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Unexpected formal [4+2]-cycloaddition of chalcone imines and homophthalic anhydrides: preparation of dihydropyridin-2(1*H*)-ones

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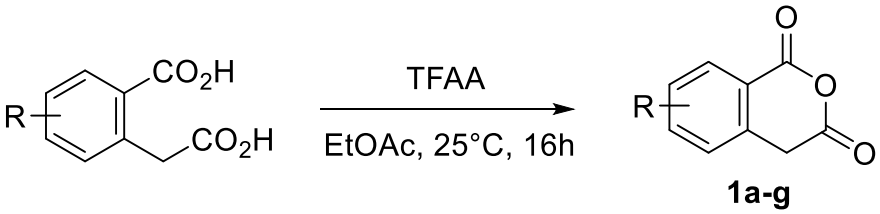
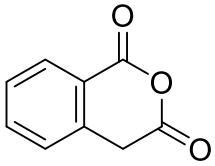
General information: NMR spectroscopic data were recorded with a 400 MHz spectrometer (400.13 MHz for ^{1}H and 100.61 MHz for ^{13}C, and 376 MHz for ^{19}F) in DMSO-d_6 and $CDCl_3$, and were referenced to residual solvent proton signals (δ_H = 2.50 and 7.26, respectively) and solvent carbon signals (δ_C = 39.5 and 77.0, respectively). Melting points were determined with a melting point apparatus Stuart SMP 30 in the open capillary tubes. Mass spectra were recorded with a HRMS-ESI-qTOF MaXis, Brucker GmbH and Nexera LCMS-9030 (qTOF) spectrometers (electrospray ionization mode). For centrifugation multi-spin BioSan MSC-6000 centrifuge was used. Acetonitrile HPLC grade was used for the synthesis.

Synthesis of 7-(Carboxymethyl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid was performed according to ref.[1]. Yield 2.3 g (46%) for 3 steps, starting from 2,3,7,8-tetrahydro-6*H*-indeno[5,6-b][1,4]dioxin-6-one (4.1 g, 21 mmol) white powder, m.p. 225-227°C with decarboxylation. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.30 (s, 2H), 7.39 (s, 1H), 6.83 (s, 1H), 4.38 – 4.18 (m, 4H), 3.82 (s, 2H) ppm.^{13}C NMR (101 MHz, DMSO-d_6): δ = 173.1, 167.8, 146.61, 142.0, 131.2, 123.4, 121.2, 119.9, 65.0, 64.4 ppm. HRMS (ESI): *m/z* calcd for $C_{11}H_{10}O_6$ + Na^+: 261.0370 $[M+Na]^+$; found 261.0371.

General procedure for the synthesis of anhydrides 1a-g: corresponding dicarboxylic acid (5 mmol) was suspended in 50 mL of EtOAc round-bottom flask and TFAA (2.5 eq, 13 mmol) was added to it in one portion. The mixture was stirred overnight at room temperature, the solvent was evaporated, and the residue was dissolved in absolute toluene and re-evaporated to remove residual TFAA. Resulting powders were dried in vacuo.

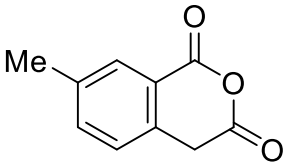


1a-g



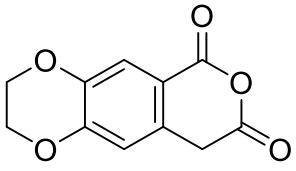
Homophthalic acid anhydride (1a):

Yield 0.73g (90%). Spectral data correspond to refs.[2,3].

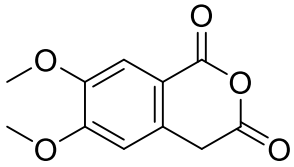


7-Methylisochromane-1,3-dione (1b):

Yield 0.84 g (95 %). Spectral data correspond to ref.[4]

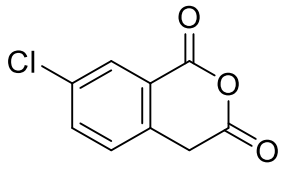


2,3-Dihydro-6*H*-[1,4]dioxino[2,3-*g*]isochromene-6,8(9*H*)-dione (1c): yield 1.04 g (95%), white powder, m.p. 205-206°C. ^{1}H NMR (400 MHz, DMSO-*d6*): δ = 7.45 (s, 1H), 6.93 (s, 1H), 4.44 – 4.34 (m, 2H), 4.34 – 4.27 (m, 2H), 4.14 (s, 2H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 166.5, 161.4, 150.2, 143.5, 130.8, 117.8, 115.9, 114.4, 65.3, 64.4, 34.0 ppm. HRMS (ESI): *m/z* calcd for $C_{11}H_8O_5$ + H^+: 221.0445 $[M+H]^+$; found 221.0449.

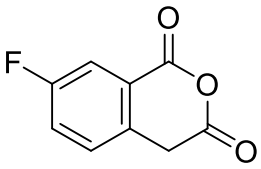


6,7-Dimethoxyisochromane-1,3-dione (1d):
Yield 0.84 g (76 %)
Spectral data correspond to ref.[5]

7-Chloroisochromane-1,3-dione (1e):

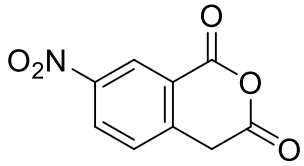


Yield 0.95 g (97 %)
Spectral data correspond to ref.[5]



7-Fluoroisochromane-1,3-dione (1f):

Yield 0.93 g (94%).Spectral data correspond to ref.[6]

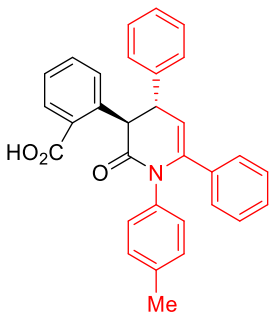


7-Nitroisochromane-1,3-dione (1g):
Yield 0.83 g (80%). Spectral data correspond to refs.[7-9]

Chalcone imines **2a-p** were synthesized according to refs.[10,11]

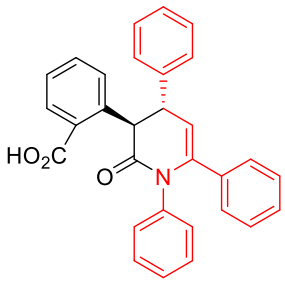
General procedure 1 for the synthesis of pyridones (3a-aa): the accurate weighs of anhydride (0.25 mmol) and chalcone imine (0.25 mmol) were put into preliminary weighted 2 mL conical microcentrifuge tube, and dry acetonitrile (0.5mL) was added. The mixture was vigorously stirred at room temperature for 1h, and further was centrifuged at 6000 rpm for 16 min (in all cases the precipitate was formed right after complete dissolution of starting materials). The supernatant was removed, the precipitate was washed with 100µL of acetonitrile, and centrifuged for 16 min at 6000 rpm. The supernatant was withdrawn and the precipitate was dried in vacuum to provide pure title compounds.

2-((2-oxo-4,6-diphenyl-1-(p-tolyl)-1,2,3,4-tetrahydropyridin-3-yl)benzoic acid (3a): yield 62 mg (54%), pale yellow powder, m.p. 168-170°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 13.03 (s, 1H), 7.85 (dd, J = 7.7, 1.5 Hz, 1H), 7.48 – 7.35 (m, 2H), 7.36 – 7.24 (m, 7H), 7.24 – 7.11 (m, 4H), 7.11 – 6.99 (m, 4H), 5.58 (d, J = 4.3 Hz, 1H), 5.13 (d, J = 8.9 Hz, 1H), 4.39 (dd, J = 8.9, 4.4 Hz, 1H), 2.19 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.3, 169.2, 142.4, 142.1, 139.4, 136.8, 136.5, 136.0, 131.9, 131.2, 131.1, 129.1, 128.9, 128.5, 128.5, 128.2, 128.2, 128.1, 127.4, 127.2, 114.7, 52.9,

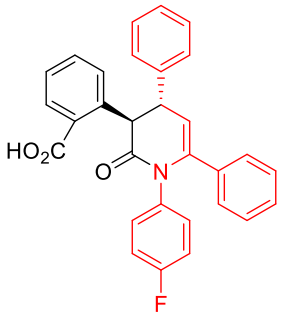


45.0, 21.0 ppm. HRMS (ESI): *m/z* calcd for $C_{31}H_{25}NO_3$ + H^+: 460.1907 [*M*+H]$^+$; found 460.1911.

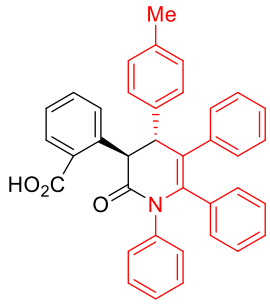
2-(2-Oxo-1,4,6-triphenyl-1,2,3,4-tetrahydropyridin-3-yl)benzoic acid (3b): yield 75 mg (67%), almost white powder, m.p. 186-188°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 13.03 (s, 1H), 7.84 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.50 – 7.00 (m, 18H), 5.60 (d, *J* = 4.2 Hz, 1H), 5.13 (d, *J* = 9.2 Hz, 1H), 4.41 (dd, *J* = 9.1, 4.3 Hz, 1H) ppm. ^{13}C NMR (101 MHz, DMSO): δ = 170.3, 169.2, 142.4, 141.9, 139.4, 139.4, 136.4, 131.9, 131.2, 131.1, 130.7, 128.9 (2C), 128.8 (2C), 128.6 (2C), 128.4 (2C), 128.3 (2C), 128.2, 128.1(2C), 127.4, 127.2, 126.8, 114.9, 53.0, 45.0 ppm. HRMS (ESI): *m/z* calcd for $C_{30}H_{23}NO_3$ + Na^+: 468.1570 [*M*+Na]$^+$; found 468.1572.



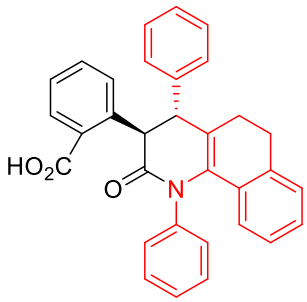
2-(1-(4-Fluorophenyl)-2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl) benzoic acid (3c): yield 154 mg (70%), almost white powder, m.p. 184-186°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 13.02 (s, 1H), 7.84 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.41 (td, *J* = 7.5, 1.5 Hz, 1H), 7.35 – 7.13 (m, 14H), 7.07 (t, *J* = 8.8 Hz, 2H), 5.59 (d, *J* = 4.0 Hz, 1H), 5.11 (d, *J* = 9.5 Hz, 1H), 4.42 (dd, *J* = 9.6, 4.1 Hz, 1H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.4, 169.2, 160.5 (d, *J* = 243.6 Hz), 142.4, 141.8, 139.3, 136.2, 135.6 (d, *J* = 2.9 Hz), 133.0, 131.1, 130.7 (d, *J* = 8.8 Hz), 128.9, 128.5, 128.3, 128.2, 127.3 (d, *J* = 18.1 Hz), 115.4 (d, *J* = 22.7 Hz), 114.9, 53.0, 45.1 ppm. ^{19}F NMR (376 MHz, DMSO-d_6): δ = -115.59 ppm. HRMS (ESI): *m/z* calcd for $C_{30}H_{22}FNO_3$ + Na^+: 486.1476 [*M*+Na]$^+$; found 486.1477.



2-(2-Oxo-1,5,6-triphenyl-4-(*p*-tolyl)-1,2,3,4-tetrahydropyridin-3-yl)benzoic acid (3d): yield 87 mg (65%), white powder, m.p. 204-205°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 13.29 (s, 1H), 8.00 (d, *J* = 7.8 Hz, 1H), 7.94 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.82 (t, *J* = 7.9 Hz, 3H), 7.51 (td, *J* = 7.6, 1.2 Hz, 1H), 7.34 (d, *J* = 7.8 Hz, 2H), 7.25 – 7.14 (m, 6H), 7.14 – 6.97 (m, 4H), 6.89 (q, *J* = 2.9 Hz, 3H), 6.49 (dd, *J* = 6.7, 2.9 Hz, 2H), 5.08 (d, *J* = 1.9 Hz, 1H), 3.96 (d, *J* = 1.8 Hz, 1H), 2.37 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 169.5, 169.0, 140.9, 139.3, 138.8, 138.7, 137.6, 136.9, 134.7, 132.5, 131.5, 131.3, 131.2, 130.1, 129.4, 128.6, 128.3, 128.2, 128.1, 128.0, 128.0, 127.3, 126.5, 120.2, 53.1, 52.3, 21.1 ppm. HRMS (ESI): *m/z* calcd for $C_{37}H_{29}NO_3$ + H^+: 536.2220 [*M*+H]$^+$; found 536.2225.

