Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Cobalt-Catalyzed C(sp^2)-H Bond Imination of Phenylalanine Derivatives

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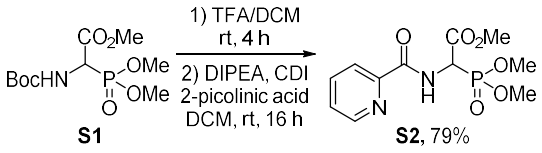
General considerations

Reactions were performed using standard glassware or were run in 4 mL vials with PTFE/liner screw caps and 30 mL vials using w/polyseal screw caps. Reactions were heated using Chemglass aluminum reaction blocks. Column chromatography was performed using Kieselgel silicagel (35 – 70 and 60 – 200 μm). Thin layer chromatography (TLC) was performed on silica gel using Merck TLC Silica gel 60 F254 aluminum sheets and was visualized by UV lamp, staining with $KMnO_4$. ^{1}H, ^{13}C and ^{19}F spectra were recorded on 400 MHz or 600 MHz Bruker spectrometers using residual solvent peak as a reference. Compounds for HRMS were analyzed by positive mode electrospray ionization (ESI) using Waters Synapt G2-Si mass spectrometer. IR spectra were obtained using a Shimadzu IR Prestige-21 FT-IR spectrometer. All procedures were performed under ambient air unless otherwise noted. Reagents and starting materials were obtained from commercial sources and used without further purification unless otherwise noted.

1. Substrate synthesis

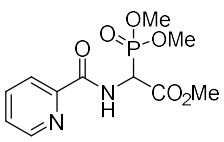
1.1. Synthesis of substrate S2

Methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** was synthesized in two steps from commercially available **S1** (Scheme S-1). First step involved the removal of Boc protecting group followed by installation of picolinamide directing group.



Scheme S-1. Synthesis of **S2**

Methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate (S2)



Step 1: To a solution of Boc-protected phosphonate **S1** (3.00 g, 10.1 mmol, 1.00 equiv) in dry DCM (25 mL), TFA (3.9 mL, 50.5 mmol, 5.00 equiv) was added. The reaction mixture was further stirred for 4 h at room temperature. The solvent was then evaporated under reduced pressure and the crude product was redissolved in Et_2O (30 mL). This cycle was repeated 3 times to obtain the white solid.

Step 2: 2-Picolinic acid (1.37 g, 11.10 mmol, 1.10 equiv) and CDI (1.80 g, 11.10 mmol, 1.10 equiv) were dissolved in dry DCM (25 mL) and were stirred for 1 h at room temperature. The crude solid form the previous step was dissolved in dry DCM (20 mL), DIPEA (5.24 mL, 30.28 mmol, 3.00 equiv) was slowly added, and the resulting solution was slowly added to the reaction mixture. The reaction mixture was further stirred for 16 h at room temperature and solvent was evaporated under reduced pressure. Product was purified by column chromatography (eluent: EtOAc) to obtain methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (2.41 g, 79%) as a colourless oil. R_f = 0.15 (EtOAc).

^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.76 (d, *J* = 9.4 Hz, 1H), 8.61 (ddd, *J* = 4.7, 1.7, 0.9 Hz, 1H), 8.16 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.85 (td, *J* = 7.7, 1.7 Hz, 1H), 7.46 (ddd, *J* = 7.6, 4.7, 1.2 Hz, 1H), 5.49 – 5.36 (m, 1H), 3.91 – 3.79 (m, 9H).

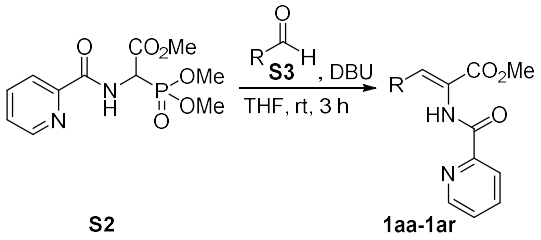
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 167.0 (d, *J* = 1.9 Hz), 164.0 (d, *J* = 5.3 Hz), 148.7, 148.5, 137.4, 126.8, 122.5, 54.3 (d, *J* = 6.4 Hz), 54.1 (d, *J* = 6.8 Hz), 53.4, 50.3 (d, *J* = 147.4 Hz).

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{11}H_{16}N_2O_6P$ 303.0746; Found 303.0748.

FT-IR (thin film, cm^{-1}) υ 3387, 2960, 2856, 1750, 1508, 1465, 1436, 1329, 1265, 1165, 1031.

1.2. Synthesis of substrates 1aa-1ar

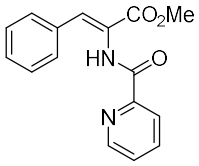
α,β-Unsaturated amino acid derivatives **1aa-1ar** were synthesized in one step from methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2**, employing Horner-Wadsworth-Emmons olefination with different aldehydes **S3** (Scheme **S-2**).



Scheme S-2. Synthesis of *α,β*-unsaturated amino acids **1aa-1ar**

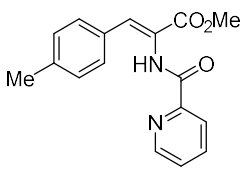
*General procedure for the preparation of α,β-unsaturated amino acid derivatives **1aa-1ar**.*
DBU was (1.50 equiv) dropwise added to a solution of methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (1.00 equiv) in dry THF at room temperature. The reaction mixture was stirred for 15 min. Aldehyde **S3** (1.20 equiv) solution in dry THF was added via cannula to the initial mixture and the resulting solution was stirred at room temperature until the consumption of starting material was observed by TLC. The resulting reaction mixture was concentrated under reduced pressure. Product was further purified by column chromotography (eluent petroleum ether/EtOAc system) to obtain enamines **1aa-1ar**.

Methyl (*Z*)-3-phenyl-2-(picolinamido)acrylate (1aa)



Prepared by the general procedure from benzaldehyde (242 µL, 2.38 mmol), DBU (445 µL, 2.98 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (600 mg, 1.99 mmol), THF (8 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1aa** (330 mg, 59%) was obtained as a colorless oil.
This compound is known.[1]
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.71 (s, 1H), 8.61 (ddd, *J* = 4.7, 1.6, 0.9 Hz, 1H), 8.20 (dt, *J* = 7.8, 1.0 Hz, 1H), 7.87 (td, *J* = 7.7, 1.7 Hz, 1H), 7.56 – 7.52 (m, 2H), 7.50 – 7.45 (m, 2H), 7.36 – 7.29 (m, 3H), 3.87 (s, 3H).

Methyl (*Z*)-2-(picolinamido)-3-(*p*-tolyl)acrylate (1ab)



Prepared by the general procedure from 4-methyl benzaldehyde (291 µL, 2.38 mmol), DBU (445 µL, 2.98 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (600 mg, 1.99 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1ab** (477 mg, 81%) was obtained as a colorless oil. R_f = 0.45 (EtOAc/PE = 1/1).

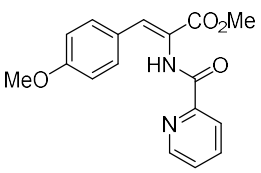
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.68 (s, 1H), 8.63 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.22 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.88 (td, *J* = 7.7, 1.7 Hz, 1H), 7.49 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 7.46 (d, *J* = 2.8 Hz, 2H), 7.43 (t, *J* = 1.0 Hz, 1H), 7.18 – 7.11 (m, 2H), 3.87 (s, 3H), 2.34 (s, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.8, 162.6, 149.3, 148.3, 139.8, 137.5, 132.3, 131.0, 129.9, 129.4, 126.6, 123.3, 122.8, 52.7, 21.5.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{17}H_{17}N_2O_3$ 297.1239; Found 297.1242.

FT-IR (thin film, cm^{-1}) υ 3344, 2951, 1722, 1684, 1641, 1490, 1436, 1320, 1291, 1265, 1185, 1147, 1088.

Methyl (*Z*)-3-(4-methoxyphenyl)-2-(picolinamido)acrylate (1ac)



Prepared by the general procedure from 4-methoxy benzaldehyde (362 μL, 2.38 mmol), DBU (445 μL, 2.98 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (600 mg, 1.99 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1ac** (609 mg, 98%) was obtained as a colorless oil. R_f = 0.53 (EtOAc/PE = 1/1).

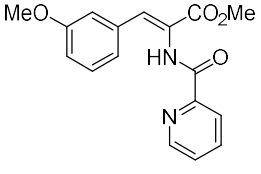
^{1}H-NMR (600 MHz, $CDCl_3$, ppm) δ 9.63 (s, 1H), 8.65 – 8.60 (m, 1H), 8.22 (dt, *J* = 7.9, 1.1 Hz, 1H), 7.87 (td, *J* = 7.7, 1.7 Hz, 1H), 7.54 – 7.45 (m, 4H), 6.89 – 6.82 (m, 2H), 3.85 (s, 3H), 3.79 (s, 3H).

^{13}C-NMR (151 MHz, $CDCl_3$, ppm) δ 165.8, 162.7, 160.6, 149.3, 148.4, 137.5, 132.7, 131.8, 126.6, 126.4, 122.8, 121.9, 114.1, 55.3, 52.6.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{17}H_{17}N_2O_4$ 313.1188; Found 313.1190.

FT-IR (thin film, cm^{-1}) υ 3341, 3012, 2951, 2839, 1720, 1692, 1638, 1605, 1570, 1512, 1489, 1464, 1436, 1320, 1256, 1178, 1088.

Methyl (*Z*)-3-(3-methoxyphenyl)-2-(picolinamido)acrylate (1ad)



Prepared by the general procedure from 3-methoxy benzaldehyde (362 μL, 2.38 mmol), DBU (445 μL, 2.98 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (600 mg, 1.99 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1ad** (613 mg, 99%) was obtained as a colorless oil. R_f = 0.45 (EtOAc/PE = 1/1).

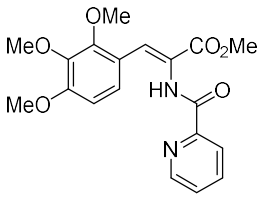
^{1}H-NMR (600 MHz, $CDCl_3$, ppm) δ 9.73 (s, 1H), 8.63 (ddd, *J* = 4.7, 1.7, 0.9 Hz, 1H), 8.23 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.90 (td, *J* = 7.7, 1.7 Hz, 1H), 7.50 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 7.42 (s, 1H), 7.30 – 7.25 (m, 1H), 7.17 – 7.11 (m, 2H), 6.89 (ddd, *J* = 8.3, 2.6, 1.0 Hz, 1H), 3.90 (s, 3H), 3.71 (s, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.5, 162.6, 159.6, 149.1, 148.3, 137.6, 135.1, 131.6, 129.6, 126.7, 124.6, 122.8, 122.5, 115.8, 114.3, 55.1, 52.7.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{17}H_{17}N_2O_4$ 313.1188; Found 313.1195.

FT-IR (thin film, cm^{-1}) υ 3341, 2995, 2953, 2836, 1722, 1685, 1638, 1576, 1491, 1465, 1435, 1299, 1272, 1427, 1163, 1088, 1041.

Methyl (*Z*)-2-(picolinamido)-3-(2,3,4-trimethoxyphenyl)acrylate (1ae)



Prepared by the general procedure from 2,3,4-trimethoxy benzaldehyde (420 mg, 2.14 mmol), DBU (399 μL, 2.68 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (539 mg, 1.78 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1ae** (543 mg, 82%) was obtained as a colorless oil. R_f = 0.34 (EtOAc/PE = 1/1).

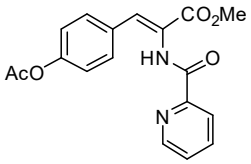
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.87 (s, 1H), 8.60 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.19 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.85 (td, *J* = 7.7, 1.7 Hz, 1H), 7.58 (d, *J* = 0.6 Hz, 1H), 7.46 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 7.26 (dd, *J* = 8.8, 0.7 Hz, 1H), 6.61 (d, *J* = 8.8 Hz, 1H), 3.94 (s, 3H), 3.88 (d, *J* = 3.1 Hz, 6H), 3.84 (s, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.8, 162.6, 154.7, 152.7, 149.4, 148.3, 142.2, 137.4, 126.5, 126.0, 124.6, 124.1, 122.7, 120.9, 107.4, 61.9, 61.0, 56.0, 52.6.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{19}H_{21}N_2O_6$ 373.1400; Found 373.1412.

FT-IR (thin film, cm^{-1}) υ 3344, 3004, 2949, 2841, 2593, 1722, 1689, 1638, 1592, 1570, 1497, 1463, 1435, 1414, 1374, 1305, 1281, 1252, 1233, 1148, 1098, 1044.

Methyl (*Z*)-3-(4-acetoxyphenyl)-2-(picolinamido)acrylate (1af)



Prepared by the general procedure from 4-acetoxybenzaldehyde (251 μL, 1.79 mmol), DBU (333 μL, 2.23 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (450 mg, 1.49 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/4 to 1/2) product **1af** (435 mg, 86%) was obtained as a colorless oil. R_f = 0.33 (EtOAc/PE = 1/1).

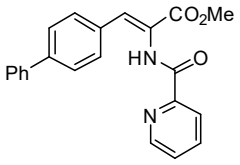
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.69 (s, 1H), 8.62 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.21 (dt, *J* = 7.9, 1.1 Hz, 1H), 7.89 (td, *J* = 7.7, 1.7 Hz, 1H), 7.61 – 7.52 (m, 2H), 7.49 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 7.45 (s, 1H), 7.12 – 7.04 (m, 2H), 3.87 (s, 3H), 2.28 (s, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 169.1, 165.5, 162.7, 151.2, 149.1, 148.4, 137.6, 131.5, 131.1, 126.8, 124.3, 122.8, 121.8, 52.8, 21.2.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{18}H_{17}N_2O_5$ 341.1137; Found 341.1141.

FT-IR (thin film, cm^{-1}) υ 3345, 3060, 3018, 2953, 2853, 1768, 1722, 1691, 1644, 1601, 1591, 1507, 1489, 1465, 1435, 1369, 1314, 1283, 1266, 1201, 1168, 1096, 1016.

Methyl (*Z*)-3-([1,1'-biphenyl]-4-yl)-2-(picolinamido)acrylate (1ag)



Prepared by the general procedure from [1,1'-biphenyl]-4-carbaldehyde (326 mg, 1.79 mmol), DBU (333 μL, 2.23 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (450 mg, 1.49 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/4 to 1/2) product **1ag** (462 mg, 87%) was obtained as a white solid. R_f = 0.55 (EtOAc/PE = 1/1), mp 129 – 131 ^oC (Et_2O).

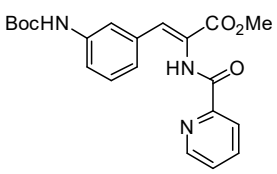
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.77 (s, 1H), 8.64 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.23 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.89 (td, *J* = 7.7, 1.7 Hz, 1H), 7.68 – 7.55 (m, 6H), 7.54 – 7.47 (m, 2H), 7.46 – 7.39 (m, 2H), 7.38 – 7.31 (m, 1H), 3.90 (s, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.7, 162.6, 149.2, 148.4, 142.1, 140.3, 137.6, 132.9, 131.7, 130.4, 128.8, 127.7, 127.3, 127.1, 126.7, 124.0, 122.8, 52.8.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{22}H_{19}N_2O_3$ 359.1396; Found 359.1394.

FT-IR (thin film, cm^{-1}) υ 3341, 3057, 3028, 2951, 1724, 1674, 1638, 1488, 1434, 1372, 1321, 1290, 1264.

Methyl (*Z*)-3-(3-((*tert*-butoxycarbonyl)amino)phenyl-2-(picolinamido)acrylate (1ah)



Prepared by the general procedure from *tert*-butyl (3-formylphenyl)carbamate (273 mg, 1.23 mmol), DBU (230 μL, 1.54 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (310 mg, 1.03 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/4 to 1/2) product **1ah** (350 mg, 86%) was obtained as a yellow-colored amorphous solid. R_f = 0.51 (EtOAc/PE = 1/1).

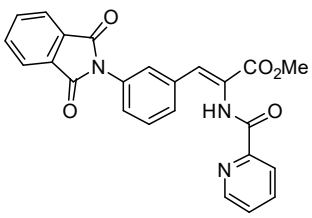
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.71 (s, 1H), 8.62 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.20 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.86 (td, *J* = 7.7, 1.7 Hz, 1H), 7.59 (s, 1H), 7.47 (ddd, *J* = 7.6, 4.8, 1.3 Hz, 1H), 7.42 (s, 1H), 7.33 – 7.17 (m, 3H), 6.51 (s, 1H), 3.87 (s, 3H), 1.43 (s, 9H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 160.8, 157.9, 147.8, 144.5, 143.5, 134.0, 132.7, 129.8, 127.0, 124.4, 121.8, 119.8, 119.5, 118.0, 115.0, 114.7, 75.9, 48.0, 23.5.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{21}H_{24}N_3O_5$ 398.1716; Found 398.1703.

FT-IR (thin film, cm^{-1}) υ 3334, 2980, 1722, 1685, 1588, 1543, 1495, 1436, 1368, 1237, 1160, 1053.

Methyl (*Z*)-3-(3-(1,3-dioxoisoindolin-2-yl)phenyl)-2-(picolinamido)acrylate (1ai)



Prepared by the general procedure from 3-(1,3-dioxoisoindolin-2-yl)benzaldehyde (269 mg, 1.07 mmol), DBU (200 μL, 1.34 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (270 mg, 0.89 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/4 to 1/1) product **1ai** (323 mg, 85%) was obtained as a white solid. R_f = 0.31 (EtOAc/PE = 1/1), mp 149 – 151 °C (Et_2O).

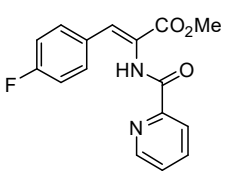
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.78 (s, 1H), 8.61 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.21 (dt, *J* = 7.9, 1.1 Hz, 1H), 7.96 – 7.81 (m, 3H), 7.80 – 7.72 (m, 2H), 7.64 – 7.55 (m, 2H), 7.52 – 7.38 (m, 4H), 3.88 (s, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 166.9, 165.4, 162.7, 149.1, 148.3, 137.5, 135.0, 134.5, 132.1, 131.7, 130.4, 129.3, 128.8, 127.8, 127.1, 126.6, 125.3, 123.8, 122.8, 52.8.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{24}H_{18}N_3O_5$ 428.1246; Found 428.1253.

FT-IR (thin film, cm^{-1}) υ 3334, 3022, 2954, 1779, 1723, 1699, 1490, 1436, 1374, 1293, 1265, 1234, 1192, 1147, 1111, 1081.

Methyl (*Z*)-3-(4-fluorophenyl)-2-(picolinamido)acrylate (1aj)



Prepared by the general procedure from 4-fluorobenzaldehyde (259 μL, 2.42 mmol), DBU (450 μL, 3.02 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (608 mg, 2.01 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/4 to 1/1) product **1aj** (397 mg, 66%) was obtained as a colorless oil. R_f = 0.61 (EtOAc/PE = 1/1).

^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.72 (s, 1H), 8.64 (ddd, *J* = 4.8, 1.8, 1.0 Hz, 1H), 8.21 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.90 (td, *J* = 7.7, 1.7 Hz, 1H), 7.58 – 7.42 (m, 4H), 7.07 – 6.97 (m, 2H), 3.88 (s, 3H).

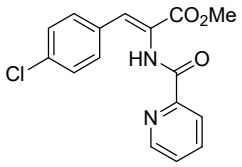
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.6, 163.0 (d, *J* = 251.0 Hz), 162.5, 149.0, 148.3, 137.7, 131.8 (d, *J* = 8.4 Hz), 131.0, 130.2 (d, *J* = 3.5 Hz), 126.8, 123.6 (d, *J* = 2.0 Hz), 122.9, 115.9, 115.7, 52.8.

^{19}F-NMR (376 MHz, $CDCl_3$, ppm) δ -110.08 – -110.20 (m).

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{16}H_{14}N_2O_3F$ 301.0988; Found 301.0983.

FT-IR (thin film, cm^{-1}) υ 3341, 2954, 1722, 1696, 1601, 1507, 1488, 1434, 1311, 1263, 1233, 1160.

Methyl (*Z*)-3-(4-chlorophenyl)-2-(picolinamido)acrylate (1ak)



Prepared by the general procedure from 4-chlorobenzaldehyde (360 mg, 2.56 mmol), DBU (478 μL, 3.20 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (645 mg, 2.13 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1ak** (547 mg, 81%) was obtained as a white solid. R_f = 0.64 (EtOAc/PE = 1/1), mp 96 – 98 ^oC (Et_2O).

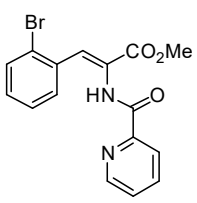
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.76 (s, 1H), 8.63 (ddd, J = 4.8, 1.7, 0.9 Hz, 1H), 8.19 (dt, J = 7.9, 1.1 Hz, 1H), 7.88 (td, J = 7.7, 1.7 Hz, 1H), 7.50 (ddd, J = 7.6, 4.8, 1.2 Hz, 1H), 7.47 – 7.42 (m, 3H), 7.34 – 7.27 (m, 2H), 3.88 (s, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.5, 162.4, 149.0, 148.4, 137.6, 135.2, 132.6, 131.0, 130.4, 128.9, 126.8, 124.3, 122.8, 52.8.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{16}H_{14}N_2O_3Cl$ 317.0693; Found 317.0696.

FT-IR (thin film, cm^{-1}) υ 3341, 3058, 2954, 1722, 1694, 1590, 1495, 1486, 1434, 1372, 1313, 1287, 1262, 1147, 1089.

Methyl (*Z*)-3-(2-bromophenyl)-2-(picolinamido)acrylate (1al)



Prepared by the general procedure from 2-bromo benzaldehyde (695 mg, 2.38 mmol), DBU (445 μL, 2.98 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (600 mg, 1.99 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/4 to 1/1) product **1al** (812 mg, 75%) was obtained as a colorless oil. R_f = 0.66 (EtOAc/PE = 1/1).

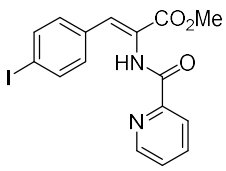
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.75 (s, 1H), 8.57 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.13 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.83 (td, *J* = 7.7, 1.7 Hz, 1H), 7.67 – 7.59 (m, 1H), 7.54 (s, 1H), 7.52 – 7.40 (m, 2H), 7.24 – 7.10 (m, 2H), 3.91 (s, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.3, 162.2, 149.0, 148.3, 137.5, 134.8, 133.0, 130.1, 129.6, 129.2, 127.2, 126.7, 125.8, 124.7, 122.7, 52.9.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{16}H_{14}N_2O_3Br$ 361.0188; Found 361.0192.

FT-IR (thin film, cm^{-1}) υ 3344, 3057, 2951, 1729, 1694, 1490, 1465, 1436, 1369, 1290, 1257, 1152.

Methyl (*Z*)-3-(4-iodophenyl)-2-(picolinamido)acrylate (1am)



Prepared by the general procedure from 4-iodobenzaldehyde (420 mg, 1.81 mmol), DBU (337 μL, 2.26 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (456 mg, 1.51 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1am** (546 mg, 89%) was obtained as a white solid. R_f = 0.63 (EtOAc/PE = 1/1), mp 143 – 145 °C (Et_2O).

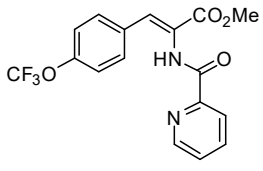
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.76 (s, 1H), 8.63 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.19 (dt, *J* = 7.9, 1.1 Hz, 1H), 7.88 (td, *J* = 7.7, 1.7 Hz, 1H), 7.71 – 7.62 (m, 2H), 7.50 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 7.38 (s, 1H), 7.26 – 7.21 (m, 2H), 3.88 (s, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.4, 162.3, 149.0, 148.4, 137.8, 137.6, 133.6, 131.2, 130.4, 126.8, 124.5, 122.8, 95.6, 52.9.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{16}H_{14}N_2O_3I$ 409.0049; Found 409.0060.

FT-IR (thin film, cm^{-1}) υ 3344, 3012, 2950, 1724, 1694, 1636, 1582, 1491, 1464, 1431, 1369, 1313, 1285, 1263, 1145, 1088, 1005.

Methyl (*Z*)-2-(picolinamido)-3-((4-trifluoromethoxy)phenyl)acrylate (1an)



Prepared by the general procedure from 4-trifluoromethoxy benzaldehyde (302 mg, 1.59 mmol), DBU (296 μL, 1.99 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (400 mg, 1.32 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/4 to 1/1) product **1an** (400 mg, 82%) was obtained as a white solid. R_f = 0.45 (EtOAc/PE = 1/2), mp 61 – 63 °C (Et_2O).

^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.76 (s, 1H), 8.63 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.19 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.89 (td, *J* = 7.7, 1.7 Hz, 1H), 7.58 – 7.53 (m, 2H), 7.50 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 7.46 (s, 1H), 7.17 (dq, *J* = 7.9, 1.1 Hz, 2H), 3.88 (s, 3H).

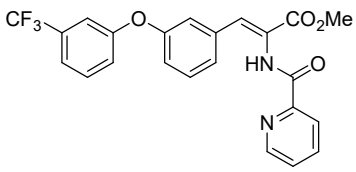
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.4, 162.5, 149.5 (q, *J* = 1.9 Hz), 149.0, 148.4, 137.6, 132.6, 131.3, 130.2, 126.8, 124.5, 122.8, 120.7, 120.4 (q, *J* = 257.9 Hz), 52.8.

^{19}F-NMR (376 MHz, $CDCl_3$, ppm) δ -57.64.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{17}H_{14}N_2O_4F_3$ 367.0906; Found 367.0914.

FT-IR (thin film, cm^{-1}) υ 3344, 2954, 1726, 1696, 1490, 1256, 1219, 1166.

Methyl (*Z*)-2-(picolinamido)-3-(3-(3-(trifluoromethyl)phenoxy)phenyl)acrylate (1ao)



Prepared by the general procedure from 3-(3-(trifluoromethyl)phenoxy)benzaldehyde (374 μL, 1.80 mmol), DBU (336 μL, 2.25 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (454 mg, 1.50 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1ao** (660 mg, 99%) was obtained as a colorless oil. R_f = 0.65 (EtOAc/PE = 1/1).

^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.72 (s, 1H), 8.55 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.14 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.86 (td, *J* = 7.7, 1.7 Hz, 1H), 7.47 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 7.42 (s, 1H), 7.38 – 7.30 (m, 2H), 7.29 – 7.16 (m, 4H), 7.13 – 7.04 (m, 1H), 6.99 (ddd, *J* = 7.8, 2.5, 1.4 Hz, 1H), 3.87 (s, 3H).

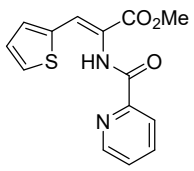
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.4, 162.3, 157.3, 156.5, 148.9, 148.3, 137.5, 136.0, 132.2 (q, *J* = 32.6 Hz), 130.6, 130.2, 126.7, 125.7, 124.8, 123.6 (q, *J* = 272.4 Hz), 122.7, 121.7, 120.2, 119.9 (q, *J* = 4.2 Hz), 119.8, 115.8 (q, *J* = 3.8 Hz), 52.8.

^{19}F-NMR (376 MHz, $CDCl_3$, ppm) δ -62.69.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{18}N_2O_4F_3$ 443.1219; Found 443.1220.

FT-IR (thin film, cm^{-1}) υ 3344, 3061, 2954, 1724, 1696, 1576, 1491, 1437, 1328, 1282, 1236, 1169, 1126, 1064.

Methyl (*Z*)-2-(picolinamido)-3-(tiophen-2-yl)acrylate (1ap)



Prepared by the general procedure from tiophen-2-carbaldehyde (112 μL, 1.19 mmol), DBU (222 μL, 1.49 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (300 mg, 0.99 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1ap** (120 mg, 42%) was obtained as a colorless oil. R_f = 0.57 (EtOAc/PE = 1/1).

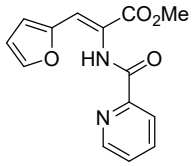
^{1}H-NMR (600 MHz, $CDCl_3$, ppm) δ 9.45 (s, 1H), 8.67 (ddd, *J* = 4.8, 1.8, 0.9 Hz, 1H), 8.26 (dt, *J* = 7.8, 1.1 Hz, 1H), 7.90 (td, *J* = 7.7, 1.7 Hz, 1H), 7.86 (s, 1H), 7.51 (ddd, *J* = 7.7, 4.7, 1.2 Hz, 1H), 7.43 (dt, *J* = 5.1, 1.0 Hz, 1H), 7.36 (dd, *J* = 3.7, 1.1 Hz, 1H), 7.07 (dd, *J* = 5.1, 3.7 Hz, 1H), 3.85 (s, 3H).

^{13}C-NMR (151 MHz, $CDCl_3$, ppm) δ 165.2, 163.6, 149.2, 148.4, 137.5, 136.5, 133.0, 130.7, 129.0, 127.3, 126.7, 122.8, 121.5, 52.6, 29.7.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{14}H_{13}N_2O_3S$ 289.0647; Found 289.0652.

FT-IR (thin film, cm^{-1}) υ 3303, 1679, 1626, 1490, 1434, 1337, 1262, 1208, 1181, 1142, 1076.

Methyl (*Z*)-3-(furan-2-yl)-2-(picolinamido)acrylate (1aq)



Prepared by the general procedure from furan-2-carbaldehyde (132 μL, 1.60 mmol), DBU (297 μL, 1.99 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (401 mg, 1.33 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1aq** (294 mg, 81%) was obtained as an orange-colored oil. R_f = 0.38 (EtOAc/PE = 1/1).

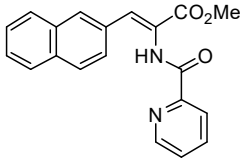
^{1}H-NMR (600 MHz, $CDCl_3$, ppm) δ 9.97 (s, 1H), 8.68 – 8.63 (m, 1H), 8.23 (dt, *J* = 7.8, 1.0 Hz, 1H), 7.88 (td, *J* = 7.7, 1.7 Hz, 1H), 7.53 – 7.46 (m, 2H), 7.17 (s, 1H), 6.65 (d, *J* = 3.5 Hz, 1H), 6.47 (dd, *J* = 3.5, 1.8 Hz, 1H), 3.86 (s, 3H)

^{13}C-NMR (151 MHz, $CDCl_3$, ppm) δ 165.2, 162.5, 149.9, 149.3, 148.4, 144.5, 137.5, 126.6, 122.8, 122.5, 117.7, 115.2, 112.3, 52.6.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{14}H_{13}N_2O_4$ 273.0875; Found 273.0875.

FT-IR (thin film, cm^{-1}) υ 3349, 3131, 3018, 2951, 1724, 1685, 1641, 1559, 1497, 1462, 1434, 1364, 1288, 1267, 1212, 1147, 1089, 1020.

Methyl (*Z*)-3-(naphtalen-2-yl)-2-(picolinamido)acrylate (1ar)



Prepared by the general procedure from 2-naphthaldehyde (300 mg, 1.92 mmol), DBU (358 μL, 2.40 mmol), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (483 mg, 1.60 mmol), THF (10 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/2) product **1ar** (414 mg, 78%) was obtained as a white solid. R_f = 0.37 (EtOAc/PE = 1/1), mp 120 – 122 ^oC (Et_2O).

^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 9.83 (s, 1H), 8.64 (ddd, *J* = 4.8, 1.7, 0.9 Hz, 1H), 8.21 (dt, *J* = 7.9, 1.1 Hz, 1H), 8.01 (dd, *J* = 1.8, 0.9 Hz, 1H), 7.88 (td, *J* = 7.7, 1.7 Hz, 1H), 7.83 (s, 3H), 7.67 (dd, *J* = 8.7, 1.8 Hz, 1H), 7.64 (s, 1H), 7.53 – 7.40 (m, 3H), 3.91 (s, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 165.7, 162.7, 149.2, 148.4, 137.6, 133.6, 133.2, 131.9, 131.5, 130.6, 128.6, 128.2, 127.7, 127.1, 126.7, 126.5, 126.2, 124.3, 122.8, 52.8.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{20}H_{17}N_2O_3$ 333.1239; Found 333.1241.

FT-IR (thin film, cm^{-1}) υ 3347, 3057, 3015, 2951, 2846, 1718, 1690, 1640, 1591, 1571, 1489, 1464, 1433, 1347, 1255, 1143, 1081.

2. Cobalt-catalyzed imination of amino acid derivatives

2.1. Optimization of cobalt-catalyzed imination of amino acid derivatives

2.1.1. Oxidant

General procedure for oxidant optimization reactions

A 4 mL vial with a screw cap (PTFE/Liner) was charged with methyl (*Z*)-3-phenyl-2-(picolinamido)acrylate (**1aa**) (28.2 mg, 0.10 mmol), $Co(dpm)_2$ (8.5 mg, 0.02 mmol, 20 mol%), oxidant (0.20 mmol, 2.00 equiv), NaOPiv (25 mg, 0.20 mmol, 2.00 equiv), and PhCl (1 mL). Then *t*-BuNC (23 μL, 0.20 mmol, 2.00 equiv) was added and the reaction mixture was heated at 100 °C for 1 h, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To the reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with EtOAc (1.5 mL). The organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy.

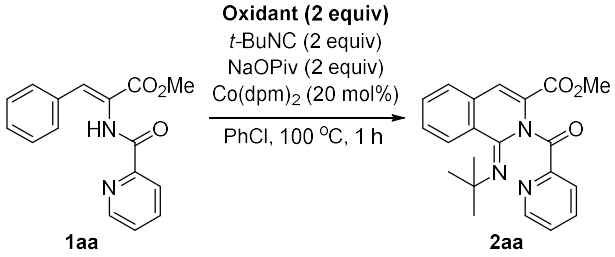


Table S-1

entry	oxidant	NMR yield, %[a]
1	Ag_2CO_3	71
2	Ag_2CO_3 (1.5 equiv)	75
3	AgOAc	36
4	$Mn(OAc)_3 \cdot 2H_2O$	0
5	$Mn(OAc)_3 \cdot 2H_2O$ + Ag_2CO_3 (1.5 equiv)	58
6	$Mn(OAc)_2 \cdot 4H_2O$	0
7	w/o oxidant	0

[a]NMR yield using triphenylmethane as an internal standard.

2.1.2. Additive

General procedure for additive optimization reactions

A 4 mL vial with a screw cap (PTFE/Liner) was charged with methyl (*Z*)-3-phenyl-2-(picolinamido)acrylate (**1aa**) (28.2 mg, 0.10 mmol), $Co(dpm)_2$ (8.5 mg, 0.02 mmol, 20 mol%), Ag_2CO_3 (41 mg, 0.15 mmol, 1.50 equiv), additive (0.20 mmol, 2.00 equiv), and PhCl (1 mL). Then *t*-BuNC (23 μL, 0.20 mmol, 2.00 equiv) was added and the reaction mixture was heated at 100 °C for 1 h, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with EtOAc (1.5 mL). The organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy.

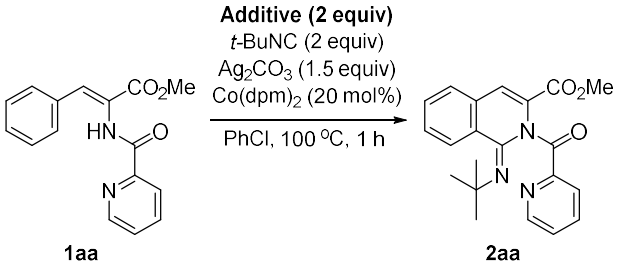


Table S-2

entry	additive	NMR yield, %[a]
1	NaOPiv	75
2	NaOPiv (1.5 equiv)	58
3	NaOPiv (1 equiv)	55
4	LiOPiv	57
5	Et_3N	0
6	Pyridine	0
7	AcOH	73
8	PivOH	71
9	w/o additive	0

[a]NMR yield using triphenylmethane as an internal standard.

2.1.3. Catalyst

General procedure for catalyst screening

A 4 mL vial with a screw cap (PTFE/Liner) was charged with methyl (*Z*)-3-phenyl-2-(picolinamido)acrylate (**1aa**) (28.2 mg, 0.10 mmol), catalyst (0.02 mmol, 20 mol%), Ag_2CO_3 (41 mg, 0.15 mmol, 1.50 equiv), NaOPiv (25 mg, 0.20 mmol, 2.00 equiv), and PhCl (1 mL). Then *t*-BuNC (23 µL, 0.20 mmol, 2.00 equiv) was added and the reaction mixture was heated at 100 °C for 1 h, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with EtOAc (1.5 mL). Combined organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy.

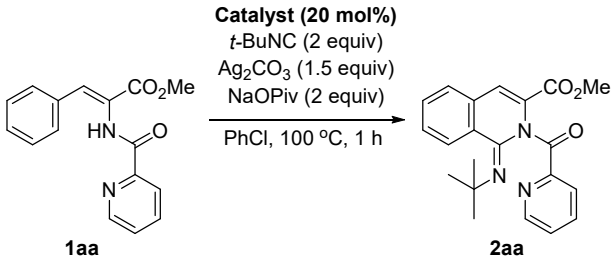


Table S-3

entry	catalyst	NMR yield, %[a]
1	$Co(dpm)_2$	75
2	$Co(dpm)_2$ (15 mol%, 2h)	58
3	$Co(acac)_2$	21
4	$Co(acac)_3$	3
5	$Co(OAc)_2 \cdot 4H_2O$	16
6	$CoCl_2$	0
7	$Co(hfacac)_2$	24

[a]NMR yield using triphenylmethane as an internal standard.

2.1.4. Solvent

General procedure for solvent optimization reactions

A 4 mL vial with a screw cap (PTFE/Liner) was charged with Methyl (*Z*)-3-phenyl-2-(picolinamido)acrylate (**1aa**) (28.2 mg, 0.10 mmol), $Co(dpm)_2$ (8.5 mg, 0.02 mmol, 20 mol%), Ag_2CO_3 (41 mg, 0.15 mmol, 1.50 equiv), NaOPiv (25 mg, 0.20 mmol, 2.00 equiv), and solvent (1 mL). Then *t*-BuNC (23 μL, 0.20 mmol, 2.00 equiv) was added and the reaction mixture was heated at 100 °C for 1 h, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with EtOAc (1.5 mL). Combined organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy.

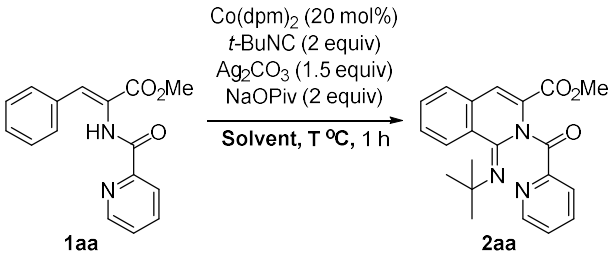


Table S-4

entry	solvent	temperature, °C	NMR yield, %[a]
1	PhCl	100	75
2	PhCl	100	72[b]
3	THF	100	84
4	THF	100	92[c]
5	DCE	100	73
6	MeOH	100	0
7	MeCN	100	73
8	$PhCF_3$	100	78
9	Toluene	100	66
10	Dioxane	100	56
11	EtOAc	100	81
12	*t*-BuOAc	120	79
13	*t*-BuOAc	80	74

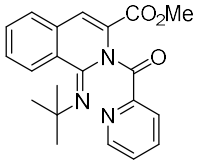
[a]NMR yield using triphenylmethane as an internal standard.
[b]1.5 equiv *t*-BuNC; [c]300 mg 4 Å MS.

2.2. Cobalt-catalyzed imination of amino acid derivatives and characterization of products

General procedure for cobalt-catalyzed C(sp)^2-H functionalization

A 30 mL vial equivuipped with a magnetic stir bar was charged with amino acid derivative **1aa-1ar** (0.50 mmol), $Co(dpm)_2$ (43 mg, 0.10 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), NaOPiv (125 mg, 1.00 mmol, 2.00 equiv), and dry THF (5 mL). Then 4 Å MS (1500 mg) and isocyanide (1.00 mmol, 2.00 equiv) were added and the reaction mixture was heated at 100 ^oC. Reaction mixture was monitored by TLC every 1 h to determine the completion time. The reaction mixture was cooled to room temperature and the solvent was evaporated under reduced pressure. Product was purified by column chromatography on silica gel using appropriate eluent. After purification product was dried under reduced pressure.

Methyl (*E*)-1-(*tert*-butylimino)-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2aa)



1aa (141 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.0 equiv), 1 h at 100 ^oC. After column chromatography (gradient petroleum ether/EtOAc from 4:1 to 1:1), 153 mg (84%) of a white solid was obtained. R_f = 0.37 (EtOAc/PE = 1/1), mp 140 – 142 ^oC (Et_2O).

^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.39 (s, 1H), 8.28 – 8.19 (m, 1H), 7.82 (dt, *J* = 7.8, 2.7 Hz, 1H), 7.76 (dt, *J* = 4.8, 1.3 Hz, 1H), 7.71 – 7.60 (m, 2H), 7.52 – 7.45 (m, 1H), 7.34 (td, *J* = 7.7, 1.8 Hz, 1H), 6.78 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 4.00 (s, 3H), 1.63 (s, 9H).

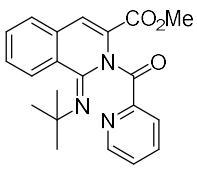
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.6, 166.1, 155.0, 154.8, 147.3, 139.8, 136.9, 135.7, 130.8, 130.2, 129.8, 127.9, 126.5, 124.0, 123.6, 123.3, 60.8, 52.7, 28.7.

HRMS (ESI-TOF) m/z: $[M+Na]^+$ calcd for $C_{21}H_{21}N_3O_3Na$ 386.1481; Found 386.1491.

FT-IR (thin film, cm^{-1}) υ 2975, 1738, 1718, 1653, 1560, 1345, 1292, 1243, 1214, 1150, 1096.

<u>Procedure for 1.77 mmol scale synthesis</u>

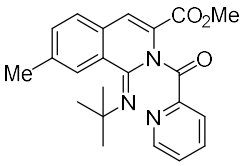
Methyl (*E*)-1-(*tert*-butylimino)-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2aa)



A 110 mL pressure tube equipped with a magnetic stir bar was charged with methyl (*Z*)-3-phenyl-2-(picolinamido)acrylate (**1aa**) (500 mg, 1.77 mmol),

Ag_2CO_3 (728 mg, 2.65 mmol, 1.5 equiv), $Co(dpm)_2$ (149 mg, 0.35 mmol, 20 mol%), NaOPiv (439 mg, 3.54 mmol, 2 equiv), and dry THF (18 mL). 4 Å MS (5 g) were then added, followed by addition of *t*-BuNC (391 µL, 3.54 mmol, 2 equiv), and the mixture was heated at 100 °C for 4 h. The reaction mixture was cooled to room temperature, and the solvent was evaporated under reduced pressure. After column chromatography (gradient petroleum ether/EtOAc 4:1 to 1:1) 462 mg (72%) of a white solid obtained.

Methyl (*E*)-1-(*tert*-butylimino)-7-methyl-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2ab)



1ab (148 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.0 equiv), 1 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 3:1 to 1:1), 181 mg (96%) of a white solid was obtained. R_f = 0.30 (EtOAc/PE = 1/1), mp 136 – 138 °C (Et_2O).

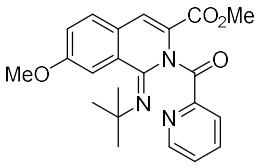
^{1}H-NMR (600 MHz, $CDCl_3$, ppm) δ 8.35 (s, 1H), 7.96 (s, 1H), 7.81 (d, *J* = 4.7 Hz, 1H), 7.70 (d, *J* = 8.3 Hz, 1H), 7.49 – 7.41 (m, 2H), 7.32 (t, *J* = 7.8 Hz, 1H), 6.77 (t, *J* = 6.2 Hz, 1H), 3.99 (s, 3H), 2.53 (s, 3H), 1.63 (s, 9H).

^{13}C-NMR (151 MHz, $CDCl_3$, ppm) δ 168.6, 166.2, 154.9, 154.2, 147.3, 140.4, 139.0, 135.5, 135.2, 133.1, 130.2, 127.7, 125.2, 123.9, 123.4, 123.2, 60.7, 52.7, 28.7, 22.3.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{22}H_{24}N_3O_3$ 378.1818; Found 378.1810.

FT-IR (thin film, cm^{-1}) υ 2768, 1734, 1717, 1653, 1560, 1347, 1297, 1243, 1216, 1191, 1094, 1001.

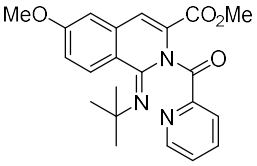
Methyl (*E*)-1-(*tert*-butylimino)-7-methoxy-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2ac)



1ac (156 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.0 equiv), 1 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 2:1 to pure EtOAc), 175 mg (89%) of a yellow-colored solid was obtained. R_f = 0.23 (EtOAc/PE = 1/1), mp 163 – 165 °C (Et_2O).

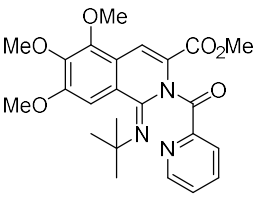
^{1}H-NMR (600 MHz, $CDCl_3$, ppm) δ 8.33 (s, 1H), 7.86 (d, *J* = 4.9 Hz, 1H), 7.70 (d, *J* = 8.9 Hz, 1H), 7.45 (d, *J* = 2.5 Hz, 1H), 7.40 (d, *J* = 7.9 Hz, 1H), 7.32 (td, *J* = 7.7, 1.7 Hz, 1H), 7.29 – 7.24 (m, 1H), 6.83 – 6.78 (m, 1H), 3.98 (s, 3H), 3.96 (s, 3H), 1.63 (s, 9H).
^{13}C-NMR (151 MHz, $CDCl_3$, ppm) δ 168.6, 166.2, 160.5, 154.9, 153.4, 147.5, 137.9, 135.5, 132.4, 131.6, 129.5, 124.0, 123.9, 123.3, 123.3, 104.2, 60.8, 55.8, 52.7, 28.8.
HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{22}H_{24}N_3O_4$ 394.1767; Found 394.1769.
FT-IR (thin film, cm^{-1}) υ 2975, 1739, 1718, 1659, 1623, 1569, 1496, 1409, 1348, 1299, 1257, 1212, 1189, 1115, 1028, 1002.

Methyl (*E*)-1-(*tert*-butylimino)-6-methoxy-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2ad)



1ad (156 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.0 equiv), 1 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 3:1 to EtOAc), 165 mg (84%) of a yellow-colored solid was obtained. R_f = 0.26 (EtOAc/PE = 1/1), mp 182 – 184 °C (Et_2O).
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.27 (s, 1H), 8.12 (d, *J* = 9.2 Hz, 1H), 7.85 (d, *J* = 4.8 Hz, 1H), 7.41 (d, *J* = 7.9 Hz, 1H), 7.33 (td, *J* = 7.7, 1.7 Hz, 1H), 7.28 – 7.22 (m, 1H), 7.03 (d, *J* = 2.5 Hz, 1H), 6.83 – 6.75 (m, 1H), 3.98 (s, 3H), 3.90 (s, 3H), 1.61 (s, 9H).
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.6, 166.2, 161.1, 155.0, 154.3, 147.5, 140.4, 139.1, 135.6, 128.3, 125.6, 123.3, 123.2, 123.2, 122.5, 105.3, 60.7, 55.6, 52.7, 28.7.
HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{22}H_{24}N_3O_4$ 394.1767; Found 394.1769.
FT-IR (thin film, cm^{-1}) υ 3067, 2975, 1735, 1719, 1653, 1624, 1412, 1352, 1284, 1256, 1236, 1193, 1157, 1098, 1024.

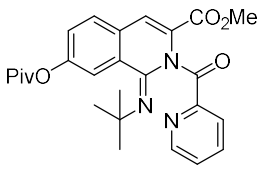
Methyl (*E*)-1-(*tert*-butylimino)-5,6,7-trimethoxy-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2ae)



1ae (186 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.0 equiv), 1 h at 100 °C. After column chromatography (pure EtOAc), 170 mg (75%) of a yellow-colored solid was obtained. R_f = 0.45 (EtOAc), mp 120 – 122 °C (Et_2O).

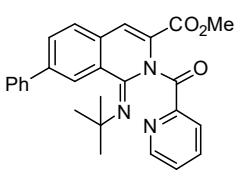
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.55 (s, 1H), 7.91 (d, *J* = 4.8 Hz, 1H), 7.45 – 7.07 (m, 3H), 6.81 (t, *J* = 6.4 Hz, 1H), 4.02 – 3.93 (m, 12H), 1.61 (s, 9H).
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.6, 166.2, 155.7, 155.0, 152.8, 147.7, 147.3, 143.8, 138.1, 135.4, 128.9, 127.2, 123.3, 123.1, 118.4, 100.9, 61.7, 61.2, 60.8, 56.3, 52.6, 28.8.
HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{24}H_{28}N_3O_6$ 454.1978; Found 454.1984.
FT-IR (thin film, cm^{-1}) υ 2976, 2950, 2840, 1735, 1718, 1653, 1487, 1465, 1405, 1349, 1284, 1246, 1197, 1140, 1101, 1005.

Methyl (*E*)-1-(*tert*-butylimino)-2-picolinoyl-7-(pivaloyloxy)-1,2-dihydroisoquinoline-3-carboxylate (2af)



1af (170 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.00 equiv), 1 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 2:1 to pure EtOAc), 167 mg (72%) of a white-off solid was obtained. R_f = 0.51 (EtOAc/PE = 1/1), mp 169 – 171 °C (Et_2O).
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.41 – 8.37 (m, 1H), 7.95 – 7.90 (m, 1H), 7.85 (d, *J* = 8.8 Hz, 1H), 7.75 (d, *J* = 4.8 Hz, 1H), 7.55 (d, *J* = 8.0 Hz, 1H), 7.39 (td, *J* = 8.3, 2.0 Hz, 2H), 6.85 – 6.77 (m, 1H), 3.98 (s, 3H), 1.62 (s, 9H), 1.40 (s, 9H).
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 176.7, 168.6, 166.0, 154.9, 154.5, 151.6, 147.2, 139.6, 135.8, 134.6, 131.2, 129.3, 126.5, 123.7, 123.6, 123.5, 117.8, 60.9, 52.7, 39.3, 28.6, 27.1.
HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{26}H_{30}N_3O_5$ 464.2185; Found 464.2185.
FT-IR (thin film, cm^{-1}) υ 3472, 3329, 3066, 2977, 2875, 1754, 1719, 1662, 1586, 1569, 1496, 1481, 1441, 1397, 1343, 1290, 1274, 1212, 1210, 1179, 1149, 1119, 1103, 1029, 1004.

Methyl (*E*)-1-(*tert*-butylimino)-7-phenyl-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2ag)



1ag (179 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 4:1 to 2:1) 172 mg (95%) of a yellow-colored amorphous solid was obtained. R_f = 0.45 (EtOAc/PE = 1/1).

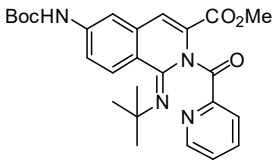
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.46 – 8.34 (m, 2H),7.95 – 7.79 (m, 3H), 7.75 – 7.67 (m, 2H), 7.58 – 7.38 (m, 4H), 7.31 (td, *J* = 7.7, 1.7 Hz, 1H), 6.81 – 6.73 (m, 1H), 4.01 (s, 3H), 1.66 (s, 9H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.6, 166.1, 155.1, 154.9, 147.4, 142.5, 139.7, 139.6, 134.0, 135.6, 130.5, 130.3, 129.3, 128.5, 128.4, 127.5, 124.2, 123.8, 123.4, 123.3, 60.9, 52.8, 28.8.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{27}H_{26}N_3O_3$ 440.1974; Found 440.1985.

FT-IR (thin film, cm^{-1}) υ 3063, 2976, 1740, 1718, 1663, 1487, 1437, 1380, 1346, 1269, 1234, 1213, 1191, 1155, 1096.

Methyl (*E*)-6-((-tertbutoxycarbonyl)amino)-1-(*tert*-butylimino)-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2ah)



1ah (199 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 2:1 to EtOAc) 195 mg (82%) of a white-off solid was obtained. R_f = 0.18 (EtOAc/PE = 1/1), mp 191 –193 °C (Et_2O).

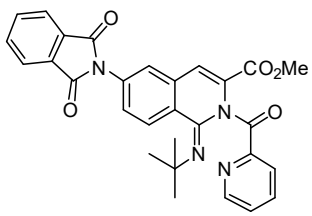
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.28 (d, *J* = 0.9 Hz, 1H), 8.15 – 8.05 (m, 2H), 7.84 (dt, *J* = 5.0, 1.3 Hz, 1H), 7.46 – 7.38 (m, 2H), 7.33 (td, *J* = 7.7, 1.8 Hz, 1H), 6.96 (s, 1H), 6.80 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 3.98 (s, 3H), 1.63 – 1.50 (m, 18H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.7, 166.1, 154.9, 154.3, 152.3, 147.5, 140.4, 140.3, 138.3, 135.6, 127.7, 126.3, 123.7, 123.4, 123.3, 122.3, 113.1, 81.6, 60.7, 52.7, 28.7, 28.3.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{26}H_{31}N_4O_5$ 479.2294; Found 479.2302.

FT-IR (thin film, cm^{-1}) υ 3311, 2978, 1734, 1653, 1570, 1545, 1436, 1362, 1350, 1285, 1241, 1192, 1155, 7098, 1051.

Methyl (*E*)-1-(*tert*-butylimino)-6-(1,3-dioxoisoindolin-2-yl)-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2ai)



1ai (214 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.00 equiv), 1 h at 100 °C. After

column chromatography (gradient petroleum ether/EtOAc from 4:1 to 1:1) 210 mg (83%) of white amporhous solid was obtained. R_f = 0.17 (EtOAc/PE = 1/1).

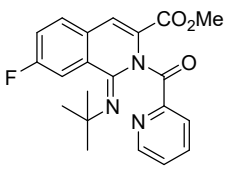
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.43 (s, 1H), 8.37 (d, *J* = 9.0 Hz, 1H), 8.05 – 7.95 (m, 3H), 7.88 – 7.75 (m, 4H), 7.56 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.40 (td, *J* = 7.7, 1.8 Hz, 1H), 6.83 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 3.99 (s, 3H), 1.63 (s, 9H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.5, 166.7, 165.8, 155.1, 154.5, 147.3, 140.5, 137.1, 135.9, 134.9, 133.9, 131.4, 128.9, 127.7, 127.4, 124.1, 124.1, 124.1, 123.8, 123.6, 61.0, 52.8, 28.7.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{29}H_{25}N_4O_5$ 509.1825; Found 509.1833.

FT-IR (thin film, cm^{-1}) υ 2978, 1726, 1653, 1569, 1430, 1378, 1347, 1286, 1245, 1193, 1103, 1084.

Methyl (*E*)-1-(*tert*-butylimino)-7-fluoro-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2aj)



1aj (150 mg, 0.50 mmol, 1 equiv), PivOH (102 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 4:1 to 1:1), 120 mg (63%) of a white solid was obtained. R_f = 0.35 (EtOAc/PE = 1/1), mp 144 – 146 °C (Et_2O).

^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.38 (d, *J* = 0.9 Hz, 1H), 7.91 – 7.80 (m, 2H), 7.72 – 7.66 (m, 1H), 7.58 (dt, *J* = 7.9, 1.1 Hz, 1H), 7.48 – 7.35 (m, 2H), 6.80 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 3.96 (s, 3H), 1.60 (s, 9H).

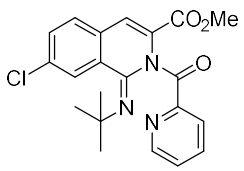
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.4, 165.9, 162.5 (d, *J* = 253.3 Hz), 154.8 (d, *J* = 5.7 Hz), 154.4, 147.0, 139.4 (d, *J* = 3.1 Hz), 135.9, 133.7, 131.8 (d, *J* = 8.8 Hz), 130.7 (d, *J* = 8.8 Hz), 123.9, 123.6, 123.5, 121.5 (d, *J* = 25.6 Hz), 110.5 (d, *J* = 22.5 Hz), 60.9, 52.7, 28.6.

^{19}F-NMR (376 MHz, $CDCl_3$, ppm) δ -105.86 – -105.96 (m).

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}N_3O_3F$ 382.1567; Found 382.1564.

FT-IR (thin film, cm^{-1}) υ 3072, 2977, 1742, 1662, 1498, 1442, 1343, 1288, 1248, 1210, 1187, 1145, 1111, 1002.

Methyl (*E*)-1-(*tert*-butylimino)-7-chloro-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2ak)



1ak (158 mg, 0.50 mmol, 1 equiv), PivOH (102 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 μL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 3:1 to 1:1), 129 mg (65%) of a white-off solid was obtained. R_f = 0.43 (EtOAc/PE = 1/1), mp 144 – 146 °C (Et_2O).

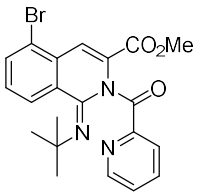
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.37 (d, *J* = 1.0 Hz, 1H), 8.21 (dd, *J* = 2.0, 1.0 Hz, 1H), 7.78 (d, *J* = 8.7 Hz, 1H), 7.69 (ddd, *J* = 4.8, 1.8, 0.9 Hz, 1H), 7.65 – 7.56 (m, 2H), 7.42 (td, *J* = 7.8, 1.8 Hz, 1H), 6.82 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 3.97 (s, 3H), 1.61 (s, 9H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.4, 165.8, 154.5, 154.2, 147.0, 140.1, 136.0, 135.8, 135.0, 131.9, 131.2, 129.4, 125.6, 123.9, 123.6, 123.5, 61.0, 52.8, 28.6.

HRMS (ESI-TOF) m/z: $[M+Na]^+$ calcd for $C_{21}H_{20}N_3O_3ClNa$ 420.1091; Found 420.1088.

FT-IR (thin film, cm^{-1}) υ 2978, 1740, 1653, 1437, 1341, 1288, 1233, 1099.

Methyl (*E*)-5-bromo-1-(*tert*-butylimino)-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2al)



1al (180 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 μL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 4:1 to 1:1), 137 mg (62%) of a white solid was obtained. R_f = 0.49 (EtOAc/PE = 1/1), mp 163 – 165 °C (Et_2O).

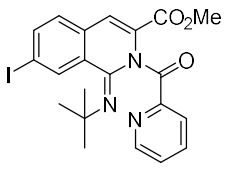
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.73 (d, *J* = 1.0 Hz, 1H), 8.25 (dt, *J* = 8.4, 1.0 Hz, 1H), 7.93 (dd, *J* = 7.5, 1.0 Hz, 1H), 7.72 (d, *J* = 4.8 Hz, 1H), 7.58 (dt, *J* = 7.9, 1.1 Hz, 1H), 7.51 (dd, *J* = 8.5, 7.5 Hz, 1H), 7.41 (td, *J* = 7.7, 1.8 Hz, 1H), 6.83 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 4.00 (s, 3H), 1.60 (s, 9H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.4, 165.7, 155.8, 154.3, 147.2, 140.9, 136.2, 136.0, 134.6, 131.7, 129.8, 126.4, 123.9, 123.6, 122.8, 61.1, 52.9, 28.6.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}N_3O_3Br$ 442.0766; Found 442.0771.

