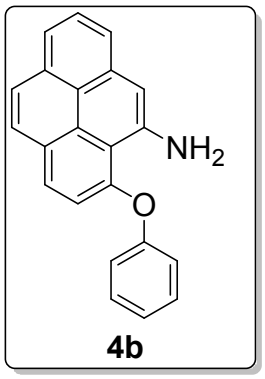
3z

***N*-(8-Phenoxy-1,2,3,4-tetrahydronaphthalen-1-yl)picolinamide 3z.** Yellow solid; yield 50% (34.5 mg) analytical TLC on silica gel R_f 0.3 in 25% ethyl acetate/hexane; mp 139-141 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.36 (s, 1H), 7.7 (d, *J*=7.8 Hz, 1H), 7.53 (t, *J*=7.2 Hz, 1H), 7.37 (d, *J*=7.2 Hz, 1H), 7.29-7.27 (m, 1H), 7.20-7.18 (m, 1H), 7.09-7.01 (m, 4H), 6.81 (d, *J*=6.6 Hz, 2H), 6.33-6.31 (m, 1H), 2.68-2.64 (m, 2H), 2.09-2.08 (m, 1H), 1.76-1.71 (m, 3H), 1.29-1.25 (m, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 169.7, 155.2, 148.87, 140.8, 138.3, 136.4, 136.1, 129.5, 129.4, 128.6, 128.1, 127.2, 127.0, 126.5, 123.7, 54.98, 29.63, 28.20, 22.04; IR (KBr): 3437, 3062, 2925, 2859, 1650, 1595, 1494, 1386, 1340, 1146, 1112, 913, 744 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{22}H_{20}N_2O_2$, 345.1598; found 345.1601.



4a

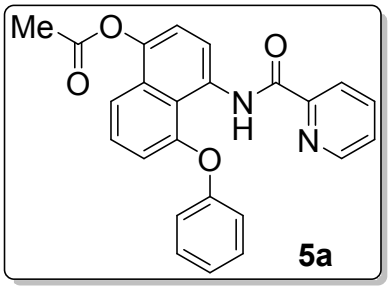
8-Phenoxynaphthalen-1-amine 4a. Thick oil, yield 91% (21.4 mg); analytical TLC on silica gel R_f 0.43 in 3% ethyl acetate/hexane; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.49 (d, *J* = 8 Hz, 1H), 7.38 (t, *J* = 8.0 Hz, 2H), 7.29-7.14 (m, 4H), 7.09 (d, *J* = 7.6 Hz, 2H), 6.69 (d, *J* = 7.6 Hz, 1H), 6.64 (d, *J* = 6.8 Hz, 1H), 5.19 (s, 2H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 157.1, 155.4, 144.1, 137.6, 130.2, 127.5, 125.7, 124.2, 124.1, 119.8, 117.4, 116.5, 113, 110.2; IR (KBr): 3399, 2924, 2854, 1592, 1487, 1393, 1229, 1029, 819, 756 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{16}H_{13}NO$, 236.1070; found 236.1074.



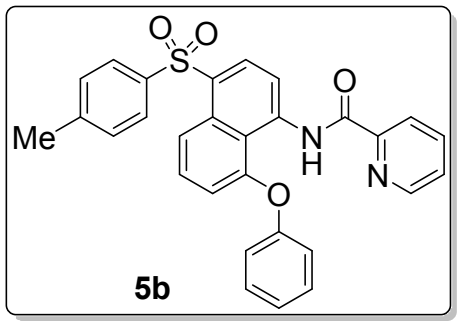
4b

3-Phenoxypyren-4-amine 4b. Thick liquid; yield 87% (26.9 mg); analytical TLC on silica gel R_f 0.46 in 5% ethyl acetate/hexane; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.98-7.68 (m, 6H), 7.46-7.24 (m, 2H), 7.25-7.23 (m, 4H), 7.08 (s, 1H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 155.6, 154.9, 132.2, 132.1, 130.2, 130.1, 128.0, 127.5, 127.5, 126.4, 125.1, 124.6, 124.4, 122.9, 122.3, 120.0, 117.1,

112.2, 112.2, 110.3; IR (KBr): 3443, 2924, 2850, 1638, 1460, 1382, 1111, 760, 622 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{22}H_{15}NO$, 310.1226; found 310.1234.

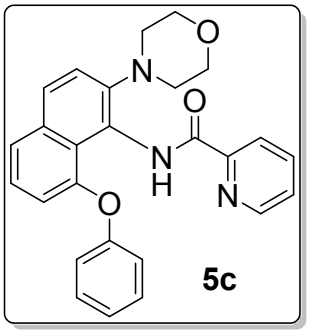


5-Phenoxy-4-(picolinamido)naphthalen-1-yl acetate 5a. Thick liquid; yield 60% (23.9 mg); analytical TLC on silica gel R_f 0.34 in 35% ethyl acetate/hexane; ^1H NMR (600 MHz, $CDCl_3$): δ 13.04 (s, 1H), 9.03 (d, *J*=6 Hz, 1H), 8.25-8.21 (m, 2H), 7.84-7.82 (m, 1H), 7.64-7.55 (m, 2H), 7.44-7.39 (m, 2H), 7.38-7.33 (m, 2H), 7.24-7.13 (m, 3H), 7.04-6.98 (m, 1H), 2.48 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 169.9, 162.8, 156.4, 154.8, 150.6, 148, 142.4, 137.6, 136.4, 133.1, 130.0, 126.5, 126.3, 124.5, 122.4, 120.8, 120.5, 119.5, 118.9, 117.7, 117.1, 116.5, 114.53, 21.18; IR (KBr): 3453, 2921, 1730, 1638, 1384, 1263, 1189, 1115, 620 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{24}H_{18}N_2O_4$ 399.1339; found 399.1355.



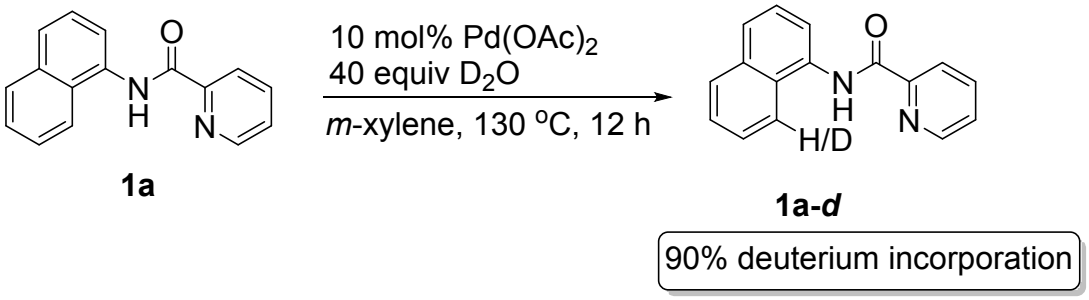
***N*-(1-Phenoxy-5-tosylnaphthalen-8-yl)picolinamide 5b**. Colorless solid; yield 61% (30.2 mg); analytical TLC on silica gel R_f 0.37 in 35% ethyl acetate/hexane; mp 201-203 °C; ^1H NMR

(400 MHz, $CDCl_3$): δ 13.44 (s, 1H), 9.2 (d, *J*=8.8 Hz, 1H), 8.61 (d, *J*=8.4 Hz, 1H), 8.42 (d, *J*=8.4 Hz, 1H), 8.26 (d, *J*=8 Hz, 1H), 8.17-8.16 (m, 1H), 7.85 (d, *J*=8.4 Hz, 3H), 7.44-7.35 (m, 4H), 7.28-7.24 (m, 2H), 7.22-7.19 (m, 3H), 6.97 (d, *J*=8 Hz, 1H), 2.37 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163.5, 155.9, 155.4, 150.0, 148.0, 144. 140., 139.2 137.8, 137.4, 132.3, 132.0, 130.2, 129.9, 128.2, 127.6, 125, 122.7, 120.7, 120.2, 118.2, 114.5, 114.5, 21.83; IR (KBr): 3451, 2924, 2854, 1639, 1382, 1114, 767, 620 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+$ $C_{29}H_{22}N_2O_4S$, 495.1373; found 495.1379.



***N*-(7-Morpholino-1-phenoxynaphthalen-8-yl)picolinamide 5c**. Yellow oil; yield 43% (18.3 mg); analytical TLC on silica gel R_f 0.3 in 35% ethyl acetate/hexane; ^1H NMR (400 MHz, $CDCl_3$): δ 10.13 (s, 1H), 8.51-8.5 (m, 1H), 8.13 (d, *J*=7.6 Hz, 1H), 7.84-7.80 (m, 2H), 7.64 (d, *J*=8 Hz, 1H), 7.44-7.40 (m, 2H), 7.32 (t, *J*=8 Hz, 1H), 7.06-7.02 (m, 3H), 6.88-6.84 (m, 1H), 6.58 (d, *J*=8 Hz, 2H), 3.73-3.71 (m, 4H), 3.04-3.02 (m, 4H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163.3, 158.8, 151.6, 150.6, 148.1, 146.4, 137.4, 133.7, 129.4, 128.5, 126.2, 125.2, 125.1, 124.9, 124.1, 122.6, 122.2, 120.5, 118.6, 117.4, 67.74, 51.97; IR (KBr):3449, 2964, 2923, 2852, 1637, 1464, 1384, 1220, 1111, 772 cm^{-1}. HRMS (ESI): calcd for $[M+H]^+C_{22}H_{15}NO$, 426.1812; found 426.1818.

Preparation of *N*-(Naphthalen-1-yl-8-d)picolinamide 1a-*d* (Scheme S1).[2a]



Compound **1a** (0.25 mmol, 62 mg), D_2O (10 mmol, 200 mg), $Pd(OAc)_2$ (15 mol %, 0.0375 mmol, 9 mg) and *m*-xylene (5 mL) were stirred at 130 °C for 12 h. The reaction mixture was cooled to room temperature, diluted with ethyl acetate (20 mL), washed with brine (2 × 5 mL) and water (1 x 5 mL). Drying (Na_2SO_4) and evaporation of the solvent gave a residue that was purified on silica gel column chromatography using *n*-hexane and ethyl acetate (96/4 v/v) as an eluent. The deuterium incorporation was determined using 400 MHz ^{1}H NMR as 90%.

Intermolecular Kinetic Isotope Study.[2b] *N*-(Naphthalen-1-yl)picolinamide **1a** (0.2 mmol, 49.6 mg), *N*-(naphthalen-1-yl-8-d)picolinamide **1a-*d*** (0.2 mmol, 49.8 mg), phenylboronic acid **2a** (0.4 mmol, 48.8 mg), Cs_2CO_3 (0.5 mmol, 163 mg), $Cu(OAc)_2$ (0.3 mmol, 55 mg) and DMSO (1.5 mL) were stirred at 130 °C under air for 2 h. The reaction mixture was cooled to room temperature, diluted with ethyl acetate (45 mL) and washed with 3 ml of aqueous ammonia, brine (5 mL) and water (5mL). Drying (Na_2SO_4) and evaporation of the solvent gave a residue that was purified on silica gel column chromatography using *n*-hexane and ethyl acetate as an eluent to give **3a** and a mixture of unreacted **1a** and **1a-*d***. The intermolecular k_H/k_D was found to be 1.94, based on 600 MHz ^{1}H NMR analysis of the recovered substrates **1a** and **1a-*d***.

H_2O^{18} Labeling Experiment.[3] Compound **1a** (0.1 mmol, 25 mg) was mixed with **2a** (0.2 mmol, 24.5 mg), Cs_2CO_3 (0.25 mmol, 81.5 mg), $Cu(OAc)_2$ (0.15 mmol, 49 mg), DMSO (1 mL) and H_2O^{18} (0.1 mmol, 2 mg) were stirred at 130 °C for 3 h. The reaction mixture was then cooled to room temperature and diluted with ethyl acetate (45 mL). The solution was washed with aqueous ammonia (3 mL), brine (2 × 5 ml) and water (5 mL). Drying (Na_2SO_4) and evaporation of the solvent gave a residue that was purified on silica gel column chromatography using ethyl acetate and hexane as an eluent to provide a 1:2 mixtures of ethers O^{16} (**3a**) and O^{18} (**3a'**) as determined by ESI-MS analysis.

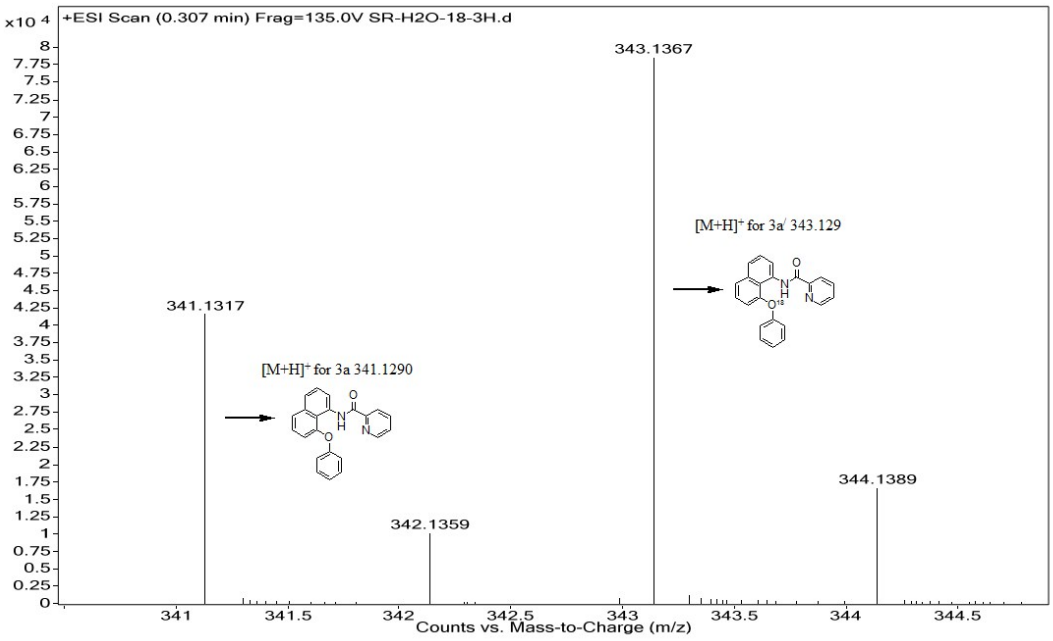


Figure S3. ESI-MS analysis of labelling experiment (**3a** and **3a'**) after 3 h.

Removal of Directing Group.[4] To a stirred solution of NaOH (0.7 mmol, 28 mg) in EtOH (1.5 mL), compound **3a** or **3y** (0.1 mmol) was added. The reaction mixture was then stirred at room temperature for 2 min and heated at 80 °C for 3 h. The progress of the reaction was monitored by

TLC using ethyl acetate and hexane as an eluent. After completion, the reaction mixture was allowed to cool to room temperature, diluted with ethyl acetate (40 mL). The solution was washed with 0.5 N HCl (4 × 5 mL), brine (5 mL) and water (5 mL). Drying (Na_2SO_4) and evaporation of the solvent gave a residue that was purified on silica gel column chromatography using *n*-hexane and ethyl acetate (96/4 v/v) as an eluent.

Procedure for C-4 Tosylation of 3a.[5a]Compound **3a** (0.1 mmol, 34.1 mg), K_2CO_3 (28 mg, 0.2 mmol), $Cu(OAc)_2•H_2O$ (4.0 mg, 0.02 mmol) and TsCl (0.3 mmol, 58 mg) were stirred in 1,2-dichloroethane (1 mL) at 80 °C under air for 16 h. Progress of the reaction was monitored by TLC using ethyl acetate and hexane. After completion, the reaction mixture was cooled to room temperature, diluted with ethyl acetate (50 mL). The organic solution was washed with brine (10 mL) and water (5 mL). Drying (Na_2SO_4) and evaporation of the solvent gave a residue that was purified on silica gel column chromatography using ethyl acetate/hexane as an eluent.

Procedure for C-4 Acetoxylation of 3a.[5a] Compound **3a** (0.1 mmol, 34.1 mg), $Cu(OAc)_2•H_2O$ (0.02 mmol, 4.0 mg) and $PhI(OAc)_2$ (0.2 mmol, 64.4 mg) were stirred in AcOH (1 mL) at 80 °C under air for 6 h. Progress of the reaction was monitored by TLC using ethyl acetate and hexane. After completion, the reaction mixture was cooled to room temperature, diluted with ethyl acetate (50 mL), washed with saturated $Na_2S_2O_3$ (2 × 10 mL), brine (10 mL) and water (5 mL). Drying (Na_2SO_4) and evaporation of the solvent gave a residue that was purified on silica gel column chromatography using ethyl acetate/hexane as eluent.

Procedure for C-2 Amination of 3a.[5b] Compound **3a** (0.1 mmol, 34.1 mg), morpholine (0.2 mmol, 175 mg), $Cu(OAc)_2•H_2O$ (0.01 mmol, 2.0 mg), $PhI(OAc)_2$ (64.4 mg, 0.2 mmol) and $MgCl_2$ (20 mol %, 0.02 mmol, 2 mg) were stirred in 2 mL 1,4-dioxane at room temperature

under nitrogen atmosphere for 8 h. Progress of the reaction was monitored by TLC using ethyl acetate and hexane. After completion, the reaction mixture was cooled to room temperature, diluted with ethyl acetate (45 mL), washed with saturated $Na_2S_2O_3$ (2 × 10 mL), brine (2 × 10 mL) and water (1 x 5 mL). Drying (Na_2SO_4) and evaporation of the solvent gave a residue that was purified on silica gel column chromatography using ethyl acetate/hexane as eluent.

References

1. (a) R. Odani, K. Hirano, T. Satoh and M. Miura, *J. Org. Chem*., 2013, **78**, 11045; (b) R. Shang, L. Ilies and E. Nakamura, *J. Am. Chem. Soc*., 2015, **137**, 7660. c) A. M. Martìnez, N. Rodrıguez, R. G. Arraýs and J. C. Carretero, *Chem. Commun*., 2014, **50**, 2801.

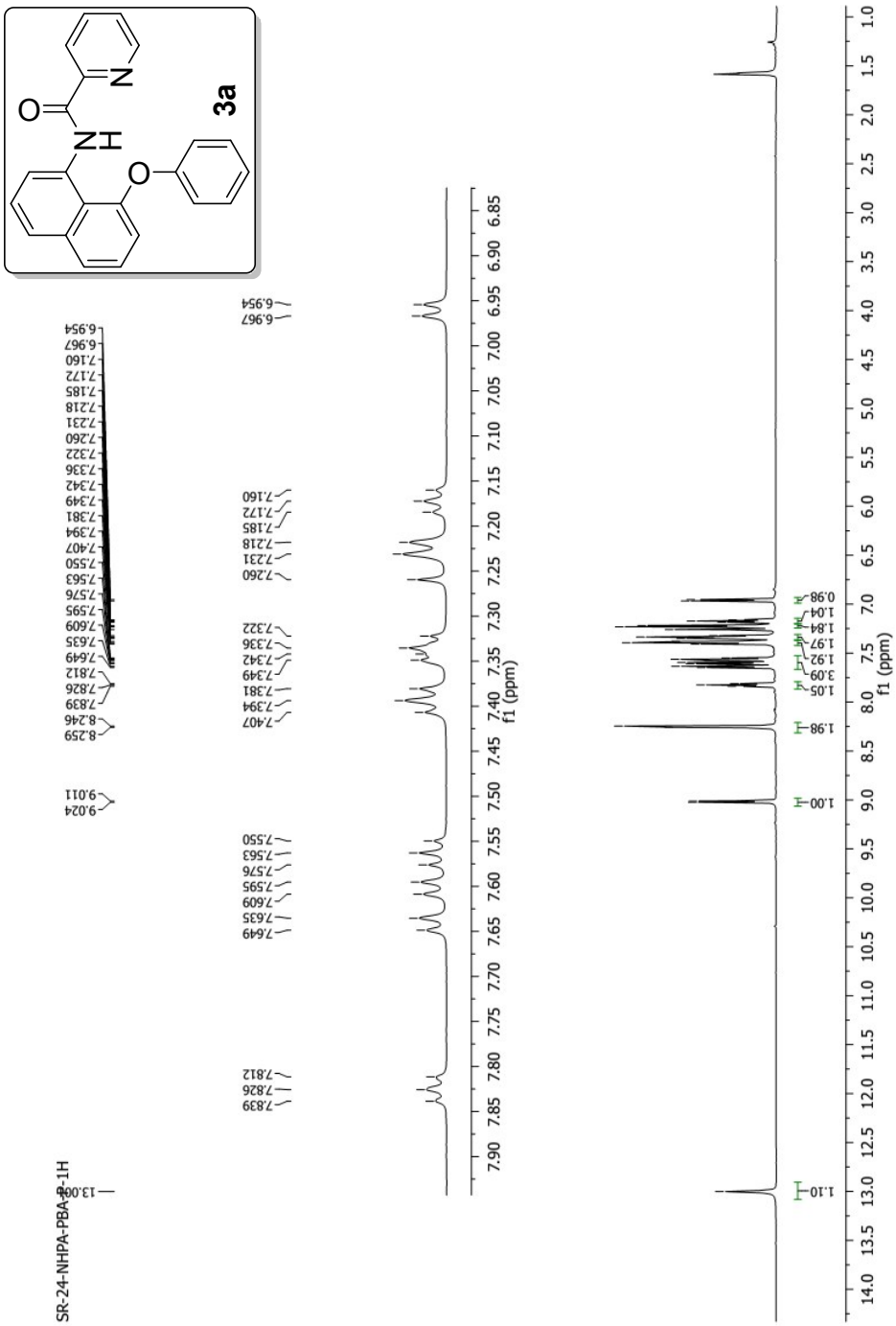
2. a) L. Huang, Q. Li, C. Wang and C. Qi, *J. Org. Chem*., 2013, **78**, 3030; (b) S. Pradhan and P. B. De, T. Punniyamurthy, *J. Org. Chem*., 2017, **82**, 4883.

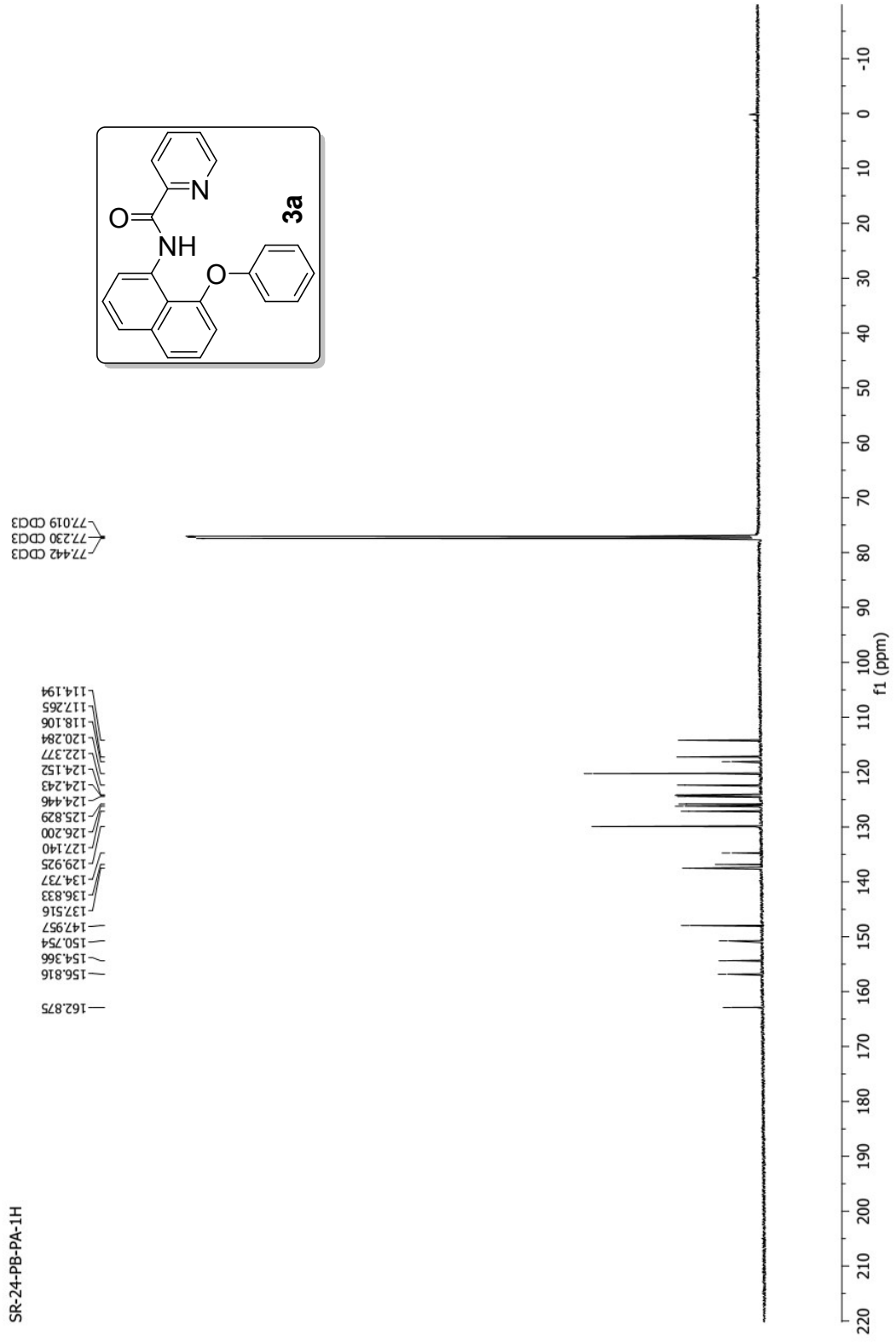
3. J. Zhang, H. Chen, B. Wang, Z. Liu and Y. Zhang, *Org. Lett*., 2015, **17**, 2768.

4. E. T. Nadres, G. I. F. Santos, D. Shabashov and O. Daugulis, *J. Org. Chem*., 2013, **78**, 9689.

5. (a) J.-M. Li, Y.-H. Wang, Y. Yu, R.-B. Wu, J. Weng and G. Lu, *ACS Catal*., 2017, **7**, 2661; (b) Q. Li, S.-Y. Zhang, G. He, Z. Ai, W. A. Nack and G. Chen, *Org. Lett*. 2014, **16**, 1764.