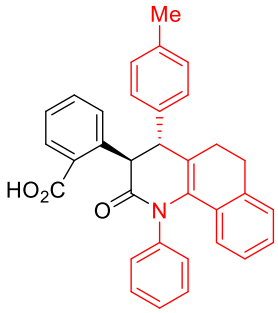


7-(2-Oxo-1,4-diphenyl-1,2,3,4,5,6-hexahydrobenzo[*h*]quinolin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3e): yield 93 mg (70%), white powder, m.p. 149-151°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 13.14 (s, 1H), 7.86 (dd, *J* = 7.3, 1.7 Hz, 1H), 7.62 – 7.45 (m, 2H), 7.41 – 7.28 (m, 10H), 7.27 – 7.21 (m, 1H), 7.21 – 7.11 (m, 2H), 7.04 (td, *J* = 7.4, 1.3 Hz, 1H), 6.93 (td, *J* = 7.6, 1.4 Hz, 1H), 6.84 (dd, *J* = 7.8, 1.3 Hz, 1H), 5.13 (d, *J* = 4.6 Hz, 1H), 3.99 (d, *J* = 4.6 Hz, 1H), 2.91 – 2.60 (m, 2H), 2.13 (dt, *J* = 17.4, 5.8 Hz, 1H), 1.85 (ddd, *J* = 17.7, 12.4, 5.8 Hz, 1H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.1, 169.4, 140.5, 140.1, 138.8, 136.9, 134.3, 132.0, 131.1, 130.5, 129.1, 128.7, 128.5, 128.4, 127.8, 127.6, 127.5, 127.0, 126.9, 126.9, 126.4, 126.2, 123.8, 52.9,

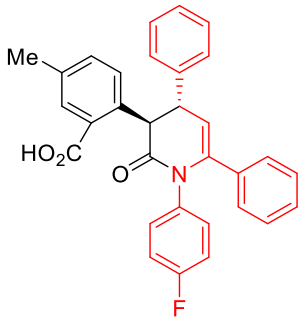


50.0, 28.4, 28.1 ppm. HRMS (ESI): *m/z* calcld for $C_{34}H_{27}NO_5$ +Na^+: 552.1781 [*M*+Na]$^+$; found: 552.1781.

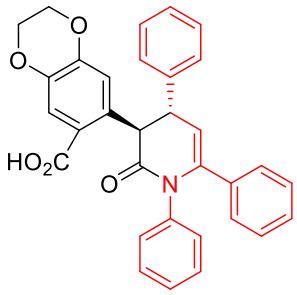
2-(2-oxo-1-phenyl-4-(p-tolyl)-1,2,3,4,5,6-hexahydrobenzo[*h*]quinolin-3-yl)benzoic acid (3f): yield 55 mg (45%), white powder, m.p. 155-157°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 13.28 (s, 1H), 7.86 (dd, *J* = 7.2, 1.4 Hz, 1H), 7.45 – 7.27 (m, 9H), 7.20 – 7.10 (m, 4H), 7.03 (td, *J* = 7.4, 1.3 Hz, 1H), 6.93 (td, *J* = 7.6, 1.3 Hz, 1H), 6.82 (dd, *J* = 7.9, 1.2 Hz, 1H), 5.10 (d, *J* = 4.5 Hz, 1H), 3.92 (d, *J* = 4.5 Hz, 1H), 2.81 (td, *J* = 13.8, 13.3, 6.0 Hz, 1H), 2.68 (dt, *J* = 14.7, 5.6 Hz, 1H), 2.26 (s, 3H), 2.14 – 2.03 (m, 1H), 1.81 (ddd, *J* = 17.8, 12.6, 5.7 Hz, 1H) ppm. ^{13}C NMR (126 MHz, DMSO-d_6): δ = 170.2, 169.4, 140.0, 138.9, 137.3, 136.9, 136.7, 134.1, 132.2, 131.2, 131.2, 130.5, 129.7, 128.8, 128.3, 127.9, 127.6, 127.1, 127.0, 126.9, 126.5, 126.3, 123.8, 52.9, 49.5, 28.3, 28.0, 21.1 ppm. HRMS (ESI): *m/z* calcld for $C_{33}H_{27}NO_3$ + H^+: 486.2064 [*M*+H]$^+$; found 486.2069.



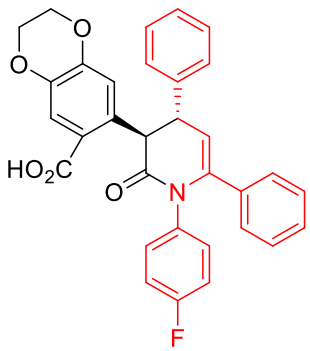
2-(1-(4-Fluorophenyl)-2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl)-5-methylbenzoic acid (3g): yield 66 mg (55%), off white solid, m.p. 186-188°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.96 (s, 1H), 7.67 (s, 1H), 7.35 – 7.13 (m, 14H), 7.07 (t, *J* = 8.8 Hz, 2H), 5.58 (d, *J* = 4.1 Hz, 1H), 5.07 (d, *J* = 9.3 Hz, 1H), 4.39 (dd, *J* = 9.3, 4.2 Hz, 1H), 2.28 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.6, 169.26, 160.47 (d, *J* = 243.7 Hz), 142.47, 141.73, 136.58, 136.37, 136.25, 135.66 (d, *J* = 3.0 Hz), 132.56, 131.62, 130.88, 130.69 (d, *J* = 8.7 Hz), 128.91, 128.50, 128.26, 128.15, 127.19, 115.40 (d, *J* = 22.6 Hz), 114.86, 45.04, 20.81 ppm. ^{19}F NMR (376 MHz, DMSO-d_6): δ = -115.62 ppm. HRMS (ESI): *m/z* calcd for $C_{31}H_{24}FNO_3$ +H^+: 478.1813 [*M*+H]$^+$; found 478.1810.



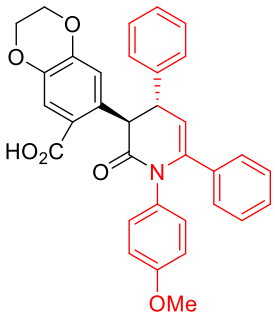
7-(2-Oxo-1,4,6-triphenyl-1,2,3,4-tetrahydropyridin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3h): yield 63 mg (50%), almost white powder, m.p. 196-198°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.77 (s, 1H), 7.38 – 3.35 (m, 3H), 7.31 – 7.11 (m, 12H), 7.08 (t, *J* = 7.3 Hz, 1H), 6.86 (br.s, 1H), 5.59 (d, *J* = 4.4 Hz, 1H), 5.15 (br.s, 1H), 4.33 (dd, *J* = 8.9, 4.4 Hz, 1H), 4.25 – 4.20 (m, 4H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.5, 168.2, 146.5, 142.5, 141.9, 141.7, 139.4, 136.4, 133.7, 128.9, 128.6, 128.5, 128.2, 128.2, 127.9, 127.2, 126.8, 123.3, 120.3, 115.1, 64.9, 64.4, 44.8 ppm. HRMS (ESI): *m/z* calcd for $C_{32}H_{25}NO_5$ + Na^+: 526.1625 [*M*+Na]$^+$;found 526.1622.



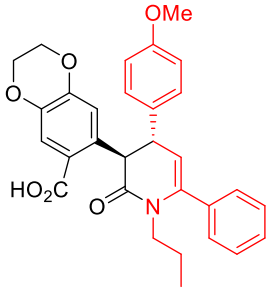
7-(1-(4-Fluorophenyl)-2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3i): yield 104 mg (80%), yellow powder, m.p. 179-181°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.75 (s, 1H), 7.37 (s, 1H), 7.35 – 7.23 (m, 6H), 7.23 – 7.14 (m, 6H), 7.06 (t, *J* = 8.6 Hz, 2H), 6.81 (br.s, 1H), 5.58 (d, *J* = 4.2 Hz, 1H), 5.13 (br.s, 1H), 4.36 (dd, *J* = 9.5, 4.1 Hz, 1H), 4.27 – 4.18 (m, 4H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.6, 168.1, 160.4 (d, *J* = 244.0 Hz), 159.2, 146.5, 142.6, 141.9, 141.5, 136.2, 135.7 (d, *J* = 3.0 Hz), 133.7, 130.6 (d, *J* = 8.9 Hz), 128.9, 128.5, 128.3, 128.0, 127.2, 123.2, 120.3, 115.5, 115.2 (d, *J* = 20.8 Hz), 64.9, 64.4, 44.8 ppm. ^{19}F NMR (376 MHz, DMSO-d_6): δ = -115.64 ppm. HRMS (ESI): *m/z* calcd for $C_{32}H_{24}FNO_5$+Na^+: 544.1531 [*M*+Na]$^+$; found 544.1532.



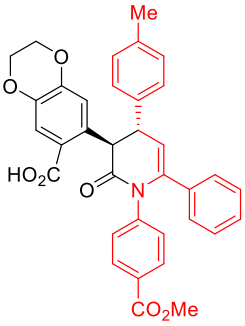
7-(1-(4-Methoxyphenyl)-2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3j): yield 99mg (74%), off white solid, m.p. 202-204°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.78 (s, 1H), 7.37 (d, *J* = 8.9 Hz, 3H), 7.32 – 7.24 (m, 4H), 7.23 – 7.16 (m, 4H), 7.10 – 7.01 (m, 2H), 6.87 (s, 1H), 6.80 – 6.72 (m, 2H), 5.55 (d, *J* = 4.5 Hz, 1H), 5.13 (s, 1H), 4.34 – 4.18 (m, 5H), 3.66 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.6, 168.2, 157.7, 146.5, 142.6, 141.9, 141.9, 136.5, 133.8, 132.1, 129.7, 128.9, 128.5, 128.2, 128.2, 128.0, 127.2, 123.3, 120.3, 114.4, 113.9, 64.9, 64.4, 55.6, 44.8 ppm. HRMS (ESI): *m/z* calcd for $C_{33}H_{27}NO_6$ +Na^+: 556.1731 [*M*+Na]$^+$; found 556.1730.



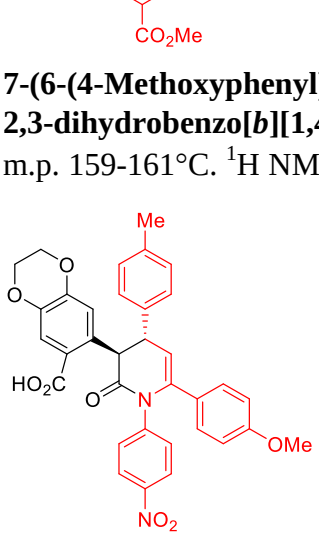
7-(4-(4-Methoxyphenyl)-2-oxo-6-phenyl-1-propyl-1,2,3,4-tetrahydropyridin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3k): yield 35% (54 mg), off white powder, m.p. 164-166°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.71 (s, 1H), 7.51 – 7.37 (m, 5H), 7.34 (s, 1H), 7.24 – 7.17 (m, 2H), 6.81 (d, *J* = 8.7 Hz, 2H), 6.77 (s, 1H), 5.29 (d, *J* = 4.6 Hz, 1H), 5.04 (s, 1H), 4.31 – 4.18 (m, 4H), 4.01 (dd, *J* = 8.3, 4.6 Hz, 1H), 3.70 (s, 3H), 3.59 – 3.36 (m, 2H), 1.32 (h, *J* = 7.2 Hz, 2H), 0.64 (t, *J* = 7.4 Hz, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.7, 168.2, 158.3, 146.5, 141.8, 141.6, 136.0, 134.2, 134.1, 129.2, 129.0, 128.9, 128.0, 123.5, 120.1, 114.3, 114.1, 64.9, 64.4, 55.4, 44.7, 43.5, 21.9, 11.5 ppm. HRMS (ESI): *m/z* calcld for $C_{30}H_{29}NO_6$ +Na^+: 522.1887 [*M*+Na]$^+$; found: 522.1887.



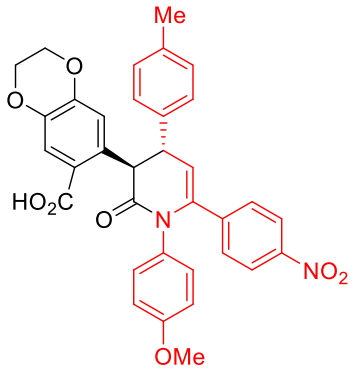
7-(1-(4-(Methoxycarbonyl)phenyl)-2-oxo-6-phenyl-4-(*p*-tolyl)-1,2,3,4-tetrahydropyridin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3l): yield 128 mg, (88%), beige powder, m.p. 158-160°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.65 (s, 1H), 7.87 – 7.74 (m, 2H), 7.40 (s, 1H), 7.35 – 7.12 (m, 9H), 7.09 (d, *J* = 7.8 Hz, 2H), 6.87 (s, 1H), 5.66 (d, *J* = 4.3 Hz, 1H), 5.20 (d, *J* = 9.1 Hz, 1H), 4.35 (dd, *J* = 9.2, 4.3 Hz, 1H), 4.29 – 4.16 (m, 4H), 3.80 (s, 3H), 2.25 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.7, 168.1, 166.1, 146.6, 143.8, 142.0, 141.0, 139.3, 136.2, 133.5, 129.5, 129.5, 128.7, 128.6, 128.3, 128.1, 127.8, 127.7, 123.4, 120.3, 119.1, 116.6, 65.0, 64.5, 52.5, 44.3, 21.0 ppm. HRMS (ESI): *m/z* calcld for $C_{35}H_{29}NO_7$+Na^+: 598.1836 [*M*+Na]$^+$; found: 598.1838.