FT-IR (thin film, cm^{-1}) υ 3072, 2978, 1743, 1719, 1663, 1474, 1445, 1353, 1288, 1252, 1212, 1190, 1128, 1098, 1005.

Methyl (*E*)-1-(*tert*-butylimino)-7-iodo-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2am)



1am (204 mg, 0.50 mmol, 1 equiv), PivOH (102 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 4:1 to 1:1), 154 mg (63%) of a yellow-colored amorphous solid was obtained. R_f = 0.36 (EtOAc/PE = 1/1).

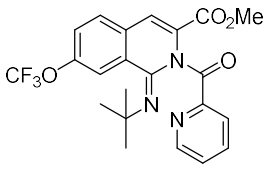
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.64 – 8.59 (m, 1H), 8.34 (d, *J* = 1.0 Hz, 1H), 7.89 (dd, *J* = 8.6, 1.7 Hz, 1H), 7.71 (ddd, *J* = 4.8, 1.8, 1.0 Hz, 1H), 7.61 (dt, *J* = 7.9, 1.1 Hz, 1H), 7.55 (d, *J* = 8.6 Hz, 1H), 7.43 (td, *J* = 7.7, 1.8 Hz, 1H), 6.82 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 3.96 (s, 3H), 1.61 (s, 9H)

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.3, 165.8, 154.3, 154.1, 147.0, 140.2, 139.5, 136.0, 135.6, 135.4, 131.4, 129.0, 123.9, 123.6, 123.6, 95.9, 61.0, 52.8, 28.7.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}N_3O_3I$ 490.0628; Found 490.0639.

FT-IR (thin film, cm^{-1}) υ 3061, 2976, 1735, 1715, 1653, 1472, 1437, 1363, 1343, 1314, 1288, 1238, 1210, 1190, 1152, 1097.

Methyl (*E*)-1-(*tert*-butylimino)-2-picolinoyl-7-(trifluoromethoxy)-1,2-dihydroisoquinoline-3-carboxylate (2an)



1an (183 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.0 equiv), 1 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 3:1 to 1:1), 136 mg (61%) of a greyish solid was obtained. R_f = 0.41 (EtOAc/PE = 1/1), mp 102 – 104 °C (Et_2O).

^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.42 (d, *J* = 0.9 Hz, 1H), 8.07 (tt, *J* = 2.2, 1.1 Hz, 1H), 7.90 (d, *J* = 8.9 Hz, 1H), 7.69 – 7.61 (m, 2H), 7.52 (ddq, *J* = 8.8, 2.4, 0.8 Hz, 1H), 6.82 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 3.99 (s, 3H), 1.61 (s, 9H).

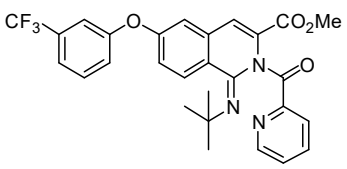
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.5, 165.8, 155.3, 154.2, 149.2 (q, *J* = 1.8 Hz), 146.8, 140.4, 136.0, 134.9, 131.2, 130.2, 124.9, 124.0, 123.7, 123.2, 120.5 (q, *J* = 259.4 Hz), 117.0, 61.0, 52.8, 28.6.

^{19}F-NMR (376 MHz, $CDCl_3$, ppm) δ -57.78.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{22}H_{21}N_3O_4F_3$ 448.1484; Found 448.1482.

FT-IR (thin film, cm^{-1}) υ 2979, 1743, 1662, 1442, 1340, 1259, 1213, 1187.

Methyl (*E*)-1-(*tert*-butylimino)-2-picolinoyl-6-(3-(trifluoromethyl)phenoxy)-1,2-dihydroisoquinoline-3-carboxylate (2ao)



1ao (221 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.0 equiv), 1 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 3:1 to 1:1), 172 mg (66%) of a yellowish oil was obtained. R_f = 0.35 (EtOAc/PE = 1/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.29 – 8.19 (m, 2H), 7.83 (ddd, *J* = 4.8, 1.8, 0.9 Hz, 1H), 7.58 – 7.43 (m, 3H), 7.43 – 7.33 (m, 2H), 7.31 – 7.22 (m, 2H), 7.12 (d, *J* = 2.5 Hz, 1H), 6.84 (ddd, *J* = 7.6, 4.8, 1.3 Hz, 1H), 3.96 (s, 3H), 1.62 (s, 9H).

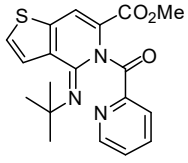
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.6, 165.8, 158.7, 155.6, 154.8, 147.3, 140.7, 138.5, 135.8, 132.8 (q, *J* = 32.8 Hz), 130.9, 129.4, 126.8, 123.6, 123.5 (q, *J* = 272.4 Hz), 123.5, 123.4, 123.4, 123.3, 122.7, 121.6 (q, *J* = 3.8 Hz), 117.0 (q, *J* = 3.8 Hz), 112.2, 60.8, 52.7, 28.7.

^{19}F-NMR (376 MHz, $CDCl_3$, ppm) δ -62.7.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{28}H_{25}N_3O_4F$ 524.1797; Found 524.1812.

FT-IR (thin film, cm^{-1}) υ 3065, 2977, 2932, 1740, 1723, 1661, 1624, 1587, 1567, 1491, 1449, 1410, 1349, 1327, 1278, 1244, 1229, 1170, 1129, 1096, 1064, 1005.

Methyl (*E*)-4-(*tert*-butylimino)-5-picolinoyl-4,5-dihydrothieno[3,2-*c*]pyridine-6-carboxylate (2ap)



1ap (144 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 µL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 2:1 to pure EtOAc), 118 mg (64%) of a yellow-colored oil was obtained. R_f = 0.22 (EtOAc/PE = 1/1).

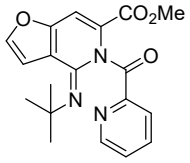
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.47 (d, *J* = 0.8 Hz, 1H), 7.90 (ddd, *J* = 4.7, 1.8, 0.9 Hz, 1H), 7.58 (d, *J* = 5.5 Hz, 1H), 7.54 – 7.42 (m, 2H), 7.37 (tdd, *J* = 7.8, 1.8, 0.7 Hz, 1H), 6.88 – 6.80 (m, 1H), 3.99 (s, 3H), 1.61 (s, 9H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.6, 165.9, 154.8, 150.3, 148.3, 147.5, 140.2, 138.4, 135.7, 130.8, 123.4, 122.9, 119.3, 60.7, 52.8, 28.9.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{19}H_{20}N_3O_3S$ 370.1225; Found 370.1213.

FT-IR (thin film, cm^{-1}) υ 3327, 3072, 2958, 1719, 1653, 1349, 1288, 1213, 1194.

Methyl (*E*)-4-(*tert*-butylimino)-5-picolinoyl-4,5-dihydrofuro[3,4-*c*]pyridine-6-carboxylate (2aq)



1aq (136 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 μL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 2:1 to pure EtOAc), 118 mg (67%) of a yellowish oil was obtained. R_f = 0.13 (EtOAc/PE = 1/1).

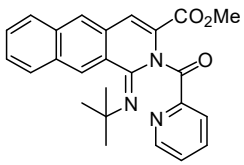
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.36 (s, 1H), 7.91 – 7.82 (m, 1H), 7.67 (d, *J* = 5.4 Hz, 1H), 7.56 (dt, *J* = 7.9, 1.1 Hz, 1H), 7.46 – 7.33 (m, 1H), 7.32 (d, *J* = 5.4 Hz, 1H), 6.86 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 3.99 (s, 3H), 1.64 (s, 9H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.1, 166.2, 154.6, 150.1, 147.2, 146.9, 141.6, 141.1, 135.7, 133.4, 123.9, 123.6, 123.6, 119.5, 61.2, 52.8, 29.0.

HRMS (ESI-TOF) m/z: $[M+Na]^+$ calcd for $C_{19}H_{19}N_3O_4Na$ 376.1273; Found 376.1277.

FT-IR (thin film, cm^{-1}) υ 3454, 3321, 3121, 2976, 2931, 1740, 1719, 1663, 1576, 1522, 1460, 1434, 1396, 1361, 1347, 1319, 1258, 1228, 1194, 1164, 1103, 1090, 1033.

Methyl (*E*)-1-(*tert*-butylimino)-2-picolinoyl-1,2-dihydrobenzo[*g*]isoquinoline-3-carboxylate (2ar)

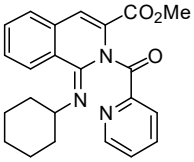


1ar (166 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), *t*-BuNC (113 μL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (petroleum ether/EtOAc 1:1) 148 mg (72%) of a yellow-colored amorphous solid was obtained. R_f = 0.26 (EtOAc/PE = 1/1).

^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.86 – 8.77 (m, 1H), 8.58 (s, 1H), 8.43 (s, 1H), 8.14 – 8.07 (m, 1H), 8.06 – 7.98 (m, 1H), 7.70 – 7.64 (m, 1H), 7.64 – 7.55 (m, 3H), 7.32 (td, *J* = 7.8, 1.8 Hz, 1H), 6.72 (ddd, *J* = 7.6, 4.8, 1.2 Hz, 1H), 4.02 (s, 3H), 1.70 (s, 9H).

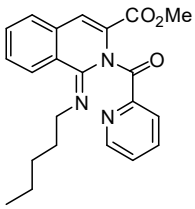
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.5, 166.3, 156.4, 154.5, 147.3, 137.8, 135.7, 134.1, 133.5, 132.7, 129.5, 128.2, 128.1, 127.7, 127.4, 126.7, 124.6, 123.7, 123.4, 61.1, 52.7, 28.8.
HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{25}H_{24}N_3O_3$ 414.1818; Found 414.1824.
FT-IR (thin film, cm^{-1}) υ 3443, 2980, 1725, 1647, 1437, 1348, 1233.

Methyl (*E*)-1-(cyclohexylimino)-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (2ba)



1aa (141 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), cyclohexyl isocyanide (122 μL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 4:1 to 1:1) 186 mg (96%) of a white-off solid was obtained. R_f = 0.22 (EtOAc/PE = 1/1), mp 158 – 160 °C (Et_2O).
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 8.46 (s, 1H), 7.98 (d, *J* = 8.4 Hz, 1H), 7.84 (d, *J* = 8.1 Hz, 1H), 7.74 (dd, *J* = 12.2, 6.3 Hz, 2H), 7.60 (t, *J* = 7.5 Hz, 1H), 7.53 (t, *J* = 7.6 Hz, 1H), 7.48 – 7.39 (m, 1H), 6.87 – 6.80 (m, 1H), 4.88 (tt, *J* = 12.4, 2.9 Hz, 1H), 4.01 (s, 1H), 2.38 (d, *J* = 12.6 Hz, 1H), 2.01 (qd, *J* = 12.6, 3.7 Hz, 1H), 1.85 (d, *J* = 12.7 Hz, 2H), 1.74 – 1.32 (m, 4H), 1.23 – 0.96 (m, 2H).
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 167.3, 166.2, 154.3, 153.1, 147.3, 140.0, 137.1, 136.0, 130.7, 129.6, 129.2, 128.0, 125.6, 124.4, 124.1, 123.6, 58.3, 52.8, 31.8, 30.2, 26.2, 26.0, 25.5.
HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{24}N_3O_3$ 390.1818; Found 390.1815.
FT-IR (thin film, cm^{-1}) υ 3294, 2933, 2855, 1740, 1718, 1653, 1437, 1363, 1289, 1243, 1216, 1098.

Methyl (*E*)-1-(pentylimino)-2-picolinoyl 1,2-dihydroisoquinoline-3-carboxylate (2ca)



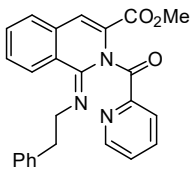
1aa (141 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), pentyl isocyanide (125 μL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 4:1 to 1:1) 148 mg (79%) of a white solid was obtained. R_f = 0.31 (EtOAc/PE = 1/1), mp 113 – 115 °C (Et_2O).
^{1}H-NMR (400 MHz, DMSO-d_6, ppm, t = 60 °C) 8.53 (s, 1H), 8.16 (d, *J* = 8.1 Hz, 1H), 8.02 (d, *J* = 8.3 Hz, 1H), 7.84 – 7.72 (m, 5H), 7.16 (s, 1H), 4.20 – 3.80 (m, 5H), 1.65 (s, 2H), 1.31 – 1.14 (m, 4H), 0.78 (t, *J* = 6.8 Hz, 3H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 167.9, 166.0, 156.0, 152.4, 147.3, 140.2, 137.3, 136.2, 130.8, 129.8, 128.2, 127.7, 125.0, 124.5, 124.4, 123.4, 52.8, 50.6, 29.3, 27.8, 22.4, 14.0.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{22}H_{24}N_3O_3$ 378.1818; Found 378.1822.

FT-IR (thin film, cm^{-1}) υ 3347, 3067, 2954, 2931, 2871, 1739, 1718, 1653, 1569, 1440, 1399, 1294, 1243, 1212, 1145, 1090.

Methyl (*E*)-1-(phenethylimino)-2-picolinoyl 1,2-dihydroisoquinoline-3-carboxylate (2da)



1aa (141 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4 Å MS (1500 mg), (2-isocyanoethyl)benzene (125 µL, 1.00 mmol, 2.00 equiv), 2 h at 100 °C. After column chromatography (petroleum ether/EtOAc from 2:1) 206 mg (80%) of a white-off solid was obtained. R_f = 0.32 (EtOAc/PE = 1/1), mp 160 – 162 °C (Et_2O).

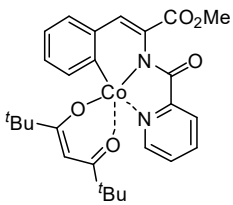
^{1}H-NMR (400 MHz, DMSO, ppm) δ 8.54 (s, 1H), 8.16 (d, *J* = 8.2 Hz, 1H), 8.06 – 7.46 (m, 6H), 7.30 – 7.07 (m, 6H), 4.28 (s, 2H), 3.92 (s, 3H), 3.06 (t, *J* = 7.8 Hz, 2H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 168.1, 166.0, 155.9, 152.2, 147.3, 140.2, 138.7, 137.4, 136.3, 130.8, 129.8, 128.9, 128.6, 128.3, 128.2, 127.4, 126.3, 125.0, 124.6, 123.5, 52.8, 51.7, 34.3.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{25}H_{22}N_3O_3$ 412.1661; Found 412.1667.

FT-IR (thin film, cm^{-1}) υ 3298, 3067, 2950, 1735, 1716, 1653, 1565, 1497, 1448, 1395, 1337, 1290, 1243, 1152, 1103.

(2-(3-Methoxy-3-oxo-2-(picolinamido)prop-1-en-1-yl)phenyl)((Z)-2,2,6,6-tetramethyl-5-oxohept-3-en-3-yl)oxy) cobalt (5)



Isolated from the reaction mixture (functionalization of Methyl (*Z*)-3-phenyl-2-(picolinamido)acrylate (**1aa**) under standard reaction conditions after 25 min) by analogy to Grigorjeva and co-workers.[1]

After column chromatography (gradient petroleum ether/EtOAc from 5/1 to 1/1, then MeCN) 18 mg (7%) of a red crystalline solid was obtained.

^{1}H NMR (400 MHz, CD_3CN) δ 9.07 (ddd, *J* = 5.6, 1.5, 0.8 Hz, 1H), 7.94 (td, *J* = 7.6, 1.5 Hz, 1H), 7.67 (ddd, *J* = 7.8, 1.6, 0.8 Hz, 1H), 7.60 (ddd, *J* = 7.4, 5.6, 1.5 Hz, 1H), 7.50 (s, 1H), 7.18 (dd, *J* = 7.8, 1.2 Hz, 1H), 7.01 (dd, *J* = 7.3, 1.8 Hz, 1H), 6.89 (td, *J* = 7.2, 1.3 Hz, 1H), 6.82 (td, *J* = 7.4, 1.8 Hz, 1H), 5.55 (s, 1H), 3.78 (s, 3H), 1.24 (s, 9H), 0.87 (s, 9H).

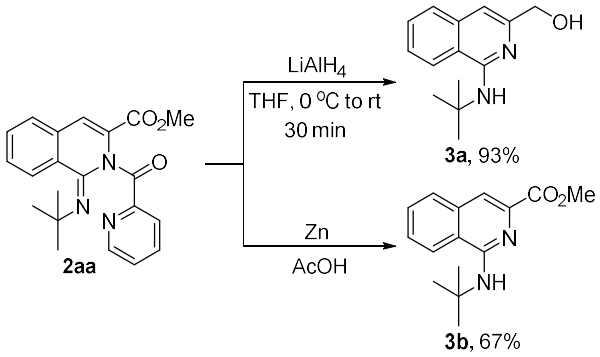
^{13}C NMR (101 MHz, CD_3CN) δ 198.74, 197.62, 170.51, 165.50, 157.91, 148.84, 142.99, 139.68, 137.75, 134.91, 133.73, 127.73, 126.74, 126.52, 125.24, 123.67, 89.83, 52.03, 40.92, 40.83, 28.83, 28.22.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{27}H_{32}N_2O_5Co$ 523.1643; Found 523.1653.

FT-IR (thin film, cm^{-1}) υ 2965, 1705, 1621, 1598, 1527, 1497, 1400, 1362, 1290, 1200.

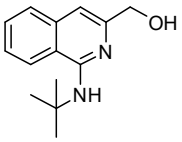
2.3. Cleavage of picolinamide directing group

Products **3a** and **3b** were synthesized according to Scheme **S-3** in one step procedures, starting from isoquinoline derivative **2aa**.



Scheme S-3. Cleavage of picolinamide directing group

(1-(*Tert*-butylamino)isoquinolin-3-yl)methanol (3a)



Methyl (*E*)-1-(*tert*-butylimino)-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (**2aa**) (50 mg, 0.137 mmol) solution in dry THF (3 mL) was cooled in a water/ice bath to 0 °C. $LiAlH_4$ (8 mg, 0.21 mmol, 3.0 equiv) was slowly added under Ar atmosphere, and the resulting solution was stirred for 15 minutes at 0 °C. The reaction mixture was allowed to warm to room temperature, and stirred for additional 15 min, until the full consumption of starting material was observed by TLC. The reaction mixture was quenched with H_2O (0.5 mL), and the solvent was evaporated under reduced pressure. After column chromatography (petroleum ether/EtOAc from 4:1 to 1:1) 29 mg (93%) of a yellow oil was obtained. R_f = 0.74 (EtOAc/PE = 1/1).

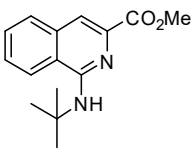
^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 7.70 – 7.59 (m, 2H), 7.54 (ddd, *J* = 8.1, 6.8, 1.1 Hz, 1H), 7.40 (ddd, *J* = 8.2, 6.8, 1.4 Hz, 1H), 6.79 (q, *J* = 1.0 Hz, 1H), 5.26 (s, 1H), 4.69 (d, *J* = 1.0 Hz, 2H), 3.75 (s, 1H), 1.60 (s, 9H).

^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 154.1, 150.0, 137.7, 129.7, 127.3, 125.4, 121.4, 117.8, 105.3, 64.3, 51.9, 29.4.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{14}H_{19}N_2O$ 231.1497; Found 231.1503.

FT-IR (thin film, cm^{-1}) υ 3404, 2962, 2926, 1627, 1569, 1528, 1438, 1398, 1362, 1318, 1215.

Methyl 1-(*tert*-butylamino)isoquinoline-3-carboxylate (3b)



Zn dust (7 mg, 0.11 mmol, 2 equiv) was added to a methyl (*E*)-1-(*tert*-butylimino)-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (**2aa**) (20 mg, 0.055 mmol) solution in EtOH (0.5 mL) at room temperature. AcOH (0.5 mL) was then added and the reaction mixture was stirred at room temperature for 30 minutes. The solvent was evaporated under reduced pressure. After column chromatography (petroleum ether/EtOAc from 4:1 to 1:1) 9.5 mg (67%) of a colorless oil was obtained. R_f = 0.80 (EtOAc/PE = 1/1).

^{1}H-NMR (400 MHz, $CDCl_3$, ppm) δ 7.80 (d, *J* = 1.0 Hz, 1H), 7.79 – 7.69 (m, 2H), 7.64 – 7.51 (m, 2H), 5.21 (s, 1H), 3.96 (s, 3H), 1.63 (s, 9H).

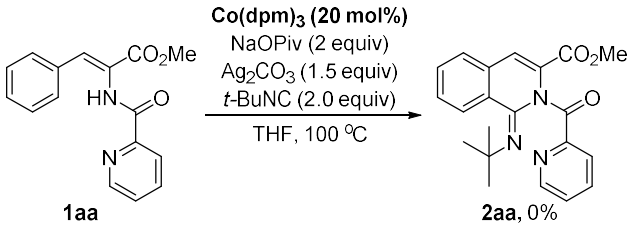
^{13}C-NMR (101 MHz, $CDCl_3$, ppm) δ 166.3, 153.1, 138.9, 135.6, 128.7, 127.9, 126.8, 120.4, 119.0, 112.7, 51.2, 51.1, 28.0.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{15}H_{19}N_2O_2$ 259.1447; Found 259.1454.

FT-IR (thin film, cm^{-1}) υ 3423, 3061, 2958, 2927, 1729, 1591, 1569, 1527, 1327, 1292, 1212, 1089, 1003.

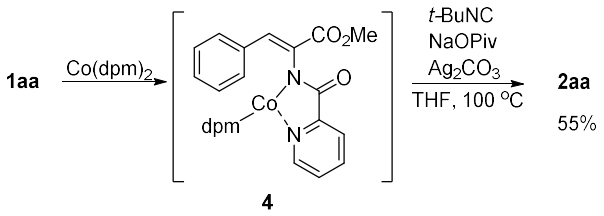
3. Mechanistic experiments

3.1. Ligand exchange experiments



Scheme S-4. C-H imination using $Co(dpm)_3$ as a catalyst

A 4 mL vial with a screw cap (PTFE/Liner) was charged with methyl (*Z*)-3-phenyl-2-(picolinamido)acrylate (**1aa**) (28.2 mg, 0.10 mmol), $Co(dpm)_3$ (12 mg, 0.02 mmol, 20 mol%), Ag_2CO_3 (41 mg, 0.15 mmol, 1.50 equiv), NaOPiv (25 mg, 0.20 mmol, 2.00 equiv), and THF (1 mL). Then *t*-BuNC (23 μL, 0.20 mmol, 2.00 equiv) was added and the reaction mixture was heated at 100 °C for 1 h, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To the reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with EtOAc (1.5 mL). Combined organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy. No formation of product **2aa** was observed.

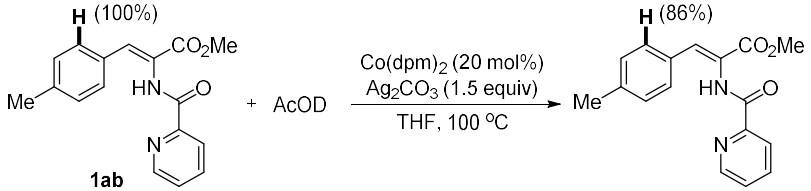


Scheme S-5. Ligand exchange experiments

Step 1: A 4 mL vial with a screw cap (PTFE/Liner) was charged with substrate **1aa** (13 mg, 0.04 mmol), $Co(dpm)_2$ (19.0 mg, 0.04 mmol), THF (1 mL) and was stirred at 100 °C for 30 min. The reaction mixture was allowed to cool to room temperature. The precipitate was filtered and washed with THF and dried under reduced pressure.

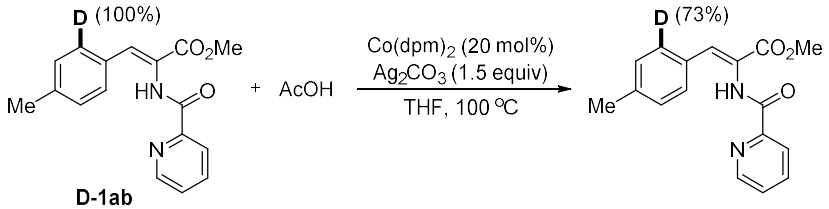
Step 2: A 4 mL vial with a screw cap (PTFE/Liner) was charged with cobalt complex **4**, Ag_2CO_3 (18 mg, 0.07 mmol, 1.50 equiv), NaOPiv (11 mg, 0.09 mmol, 2.00 equiv), and THF (1 mL). Then *t*-BuNC (7 μL, 0.07 mmol, 1.50 equiv) was added and the reaction mixture was heated at 100 °C for 1 h, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To the reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with EtOAc (1.5 mL). Combined organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy, 55% yield for **2aa** was observed.

3.2. H/D scrambling experiments



Scheme S-6. H/D scrambling in substrate **1ab**

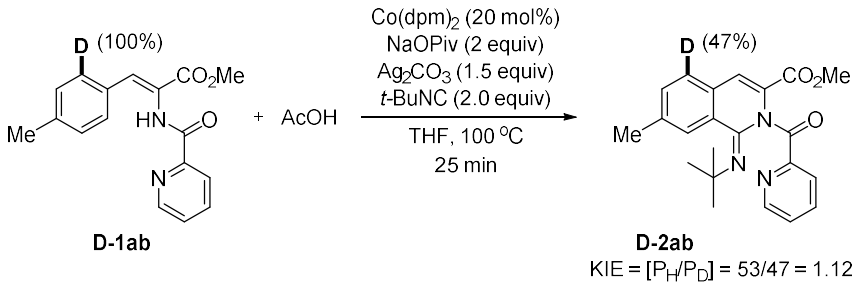
A 4 mL vial with a screw cap (PTFE/Liner) was charged with methyl (*Z*)-3-(4-methylphenyl)-2-(picolinamido)acrylate (**1aa**) (29.7 mg, 0.10 mmol), $Co(dpm)_2$ (8.5 mg, 0.02 mmol, 20 mol%), Ag_2CO_3 (41 mg, 0.15 mmol, 1.50 equiv), and THF (1 mL). Then AcOD (50 μL) was added and the reaction mixture was heated at 100 °C for 1 h, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To the reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with EtOAc (1.5 mL). Combined organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy.



Scheme S-7. H/D scrambling in deuterated substrate **D-1ab**

A 4 mL vial with a screw cap (PTFE/Liner) was charged with Methyl (*Z*)-3-(4-methylphenyl-2-*d*)-2-(picolinamido)acrylate (**D-1ab**) (29.7 mg, 0.10 mmol), $Co(dpm)_2$ (8.5 mg, 0.02 mmol, 20 mol%), Ag_2CO_3 (41 mg, 0.15 mmol, 1.50 equiv), and THF (1 mL). Then AcOH (50 µL) was added and the reaction mixture was heated at 100 °C for 1 h, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To the reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with EtOAc (1.5 mL). Combined organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy.

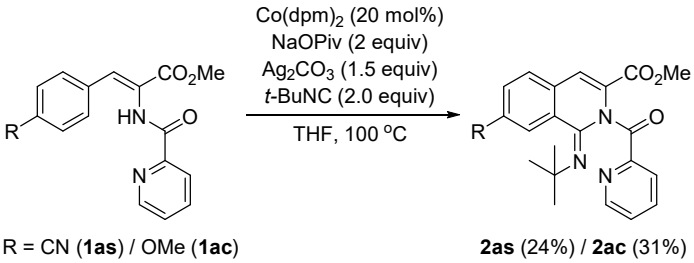
3.3. KIE



Scheme S-8. Kinetic isotope effect from competition experiment

A 4 mL vial with a screw cap (PTFE/Liner) was charged with Methyl (*Z*)-3-(4-methylphenyl-2-*d*)-2-(picolinamido)acrylate (**D-1ab**) (29.7 mg, 0.10 mmol), $Co(dpm)_2$ (8.5 mg, 0.02 mmol, 20 mol%), Ag_2CO_3 (41 mg, 0.15 mmol, 1.50 equiv), and THF (1 mL). Then *t*-BuNC (23 µL, 0.20 mmol, 2.00 equiv) and AcOH (50 µL) were added and the reaction mixture was heated at 100 °C for 25 min, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To the reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with EtOAc (1.5 mL). Combined organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy.

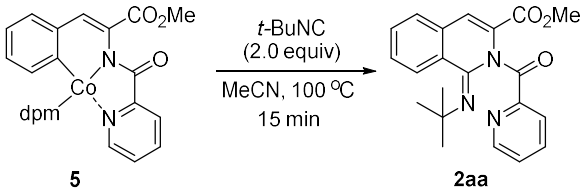
3.4. Substrate competition experiment



Scheme S-9. Substrate competition experiment

A 4 mL vial with a screw cap (PTFE/Liner) was charged with methyl (*Z*)-3-(4-methoxypheny)-2-(picolinamido)acrylate **2as** (16 mg, 0.05 mmol), methyl (*Z*)-3-(4-cyanoxypheny)-2-(picolinamido)acrylate **2ac** (16 mg, 0.05 mmol), $Co(dpm)_2$ (8.5 mg, 0.02 mmol, 20 mol%), Ag_2CO_3 (41 mg, 0.15 mmol, 1.50 equiv), and THF (1 mL). Then *t*-BuNC (23 μL, 0.20 mmol, 2.0 equiv) was added and the reaction mixture was heated at 100 °C for 1 h, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To the reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with EtOAc (1.5 mL). Combined organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy.

3.5. Complex 5 reaction with *t*-BuNC



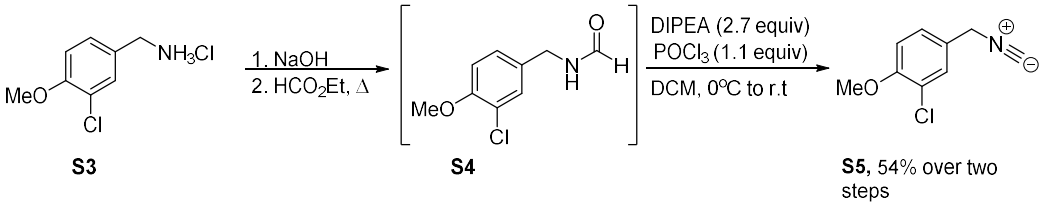
Scheme S-10. Stochiometric reaction of complex **5** with *t*-BuNC

A 4 mL vial with a screw cap (PTFE/Liner) was charged with **5** (16 mg, 0.03 mmol) and THF (1 mL). Then *t*-BuNC (6 μL, 0.06 mmol, 2.00 equiv) was added was added and the reaction mixture was heated at 100 °C for 15 min, cooled to room temperature and analyzed by TLC (petroleum ether/EtOAc 1/1). To the reaction mixture Ph_3CH (24.4 mg, 0.10 mmol, 1 equiv) was added, mixture was diluted with potassium sodium tartrate (1.5 mL) and extracted with

EtOAc (1.5 mL). Combined organic phase was separated, dried over anh. Na_2SO_4, filtered, evaporated. The residue was dissolved in $CDCl_3$ and analyzed by ^{1}H-NMR spectroscopy. Quantitative yield for **2aa** was observer.

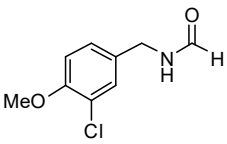
4. Synthesis of PDE5 inhibitor

Isocyanide **S5** was obtained in two steps from commercially available hydrochloride **S3**. Acylation with ethylformate yielded formamide **S4** which was then dehydrated with phosphorous oxychloride to obtain isocyanide in moderate yield (Scheme S-11).



Scheme S-11. Synthesis of isocyanide **S5**

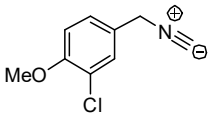
***N*-(3-chloro-4-methoxybenzyl)formamide (S4)**



Step 1: Hydrochloride **S3** (310 mg, 1.50 mmol) was dissolved in 1M $NaOH_{(aq)}$ solution (20 mL). The solution was extracted with EtOAc (3×20 mL). The combined organic extracts were dried over Na_2SO_4, filtered and evaporated to dryness under reduced pressure to obtain colorless oil, which was used directly for step 2.

Step 2: The crude amine from Step 1 was dissolved in ethylformate (5 mL) and refluxed overnight. The solvent was evaporated under reduced pressure to obtain formamide **S4**, which was used in next step without further purification.

2-Chloro-4-(isocyanomethyl)-1-methoxybenzene (S5)

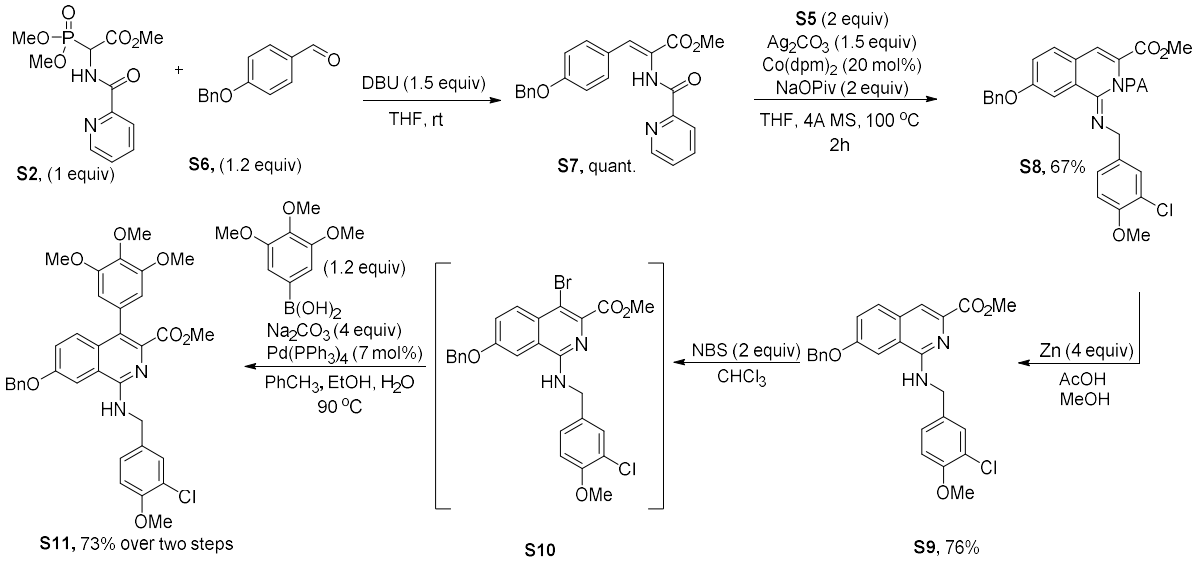


Formamide **S4** was dissolved in dry DCM (20 mL) under an Ar atmosphere. DIPEA (702 µl, 4.00 mmol, 2.70 equiv) was added and the solution was cooled to 0 °C. Slowly $POCl_3$ (154 µl, 1.65 mmol, 1.10 equiv) was added and the reaction mixture was stirred for 5 min, and then allowed to warm up to room temperature. After consumption of starting material (2h), solvent was evaporated under reduced pressure. After column chromatography (petroleum ether/EtOAc 4:1) 148 mg (54%) of a yellow oil was obtained.

^{1}H NMR (400 MHz, $CDCl_3$, ppm) δ 7.35 (d, *J* = 2.3 Hz, 1H), 7.21 (dd, *J* = 8.5, 2.3 Hz, 1H), 6.94 (d, *J* = 8.5 Hz, 1H), 4.55 (s, 2H), 3.91 (s, 2H).

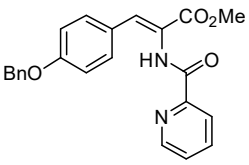
^{13}C NMR (101 MHz, $CDCl_3$, ppm) δ 157.99 (t, *J* = 7.2 Hz), 155.22, 128.86, 126.36, 125.47, 123.10, 112.36, 56.37, 44.66 (t, *J* = 7.2 Hz).

The synthesis of PDE5 inhibitor **S11** was achieved in 5 steps employing our developed methodology (Scheme S-12). First, benzaldehyde **S6** reaction with phosphonate **S2** gave phenylalanine unsaturated ester **S7** in quantitative yield. Subsequent C-H bond imination step with isocyanide **S5** gave corresponding imine **S8** in 67% yield. The picolinamide directing group was cleaved under reductive conditions using Zn/AcOH/MeOH system to obtain 1-aminoisoquinoline **S9** in 76% yield. Finally, bromination with NBS, followed by Suzuki coupling reaction delivered the desired product **S11** in 73% yield over two steps.



Scheme S-12. Synthesis of PDE5 inhibitor **S11**

Methyl-(*Z*)-3-(4-(benzyloxy)phenyl)-2-(picolinamido)acrylate (**S6**)



Prepared by the general procedure from 4-(benzyloxy)benzaldehyde (829 mg, 3.90 mmol, 1.20 equiv), DBU (728 μL, 4.88 mmol, 1.50 equiv), methyl 2-(dimethoxyphosphoryl)-2-(picolinamido)acetate **S2** (984 mg, 3.23 mmol, 1.00 equiv), THF (25 mL). After column chomotography (eluent: petroleum ether/EtOAc = 1/4 to 1/1) product **S6** (1.28g, 100%) was obtained as a colorless oil. R_f = 0.59 (EtOAc/PE = 1/1).

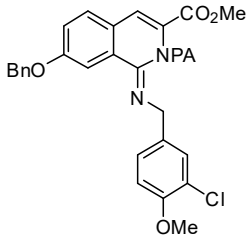
^{1}H NMR (400 MHz, $CDCl_3$, ppm) δ 9.64 (s, 1H), 8.64 (d, *J* = 5.6 Hz, 1H), 8.23 (d, *J* = 7.9 Hz, 1H), 7.93 – 7.84 (m, 1H), 7.56 – 7.45 (m, 4H), 7.44 – 7.30 (m, 5H), 6.93 (d, *J* = 8.9 Hz, 2H), 5.06 (s, 2H), 3.86 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$, ppm) δ 165.8, 162.7, 159.8, 149.3, 148.4, 137.5, 136.5, 132.6, 131.8, 128.7, 128.1, 127.5, 126.7, 126.6, 122.8, 122.0, 115.0, 70.0, 52.6.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{23}H_{21}N_2O_4$ 389.1501; Found 389.1508.

FT-IR (thin film, cm^{-1}) υ 3344, 3064, 3031, 2950, 1720, 1694, 1638, 1602, 1570, 11511, 1488, 1463, 1435, 1381, 1254, 1176, 1087.

Methyl-(*Z*)-7-(benzyloxy)-1-((3-chloro-4-methoxybenzyl)imino)-2-picolinoyl-1,2-dihydroisoquinoline-3-carboxylate (S8)



Prepared by the general procedure for C-H bond imination from ester **S6** (194 mg, 0.50 mmol, 1 equiv), NaOPiv (125 mg, 1.0 mmol, 2.00 equiv), $Co(dpm)_2$ (43 mg, 0.1 mmol, 20 mol%), Ag_2CO_3 (205 mg, 0.75 mmol, 1.50 equiv), THF (5 mL), 4Å MS (1500 mg), isocyanide **S5** (180 mg, 1.00 mmol, 2.00 equiv), 1h at 100 °C. After column chromatography (gradient petroleum ether/EtOAc from 4:1 to 1:1), 189 mg (67%) of a colorless oil. R_f = 0.66 (EtOAc/PE = 1/1).

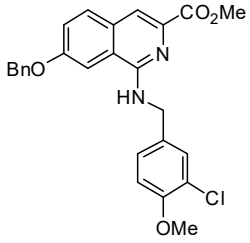
^{1}H NMR (400 MHz, MeOD-d_4, ppm) δ 8.32 (s, 1H), 7.79 – 7.70 (m, 2H), 7.51 – 7.37 (m, 3H), 7.33 – 7.17 (m, 6H), 7.01 – 6.89 (m, 2H), 6.77 – 6.67 (m, 2H), 5.57 (d, *J* = 14.3 Hz, 1H), 4.76 (s, 3H, overlaps with H_2O signal), 3.88 (s, 3H), 3.62 (s, 3H).

^{13}C NMR (101 MHz, MeOD-d_4, ppm) δ 169.9, 167.0, 161.3, 156.1, 155.0, 153.5, 148.8, 139.0, 137.9, 137.5, 134.4, 132.4, 131.4, 131.1, 130.6, 130.3, 129.8, 129.3, 128.6, 126.3, 125.9, 125.6, 125.0, 123.4, 113.1, 105.3, 71.3, 56.6, 53.3, 53.1.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{32}H_{27}N_3O_5Cl$ 568.1639; Found 568.1650.

FT-IR (thin film, cm^{-1}) υ 2950, 1730, 1655, 1501, 1444, 1383, 1294, 1258, 1206, 1064.

Methyl-7-(benzyloxy)-1-((3-chloro-4-methoxybenzyl)amino)isoquinoline-3-carboxylate (S9)



Zn dust (106 mg, 1.68 mmol, 4 equiv) was added to the imine **S11** (242 mg, 0.42 mmol) solution in EtOH (2 mL) at room temperature. AcOH (2 mL) was then added and the reaction mixture was stirred at room temperature for 1h. The solvent was evaporated under reduced pressure. After column chromatography (petroleum ether/EtOAc from 4:1 to 1:1) 194 mg (76%) of a colorless oil was obtained. R_f = 0.29 (EtOAc/PE = 1/2).

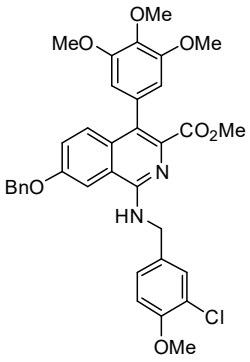
^{1}H NMR (400 MHz, $CDCl_3$, ppm) δ 7.88 (s, 1H), 7.75 (d, *J* = 8.9 Hz, 1H), 7.48 (d, *J* = 1.9 Hz, 1H), 7.45 – 7.28 (m, 7H), 7.19 (s, 1H), 6.85 (d, *J* = 8.4 Hz, 1H), 5.40 (br. s, 1H), 5.15 (s, 2H), 4.76 (d, *J* = 4.9 Hz, 3H), 3.98 (s, 3H), 3.87 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$, ppm) δ 167.2, 158.9, 154.2, 153.7, 138.0, 136.1, 132.7, 131.4, 130.5, 128.7, 128.3, 128.0, 127.6, 122.3, 121.8, 120.9, 115.4, 112.0, 103.2, 70.5, 56.1, 52.4, 45.1.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{26}H_{24}N_2O_4Cl$ 463.1425; Found 463.1435.

FT-IR (thin film, cm^{-1}) υ 3397, 2948, 2836, 1715, 1621, 1537, 1502, 1405, 1293, 1256, 1210, 1064, 1025.

Methyl-7-(benzyloxy)-1-((3-chloro-4-methoxybenzyl)amino)-4-(3,4,5-trimethoxyphenyl) isoquinoline-3-carboxylate (**S11**)



Step 1: To a solution of 1-aminoquinoline **S9** (70 mg, 0.15 mmol) in $CHCl_3$ (3 mL), NBS (26 mg, 0.3 mmol, 2.00 equiv) was added and stirred at 60 ^oC for 1h. The reaction mixture was filtered through a short silicagel pad and evaporated under reduced pressure to obtain bromide **S10** which was used in the next step directly without further purification.

Step 2: Bromide **S10** from Step 1, Na_2CO_3 (64 mg, 0.60 mmol, 4.00 equiv), (3,4,5-trimethoxyphenyl)boronic acid (38 mg, 0.18 mmol, 1.20 equiv), $Pd(PPh_3)_4$ (12 mg, 0.01 mmol, 7 mol%) were dissolved in a dry, degassed $PhCH_3$ (6mL), EtOH (3 mL), H_2O (3 mL) solvent system and stirred at 90 ^oC for 2h. The solvent was evaporated under reduced pressure. After column chromatography (petroleum ether/EtOAc from 4:1 to 1:2) 69 mg (73% over two steps) of a light brown crystalline solid was obtained. R_f = 0.68 (EtOAc/PE = 1/1), mp 70 -72 ^oC (Et_2O).

^{1}H NMR (400 MHz, $CDCl_3$, ppm) δ 7.58 (d, *J* = 9.2 Hz, 1H), 7.54 (d, *J* = 2.2 Hz, 1H), 7.48 – 7.27 (m, 7H), 7.15 (d, *J* = 2.4 Hz, 1H), 6.92 (d, *J* = 8.4 Hz, 1H), 6.54 (s, 2H), 5.28 (t, *J* = 5.3 Hz, 1H), 5.17 (s, 2H), 4.78 (d, *J* = 5.2 Hz, 2H), 3.93 (s, 3H), 3.91 (s, 3H), 3.82 (s, 6H), 3.69 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$, ppm) δ 168.5, 158.0, 154.4, 152.9, 152.8, 138.4, 137.2, 136.1, 132.7, 132.6, 131.5, 130.5, 129.0, 128.8, 128.4, 128.1, 127.6, 124.4, 122.4, 121.4, 119.6, 112.1, 107.5, 102.9, 70.5, 61.0, 56.2, 56.2, 45.2.

HRMS (ESI-TOF) m/z: $[M+H]^+$ calcd for $C_{35}H_{34}N_2O_7Cl$ 629.2055; Found 629.2071.

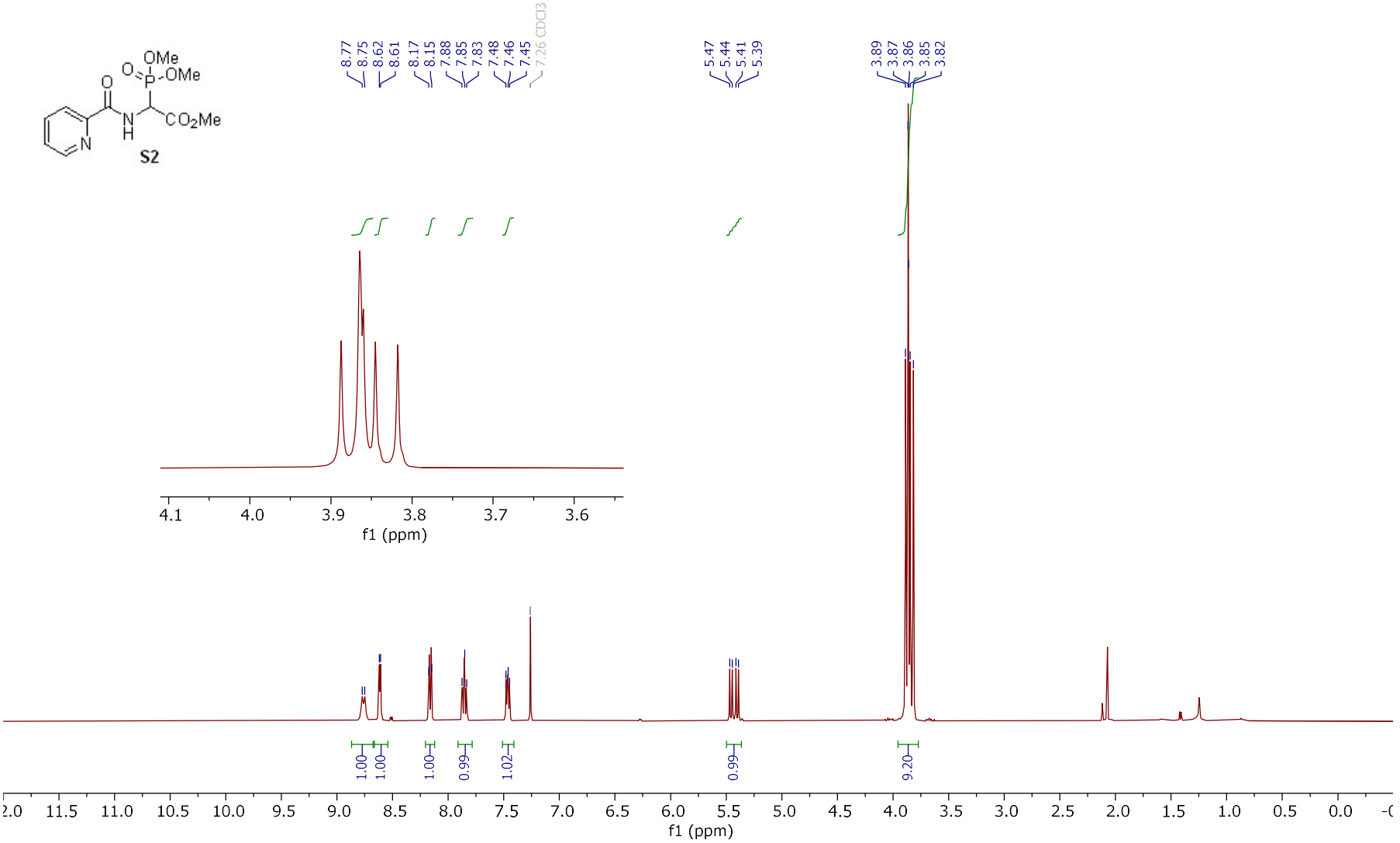
FT-IR (thin film, cm^{-1}) υ 3414, 3004, 2935, 2837, 1719, 1582, 1534, 1500, 1453, 1410, 1344, 1253, 1209, 1176, 1126, 1064, 1025.

References

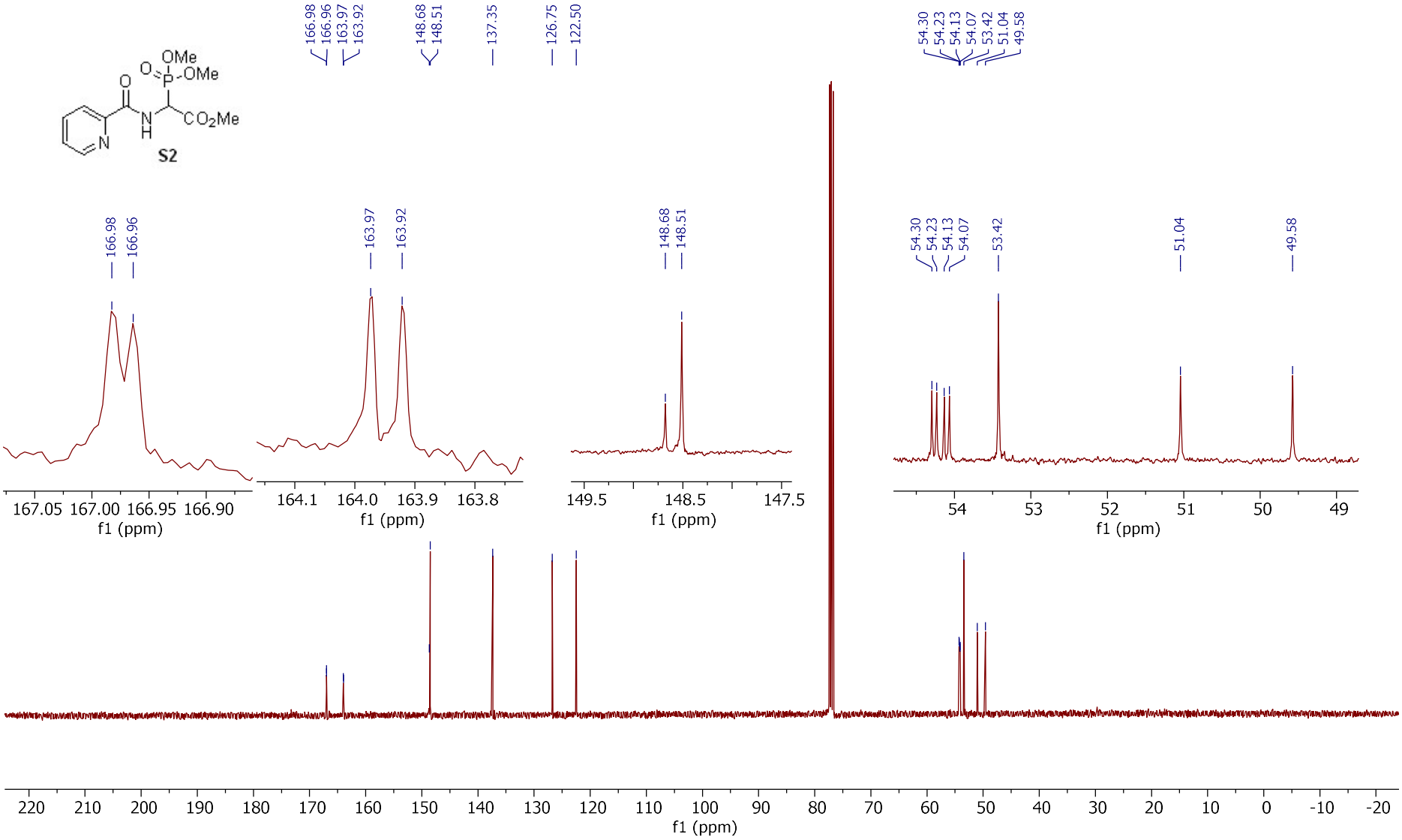
(1) Lukasevics, L.; Cizikovs, A.; Grigorjeva, L. *Org. Lett.* **2021**, *23*, 2748–2753.