NMR (^{1}H and ^{13}C) Spectra

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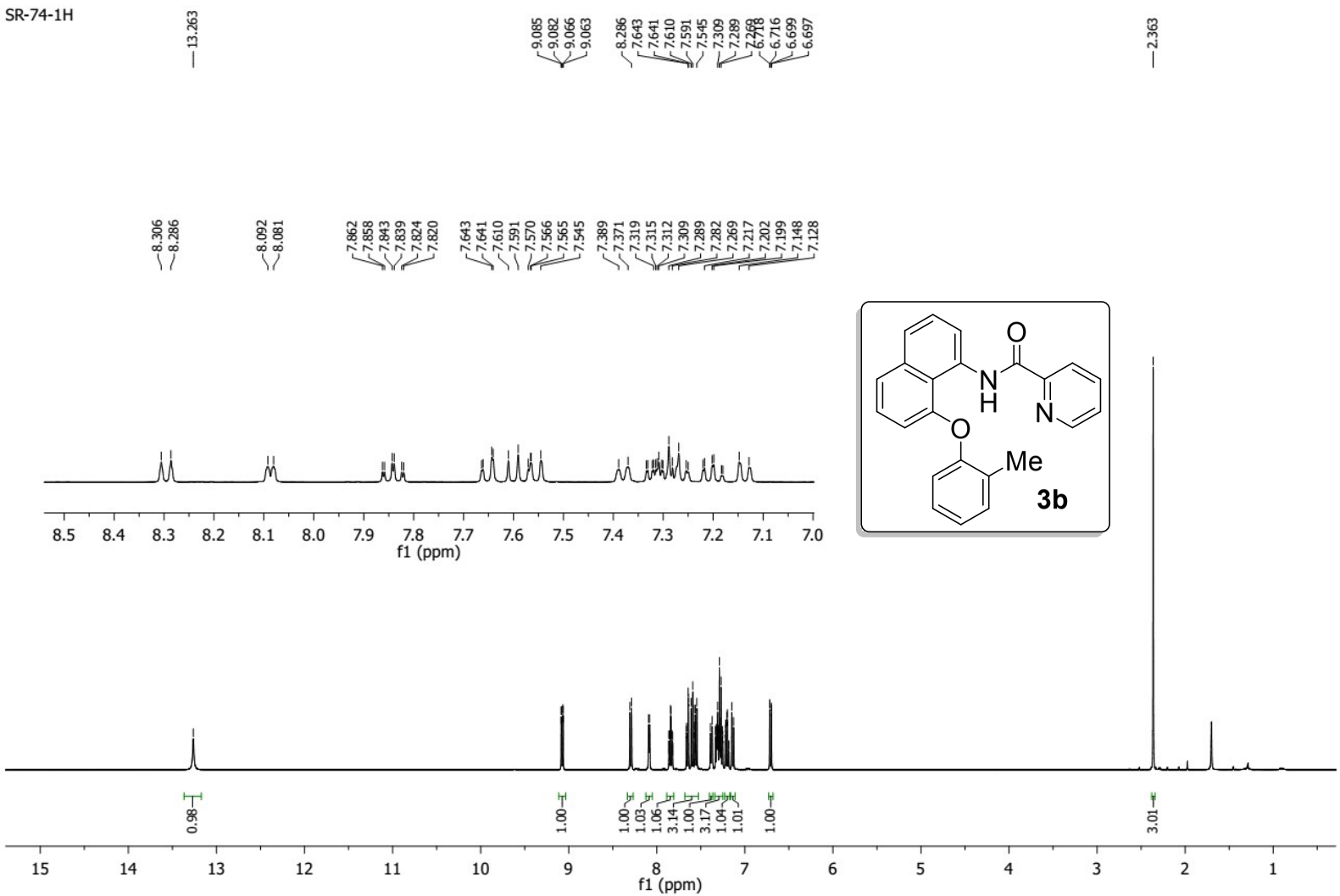
77.442 CDCl3
77.230 CDCl3
77.019 CDCl3
f1 (ppm)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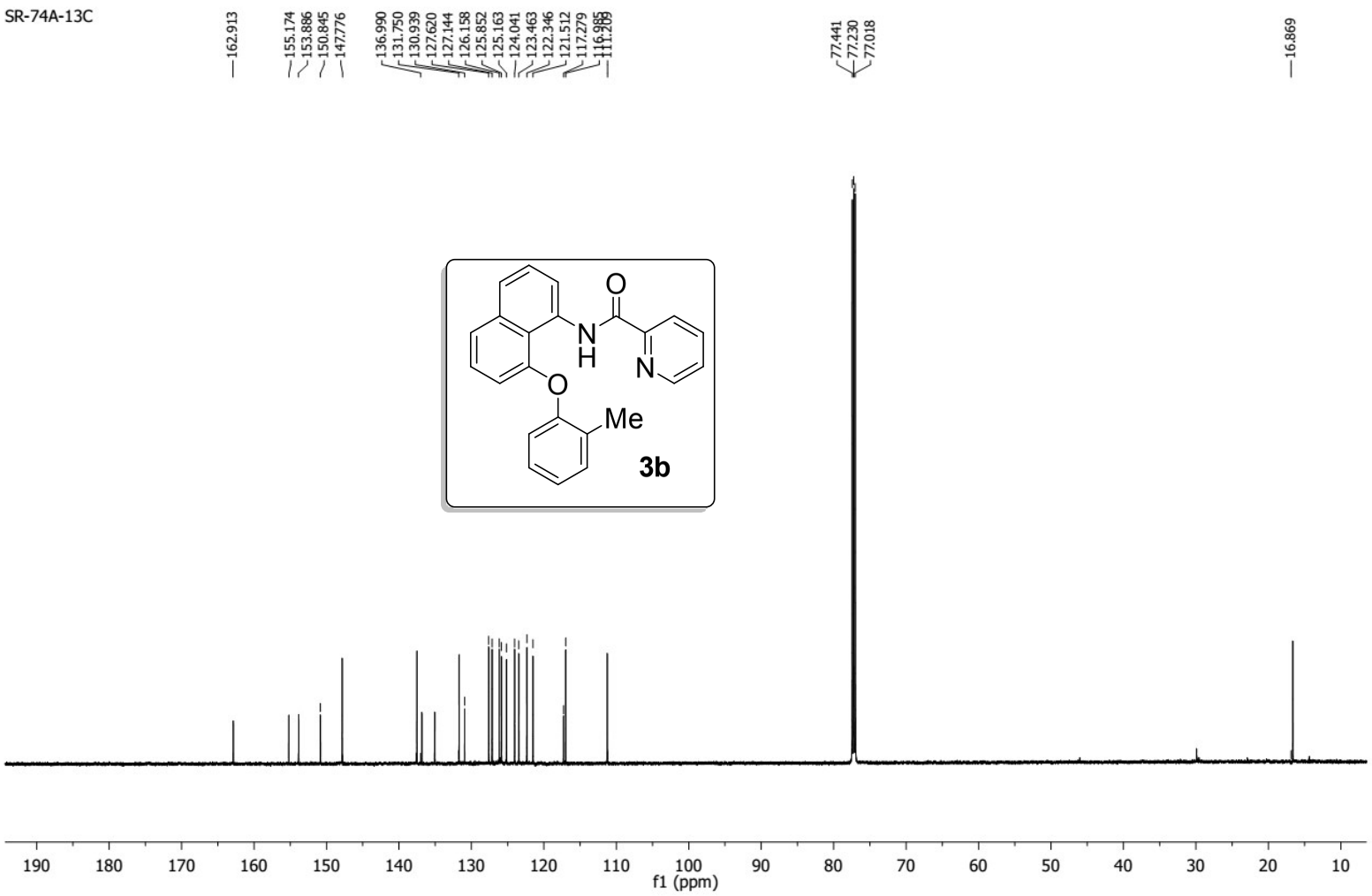
Me
3b
f1 (ppm)
f1 (ppm)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O
N
H
N
O
Me
3b
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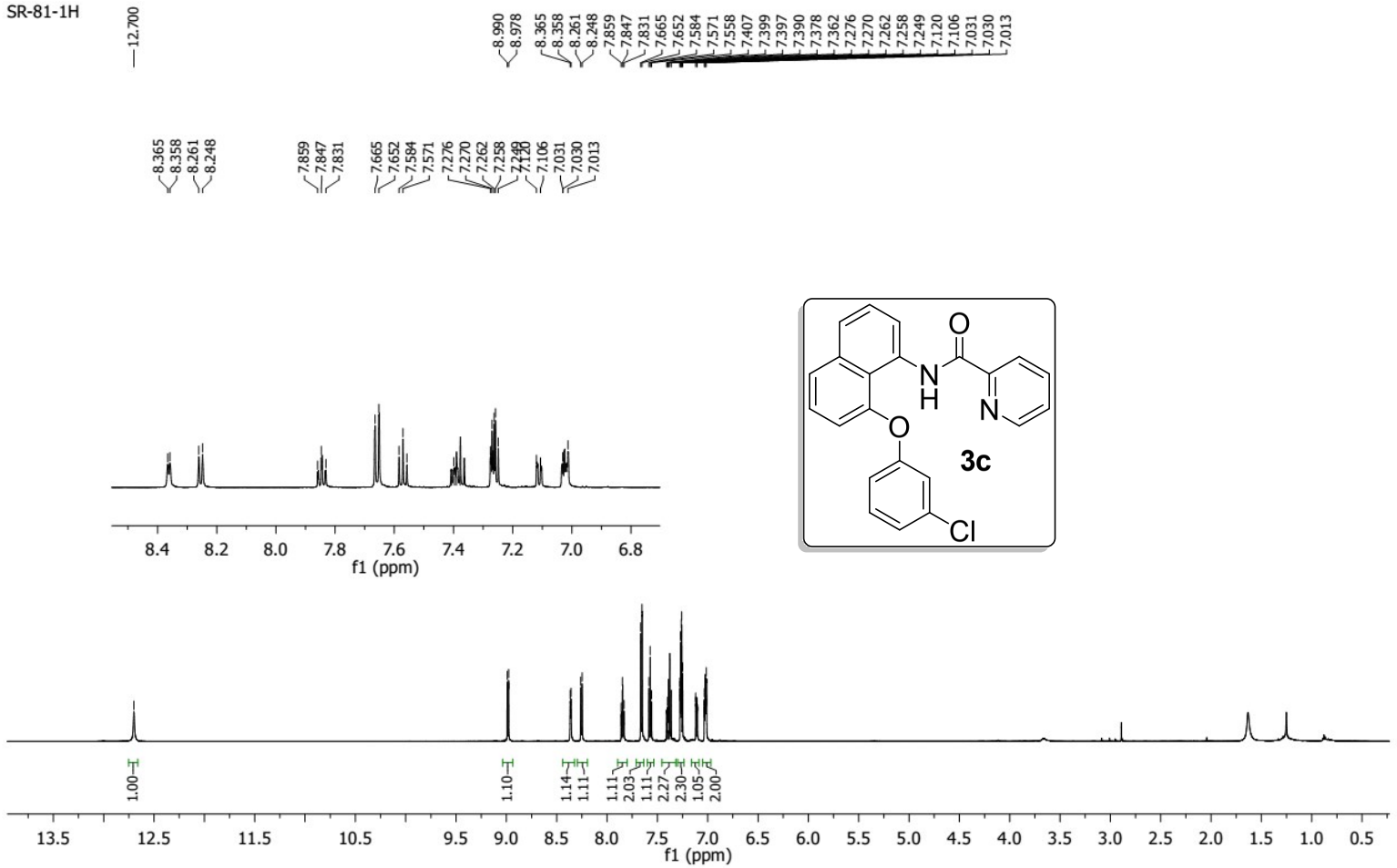
f1 (ppm)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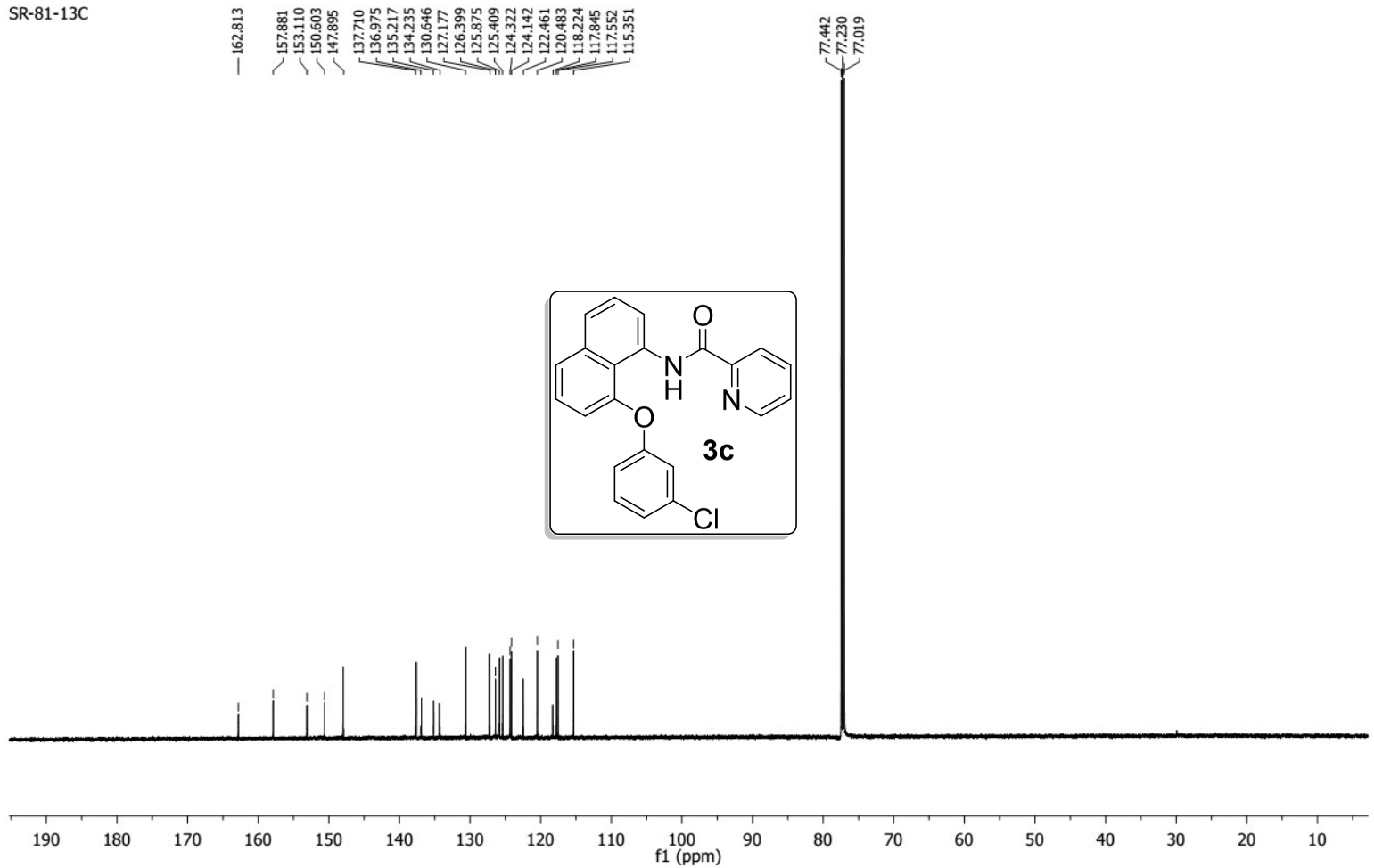
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f1 (ppm)

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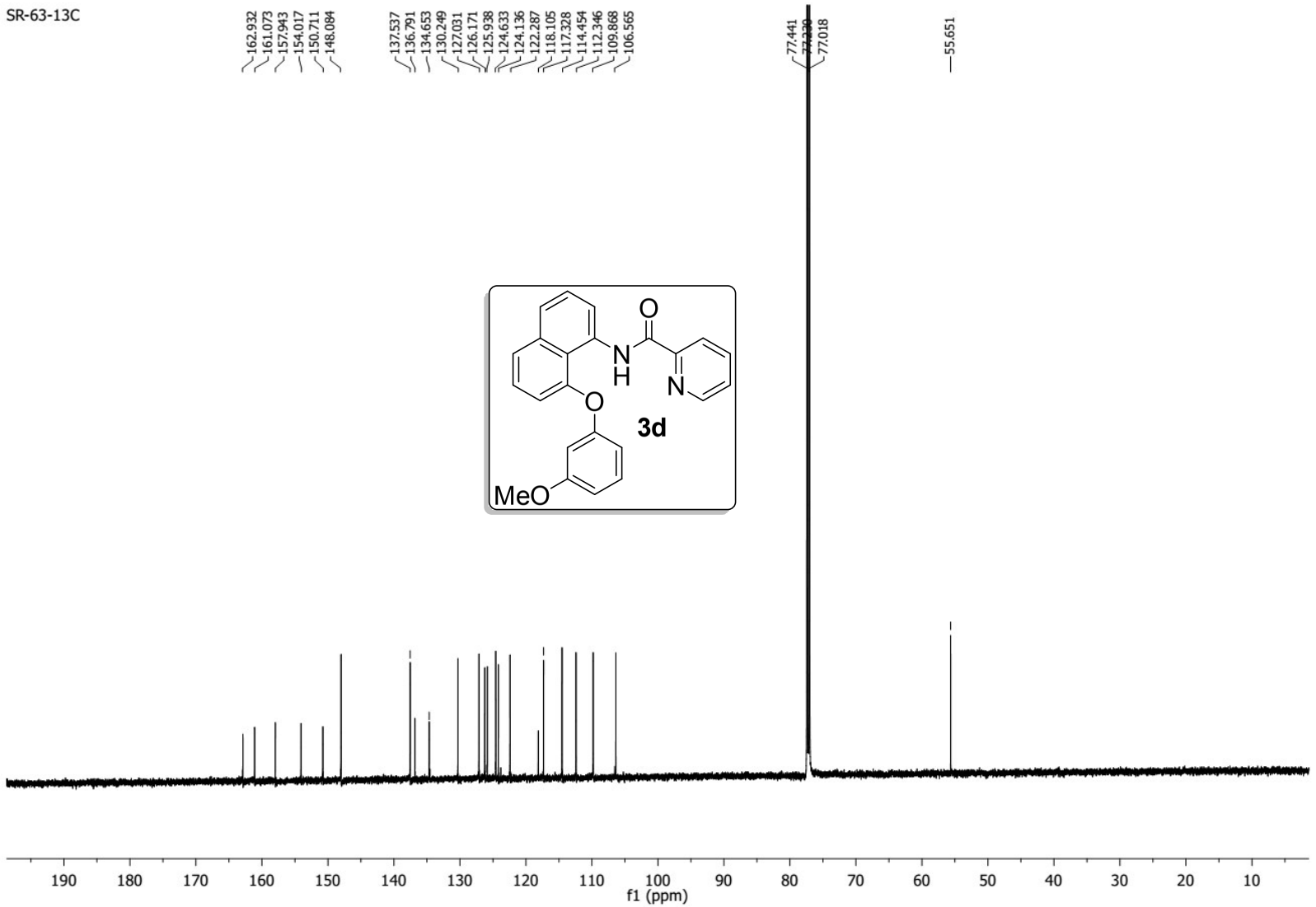
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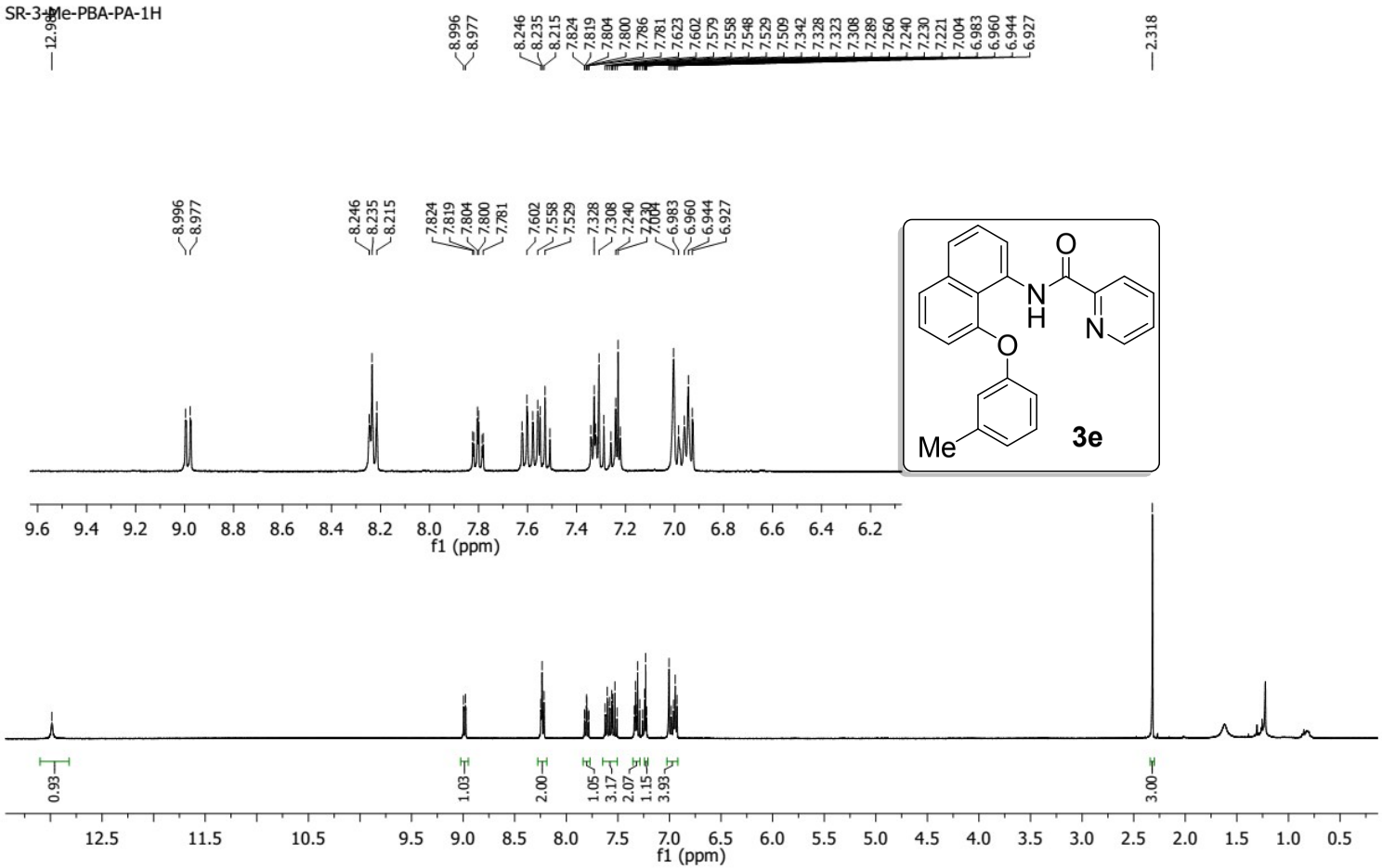
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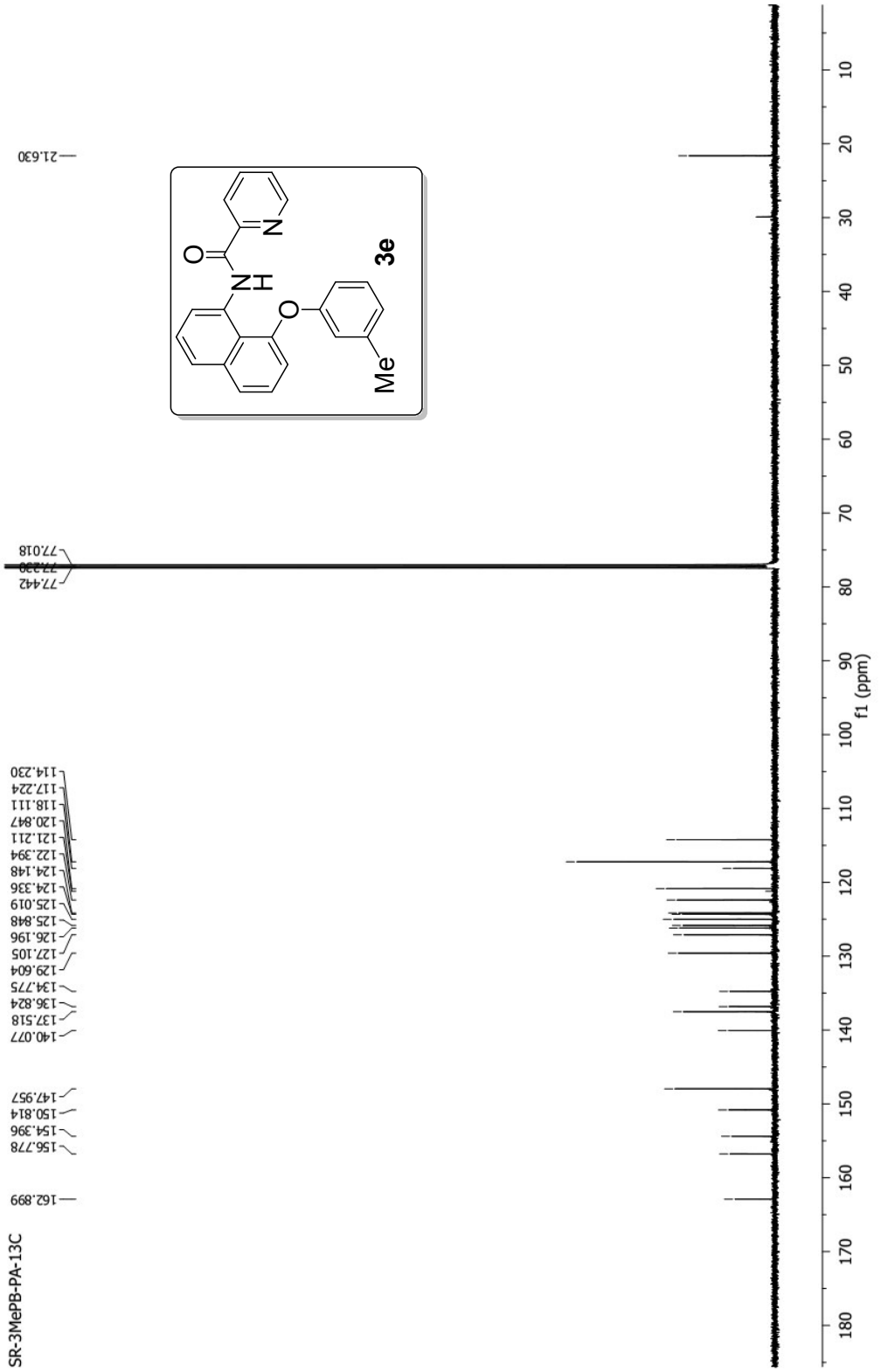
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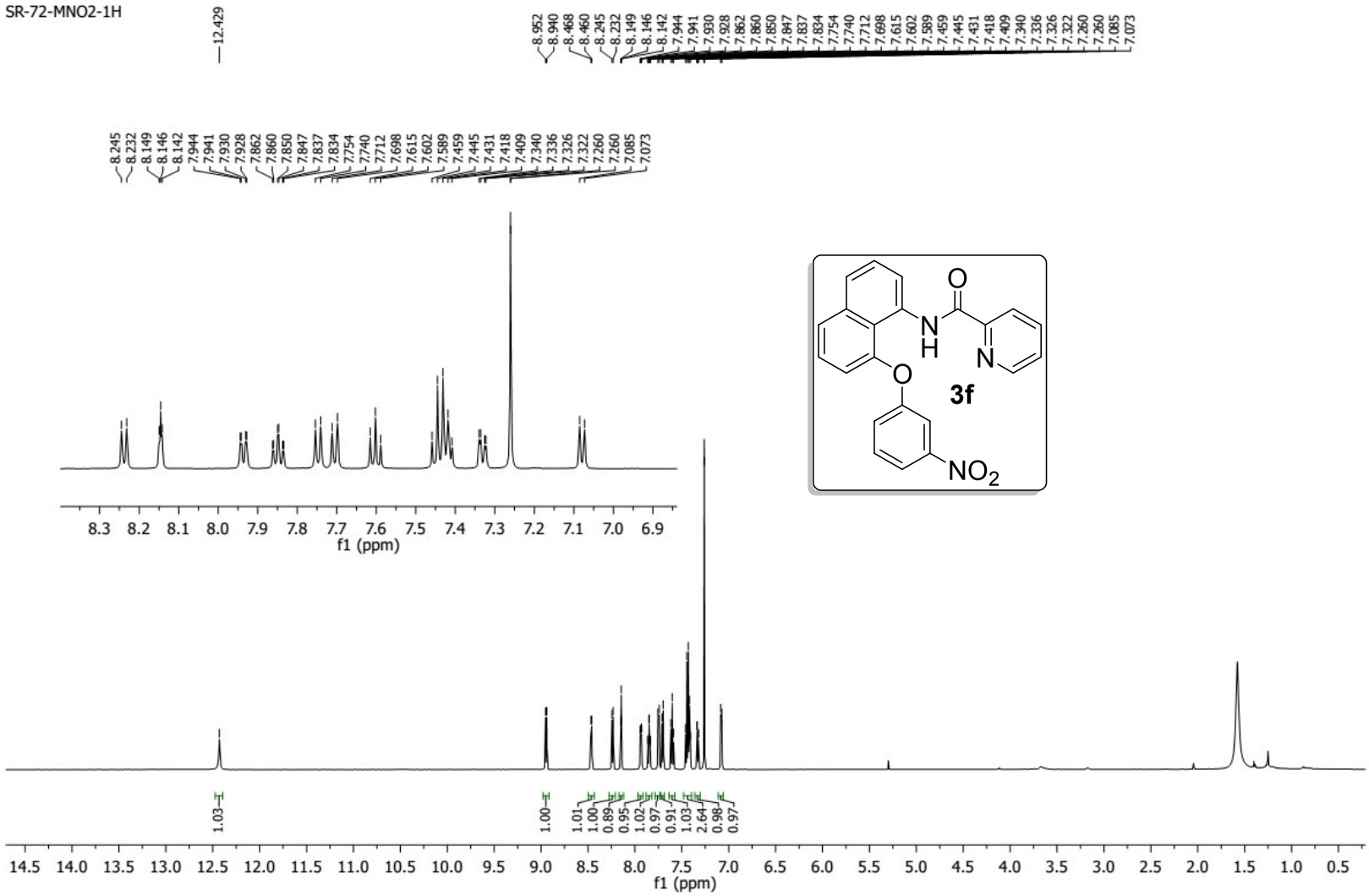
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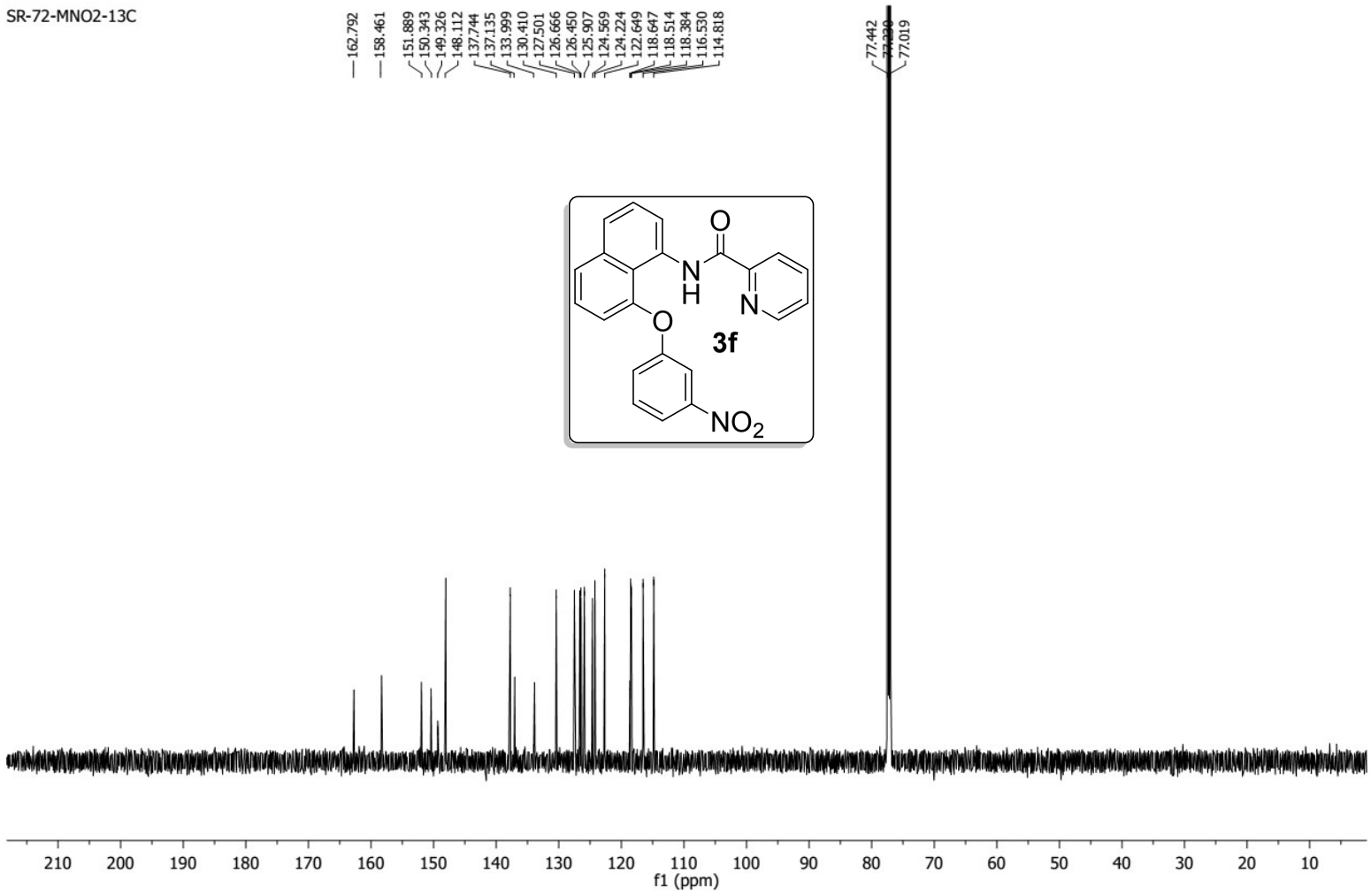
f1 (ppm)
f1 (ppm)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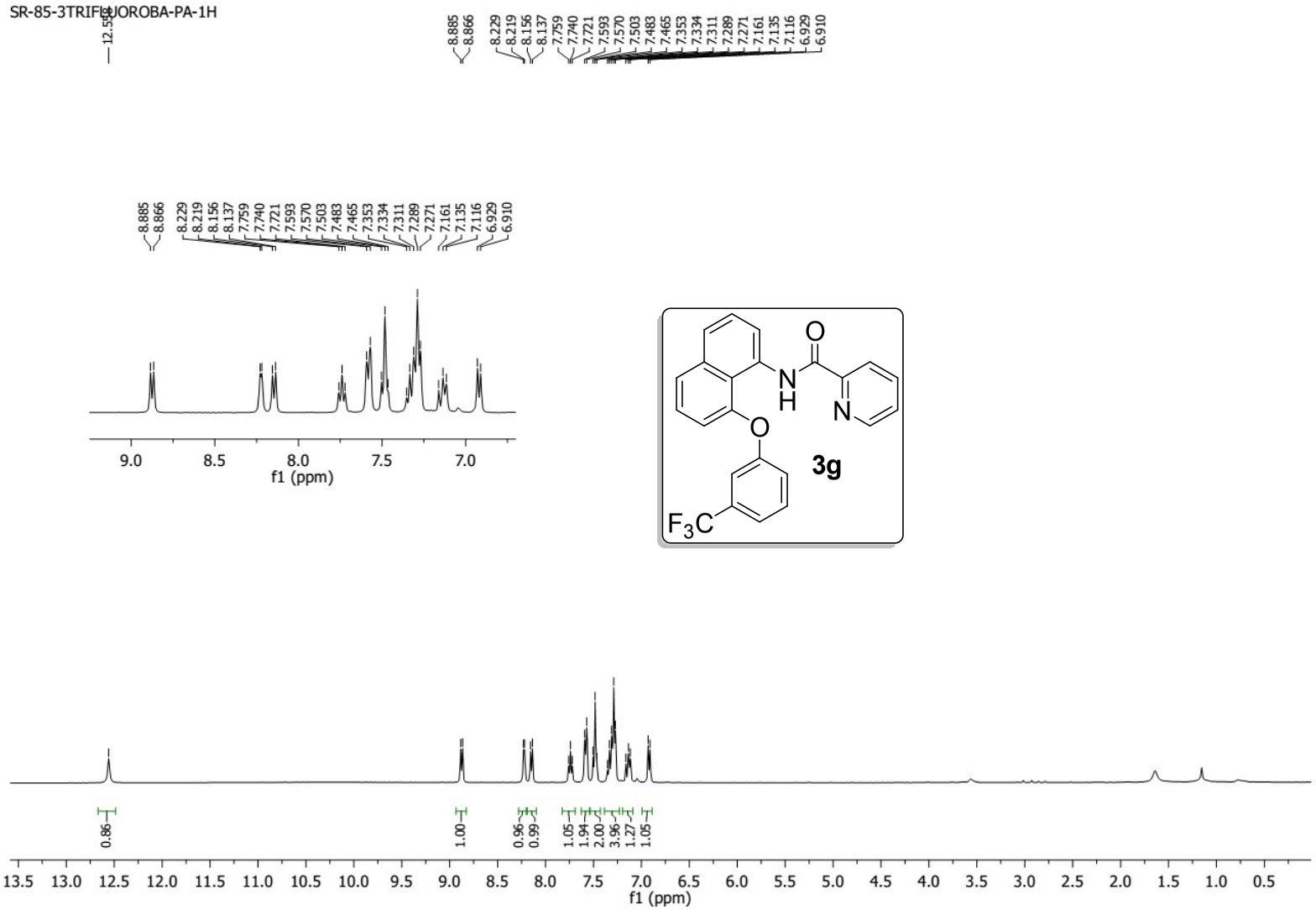
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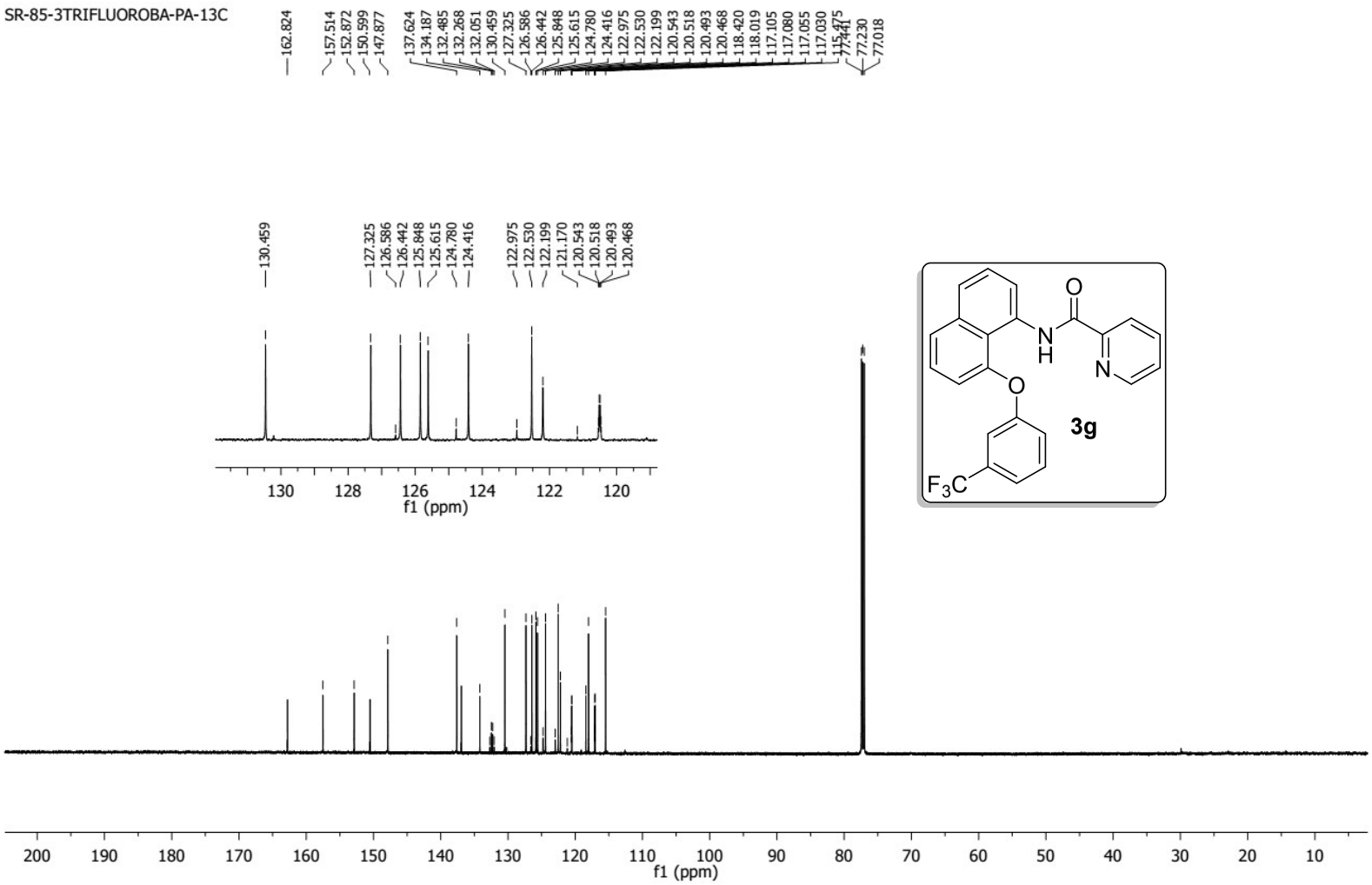
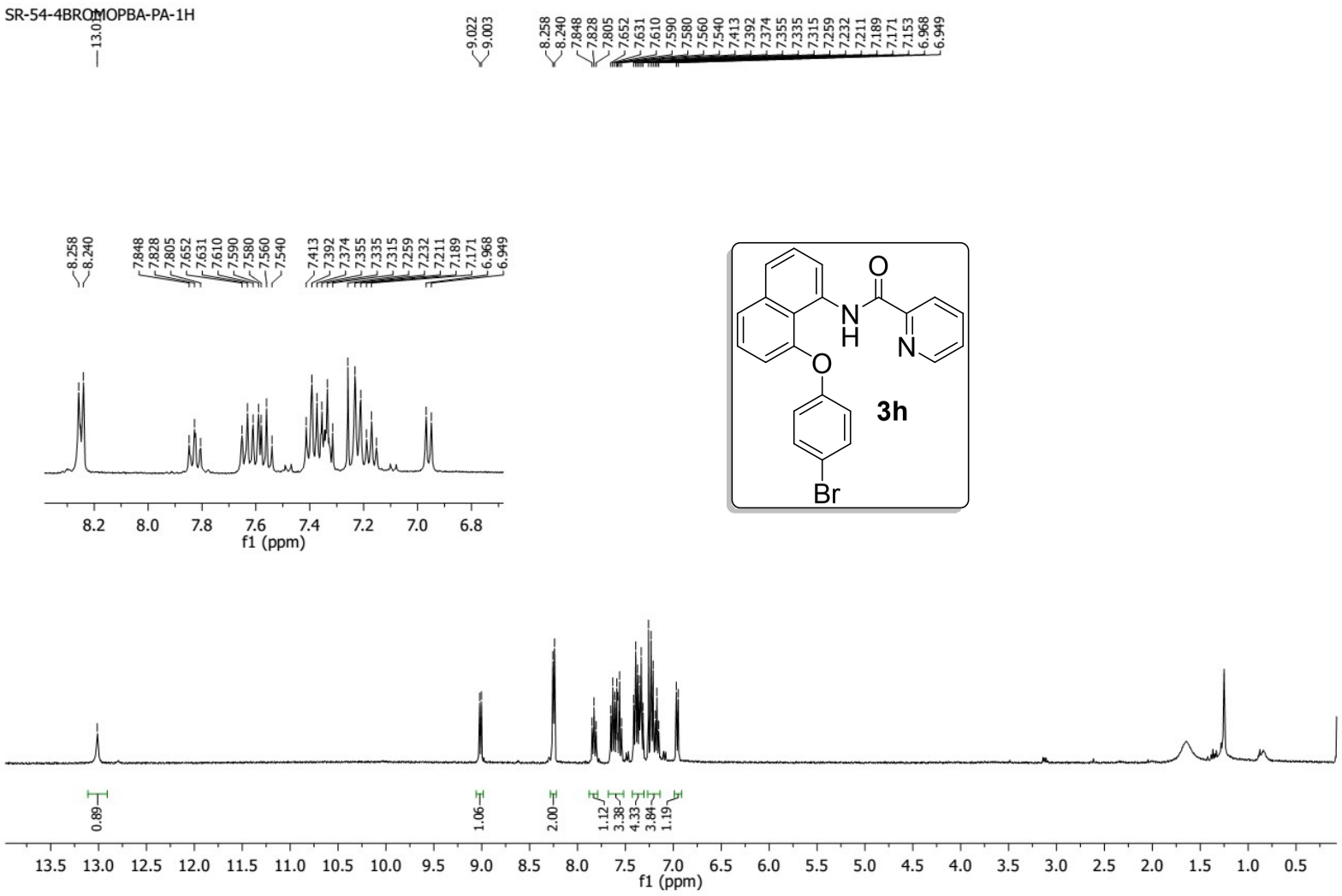
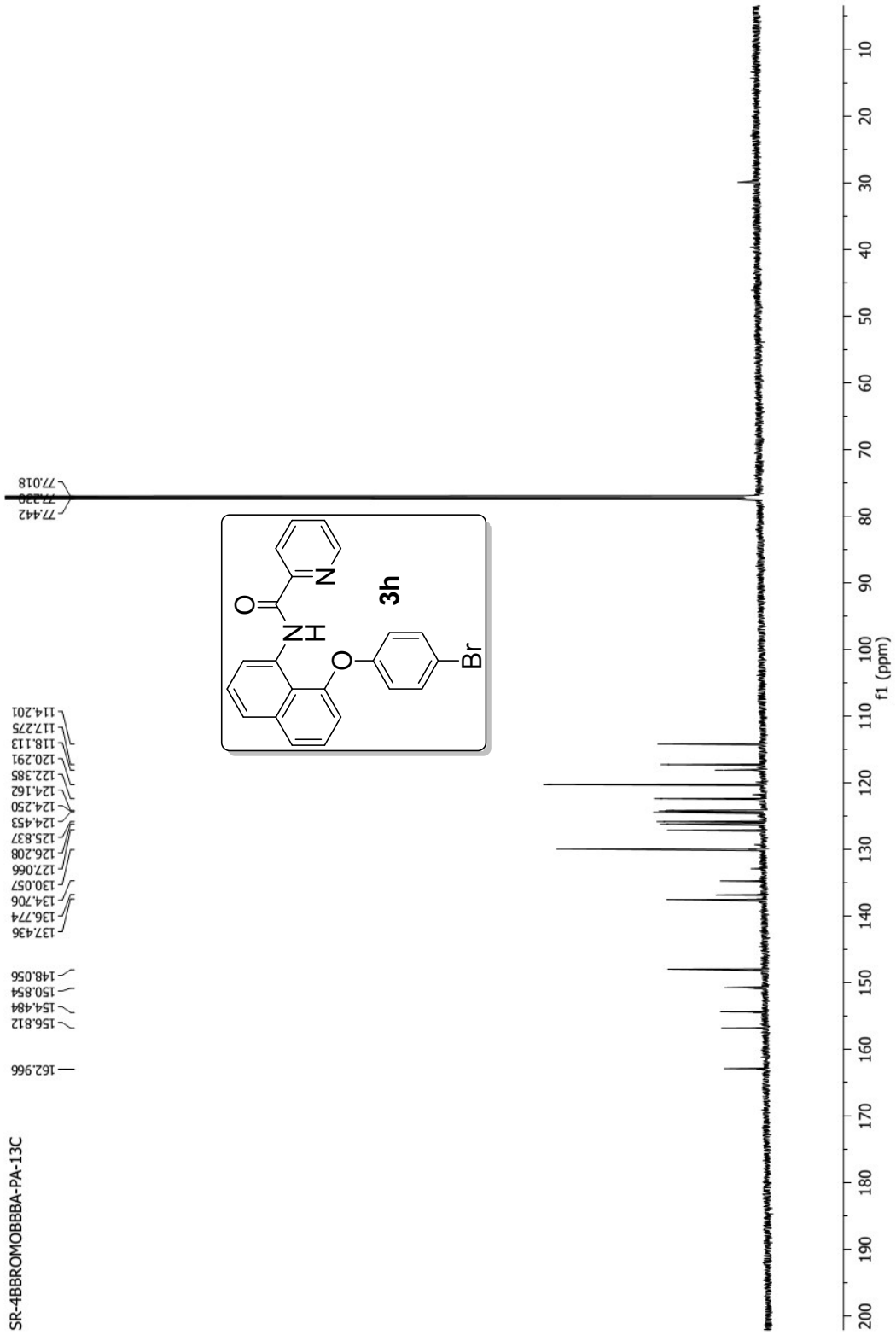
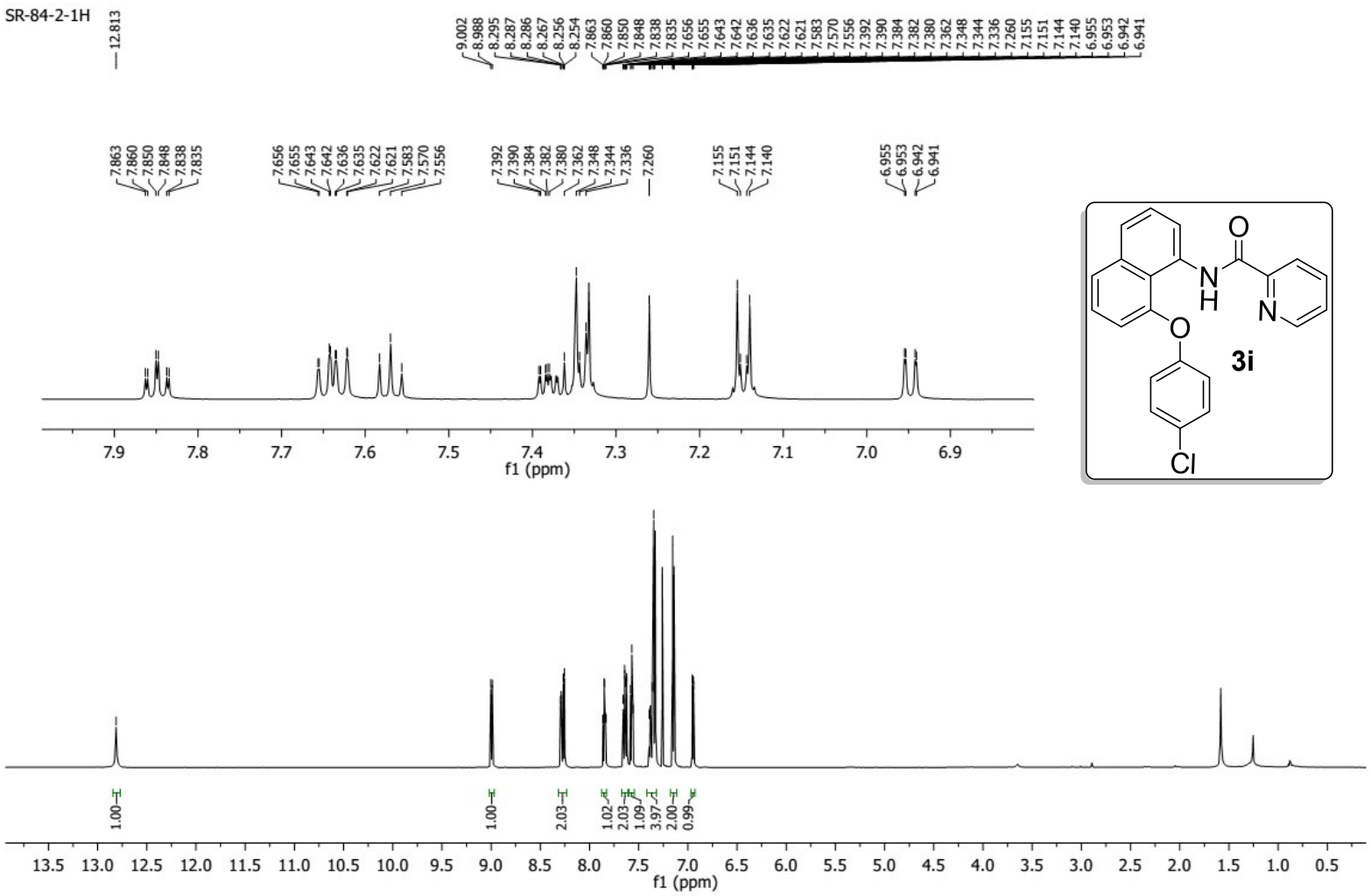
7.334
7.311
7.289
7.271
7.161
7.135
7.116
6.929
6.910
9.0
8.5
8.0
7.5
7.0
f1 (ppm)
O
N
H
N
O
3g
F3C
0.86
1.00
0.96
0.99
1.05
1.94
2.00
3.96
1.27
1.05
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