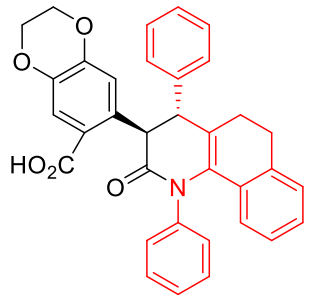
7-(6-(4-Methoxyphenyl)-1-(4-nitrophenyl)-2-oxo-4-(p-tolyl)-1,2,3,4-tetrahydropyridin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3m): yield 120 mg (81%), yellow powder, m.p. 159-161°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.77 (s, 1H), 8.14 – 8.06 (m, 2H), 7.48 – 7.40 (m, 2H), 7.37 (s, 1H), 7.20 (dd, *J* = 8.1, 5.6 Hz, 4H), 7.07 (d, *J* = 7.8 Hz, 2H), 6.78 (dd, *J* = 9.5, 7.4 Hz, 3H), 5.63 (d, *J* = 4.0 Hz, 1H), 5.17 (br.s, 1H), 4.38 (dd, *J* = 9.8, 4.0 Hz, 1H), 4.27 – 4.17 (m, 4H), 3.67 (s, 3H), 2.24 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.9, 168.1, 159.3, 146.5, 145.6, 145.3, 141.9, 140.2, 139.4, 136.1, 133.5, 129.5, 129.4, 129.1, 128.2, 128.1, 123.9, 123.2, 120.4, 116.5, 114.2, 64.9, 64.4, 55.5, 44.1, 21.1 ppm. HRMS (ESI): *m/z* calcld for $C_{34}H_{28}N_2O_8$ + Na^+: 615.1738 [*M*+Na]$^+$; found: 615.1739.



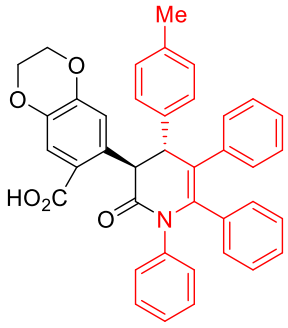
7-(1-(4-Methoxyphenyl)-6-(4-nitrophenyl)-2-oxo-4-(p-tolyl)-1,2,3,4-tetrahydropyridin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3n): yield 123 mg (83%), yellow powder, m.p. 180-181°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.73 (s, 1H), 8.05 (d, *J* = 8.8 Hz, 2H), 7.55 (d, *J* = 8.9 Hz, 2H), 7.38 (s, 1H), 7.21 (d, *J* = 7.7 Hz, 2H), 7.09 (t, *J* = 8.7 Hz, 4H), 6.81 (d, *J* = 9.0 Hz, 3H), 5.76 (d, *J* = 4.0 Hz, 1H), 5.16 (br.s, 1H), 4.41 (dd, *J* = 9.7, 4.1 Hz, 1H), 4.23 (td, *J* = 7.7, 6.5, 3.4 Hz, 4H), 3.66 (s, 3H), 2.24 (s, 3H). ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.6, 168.1, 157.9, 146.9, 146.5, 143.1, 141.9, 140.1, 139.2, 136.2, 133.7, 131.7, 129.6, 129.5, 129.1, 128.2, 123.7, 123.3, 120.4, 118.3, 114.1, 64.9, 64.4, 55.6, 44.5, 21.1 ppm. HRMS (ESI): *m/z* calcld for $C_{34}H_{28}N_2O_8$ + Na^+: 615.1738 [*M*+Na]$^+$; found: 615.1737.



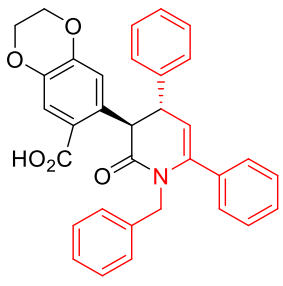
7-(2-oxo-1,4-diphenyl-1,2,3,4,5,6-hexahydrobenzo[h]quinolin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3o): yield 99 mg (75%), white powder, m.p. 248-249°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.98 (s, 1H), 7.58 – 7.53 (m, 2H), 7.43 (s, 1H), 7.34 (dd, *J* = 8.5, 5.9 Hz, 6H), 7.27 – 7.22 (m, 1H), 7.21 – 7.13 (m, 2H), 7.04 (td, *J* = 7.5, 1.3 Hz, 1H), 6.94 (td, *J* = 7.7, 1.4 Hz, 1H), 6.83 (s, 1H), 6.78 (dd, *J* = 7.9, 1.2 Hz, 1H), 5.11 (d, *J* = 4.0 Hz, 1H), 4.25 – 4.14 (m, 4H), 3.91 (d, *J* = 4.0 Hz, 1H), 2.82 (td, *J* = 14.0, 6.1 Hz, 1H), 2.70 (dt, *J* = 14.8, 5.4 Hz, 1H), 2.12 (dt, *J* = 17.5, 5.6 Hz, 1H), 1.93 (ddd, *J* = 17.9, 13.0, 5.7 Hz, 1H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.3, 168.3, 146.62, 142.1, 140.8, 140.0, 137.0, 133.9, 133.3, 130.5, 129.1, 128.8, 128.4, 128.0, 127.5, 127.1, 127.0, 126.9, 126.5, 126.3, 123.6, 123.2, 120.6, 117.2, 64.9, 64.3, 52.0, 49.8, 28.4, 28.0 ppm. HRMS (ESI): *m/z* calcld for $C_{34}H_{27}NO_5$ + H^+: 530.1962 [*M*+H]$^+$; found: 530.1966.



7-(2-oxo-1,5,6-triphenyl-4-(p-tolyl)-1,2,3,4-tetrahydropyridin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3p): yield 107 mg (72%), white powder, m.p. 252-253°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.97 (s, 1H), 7.83 (d, *J* = 7.8 Hz, 2H), 7.50 (s, 1H), 7.45 (s, 1H), 7.33 (d, *J* = 7.8 Hz, 2H), 7.21 (t, *J* = 7.7 Hz, 2H), 7.15 – 7.00 (m, 8H), 6.95 (dd, *J* = 5.2, 1.9 Hz, 3H), 6.62 – 6.54 (m, 2H), 5.08 (d, *J* = 1.9 Hz, 1H), 4.46 – 4.39 (m, 2H), 4.34 (q, *J* = 4.3, 3.6 Hz, 2H), 3.95 (d, *J* = 1.9 Hz, 1H), 2.36 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6) δ 169.2, 168.2 147.0, 142.4, 140.9, 139.1, 138.7, 137.7, 136.9, 134.8, 133.1, 131.1, 130.0, 129.2, 128.7, 128.4, 128.3, 128.1, 128.1, 128.1, 127.3, 126.6, 123.2, 121.0, 120.6, 116.9, 65.3, 64.7, 52.2, 21.1 ppm. HRMS (ESI): *m/z* calcld for $C_{39}H_{31}NO_5$ + Na^+: 616.2094 [*M*+Na]$^+$; found: 616.2096.

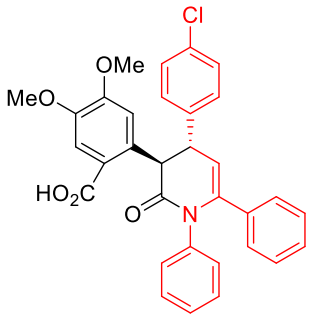


7-(1-Benzyl-2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl)-2,3-dihydrobenzo[*b*][1,4]dioxine-6-carboxylic acid (3q): yield 104 mg, (80%), beige powder, m.p. 178-180°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 7.40 – 7.36 (m, 3H), 7.34 (s, 1H), 7.27 (dd, *J* = 6.6, 2.9 Hz, 2H), 7.18 (ddd, *J* = 13.2, 6.3, 3.1 Hz, 8H), 6.90 (dd, *J* = 6.1, 3.1 Hz, 2H), 6.84 (br.s, 1H), 5.30 (d, *J* = 4.4 Hz, 1H), 5.23 (br.s, 1H), 4.87 (d, *J* = 15.5 Hz, 1H), 4.70 (d, *J* = 15.6 Hz, 1H), 4.30 – 4.19 (m, 4H), 4.15 (br.s, 1H) ppm. ^{13}C NMR (126 MHz, DMSO-d_6): δ = 170.9, 168.2, 146.5, 142.3, 141.9, 141.6, 138.1, 135.8,

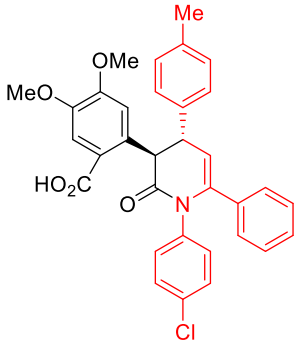


133.8, 128.9, 128.8, 128.7, 128.5, 128.3, 128.2, 127.8, 127.3, 126.9, 124.0, 120.0, 118.6, 114.2, 65.0, 64.5, 50.3, 46.4, 44.5 ppm. HRMS (ESI): *m/z* calcld for $C_{33}H_{27}NO_5$ + H^+: 518.1962 $[M+H]^+$; found: 518.1965.

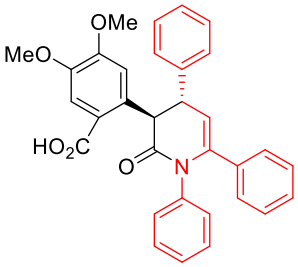
2-(4-(4-Chlorophenyl)-2-oxo-1,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl)-4,5-dimethoxybenzoic acid (3r): yield 101 mg (75%), yellow powder, m.p. 184-186°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.78 (s, 1H), 7.39 (s, 1H), 7.33 – 7.13 (m, 14H), 7.12 – 7.07 (m, 1H), 6.79 (br.s, 1H), 5.63 (d, *J* = 3.2 Hz, 1H), 5.26 – 5.19 (m, 1H), 4.60 – 4.52 (m, 1H), 3.74 (s, 3H), 3.68 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.4, 168.5, 151.4, 147.1, 141.9, 141.8, 139.4, 136.3, 133.6, 131.6, 130.3, 128.8, 128.7, 128.6, 128.5, 128.2, 128.0, 126.8, 122.7, 115.2, 114.2, 56.1, 55.9, 44.2 ppm. HRMS (ESI): *m/z* calcd for $C_{32}H_{26}ClNO_5$ + Na^+: 562.1392 $[M+Na]^+$;found 562.1389.



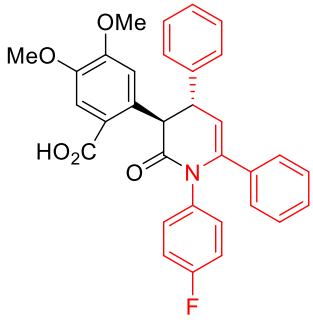
2-(1-(4-Chlorophenyl)-2-oxo-6-phenyl-4-(*p*-tolyl)-1,2,3,4-tetrahydropyridin-3-yl)-4,5-dimethoxybenzoic acid (3s): yield 108 mg (78%), almost white powder, m.p. 162-164°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.74 (s, 1H), 7.38 (s, 1H), 7.28 – 7.23 (m, 4H), 7.21 – 7.14 (m, 7H), 7.04 (d, *J* = 7.8 Hz, 2H), 6.75 (br.s, 1H), 5.64 (d, *J* = 3.7 Hz, 1H), 5.22 (d, *J* = 11.8 Hz, 1H), 4.48 (dd, *J* = 10.7, 3.7 Hz, 1H), 3.73 (s, 3H), 3.65 (s, 3H), 2.21 (s, 3H) ppm. ^{13}C NMR (126 MHz, DMSO-d_6): δ = 170.7, 168.5, 151.3, 147.0, 141.0, 139.6, 138.4, 136.2, 136.1, 133.7, 130.92, 130.4, 129.4, 128.7, 128.6, 128.6, 128.4, 128.3, 127.9, 122.6, 116.6, 114.1, 56.1, 55.8, 44.3, 21.0 ppm. HRMS (ESI): *m/z* calcd for $C_{33}H_{28}ClNO_5$ + Na^+: 576.1548 $[M+Na]^+$; found 576.1549.



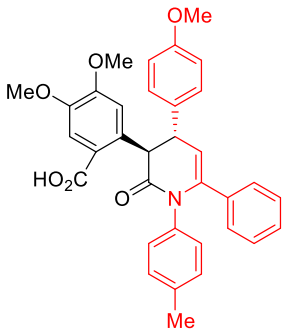
4,5-Dimethoxy-2-(2-oxo-1,4,6-triphenyl-1,2,3,4-tetrahydropyridin-3-yl)benzoic acid (3t): yield 88 mg (70%), light yellow powder, m.p. 194-195°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.73 (s, 1H), 7.38 (s, 1H), 7.34 – 7.13 (m, 14H), 7.13 – 7.04 (m, 1H), 6.78 (br.s, 1H), 5.64 (d, *J* = 3.8 Hz, 1H), 5.23 (br.s, 1H), 4.51 (dd, *J* = 10.6, 3.8 Hz, 1H), 3.73 (s, 3H), 3.66 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.6, 168.5, 151.3, 147.0, 142.8, 141.6, 139.50 136.4, 133.8, 128.8, 128.7, 128.6, 128.5, 128.4, 128.2, 128.0, 127.1, 126.7, 122.7, 115.8, 114.1, 56.1, 55.8, 44.9 ppm. HRMS (ESI): *m/z* calcd for $C_{32}H_{27}NO_5$ +Na^+: 528.1781 $[M+Na]^+$; found 528.1780.