NMR spectra

^{1}H-NMR, 400 MHz, $CDCl_3$



^{13}C-NMR, 100 MHz, $CDCl_3$



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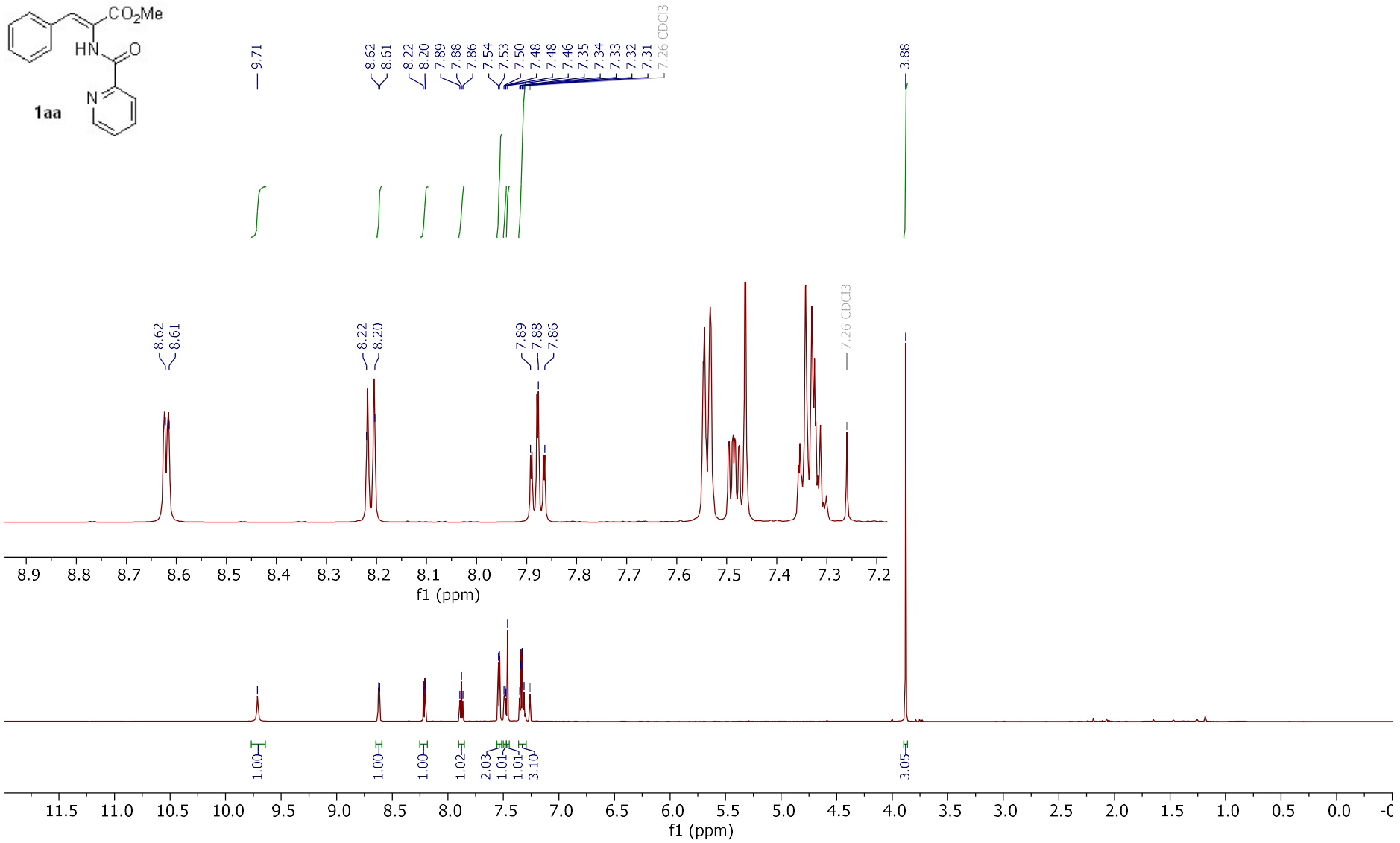

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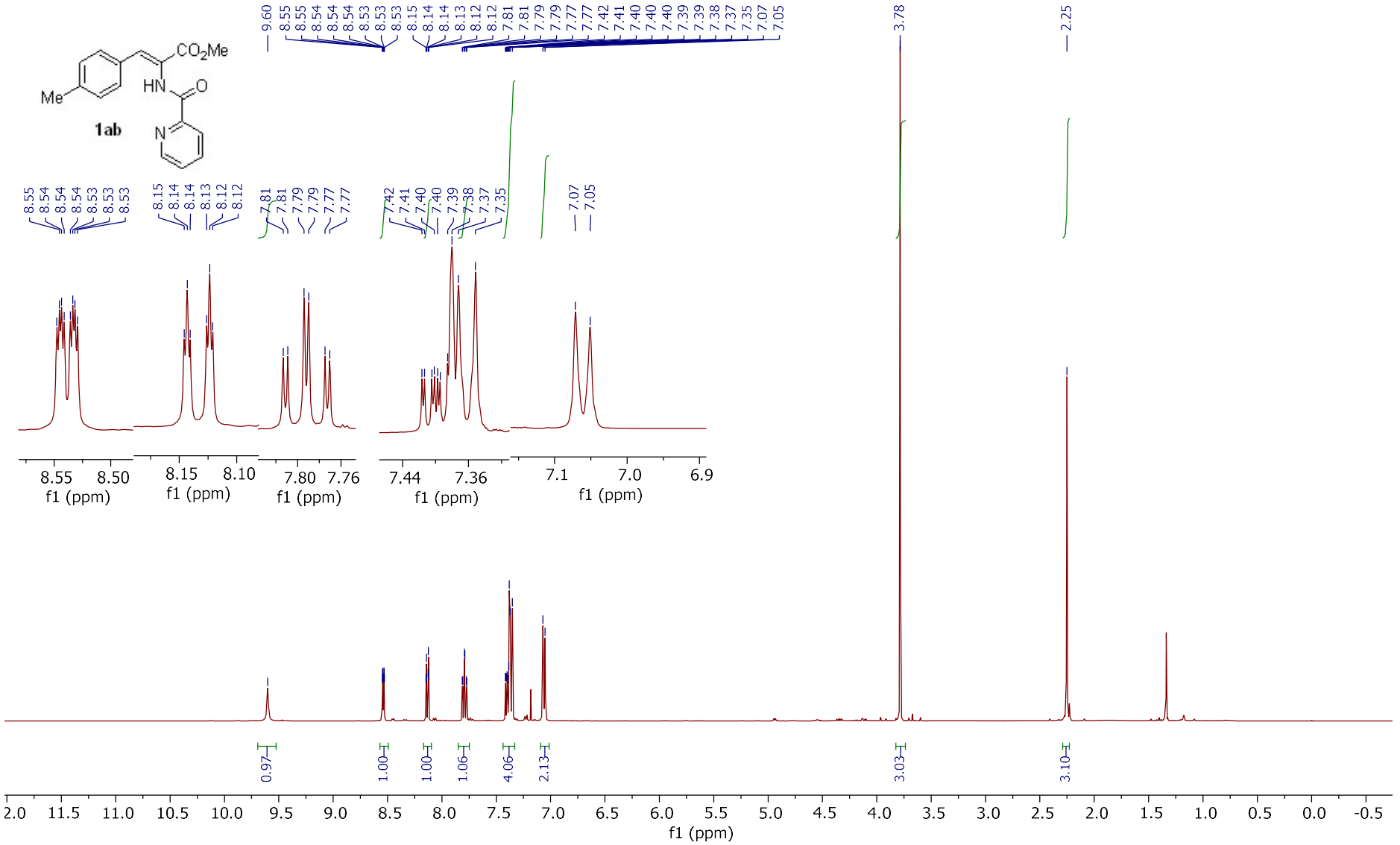

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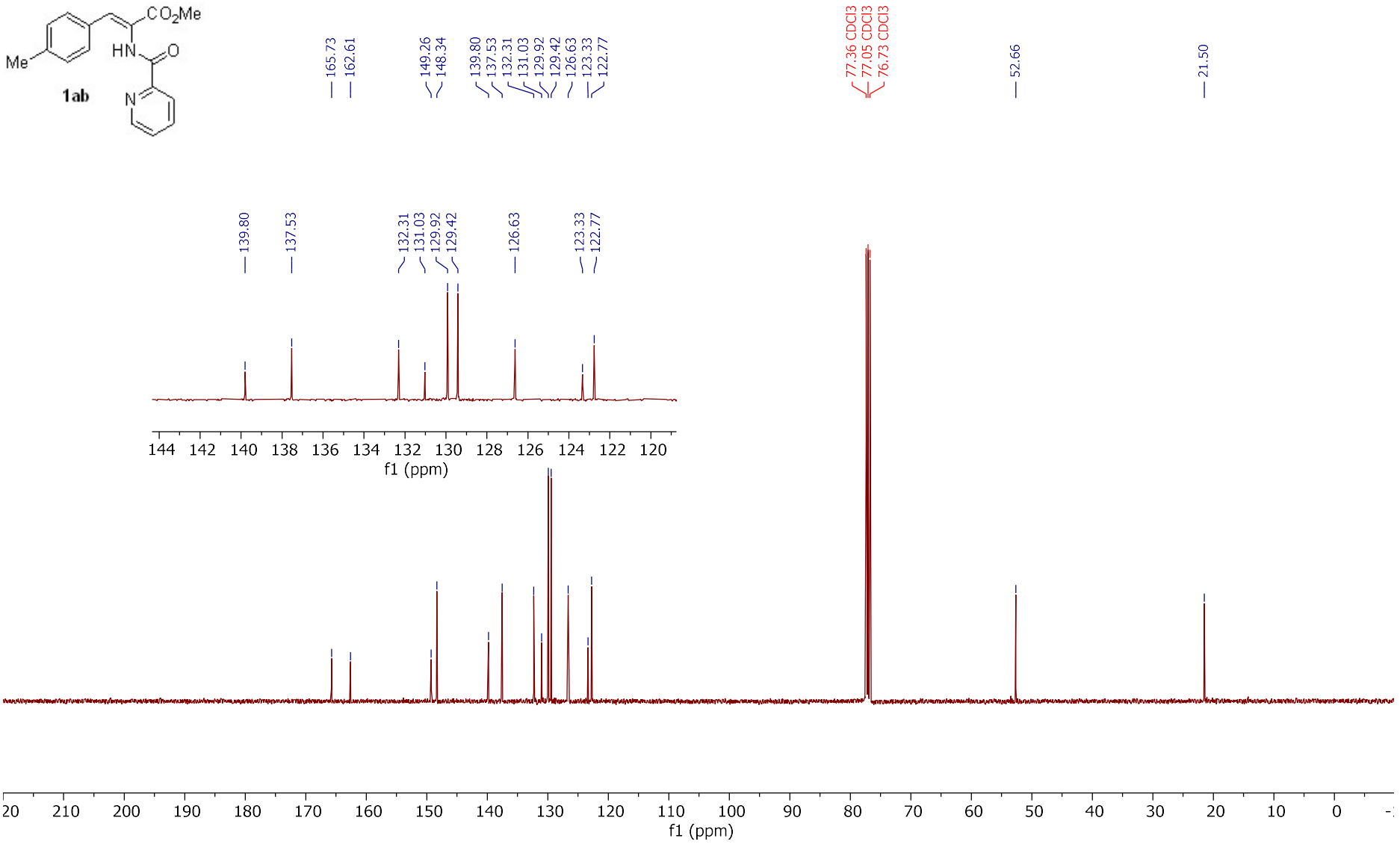

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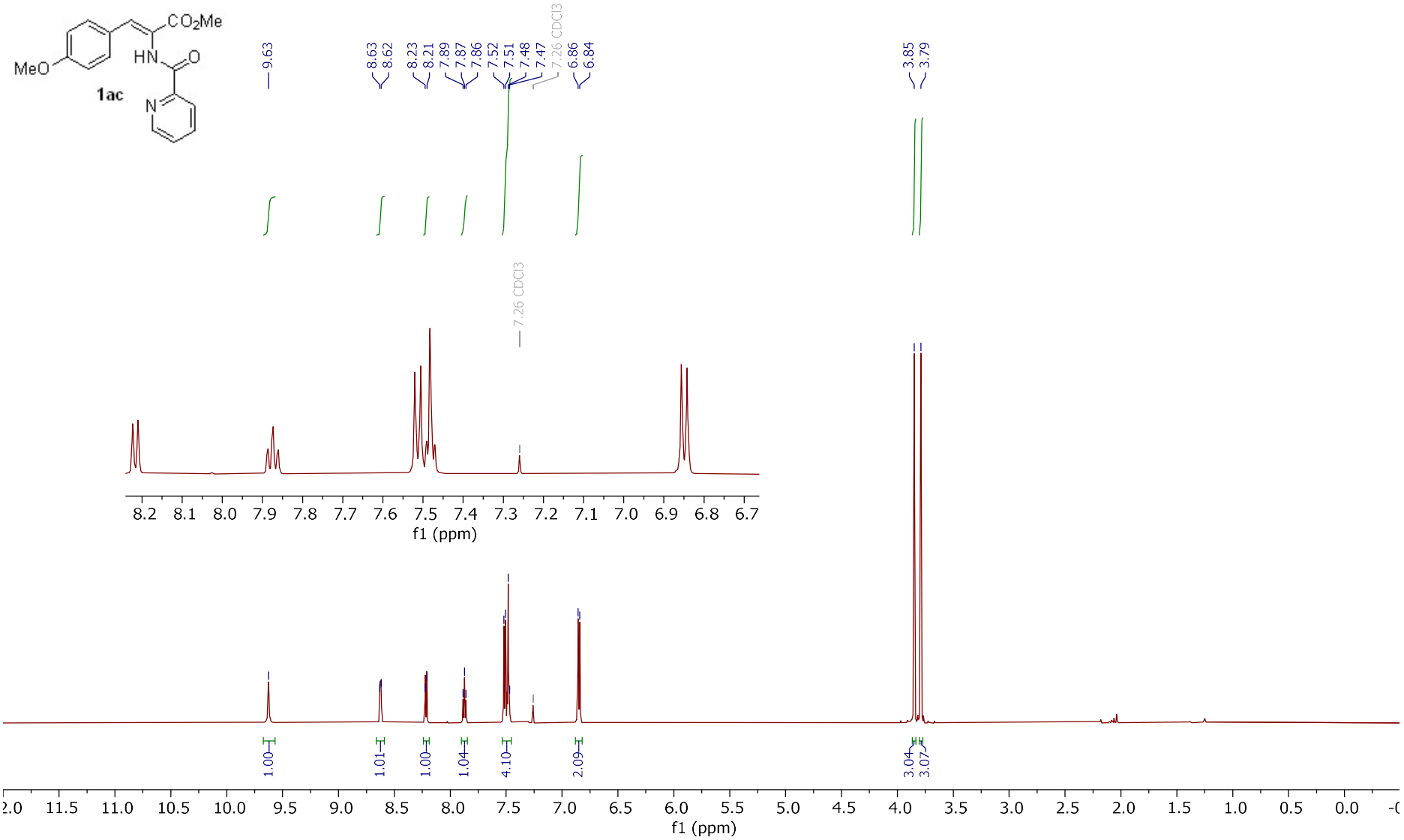

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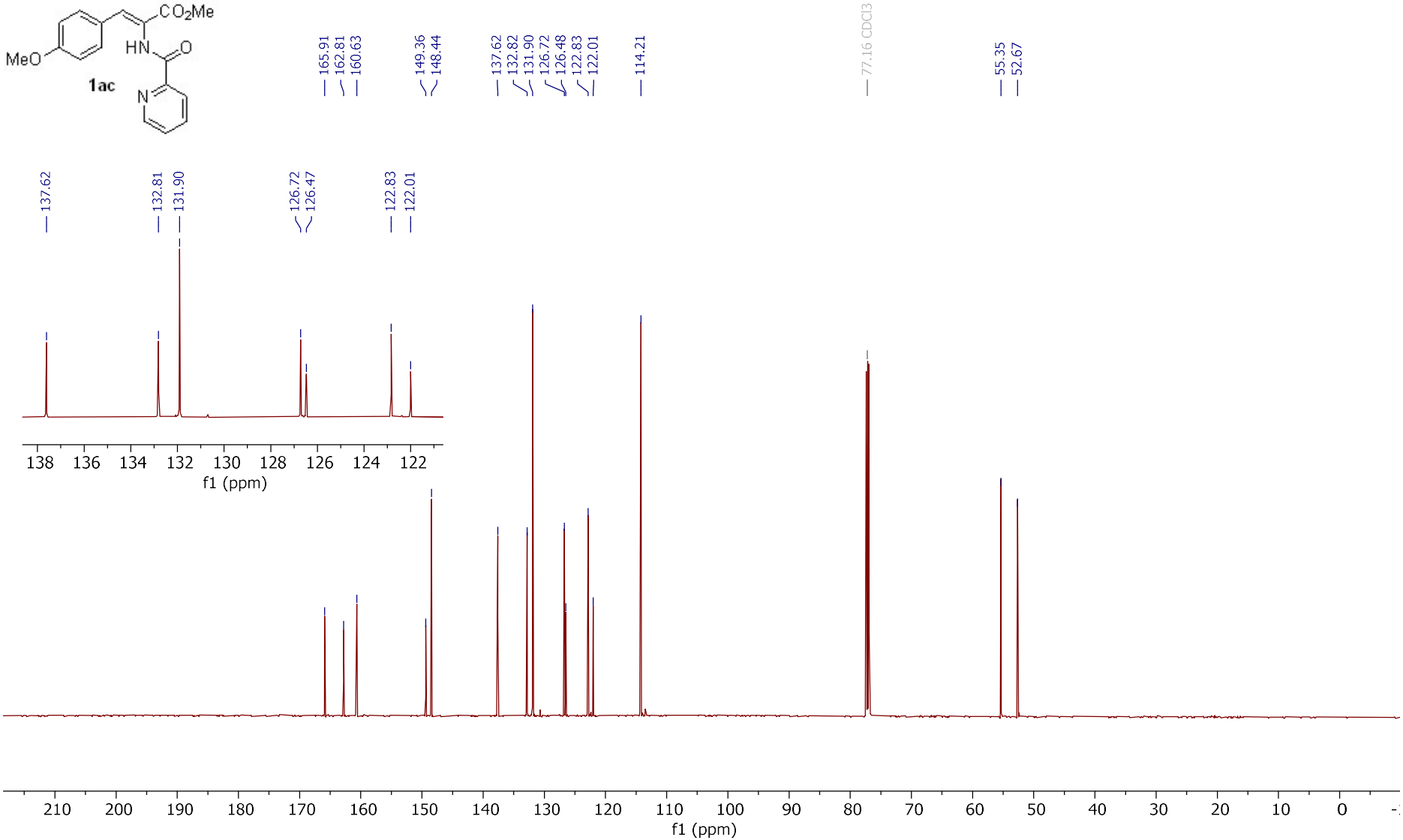

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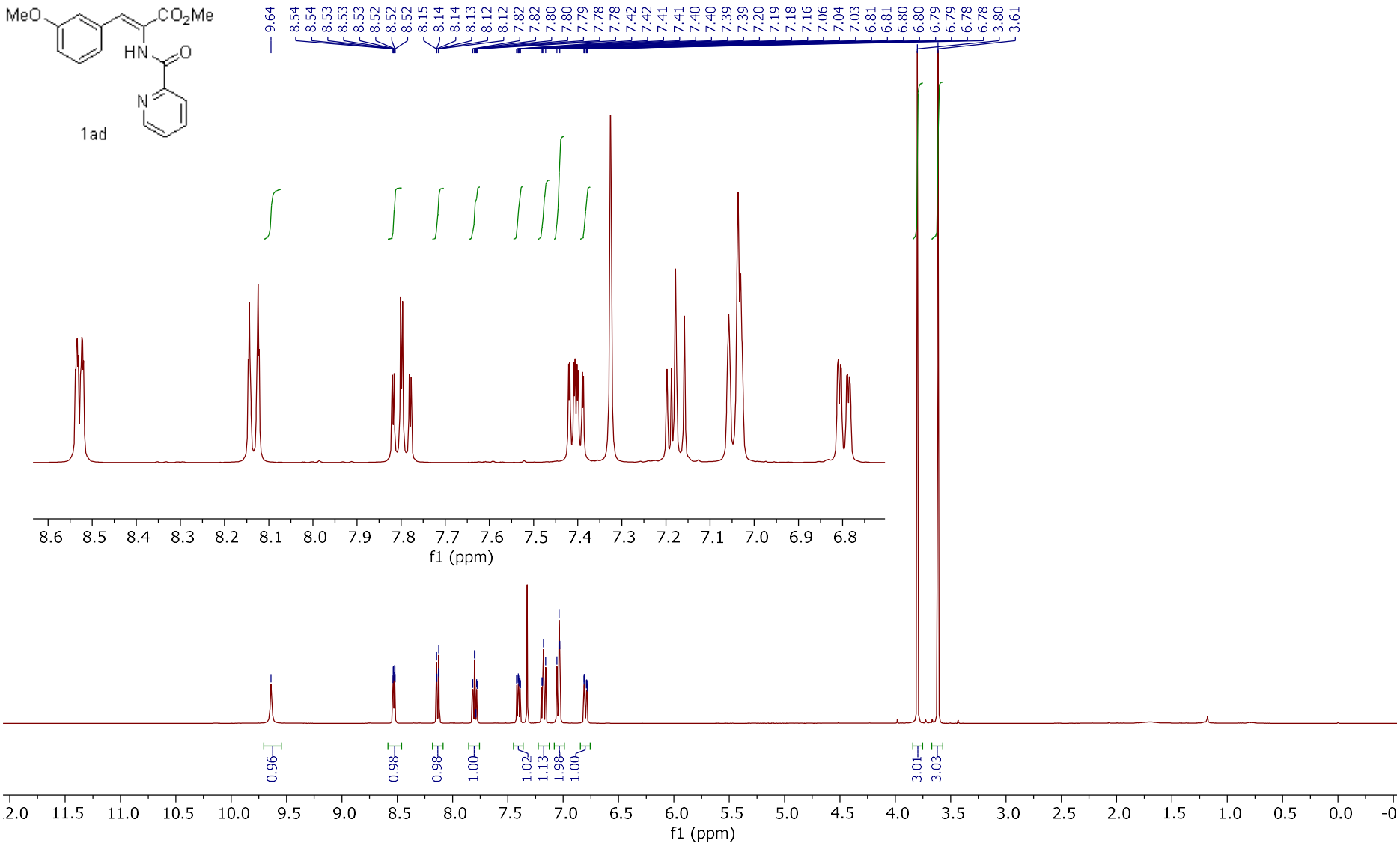

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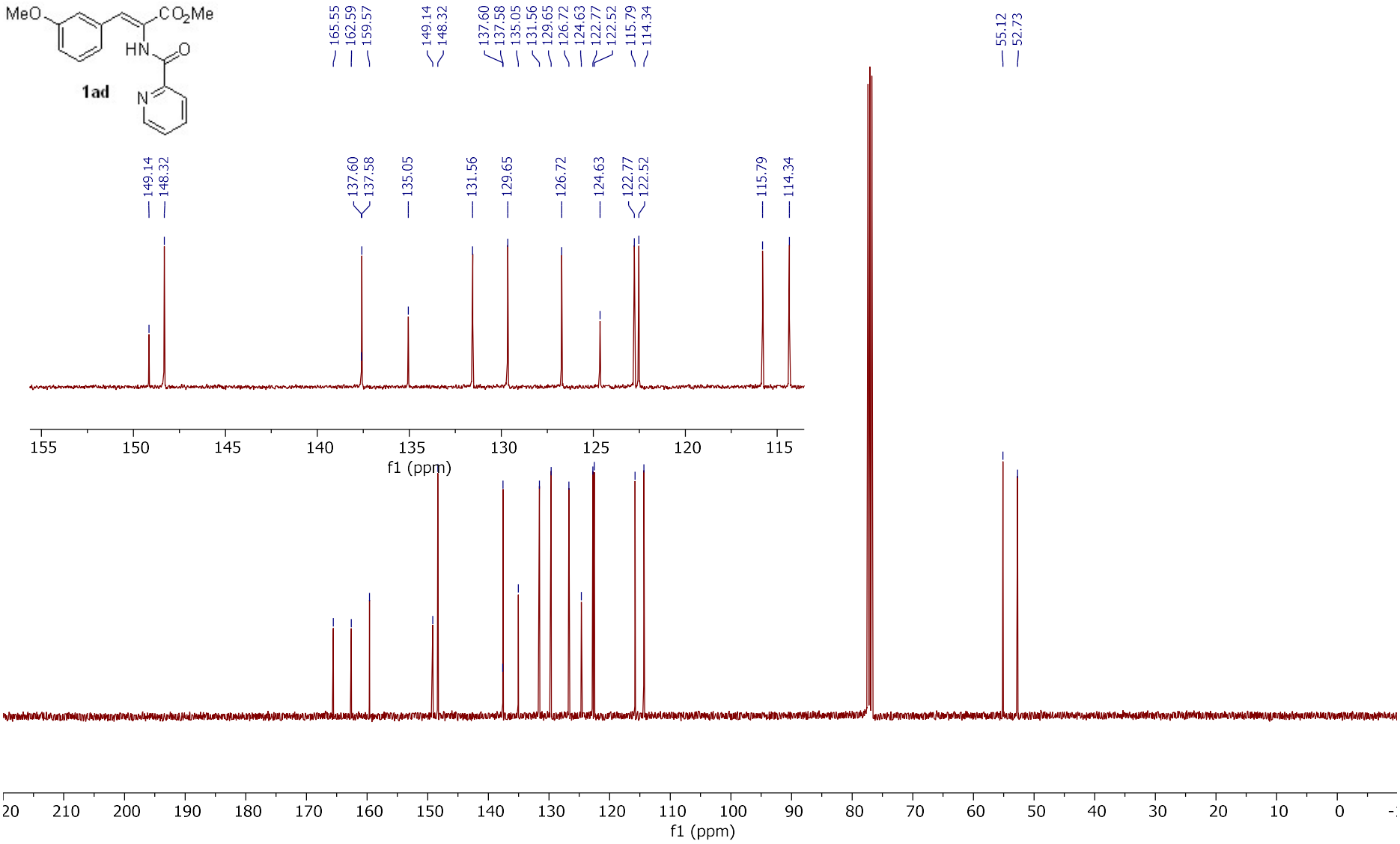

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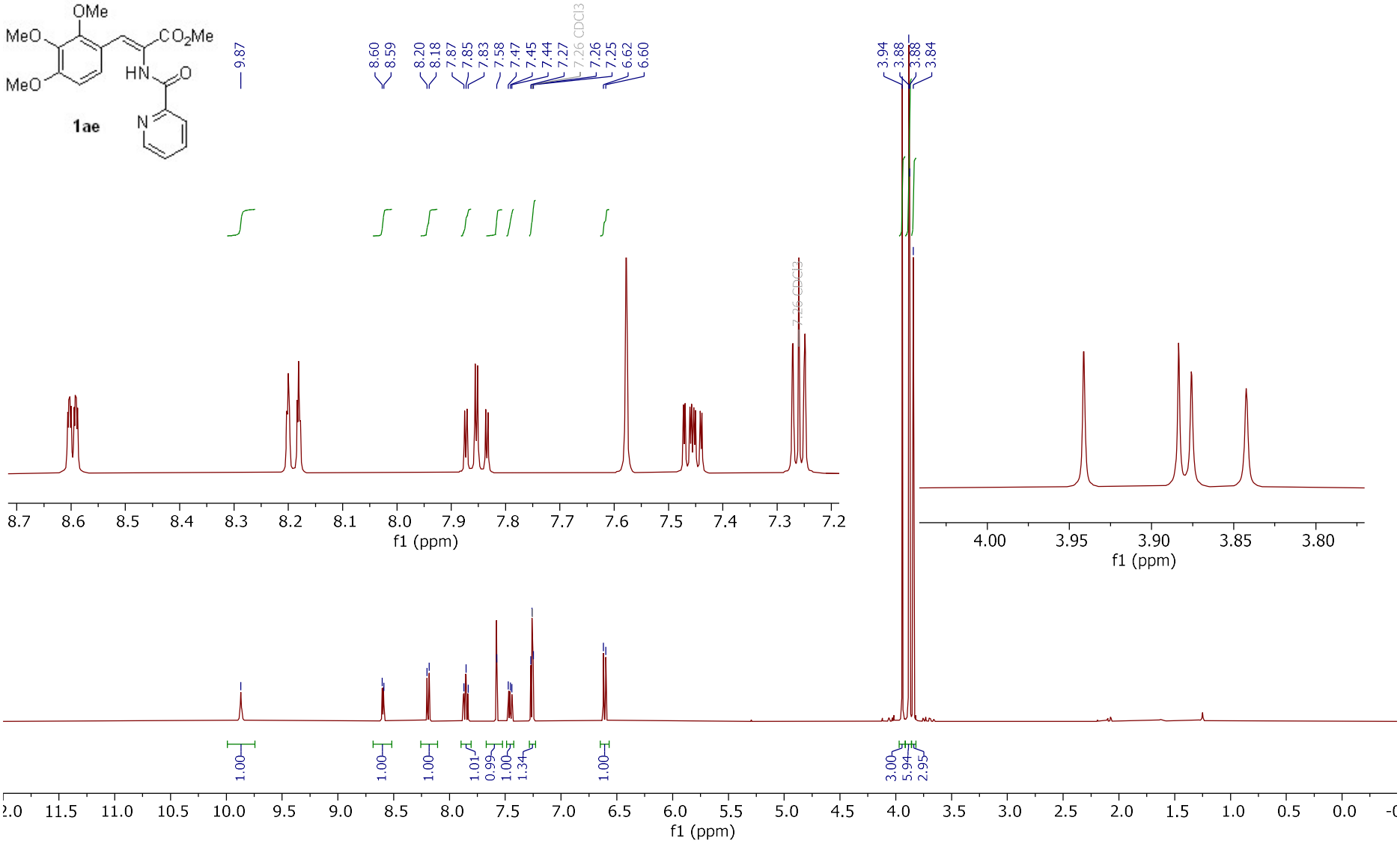

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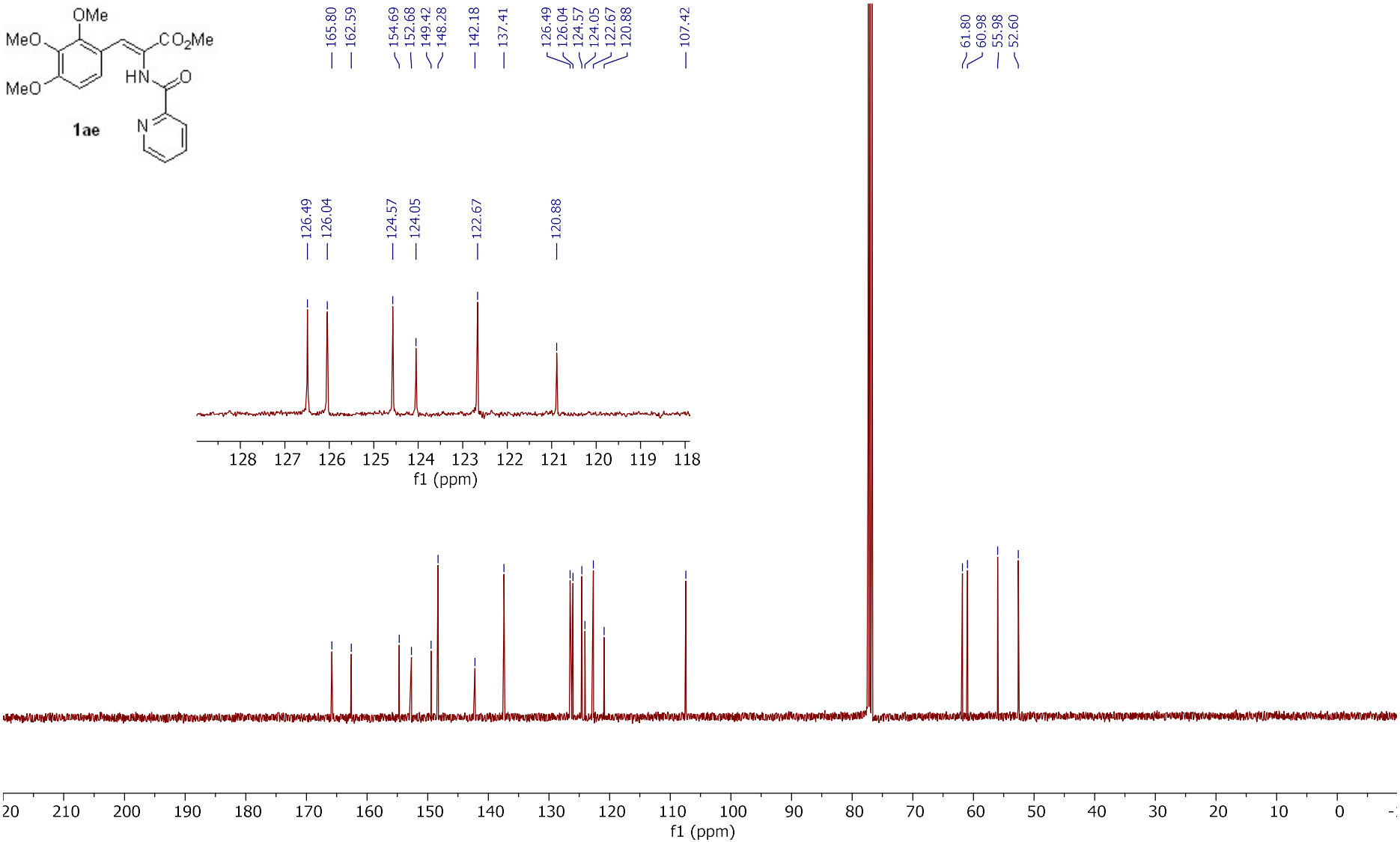

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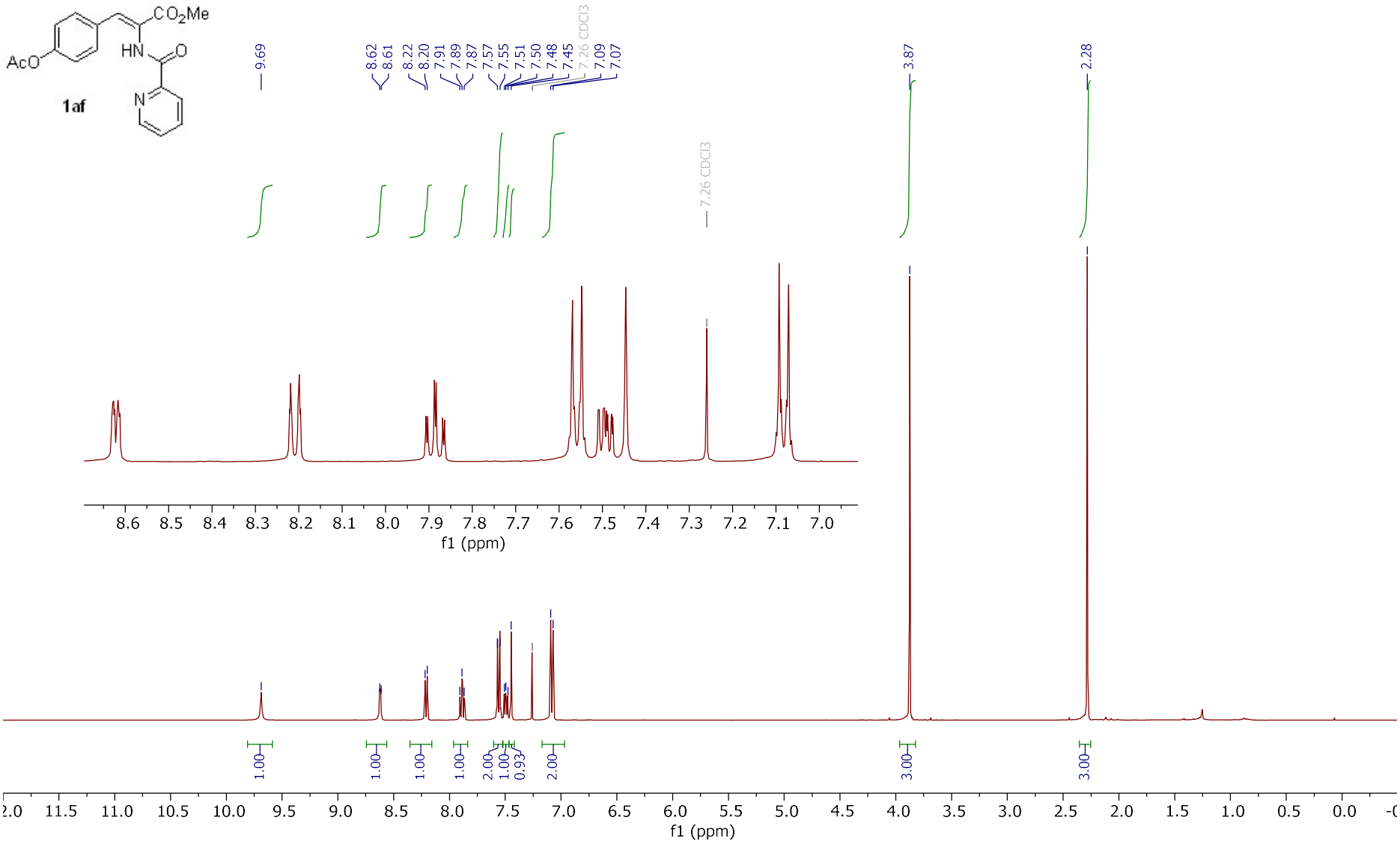

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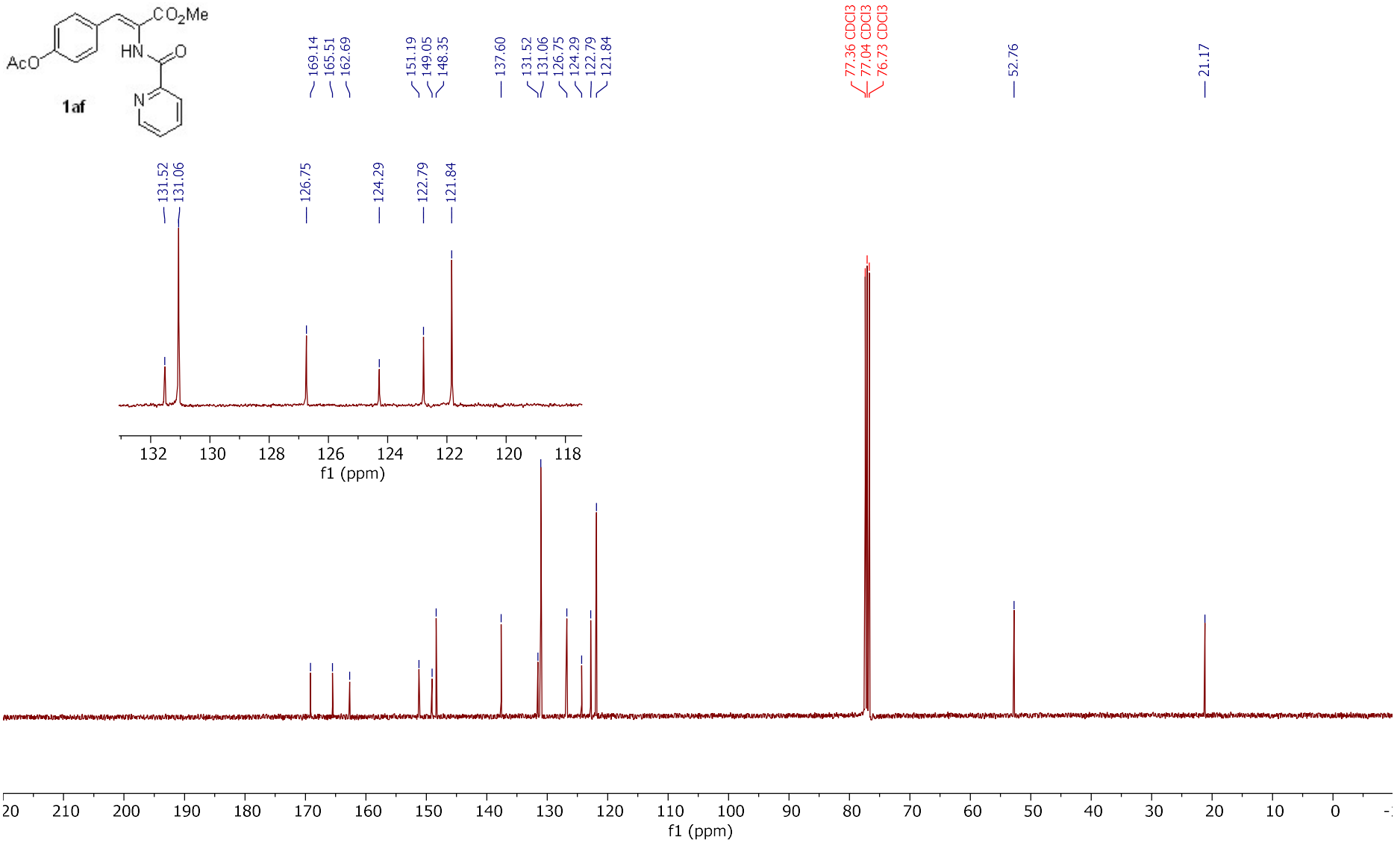

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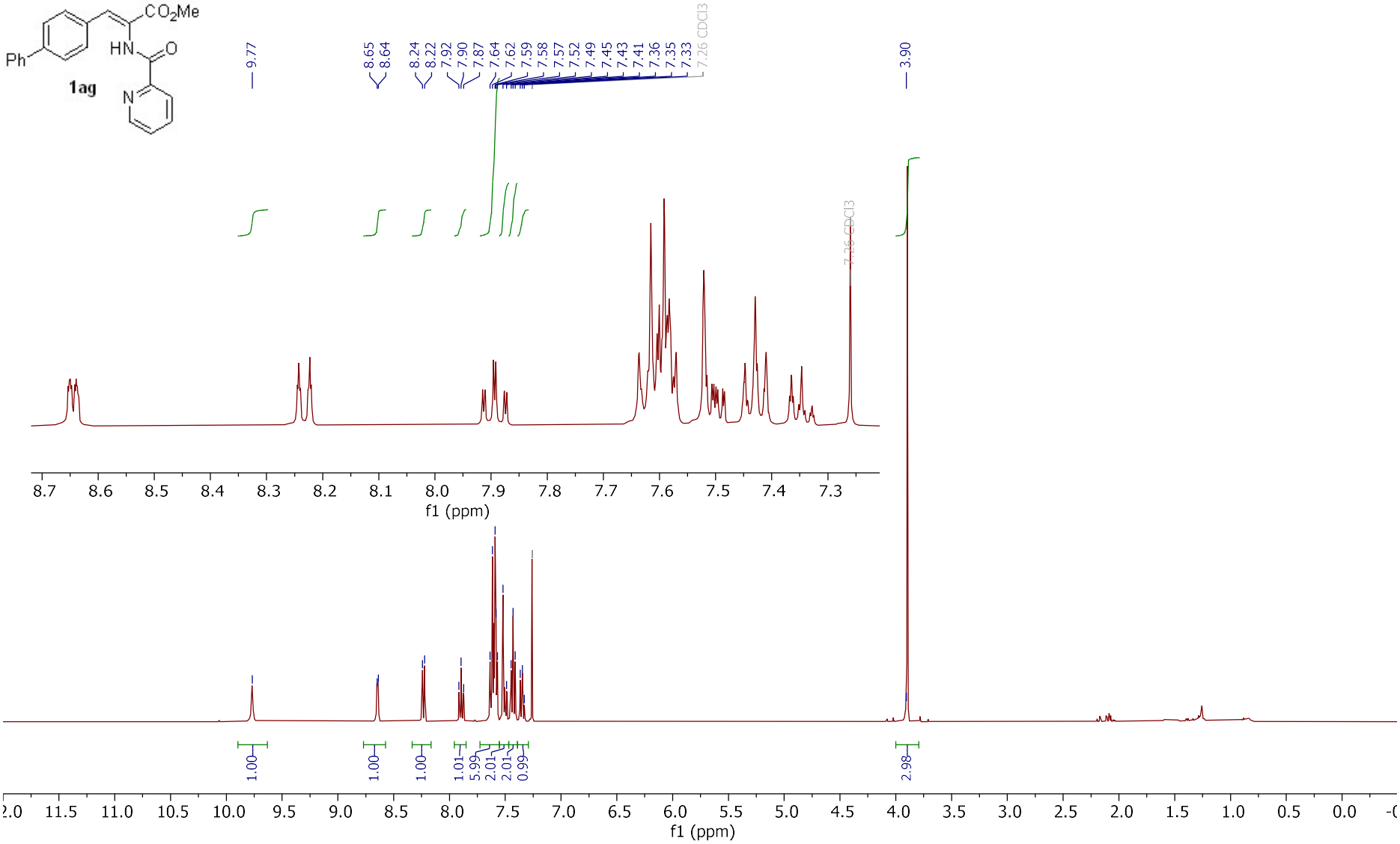

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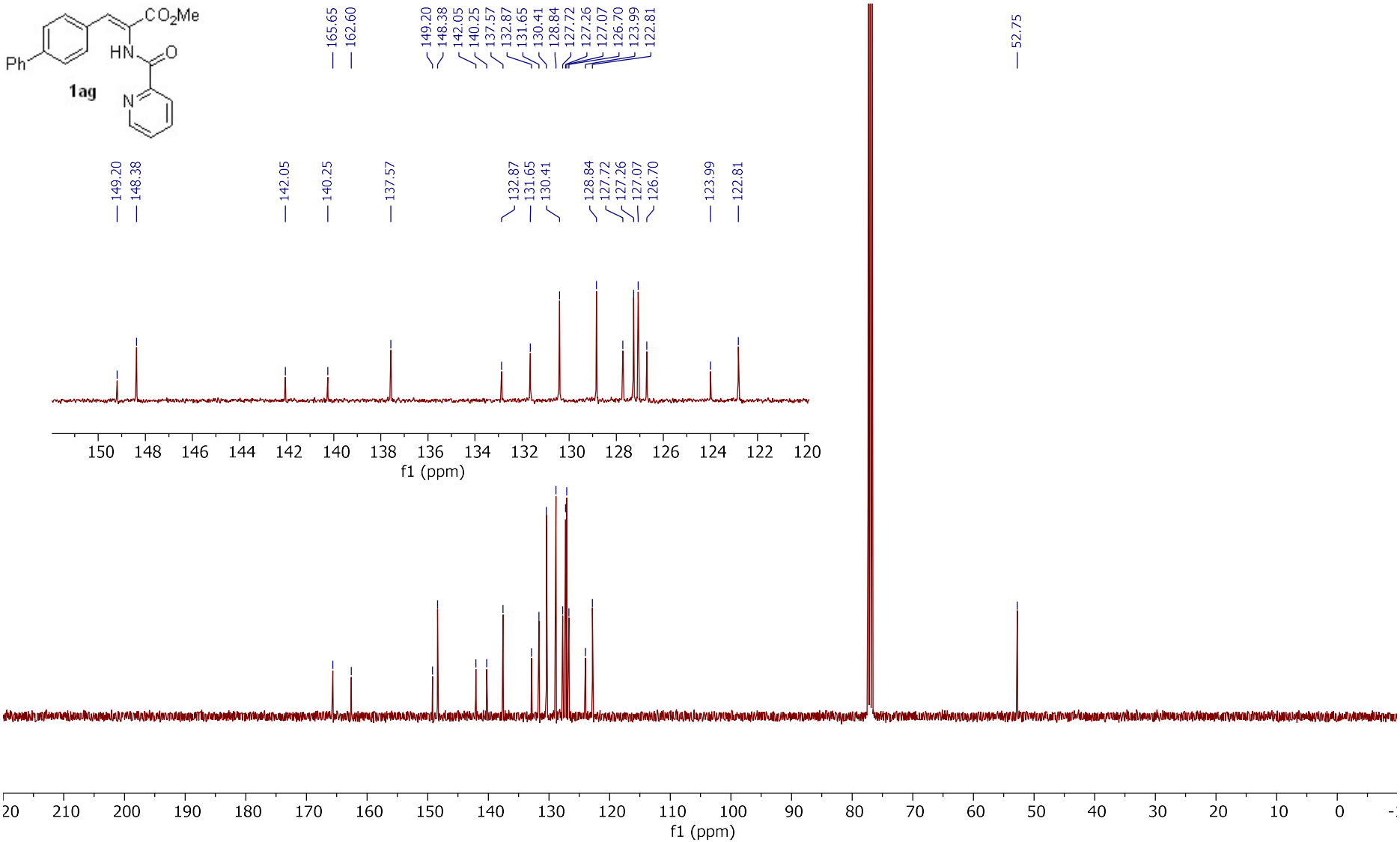

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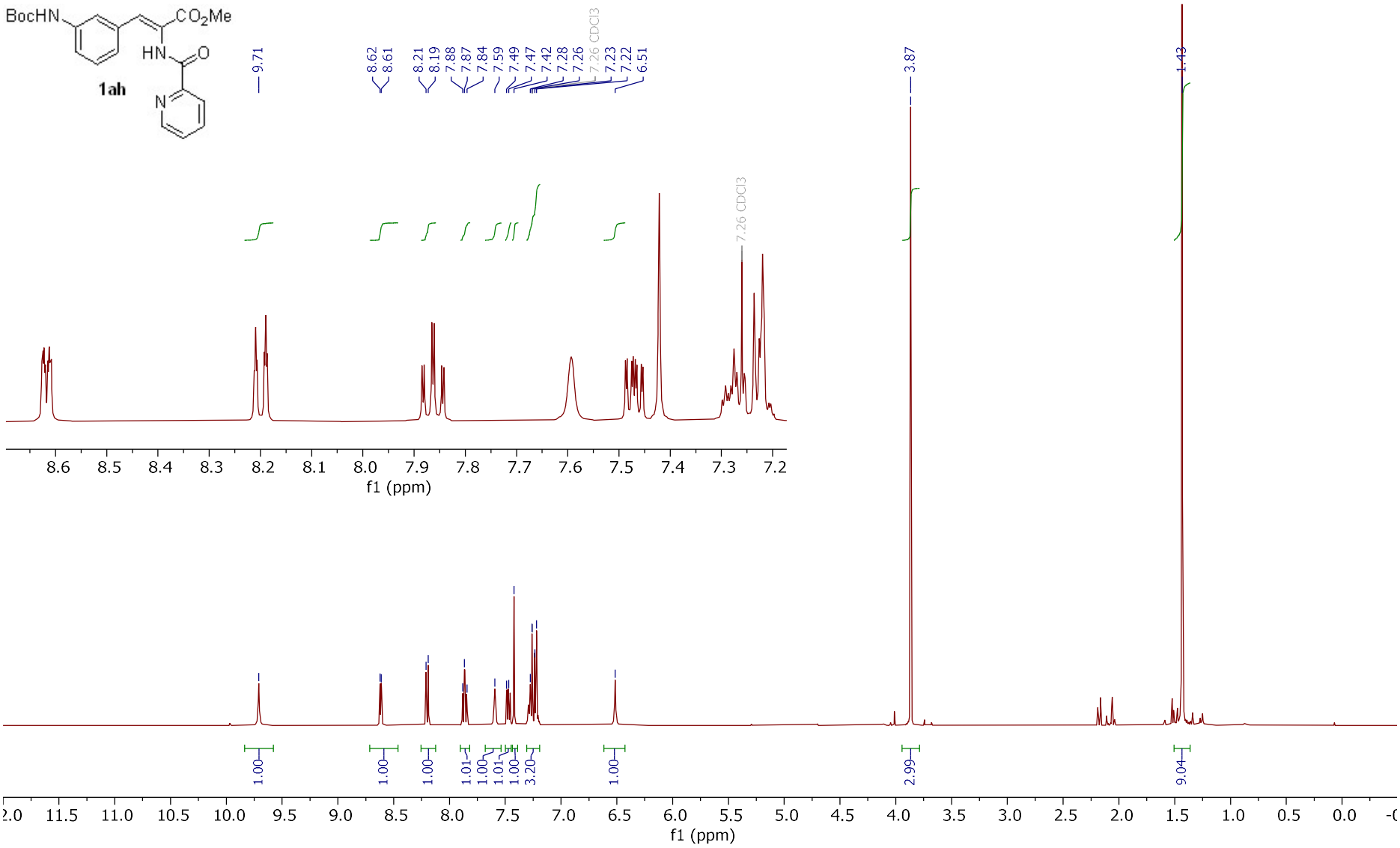

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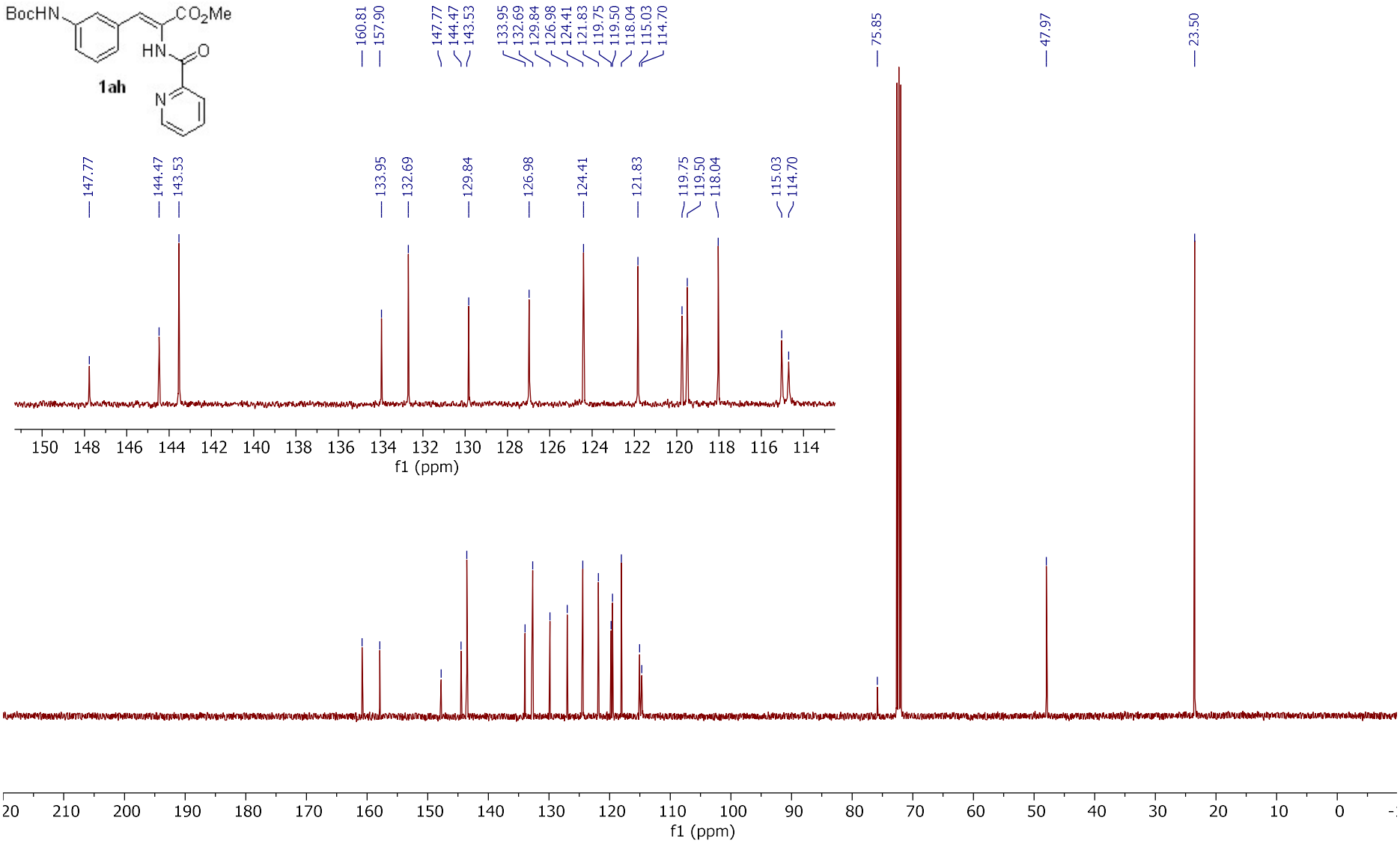

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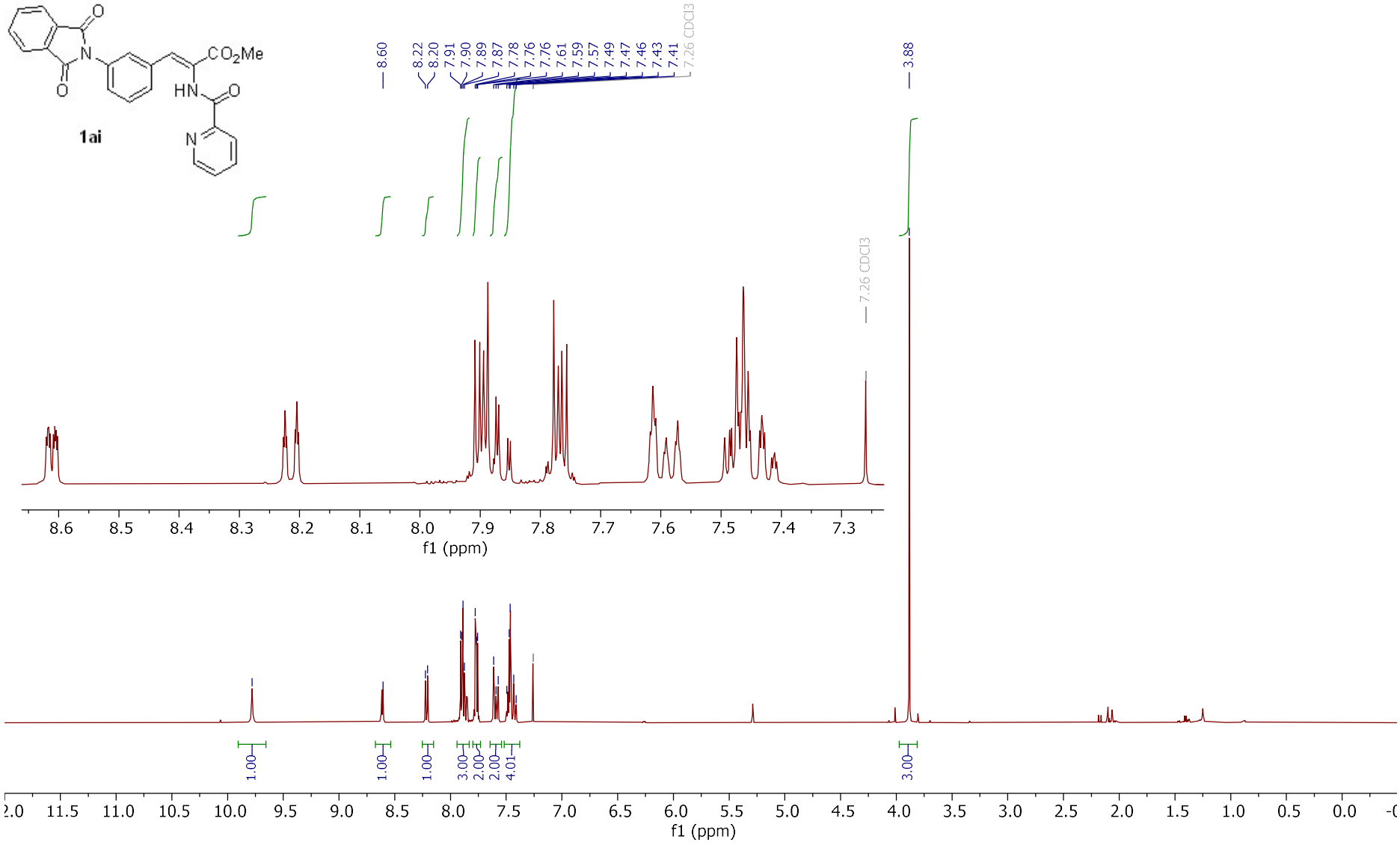

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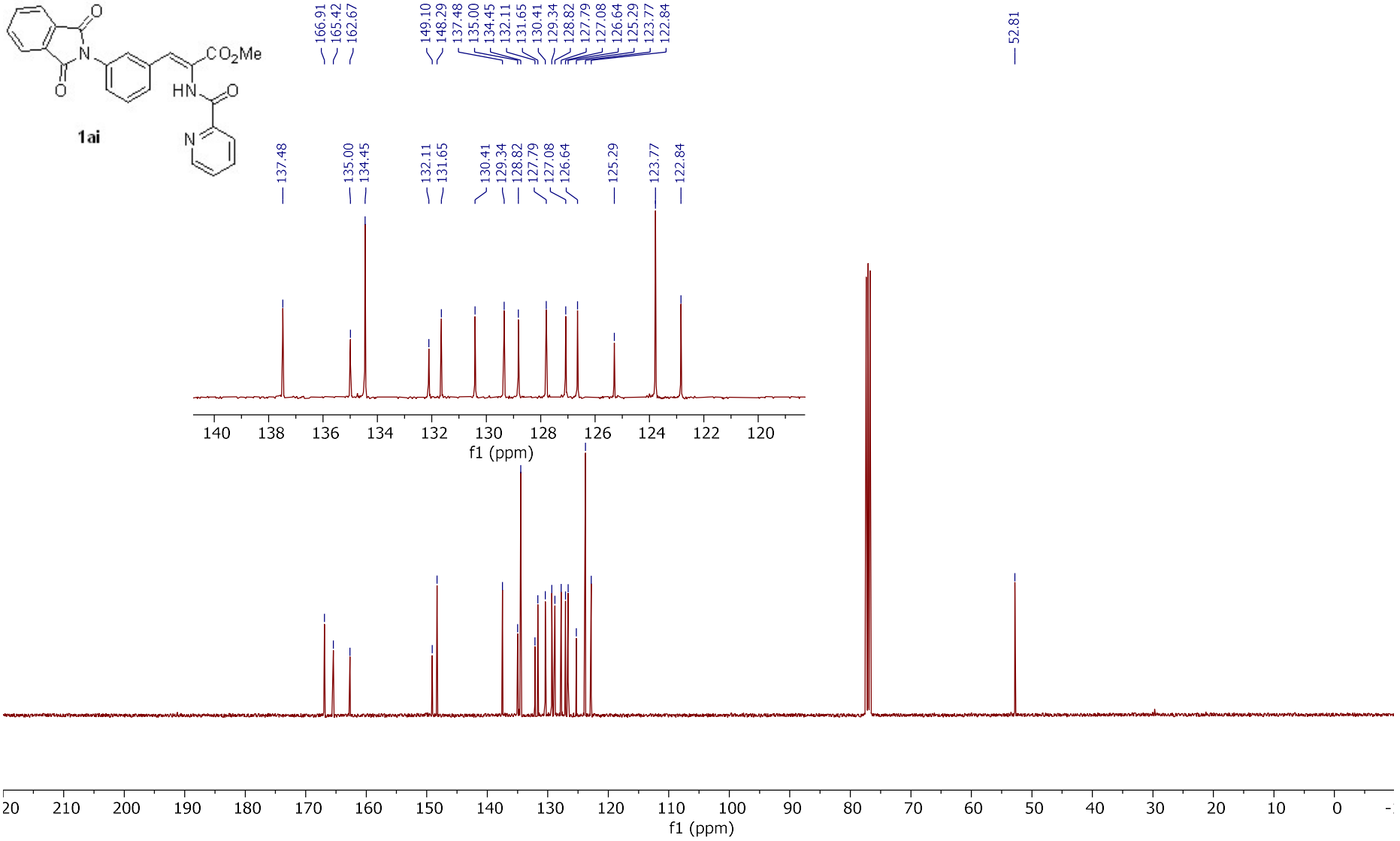