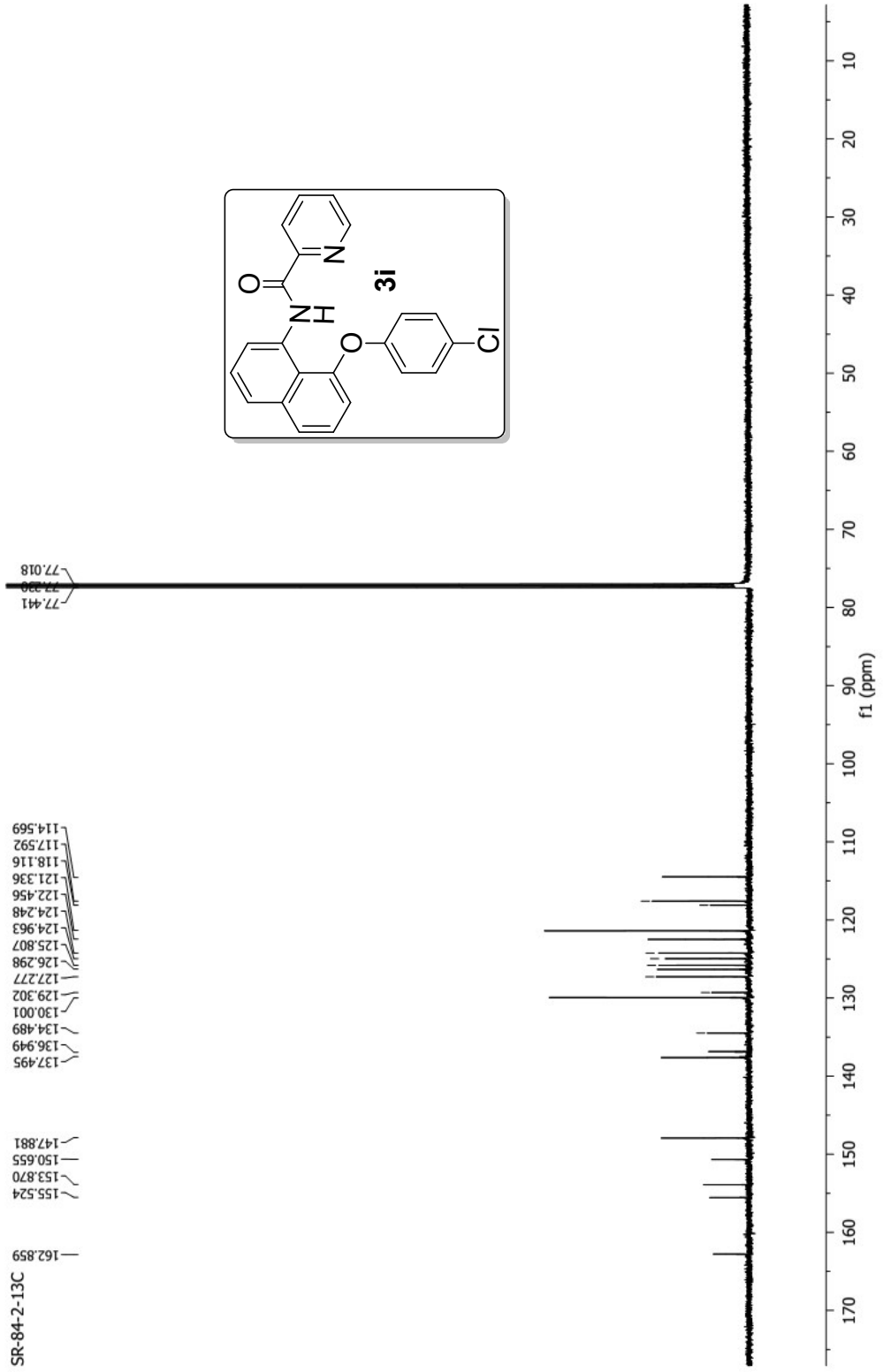
SR-85-3TRIFLUOROBA-PA-13C

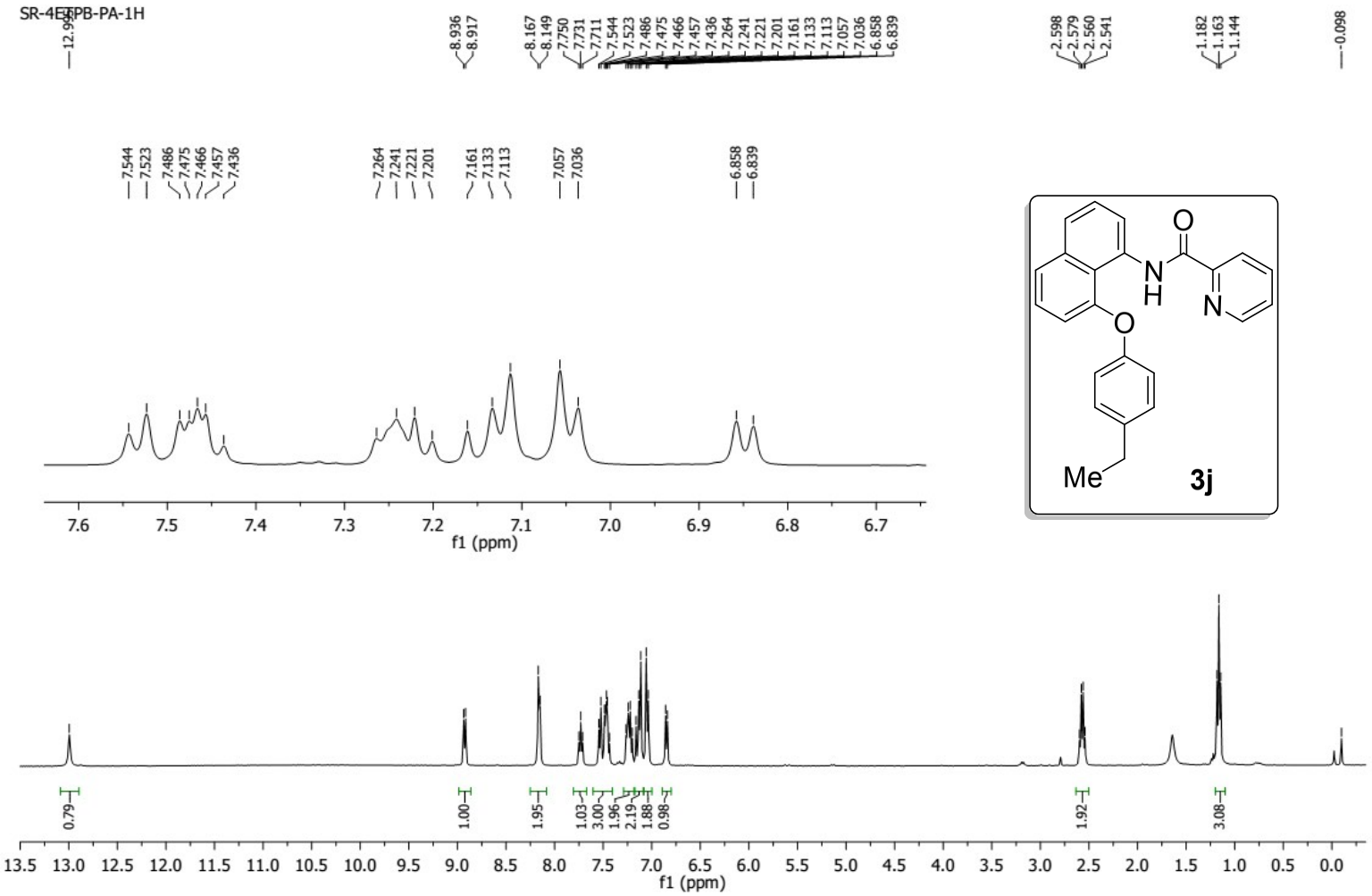


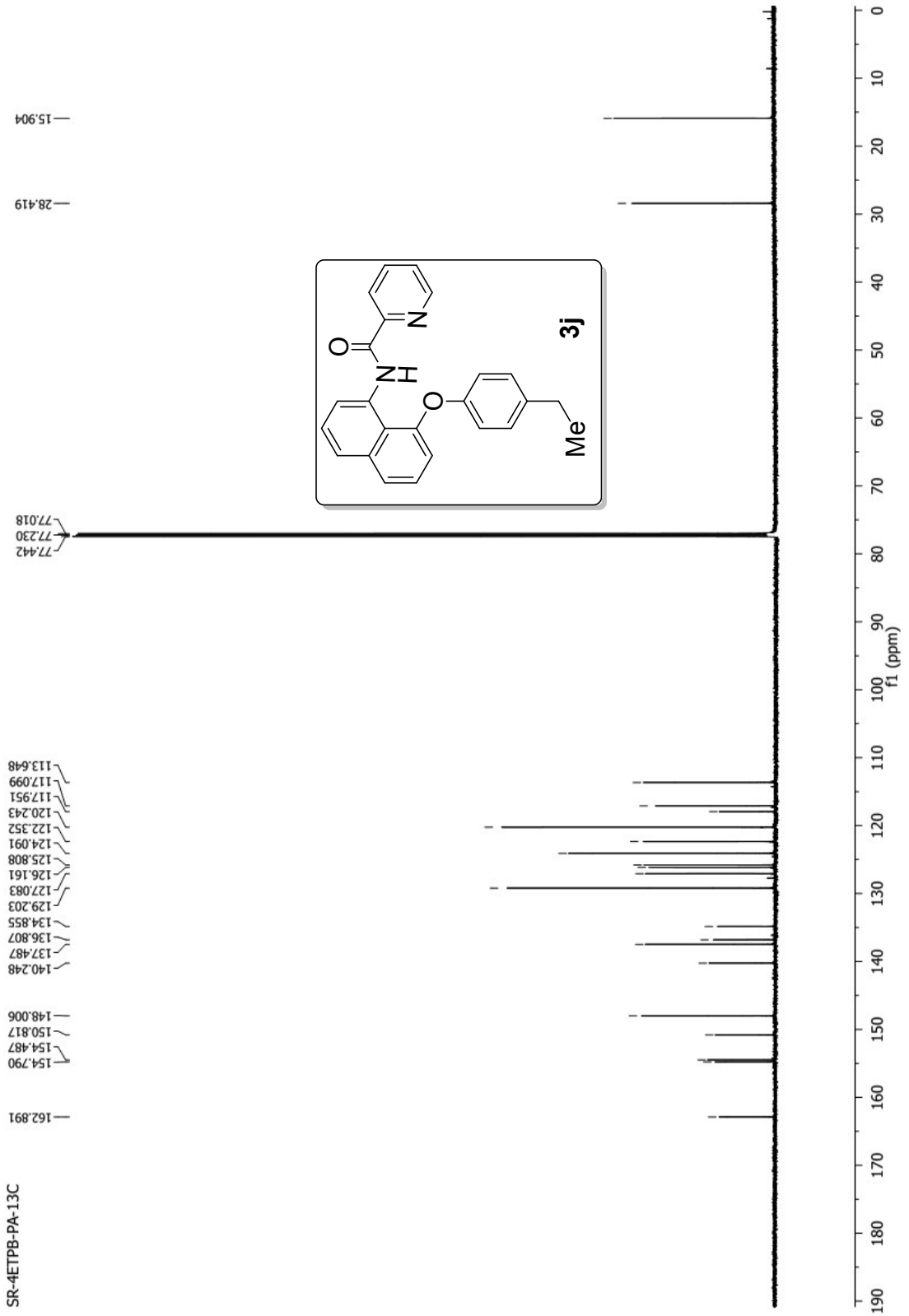

SR-54-4BROMOPBA-PA-1H
13.013
9.022
9.003
8.258
8.240
7.848
7.828
7.805
7.652
7.631
7.610
7.590
7.580
7.560
7.540
7.413
7.392
7.374
7.355
7.335
7.315
7.259
7.232
7.211
7.189
7.171
7.153
6.968
6.949
f1 (ppm)
3h
Br
0.89
1.06
2.00
1.12
3.38
4.33
3.84
1.19
f1 (ppm)

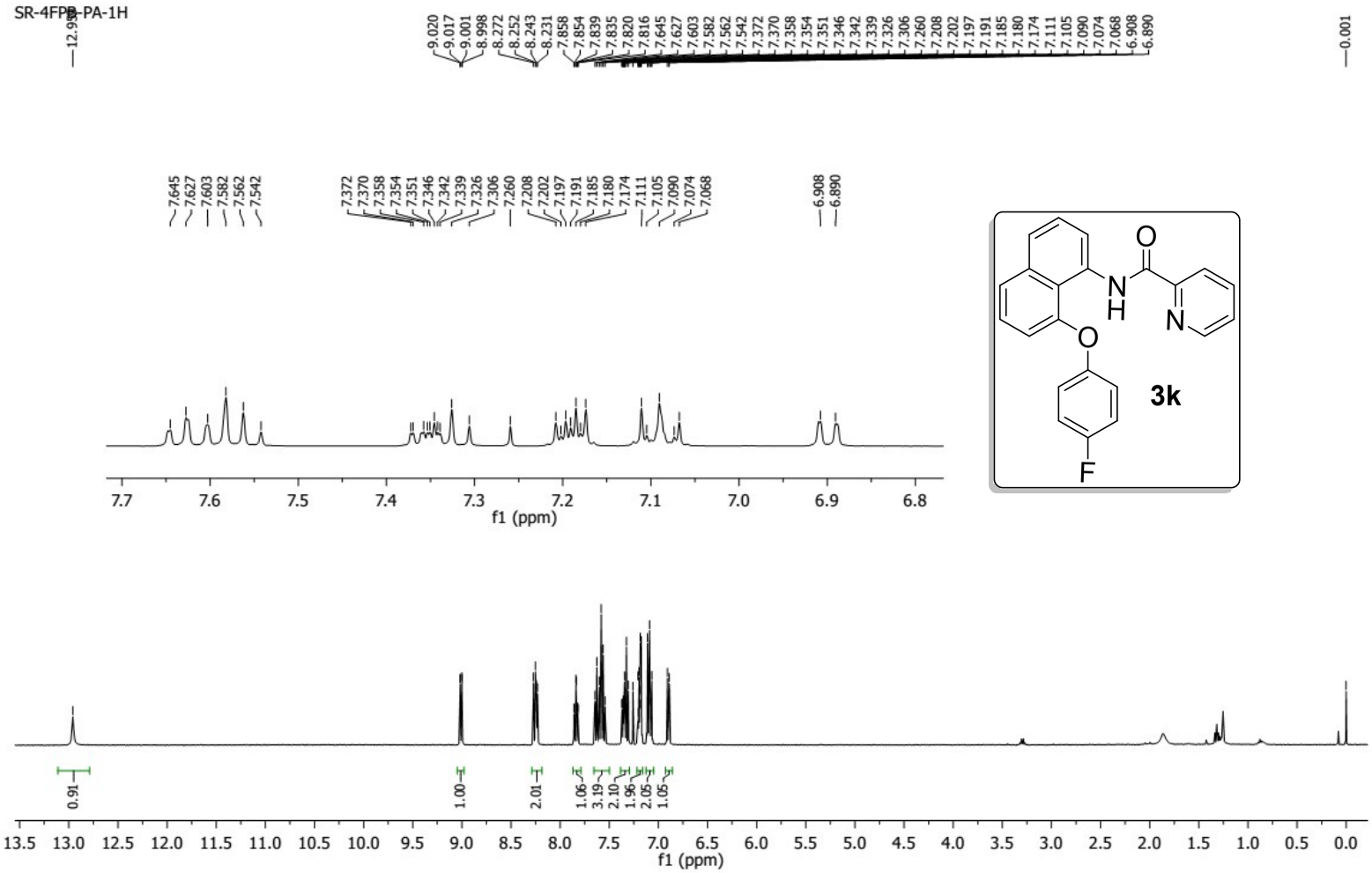

SR-4BBROMOBBBA-PA-13C
162.966
156.812
154.484
150.854
148.056
137.436
136.774
134.706
130.057
127.066
126.208
125.837
124.453
124.250
124.162
122.385
120.291
118.113
117.275
114.201
77.442
77.330
77.018
3h
O
N
H
O
N
Br
f1 (ppm)