2-(1-(4-Fluorophenyl)-2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl)-4,5-dimethoxybenzoic acid (3u): yield 79 mg (62%), yellow powder, m.p. 185-186°C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.73 (s, 1H), 7.38 (s, 1H), 7.22 (dq, *J* = 28.8, 8.2, 7.7 Hz, 13H), 7.06 (t, *J* = 8.6 Hz, 2H), 6.73 (s, 1H), 5.62 (d, *J* = 3.6 Hz, 1H), 5.19 (s, 1H), 4.52 (dd, *J* = 11.0, 3.6 Hz, 1H), 3.73 (s, 3H), 3.64 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6) δ 170.7, 168.5, 160.4 (d, *J* = 243.4 Hz), 151.3, 147.0, 142.8, 141.4, 136.3, 135.8 (d, *J* = 2.4 Hz), 130.7 (d, *J* = 8.3 Hz), 128.8, 128.5 (d, *J* = 9.7 Hz), 128.3, 128.1, 127.1, 122.6, 115.7, 115.4 (d, *J* = 22.6 Hz), 114.1, 56.1, 55.8, 44.9 ppm. ^{19}F NMR (376 MHz, DMSO-d_6): δ = -115.74 ppm. HRMS (ESI): *m/z* calcd for $C_{32}H_{26}FNO_5$ +Na^+: 546.1687 $[M+Na]^+$; found 546.1689.

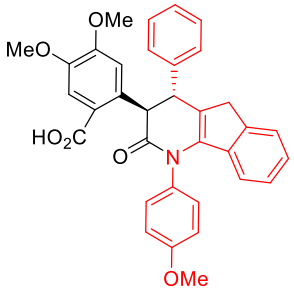


4,5-Dimethoxy-2-(4-(4-methoxyphenyl)-2-oxo-6-phenyl-1-(*p*-tolyl)-1,2,3,4-tetrahydropyridin-3-yl)benzoic acid (3v): yield 103 mg (75%), white powder, m.p. 187-189°C.



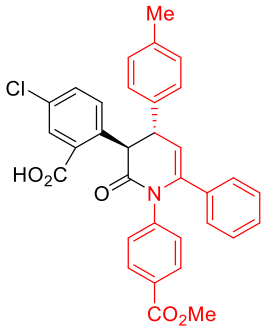
^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.74 (s, 1H), 7.39 (s, 1H), 7.30 – 7.11 (m, 7H), 7.04 (d, *J* = 1.8 Hz, 4H), 6.85 – 6.77 (m, 3H), 5.61 (d, *J* = 4.0 Hz, 1H), 5.21 (s, 1H), 4.40 (dd, *J* = 10.4, 3.9 Hz, 1H), 3.74 (s, 3H), 3.70 (d, *J* = 2.4 Hz, 6H), 2.19 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.7, 168.5, 158.4, 151.4, 147.0, 141.5, 136.9, 136.5, 135.8, 134.5, 134.0, 129.4, 129.1, 128.5, 128.4, 128.2, 127.9, 122.7, 116.0, 114.2, 114.1, 56.1, 55.8, 55.4, 43.9, 21.0 ppm. HRMS (ESI): *m/z* calcld for C34H31NO6 +H$^+$: 550.2224 [*M*+H]$^+$; found: 550.2230.

4,5-Dimethoxy-2-(1-(4-methoxyphenyl)-2-oxo-4-phenyl-2,3,4,5-tetrahydro-1*H*-indeno[1,2-*b*]pyridin-3-yl)benzoic acid (3w): yield 60 mg (44%), white powder, m.p. 208-209°C.



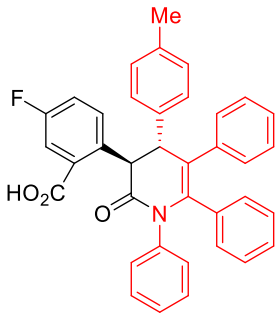
^{1}H NMR (400 MHz, DMSO-d_6): δ = 12.79 (s, 1H), 7.44 (s, 1H), 7.39 – 7.17 (m, 9H), 7.08 (dt, *J* = 7.4, 3.1 Hz, 3H), 6.98 (t, *J* = 7.7 Hz, 1H), 6.64 (br.s, 1H), 5.82 (d, *J* = 7.8 Hz, 1H), 4.60 (d, *J* = 10.2 Hz, 1H), 3.85 (s, 3H), 3.74 (s, 3H), 3.48 (s, 3H), 3.19 –3.06 (m, 2H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.4, 168.4, 159.2, 151.4, 147.1, 143.4, 142.3, 138.7, 138.0, 134.5, 131.7, 130.1, 128.9, 128.8, 127.2, 126.3, 124.9, 124.5, 122.4, 119.7, 114.8, 114.7, 56.0, 55.9, 55.8, 47.5, 37.2 ppm. HRMS (ESI): *m/z* calcld for $C_{34}H_{29}NO_6$ + H$^+$: 548.2068 [*M*+H]$^+$; found: 548.2069.

5-Chloro-2-(1-(4-(methoxycarbonyl)phenyl)-2-oxo-6-phenyl-4-(*p*-tolyl)-1,2,3,4-tetrahydropyridin-3-yl)benzoic acid (3x): yield 58 mg (42%), white powder, m.p. 162-164°C.



^{1}H NMR (400 MHz, DMSO-d_6): δ = 13.25 (s, 1H), 7.84 – 7.77 (m, 3H), 7.47 (dd, *J* = 8.4, 2.4 Hz, 1H), 7.36 – 7.26 (m, 5H), 7.23 – 7.11 (m, 5H), 7.05 (d, *J* = 7.9 Hz, 2H), 5.67 (d, *J* = 3.7 Hz, 1H), 5.18 (d, *J* = 10.8 Hz, 1H), 4.51 (dd, *J* = 10.9, 3.6 Hz, 1H), 3.81 (s, 3H), 2.23 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 170.2, 167.8, 166.1, 143.8, 141.1, 139.0, 138.2, 136.3, 136.1, 133.3, 131.9, 131.5, 130.4, 129.5, 129.5, 128.8, 128.6, 128.3, 128.2, 128.0, 127.8, 116.9, 52.5, 44.4, 21.0 ppm. HRMS (ESI): *m/z* calcld for $C_{33}H_{26}ClNO_5$ +H$^+$: 552.1572 [*M*+H]$^+$; found: 552.1578.

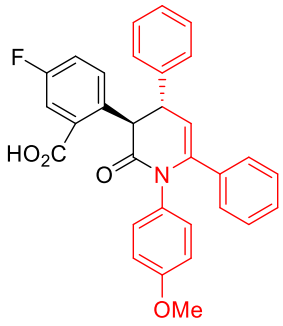
5-Fluoro-2-(2-oxo-1,5,6-triphenyl-4-(*p*-tolyl)-1,2,3,4-tetrahydropyridin-3-yl)benzoic acid (3y): yield 122 mg (88%), white powder, m.p. 200-202°C.



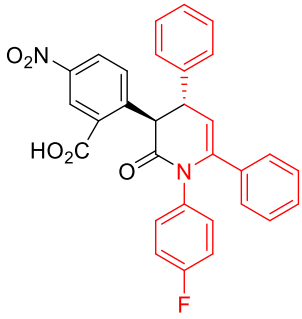
^{1}H NMR (400 MHz, DMSO-d_6): δ = 13.78 (s, 1H), 8.01 (d, *J* = 4.5 Hz, 1H), 7.80 (d, *J* = 7.9 Hz, 2H), 7.70 (ddd, *J* = 8.2, 4.2, 1.5 Hz, 2H), 7.35 (d, *J* = 7.9 Hz, 2H), 7.21 (d, *J* = 4.9 Hz, 6H), 7.11 – 6.99 (m, 3H), 6.94 – 6.88 (m, 3H), 6.49 (dd, *J* = 6.7, 3.0 Hz, 2H), 5.01 (d, *J* = 1.9 Hz, 1H), 3.92 (d, *J* = 1.9 Hz, 1H), 2.36 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 168.8, 168.2, 168.2, 161.2 (d, *J* = 245.9 Hz), 140.8, 139.4, 138.7, 137.5, 137.0, 134.9 (d, *J* = 3.5 Hz), 134.6, 133.5 (d, *J* = 6.9 Hz), 131.29, 130.5 (d, *J* = 8.2 Hz), 130.1, 129.4, 128.6, 128.3, 128.2, 128.1, 128.0, 128.0, 127.3, 126.6, 120.1, 119.4, 119.2, 118.3, 118.0, 52.5, 52.2, 21.1 ppm. ^{19}F

NMR (376 MHz, DMSO-d_6): δ = -114.05 ppm. HRMS (ESI): *m/z* calcd for $C_{37}H_{28}FNO_3$ +H^+: 554.2126 [*M*+H]$^+$; found 554.2128.

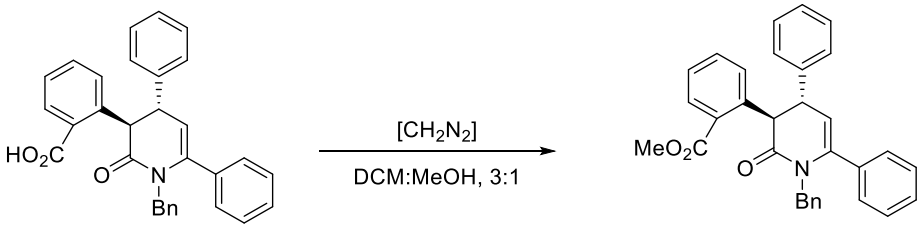
5-Fluoro-2-(1-(4-methoxyphenyl)-2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl)benzoic acid (3z): yield 73 mg (59%), yellow powder, m.p. 190-193°C, ^{1}H NMR (400 MHz, DMSO-d_6): δ = 13.19 (s, 1H), 7.56 (dt, *J* = 9.6, 2.5 Hz, 1H), 7.37 – 7.14 (m, 11H), 7.11 – 7.03 (m, 2H), 6.84 – 6.72 (m, 2H), 5.56 (d, *J* = 3.8 Hz, 1H), 5.12 (d, *J* = 10.3 Hz, 1H), 4.53 – 4.35 (m, 1H), 3.67 (s, 3H) ppm. ^{13}C NMR (101 MHz, DMSO): δ = 170.4, 168.0 (d, *J* = 2.3 Hz), 160.7 (d, *J* = 244.4 Hz), 157.8, 142.4, 142.1, 136.5, 135.6 (d, *J* = 3.5 Hz), 133.4 (d, *J* = 6.6 Hz), 132.1, 129.9, 128.9, 128.4, 128.3, 128.2, 127.2, 118.7 (d, *J* = 20.7 Hz), 117.4 (d, *J* = 22.6 Hz), 114.7, 113.8, 55.6, 45.0 ppm. ^{19}F NMR (376 MHz, DMSO): δ = -115.36 ppm. HRMS (ESI): *m/z* calcld for $C_{31}H_{24}FNO_4$ + H^+; 494.1762 [*M*+H]$^+$; found: 494.1761.



2-(1-(4-Fluorophenyl)-2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl)-5-nitrobenzoic acid (3aa): yield 64 mg (50%), yellow powder, m.p. 172-173°C with decomp. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 13.74 (s, 1H), 8.54 (d, *J* = 2.6 Hz, 1H), 8.22 (dd, *J* = 8.5, 2.7 Hz, 1H), 7.56 (d, *J* = 8.6 Hz, 1H), 7.27 – 7.13 (m, 11H), 7.09 (t, *J* = 8.6 Hz, 2H), 5.62 (d, *J* = 3.2 Hz, 1H), 5.36 (d, *J* = 11.7 Hz, 1H), 4.64 (dd, *J* = 11.7, 3.3 Hz, 1H) ppm. ^{13}C NMR (101 MHz, DMSO-d_6): δ = 169.7, 167.3, 160.6 (d, *J* = 243.6 Hz), 146.6 (d, *J* = 28.7 Hz) , 141.8, 141.7, 136.1, 135.5, 133.6, 132.8, 130.8 (d, *J* = 8.5 Hz),129.0, 128.5, 128.3, 128.3, 127.5, 126.0, 125.5, 115.6, 115.42 (d, *J* = 18.7 Hz), 45.0 ppm. ^{19}F NMR (376 MHz, DMSO-d_6) δ -115.41 ppm. HRMS (ESI): *m/z* calcld for $C_{30}H_{21}FN_2O_5$ + H^+: 509.1507 [*M*+H]$^+$; found: 509.1510.