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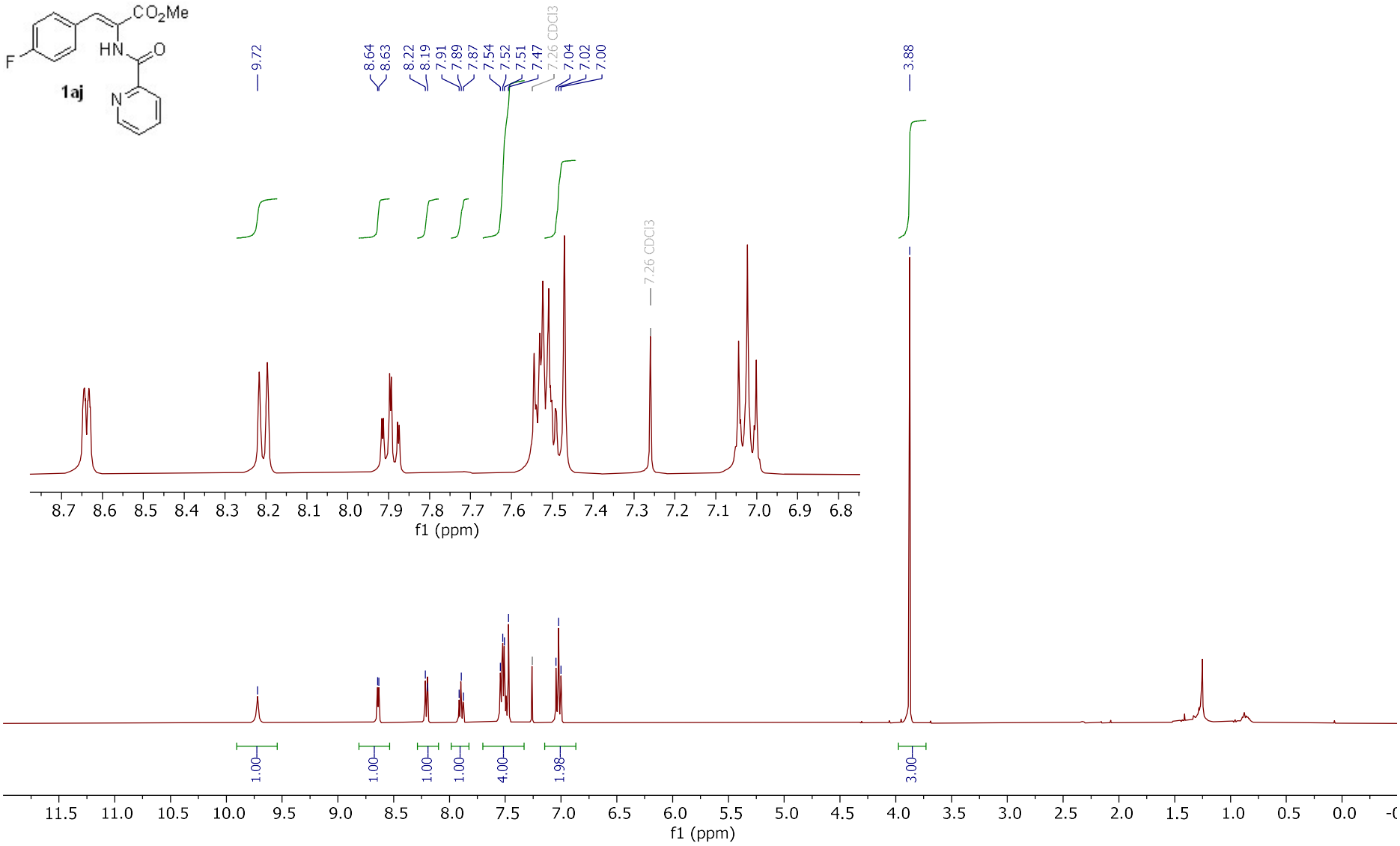

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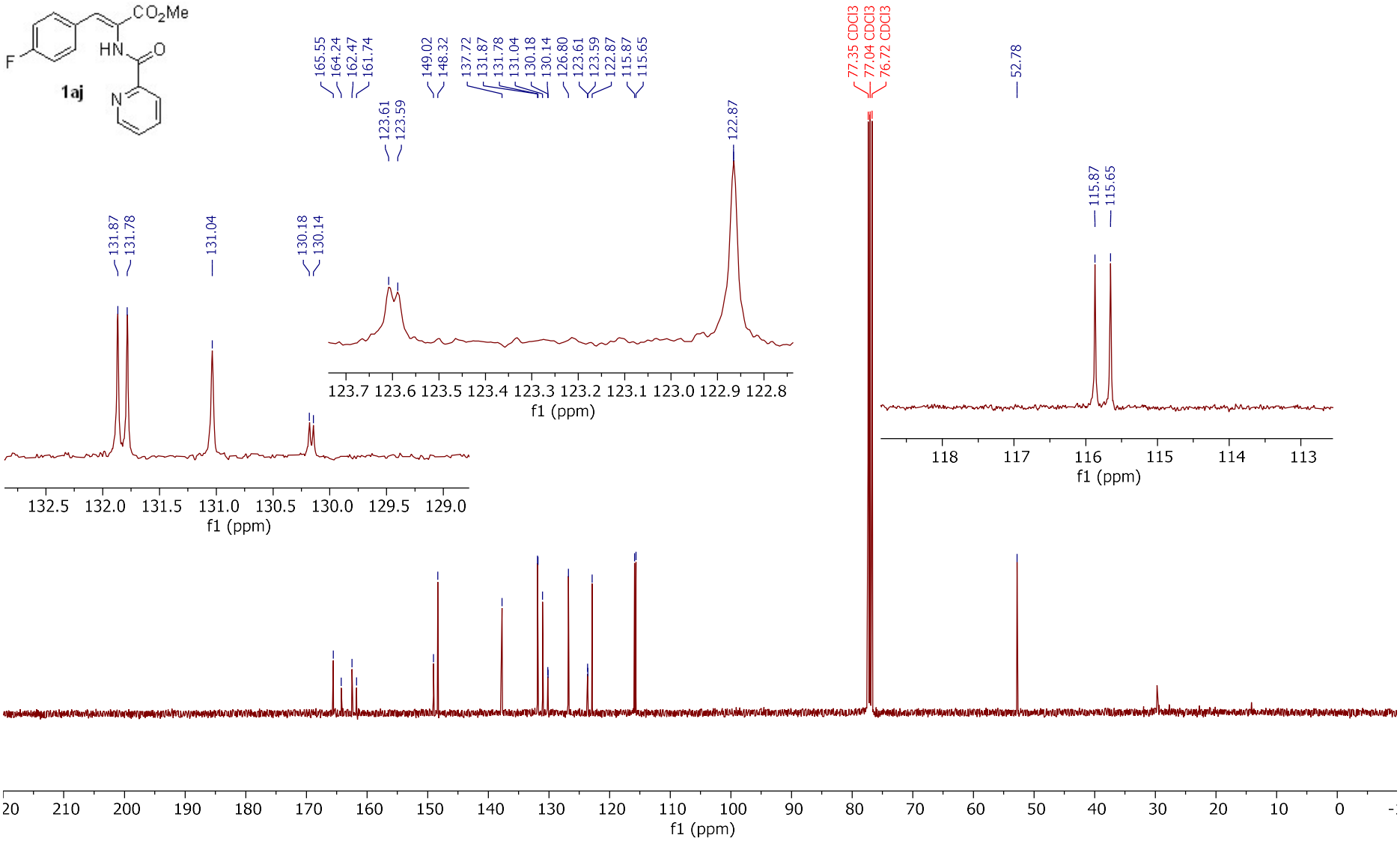
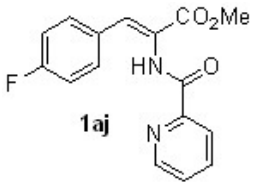


^{19}F-NMR, 376 MHz, $CDCl_3$



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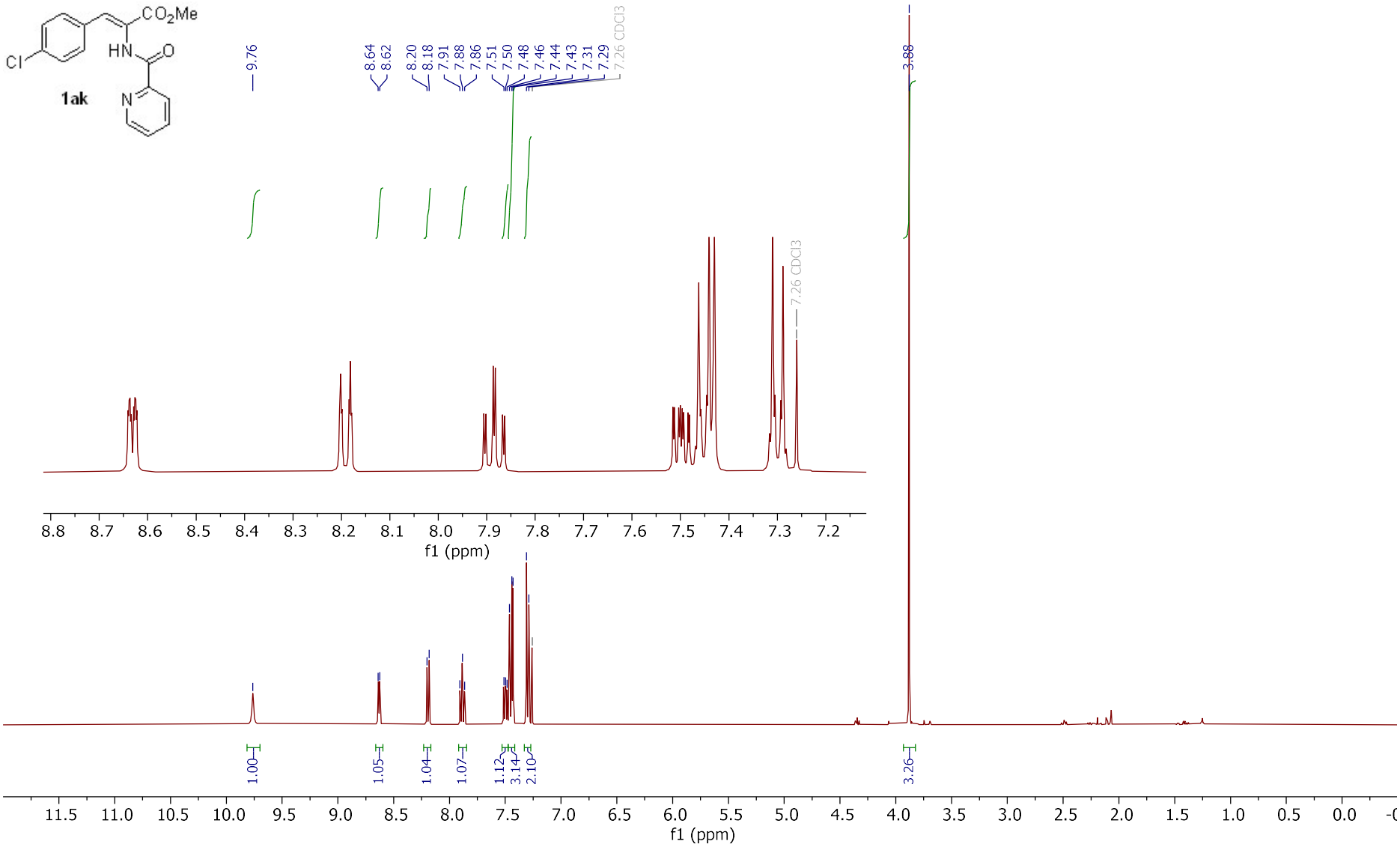
^{1}H-NMR, 400 MHz, $CDCl_3$



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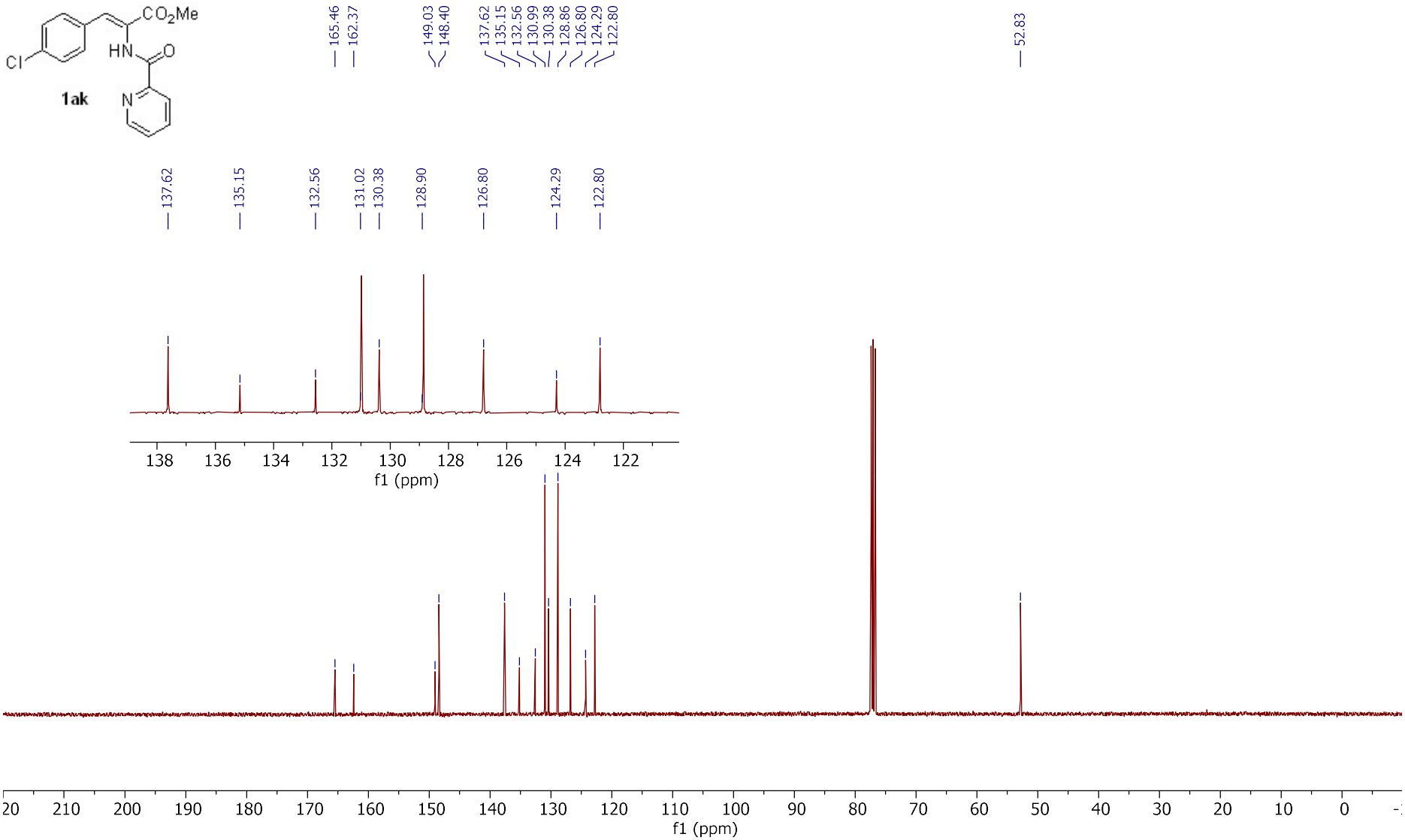

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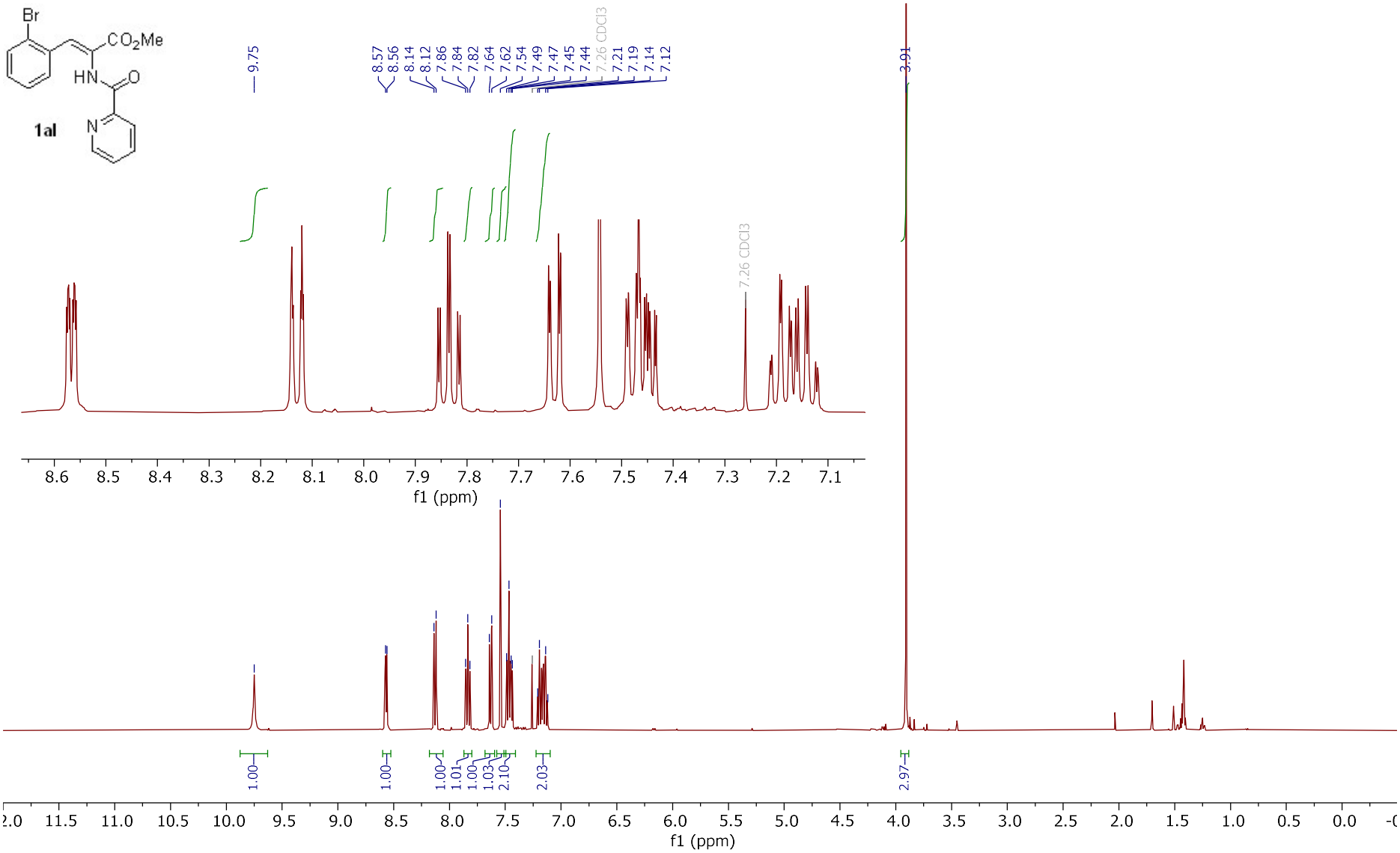

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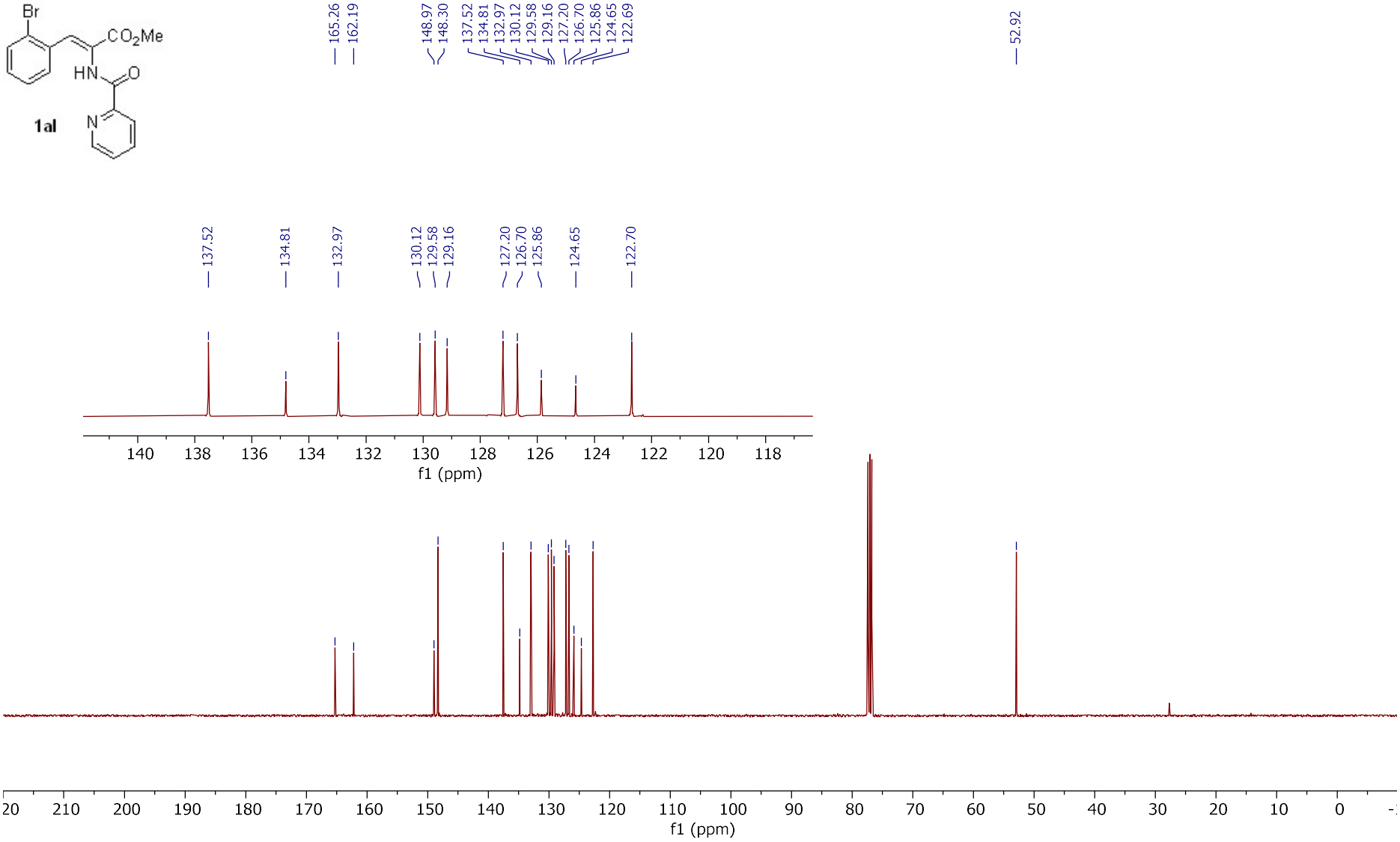

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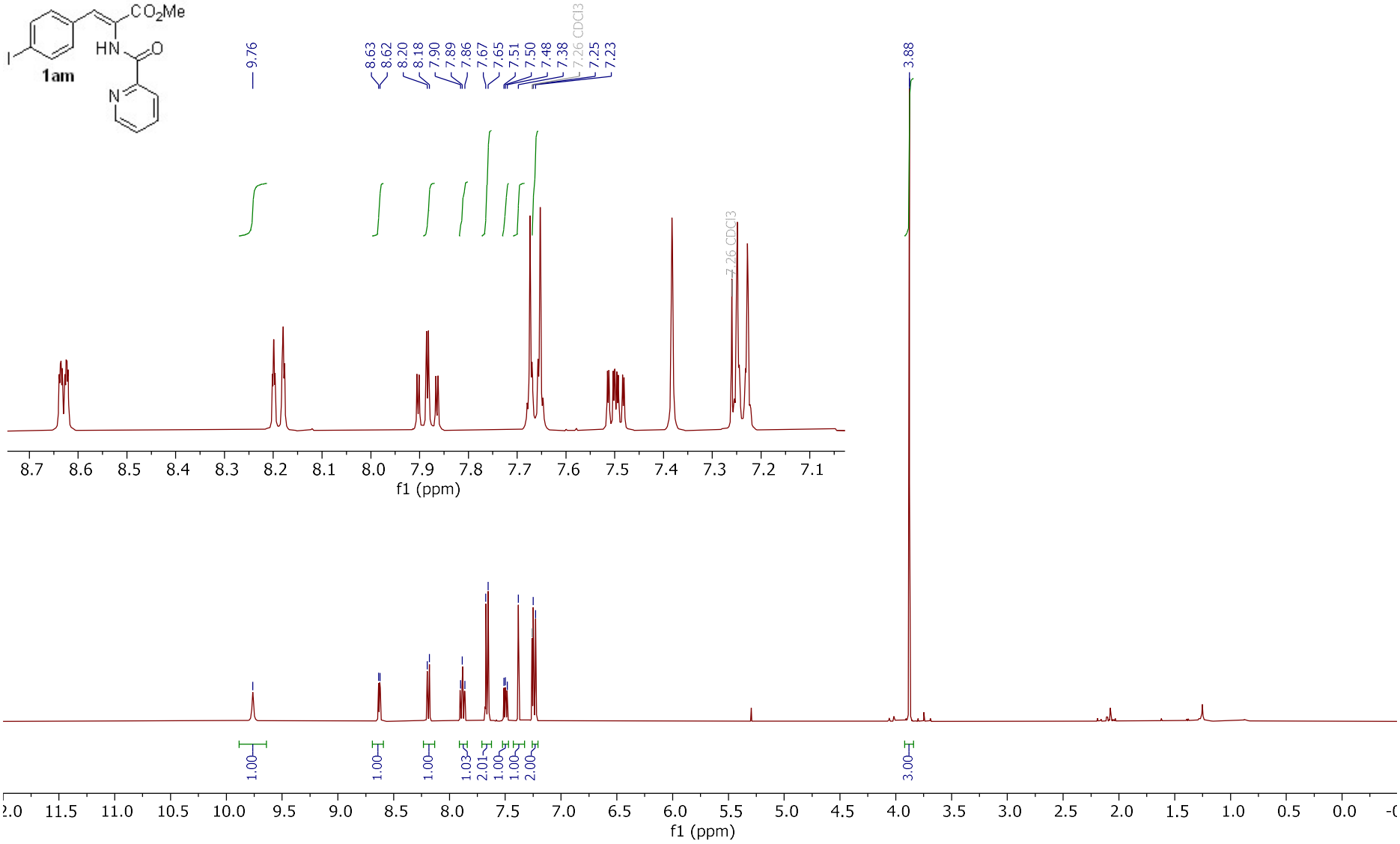

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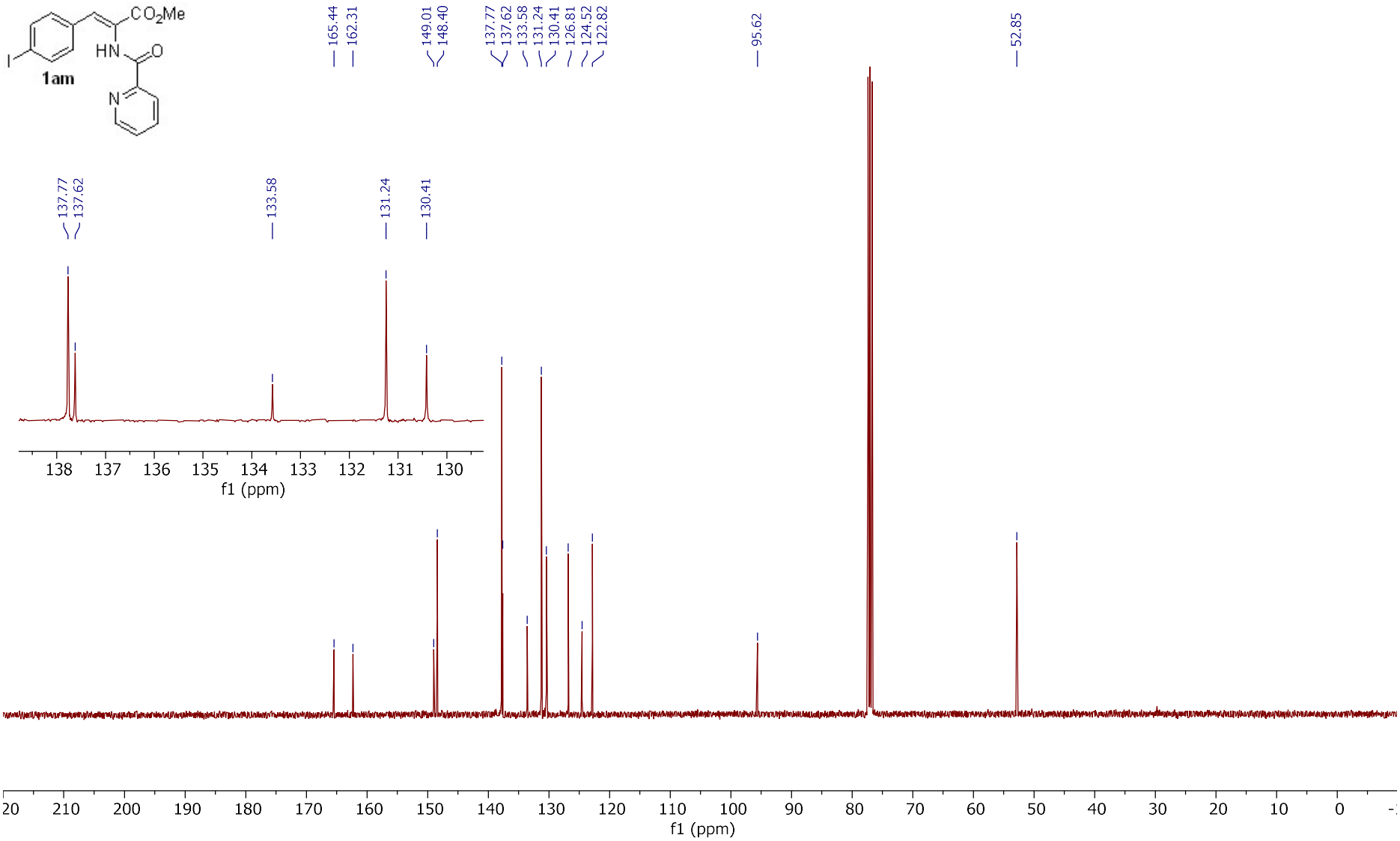

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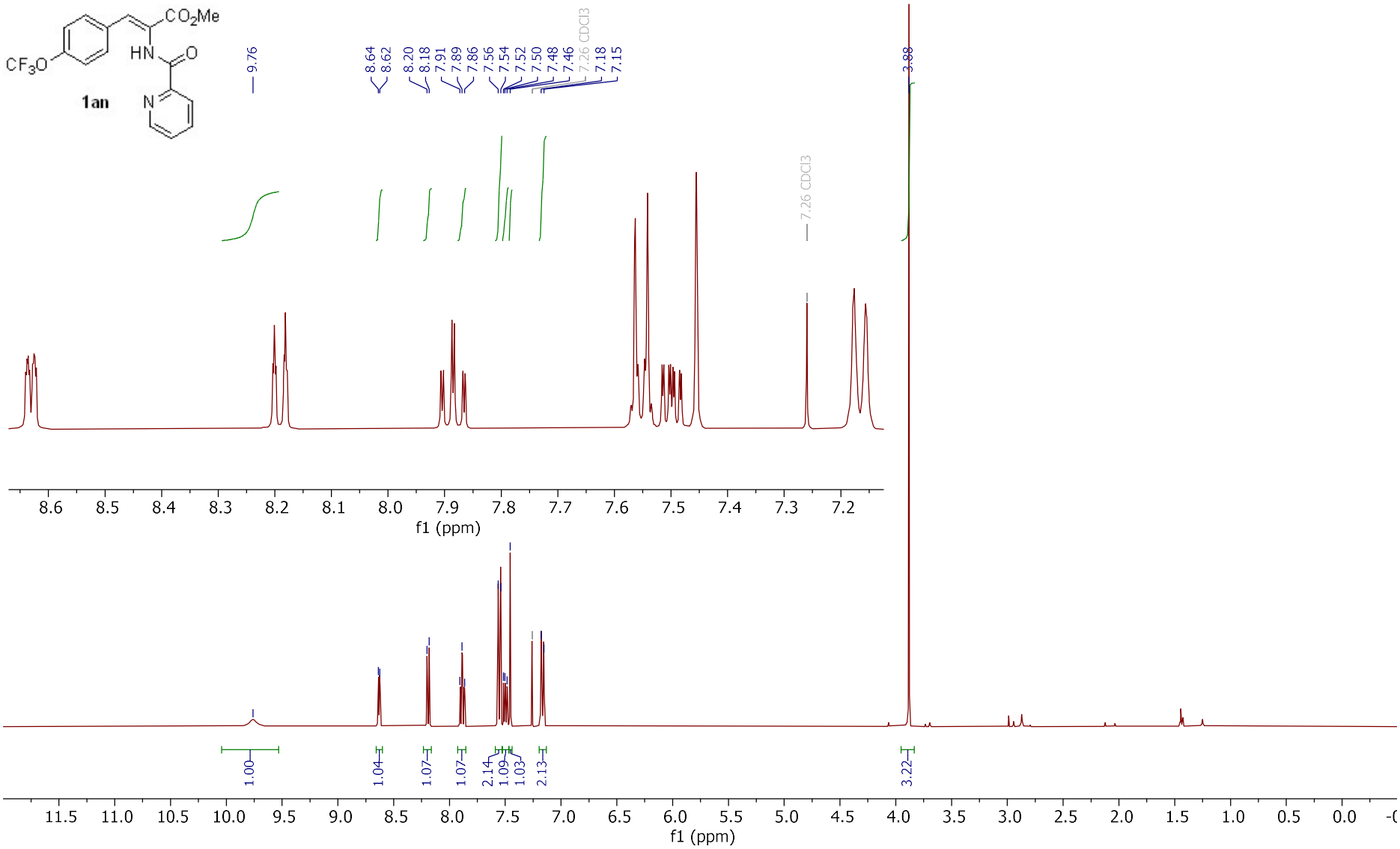

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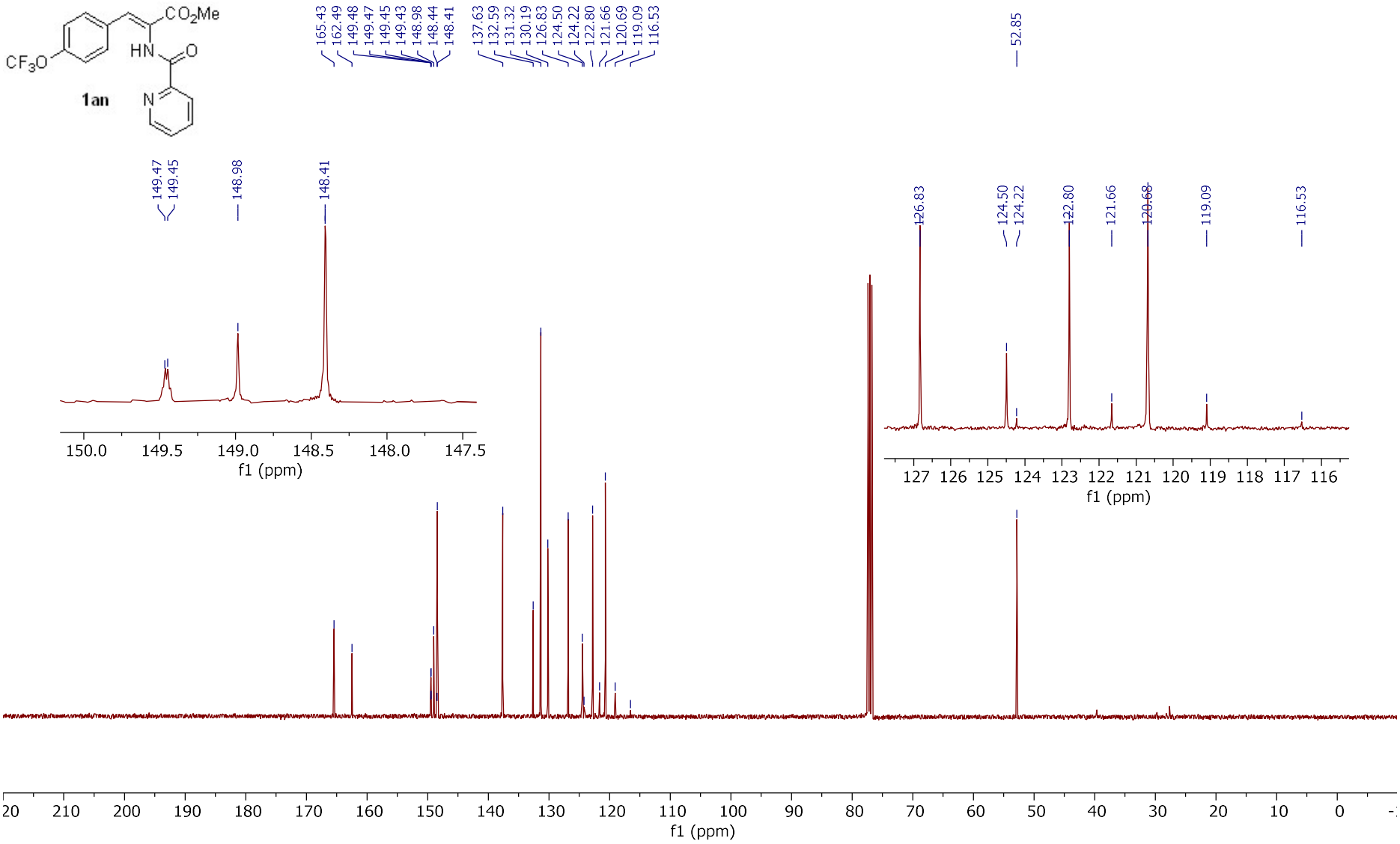
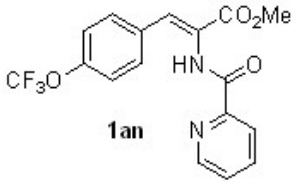


^{19}F-NMR, 376 MHz, $CDCl_3$



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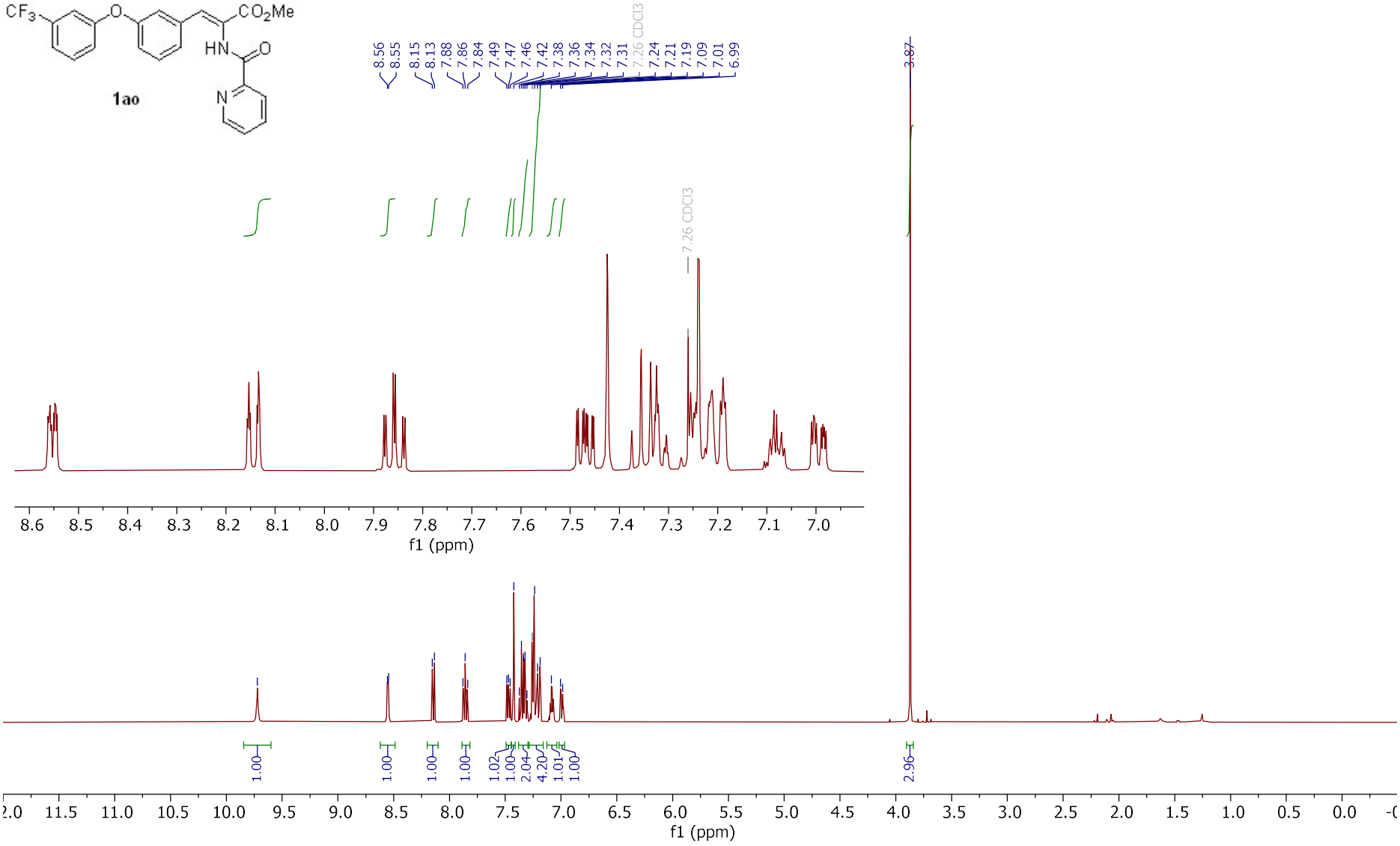

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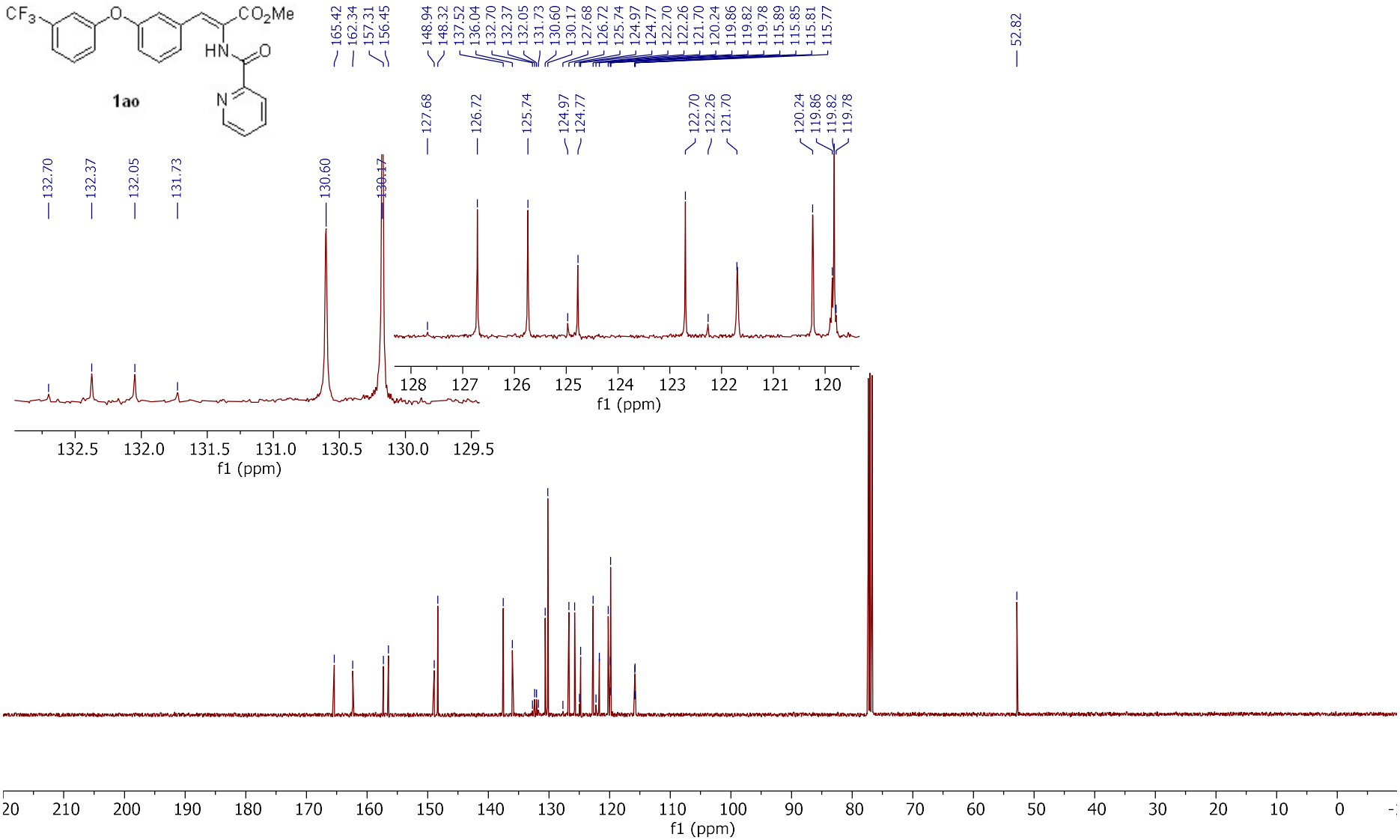

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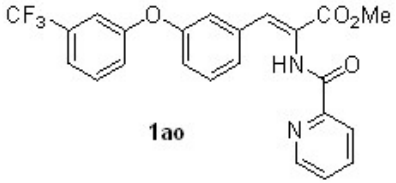

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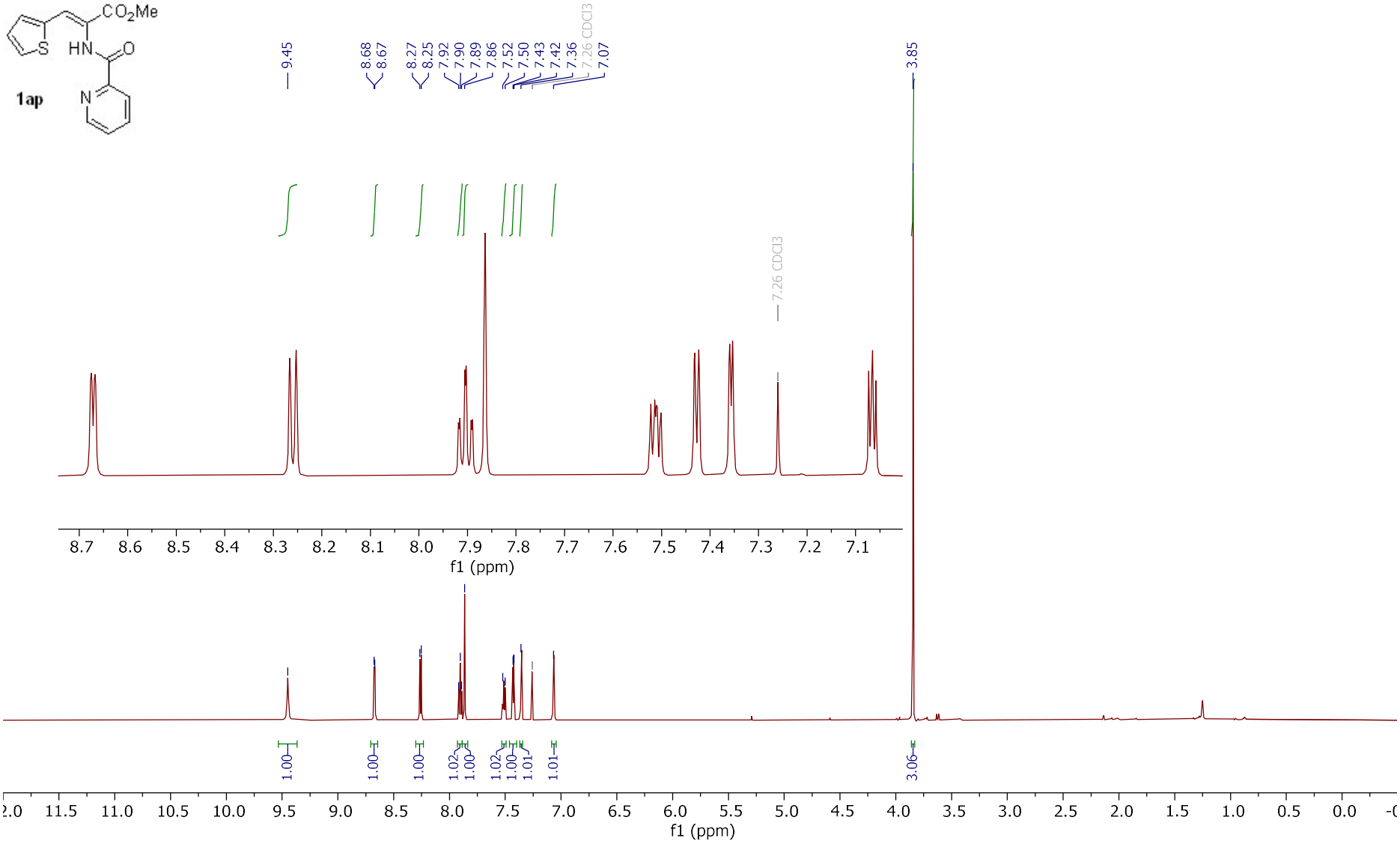

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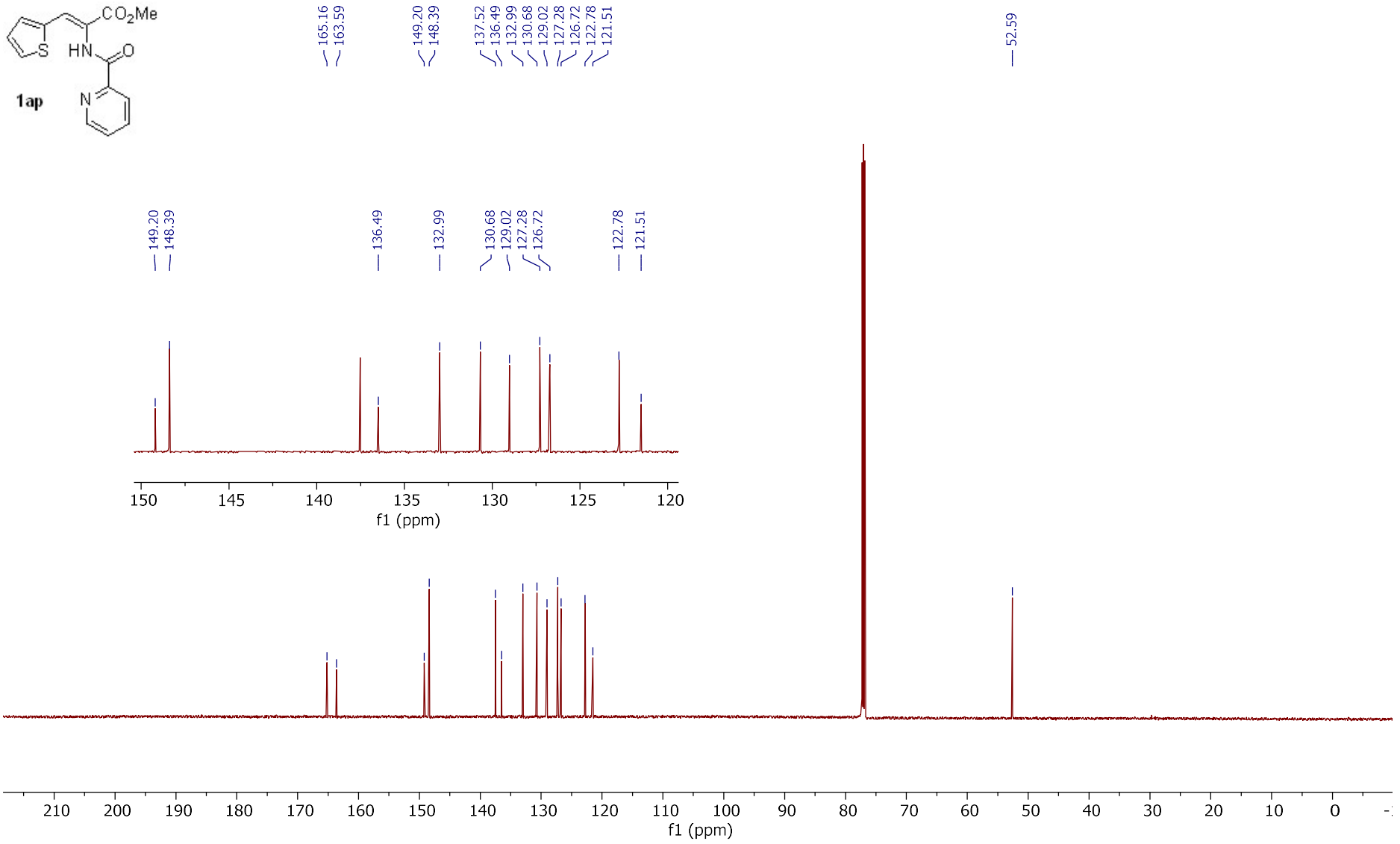

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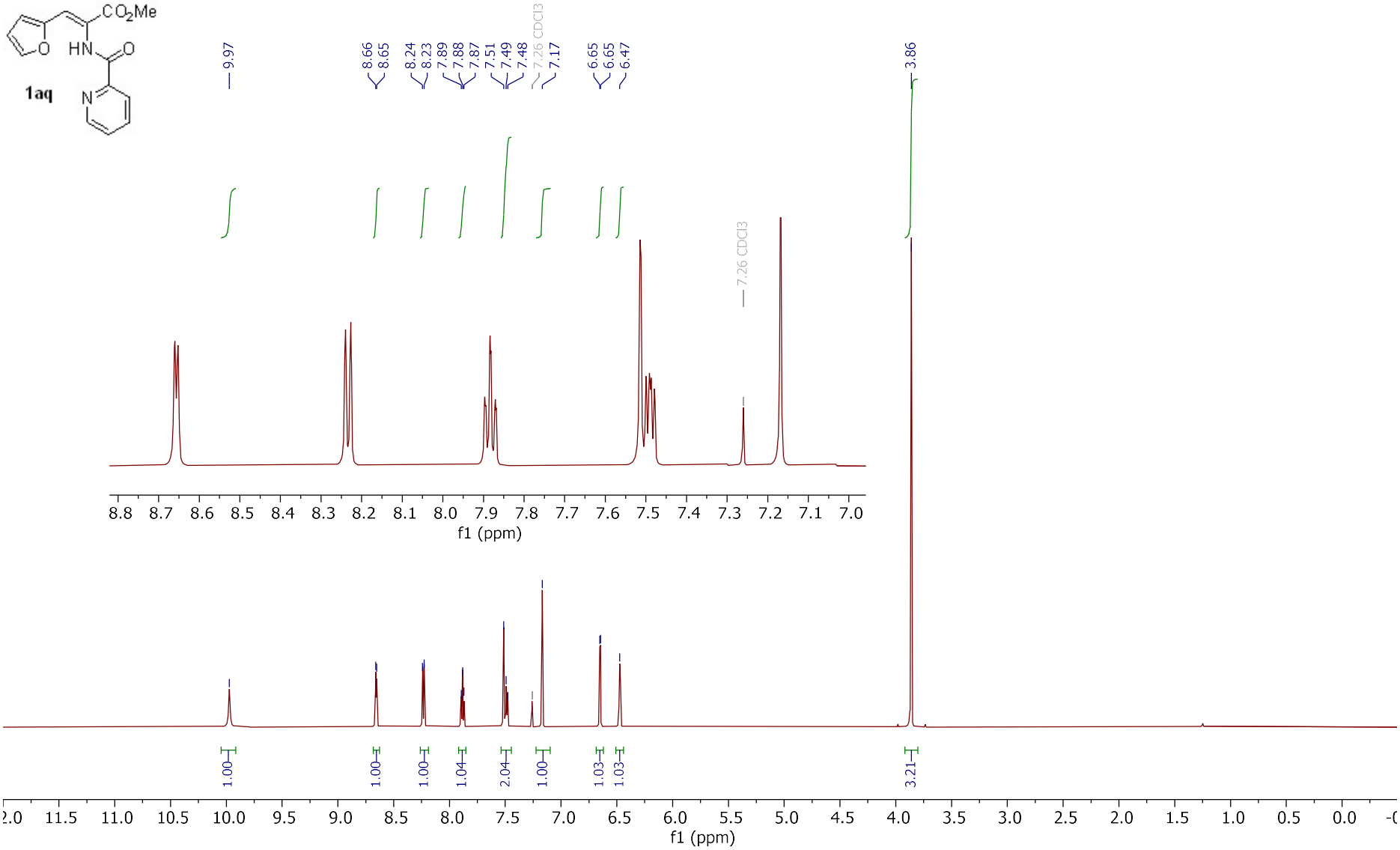

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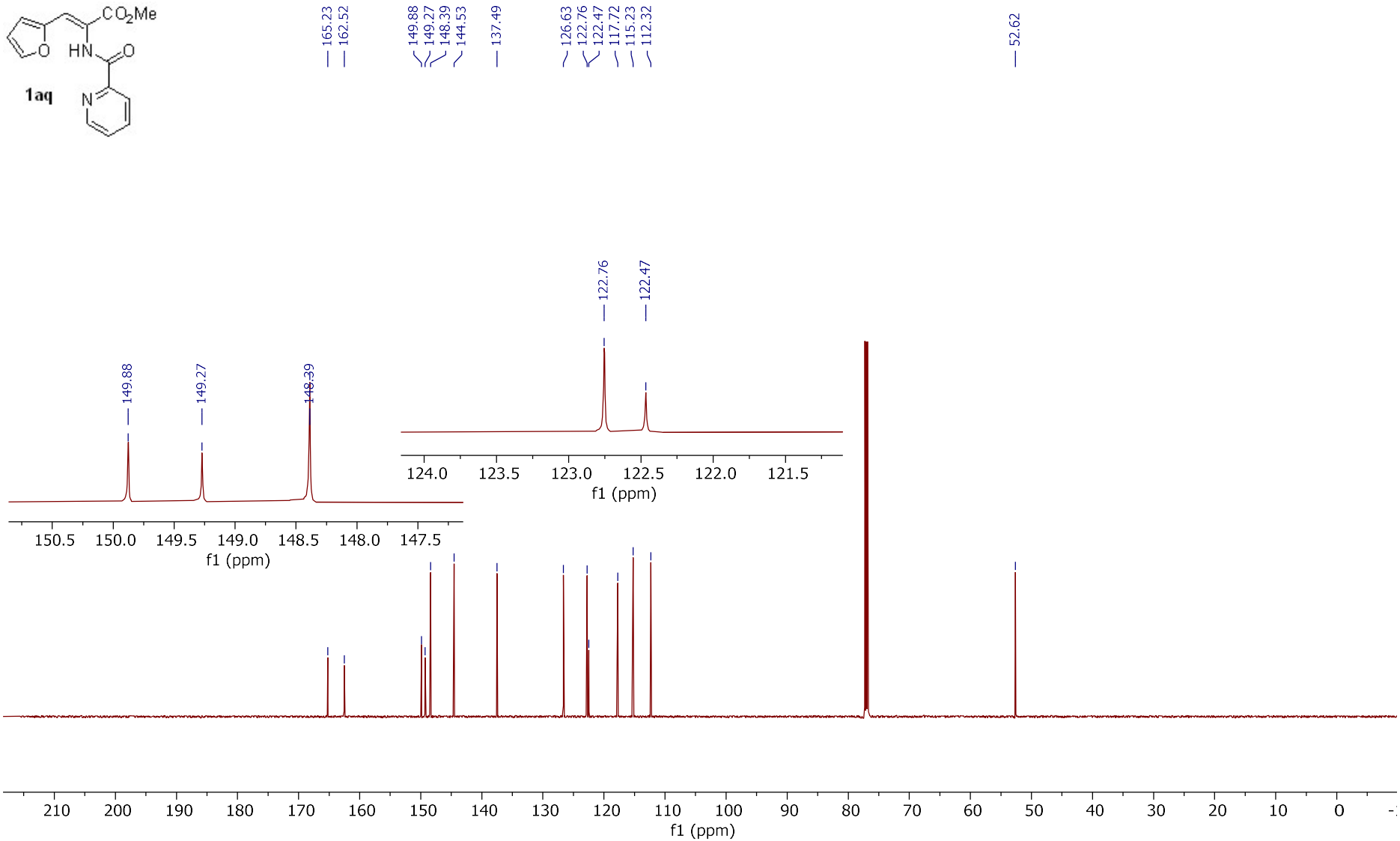