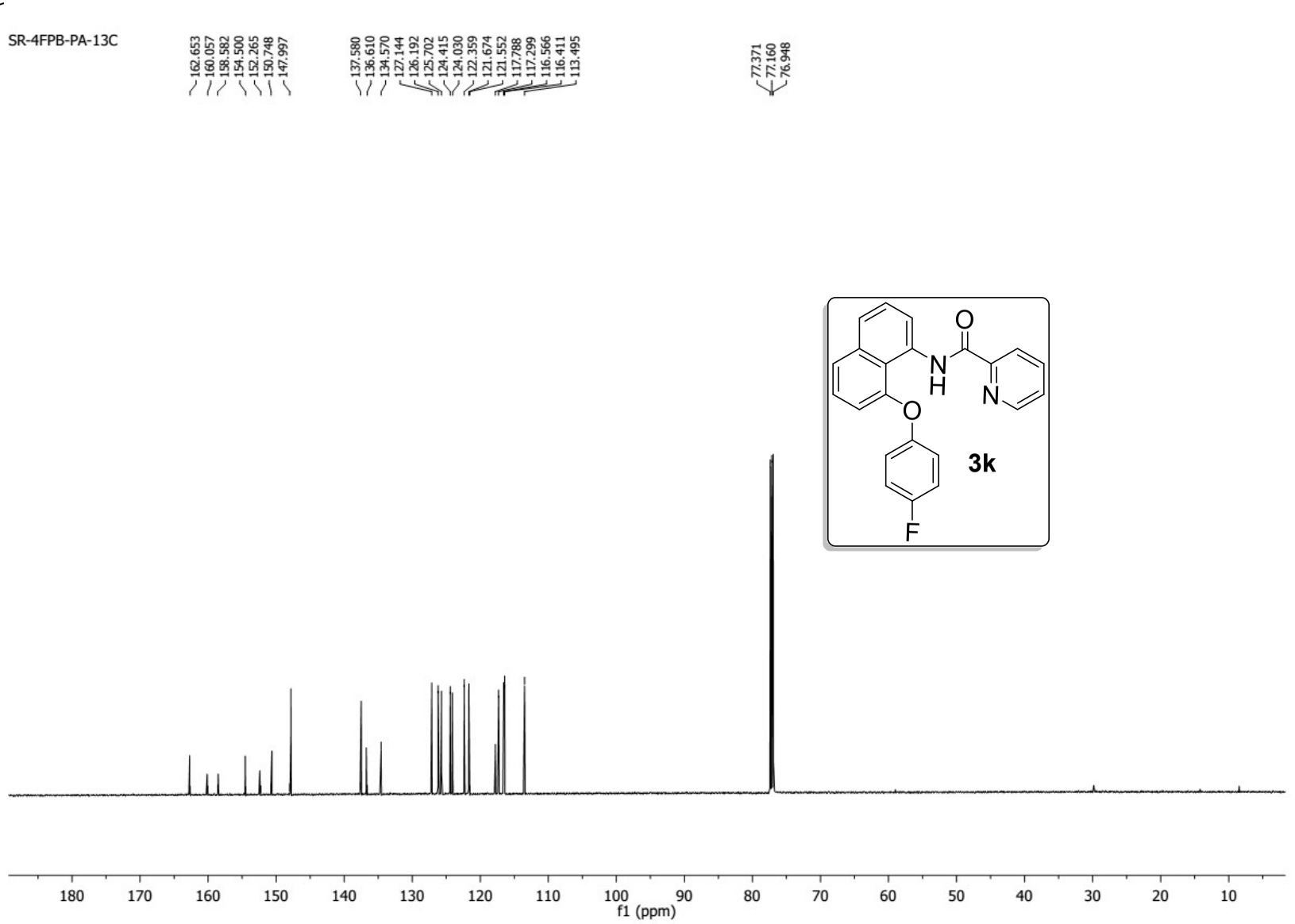

SR-84-2-1H
12.813
9.002
8.988
8.295
8.287
8.286
8.267
8.256
8.254
7.863
7.860
7.850
7.848
7.838
7.835
7.656
7.655
7.643
7.642
7.636
7.635
7.622
7.621
7.583
7.570
7.556
7.392
7.390
7.384
7.382
7.380
7.362
7.348
7.344
7.336
7.260
7.155
7.151
7.144
7.140
6.955
6.953
6.942
6.941
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7.0
6.9
f1 (ppm)
O
N
H
N
O
3i
Cl
1.00
1.00
2.03
1.02
2.03
1.09
3.97
2.00
0.99
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

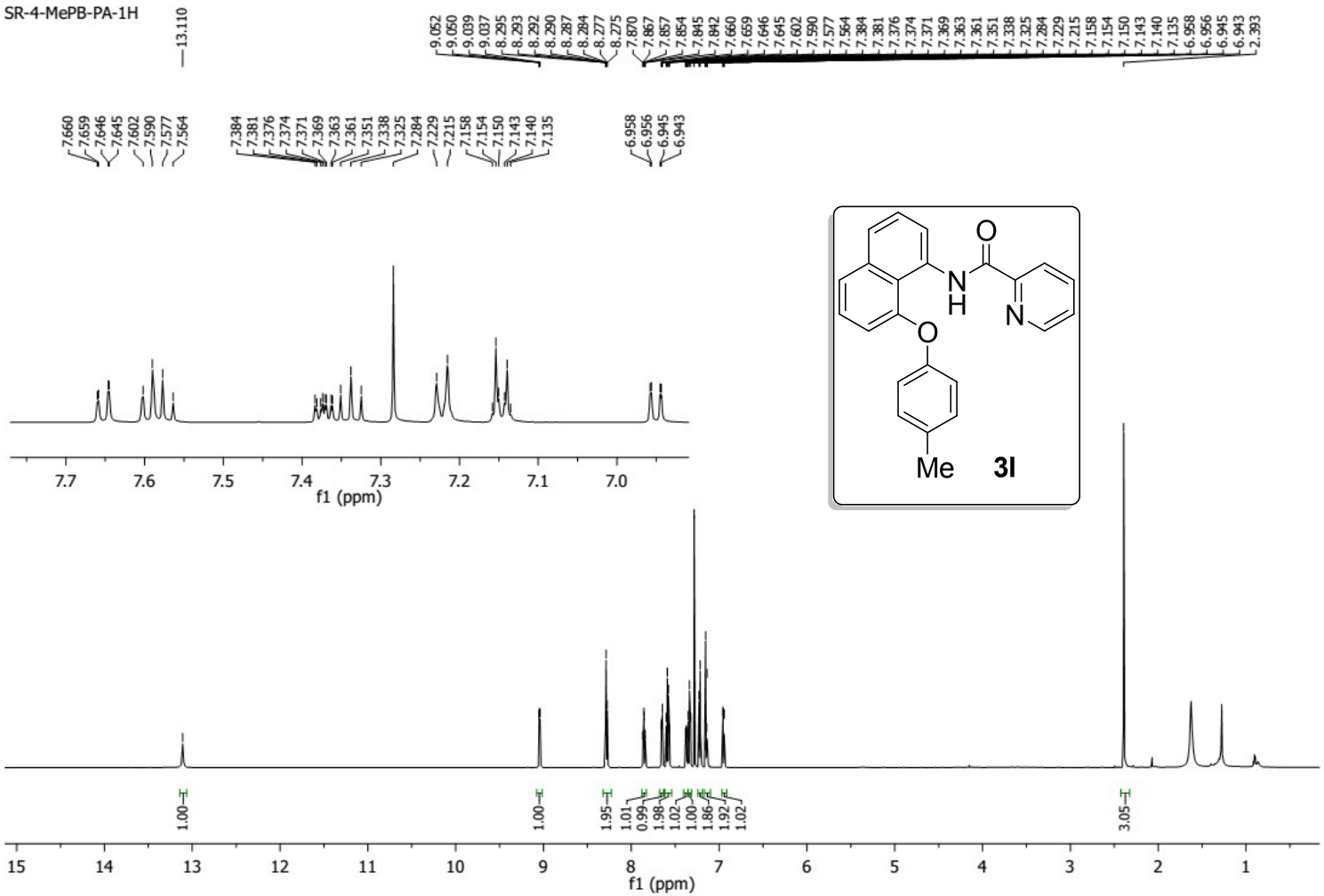

SR-84-2-13C
162.859
155.524
153.870
150.655
147.881
137.495
136.949
134.489
130.001
129.302
127.277
126.298
125.807
124.963
124.248
122.456
121.336
118.116
117.592
114.569
77.441
77.230
77.018
3i
O
N
H
O
Cl
N
f1 (ppm)

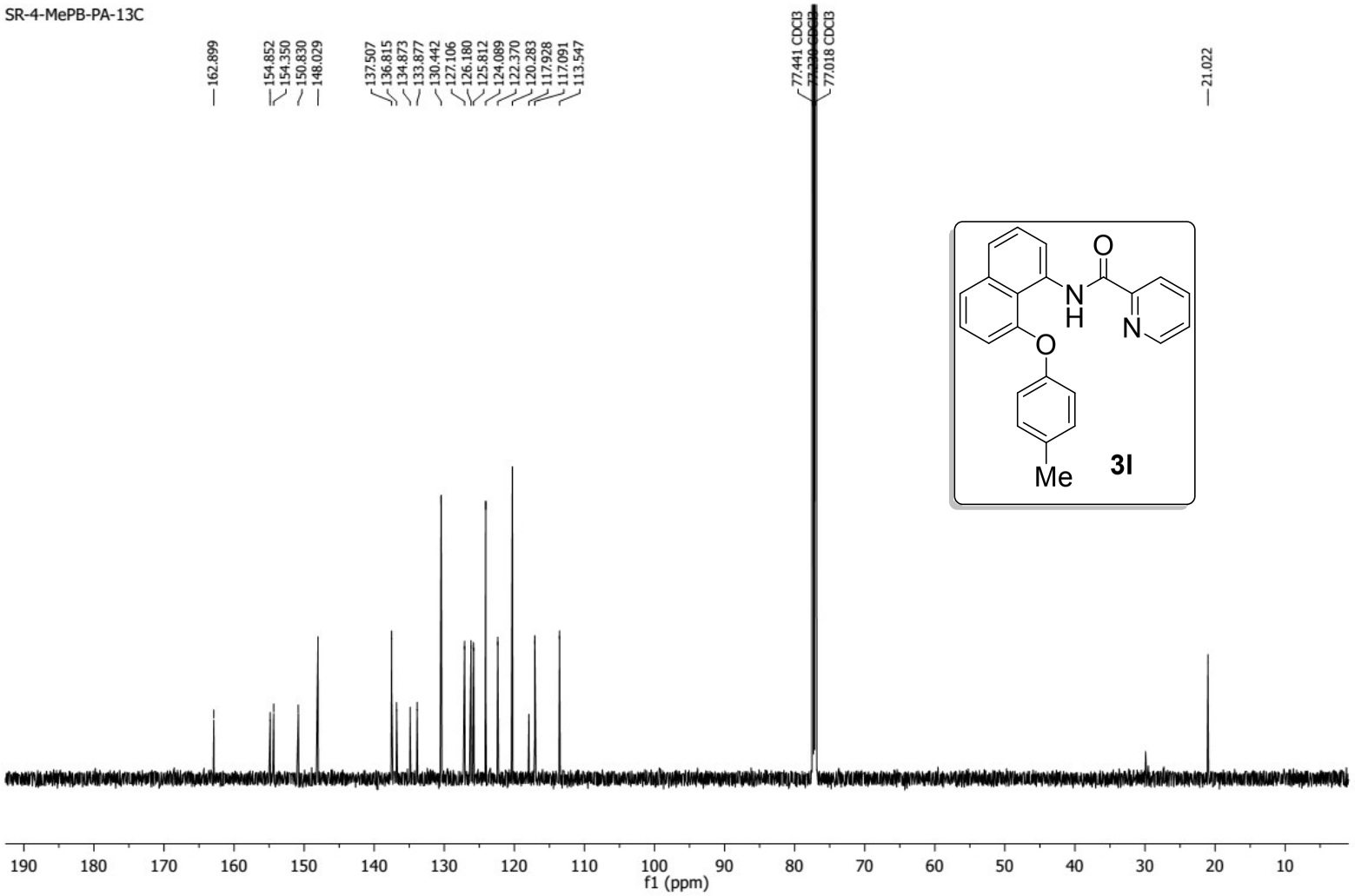

SR-4ETPB-PA-1H
12.992
8.936
8.917
8.167
8.149
7.750
7.731
7.711
7.544
7.523
7.486
7.475
7.466
7.457
7.436
7.264
7.241
7.221
7.201
7.161
7.133
7.113
7.057
7.036
6.858
6.839
2.598
2.579
2.560
2.541
1.182
1.163
1.144
-0.098
f1 (ppm)
0.79
1.00
1.95
1.03
3.00
1.96
2.19
1.88
0.98
1.92
3.08
f1 (ppm)
O
N
H
N
O
Me
3j

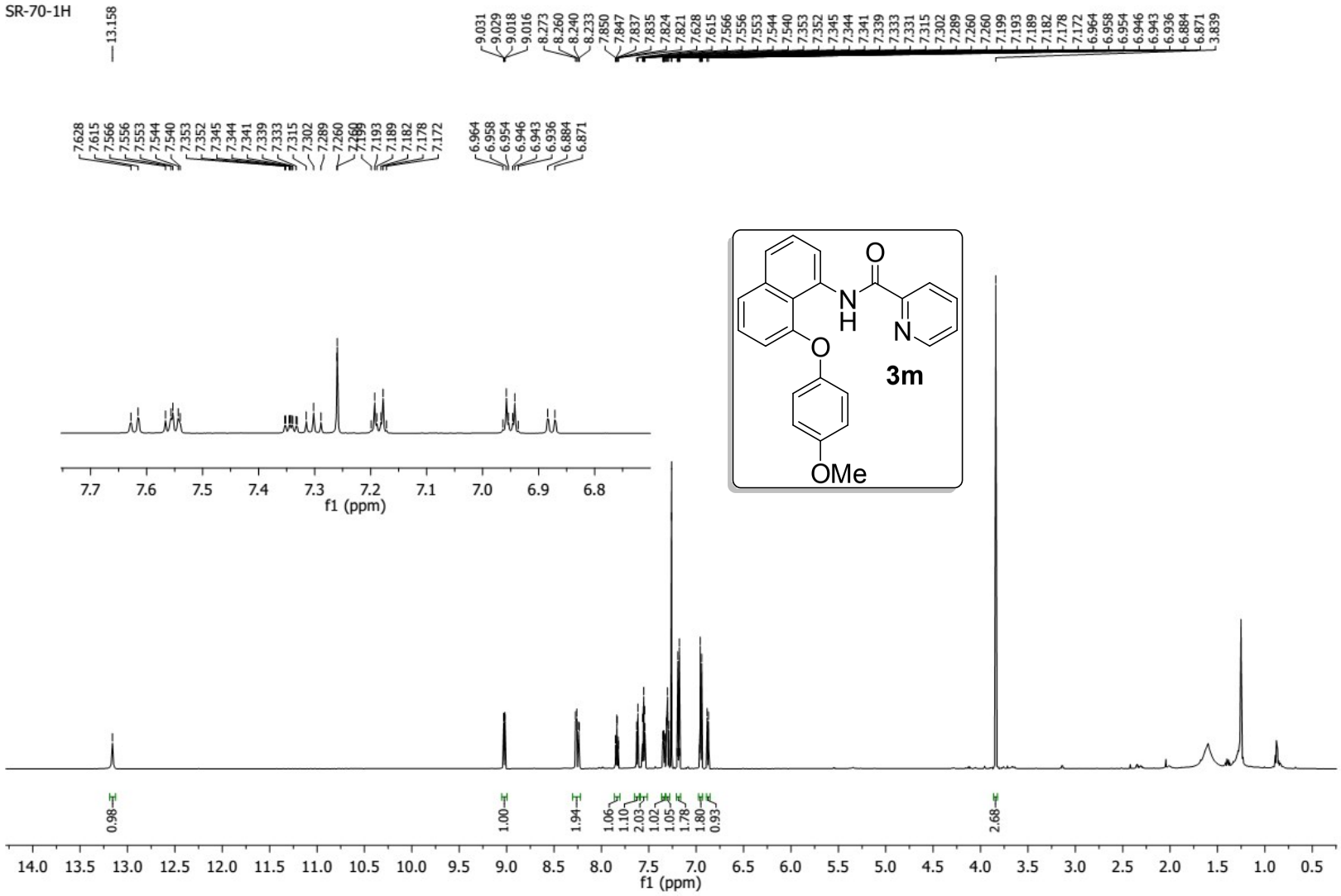

SR-4ETPB-PA-13C
162.891
154.790
154.487
150.817
148.006
140.248
137.487
136.807
134.855
129.203
127.083
126.161
125.808
124.091
122.352
120.243
117.951
117.099
113.648
77.442
77.230
77.018
28.419
15.904
3j
Me
f1 (ppm)

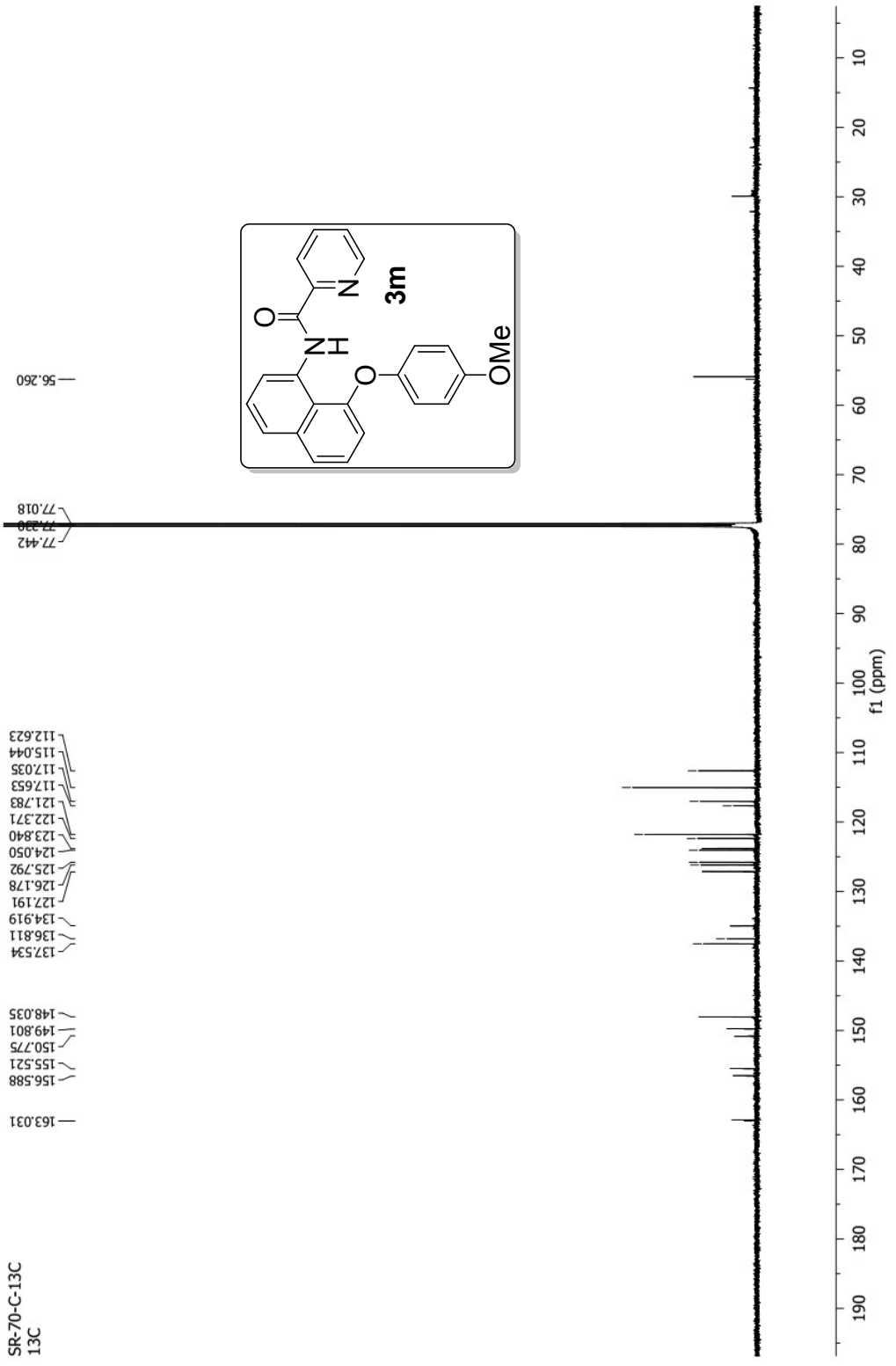

SR-4FPB-PA-1H
12.93
9.020
9.017
9.001
8.998
8.272
8.252
8.243
8.231
7.858
7.854
7.839
7.835
7.820
7.816
7.645
7.627
7.603
7.582
7.562
7.542
7.372
7.370
7.358
7.354
7.351
7.346
7.342
7.339
7.326
7.306
7.260
7.208
7.202
7.197
7.191
7.185
7.180
7.174
7.111
7.105
7.090
7.074
7.068
6.908
6.890
0.001
3k
f1 (ppm)
0.91
1.00
2.01
1.06
3.19
2.10
1.96
2.05
1.05
f1 (ppm)

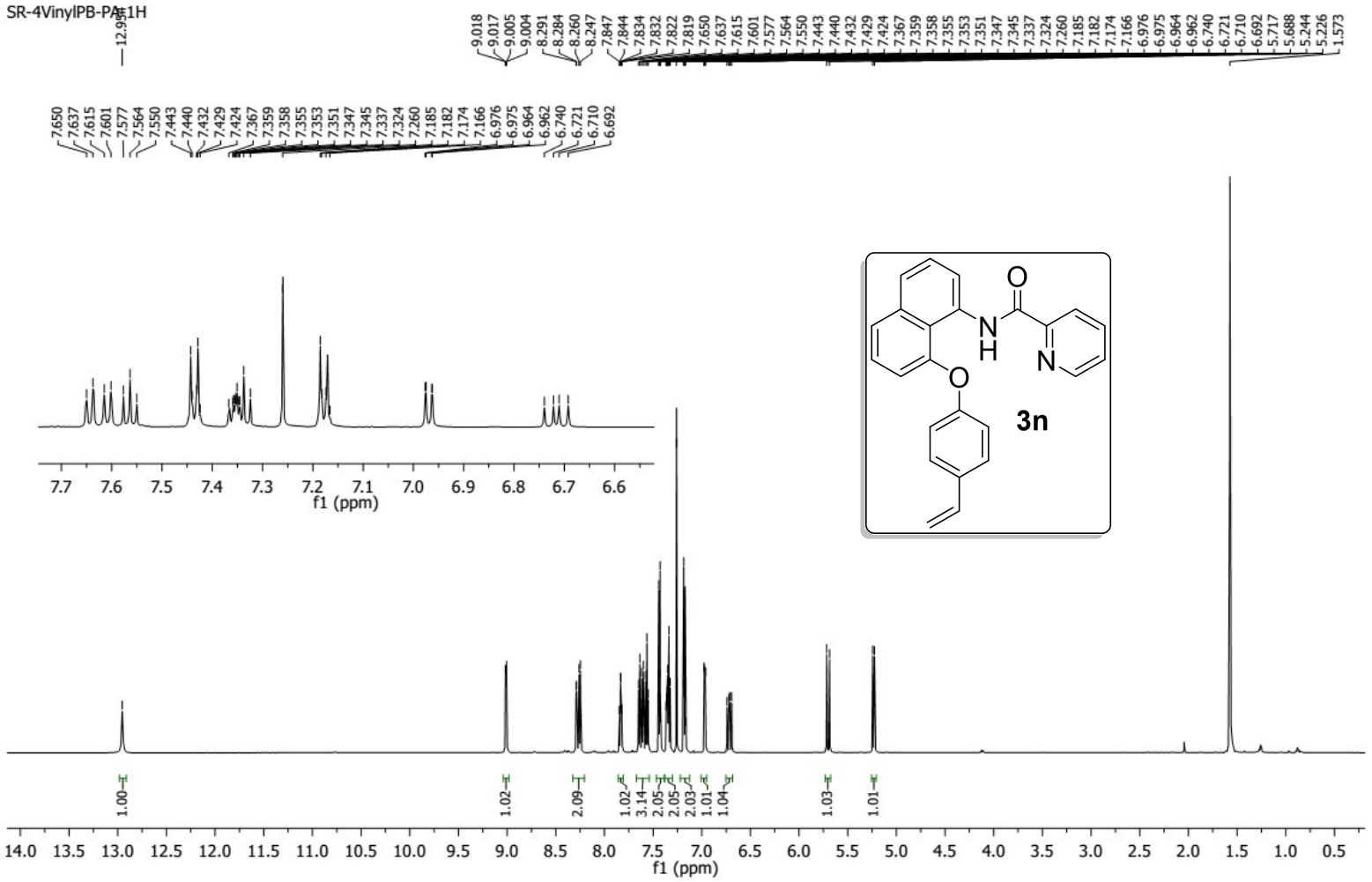

SR-4FPB-PA-13C
162.653
160.057
158.582
154.500
152.265
150.748
147.997
137.580
136.610
134.570
127.144
126.192
125.702
124.415
124.030
122.359
121.674
121.552
117.788
117.299
116.566
116.411
113.495
77.371
77.160
76.948
O
N
H
N
O
F
3k
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

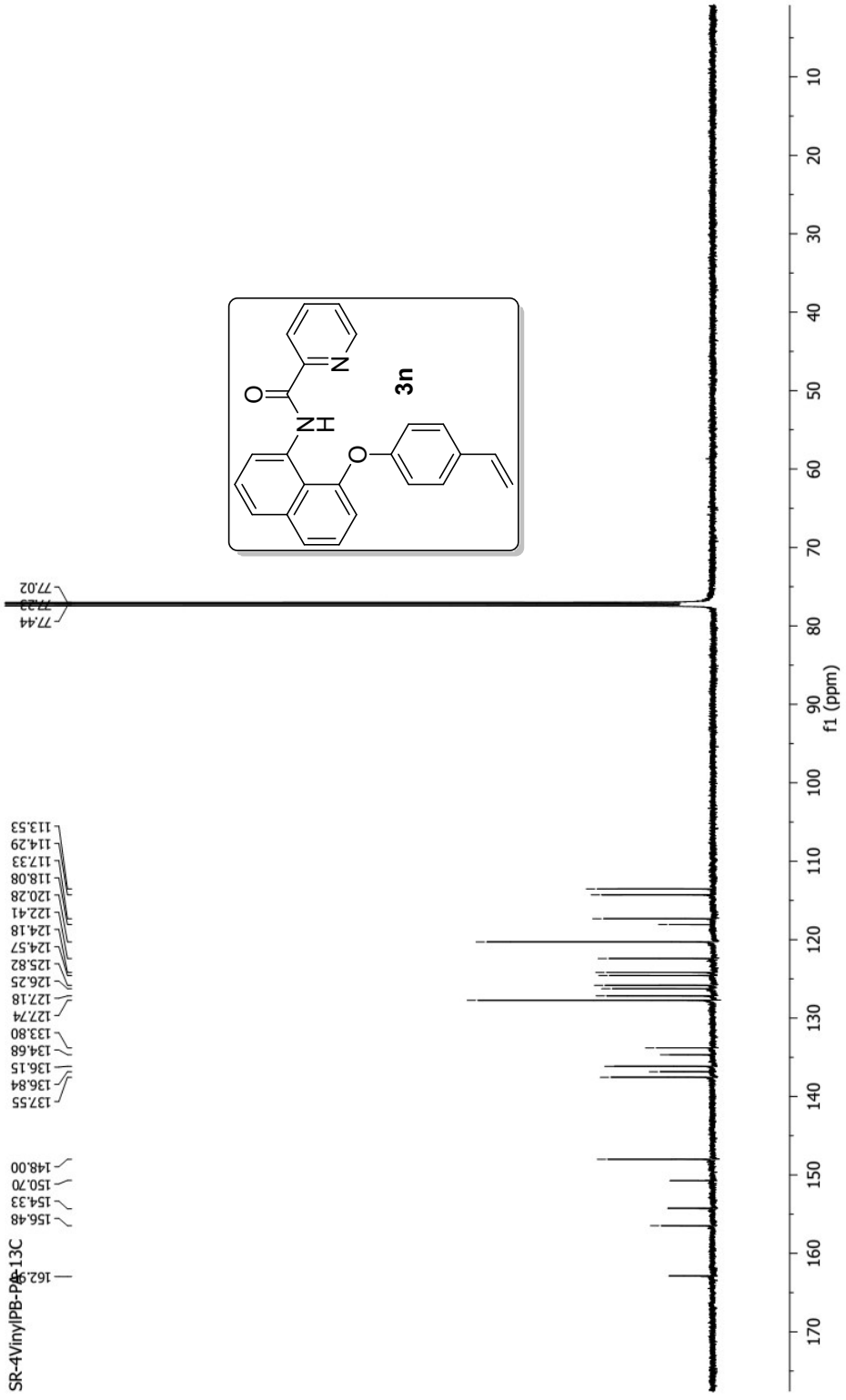

SR-4-MePB-PA-1H
13.110
9.052
9.050
9.039
9.037
8.295
8.293
8.292
8.290
8.287
8.284
8.277
8.275
7.870
7.867
7.857
7.854
7.845
7.842
7.660
7.659
7.646
7.645
7.602
7.590
7.577
7.564
7.384
7.381
7.376
7.374
7.371
7.369
7.363
7.361
7.351
7.338
7.325
7.284
7.229
7.215
7.158
7.154
7.150
7.143
7.140
7.135
6.958
6.956
6.945
6.943
2.393
O
N
H
N
O
Me
3l
f1 (ppm)
1.00
1.00
1.95
1.01
0.99
1.98
1.02
1.00
1.86
1.92
1.02
3.05

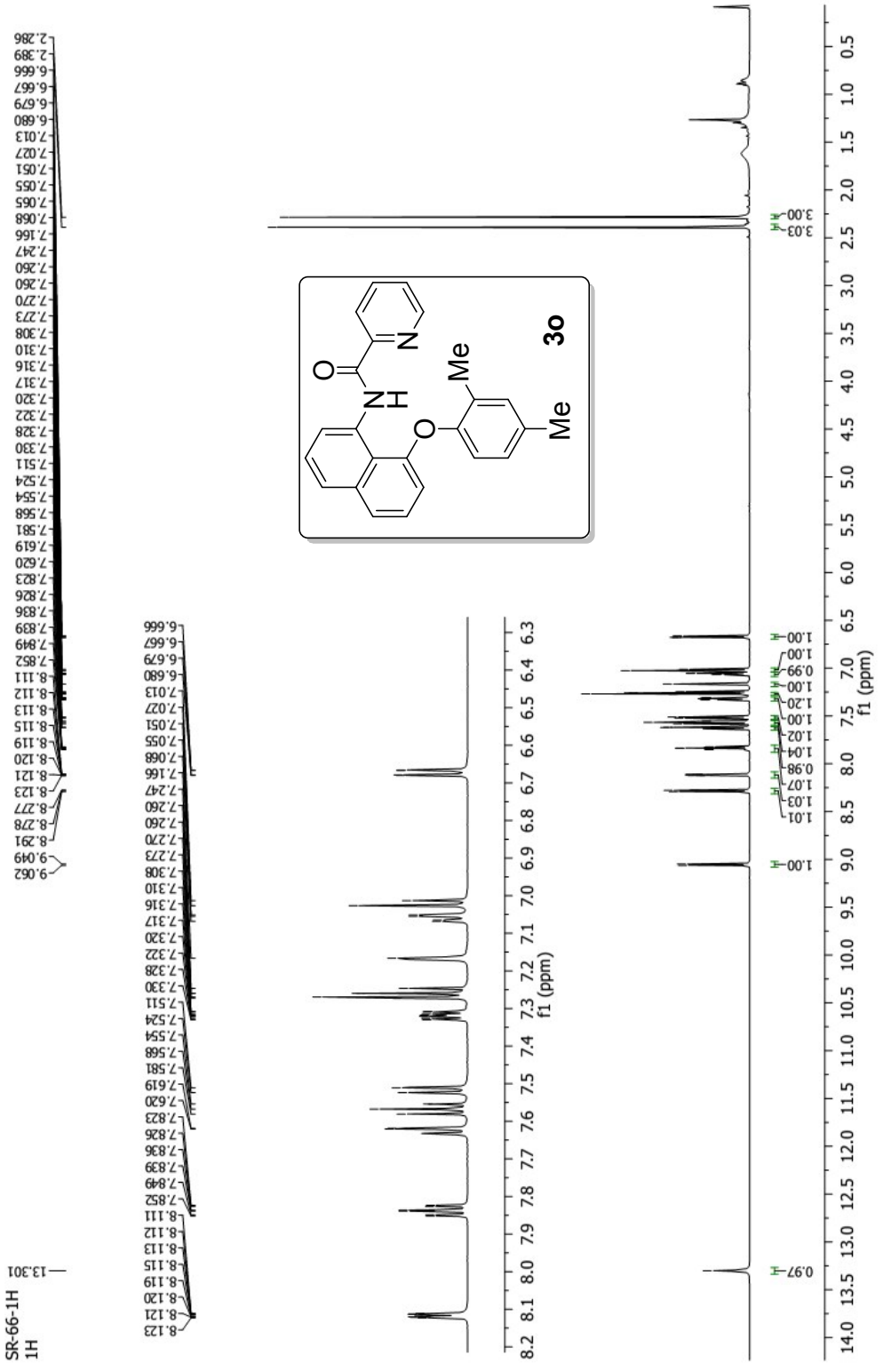

SR-4-MePB-PA-13C
162.899
154.852
154.350
150.830
148.029
137.507
136.815
134.873
133.877
130.442
127.106
126.180
125.812
124.089
122.370
120.283
117.928
117.091
113.547
77.441 CDCl3
77.336 CDCl3
77.018 CDCl3
21.022
O
N
H
N
O
Me
3l
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