Synthesis of methyl 2-(1-benzyl-2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl)benzoate (3ab):



To a suspension of 1-methyl-1-nitrosourea (1.5 mmol, 154 mg) in 4 mL of Et_2O at 0°C (cooling with ice bath) a preliminary cooled water solution of KOH (3.75 mmol, 210 mg in 800μL of H_2O) was added dropwise. The solution was stirred at 0°C for additional 10 min until complete dissolution of *N*-methyl-*N*-nitrosourea (the ether layer becomes rich yellow). The saturated with the diazomethane ether layer was added slowly at 0°C and vigorous stirring to a solution of 2-(1-benzyl-2-oxo-4,6-diphenyl-1,2,3,4-tetrahydropyridin-3-yl)benzoic acid (0.25 mmol; prepared according to general procedure 1) in DCM/MeOH, 3:1. The resulting mixture was stirred for 12h at room temperature. The solvent was removed under reduced pressure; the resulting crude product was extracted with DCM (3×10 mL) and dried over Na_2SO_4. After removal of the solvent the product was isolated by flash column chromatography on SiO_2 (60Å (0.040−0.063 mm) 230−400 mesh, Macherey-Nagel) using gradient of acetone in hexane (1:10 to 1:3). Yield 95mg (80%), white crystals, m.p. 161°C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.84 (dd, *J* = 7.8, 1.4

Hz, 1H), 7.41 – 7.32 (m, 4H), 7.31 – 7.16 (m, 6H), 7.14 – 6.97 (m, 8H), 5.44 (d, *J* = 3.2 Hz, 1H), 5.21 (d, *J* = 15.1 Hz, 1H), 5.04 (d, *J* = 11.7 Hz, 1H), 4.57 (d, *J* = 15.1 Hz, 1H), 4.32 (dd, *J* = 11.7, 3.2 Hz, 1H), 3.79 (s, 3H) ppm. ^{13}C NMR (101 MHz, $CDCl_3$): δ = 171.0, 168.0, 142.0, 141.7, 139.4, 138.0, 135.9, 131.6, 131.0, 130.5, 130.5, 128.4, 128.3, 128.2, 128.2, 128.1, 128.1, 127.9, 126.9, 126.7, 126.7, 114.9, 52.0, 46.7, 45.6 ppm. HRMS (ESI): *m/z* calcld for $C_{32}H_{27}NO_3$+Na^+: 496.1883 [*M*+Na]$^+$; found: 496.1875.

Crystallographic data

X-ray single crystal analyses were performed on Agilent Technologies "Supernova" (**3a**) or Rigaku "XtaLAB Synergy-S" (**3ab**) diffractometer with monochromated Cu Kα radiation. The temperature was kept at 293 K (**3a**) or 100 K (**3ab**) during data collection. Using Olex2[12], the structure was solved with the SHELXT[13] structure solution program using Direct Methods and refined with the SHELXL[14] refinement package using Least Squares minimisation. *CCDC 2067829* and *2067830* contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via http://www.ccdc.cam.ac.uk.

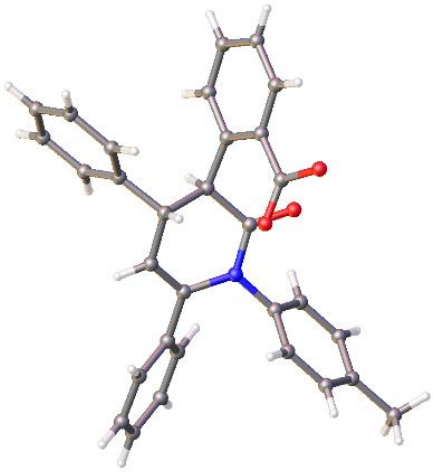


Figure S1. ORTEP representation of compound **3a** drawn at 50% probability level

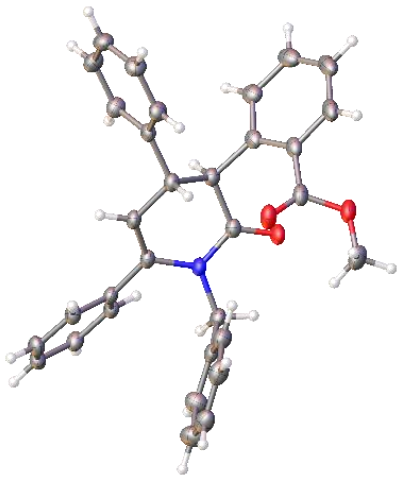


Figure S1. ORTEP representation of compound **3ab** drawn at 50% probability level

Table S1. Crystal data and structure refinement for compounds **3a** and **3ab**

Identification code	**3a**	**3ab**
Empirical formula	$C_{31}H_{25}NO_3$	$C_{21.33}H_{18}N_{0.67}O_2$
Formula weight	459.52	315.70
Temperature/K	293(2)	293(2)
Crystal system	triclinic	triclinic
Space group	P-1	P-1
a/Å	5.71200(10)	10.6020(3)
b/Å	10.0398(2)	11.2205(3)
c/Å	21.6602(3)	13.0016(2)
α/°	84.510(2)	95.410(2)
β/°	87.428(2)	112.439(2)

γ/°	78.784(2)	115.598(3)
Volume/Å^3	1212.40(4)	1225.33(6)
Z	2	3
ρ_{calc}g/cm^3	1.259	1.283
μ/mm^{-1}	0.641	0.650
F(000)	484.0	500.0
Radiation	CuKα (λ = 1.54184)	CuKα (λ = 1.54184)
2Θ range for data collection/°	4.1 to 140.966	7.74 to 154.55
Index ranges	$-6 \leq h \leq 6$, $-12 \leq k \leq 12$, $-26 \leq l \leq 19$	$-13 \leq h \leq 13$, $-14 \leq k \leq 14$, $-16 \leq l \leq 16$
Reflections collected	11518	20378
Independent reflections	4515 [R_{int} = 0.0352, R_{sigma} = 0.0435]	5076 [R_{int} = 0.0364, R_{sigma} = 0.0305]
Data/restraints/parameters	4515/0/321	5076/0/326
Goodness-of-fit on F^2	1.041	1.055
Final R indexes [I>=2σ (I)]	R_1 = 0.0451, wR_2 = 0.1198	R_1 = 0.0414, wR_2 = 0.1105
Final R indexes [all data]	R_1 = 0.0526, wR_2 = 0.1258	R_1 = 0.0467, wR_2 = 0.1142
Largest diff. peak/hole / e Å^{-3}	0.24/-0.29	0.18/-0.29
CCDC	*2067829*	2067830

References

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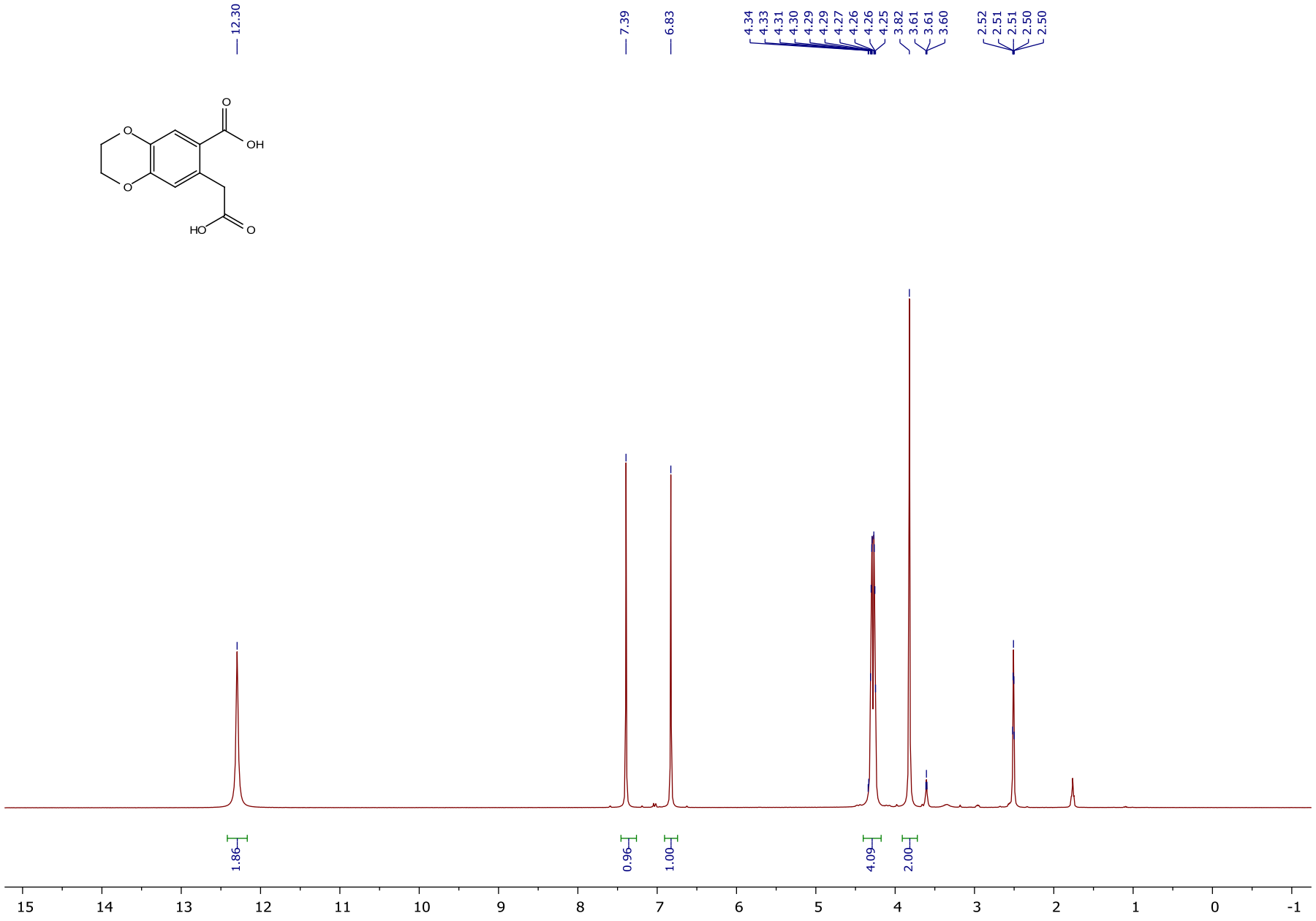
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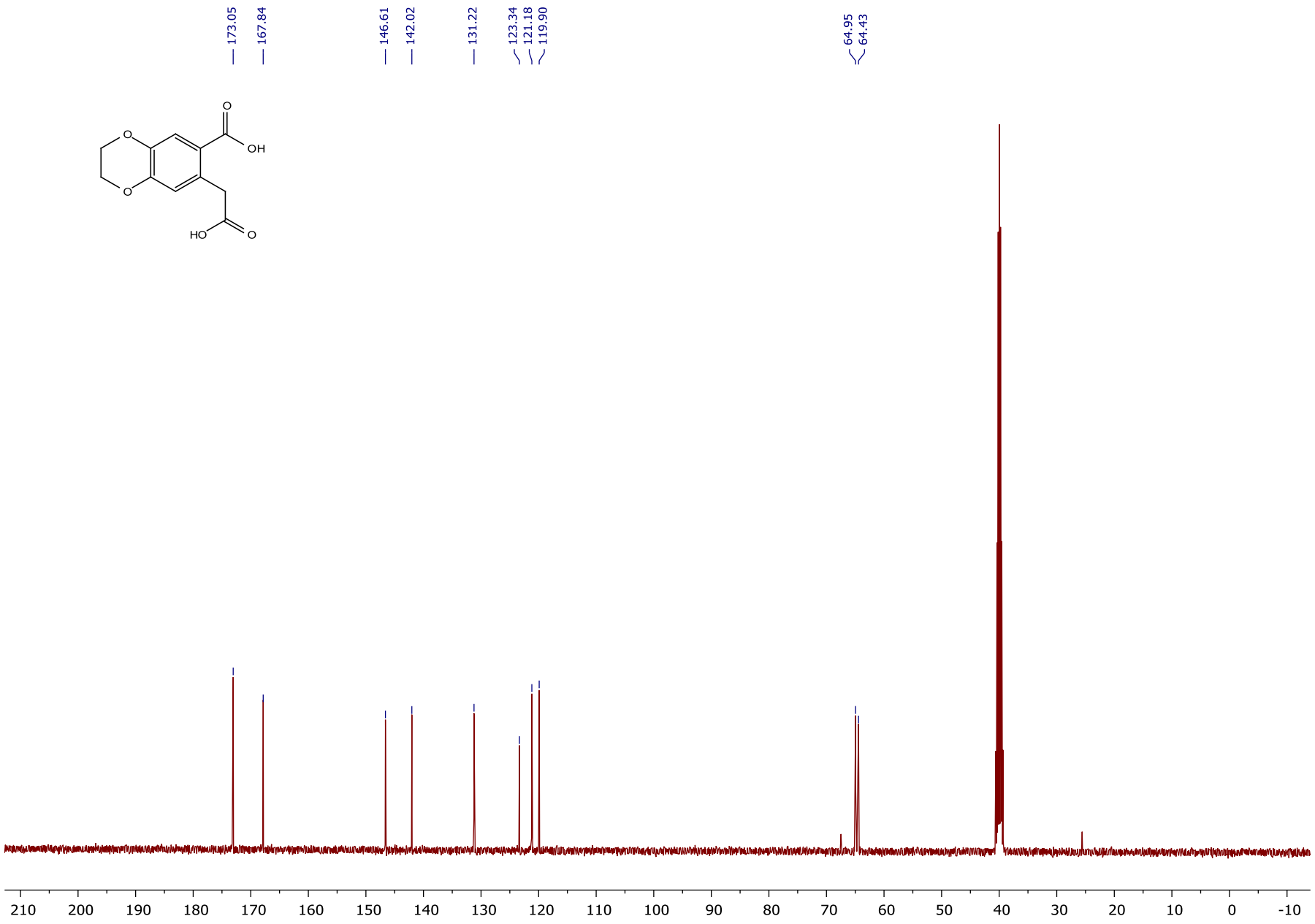
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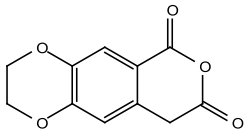