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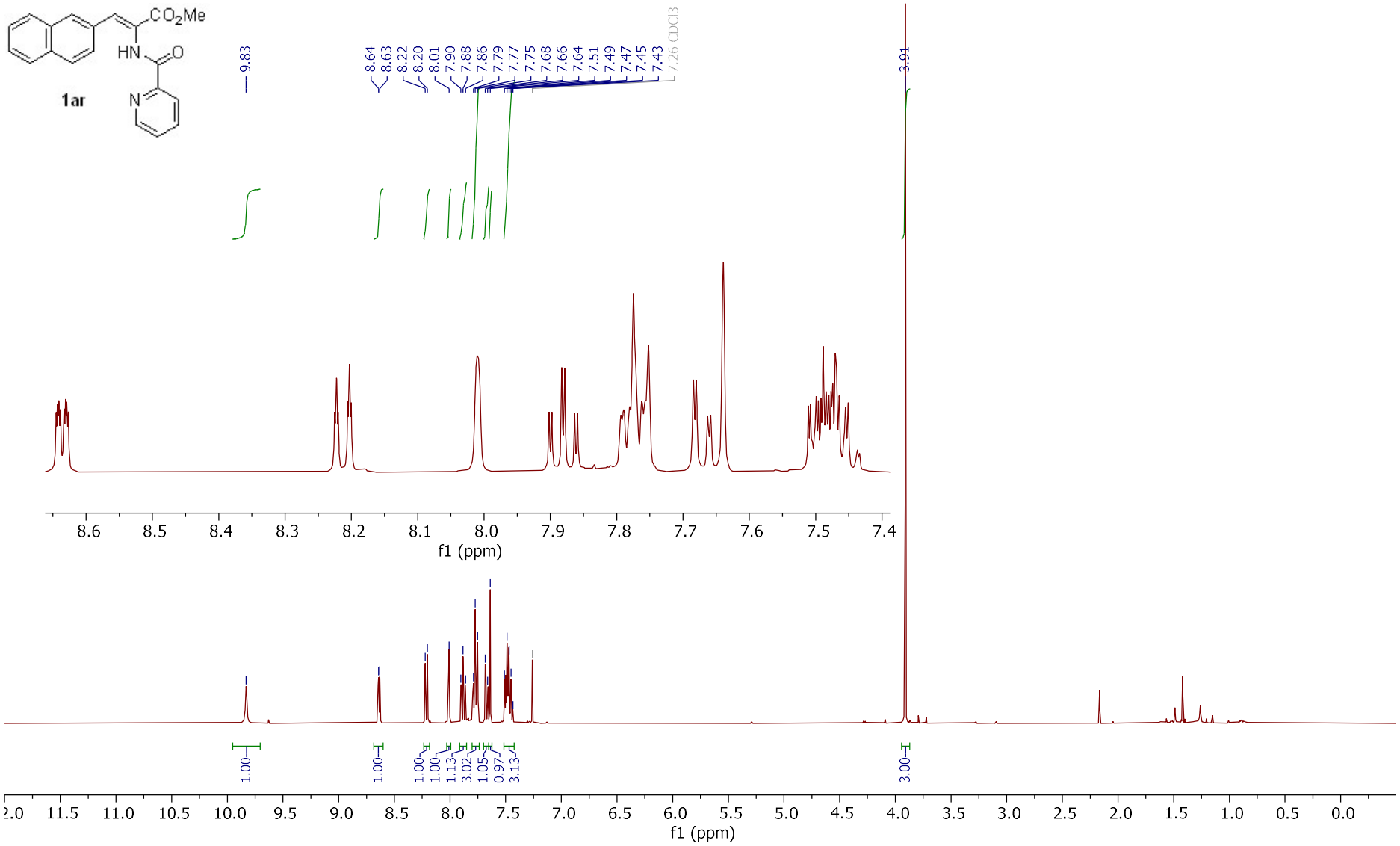

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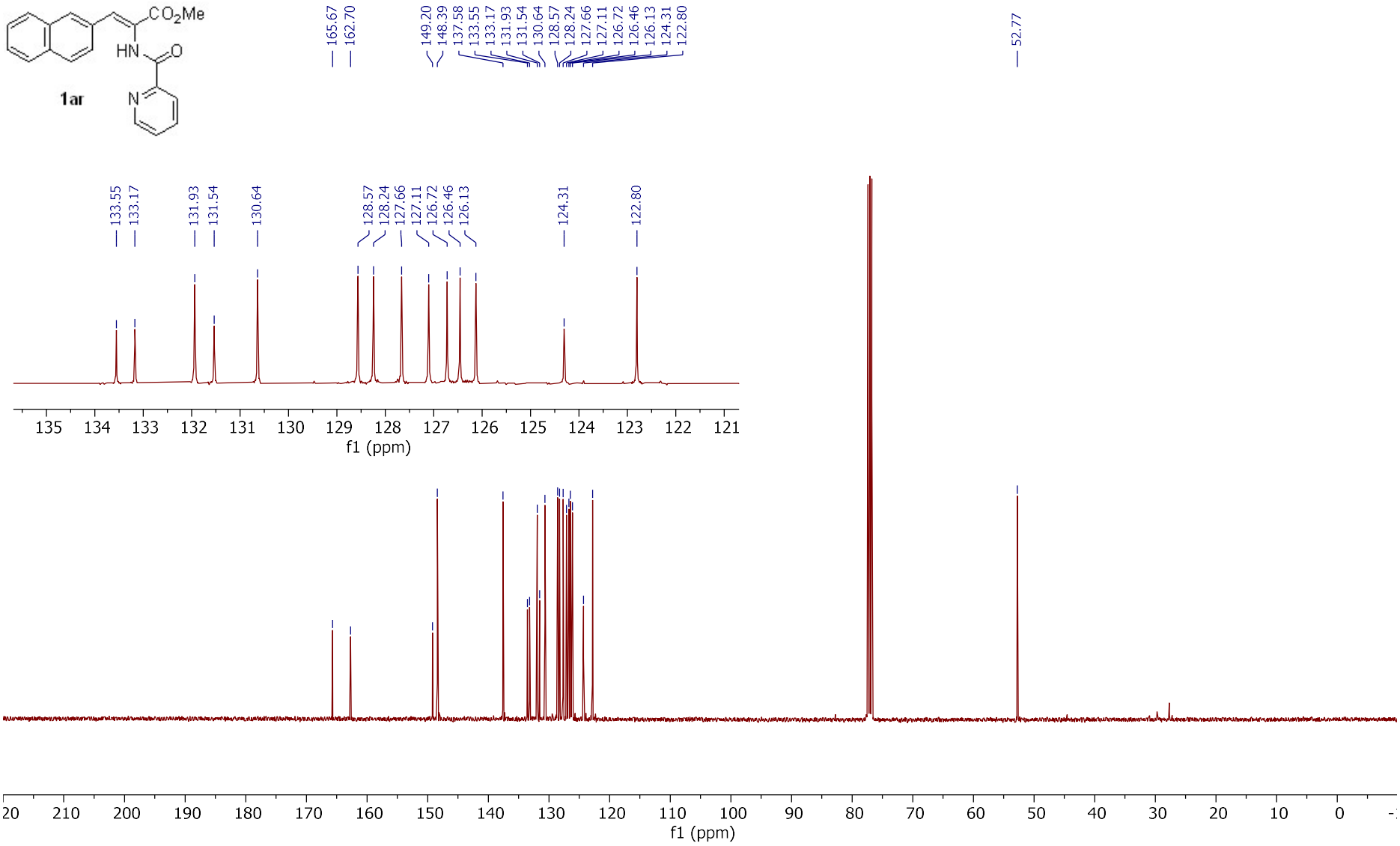

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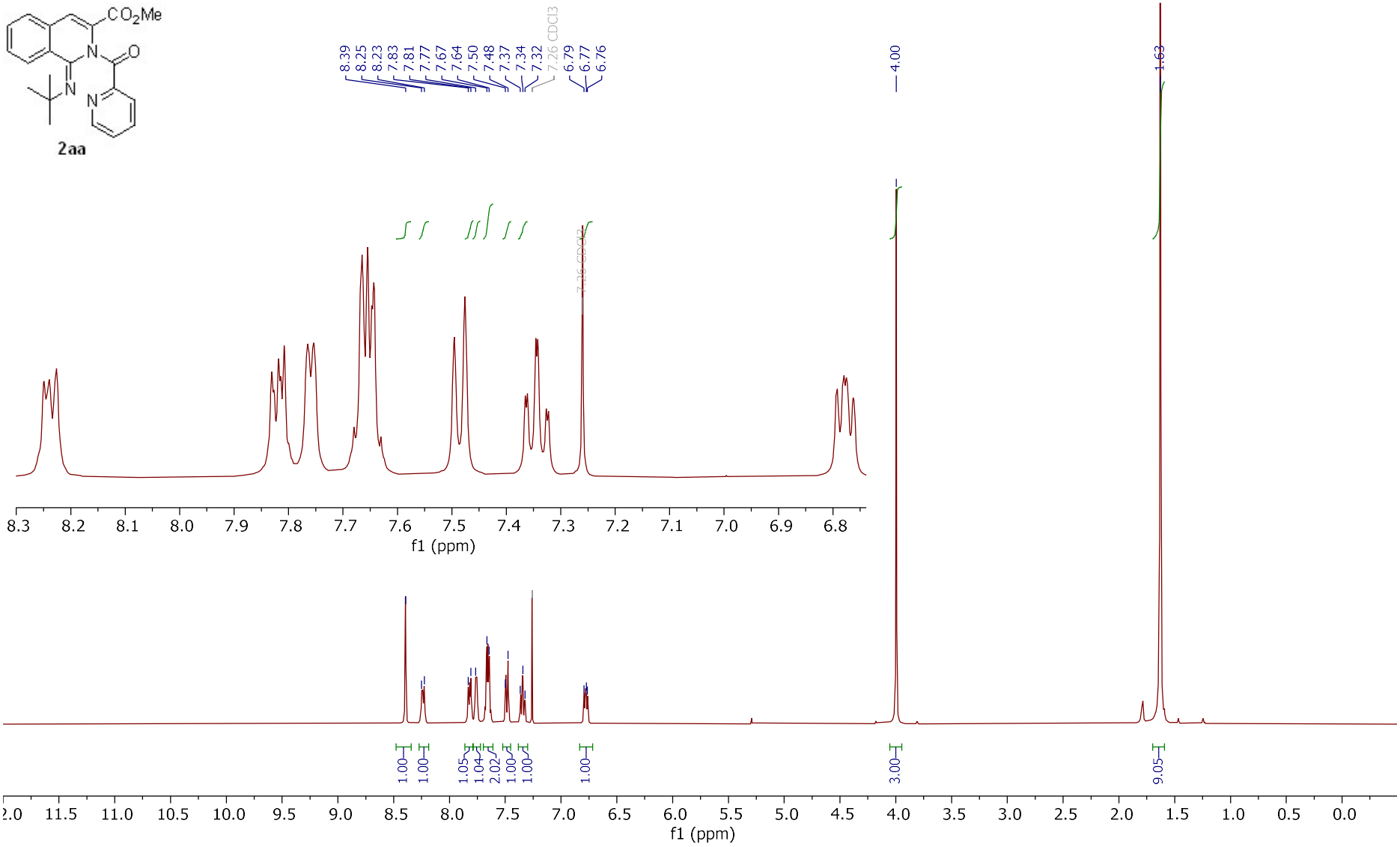

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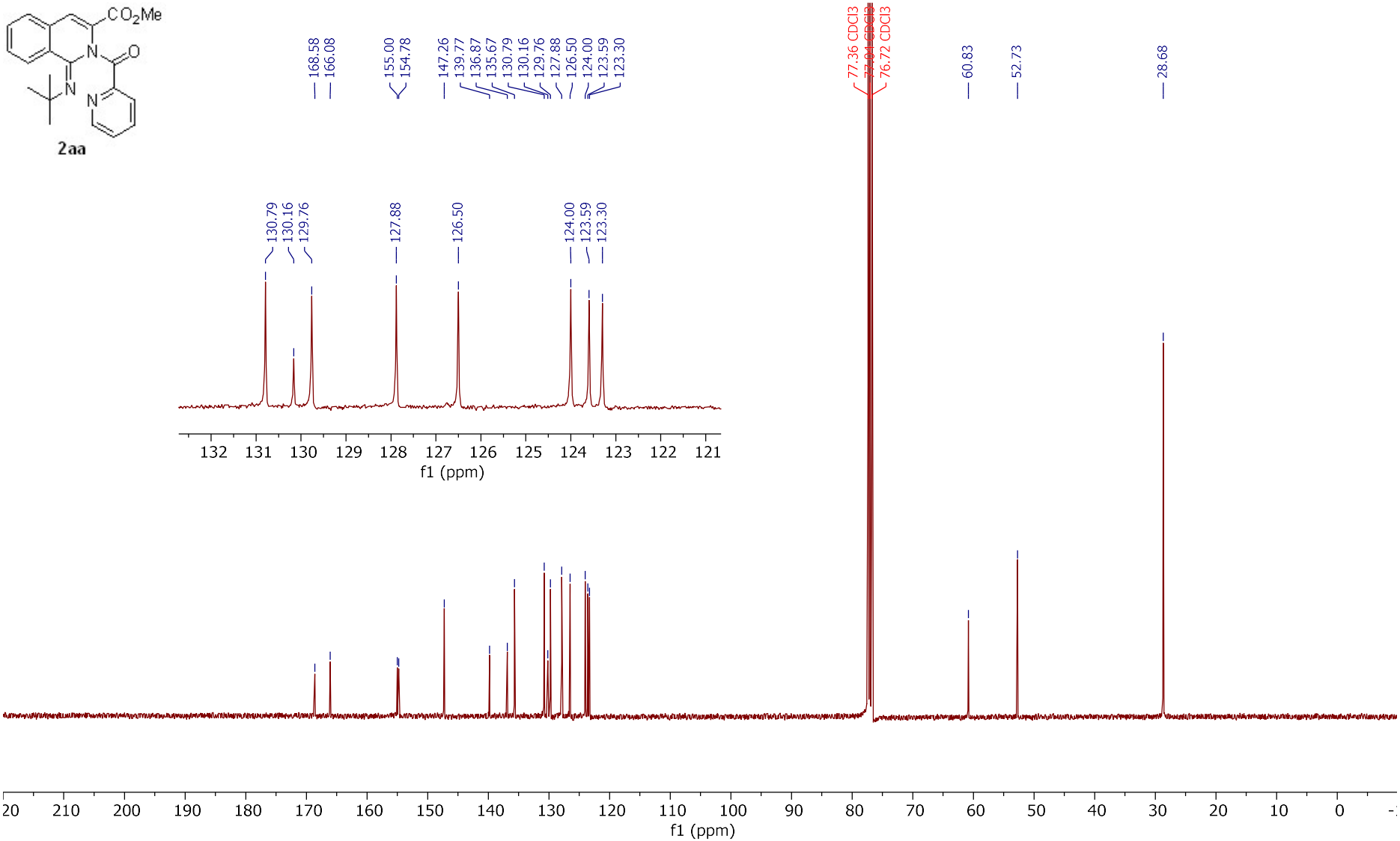

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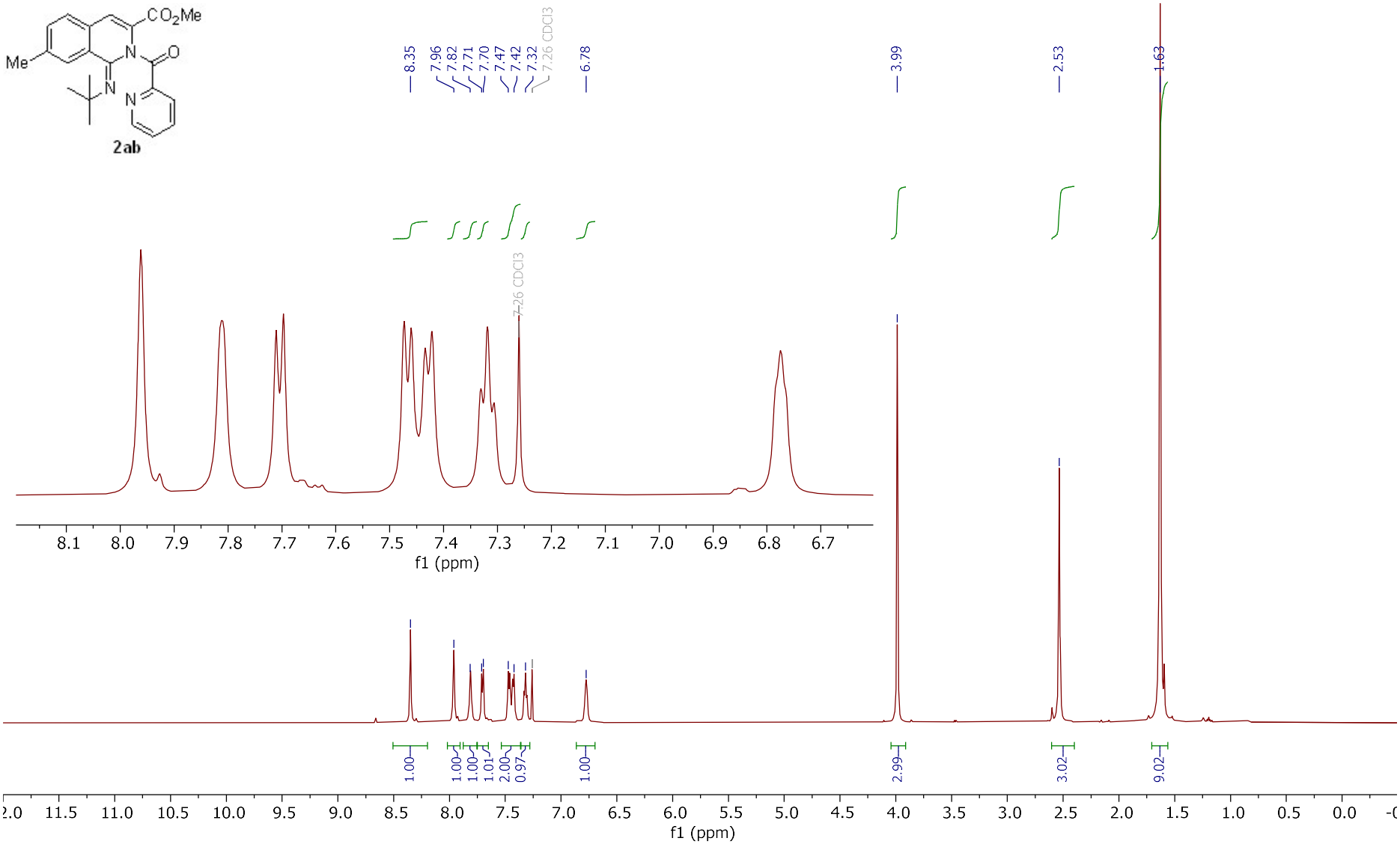
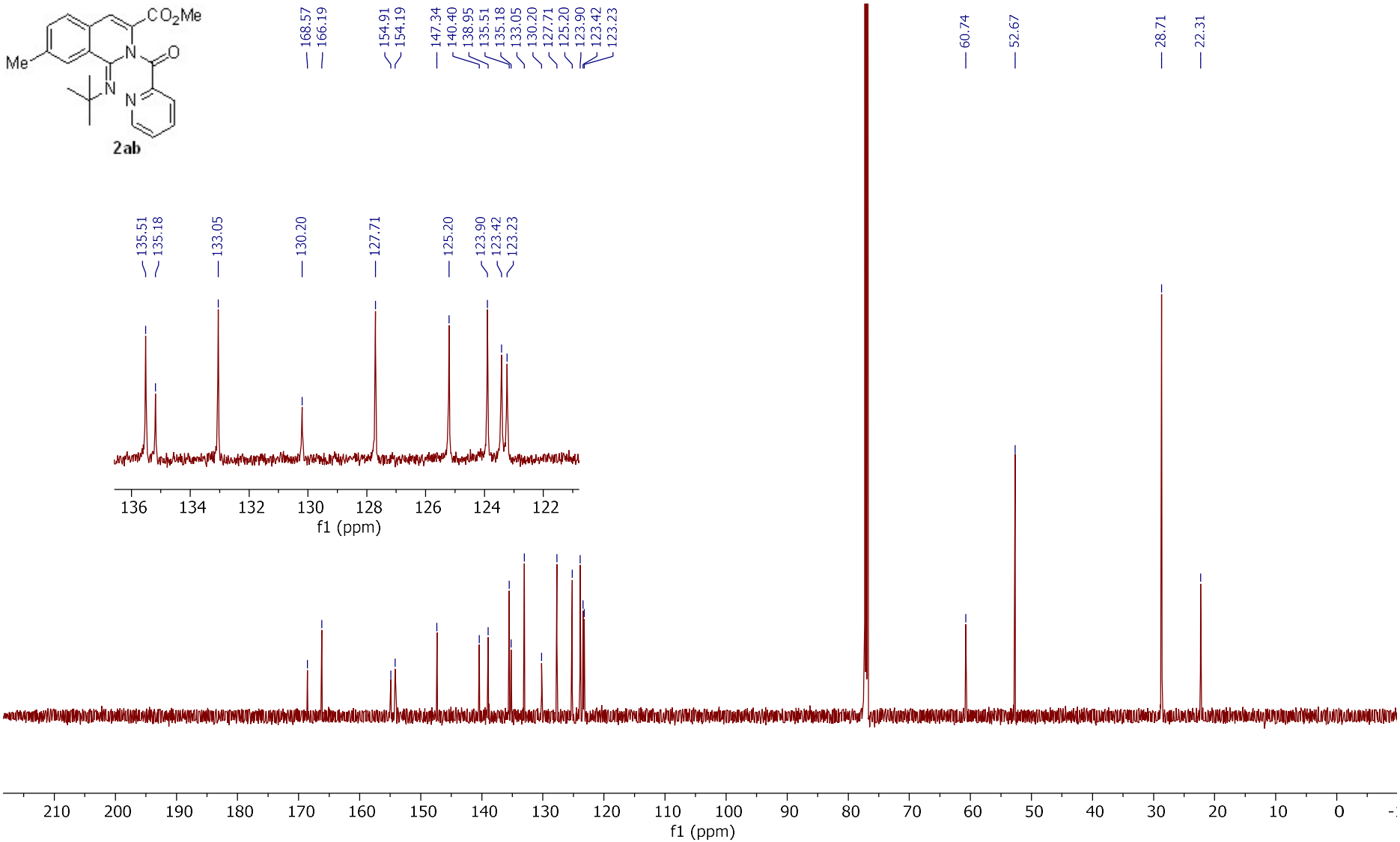
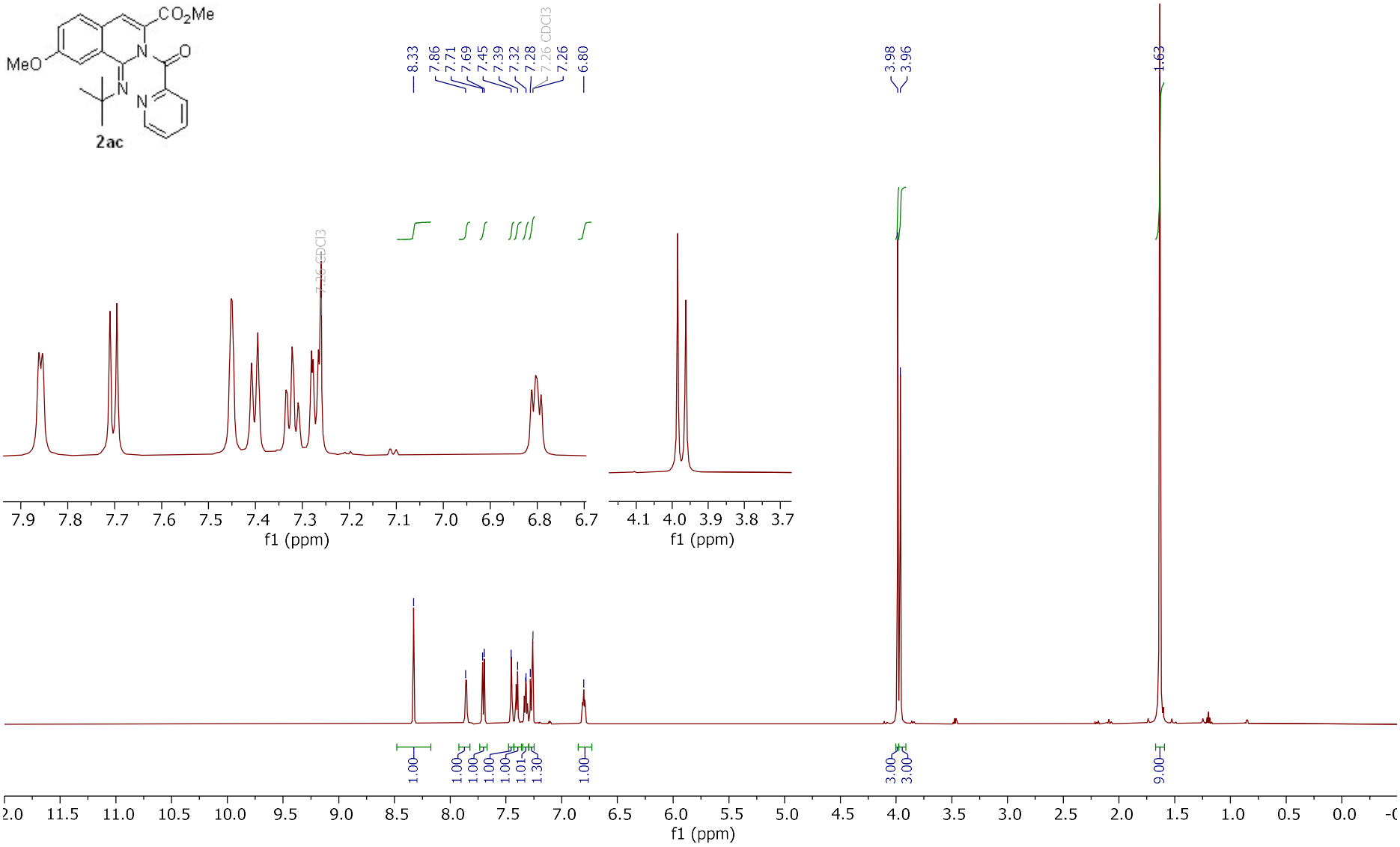


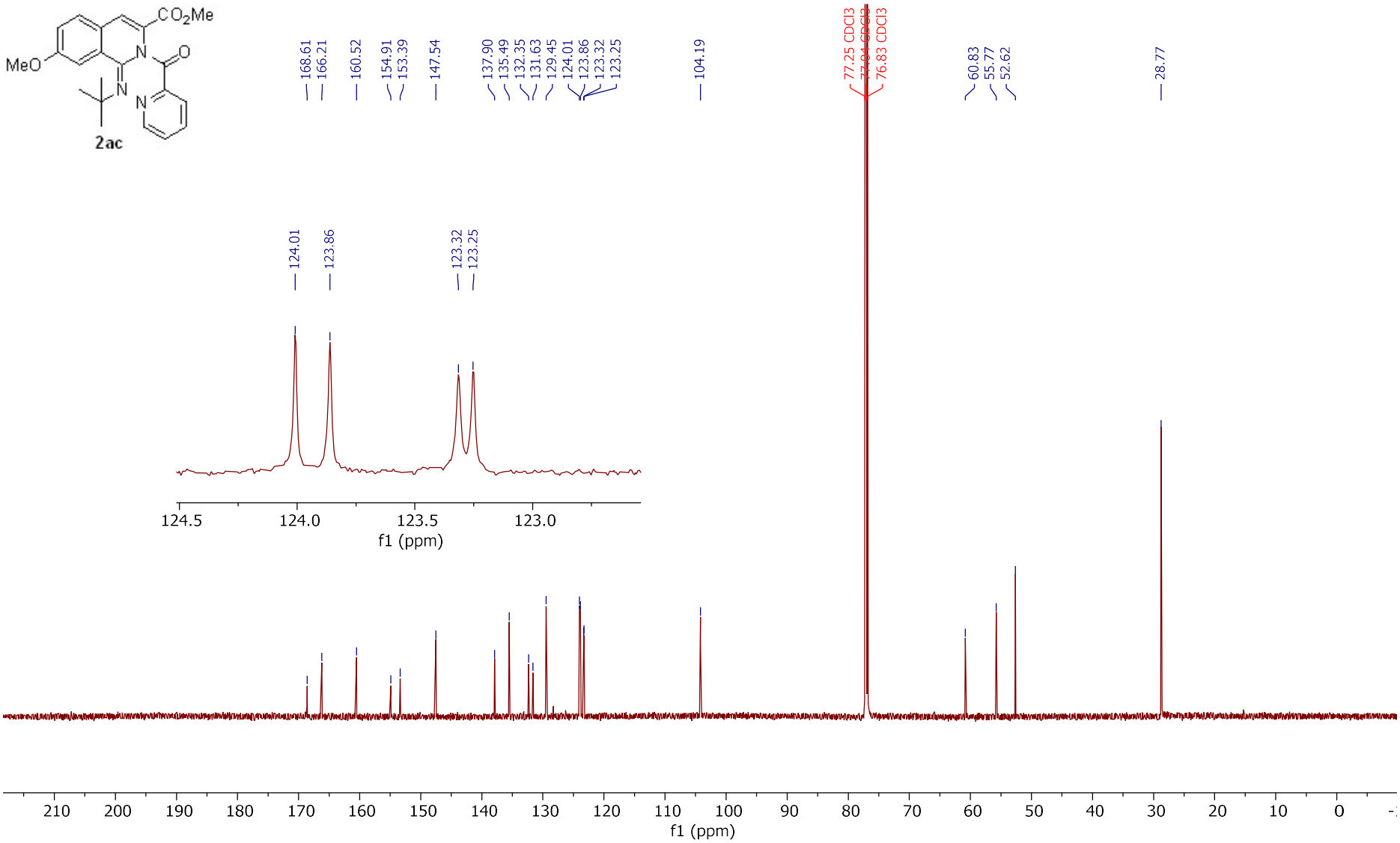
^{13}C-NMR, 100 MHz, $CDCl_3$



^{1}H-NMR, 400 MHz, $CDCl_3$



^{13}C-NMR, 100 MHz, $CDCl_3$



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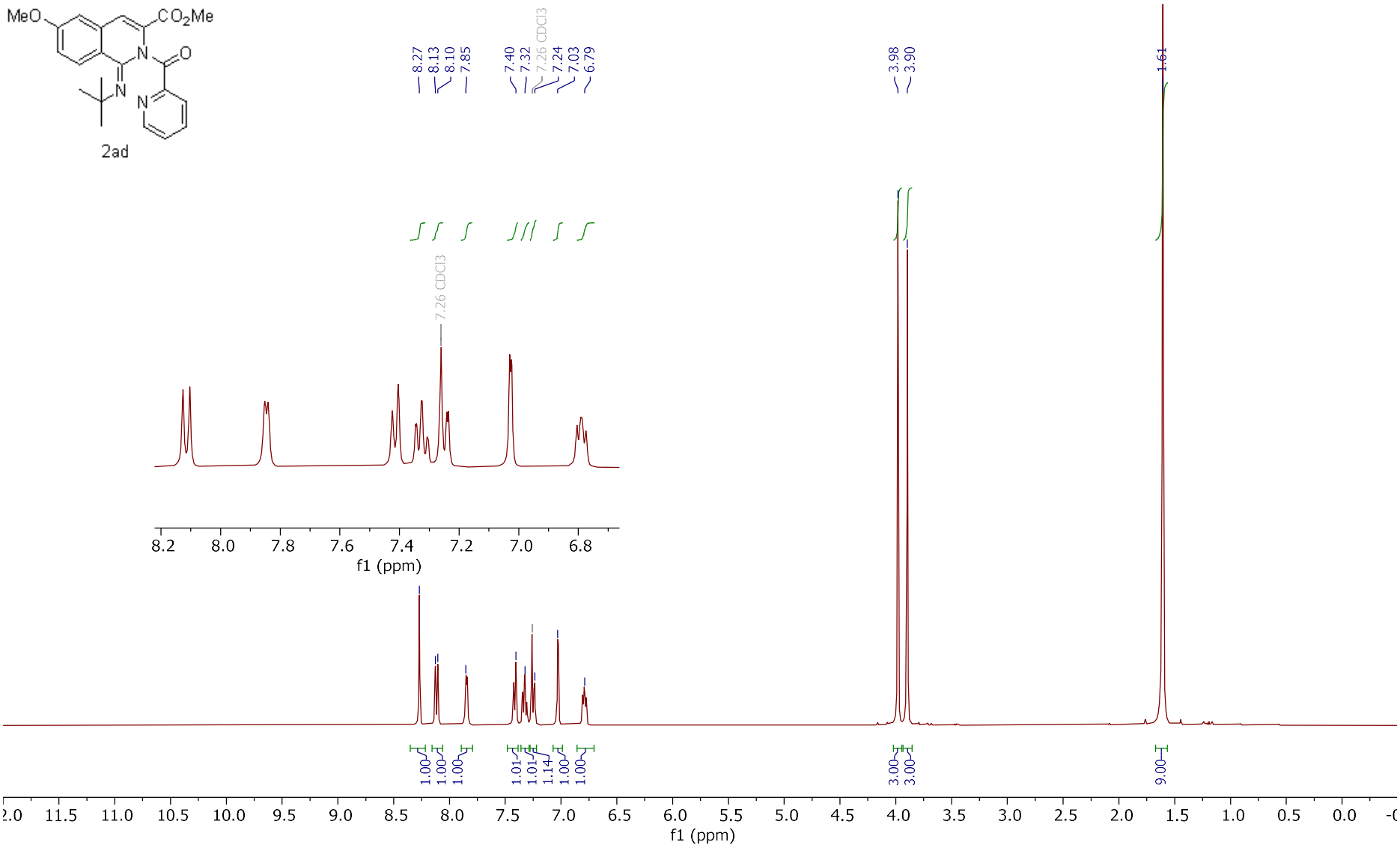

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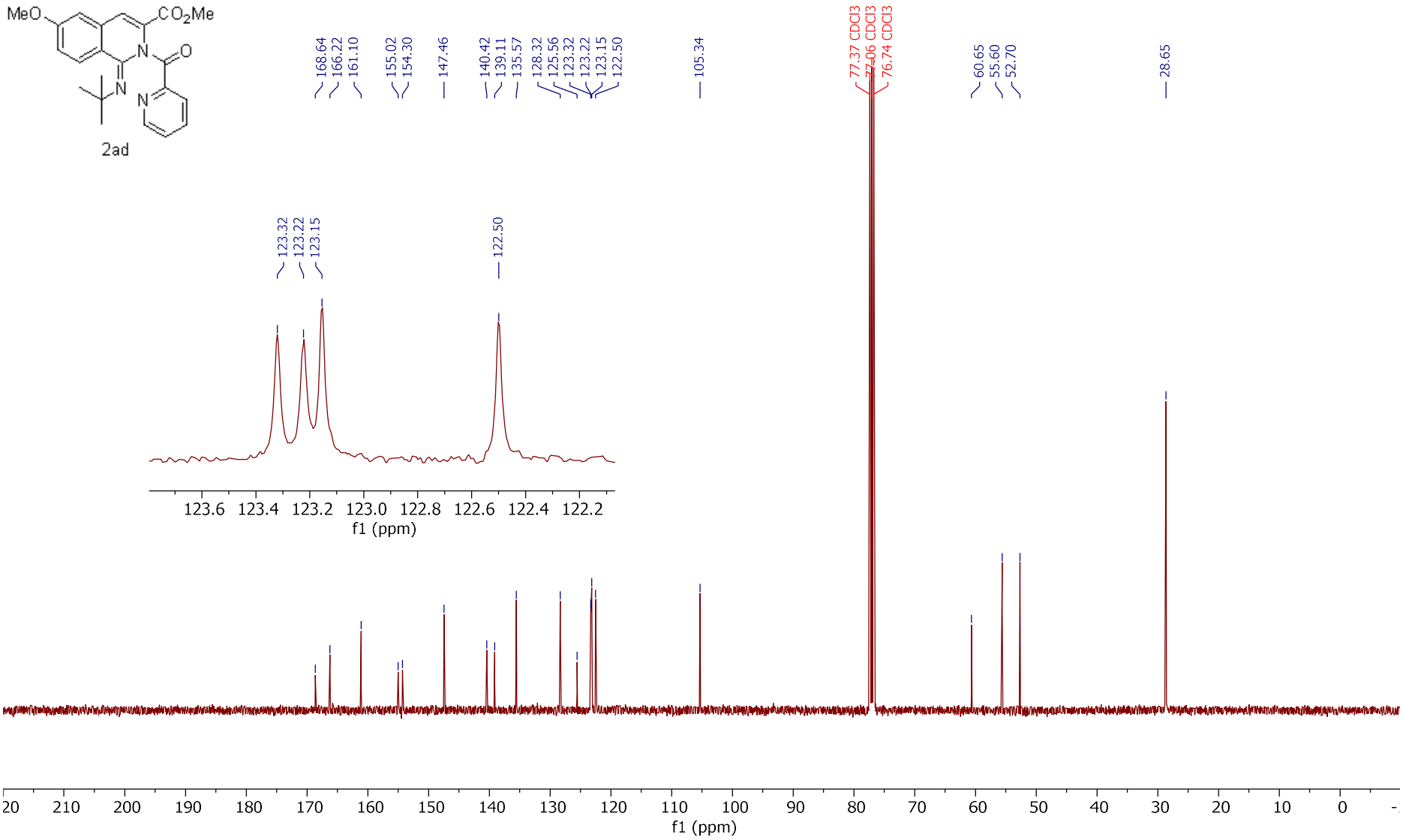

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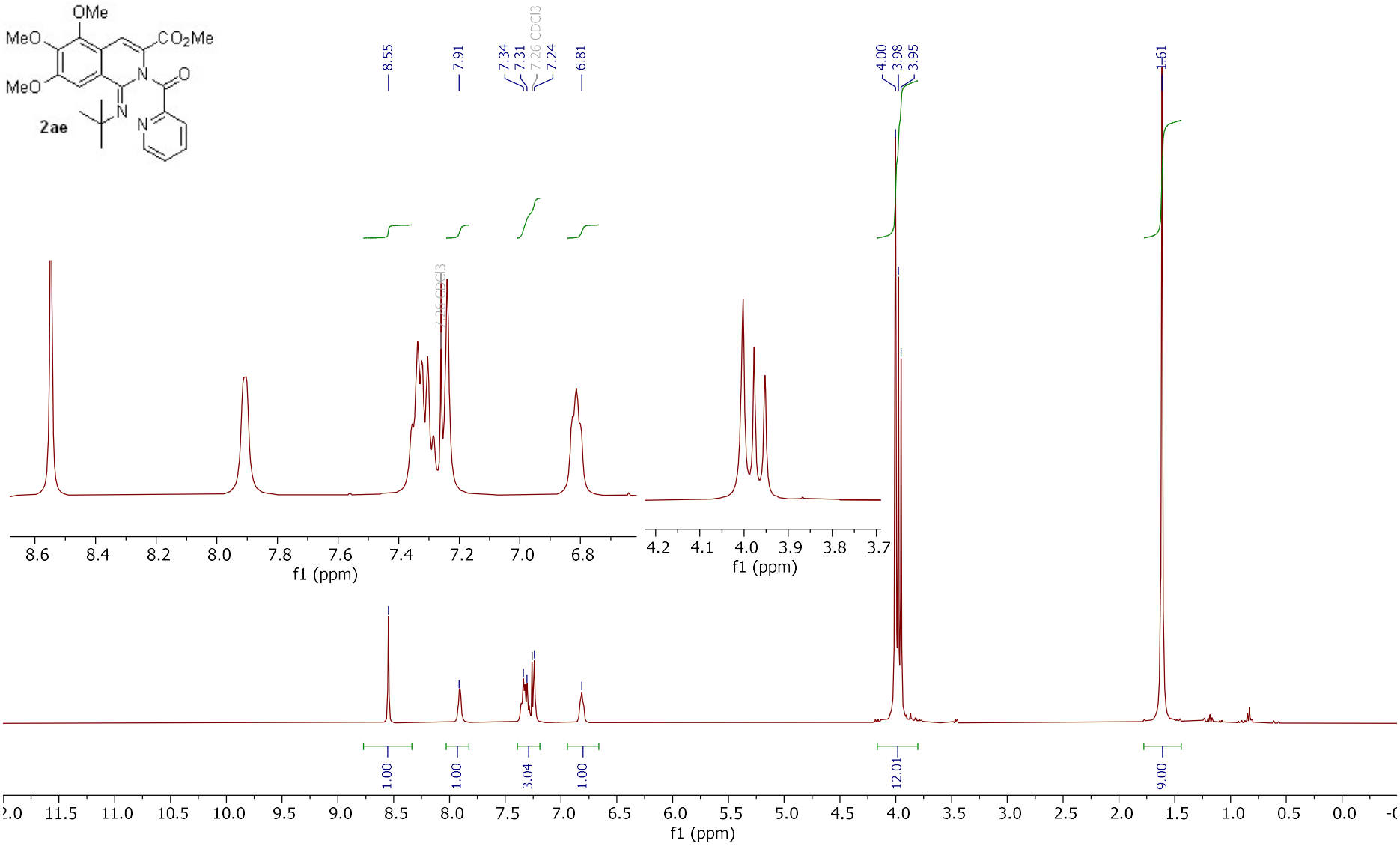

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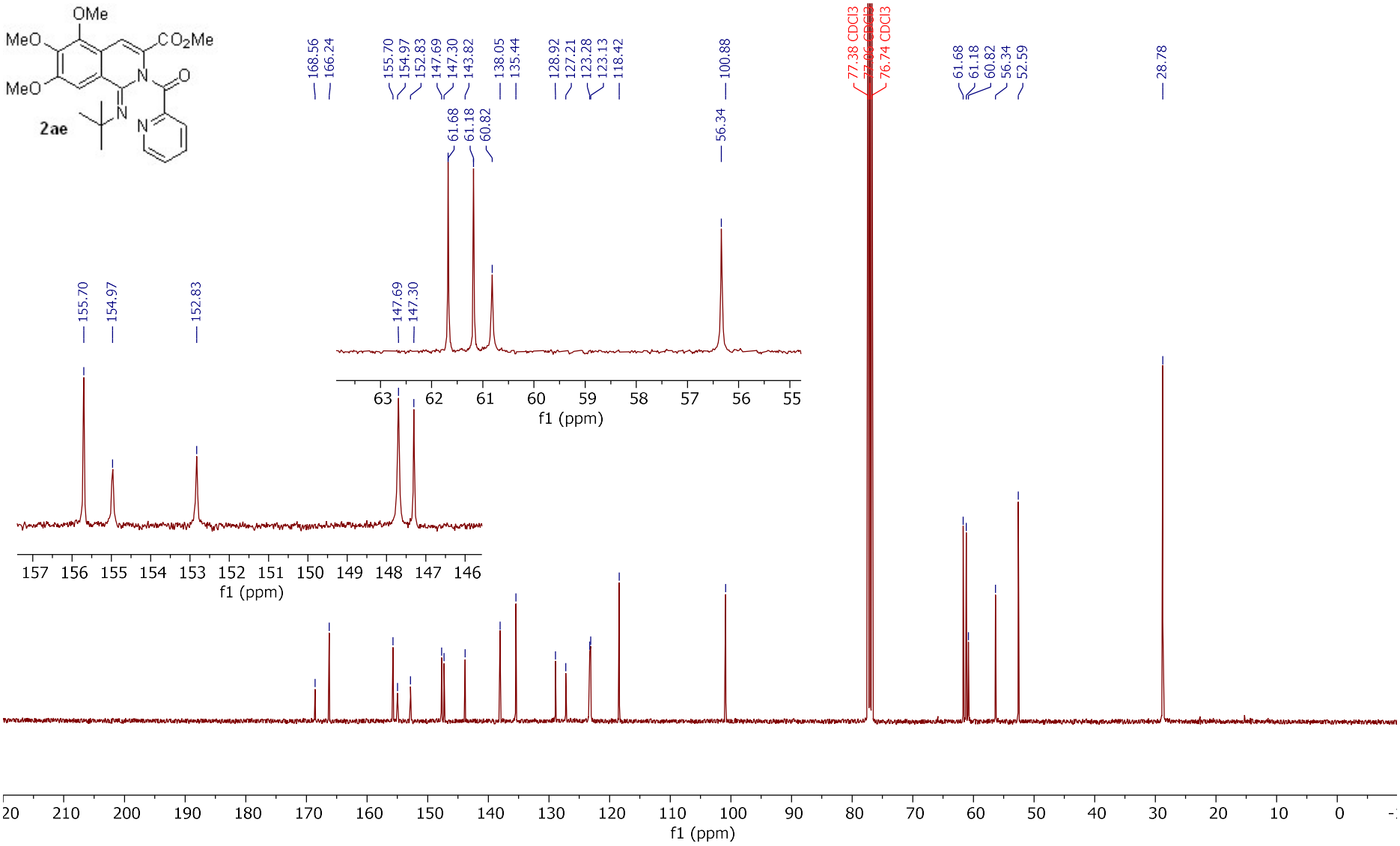

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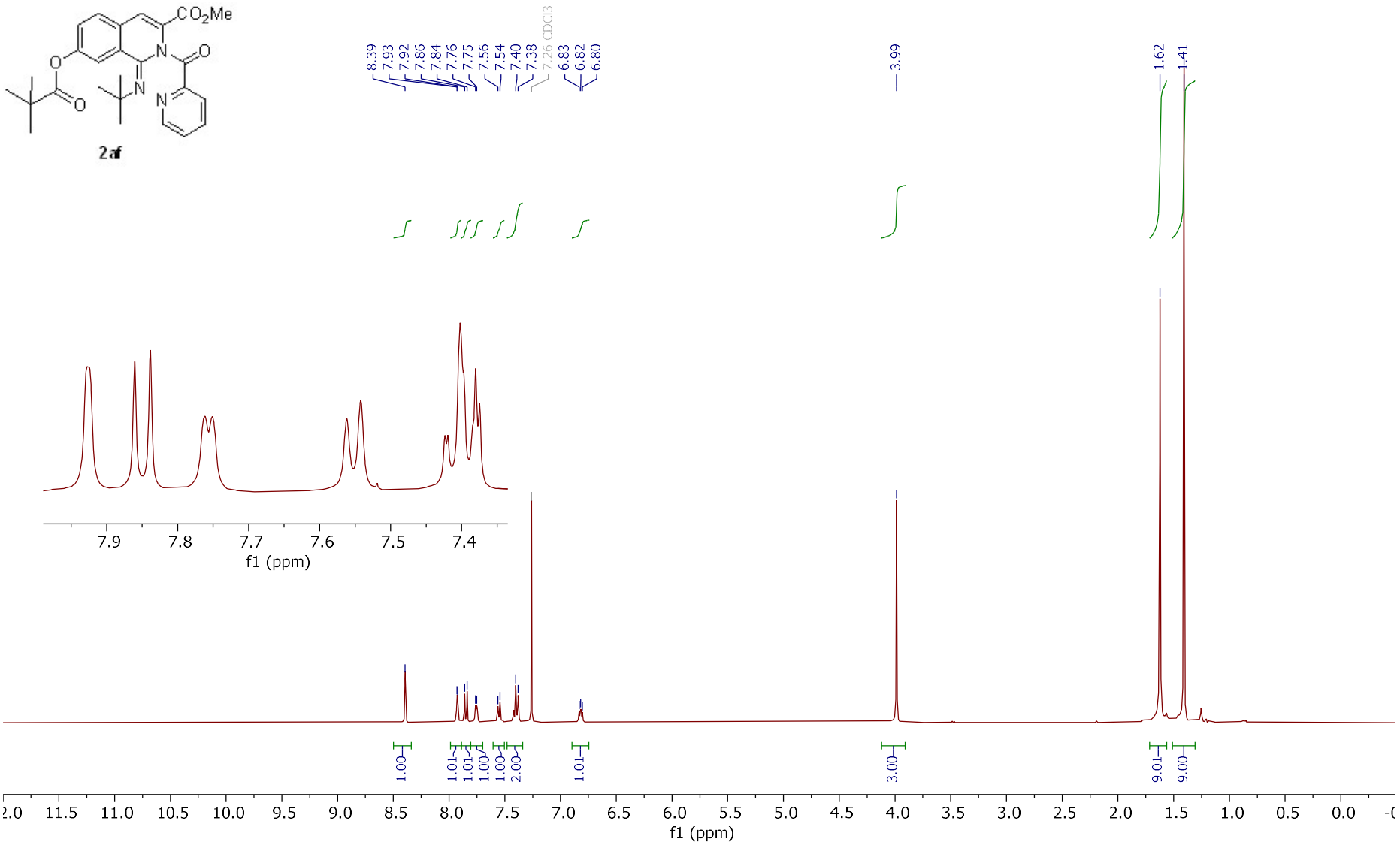

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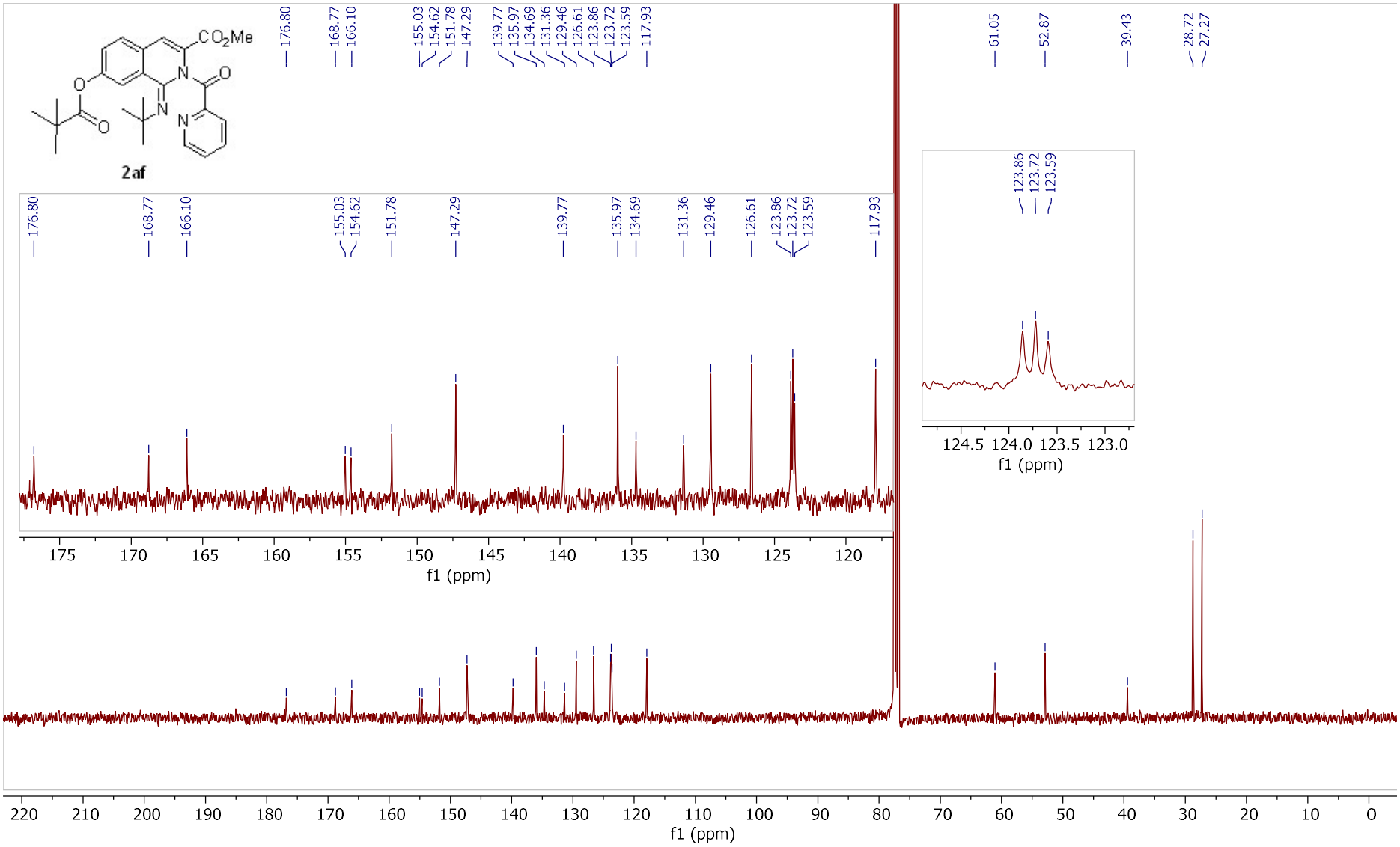

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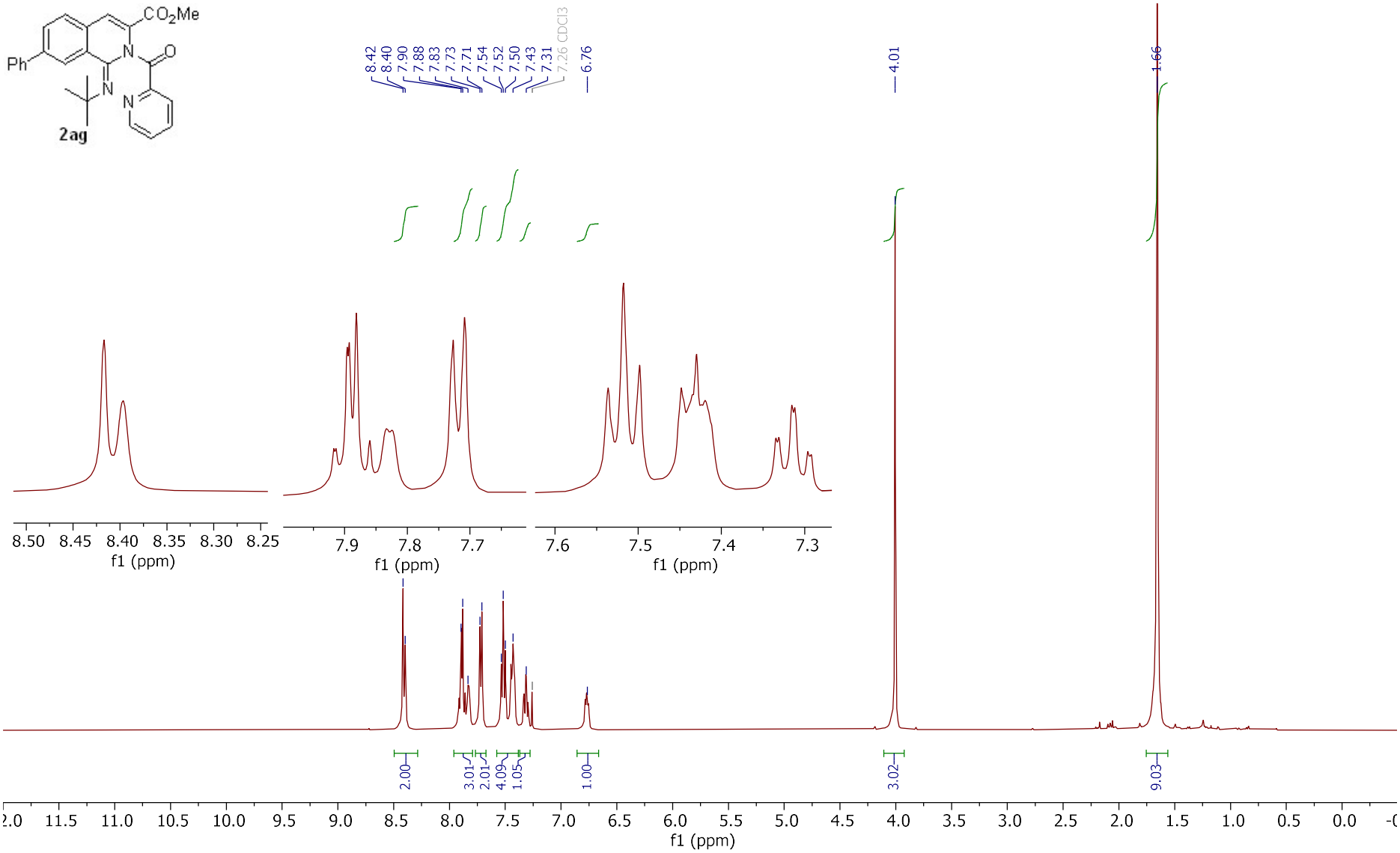
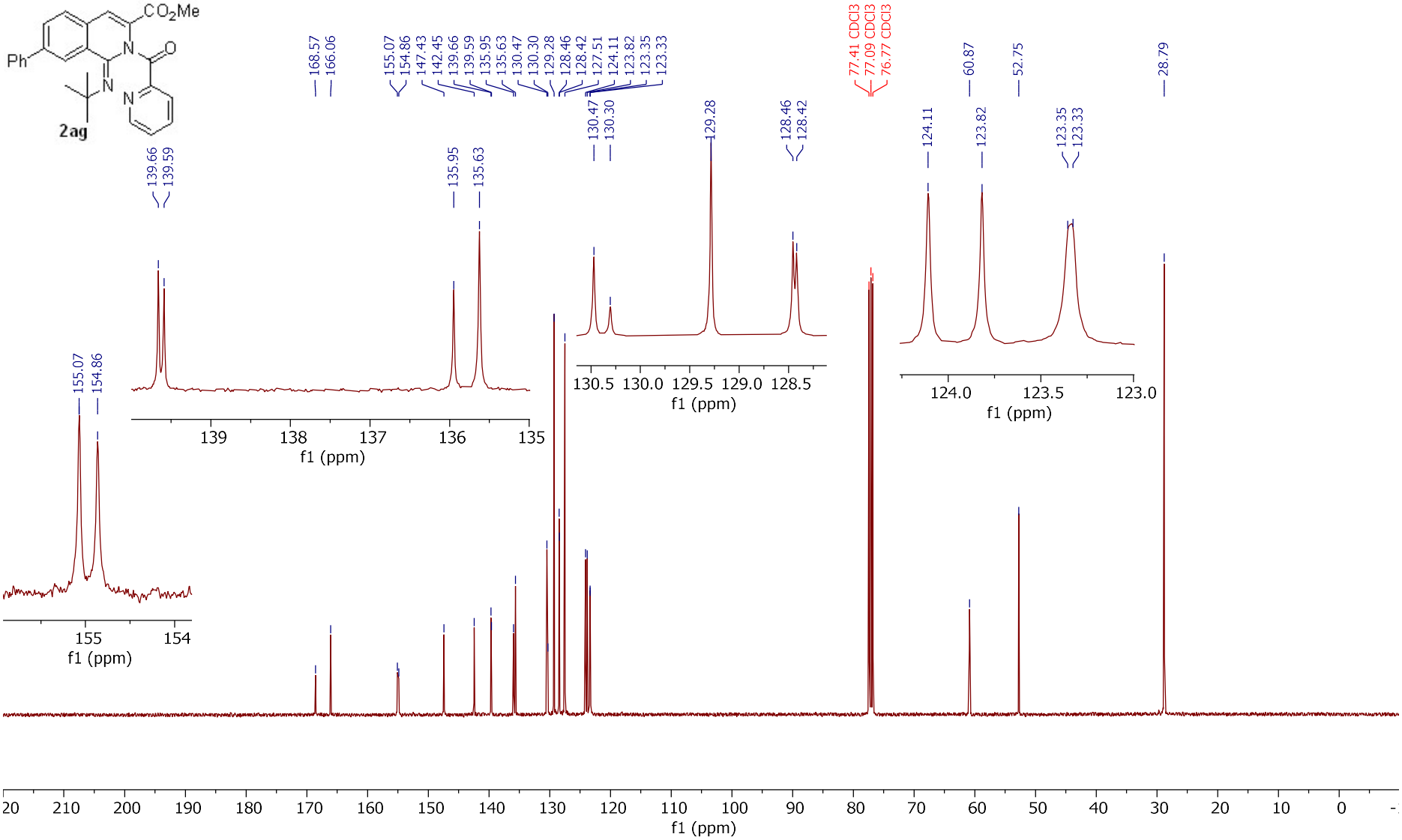