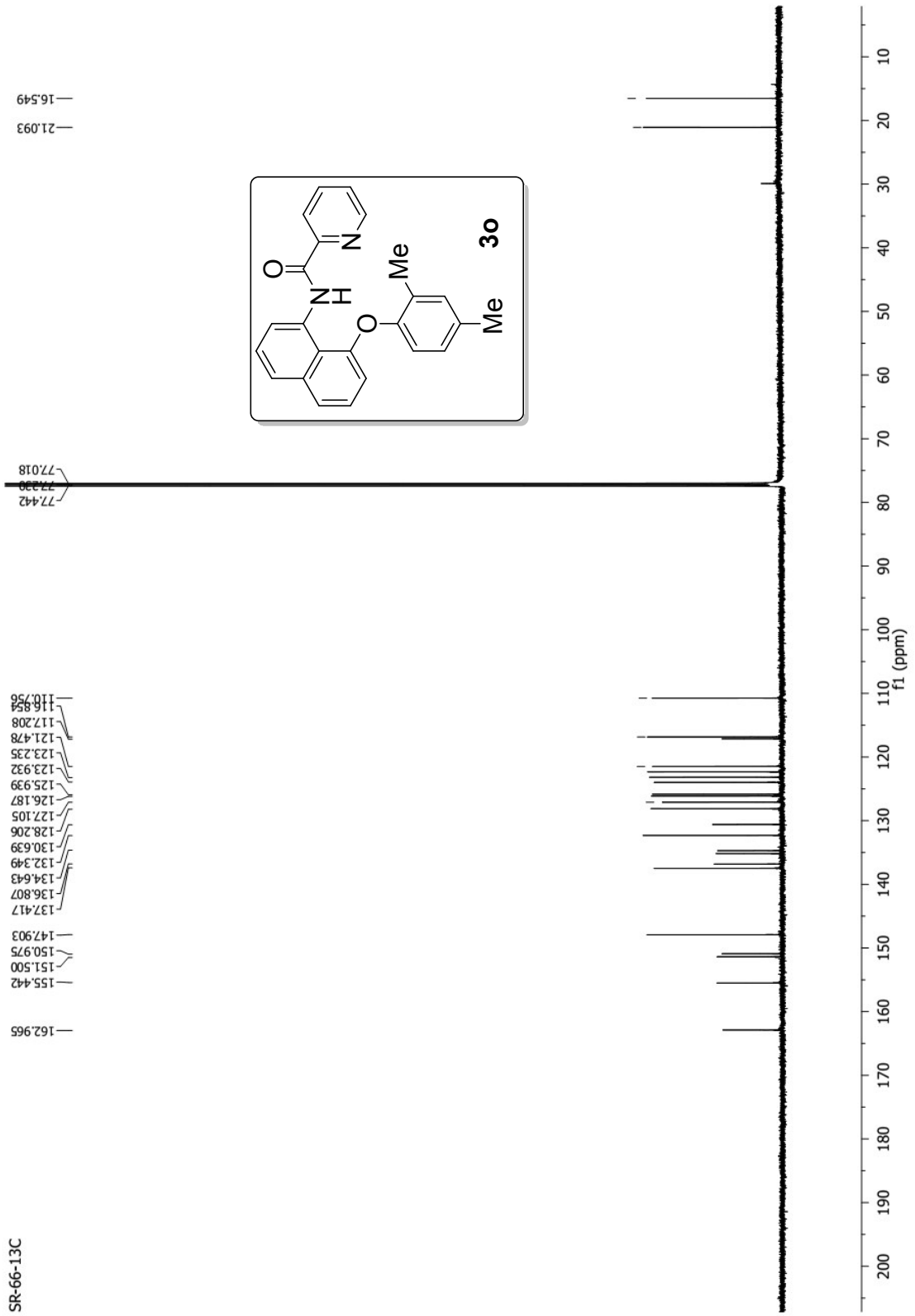

SR-70-1H
13.158
9.031
9.029
9.018
9.016
8.273
8.260
8.240
8.233
7.850
7.847
7.837
7.835
7.824
7.821
7.628
7.615
7.566
7.556
7.553
7.544
7.540
7.353
7.352
7.345
7.344
7.341
7.339
7.333
7.331
7.315
7.302
7.289
7.260
7.199
7.193
7.189
7.182
7.178
7.172
6.964
6.958
6.954
6.946
6.943
6.936
6.884
6.871
3.839
O
N
H
N
O
OMe
3m
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7.0
6.9
6.8
f1 (ppm)
0.98
1.00
1.94
1.06
1.10
2.03
1.02
1.05
1.78
1.80
0.93
2.68
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)


SR-70-C-13C
13C
163.031
156.588
155.521
150.775
149.801
148.035
137.534
136.811
134.919
127.191
126.178
125.792
124.050
123.840
122.371
121.783
117.653
117.035
115.044
112.623
77.442
77.018
56.260
3m
OMe
f1 (ppm)


SR-4VinylPB-PA-1H
12.995
9.018
9.017
9.005
9.004
8.291
8.284
8.260
8.247
7.847
7.844
7.834
7.832
7.822
7.819
7.650
7.637
7.615
7.601
7.577
7.564
7.550
7.443
7.440
7.432
7.429
7.424
7.367
7.359
7.358
7.355
7.353
7.351
7.347
7.345
7.337
7.324
7.260
7.185
7.182
7.174
7.166
6.976
6.975
6.964
6.962
6.740
6.721
6.710
6.692
5.717
5.688
5.244
5.226
1.573
f1 (ppm)
1.00
1.02
2.09
1.02
3.14
2.05
2.05
2.03
1.01
1.04
1.03
1.01
f1 (ppm)
O
N
H
N
O
3n


SR-4Vinyl/PB-PA-13C
162.96
156.48
154.33
150.70
148.00
137.55
136.84
136.15
134.68
133.80
127.74
127.18
126.25
125.82
124.57
124.18
122.41
120.28
118.08
117.33
114.29
113.53
77.44
77.33
77.02
3n
f1 (ppm)

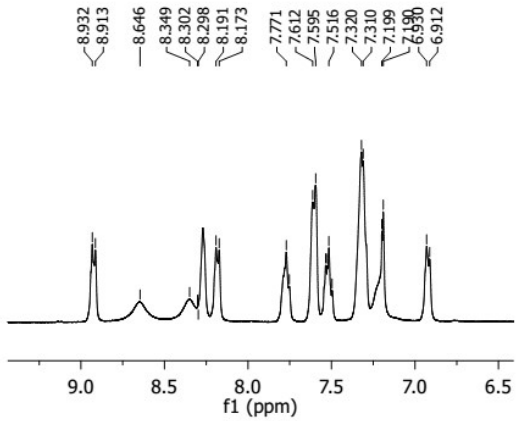

SR-66-1H
1H
3o
Me
Me
O
NH
N
f1 (ppm)

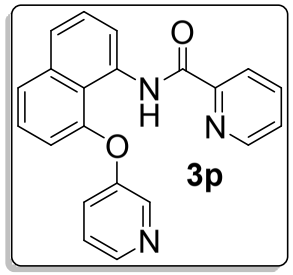

SR-66-13C
16.549
21.093
77.442
77.239
77.018
110.756
116.854
117.208
121.478
123.235
123.932
125.939
126.187
127.105
128.206
130.639
132.349
134.643
136.807
137.417
147.903
150.975
151.500
155.442
162.965
Me
Me
O
N
H
O
N
30
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
f1 (ppm)

SR-32-3PYBA-PA-1H

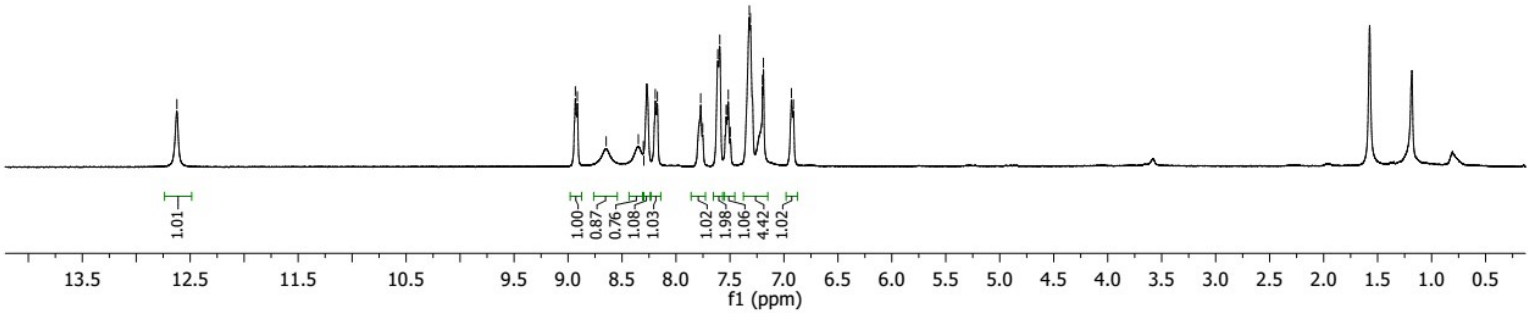
12.624

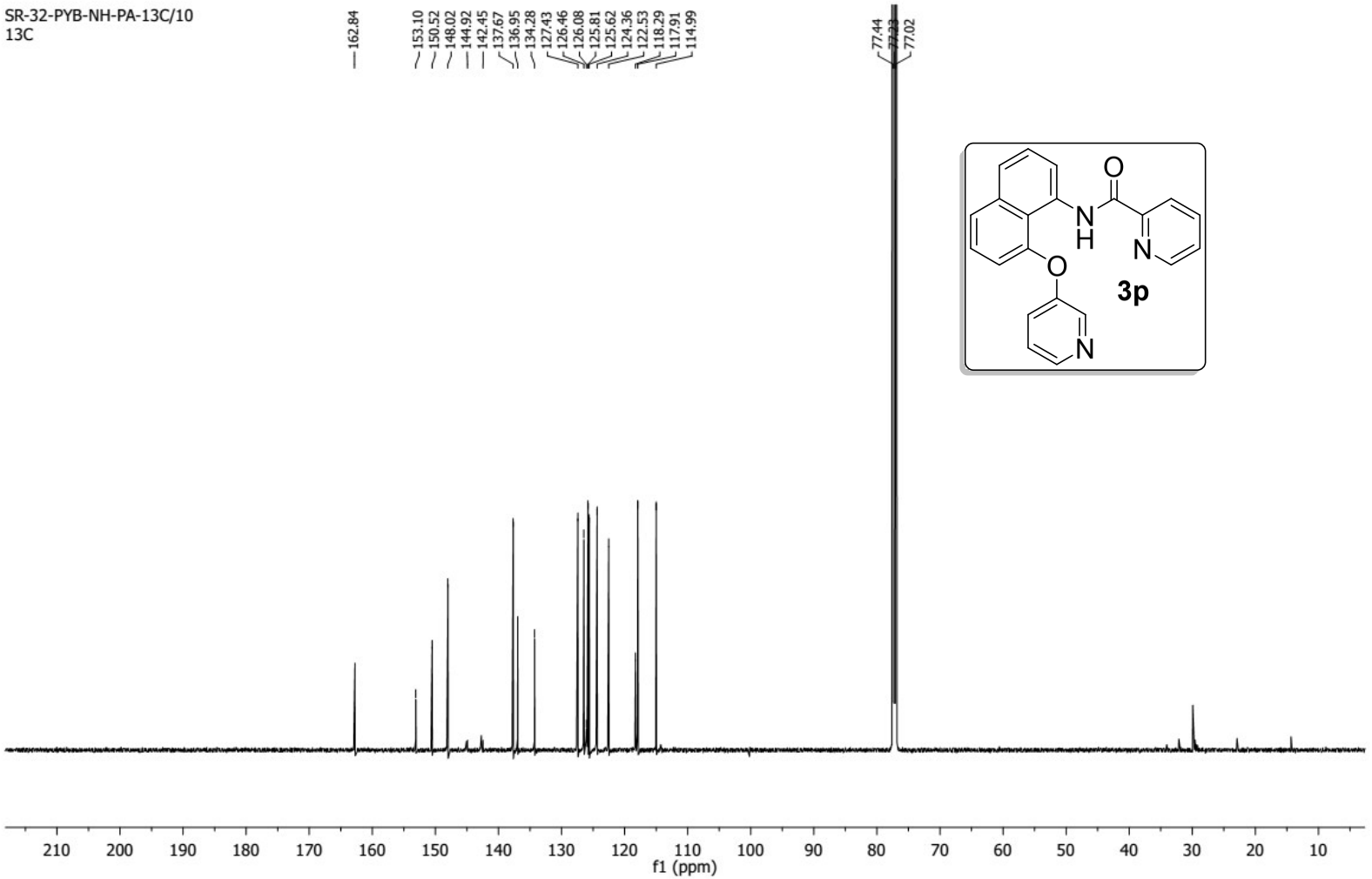
8.932
8.913
8.646
8.349
8.302
8.298
8.191
8.173
7.771
7.752
7.612
7.595
7.535
7.525
7.516
7.496
7.320
7.310
7.199
7.190
6.930
6.912

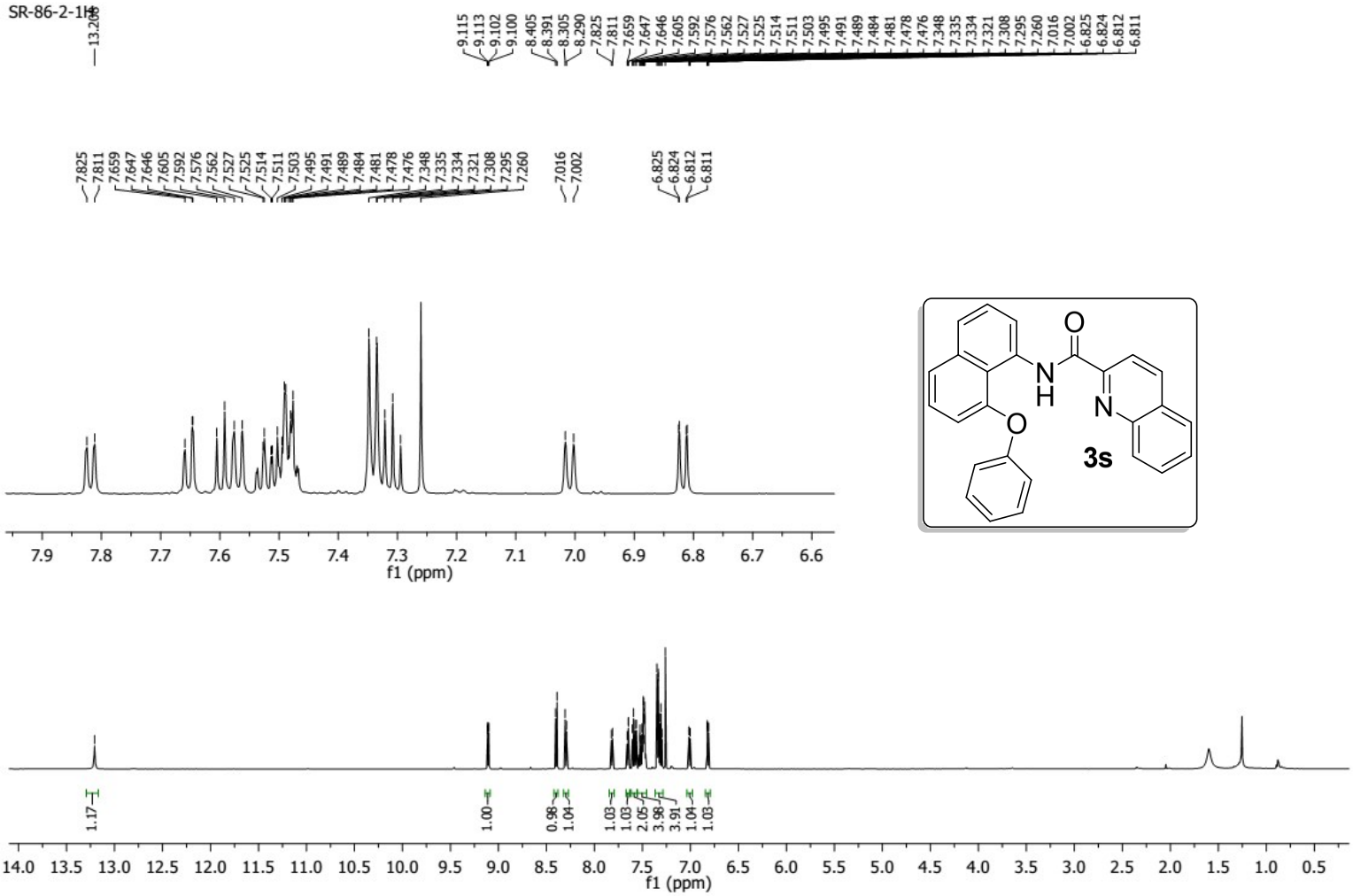


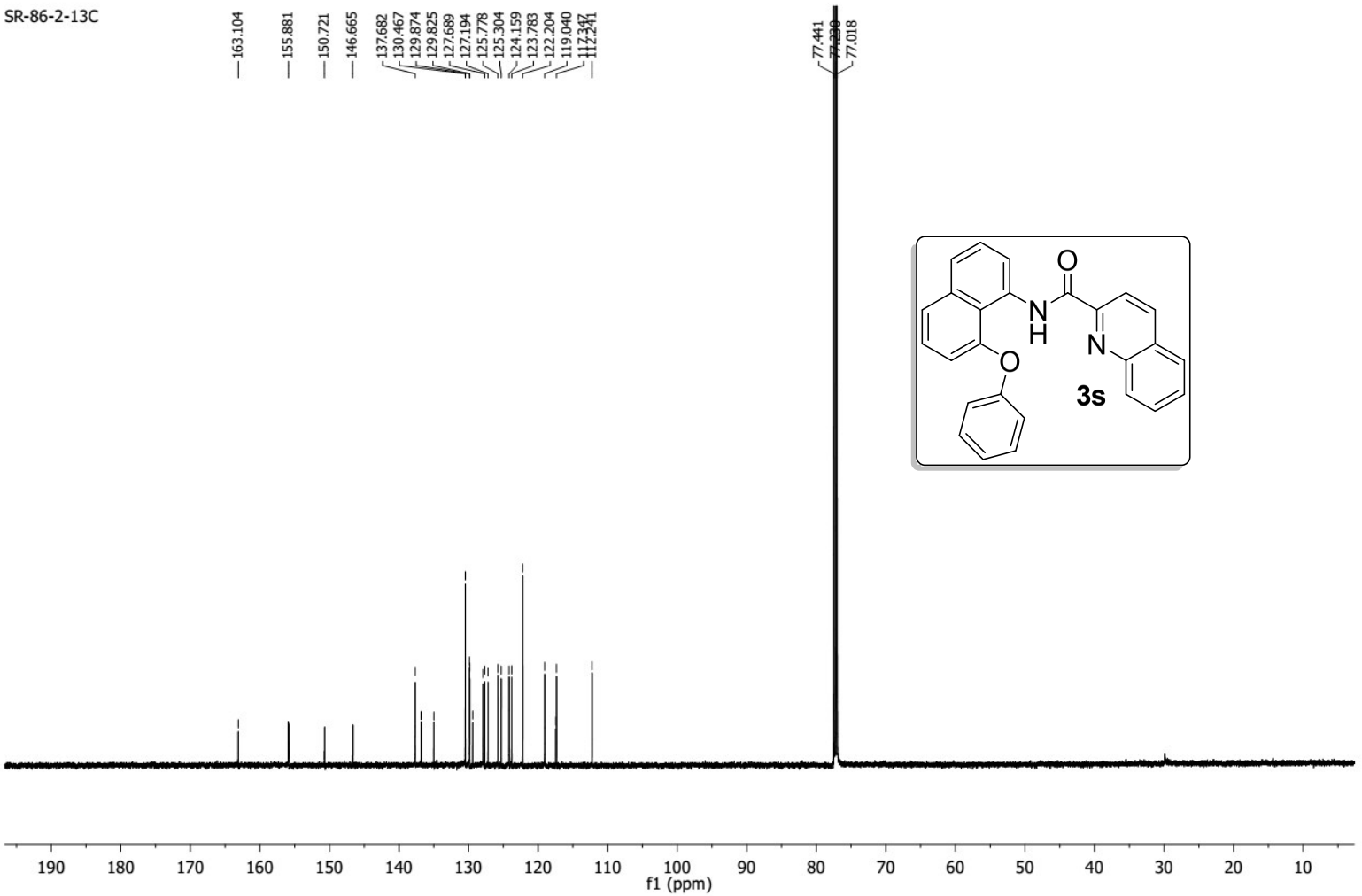


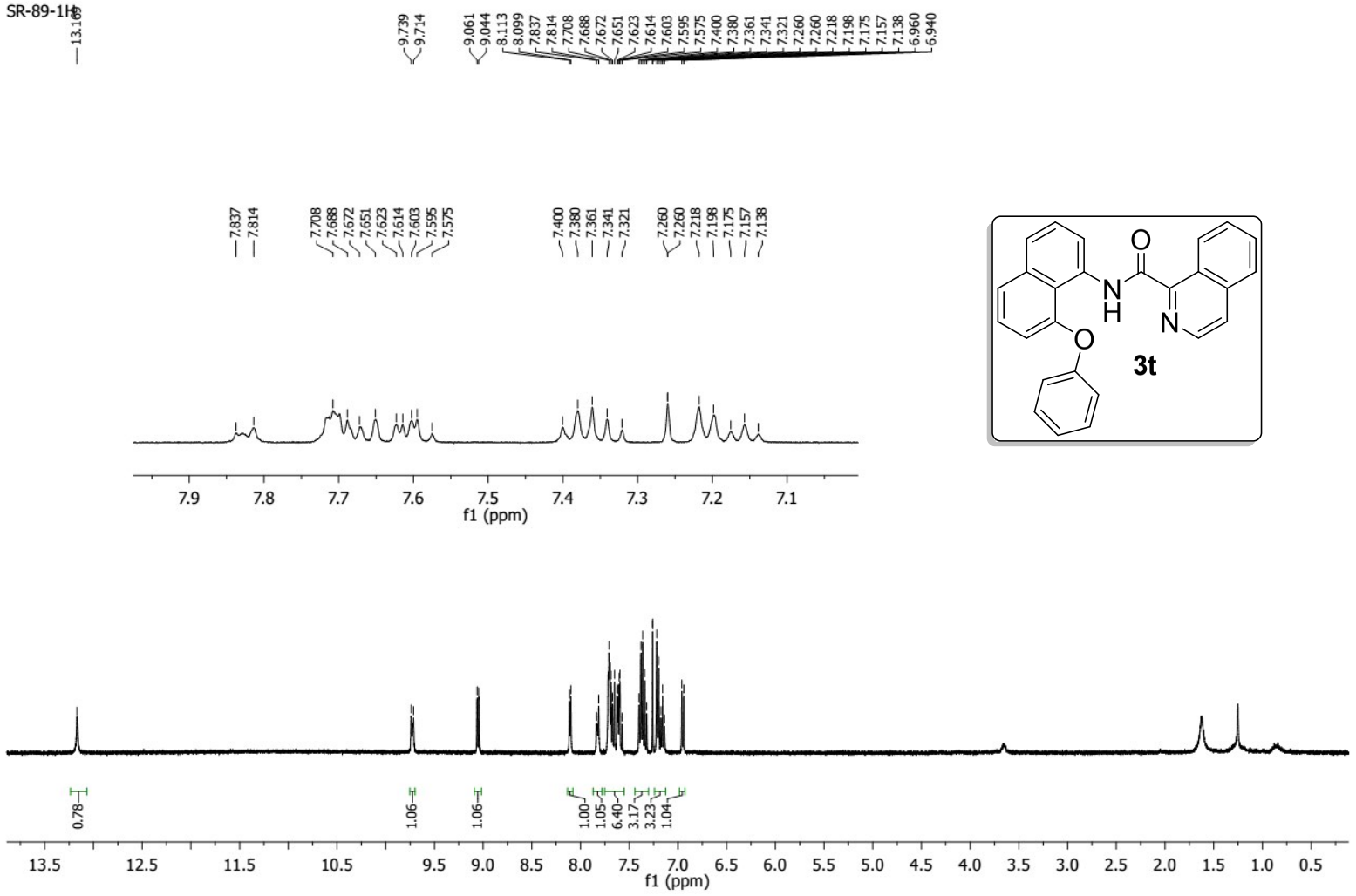
3p

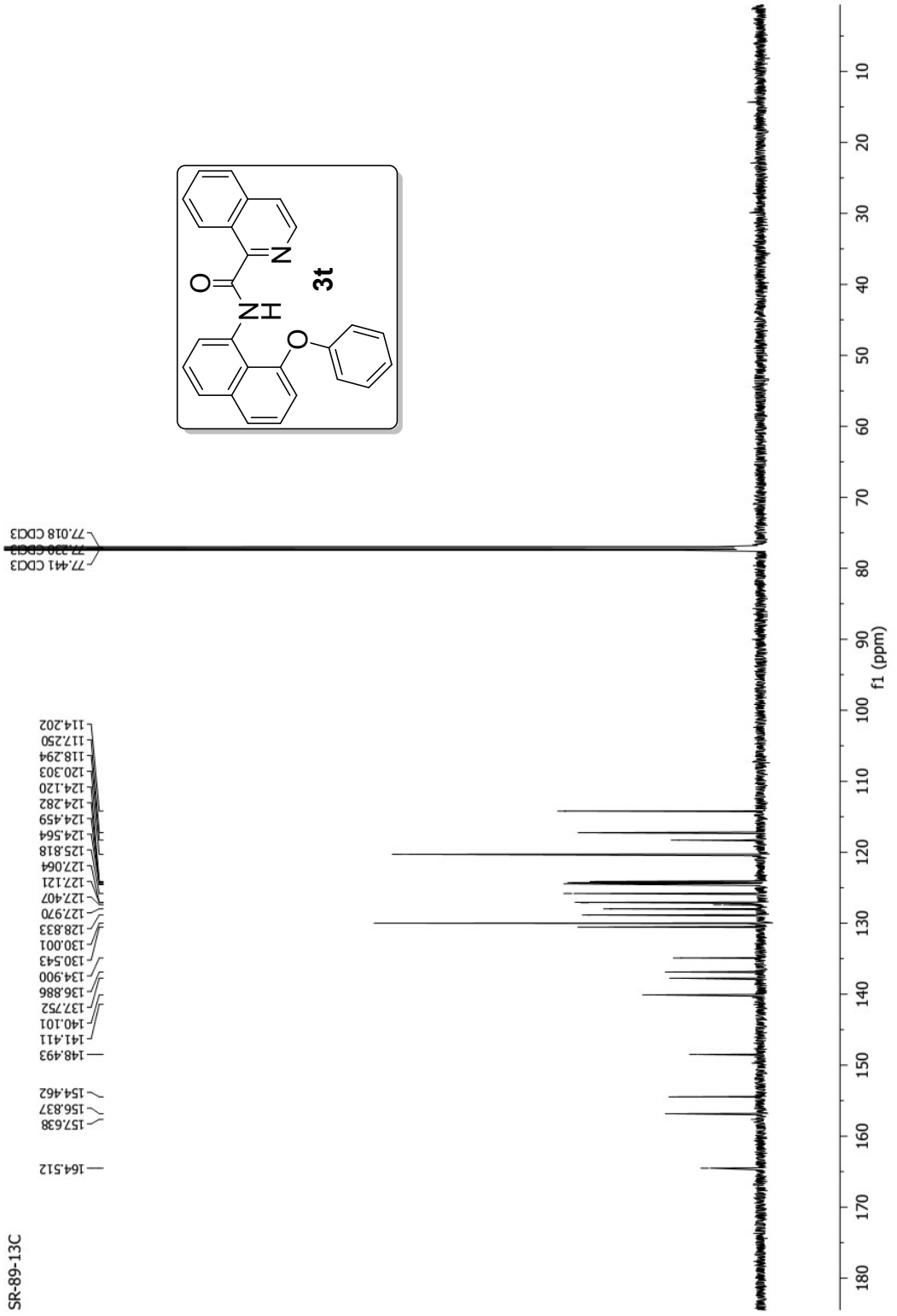


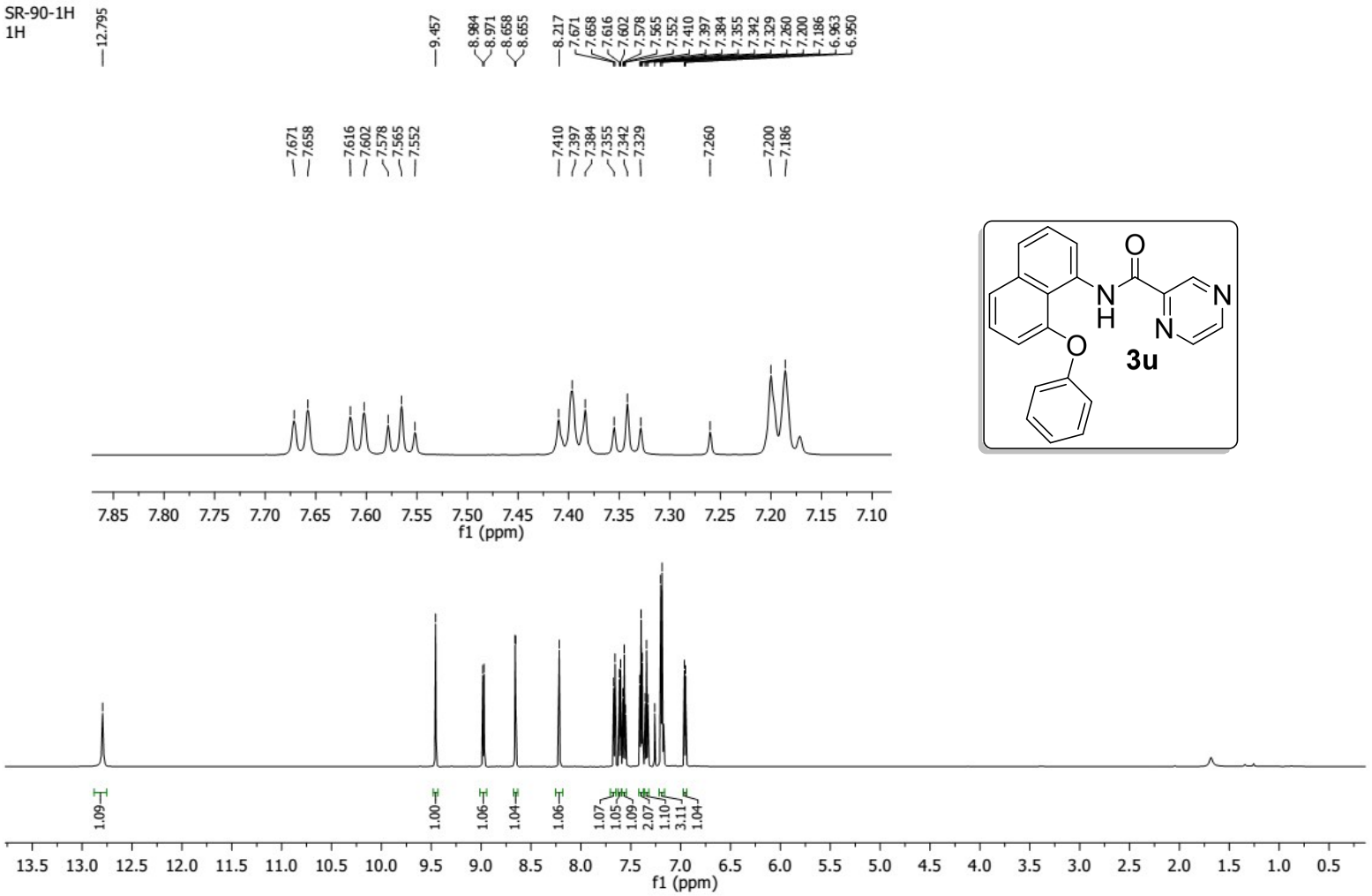

SR-32-PYB-NH-PA-13C/10
13C
162.84
153.10
150.52
148.02
144.92
142.45
137.67
136.95
134.28
127.43
126.46
126.08
125.81
125.62
124.36
122.53
118.29
117.91
114.99
77.44
77.33
77.02
O
N
H
N
O
N
3p
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