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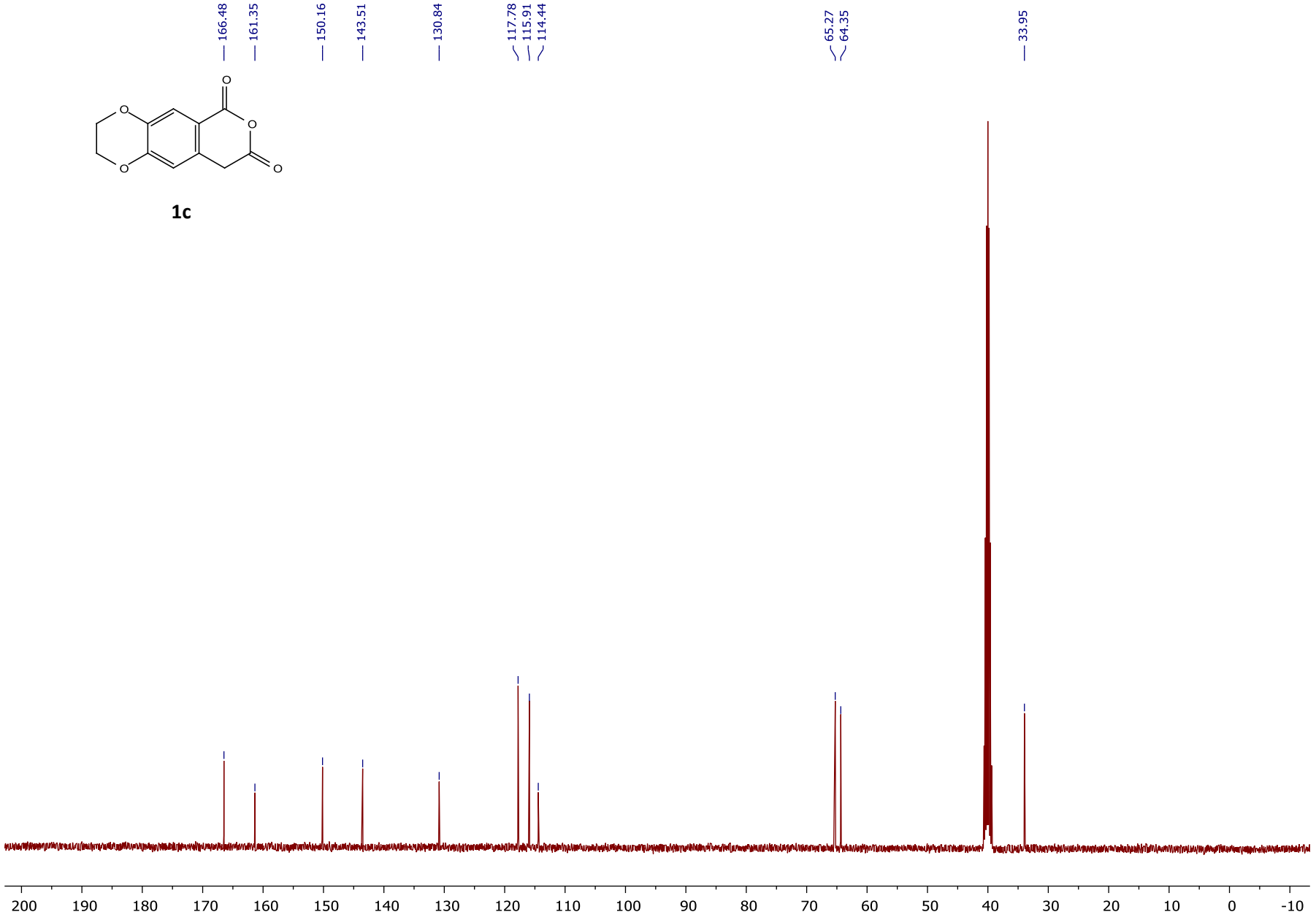
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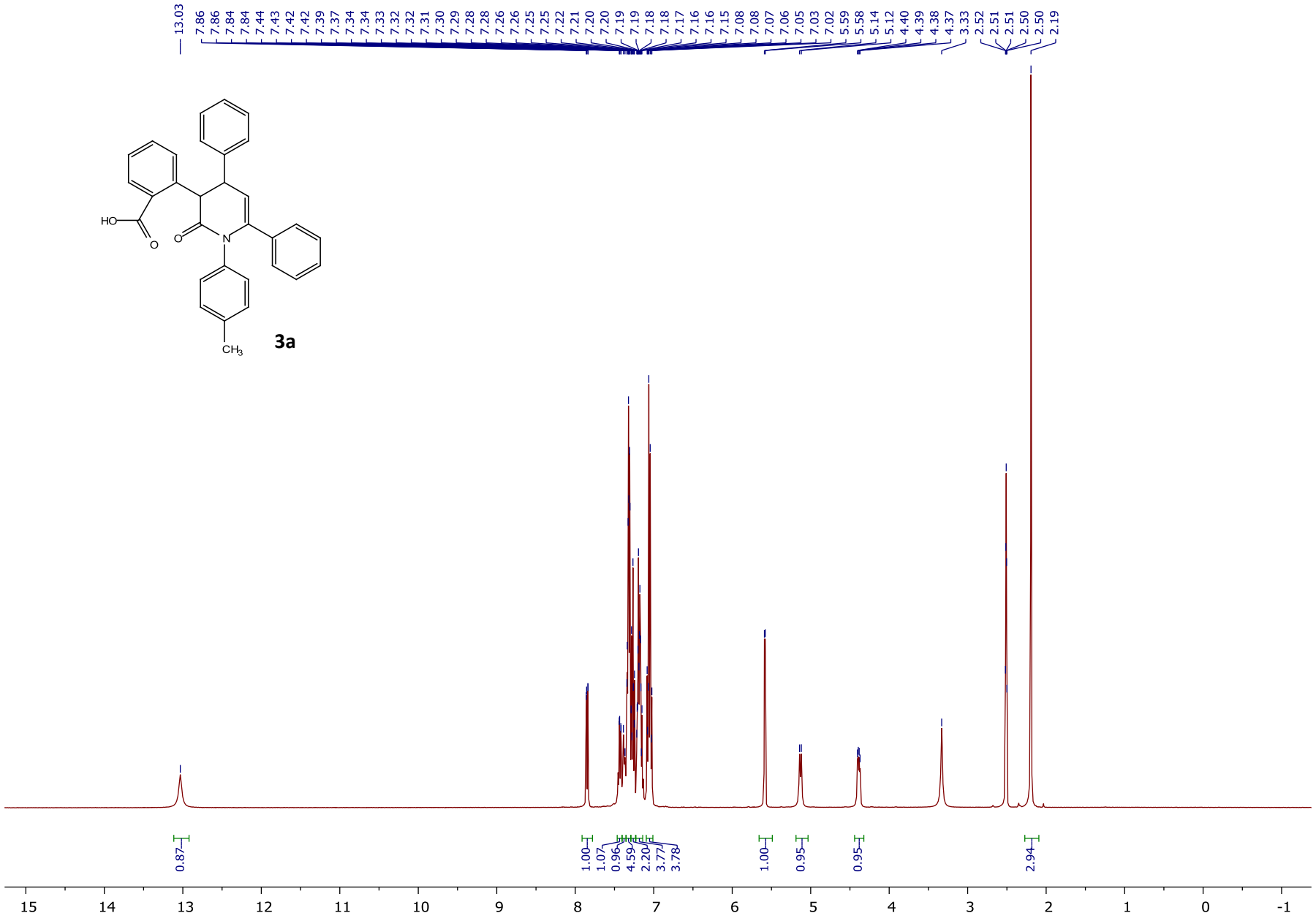
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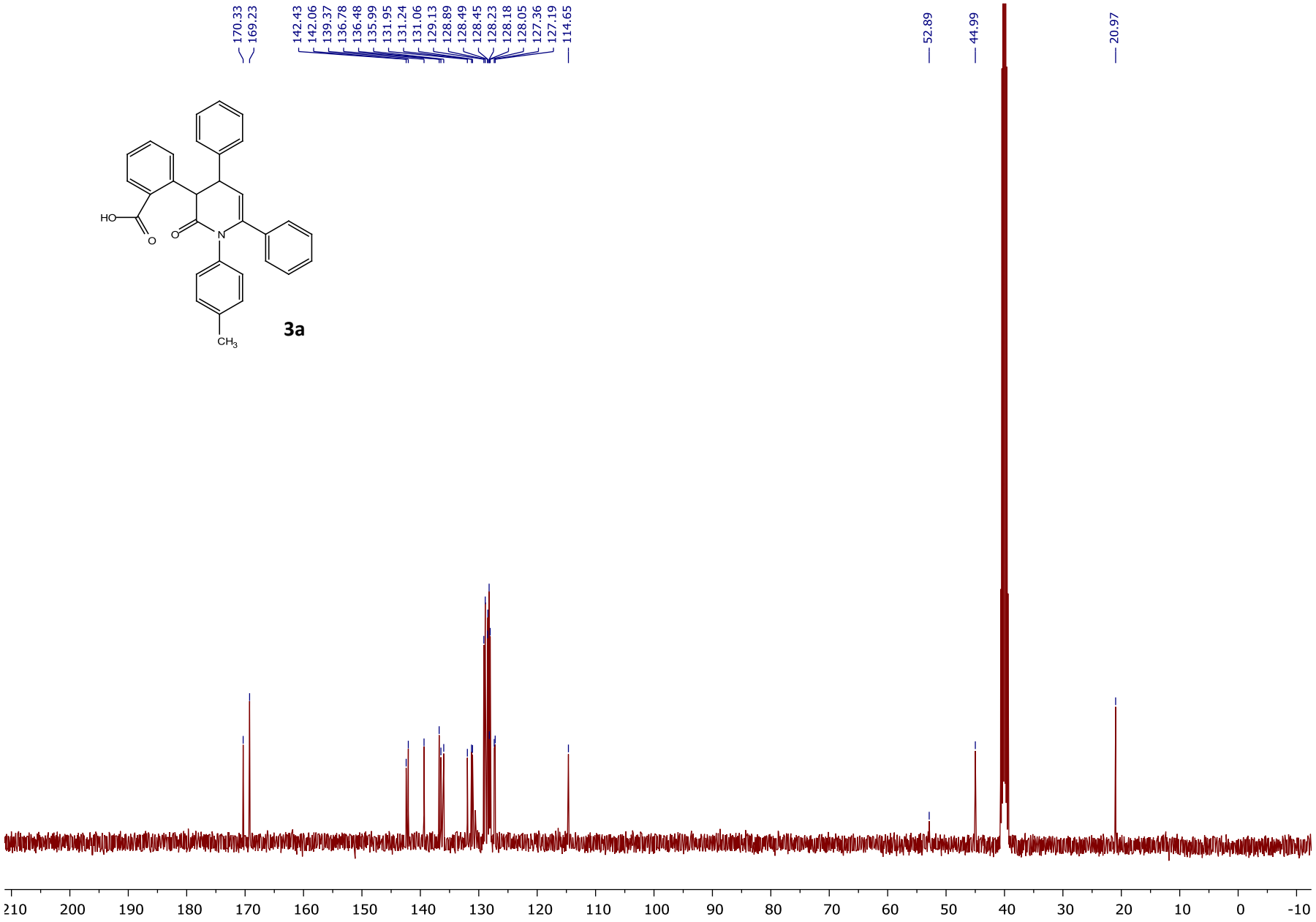
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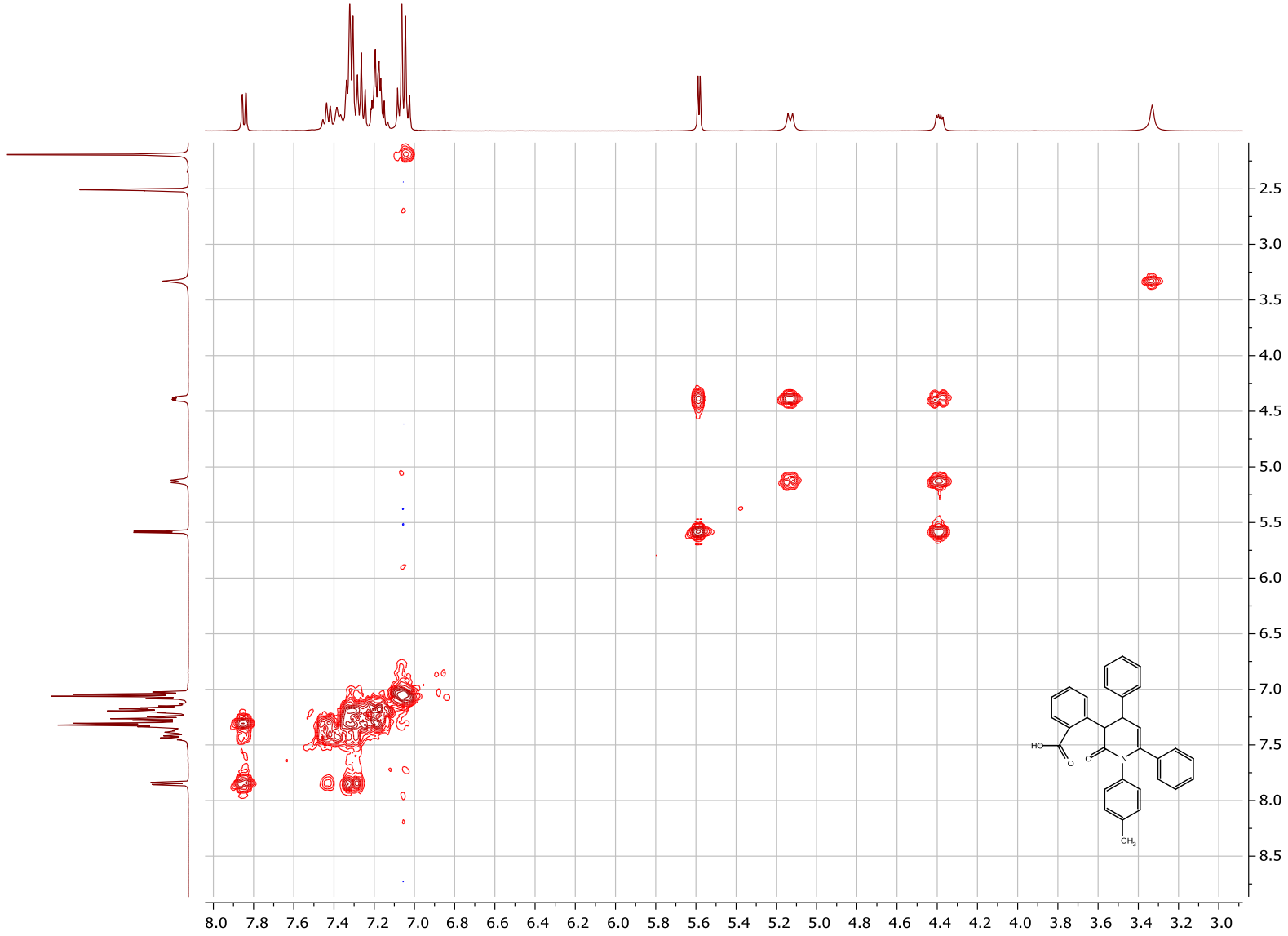
COSY **3a**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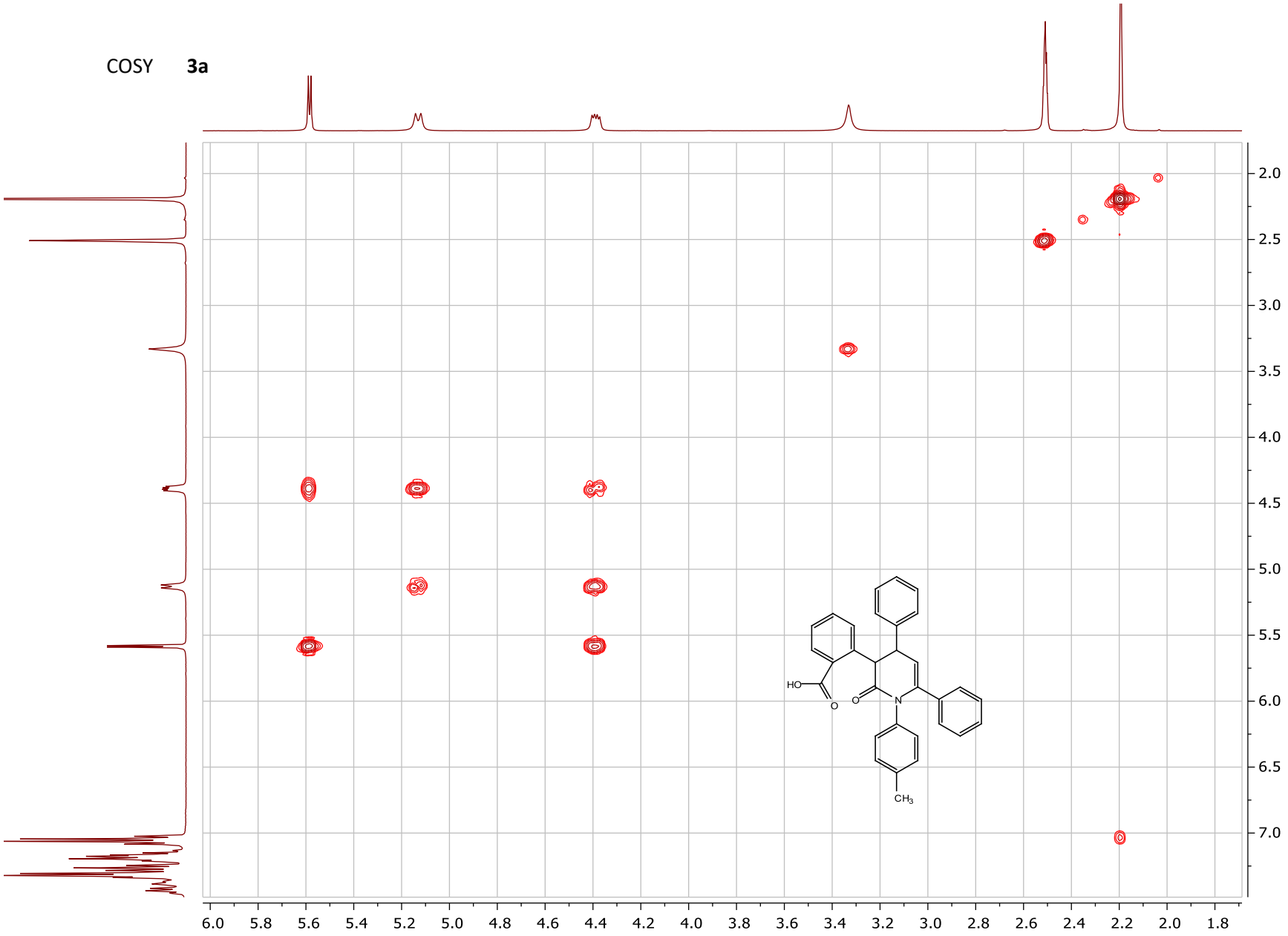
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4.4
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3.6