^{13}C-NMR, 100 MHz, $CDCl_3$



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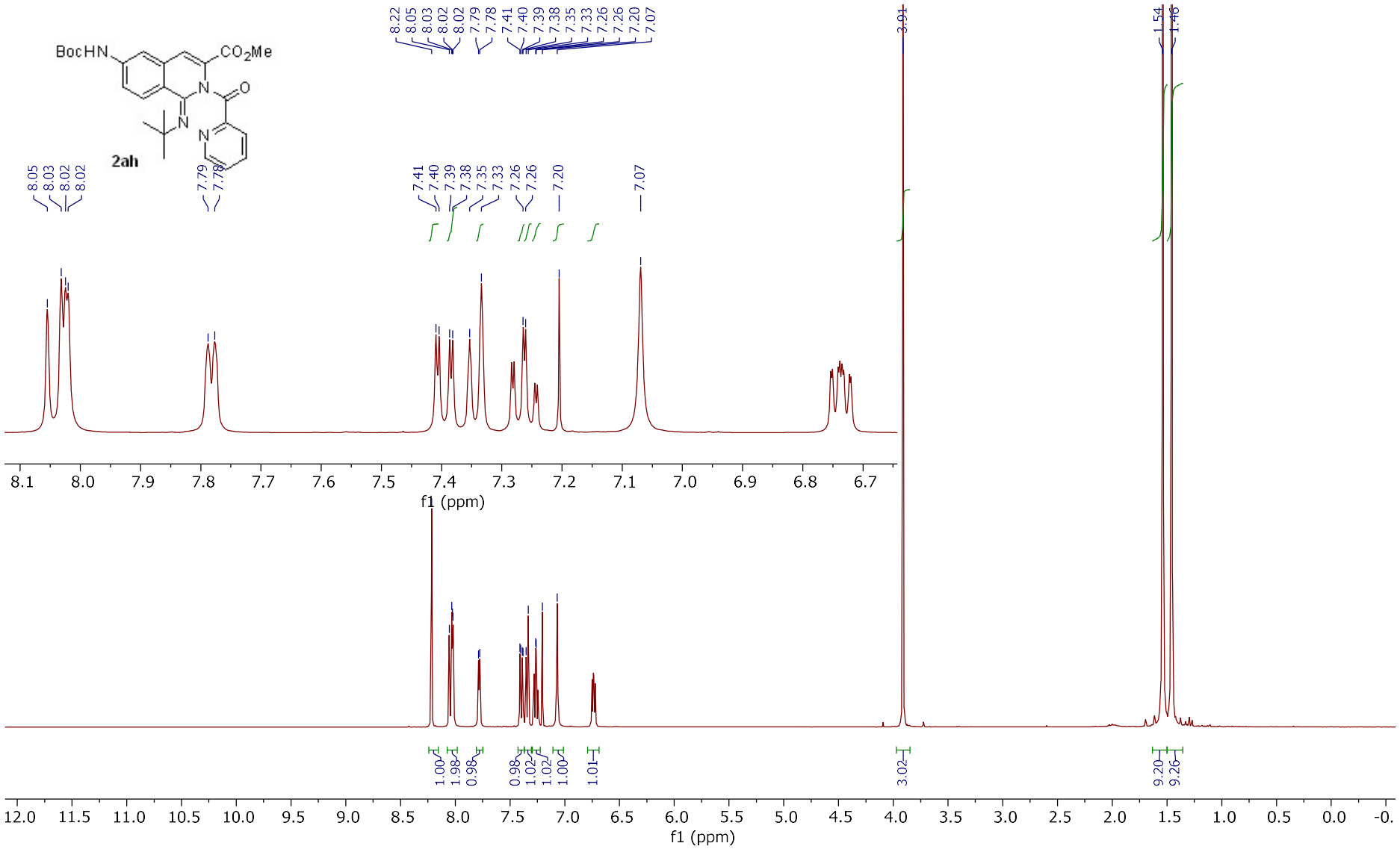

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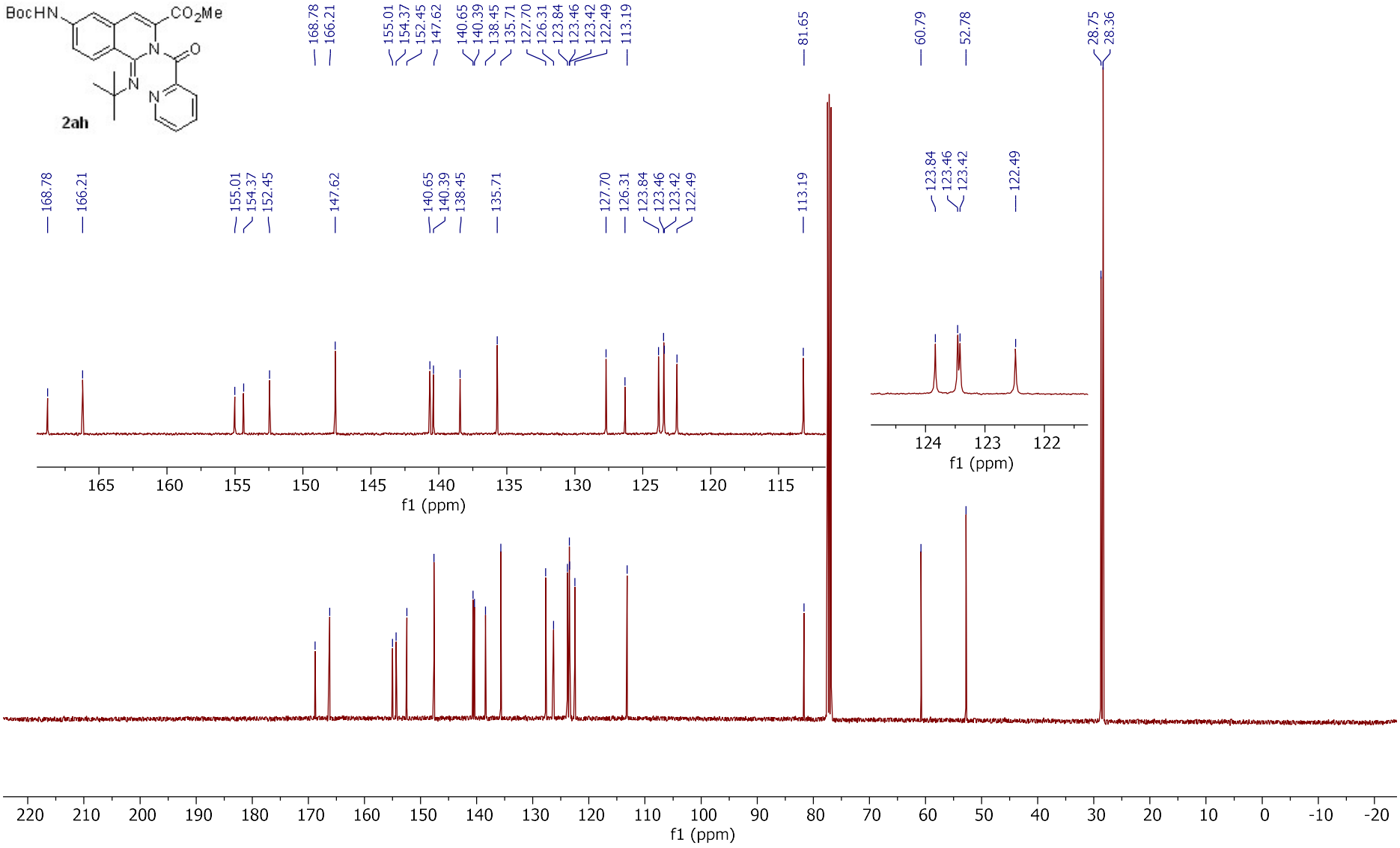

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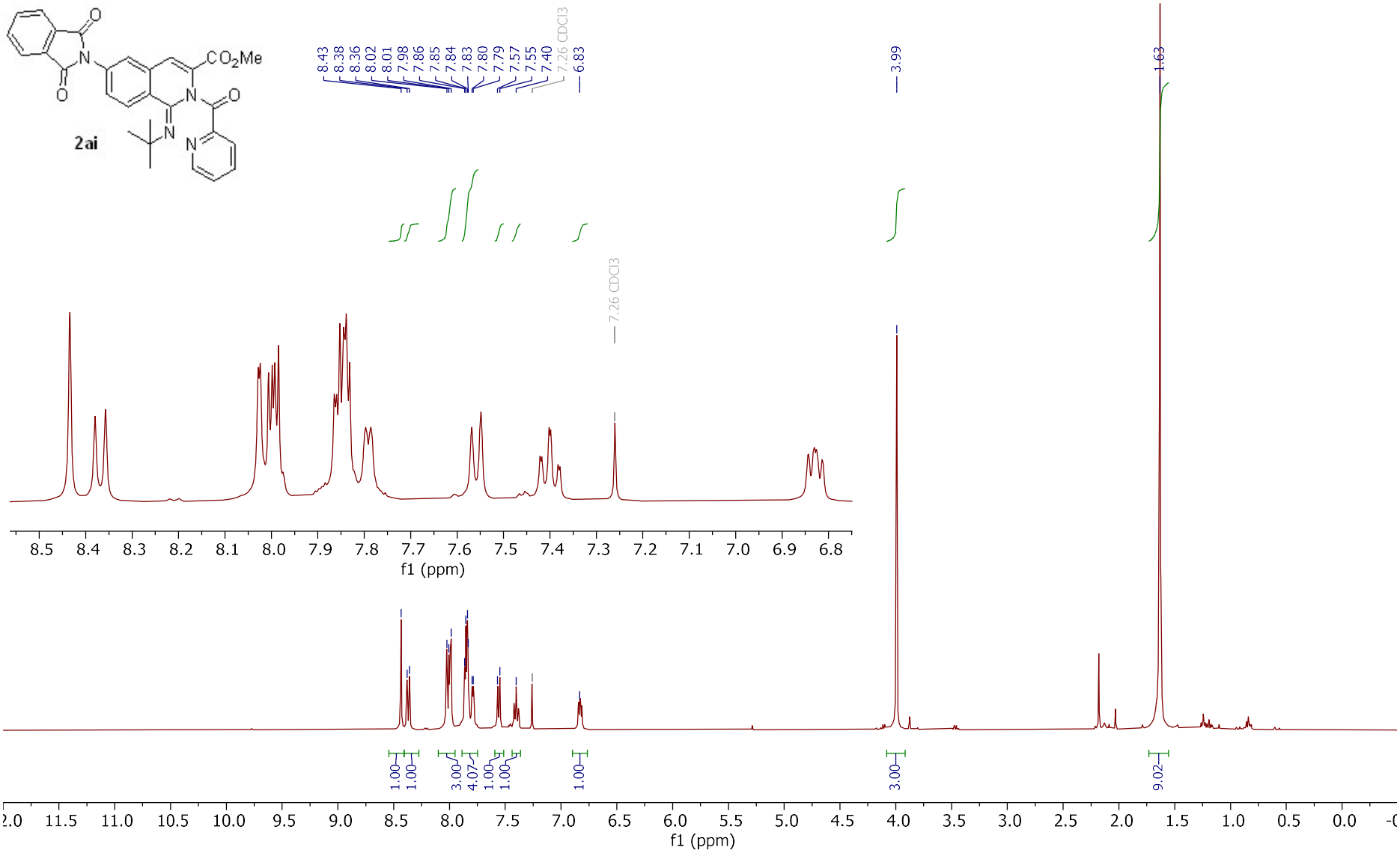

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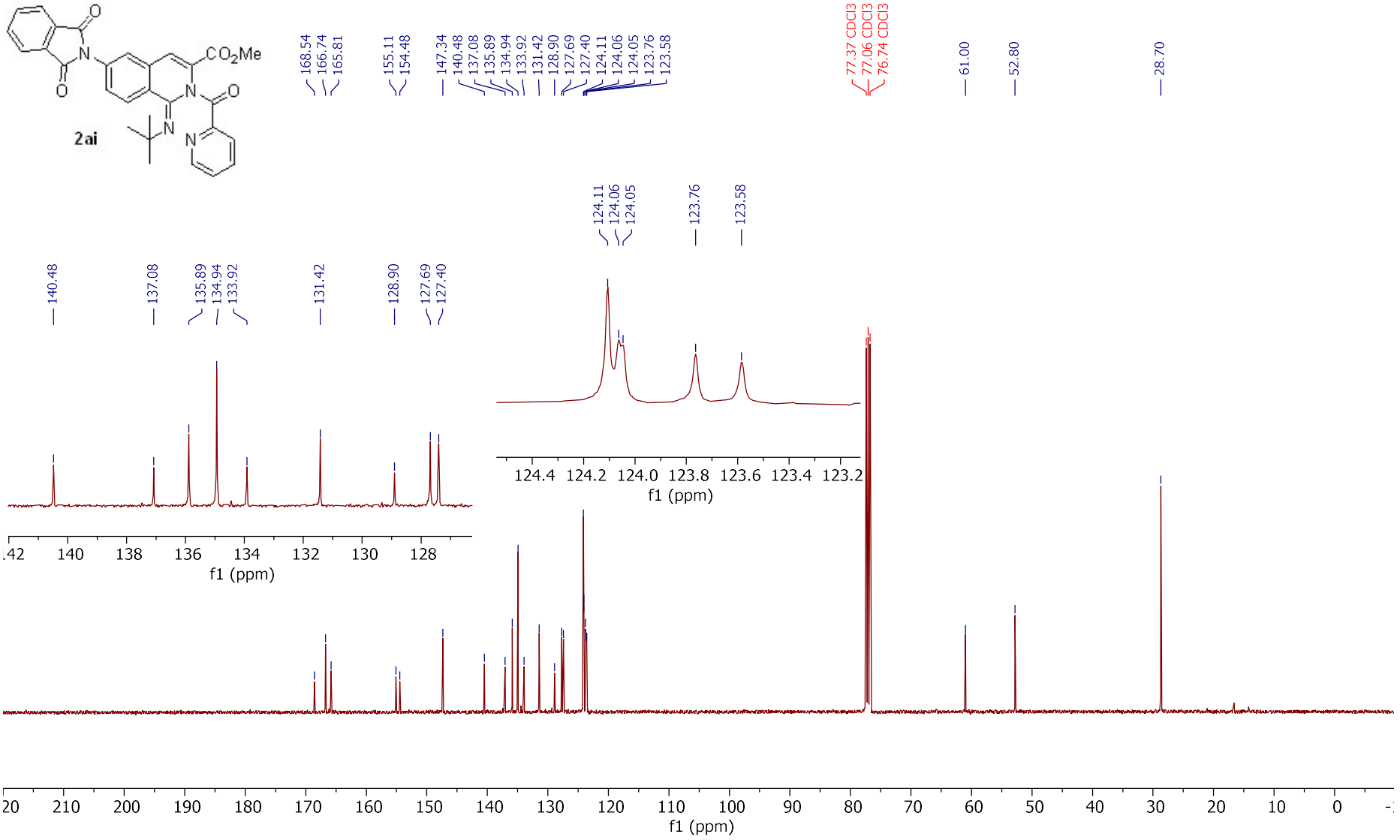

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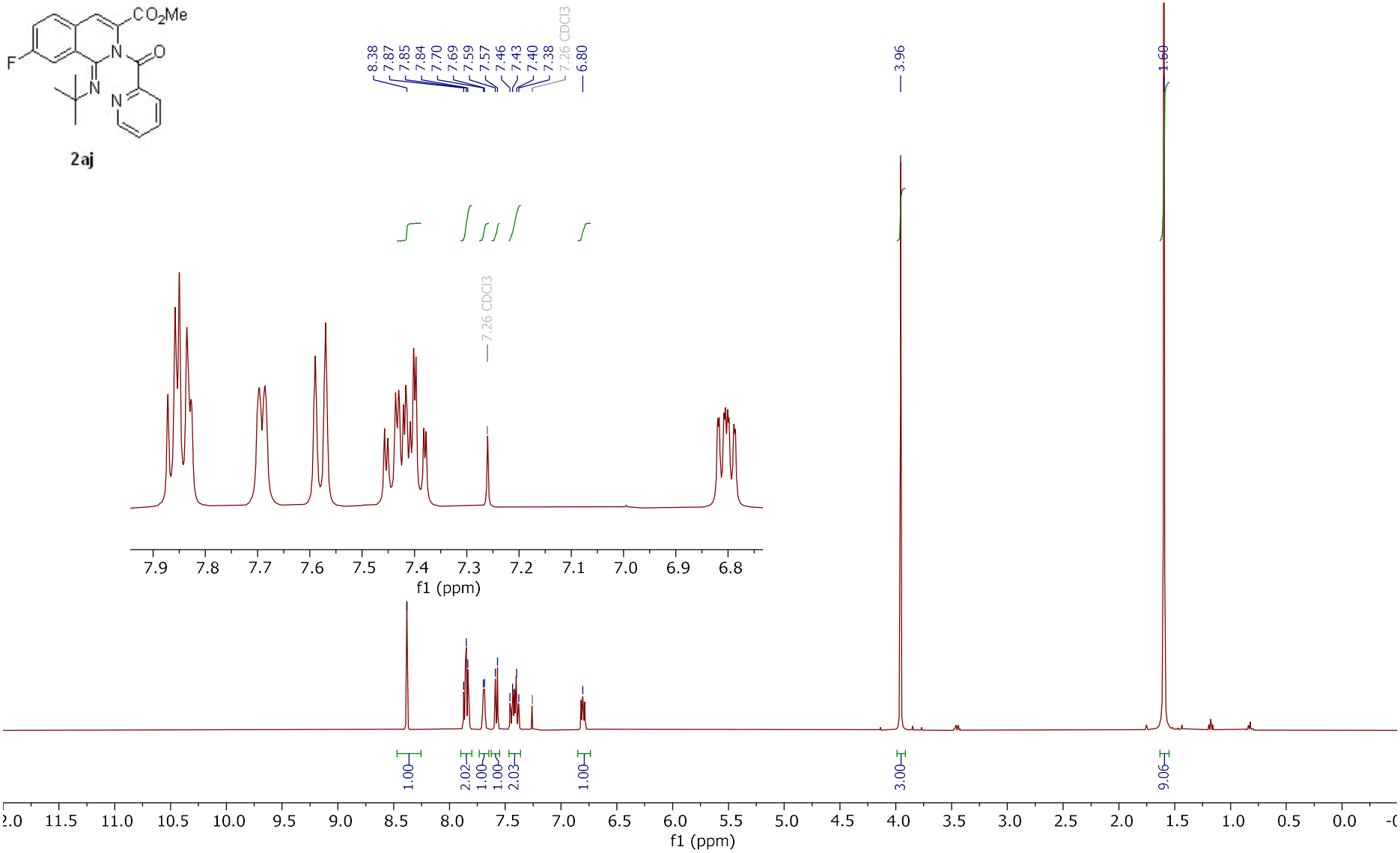
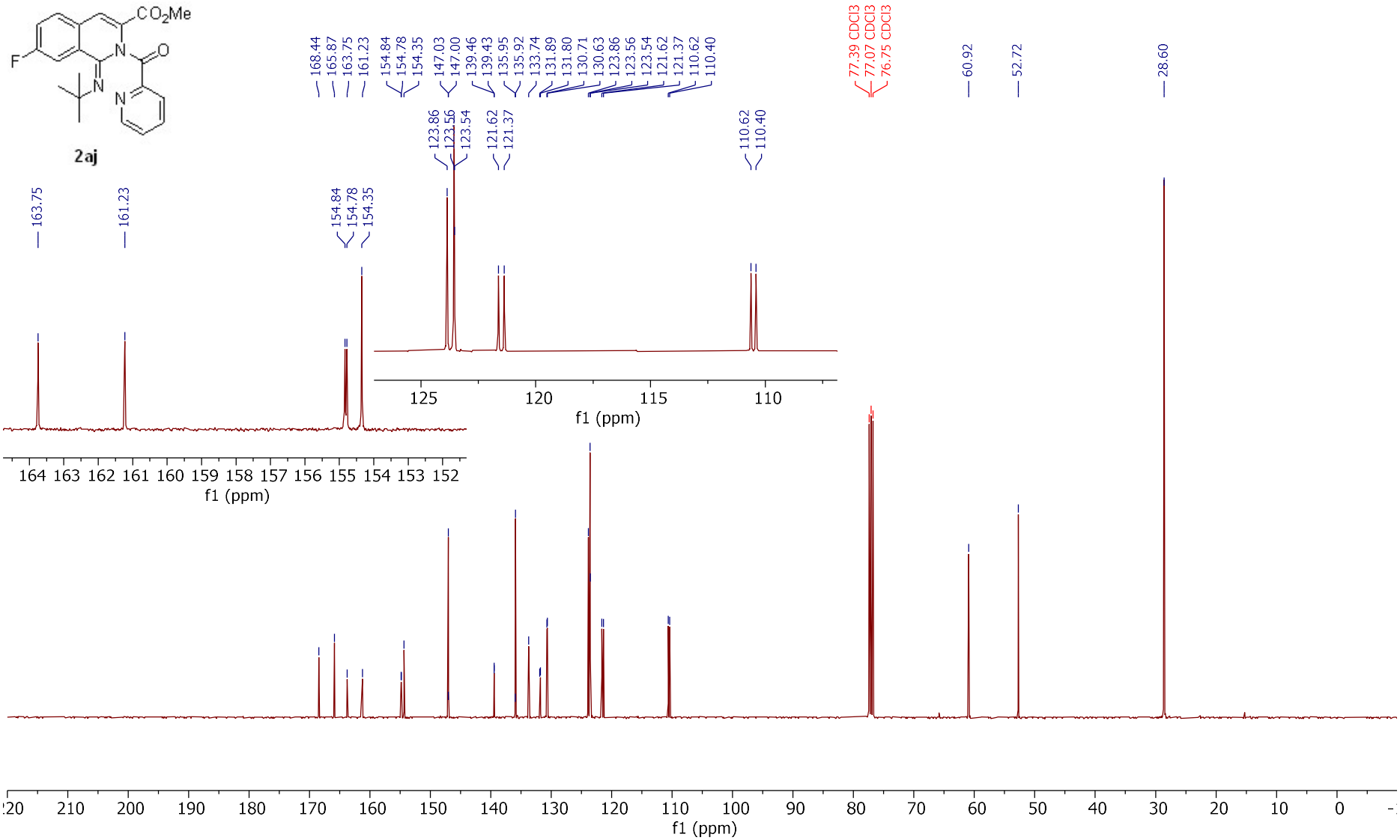
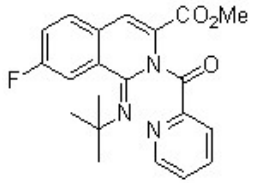


^{13}C-NMR, 100 MHz, $CDCl_3$



^{19}F-NMR, 376MHz, $CDCl_3$



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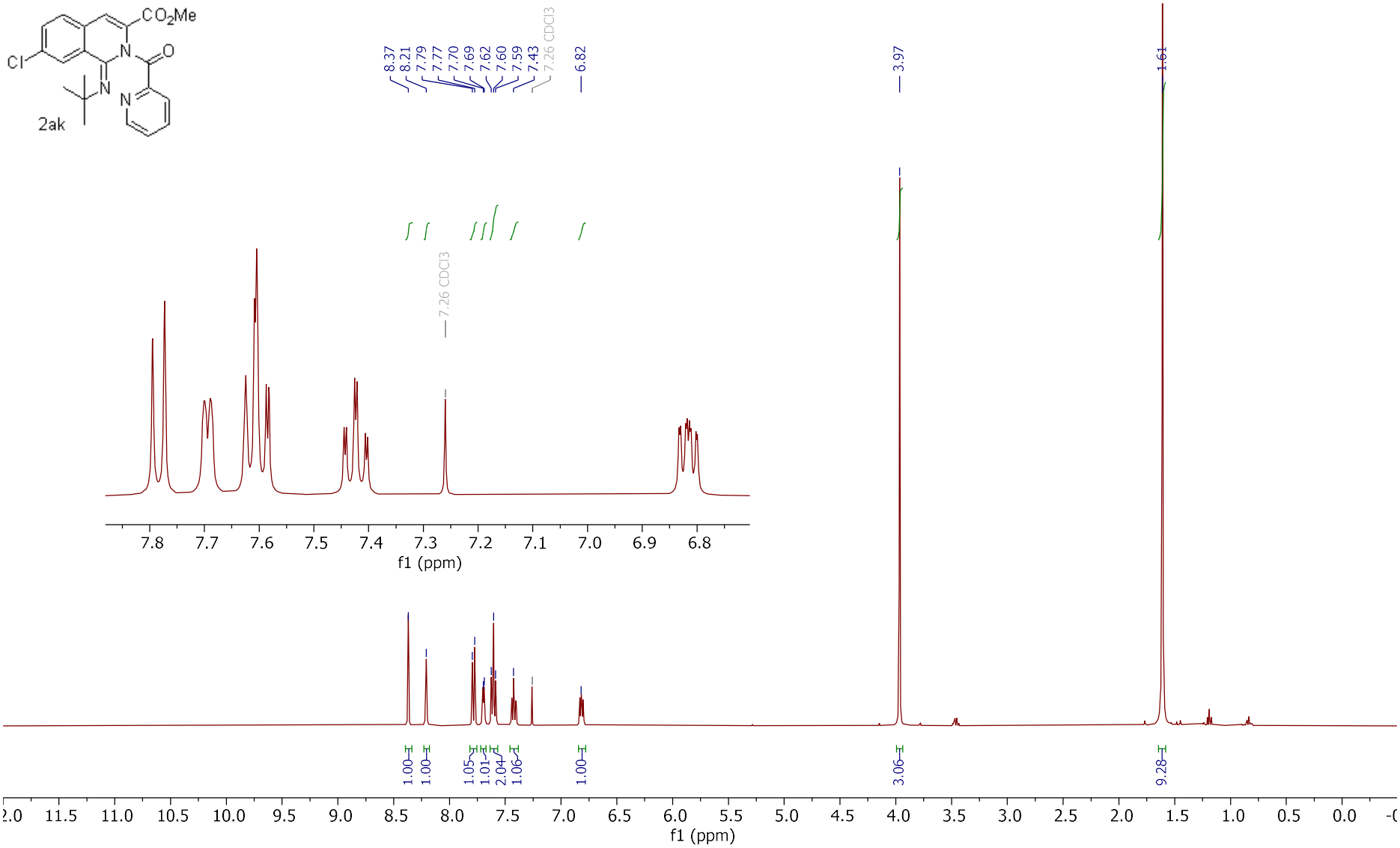
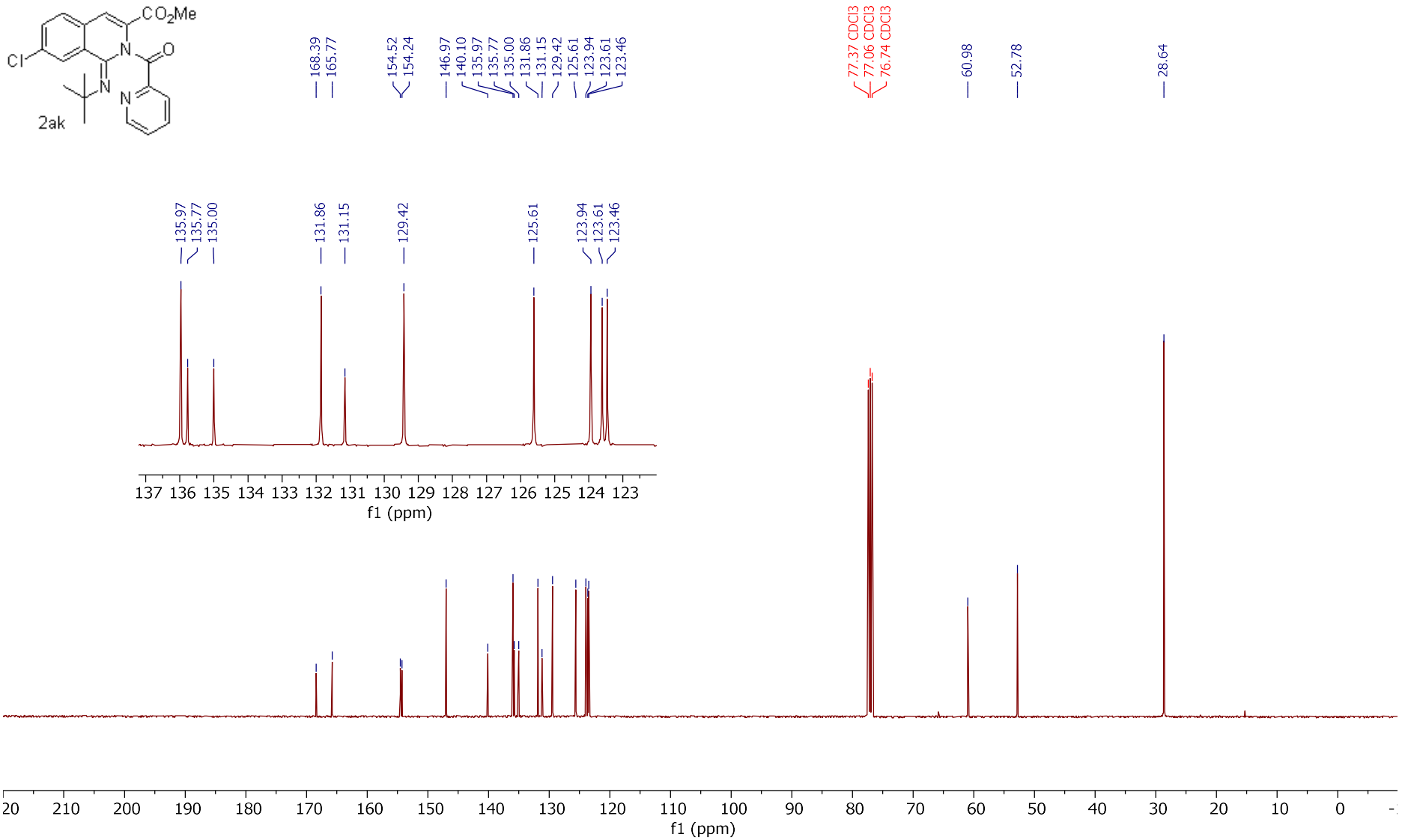
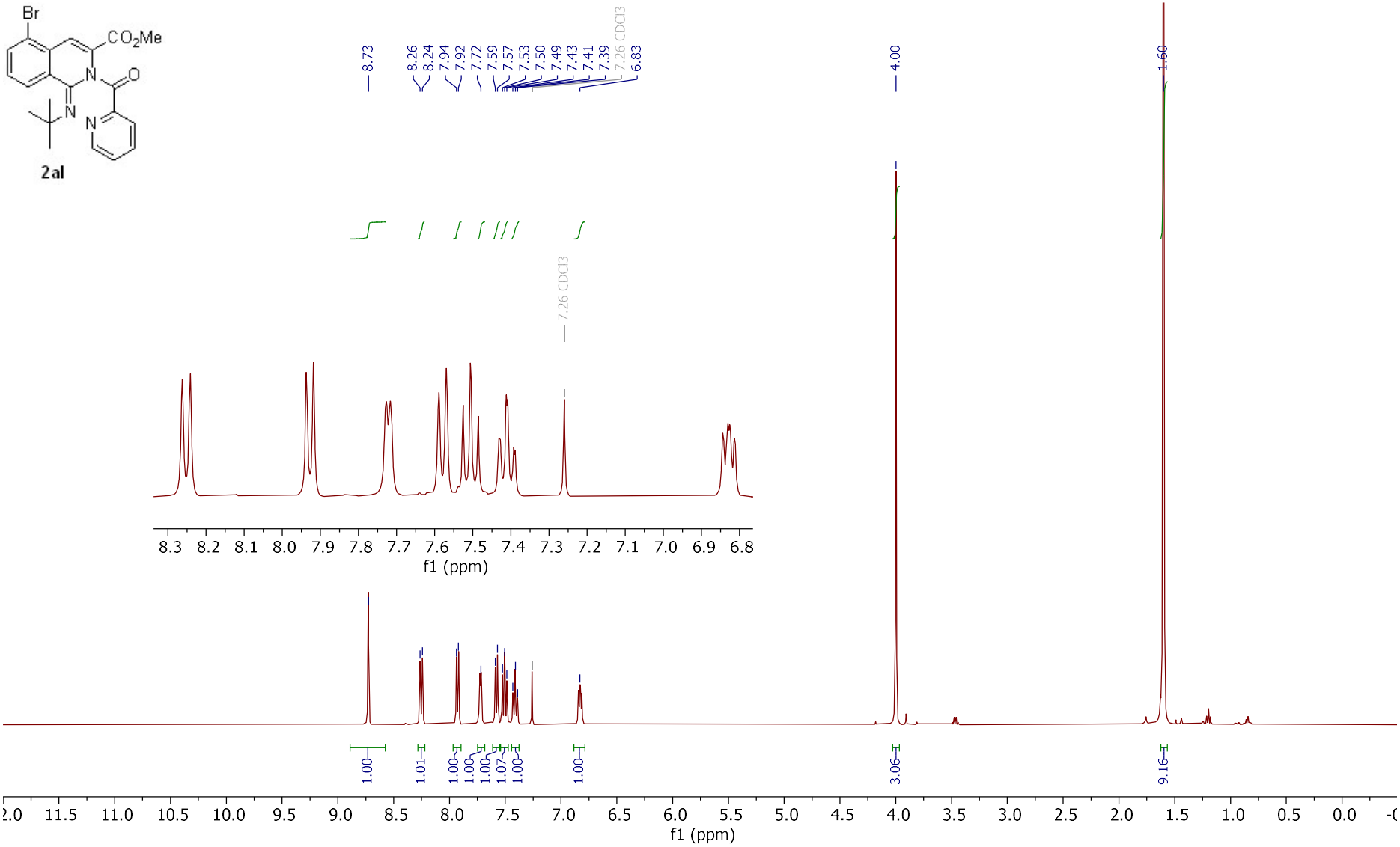
^{1}H-NMR, 400 MHz, $CDCl_3$



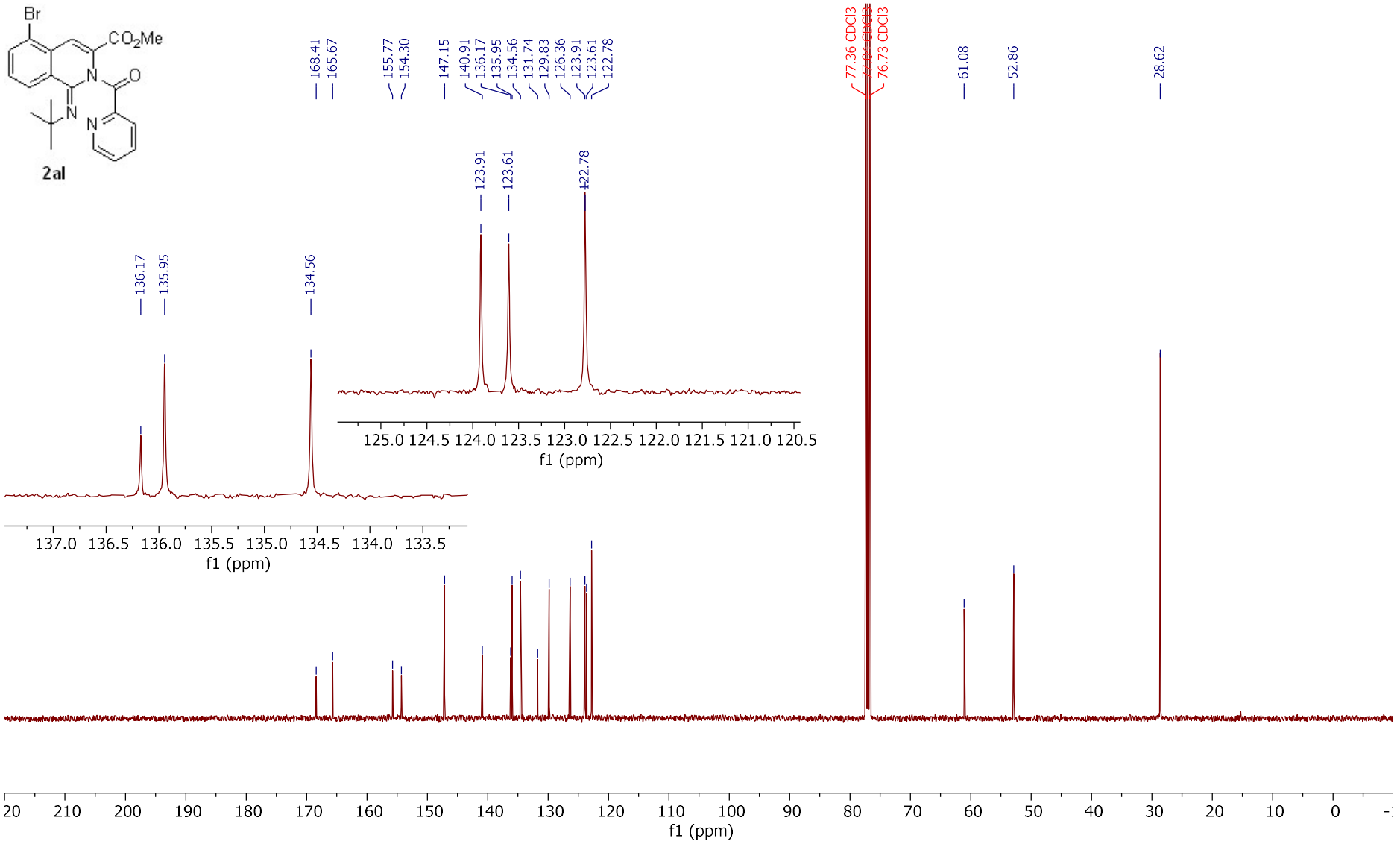
^{13}C-NMR, 100 MHz, $CDCl_3$



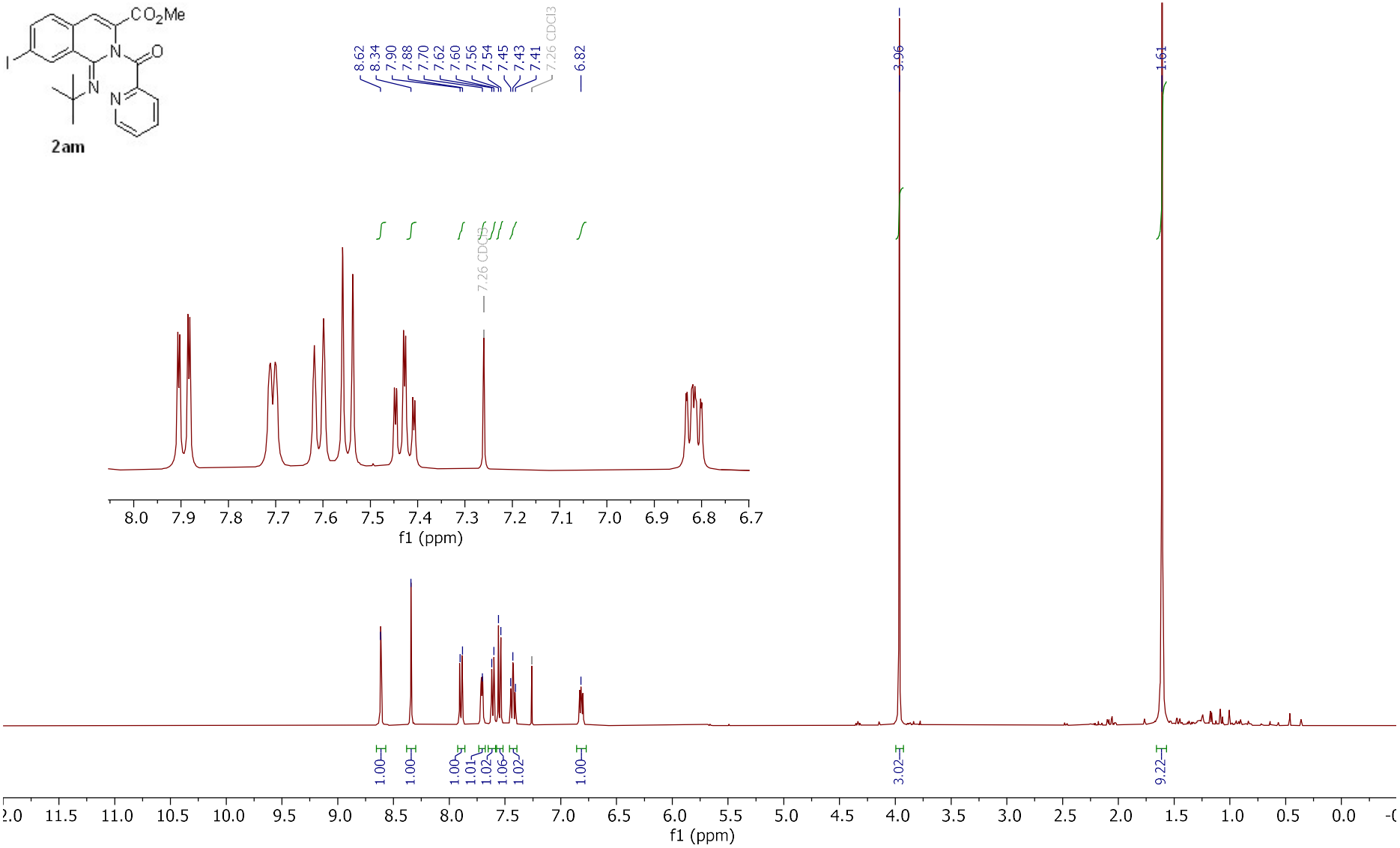
^{1}H-NMR, 400 MHz, $CDCl_3$



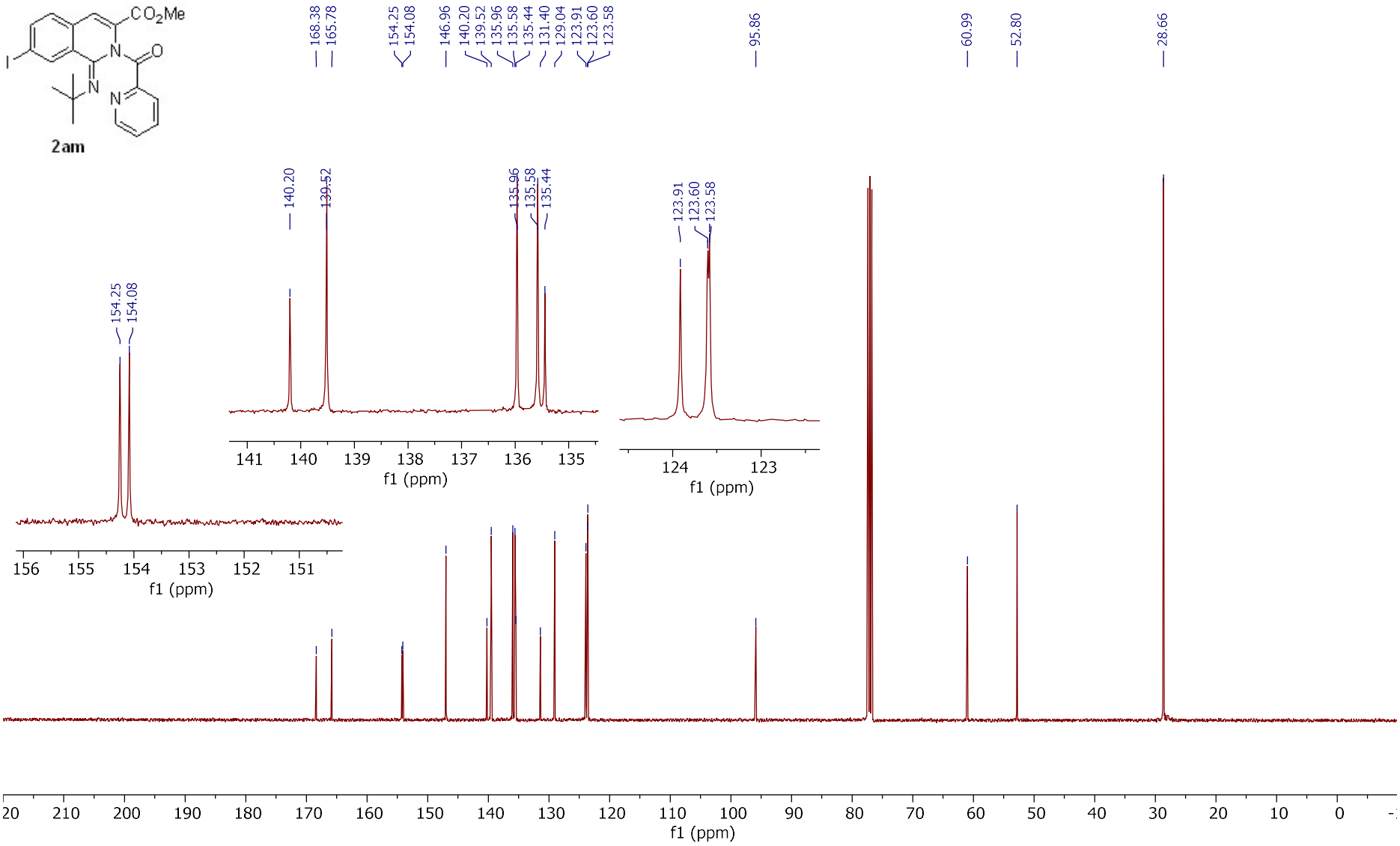
^{13}C-NMR, 100 MHz, $CDCl_3$



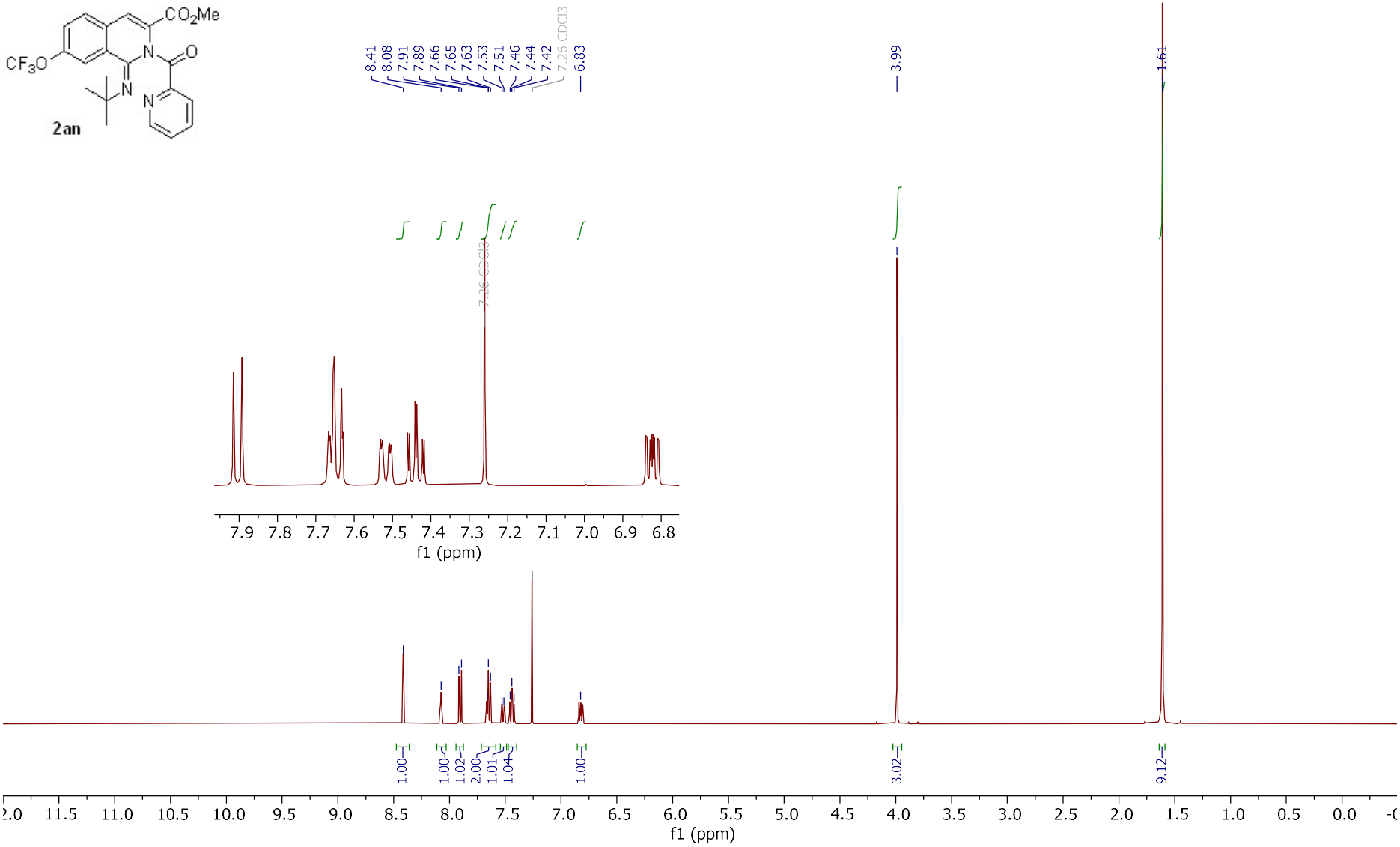
^{1}H-NMR, 400 MHz, $CDCl_3$



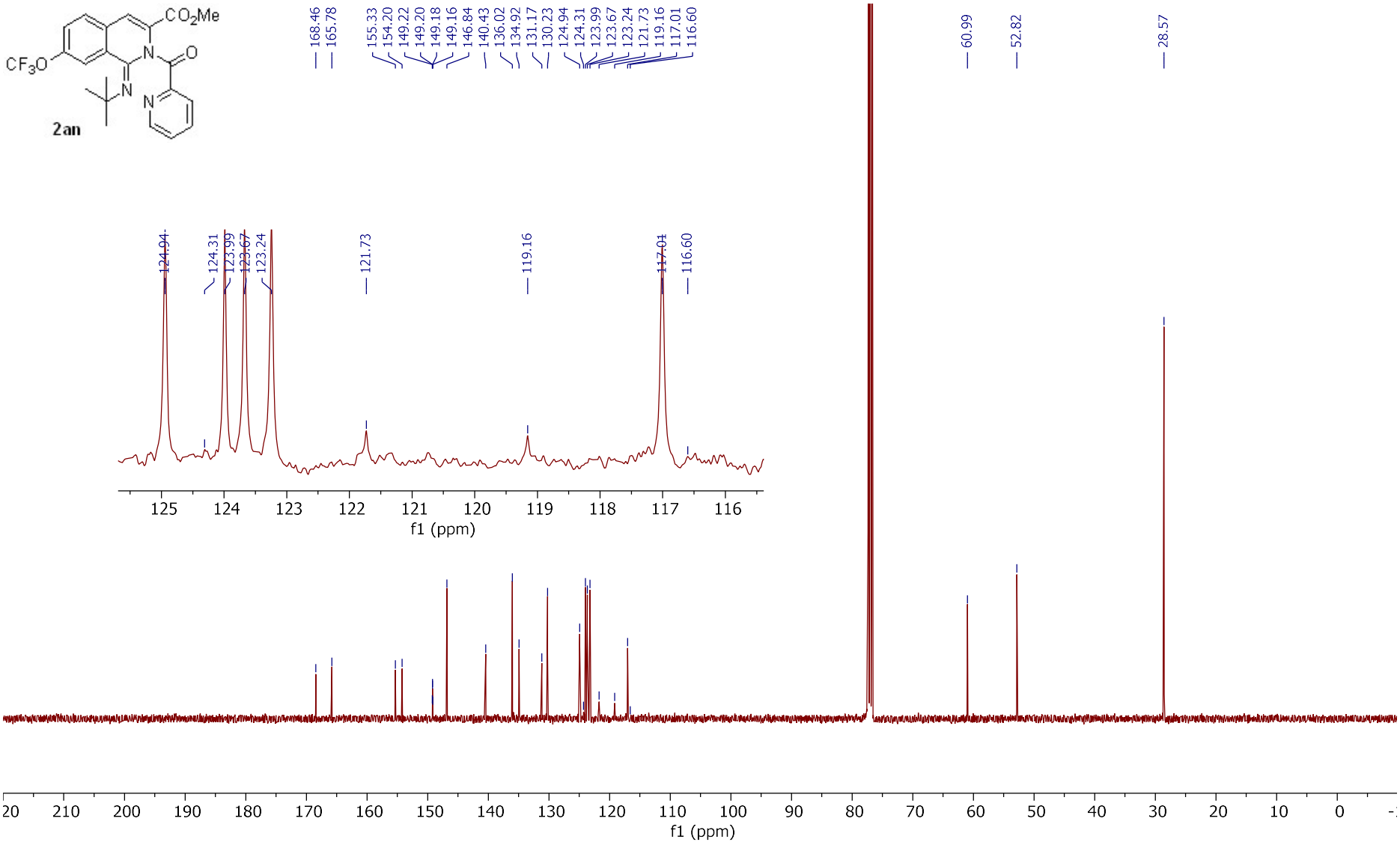
^{13}C-NMR, 100 MHz, $CDCl_3$



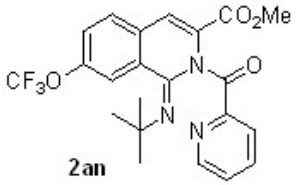
^{1}H-NMR, 400 MHz, $CDCl_3$



^{13}C-NMR, 100 MHz, $CDCl_3$



^{19}F-NMR, 376MHz, $CDCl_3$



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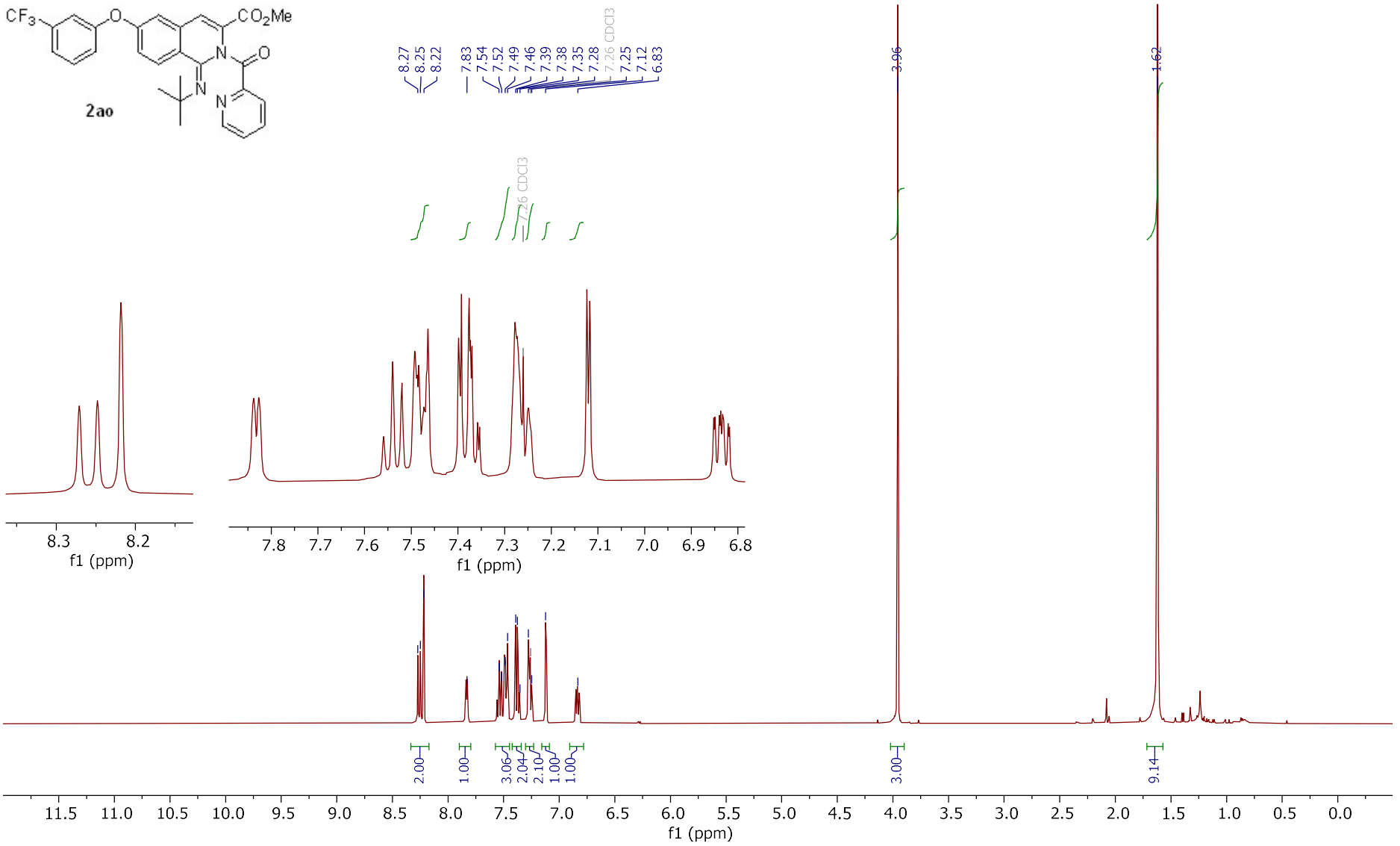
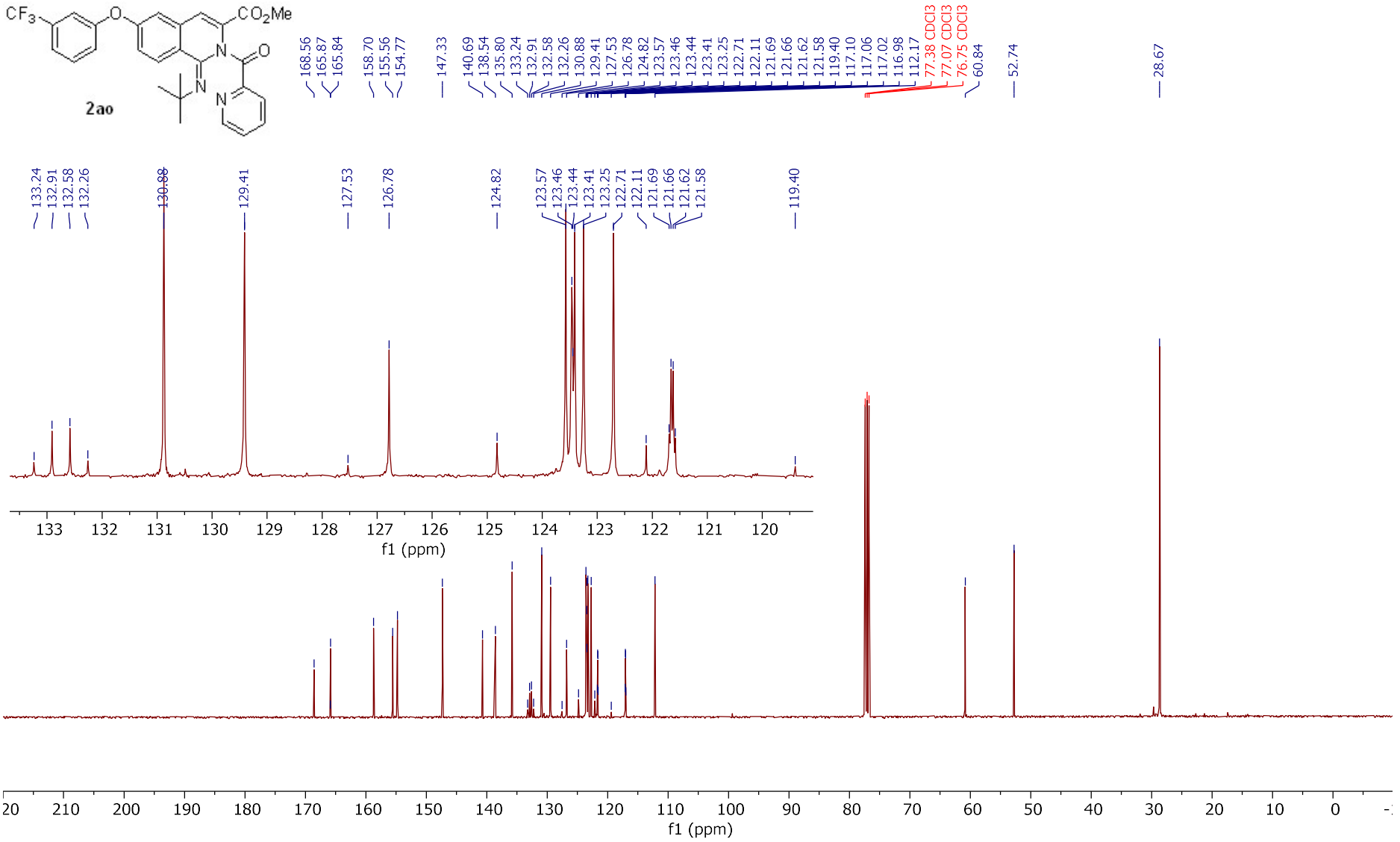
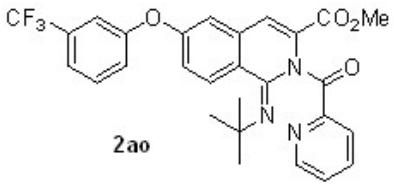
^{1}H-NMR, 400 MHz, $CDCl_3$