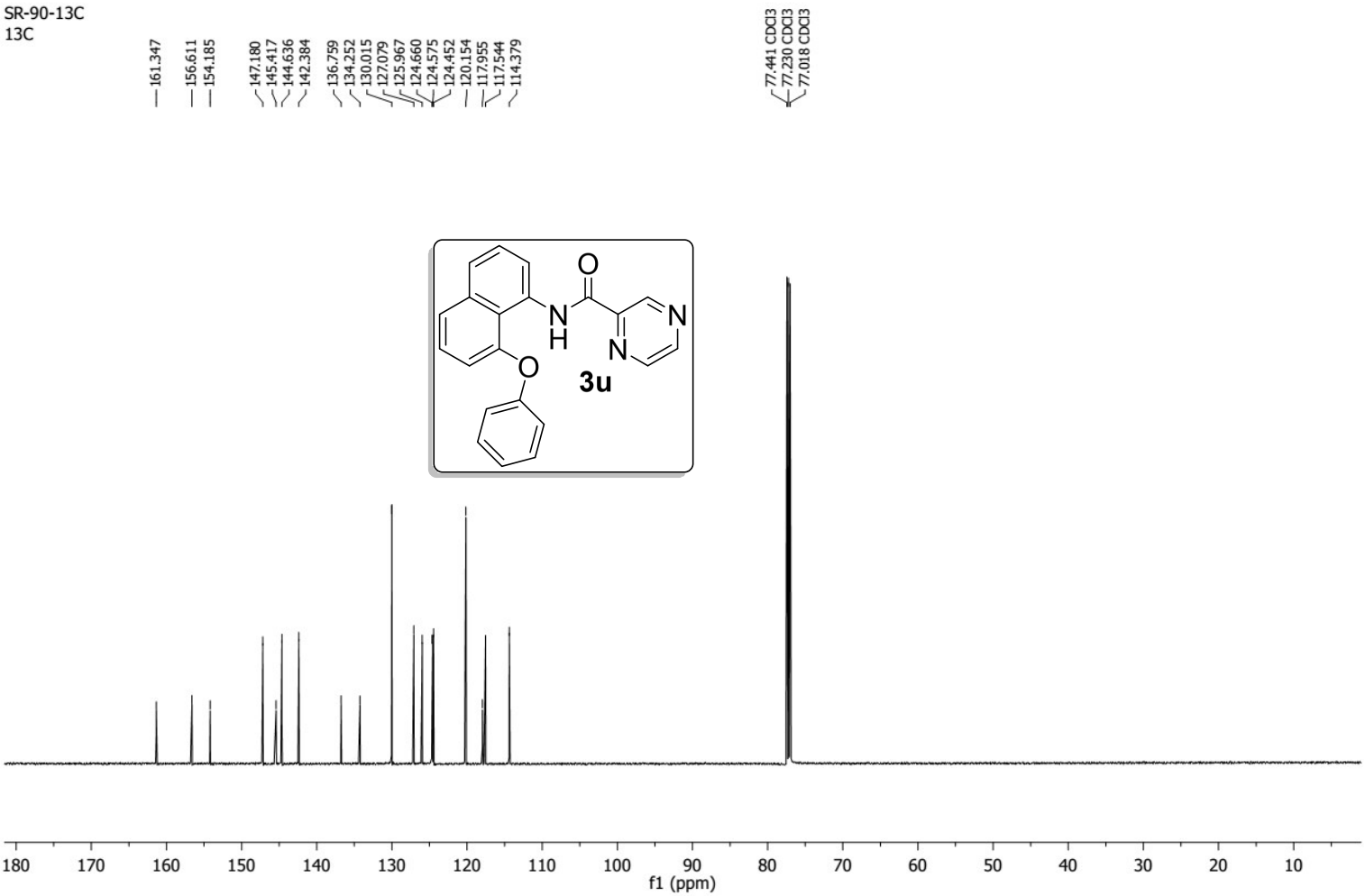

SR-86-2-1H
13.208
9.115
9.113
9.102
9.100
8.405
8.391
8.305
8.290
7.825
7.811
7.659
7.647
7.646
7.605
7.592
7.576
7.562
7.527
7.525
7.514
7.511
7.503
7.495
7.491
7.489
7.484
7.481
7.478
7.476
7.348
7.335
7.334
7.321
7.308
7.295
7.260
7.016
7.002
6.825
6.824
6.812
6.811
O
N
H
N
O
3s
f1 (ppm)
1.17
1.00
0.98
1.04
1.03
1.03
2.05
3.98
3.91
1.04
1.03
f1 (ppm)


SR-86-2-13C
163.104
155.881
150.721
146.665
137.682
130.467
129.874
129.825
127.689
127.194
125.778
125.304
124.159
123.783
122.204
119.040
77.441
77.018
O
N
H
N
O
3s
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

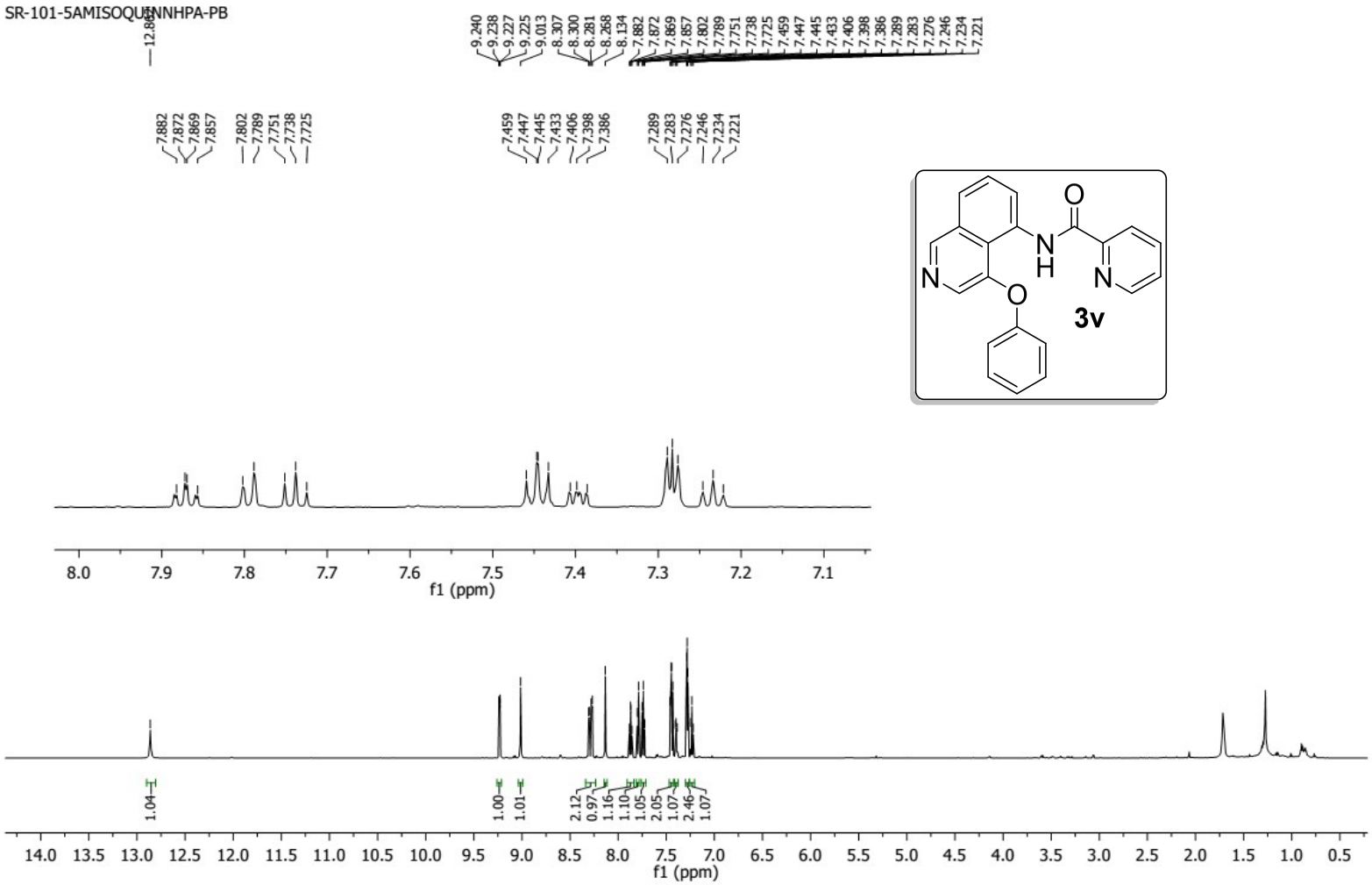

SR-89-1H
13.166
9.739
9.714
9.061
9.044
8.113
8.099
7.837
7.814
7.708
7.688
7.672
7.651
7.623
7.614
7.603
7.595
7.575
7.400
7.380
7.361
7.341
7.321
7.260
7.260
7.218
7.198
7.175
7.157
7.138
6.960
6.940
O
N
H
N
O
3t
f1 (ppm)
0.78
1.06
1.06
1.00
1.05
6.40
3.17
3.23
1.04
f1 (ppm)


SR-89-13C
164.512
157.638
156.837
154.462
148.493
141.411
140.101
137.752
136.886
134.900
130.543
130.001
128.833
127.970
127.407
127.121
127.064
125.818
124.564
124.459
124.282
124.120
120.303
118.294
117.250
114.202
77.441 CDCl3
77.018 CDCl3
3t
f1 (ppm)

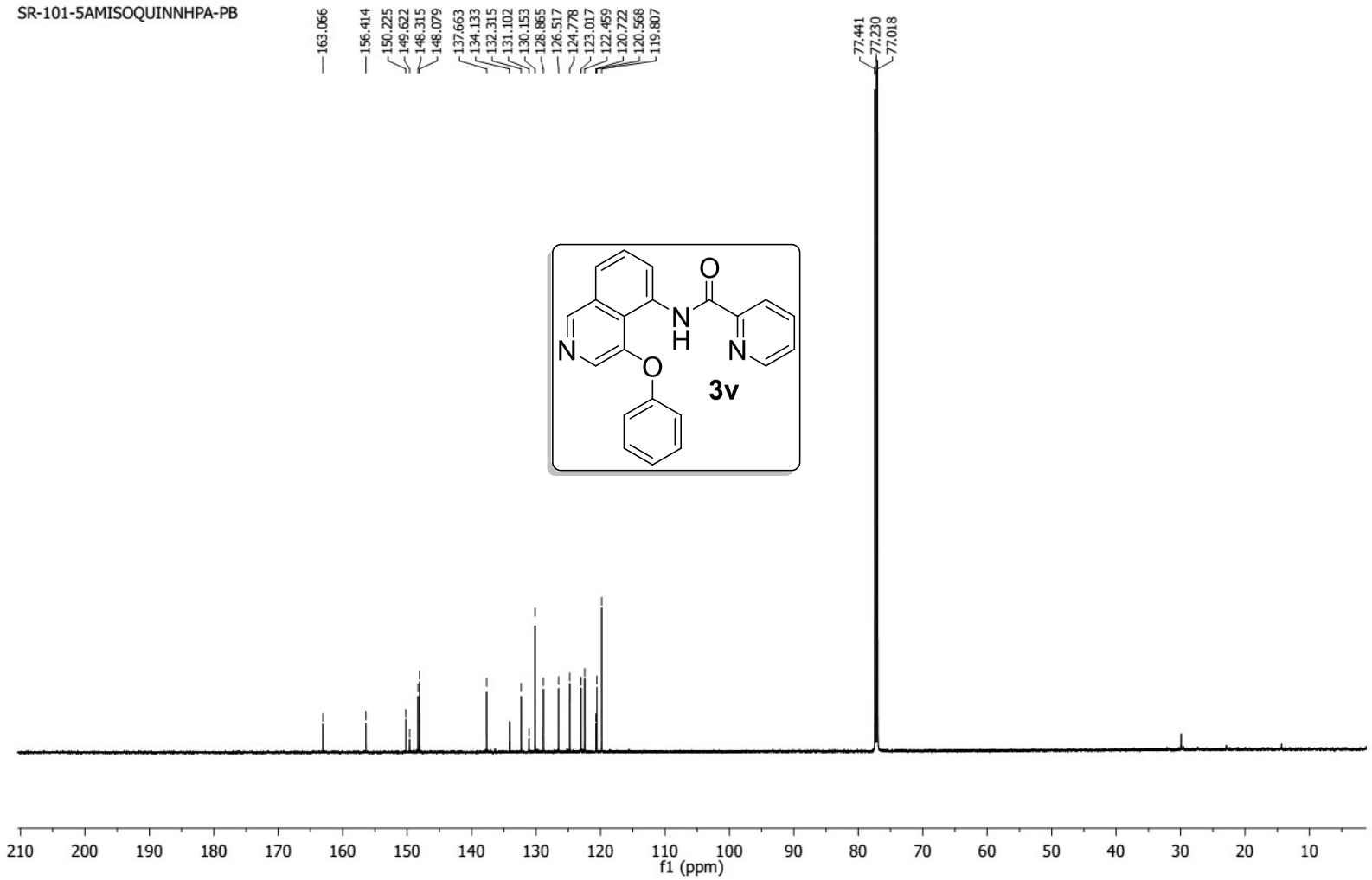

SR-90-1H
1H
12.795
9.457
8.984
8.971
8.658
8.655
8.217
7.671
7.658
7.616
7.602
7.578
7.565
7.552
7.410
7.397
7.384
7.355
7.342
7.329
7.260
7.200
7.186
6.963
6.950
O
N
H
N
N
O
3u
f1 (ppm)
1.09
1.00
1.06
1.04
1.06
1.07
1.05
1.09
2.07
1.10
3.11
1.04
f1 (ppm)

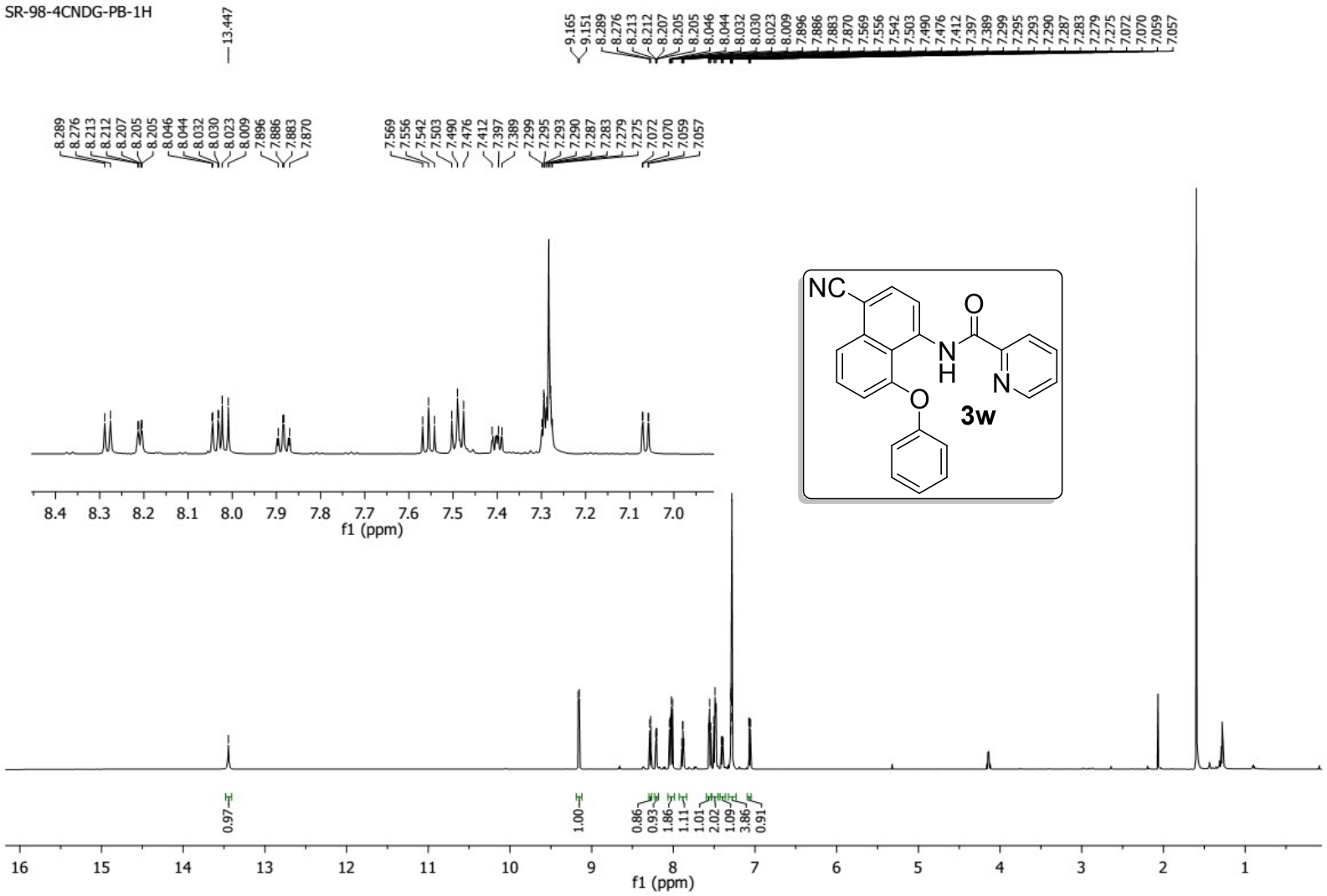

SR-90-13C
13C
161.347
156.611
154.185
147.180
145.417
144.636
142.384
136.759
134.252
130.015
127.079
125.967
124.660
124.575
124.452
120.154
117.955
117.544
114.379
77.441 CDCl3
77.230 CDCl3
77.018 CDCl3
O
N
H
N
N
O
3u
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

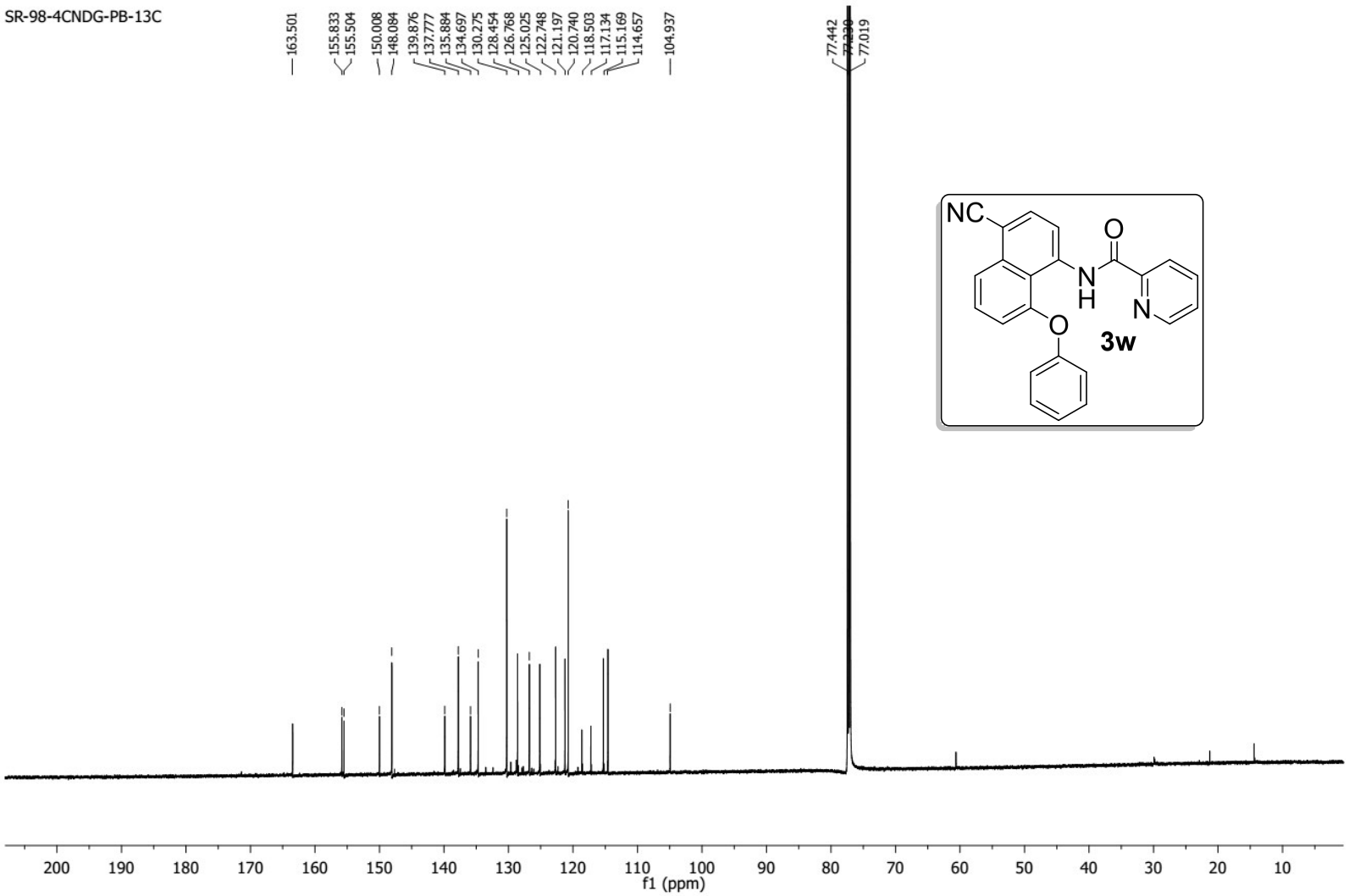
SR-101-5AMISOQUINNHPA-PB

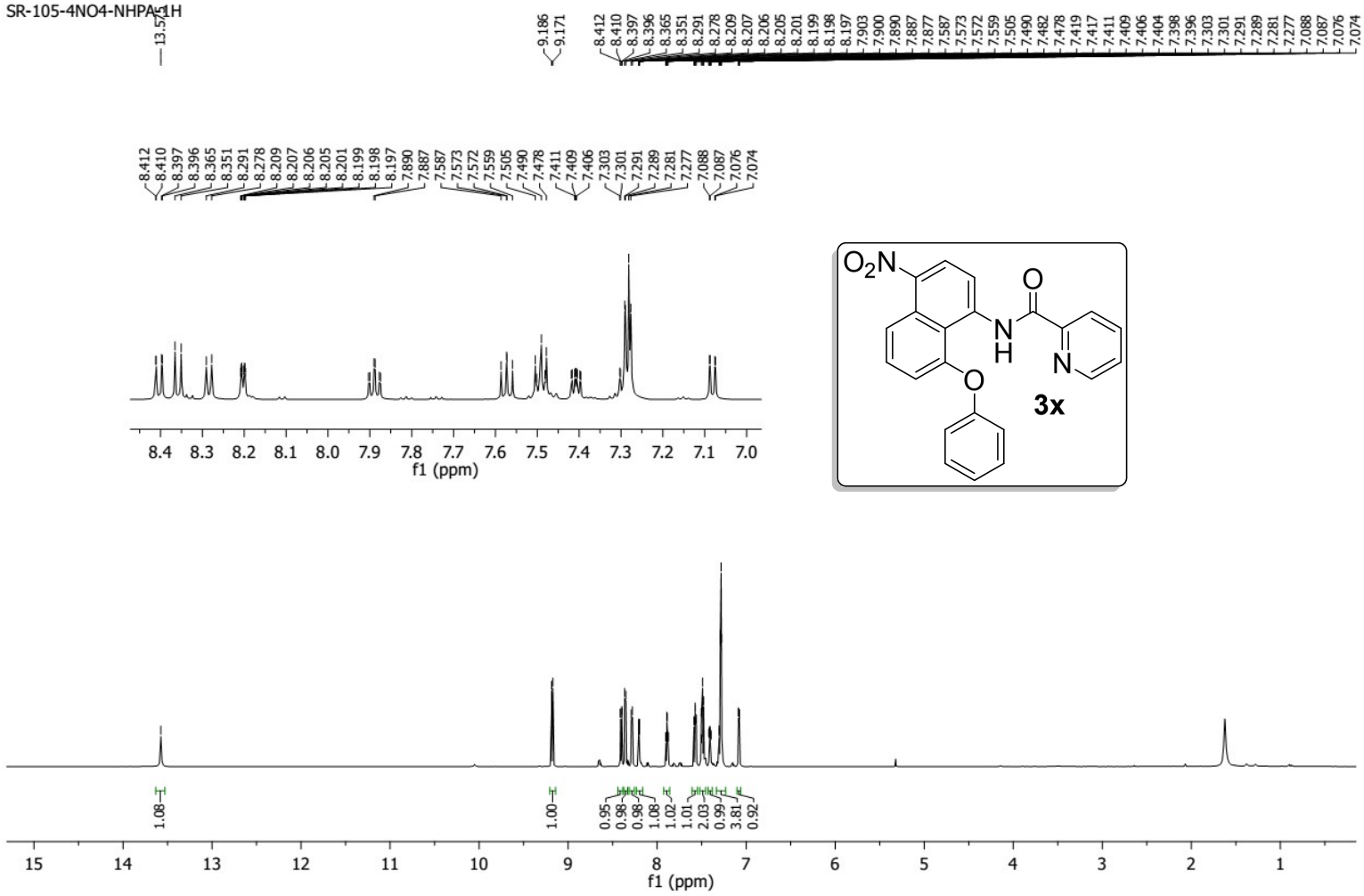


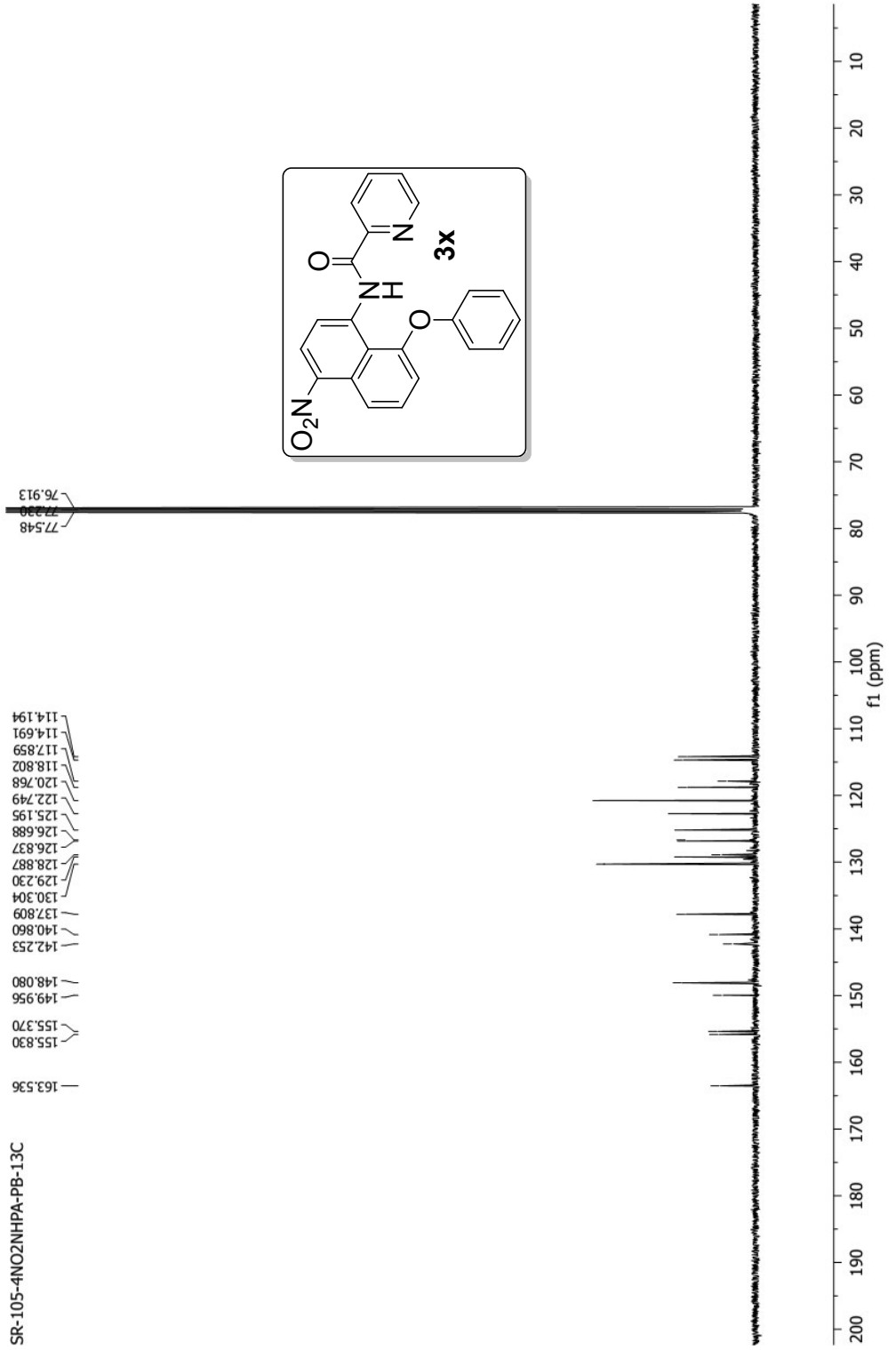
SR-101-5AMISOQUINNHPA-PB

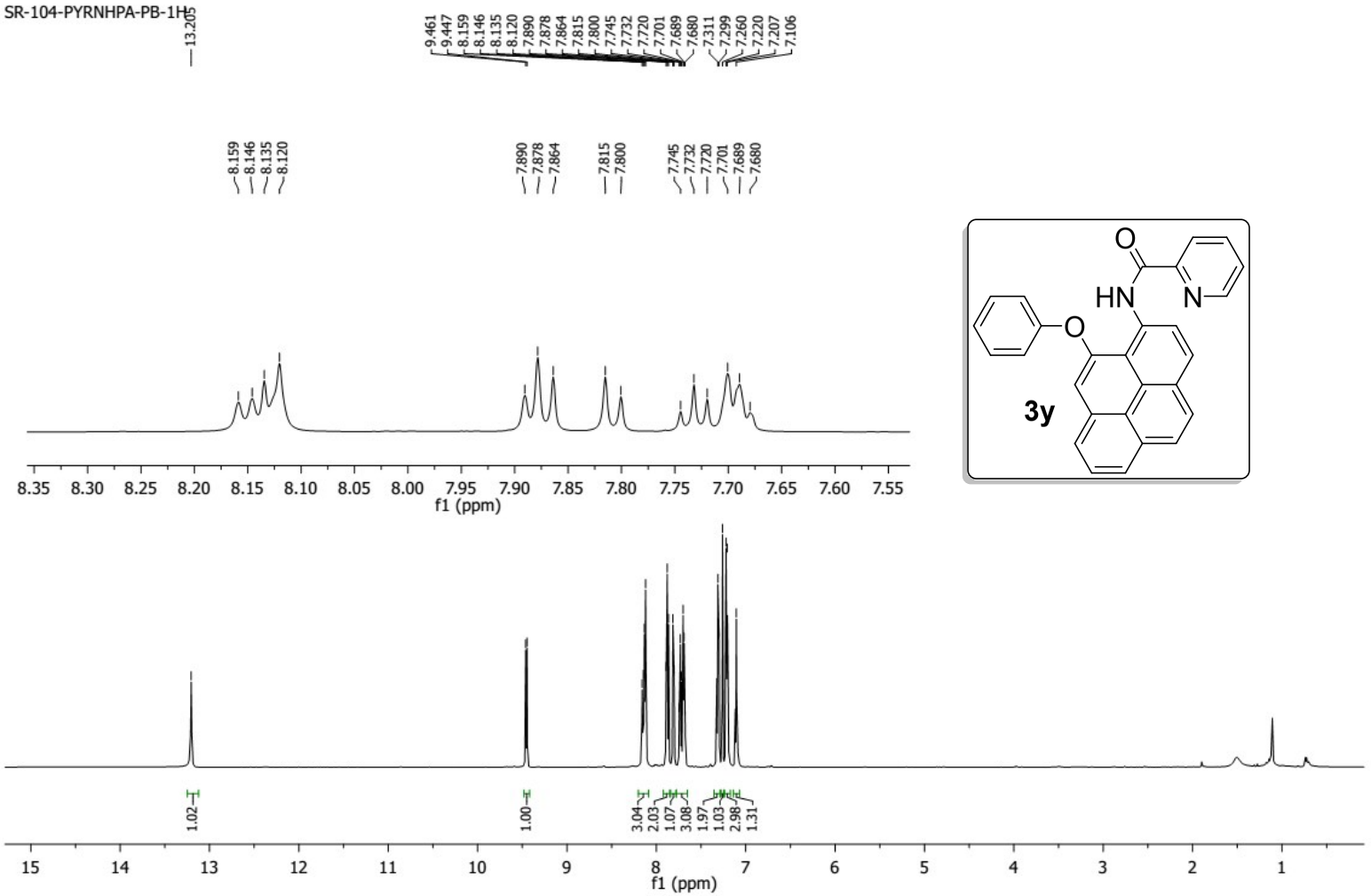


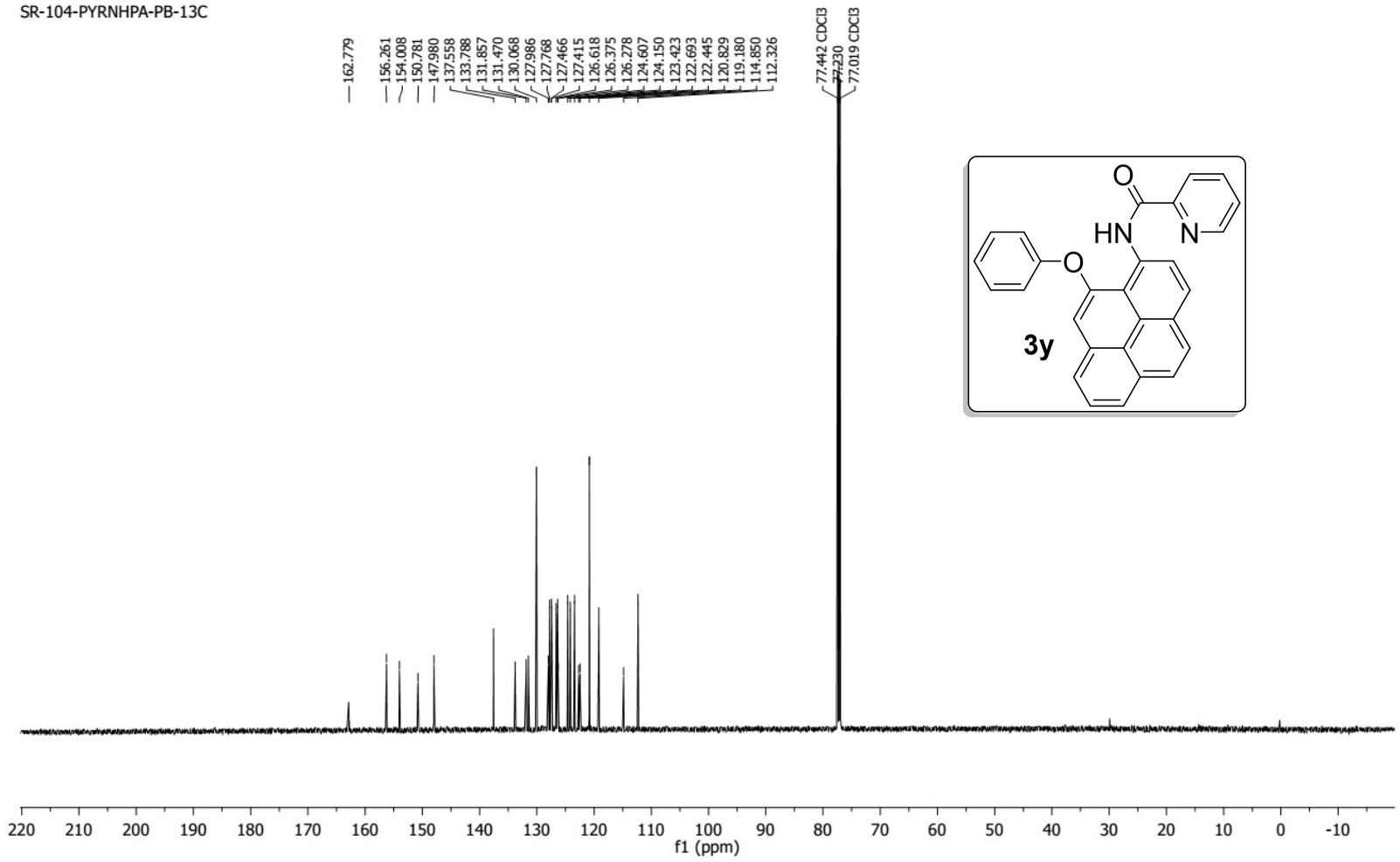

SR-98-4CNDG-PB-1H
13.447
9.165
9.151
8.289
8.276
8.213
8.212
8.207
8.205
8.205
8.046
8.044
8.032
8.030
8.023
8.009
7.896
7.886
7.883
7.870
7.569
7.556
7.542
7.503
7.490
7.476
7.412
7.397
7.389
7.299
7.295
7.293
7.290
7.287
7.283
7.279
7.275
7.072
7.070
7.059
7.057
NC
O
N
H
N
O
3w
f1 (ppm)
0.97
1.00
0.86
0.93
1.86
1.11
1.01
2.02
1.09
3.86
0.91
f1 (ppm)