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3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
2.0
2.5
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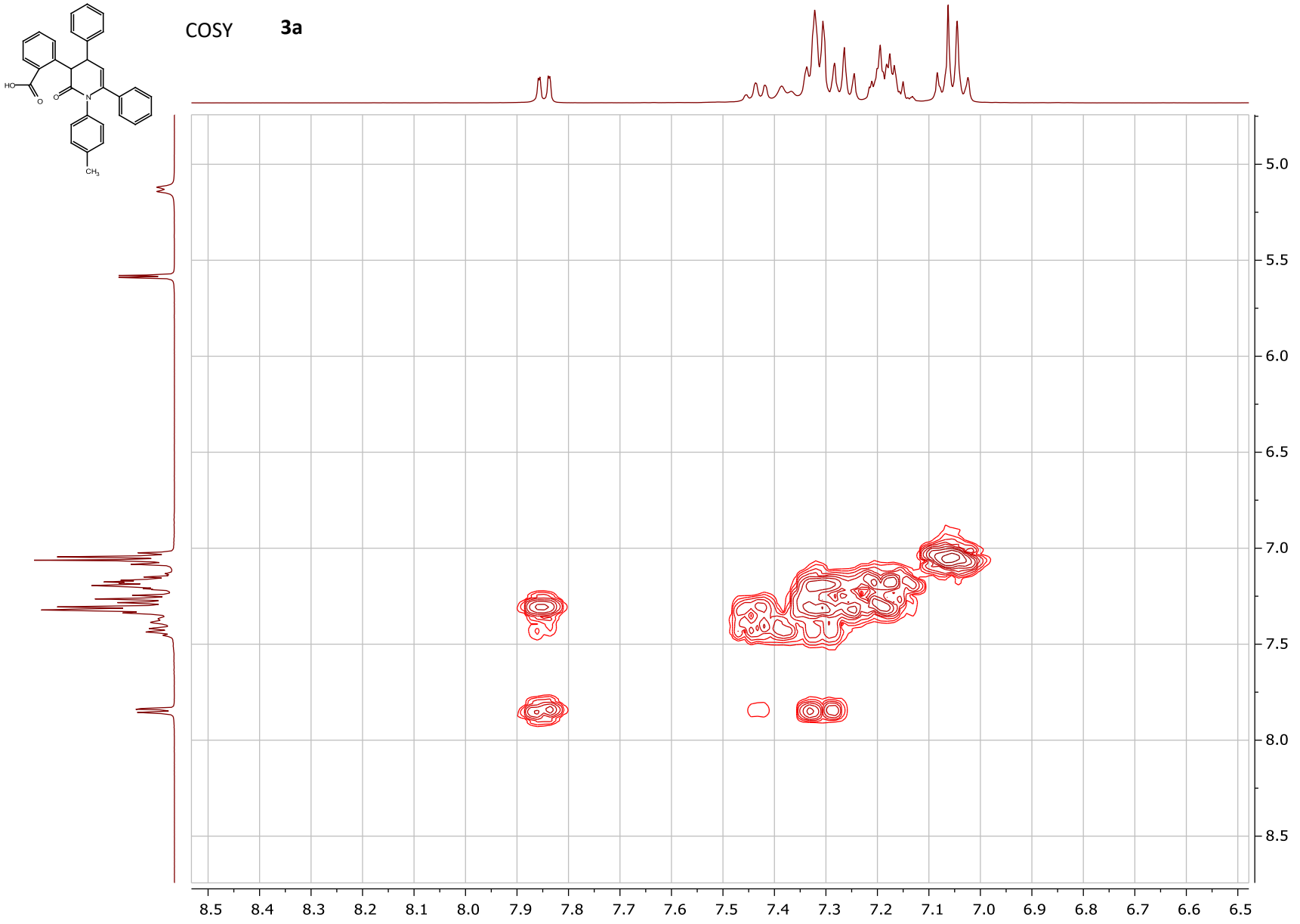
CH3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HO
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CH3
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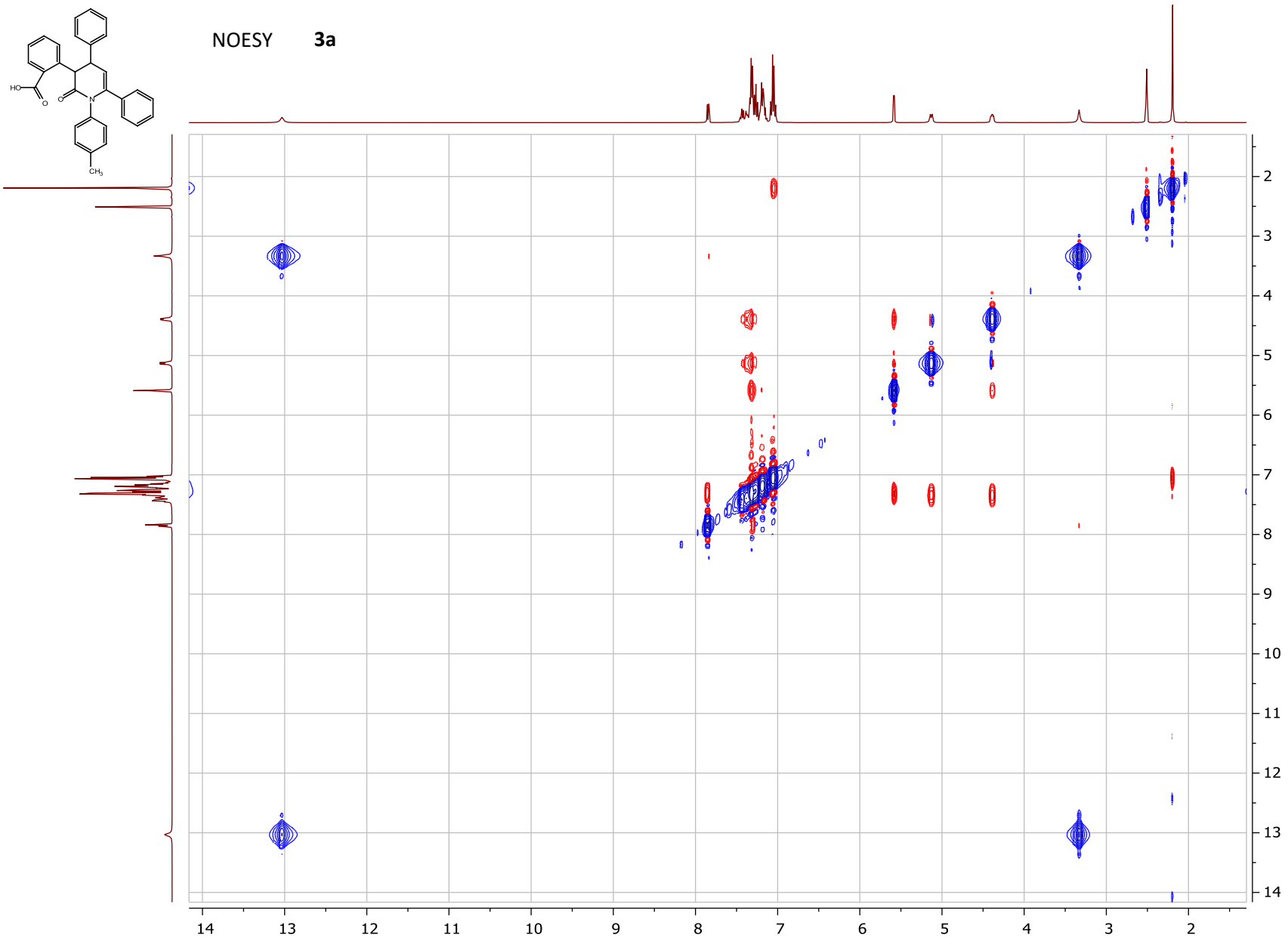
8.5
8.5 8.4 8.3 8.2 8.1 8.0 7.9 7.8 7.7 7.6 7.5 7.4 7.3 7.2 7.1 7.0 6.9 6.8 6.7 6.6 6.5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HO
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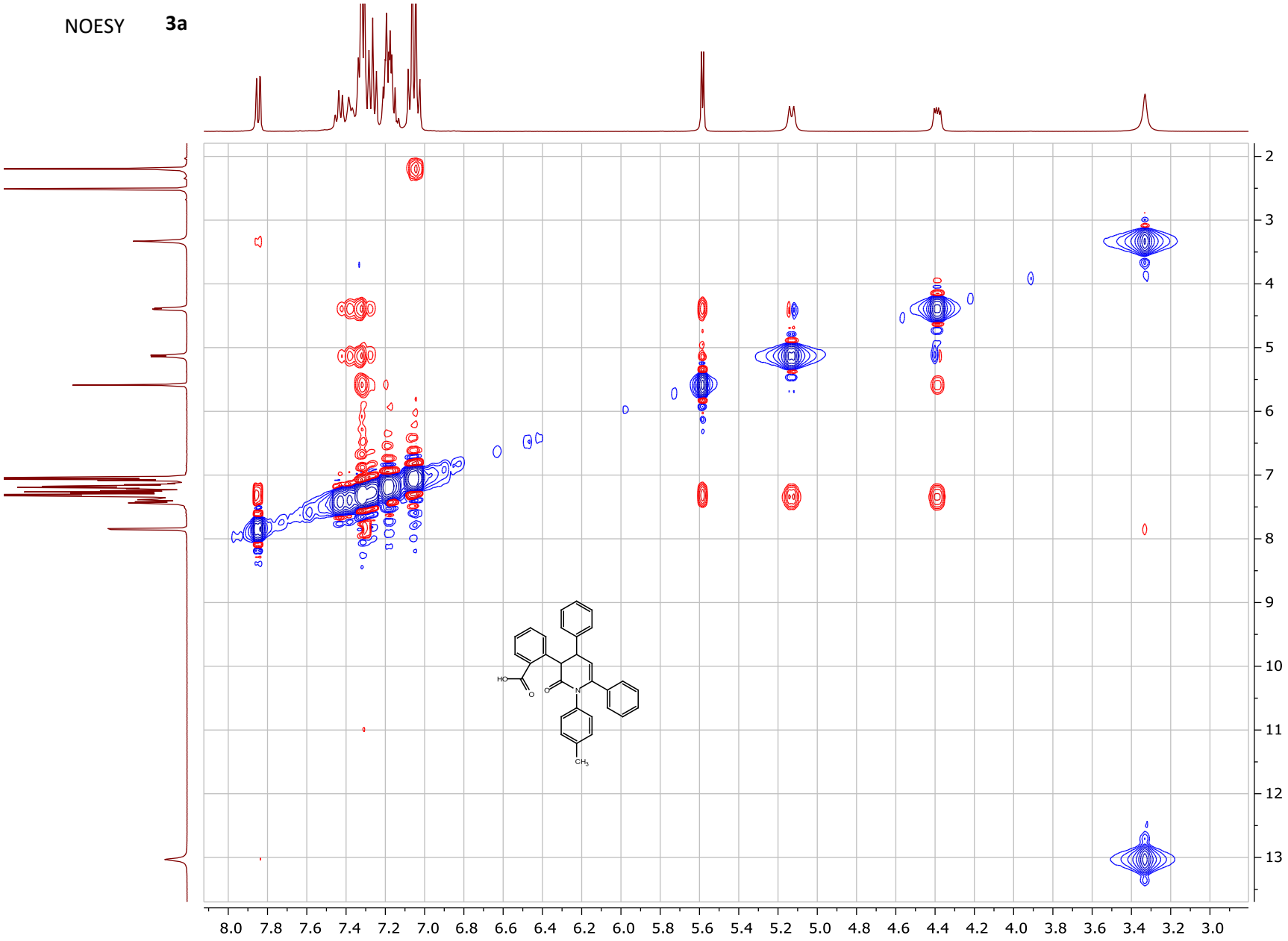
2