^{13}C-NMR, 100 MHz, $CDCl_3$



^{19}F-NMR, 376MHz, $CDCl_3$



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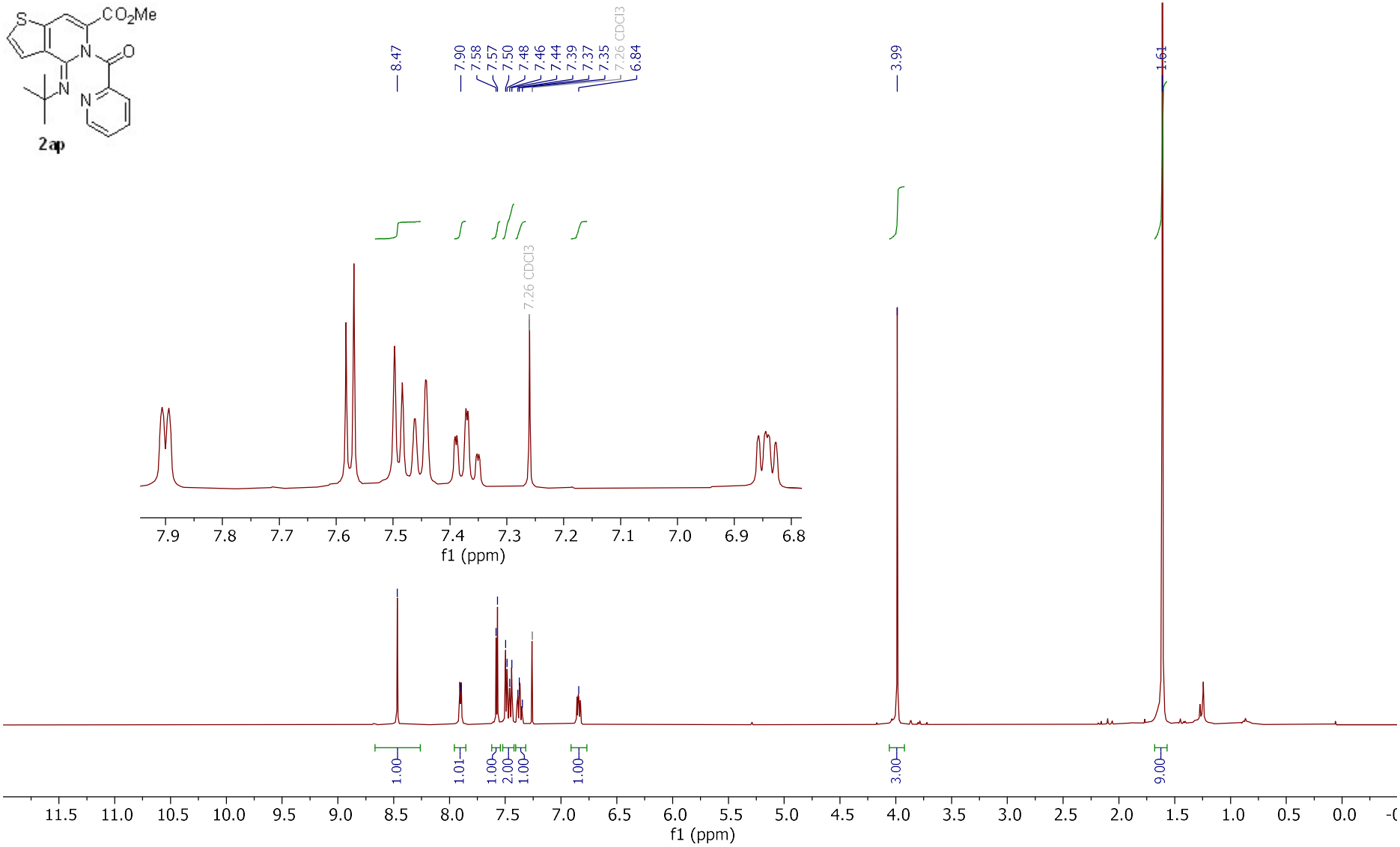
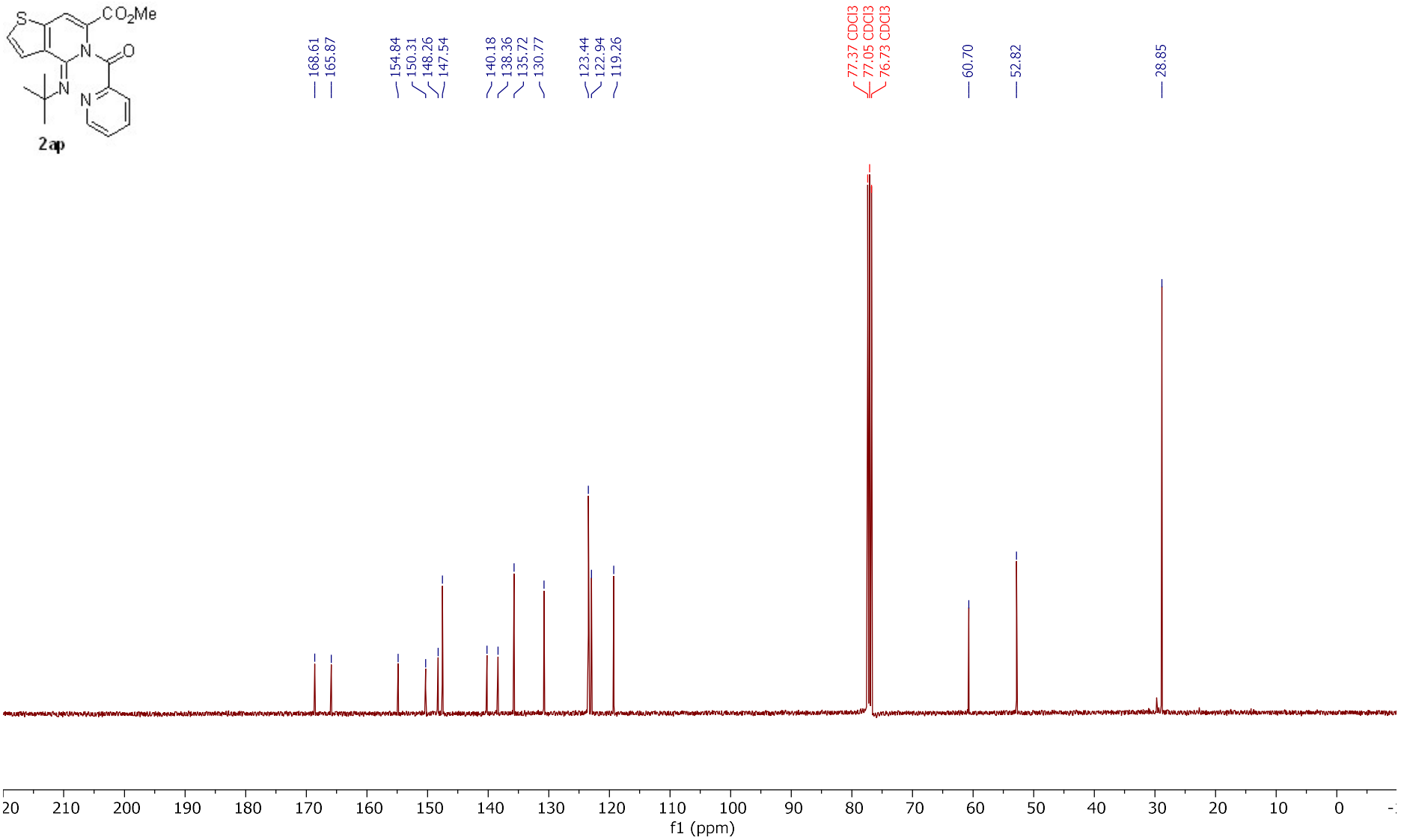
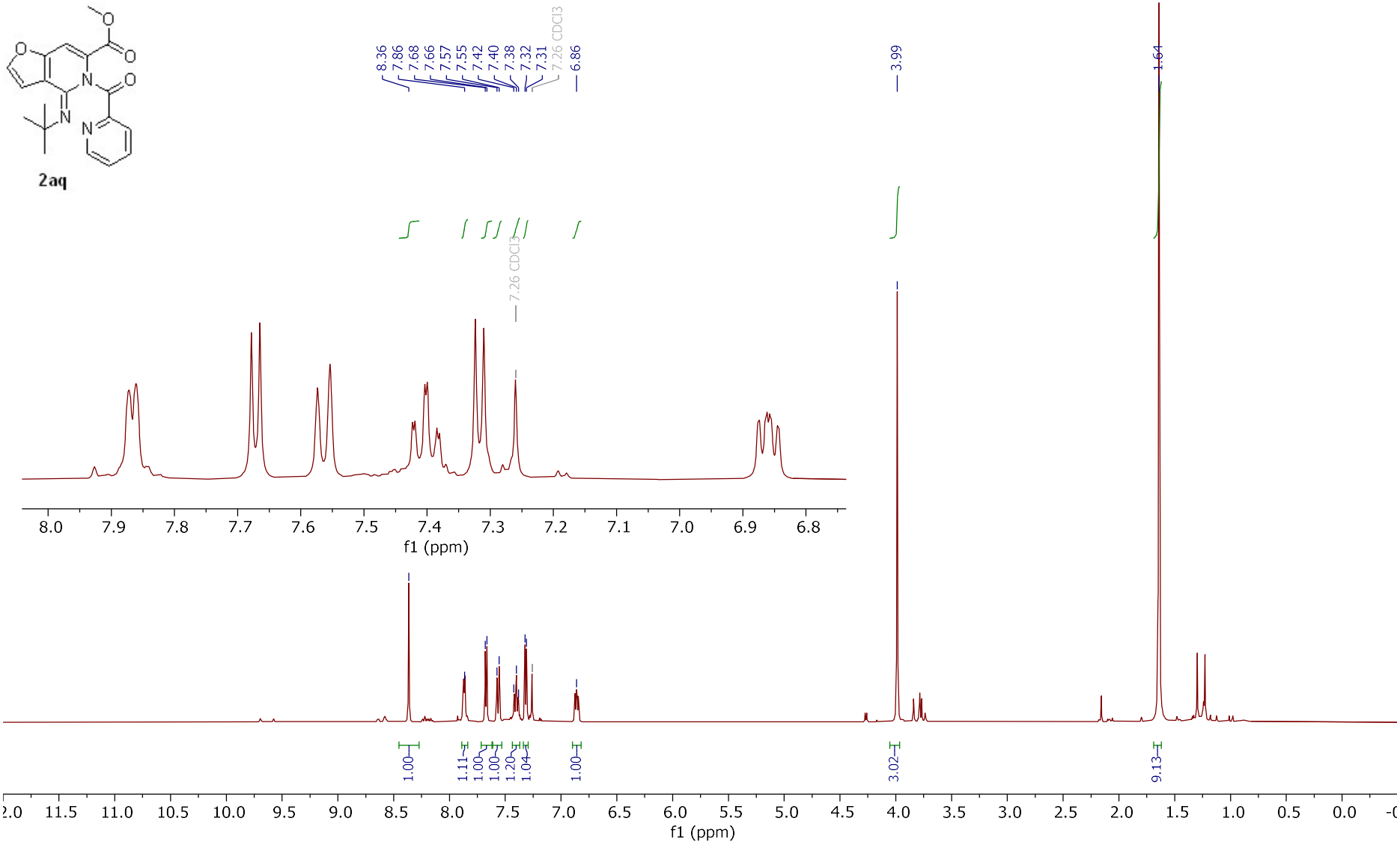
^{1}H-NMR, 400 MHz, $CDCl_3$