SR-98-4CNDG-PB-13C
163.501
155.833
155.504
150.008
148.084
139.876
137.777
135.884
134.697
130.275
128.454
126.768
125.025
122.748
121.197
120.740
118.503
117.134
115.169
114.657
104.937
77.442
77.330
77.019
NC
O
N
H
N
O
3w
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

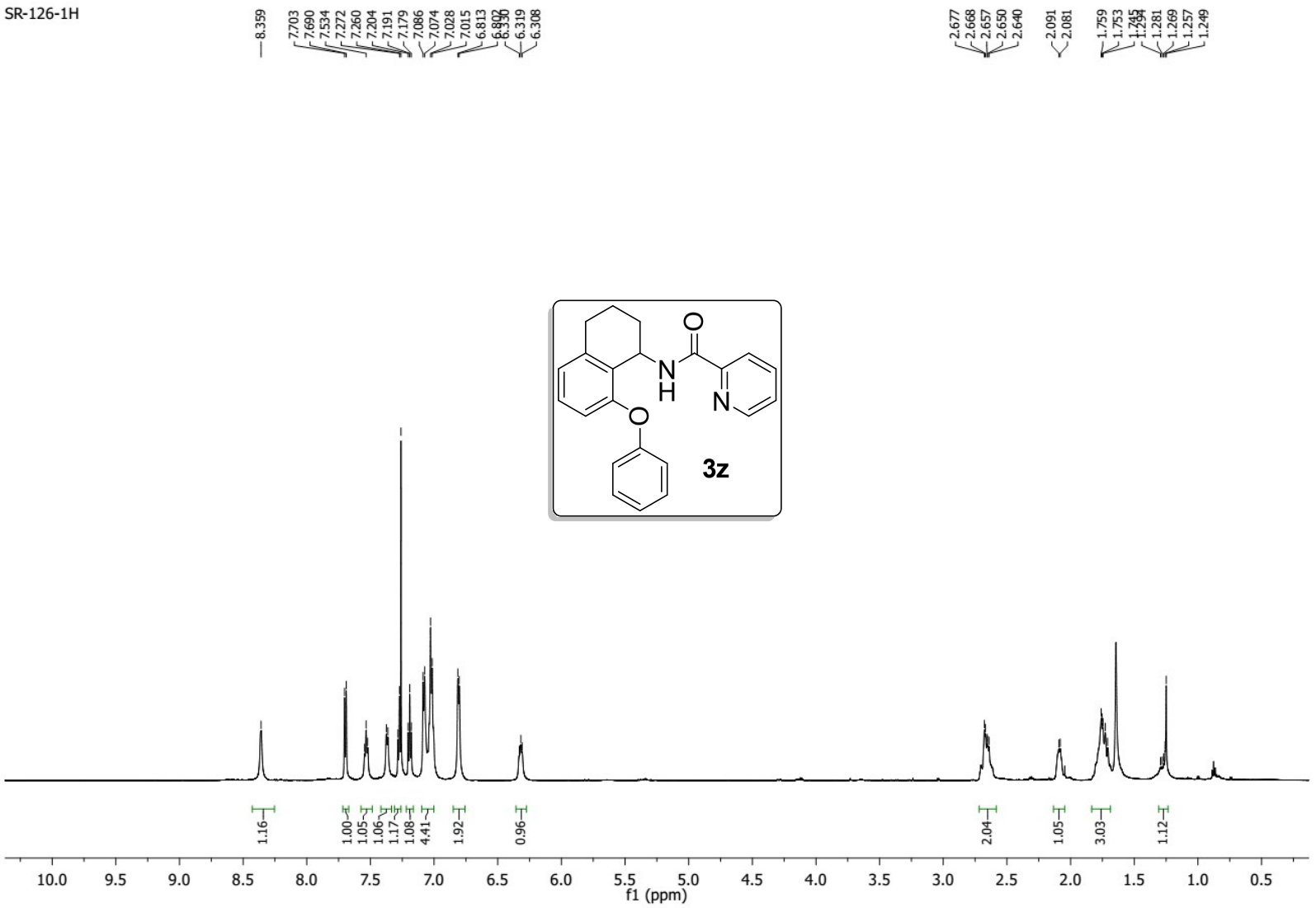

SR-105-4NO4-NHPAc-1H
13.574
9.186
9.171
8.412
8.410
8.397
8.396
8.365
8.351
8.291
8.278
8.209
8.207
8.206
8.205
8.201
8.199
8.198
8.197
7.903
7.900
7.890
7.887
7.877
7.587
7.573
7.572
7.559
7.505
7.490
7.482
7.478
7.419
7.417
7.411
7.409
7.406
7.404
7.398
7.396
7.303
7.301
7.291
7.289
7.281
7.277
7.088
7.087
7.076
7.074
8.4 8.3 8.2 8.1 8.0 7.9 7.8 7.7 7.6 7.5 7.4 7.3 7.2 7.1 7.0
f1 (ppm)
O2N
O
N
H
N
O
3x
1.08
1.00
0.95
0.98
0.98
1.08
1.02
1.01
2.03
0.99
3.81
0.92
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
f1 (ppm)

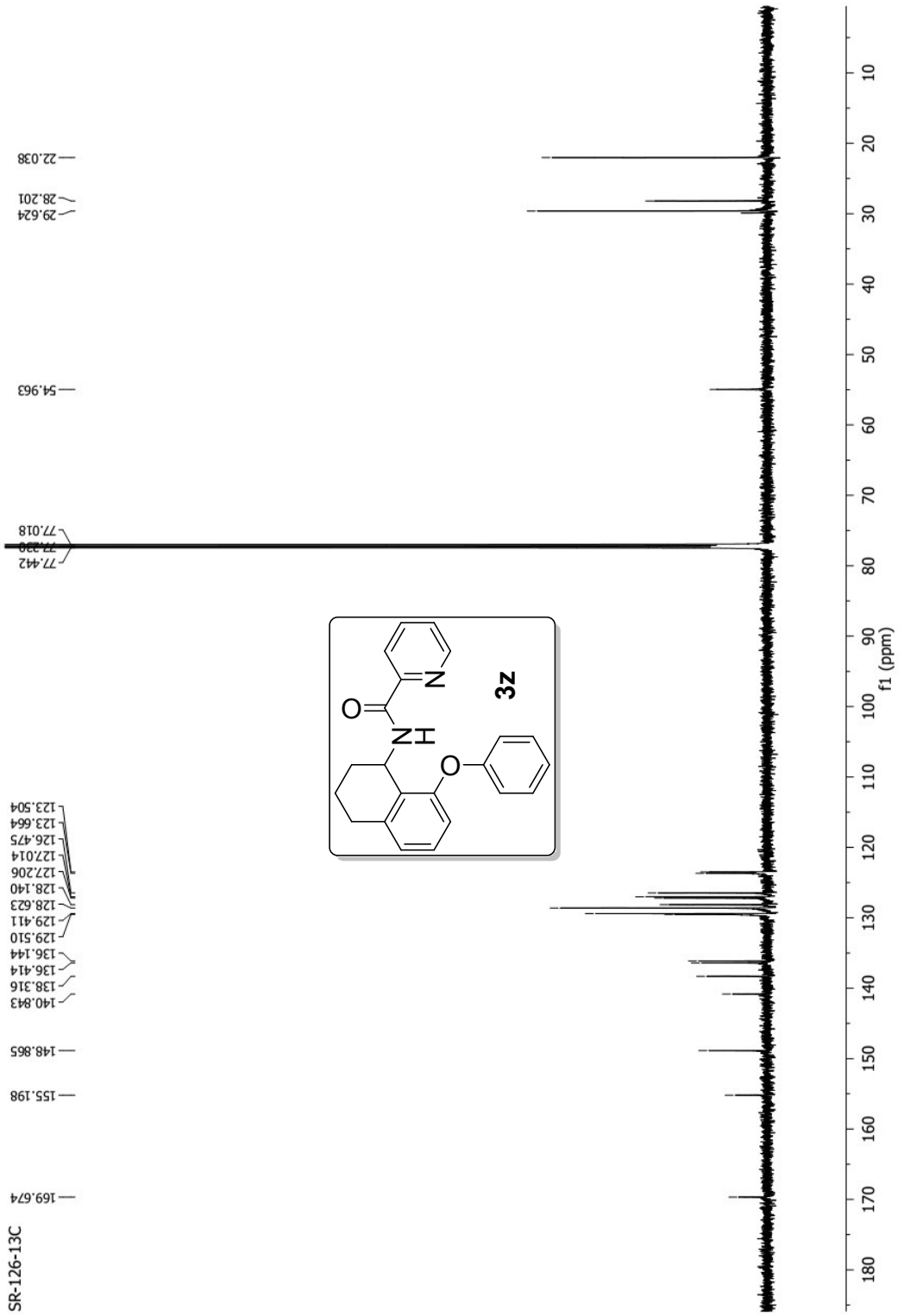

SR-105-4NO2NHPA-PB-13C
163.536
155.830
155.370
149.956
148.080
142.253
140.860
137.809
130.304
129.230
128.887
126.837
126.688
125.195
122.749
120.768
118.802
117.859
114.691
114.194
77.548
77.330
76.913
3x
f1 (ppm)

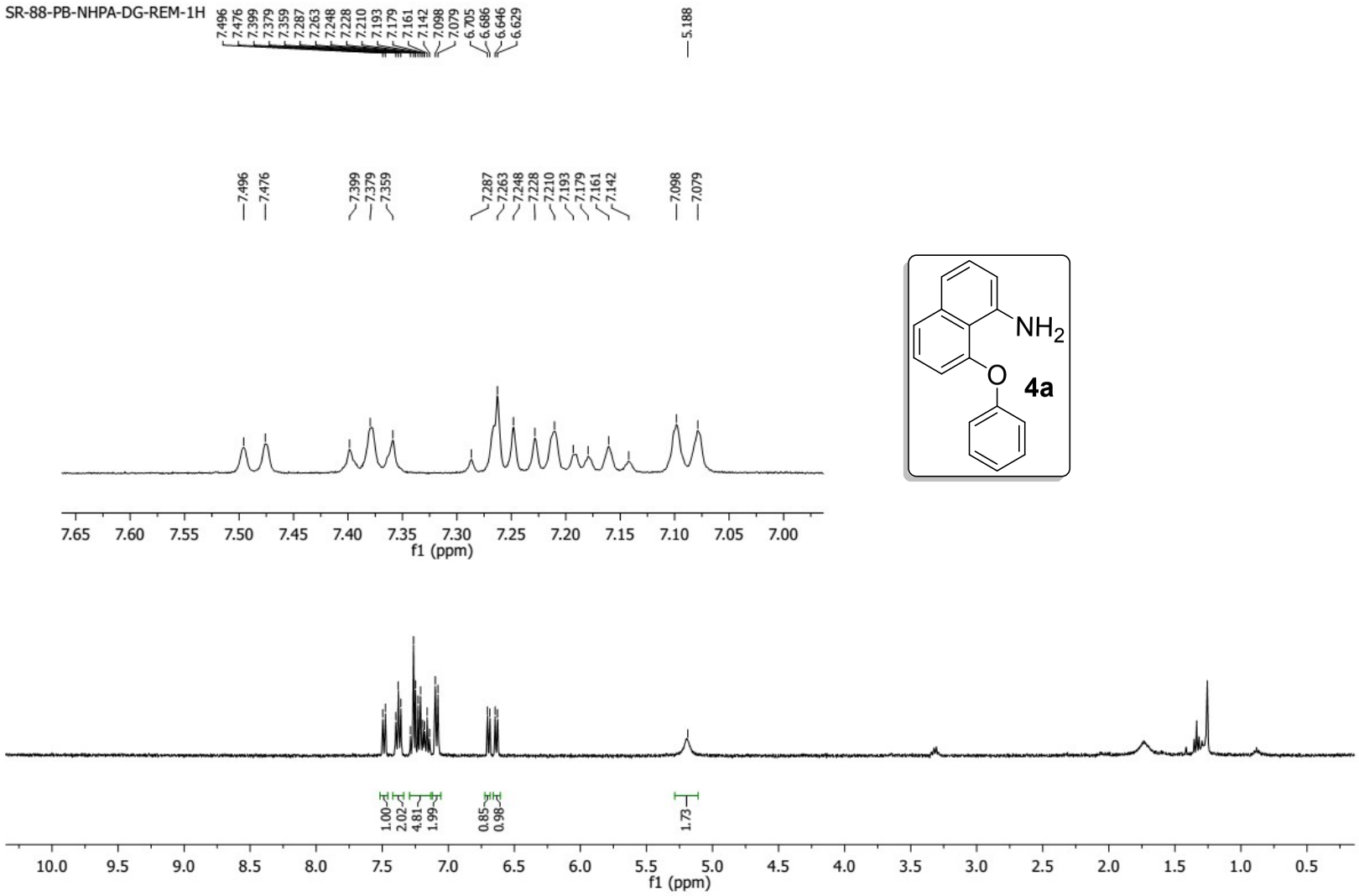

SR-104-PYRNHPA-PB-1H
13.205
9.461
9.447
8.159
8.146
8.135
8.120
7.890
7.878
7.864
7.815
7.800
7.745
7.732
7.720
7.701
7.689
7.680
7.311
7.299
7.260
7.220
7.207
7.106
f1 (ppm)
1.02
1.00
3.04
2.03
1.07
3.08
1.97
1.03
2.98
1.31
HN
N
O
O
3y

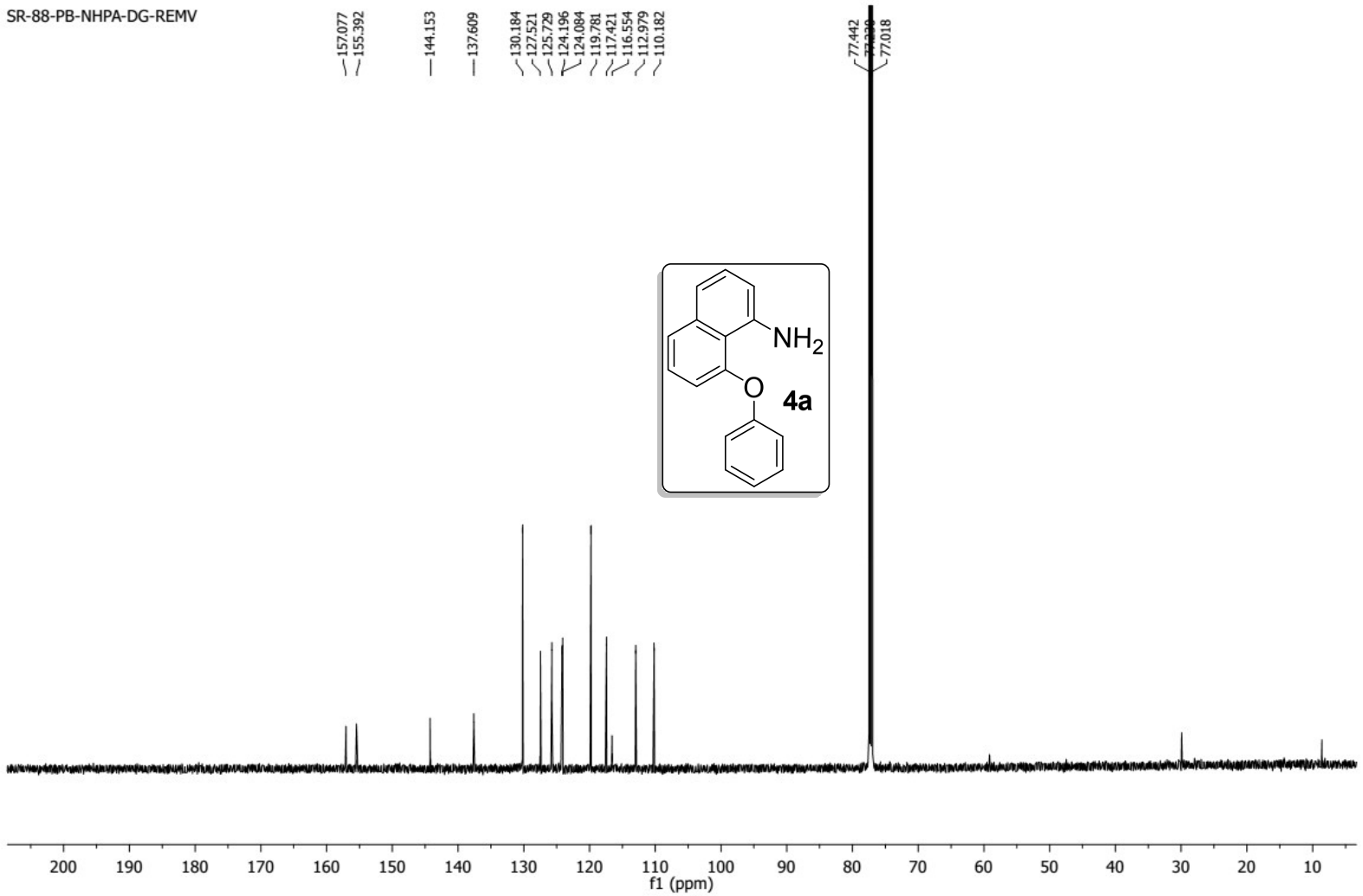

SR-104-PYRNHPA-PB-13C
162.779
156.261
154.008
150.781
147.980
137.558
133.788
131.857
131.470
130.068
127.986
127.768
127.466
127.415
126.618
126.375
126.278
124.607
124.150
123.423
122.693
122.445
120.829
119.180
114.850
112.326
77.442 CDCl3
77.230
77.019 CDCl3
O
HN
N
O
3y
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

SR-126-1H

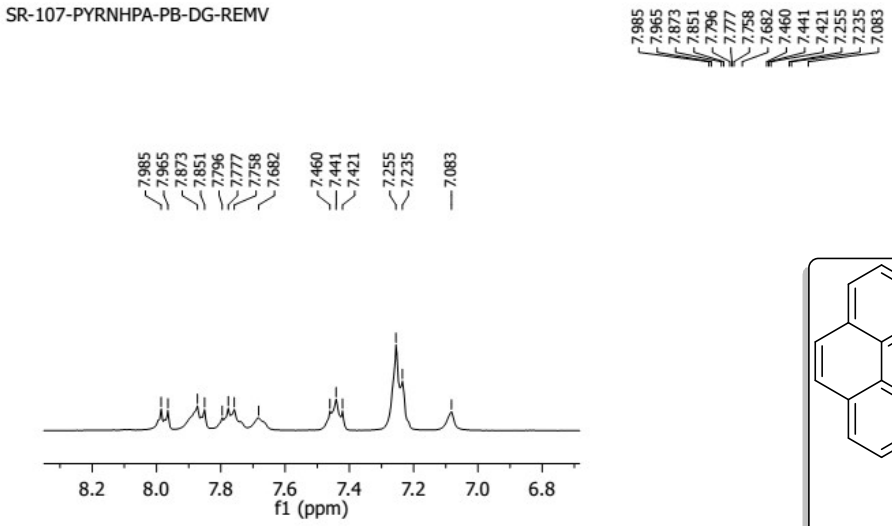

8.359
7.703
7.690
7.534
7.272
7.260
7.204
7.191
7.179
7.086
7.074
7.028
7.015
6.813
6.319
6.308
2.677
2.668
2.657
2.650
2.640
2.091
2.081
1.759
1.753
1.281
1.269
1.257
1.249
3z
1.16
1.00
1.05
1.06
1.17
1.08
4.41
1.92
0.96
2.04
1.05
3.03
1.12
f1 (ppm)

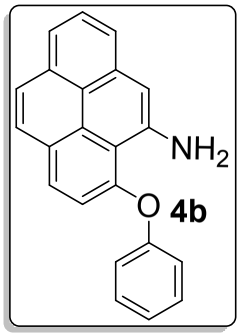

SR-126-13C
169.674
155.198
148.865
140.843
138.316
136.414
136.144
129.510
129.411
128.623
128.140
127.206
127.014
126.475
123.664
123.504
77.442
77.230
77.018
54.963
29.624
28.201
22.038
3z
f1 (ppm)

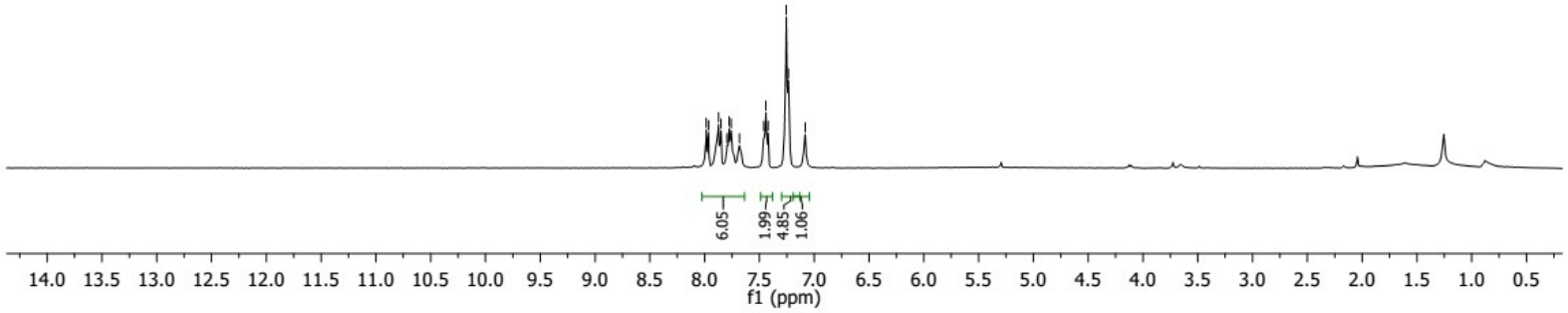

SR-88-PB-NHPA-DG-REM-1H
7.496
7.476
7.399
7.379
7.359
7.287
7.263
7.248
7.228
7.210
7.193
7.179
7.161
7.142
7.098
7.079
6.705
6.686
6.646
6.629
5.188
NH2
O
4a
f1 (ppm)
1.00
2.02
4.81
1.99
0.85
0.98
1.73

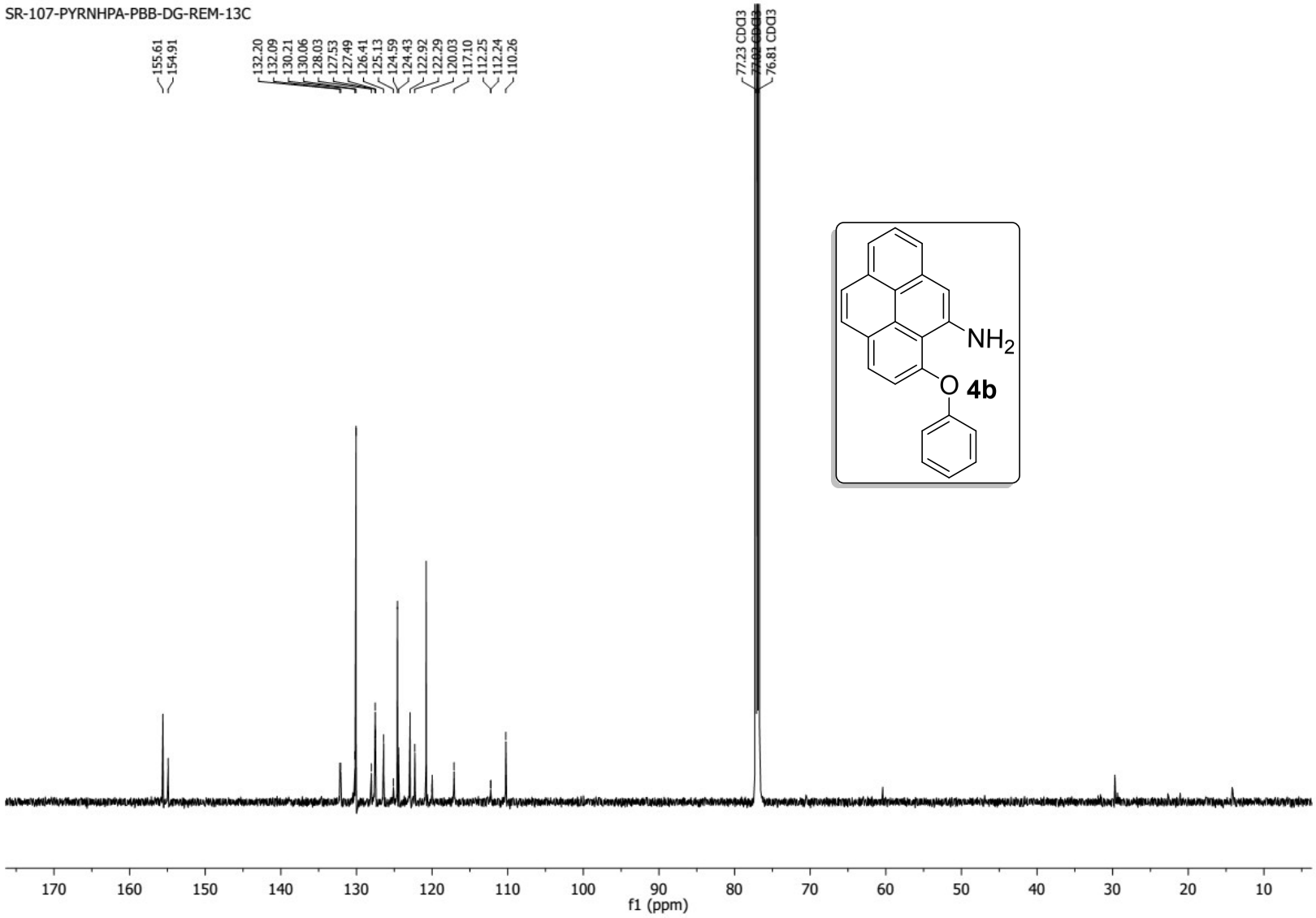

SR-88-PB-NHPA-DG-REMV
157.077
155.392
144.153
137.609
130.184
127.521
125.729
124.196
124.084
119.781
117.421
116.554
112.979
110.182
77.442
77.330
77.018
NH2
O
4a
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