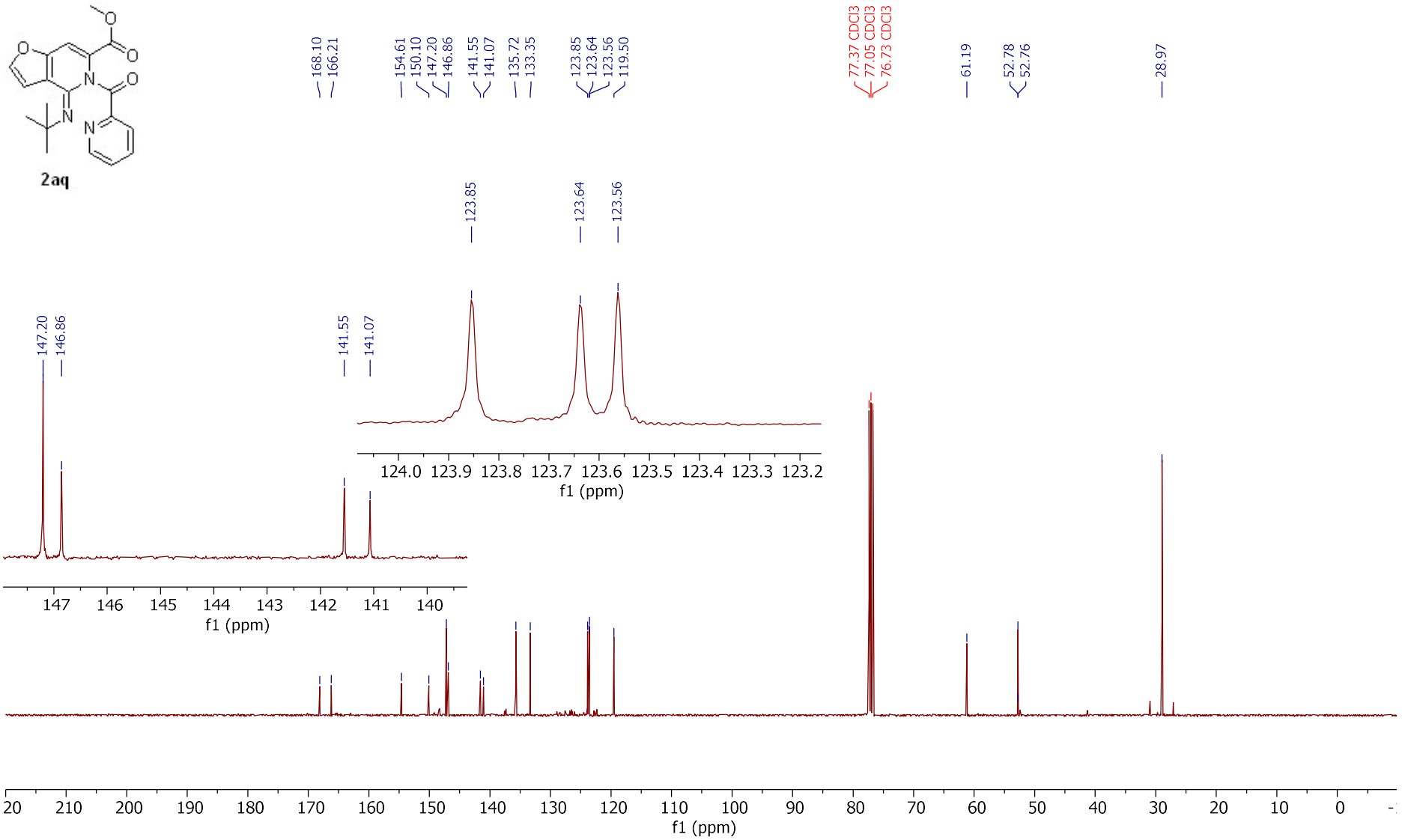
^{13}C-NMR, 100 MHz, $CDCl_3$



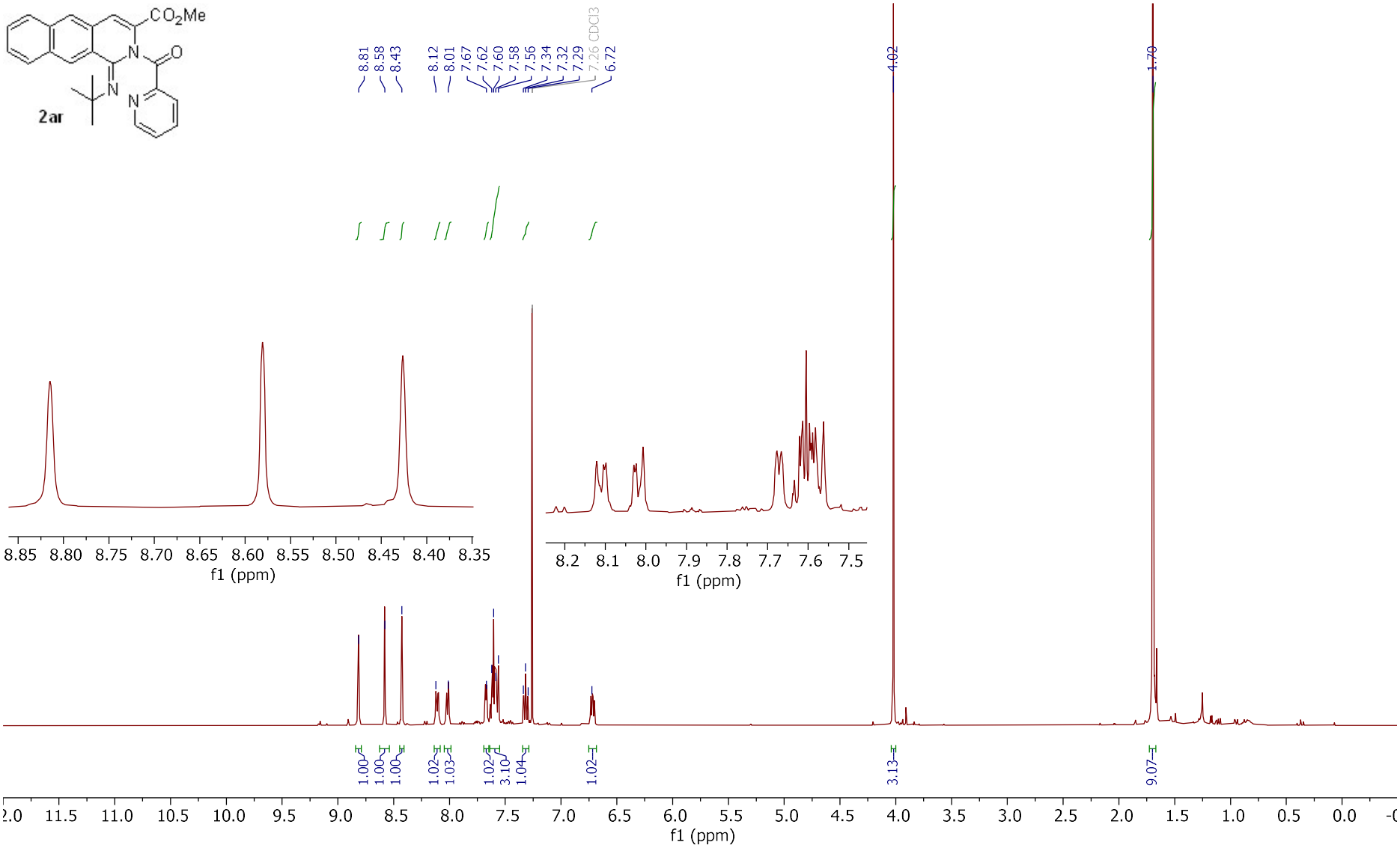
^{1}H-NMR, 400 MHz, $CDCl_3$



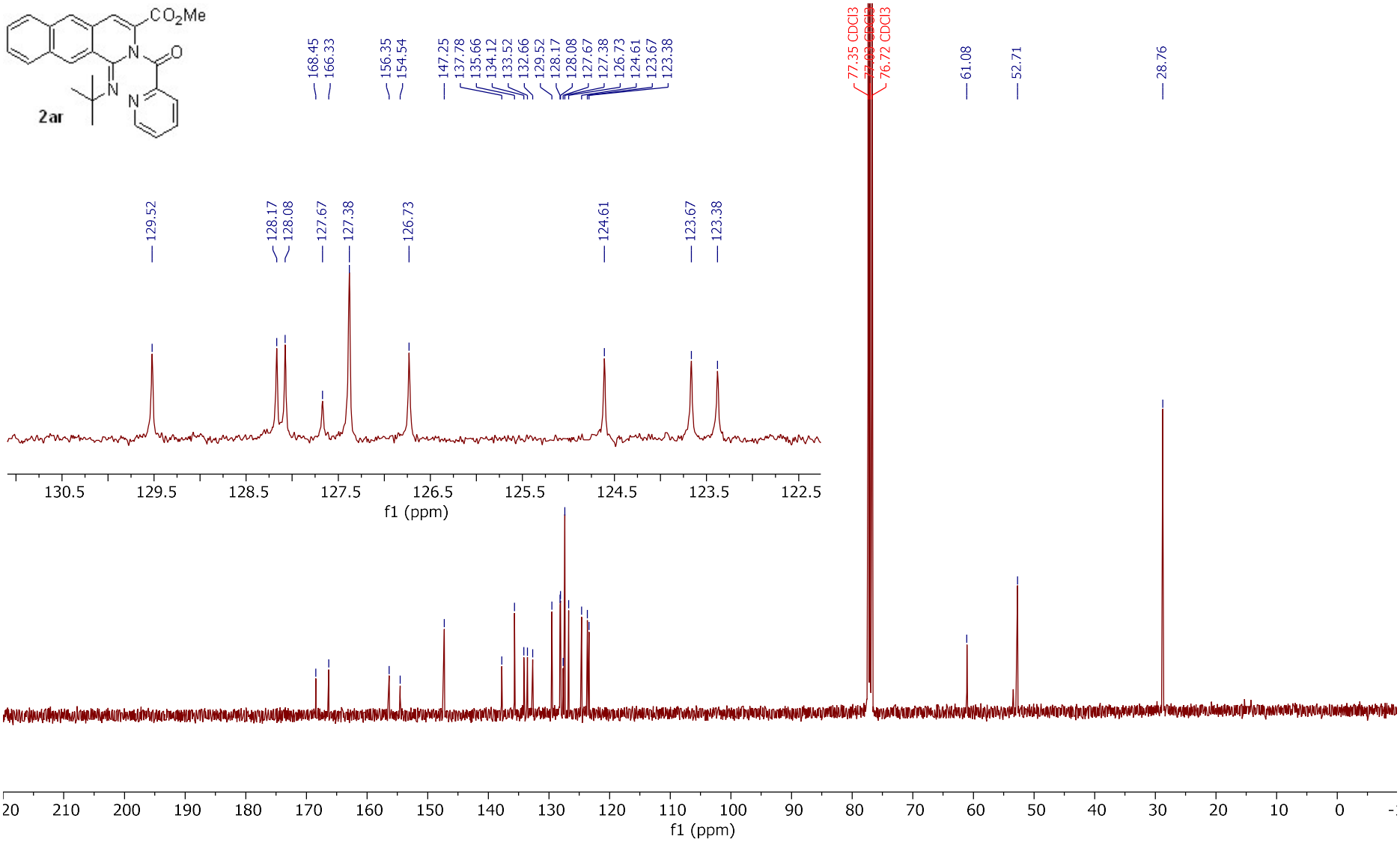
^{13}C-NMR, 100 MHz, $CDCl_3$



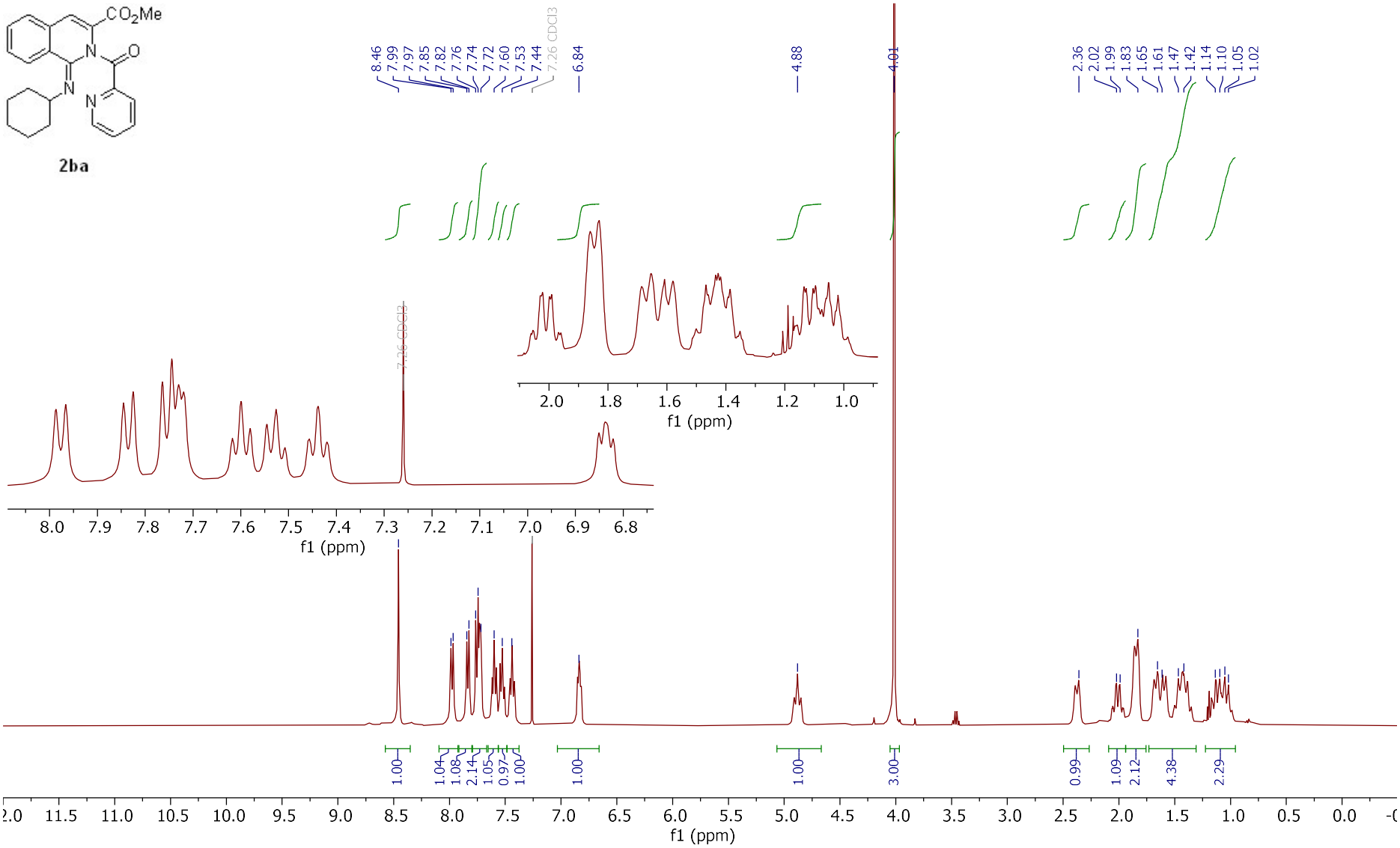
^{1}H-NMR, 400 MHz, $CDCl_3$



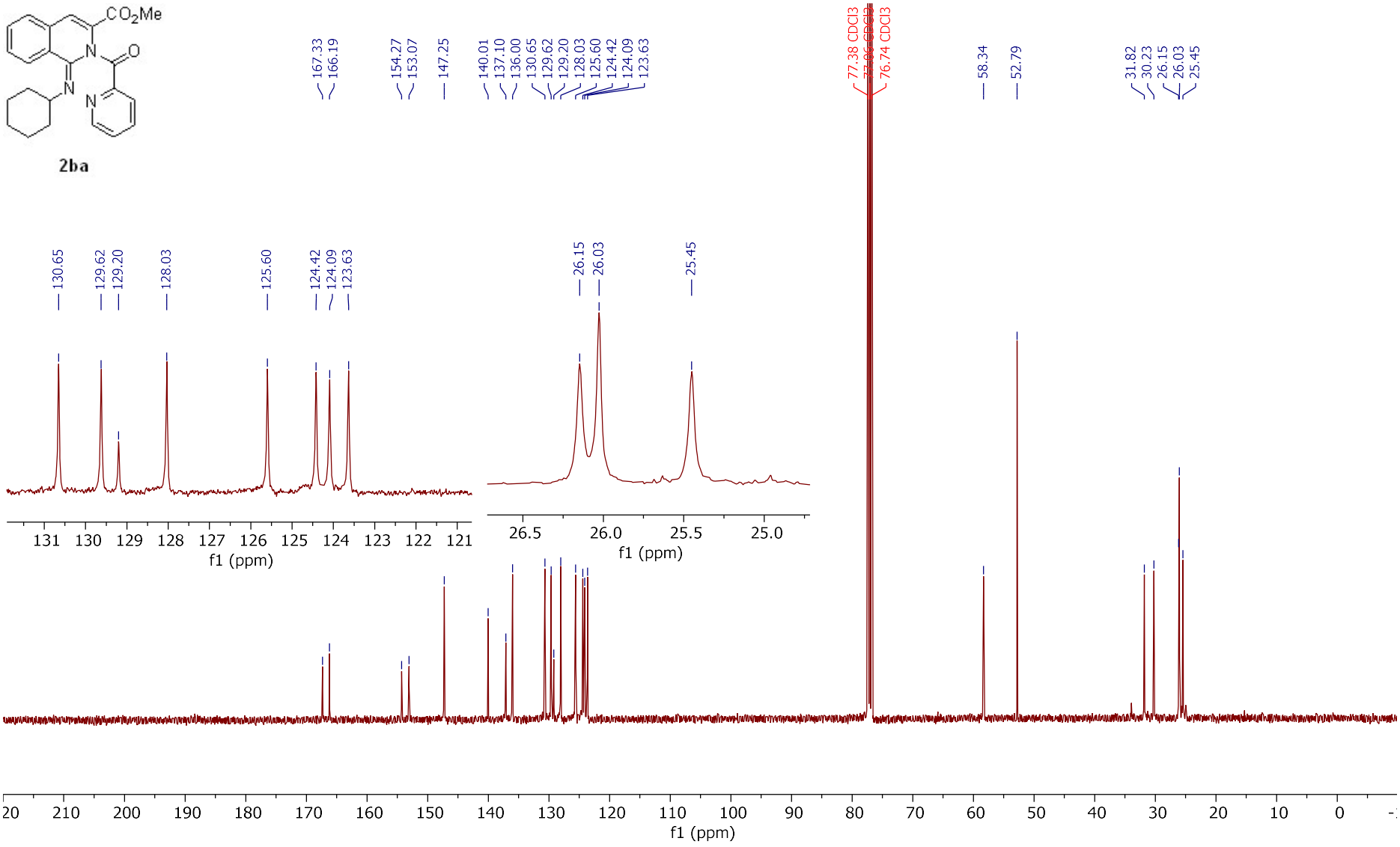
^{13}C-NMR, 100 MHz, $CDCl_3$



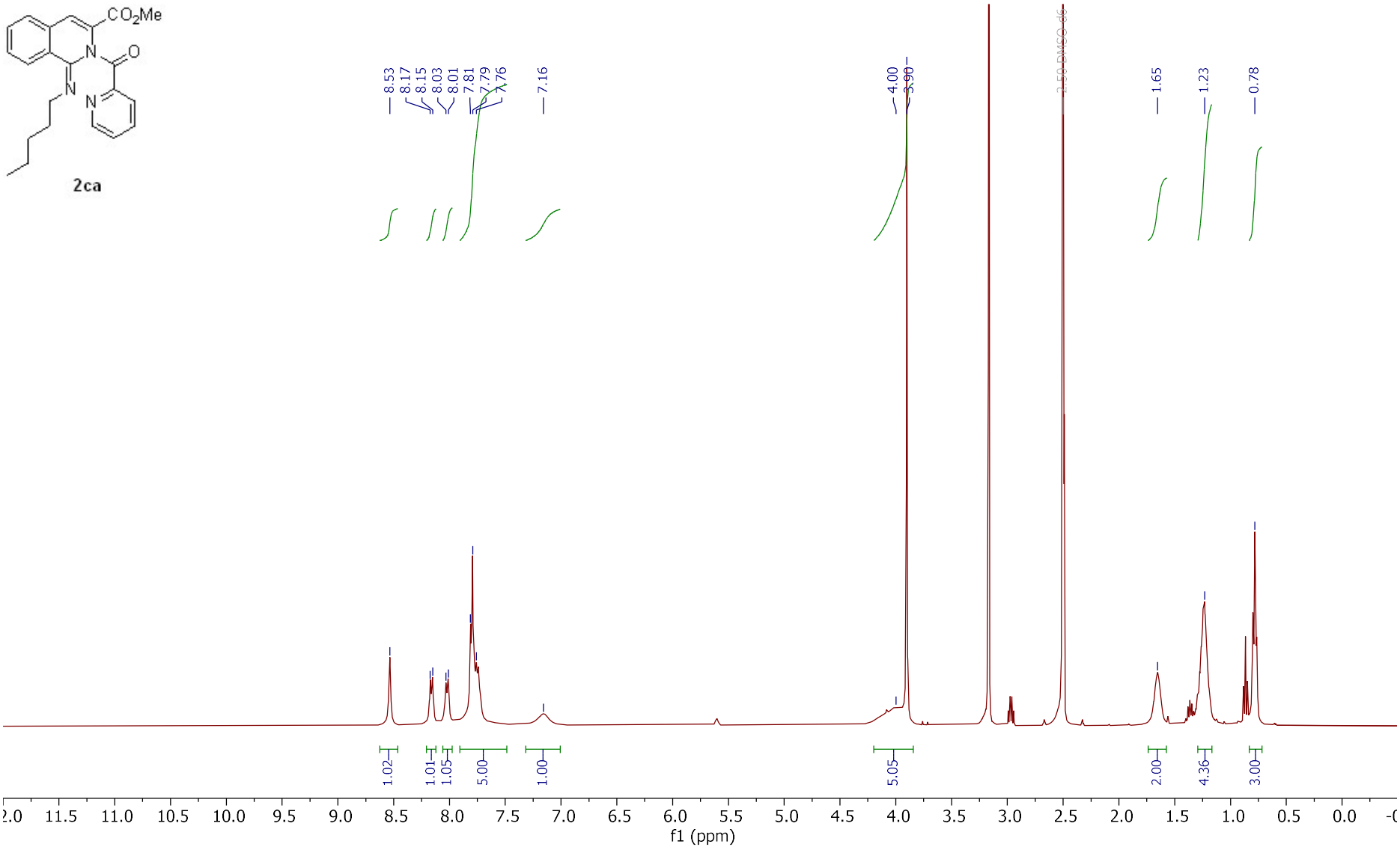
^{1}H-NMR, 400 MHz, $CDCl_3$



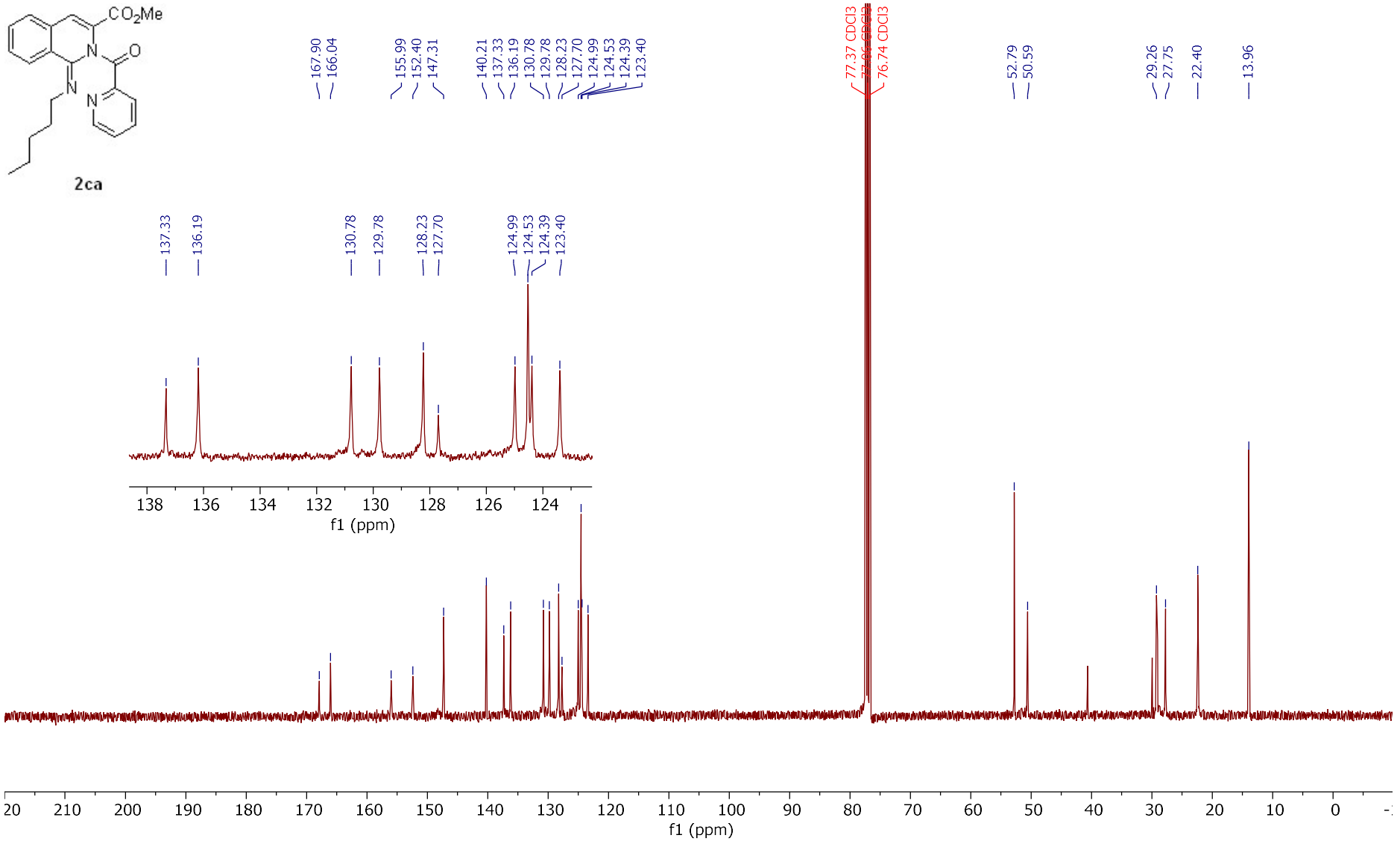
^{13}C-NMR, 100 MHz, $CDCl_3$



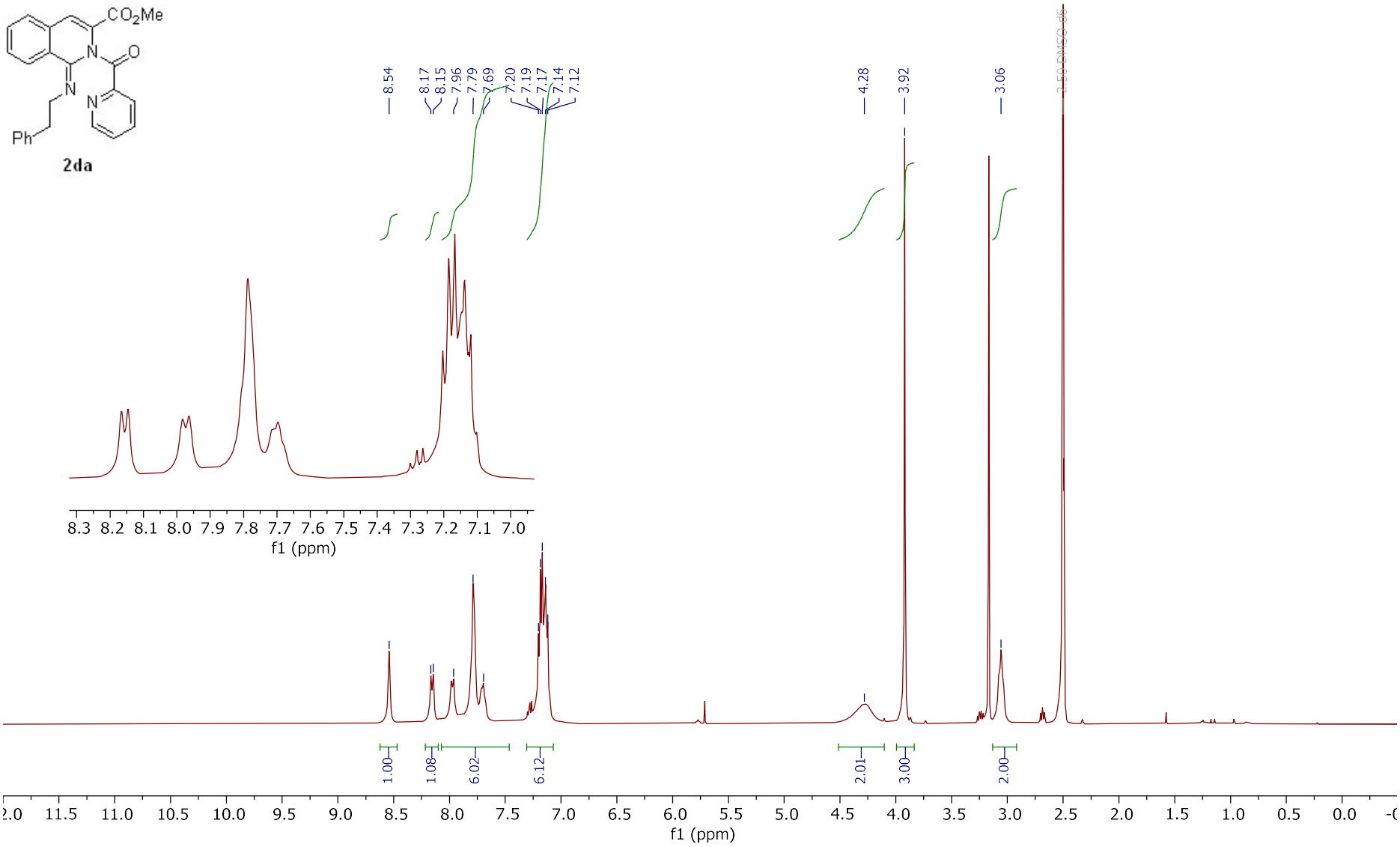
^{1}H-NMR, 400 MHz, dmso- d_6, 60 ^{o}C



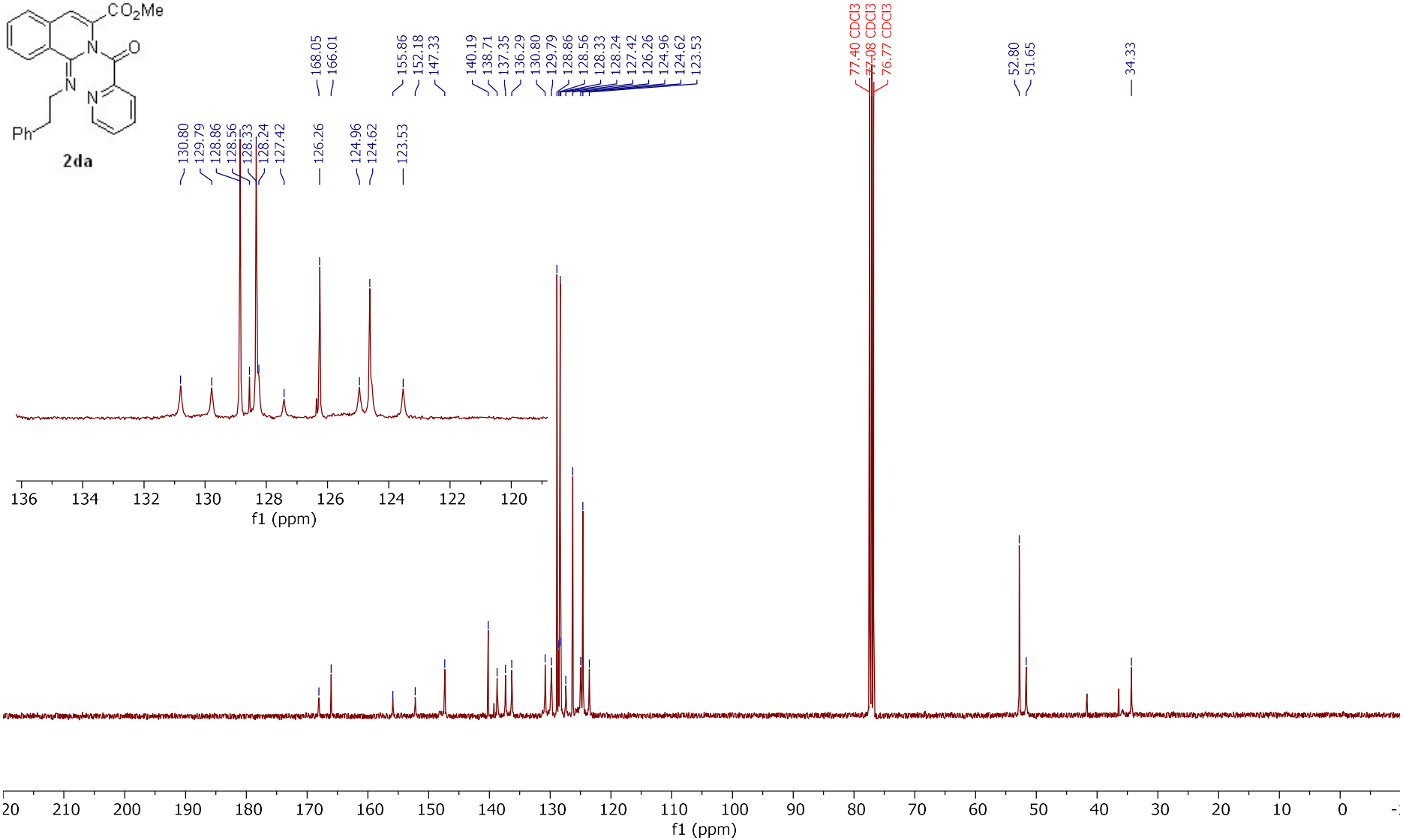
^{13}C-NMR, 100 MHz, $CDCl_3$



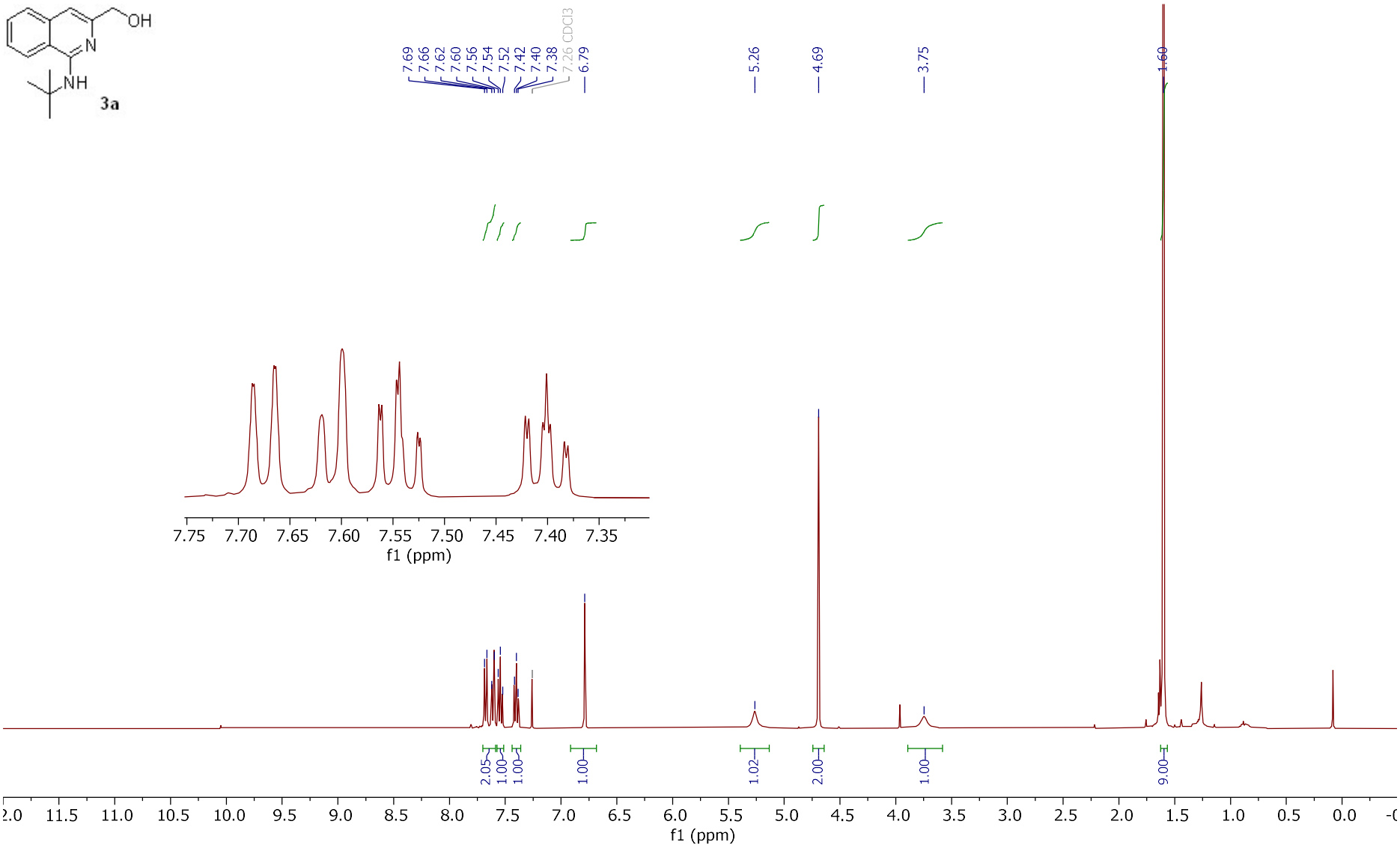
^{1}H-NMR, 400 MHz, dmso- d_6, 60 ^{o}C



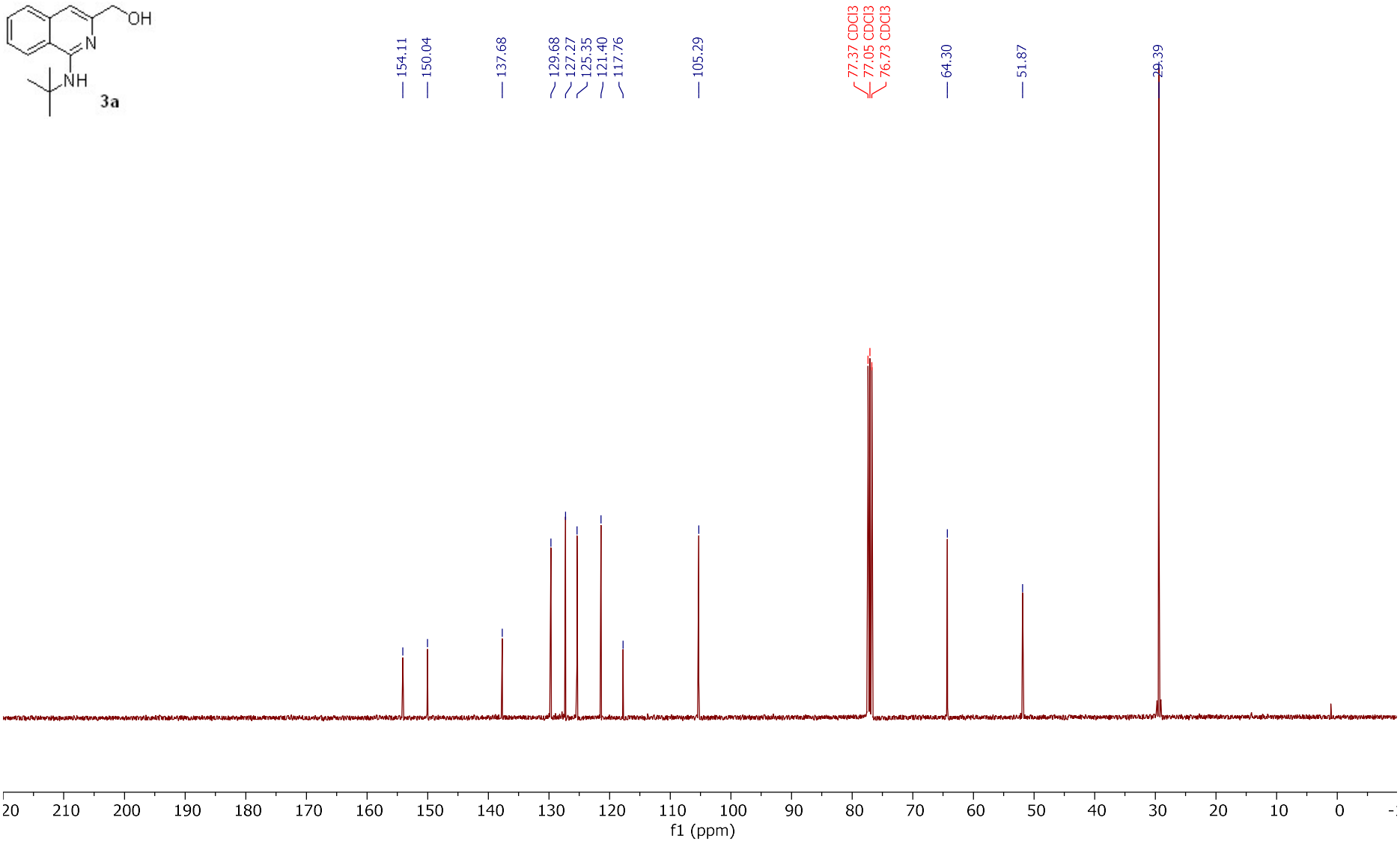
^{13}C-NMR, 100 MHz, $CDCl_3$



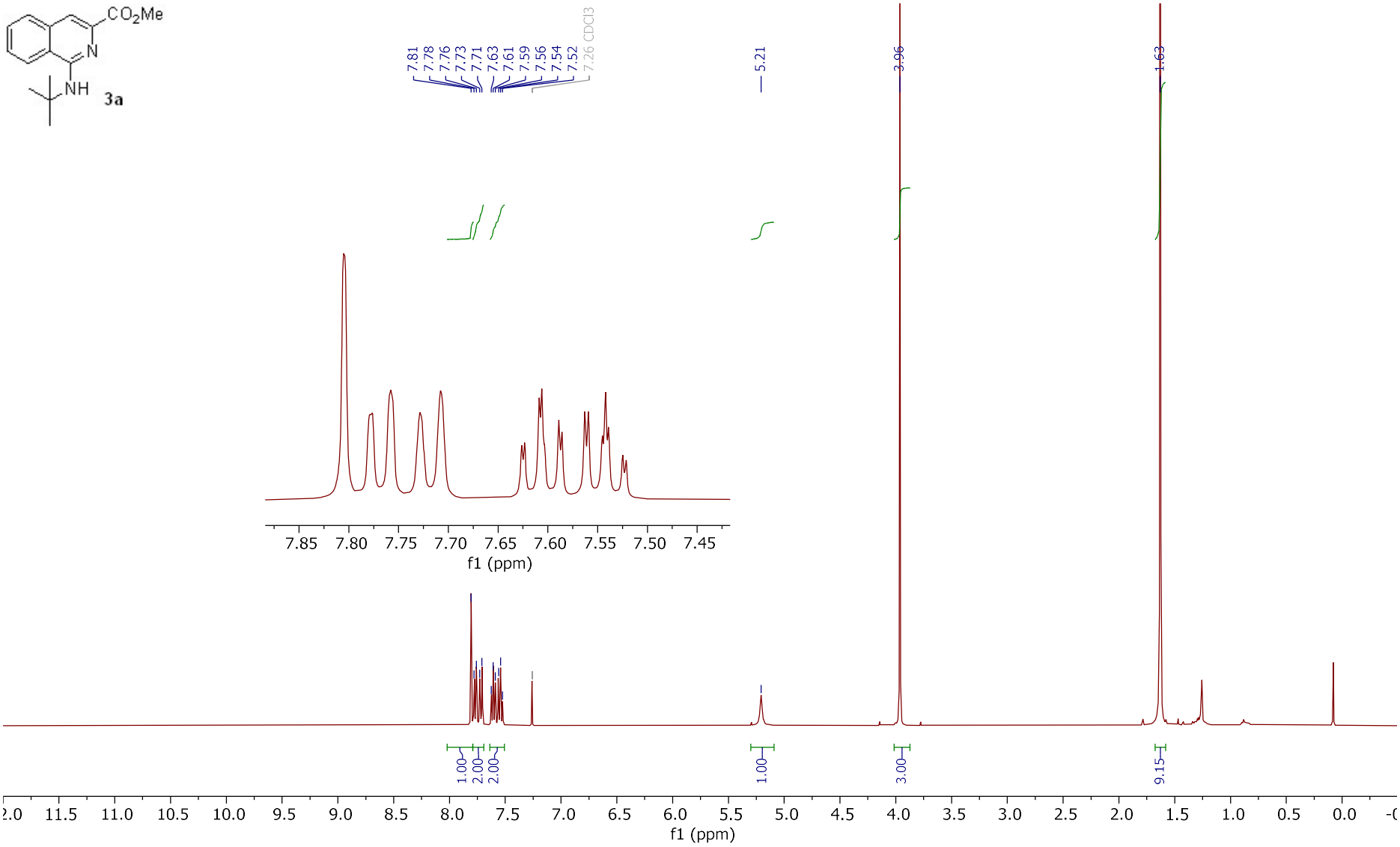
^{1}H-NMR, 400 MHz, $CDCl_3$



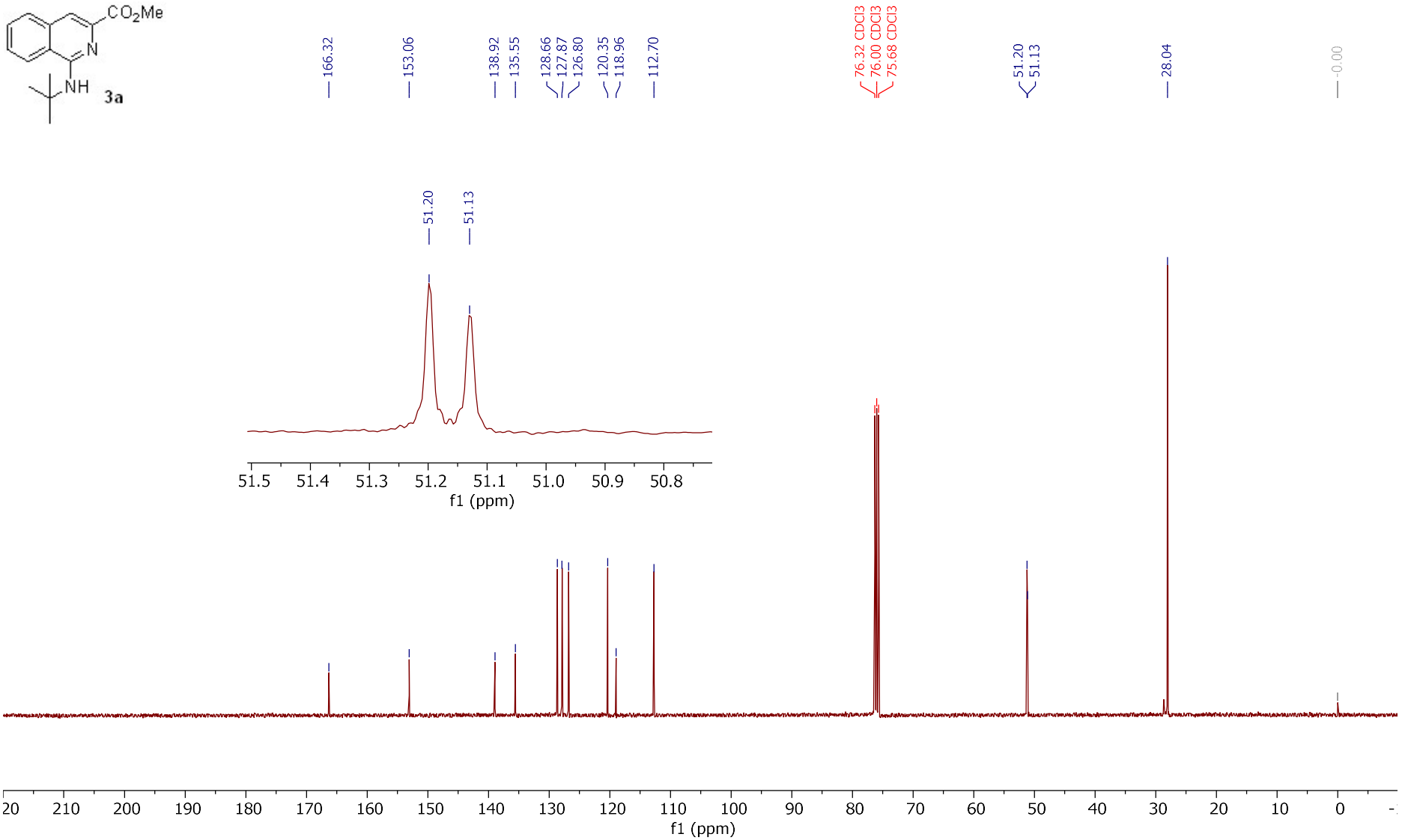
^{13}C-NMR, 100 MHz, $CDCl_3$



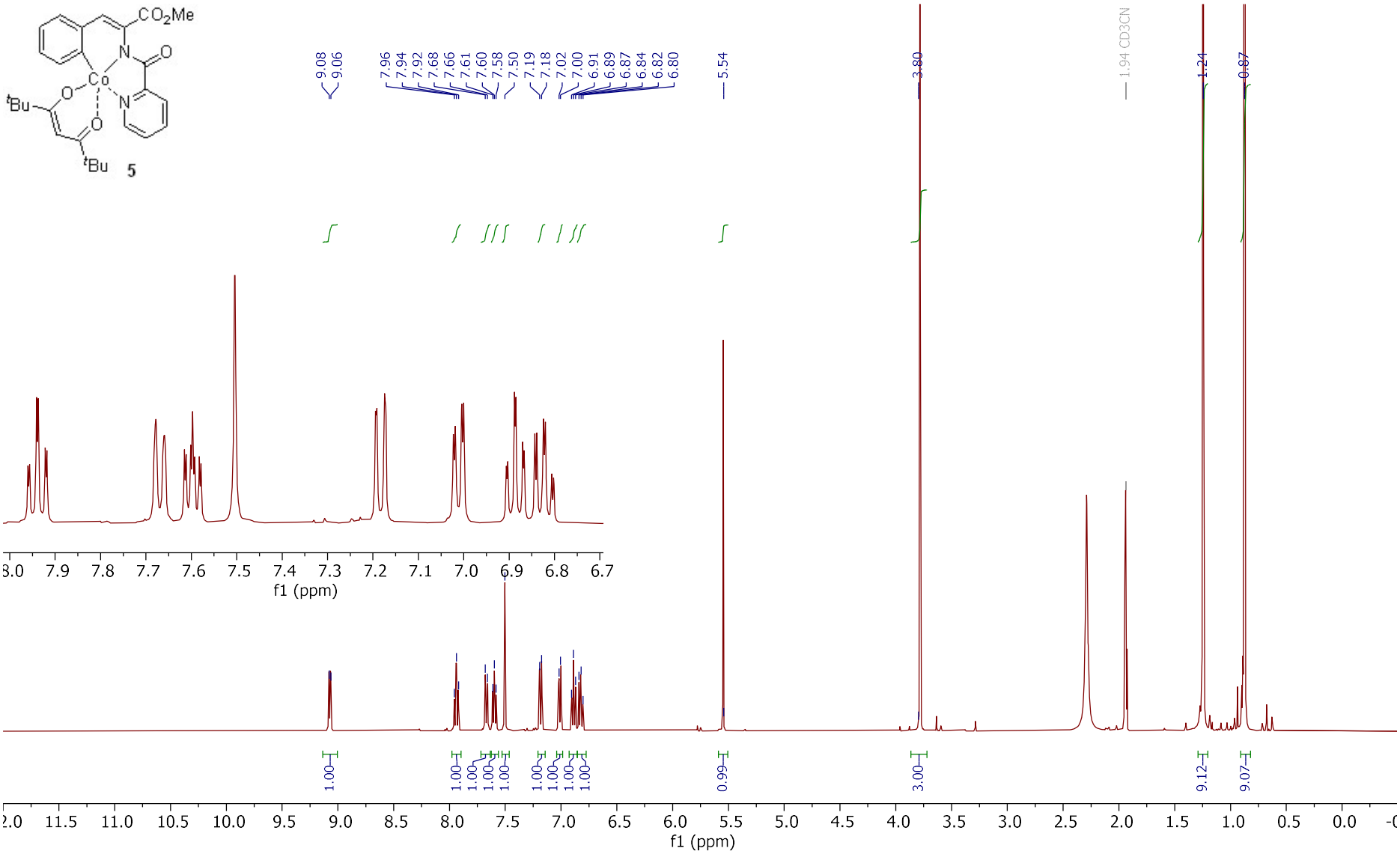
^{1}H-NMR, 400 MHz, $CDCl_3$



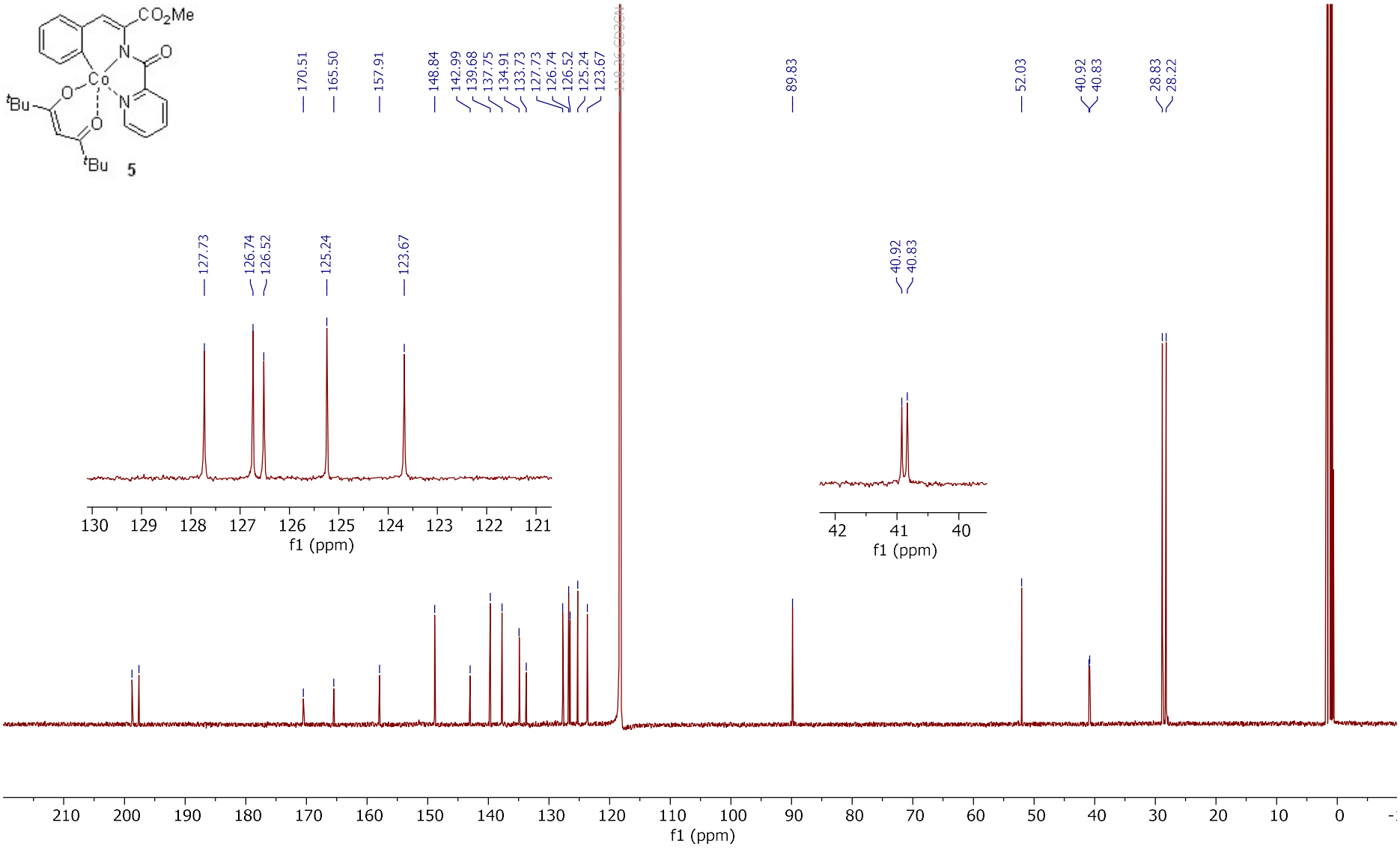
^{13}C-NMR, 100 MHz, $CDCl_3$



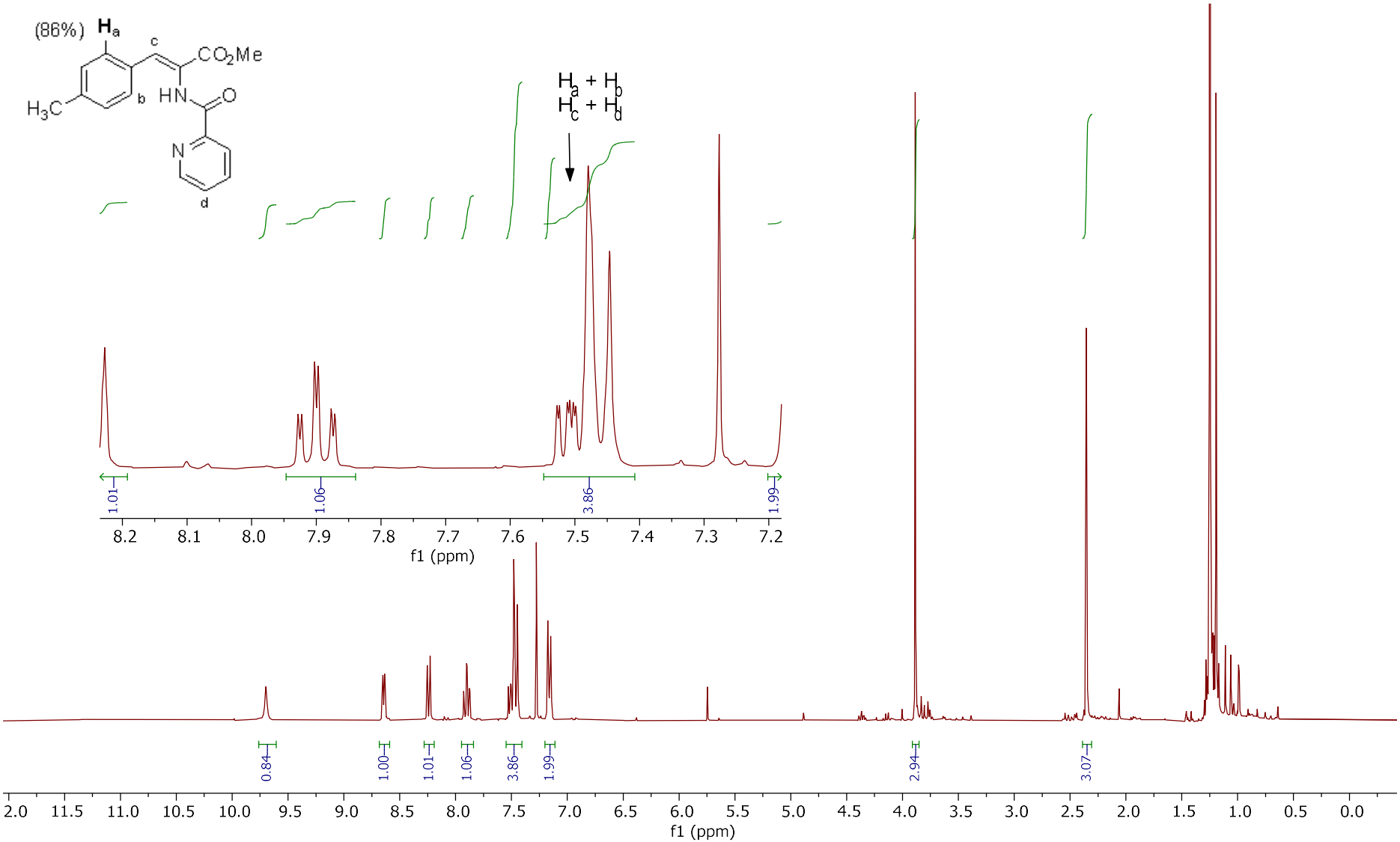
^{1}H-NMR, 400 MHz, CD_3CN



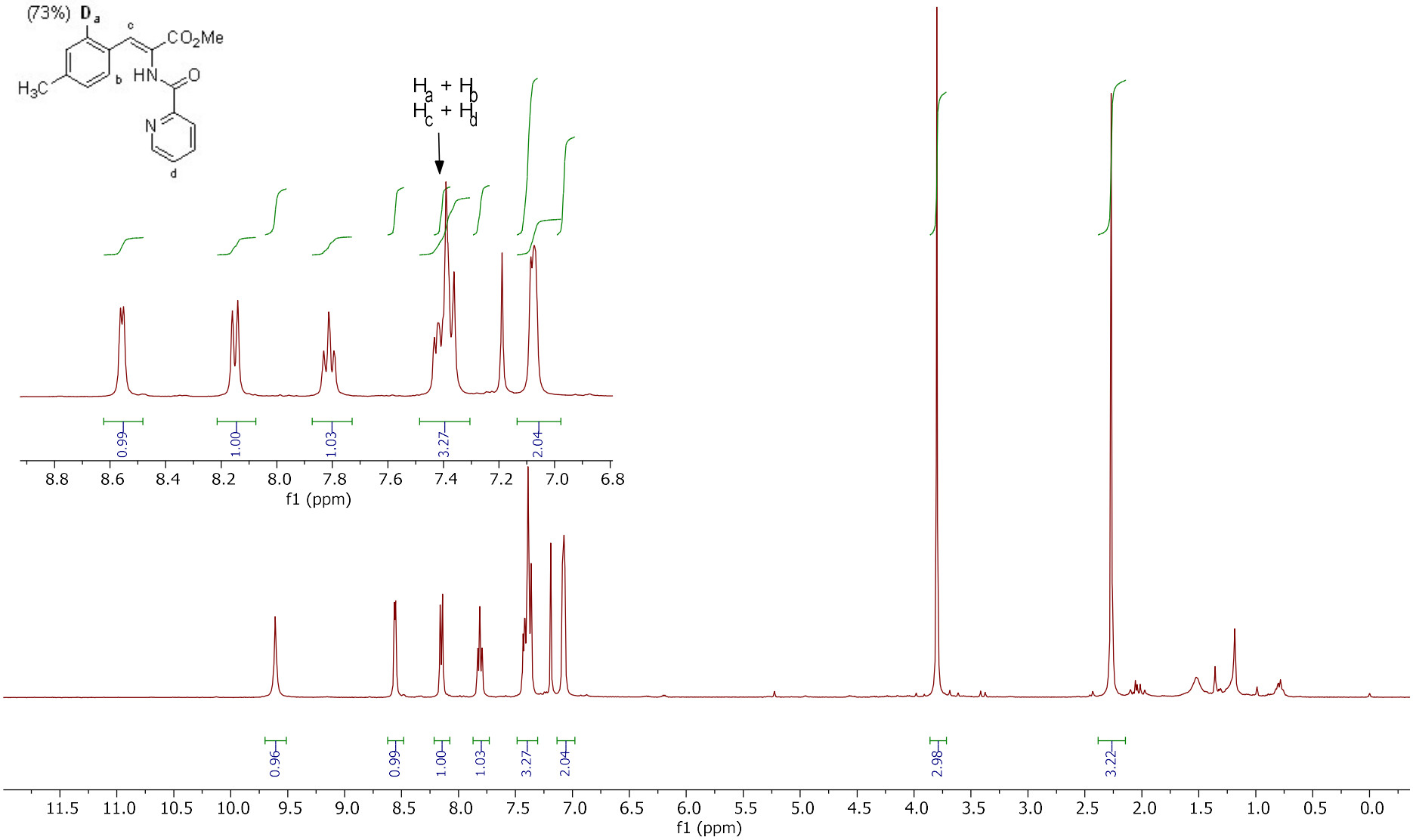
^{13}C-NMR, 100 MHz, CD_3CN



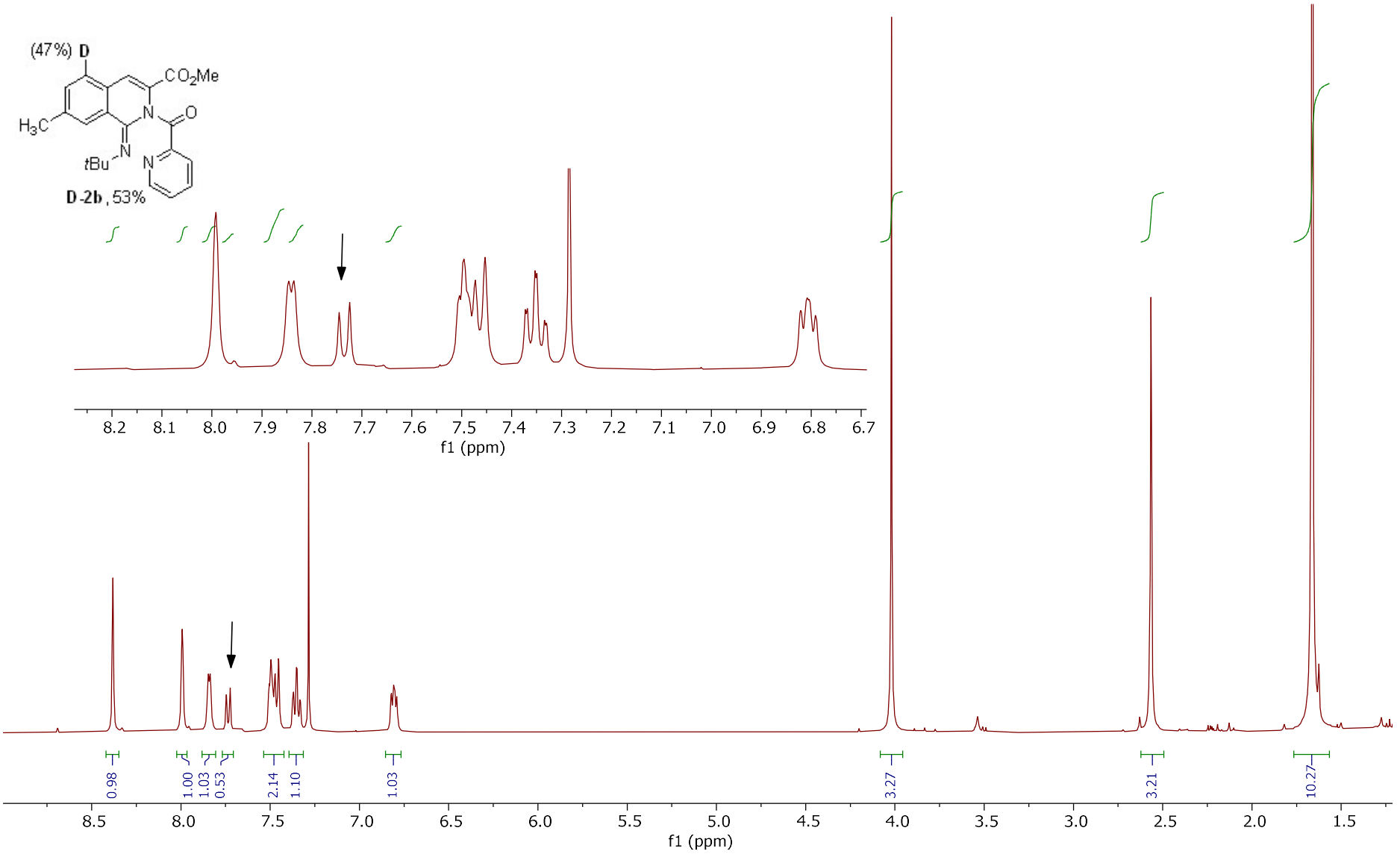
^{1}H-NMR, 400 MHz, $CDCl_3$



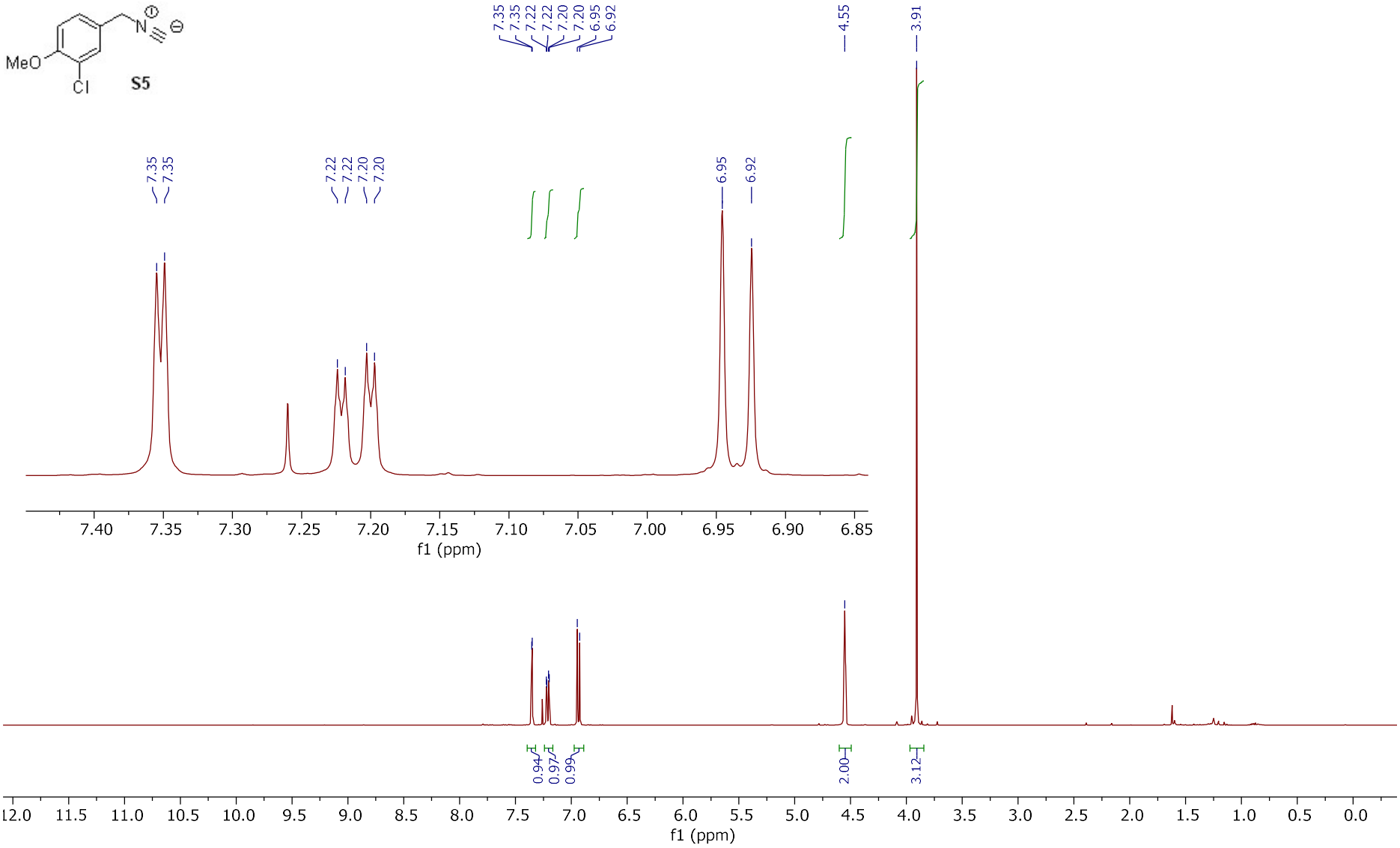
^{1}H-NMR, 400 MHz, $CDCl_3$



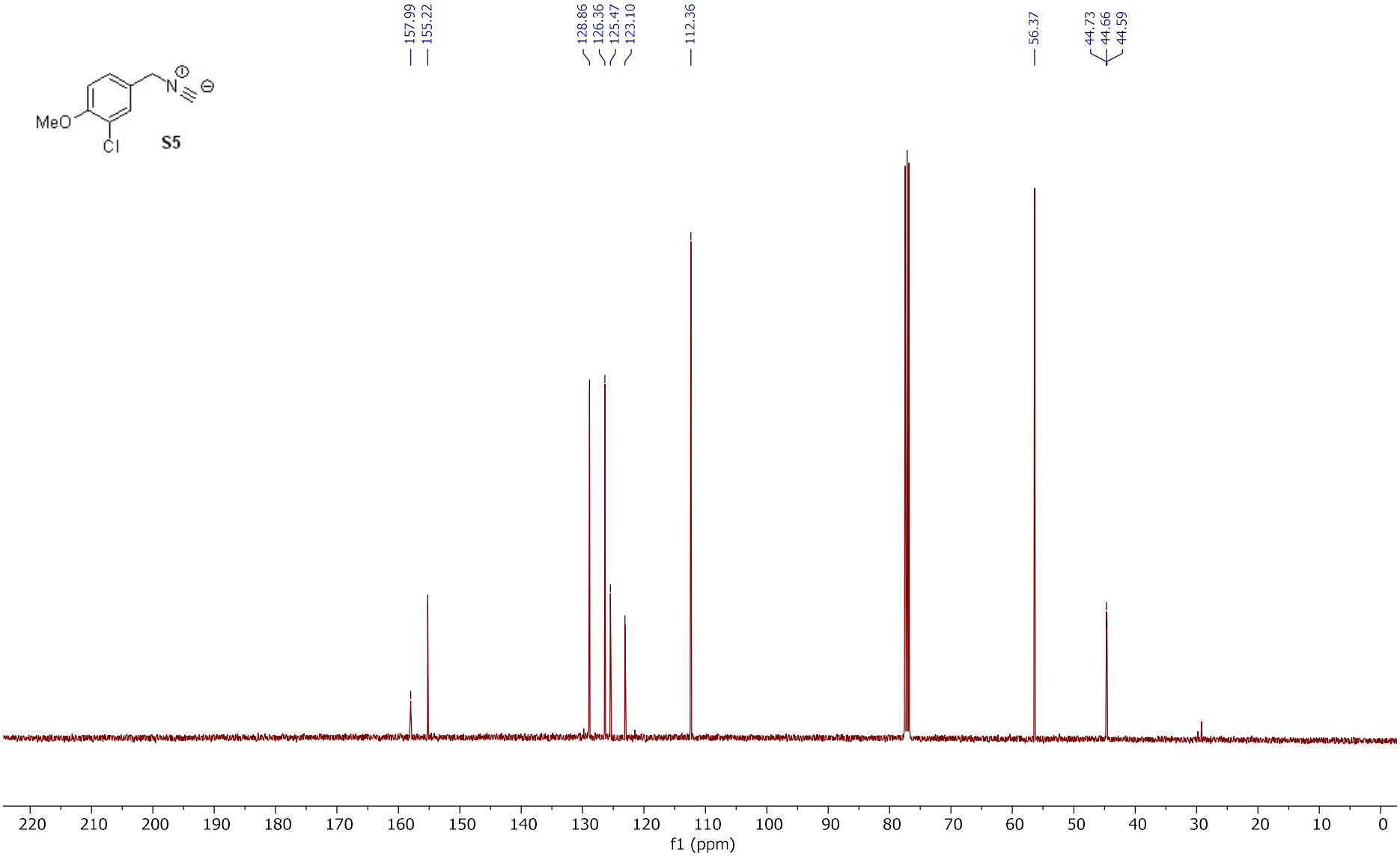
^{1}H-NMR, 400 MHz, $CDCl_3$



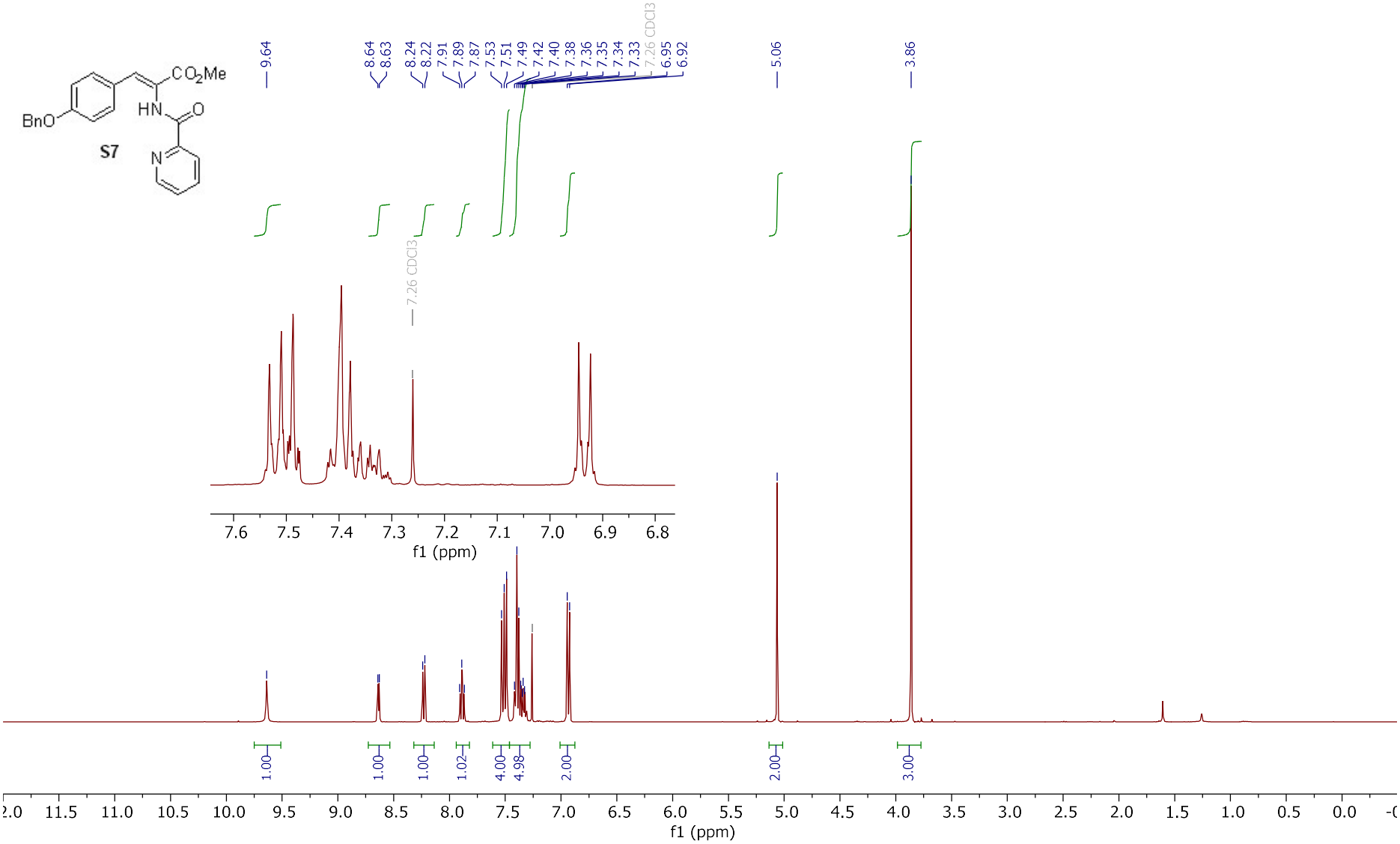
^{1}H-NMR, 400 MHz, $CDCl_3$



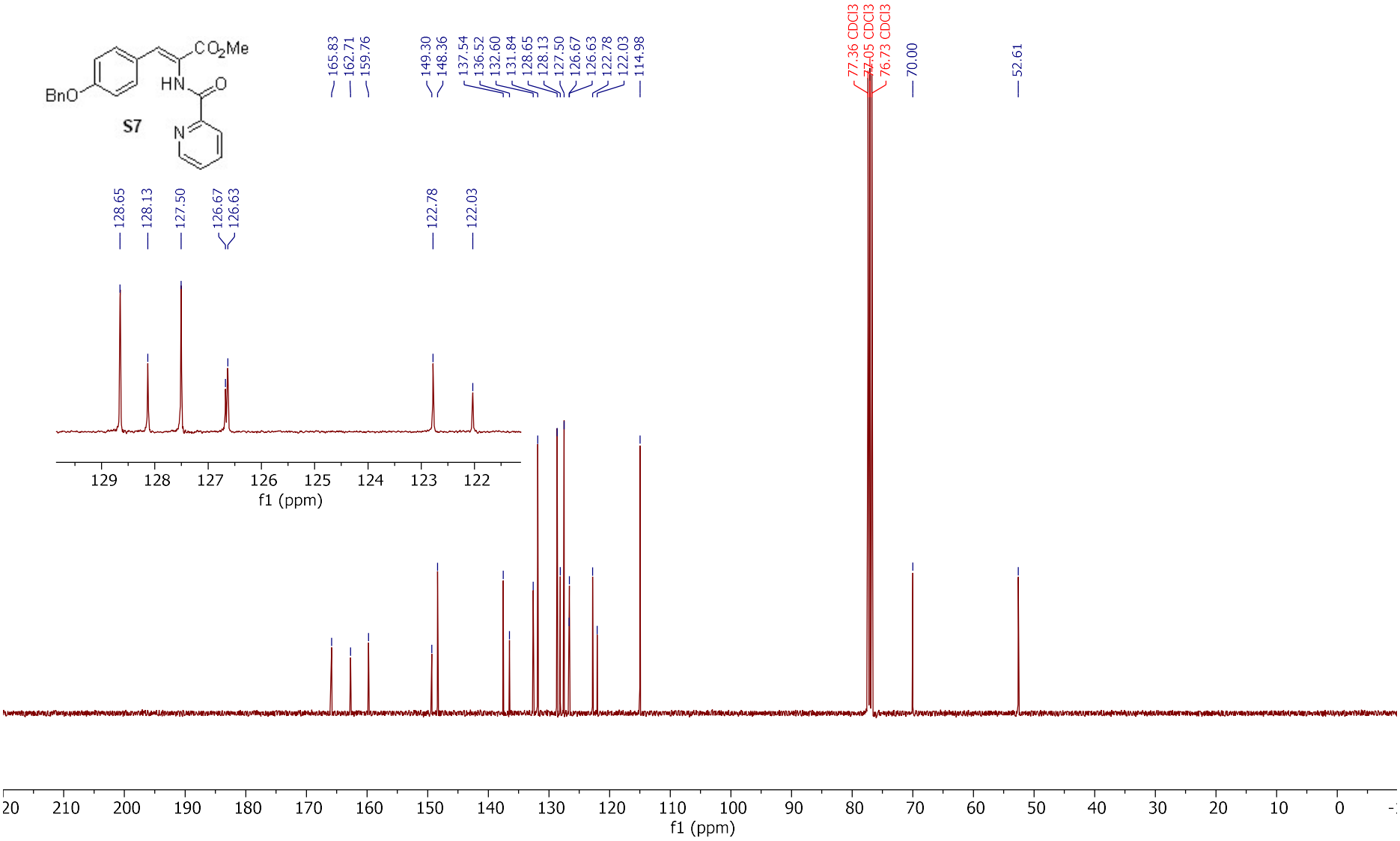
^{13}C-NMR, 100 MHz, $CDCl_3$



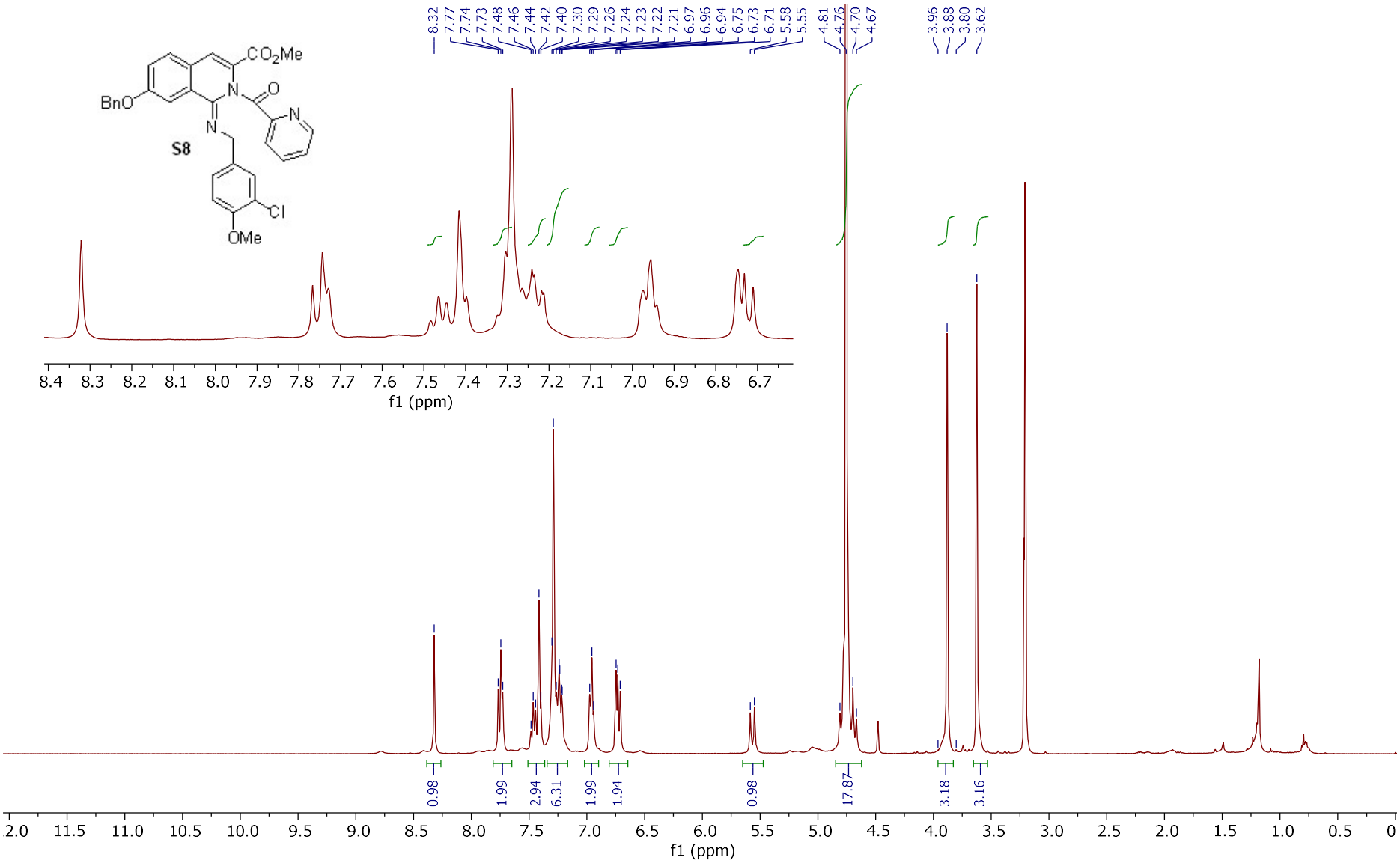
^{1}H-NMR, 400 MHz, $CDCl_3$



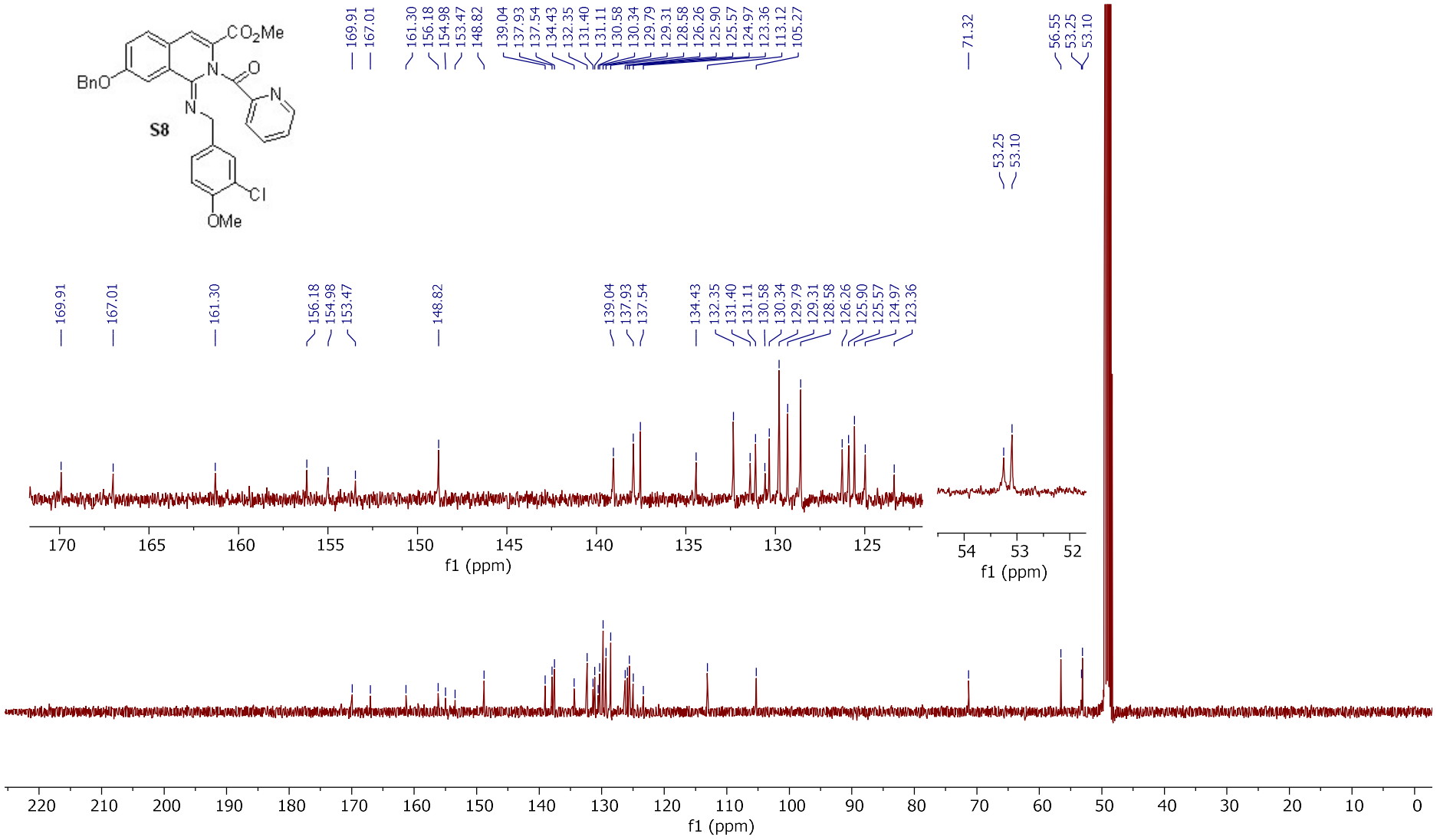
^{13}C-NMR, 100 MHz, $CDCl_3$



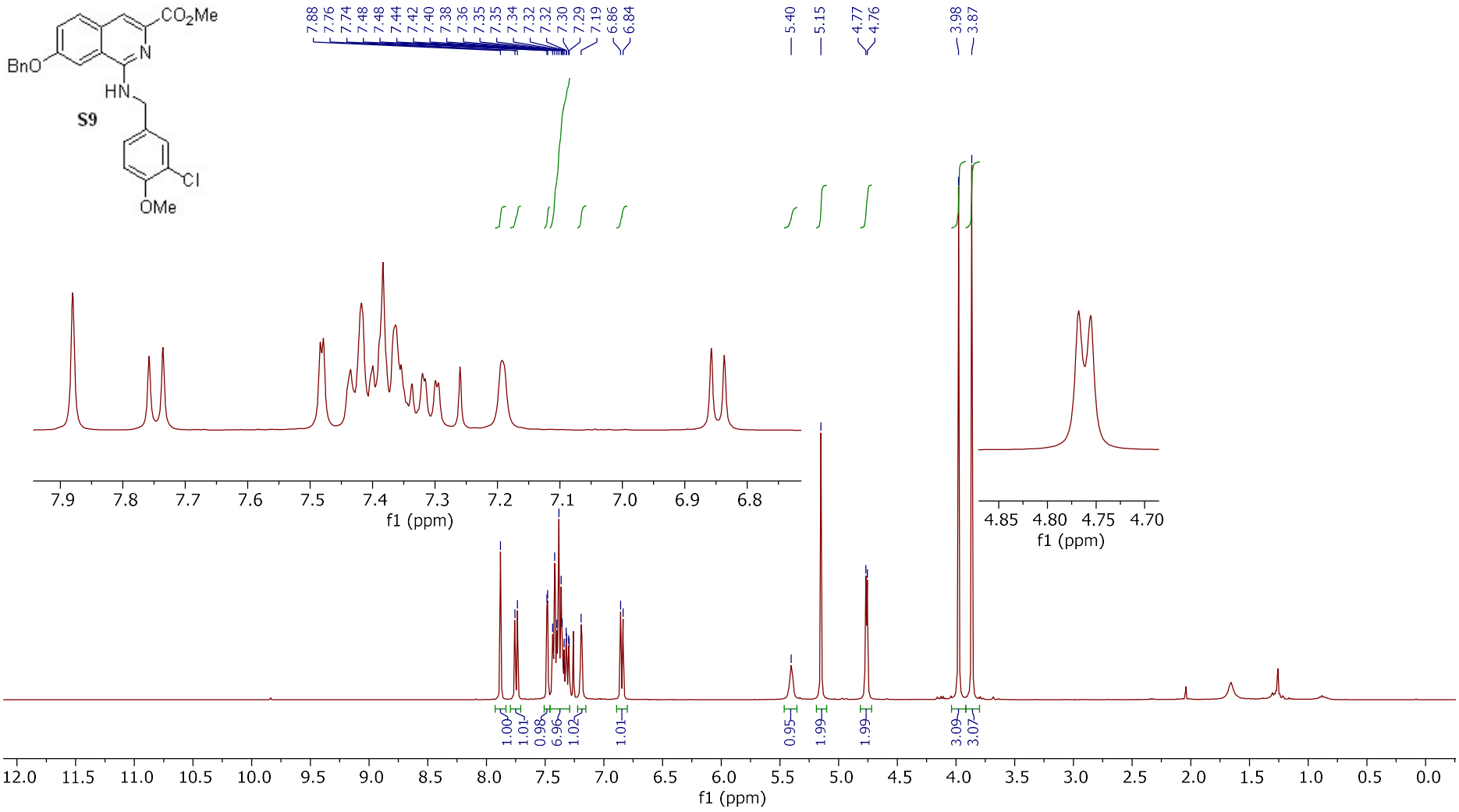
^{1}H-NMR, 400 MHz, MeOD



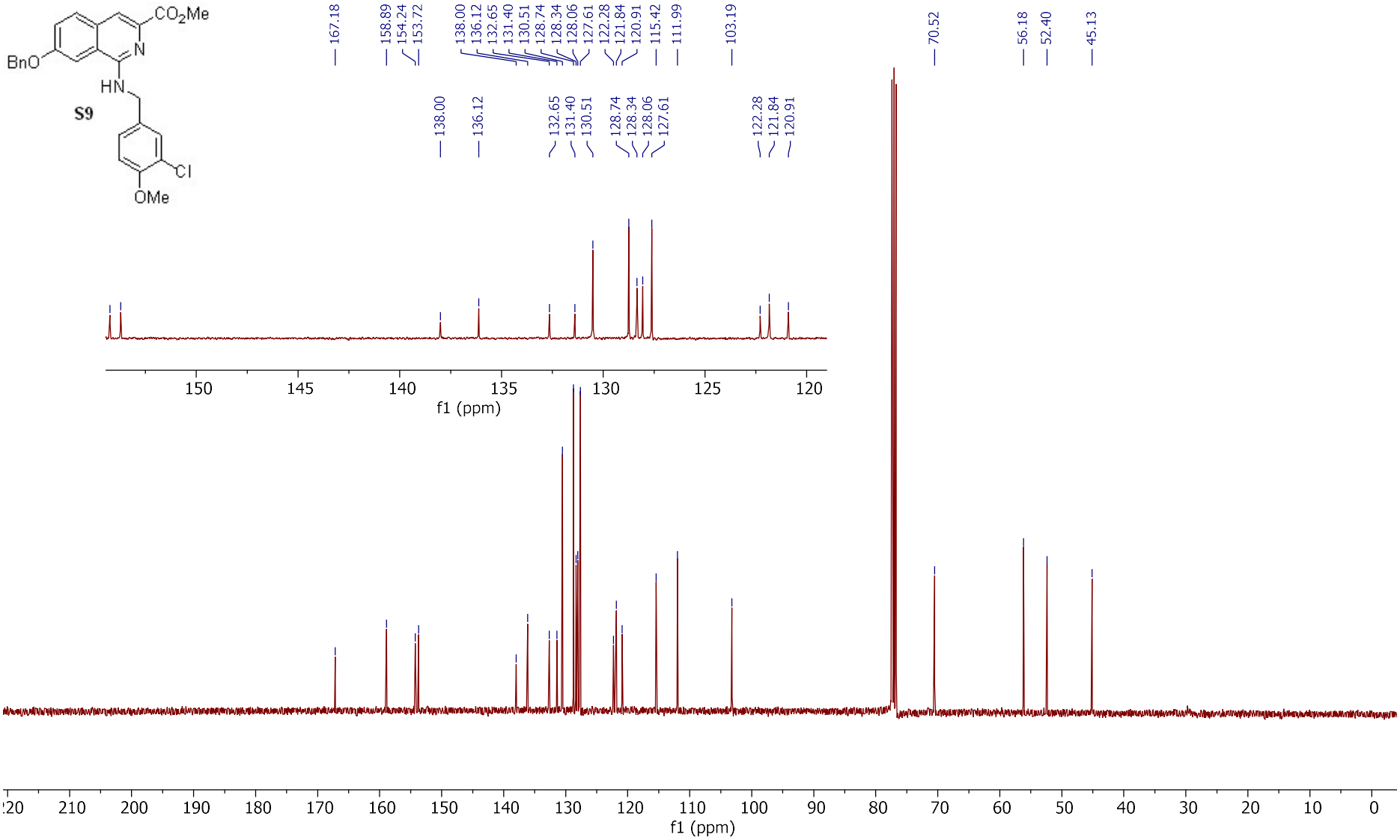
^{13}C-NMR, 100 MHz, MeOD



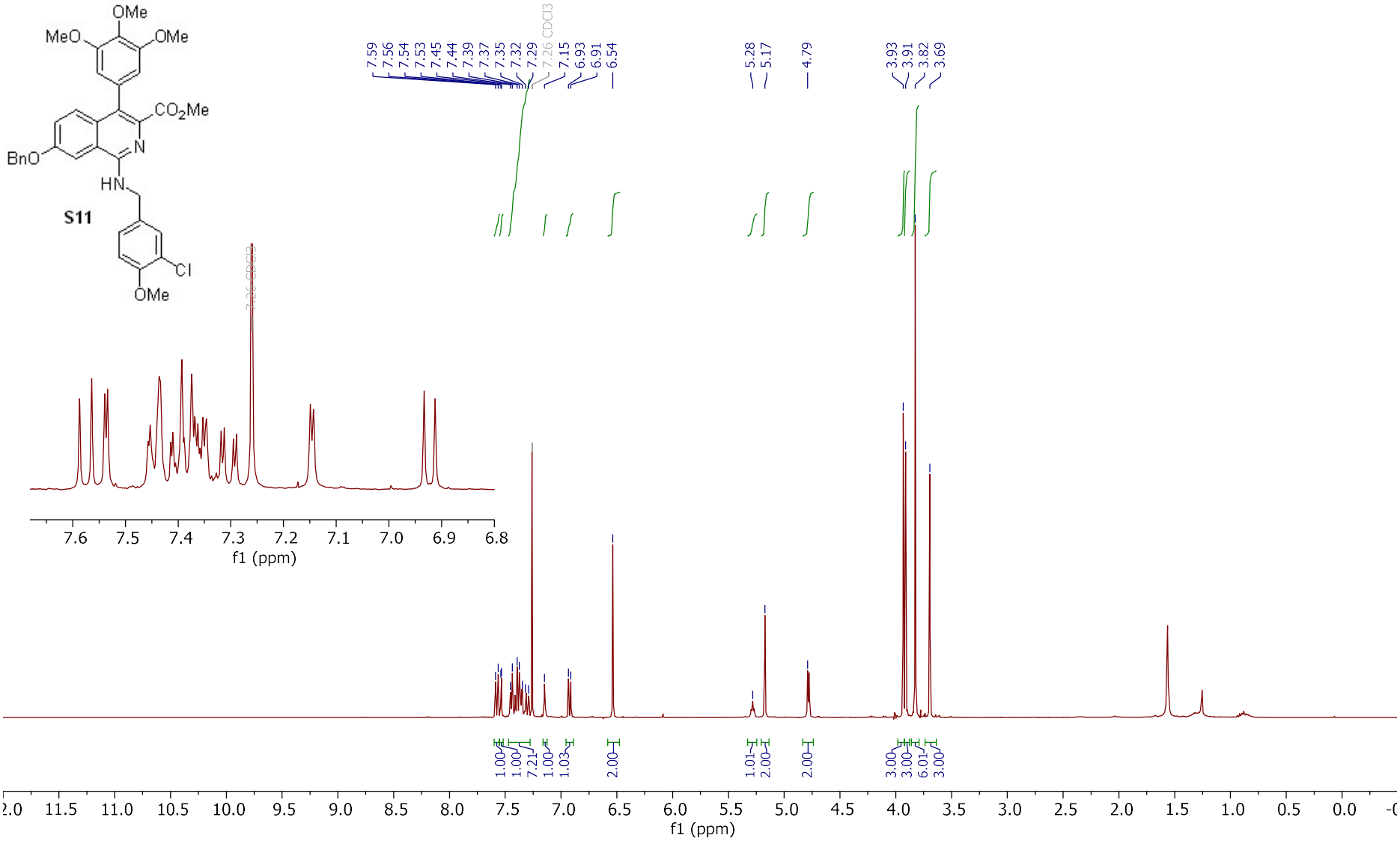
^{1}H-NMR, 400 MHz, $CDCl_3$



^{13}C-NMR, 100 MHz, $CDCl_3$



^{1}H-NMR, 400 MHz, $CDCl_3$



^{13}C-NMR, 100 MHz, $CDCl_3$