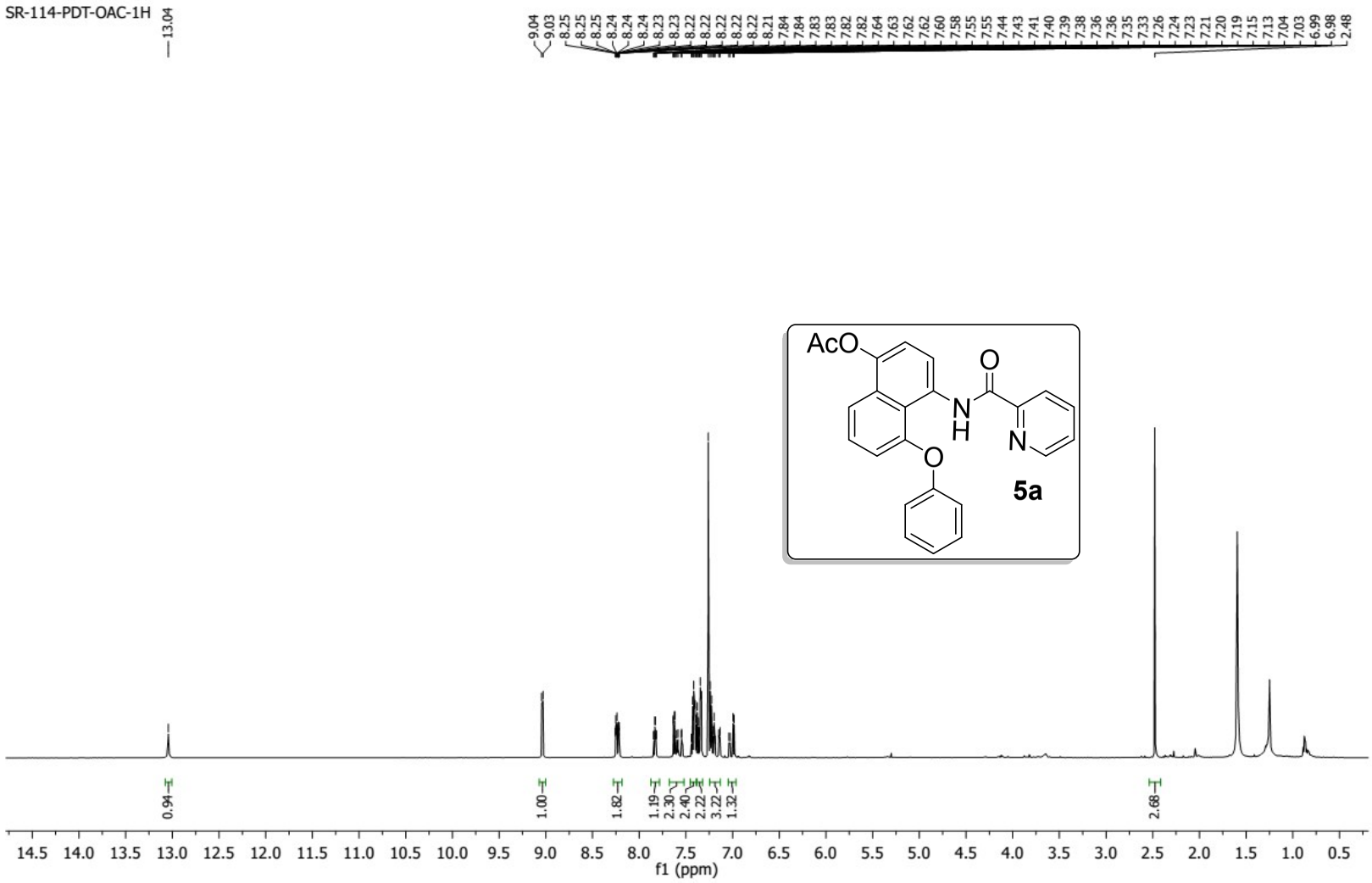
SR-107-PYRNHPA-PB-DG-REMV

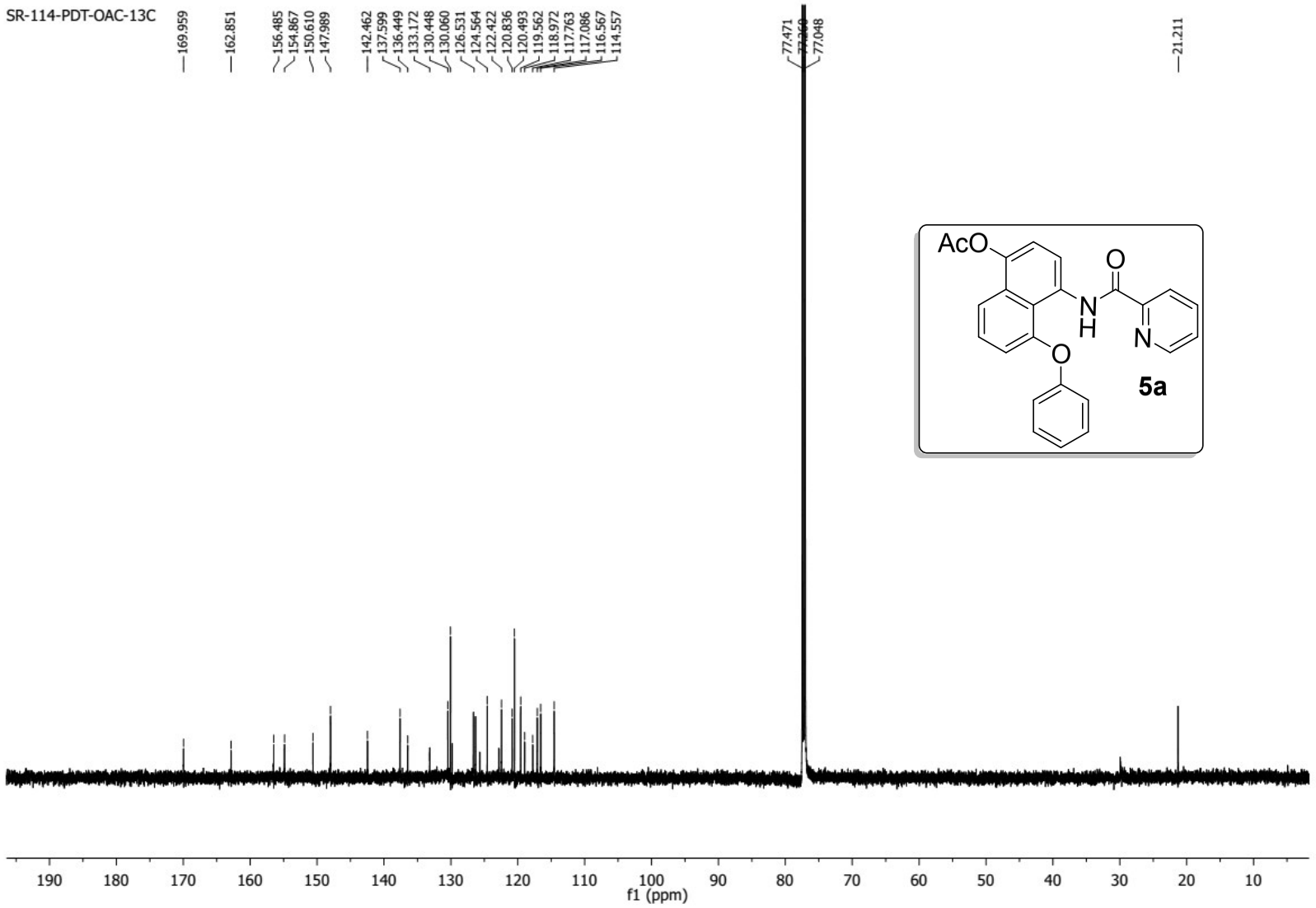


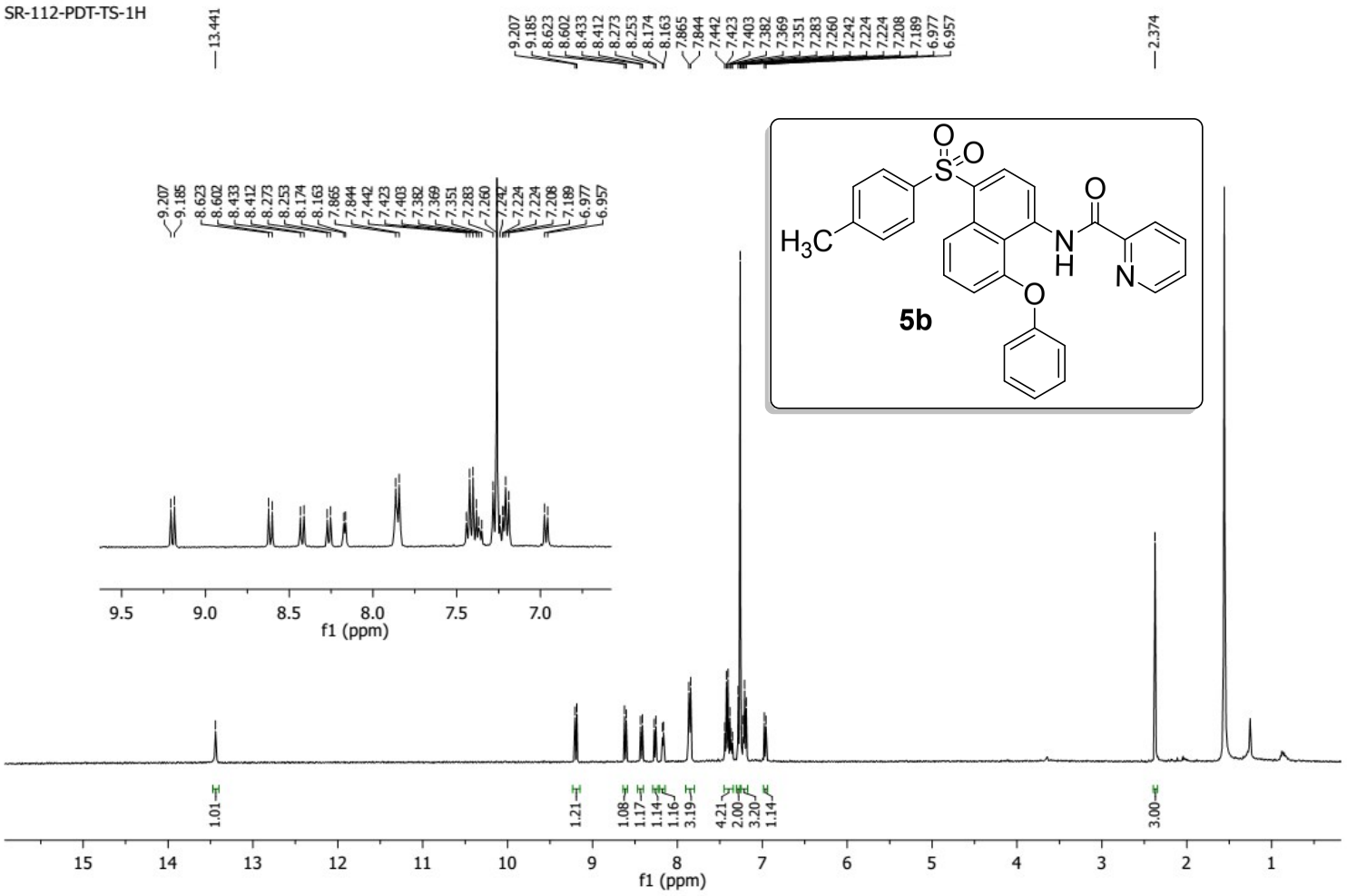


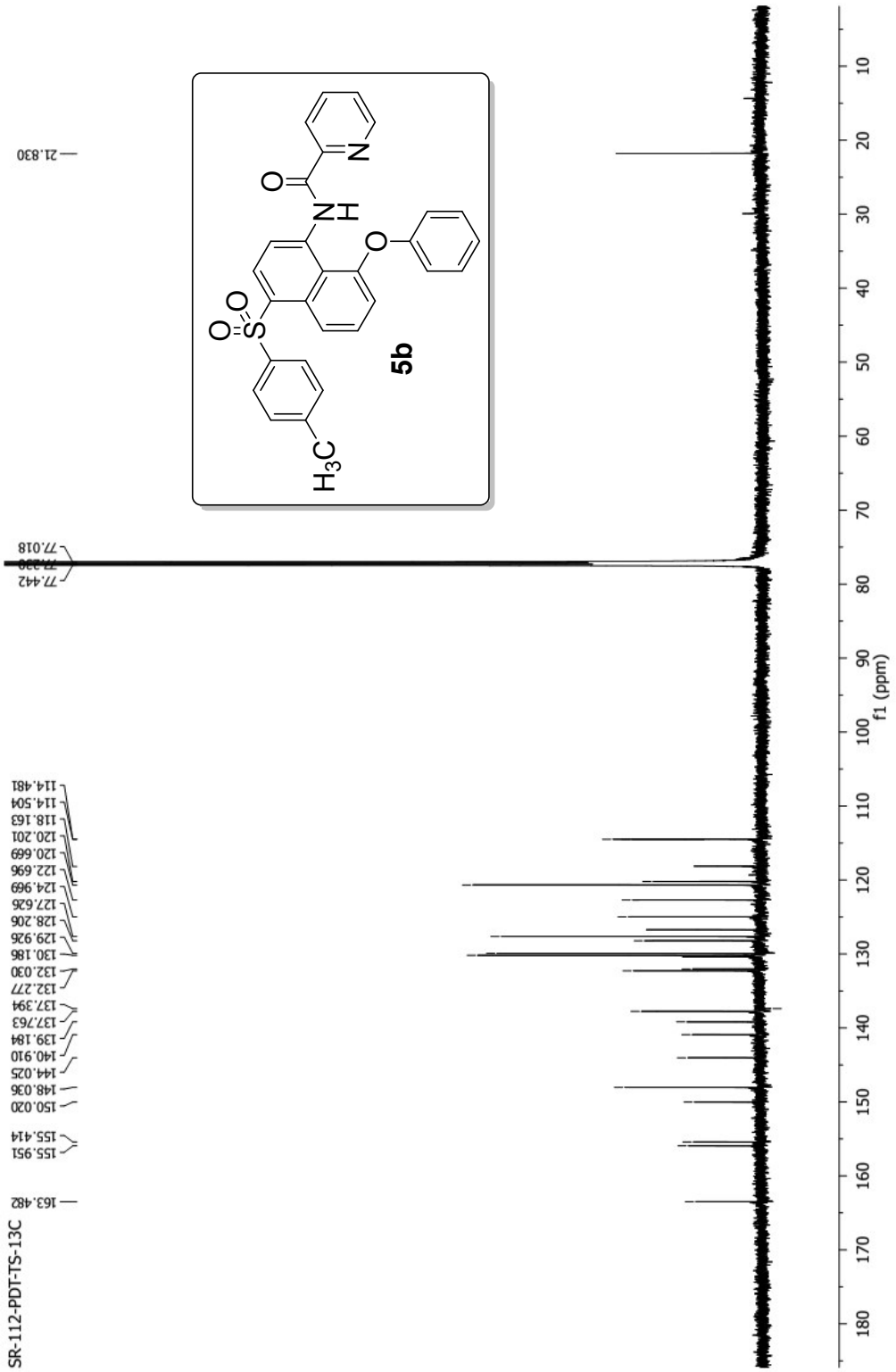


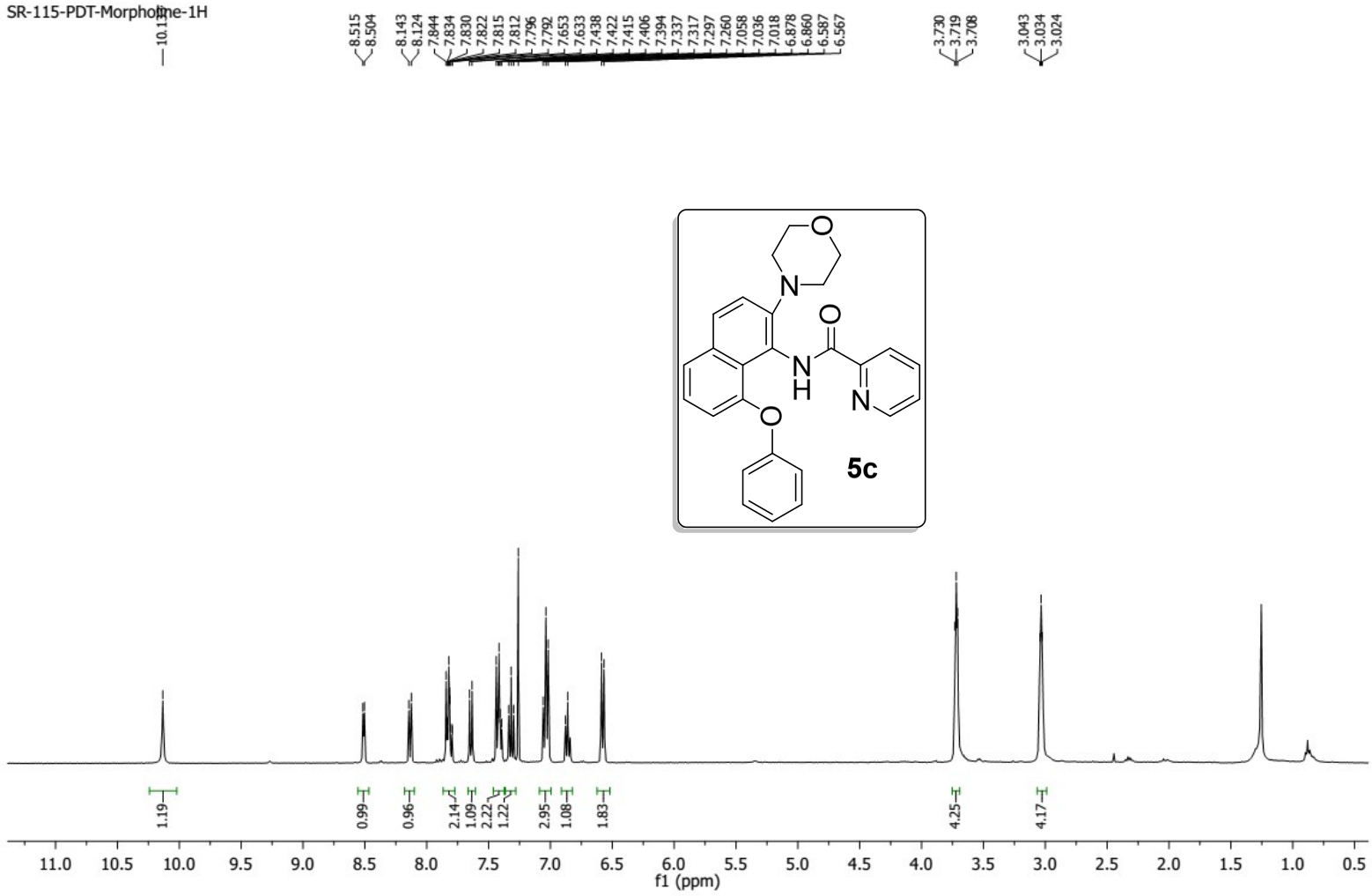

SR-107-PYRNHPA-PBB-DG-REM-13C
155.61
154.91
132.20
132.09
130.21
130.06
128.03
127.53
127.49
126.41
125.13
124.59
124.43
122.92
122.29
120.03
117.10
112.25
112.24
110.26
77.23 CDCl3
76.81 CDCl3
NH2
O
4b
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

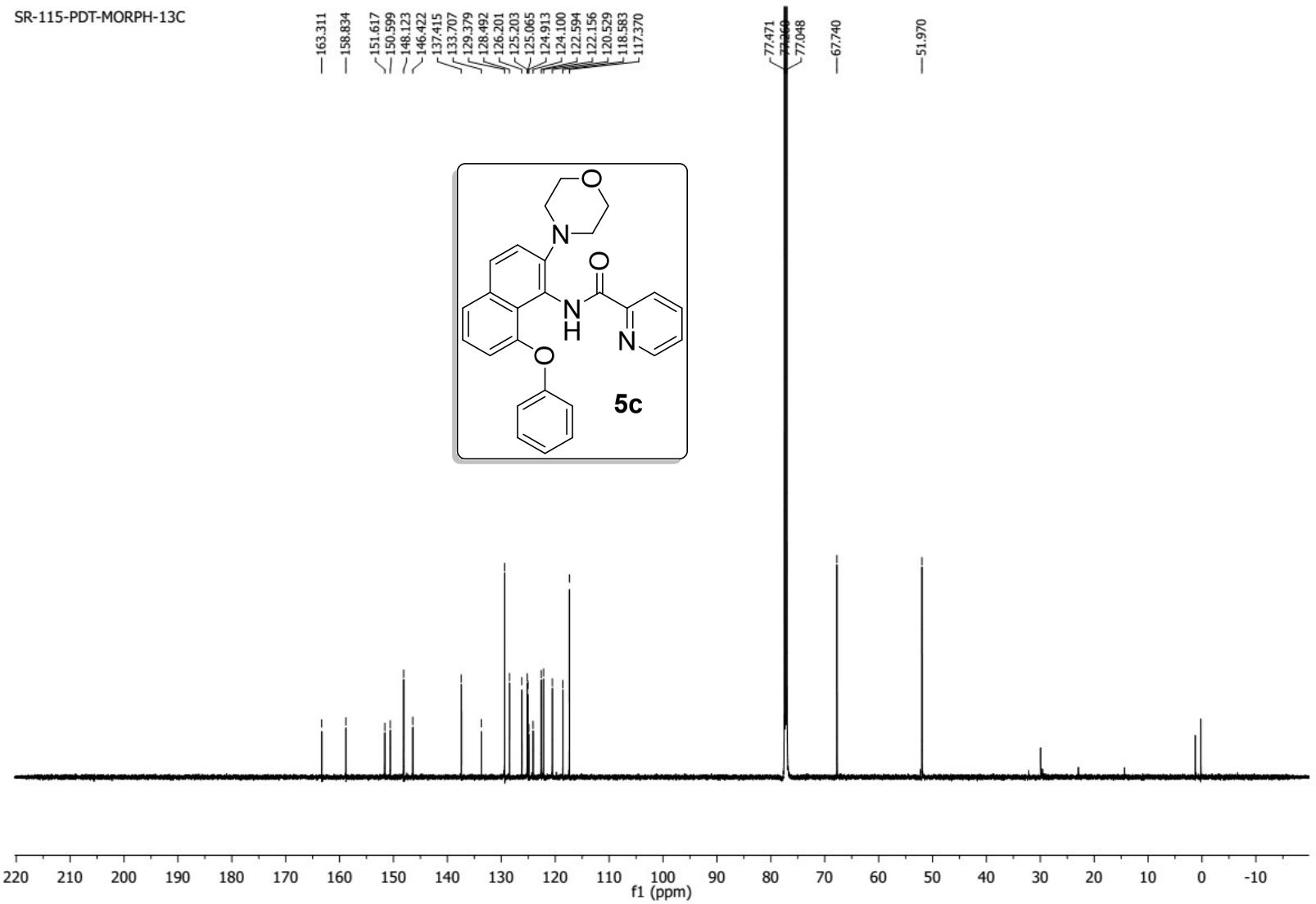

SR-114-PDT-OAC-1H
13.04
9.04
9.03
8.25
8.25
8.25
8.24
8.24
8.24
8.23
8.23
8.22
8.22
8.22
8.22
8.22
8.21
7.84
7.84
7.83
7.83
7.82
7.82
7.64
7.63
7.62
7.62
7.60
7.58
7.55
7.55
7.44
7.43
7.41
7.40
7.39
7.38
7.36
7.36
7.35
7.33
7.26
7.24
7.23
7.21
7.20
7.19
7.15
7.13
7.04
7.03
6.99
6.98
2.48
AcO
O
N
H
N
O
5a
0.94
1.00
1.82
1.19
2.30
2.40
2.22
3.22
1.32
2.68
14.5 14.0 13.5 13.0 12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)

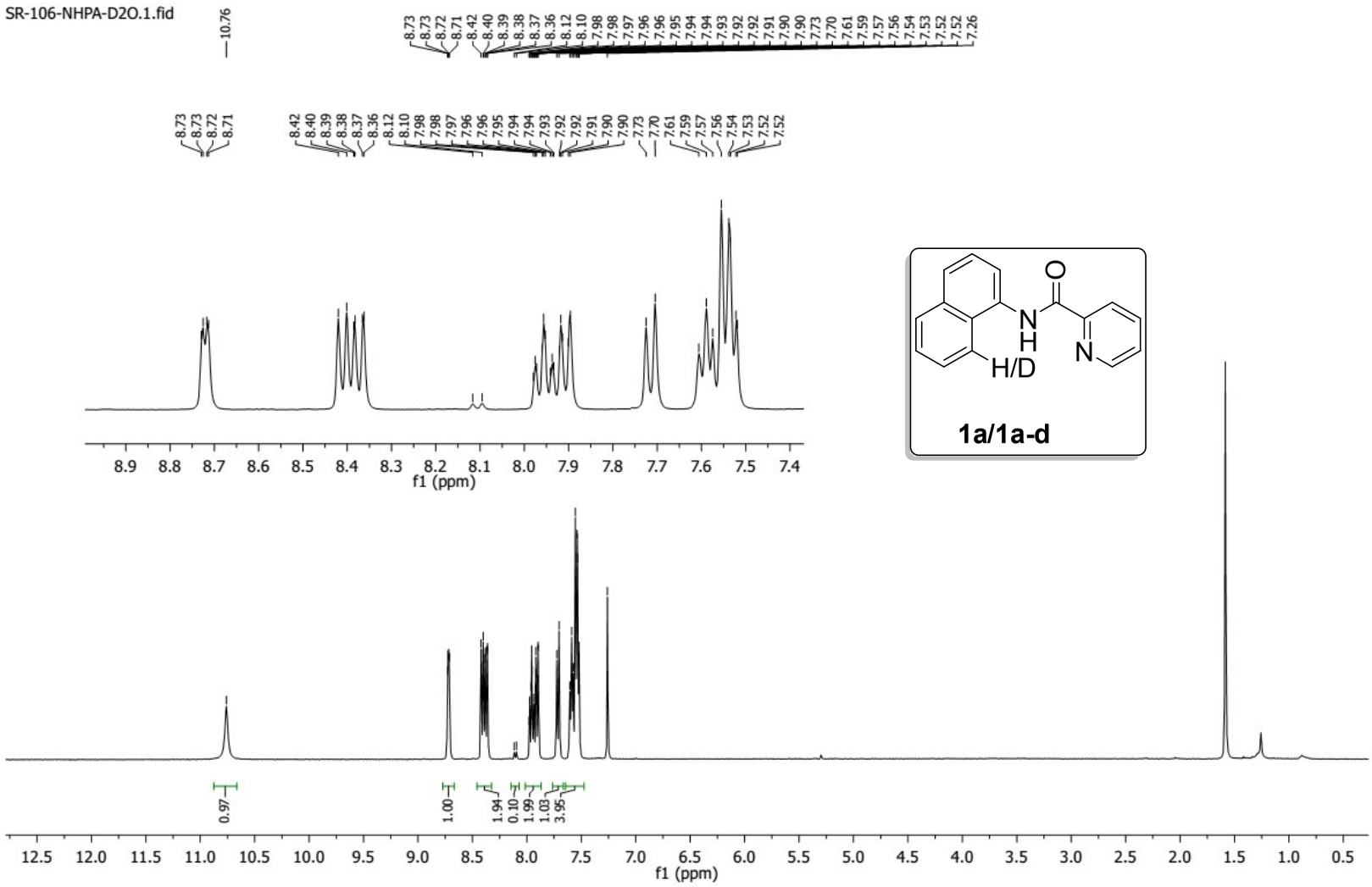

SR-114-PDT-OAC-13C
169.959
162.851
156.485
154.867
150.610
147.989
142.462
137.599
136.449
133.172
130.448
130.060
126.531
124.564
122.422
120.836
120.493
119.562
118.972
117.763
117.086
116.567
114.557
77.471
77.360
77.048
21.211
AcO
O
N
H
N
O
5a
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

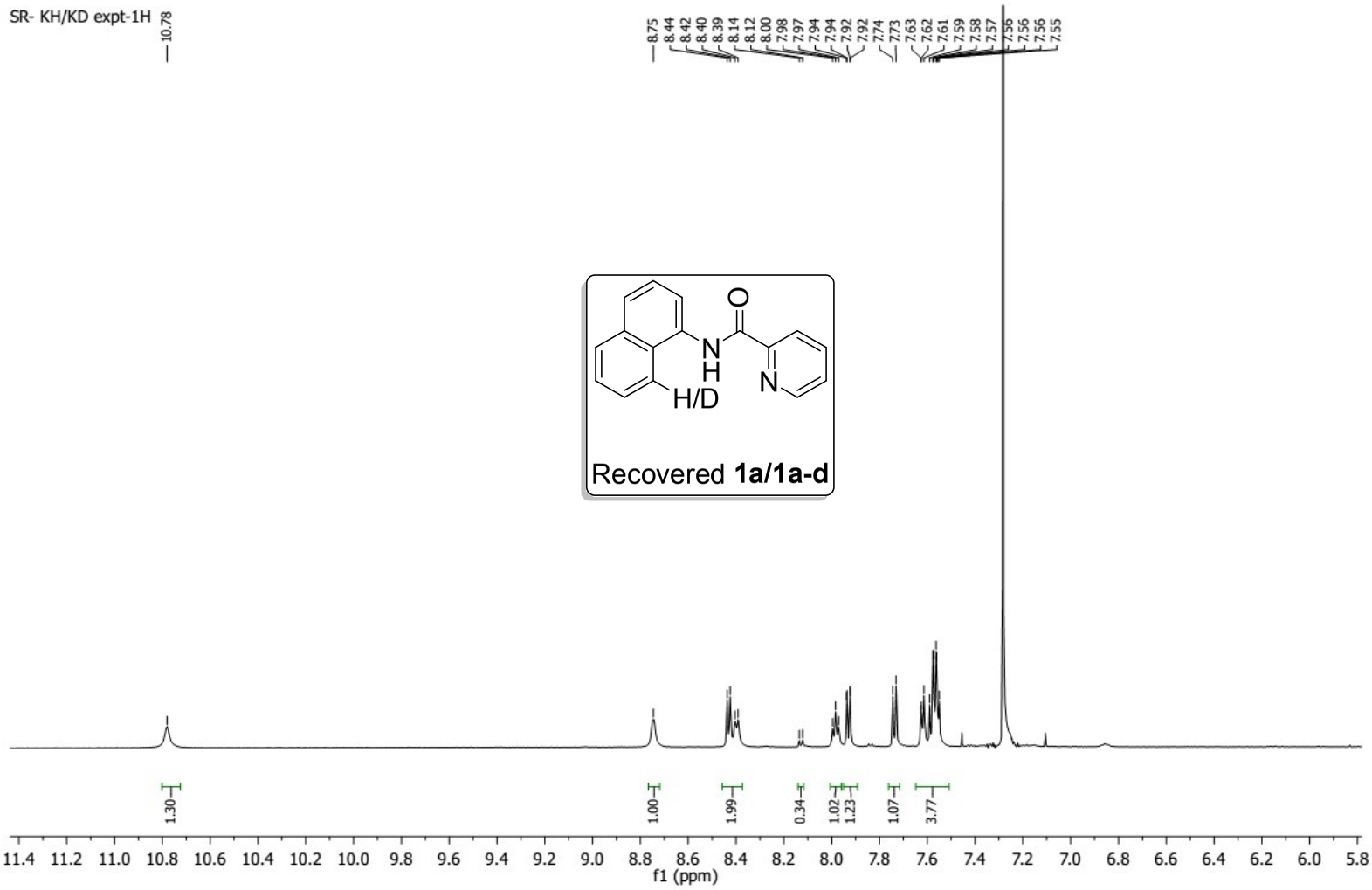

SR-112-PDT-TS-1H
13.441
9.207
9.185
8.623
8.602
8.433
8.412
8.273
8.253
8.174
8.163
7.865
7.844
7.442
7.423
7.403
7.382
7.369
7.351
7.283
7.260
7.242
7.224
7.224
7.208
7.189
6.977
6.957
2.374
5b
f1 (ppm)
1.01
1.21
1.08
1.17
1.14
1.16
3.19
4.21
2.00
3.20
1.14
3.00


SR-112-PDT-TS-13C
163.482
155.951
155.414
150.020
148.036
144.025
140.910
139.184
137.763
137.394
132.277
132.030
130.186
129.926
128.206
127.626
124.969
122.696
120.669
120.201
118.163
114.504
114.481
77.442
77.018
21.830
5b
f1 (ppm)


SR-115-PDT-Morpholine-1H
10.131
8.515
8.504
8.143
8.124
7.844
7.834
7.830
7.822
7.815
7.812
7.796
7.792
7.653
7.633
7.438
7.422
7.415
7.406
7.394
7.337
7.317
7.297
7.260
7.058
7.036
7.018
6.878
6.860
6.587
6.567
3.730
3.719
3.708
3.043
3.034
3.024
5c
1.19
0.99
0.96
2.14
1.09
2.22
1.22
2.95
1.08
1.83
4.25
4.17
f1 (ppm)


SR-115-PDT-MORPH-13C
163.311
158.834
151.617
150.599
148.123
146.422
137.415
133.707
129.379
128.492
126.201
125.203
125.065
124.913
124.100
122.594
122.156
120.529
118.583
117.370
77.471
77.260
77.048
67.740
51.970
5c
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


SR-106-NHPA-D2O.1.fid
10.76
8.73
8.73
8.72
8.71
8.42
8.40
8.39
8.38
8.37
8.36
8.12
8.10
7.98
7.98
7.97
7.96
7.96
7.95
7.94
7.94
7.93
7.92
7.92
7.91
7.90
7.90
7.73
7.70
7.61
7.59
7.57
7.56
7.54
7.53
7.52
7.52
7.26
f1 (ppm)
O
N
H
N
H/D
1a/1a-d
0.97
1.00
1.94
0.10
1.99
1.03
3.95
f1 (ppm)


SR- KH/KD expt-1H
10.78
8.75
8.44
8.42
8.40
8.39
8.14
8.12
8.00
7.98
7.97
7.94
7.94
7.92
7.92
7.74
7.73
7.63
7.62
7.61
7.59
7.58
7.57
7.56
7.56
7.56
7.55
O
N
H
H/D
N
Recovered 1a/1a-d
1.30
1.00
1.99
0.34
1.02
1.23
1.07
3.77
11.4 11.2 11.0 10.8 10.6 10.4 10.2 10.0 9.8 9.6 9.4 9.2 9.0 8.8 8.6 8.4 8.2 8.0 7.8 7.6 7.4 7.2 7.0 6.8 6.6 6.4 6.2 6.0 5.8
f1 (ppm)