NOESY **3a**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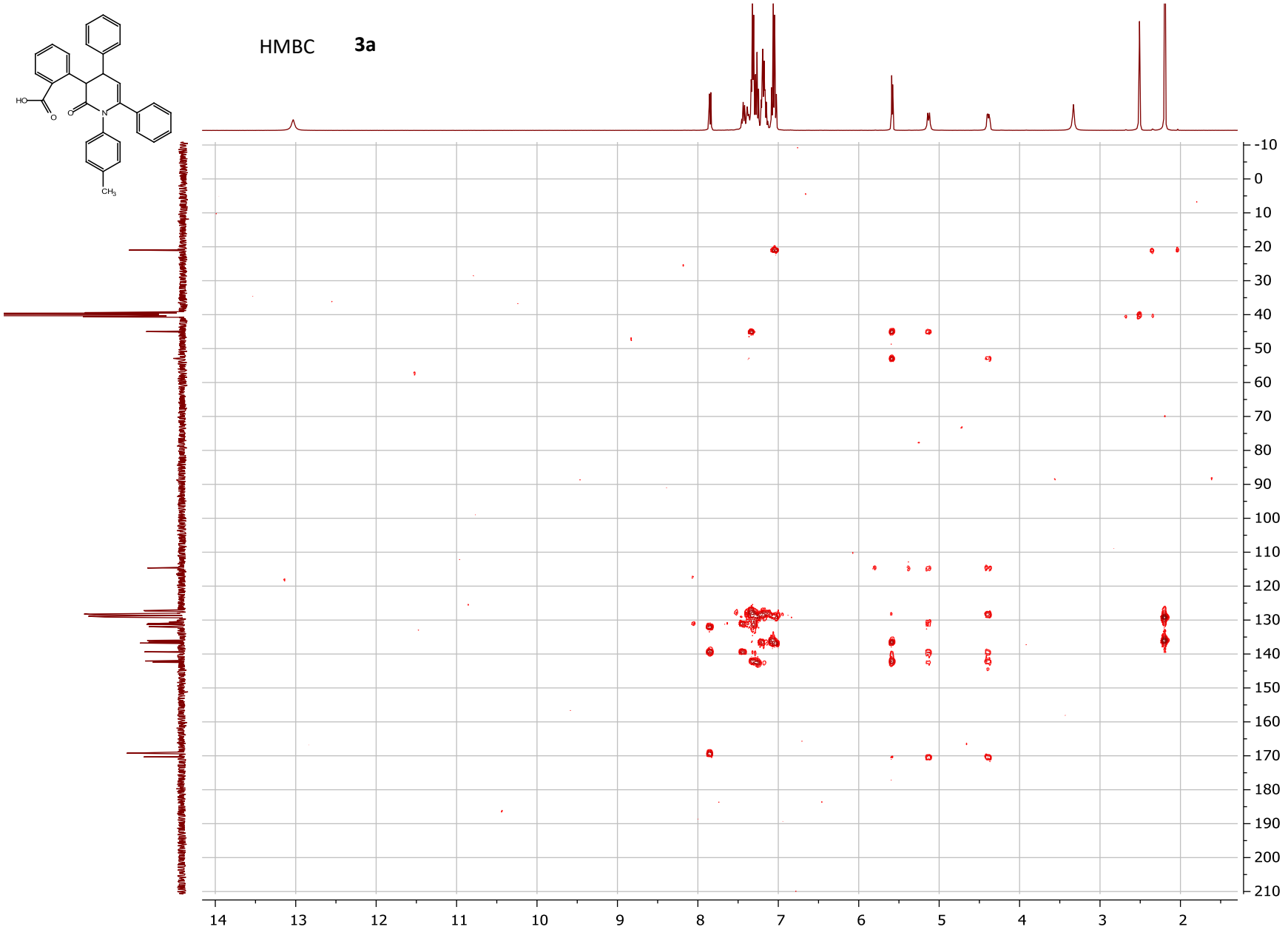
N
CH3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CH3
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-10
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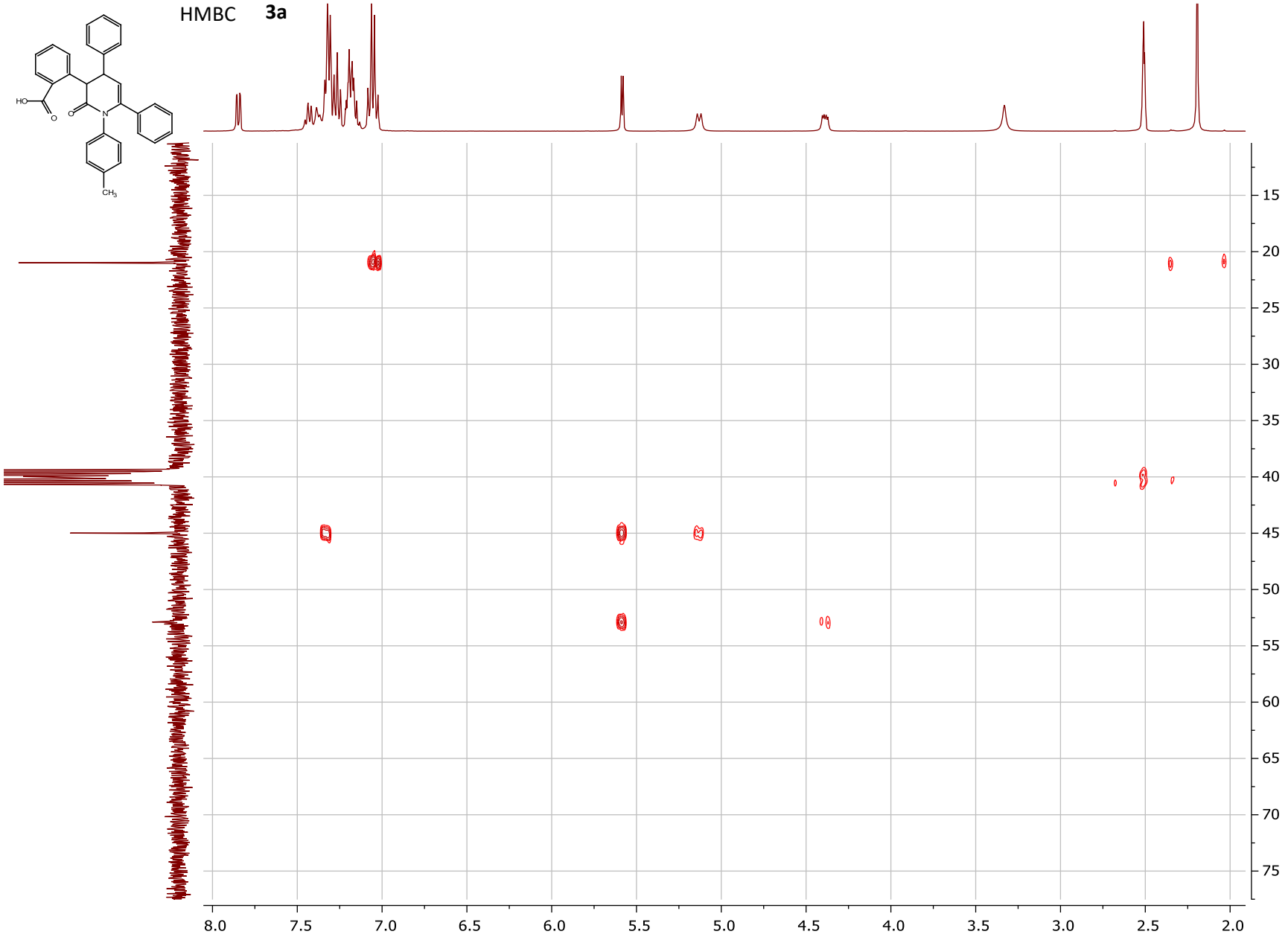
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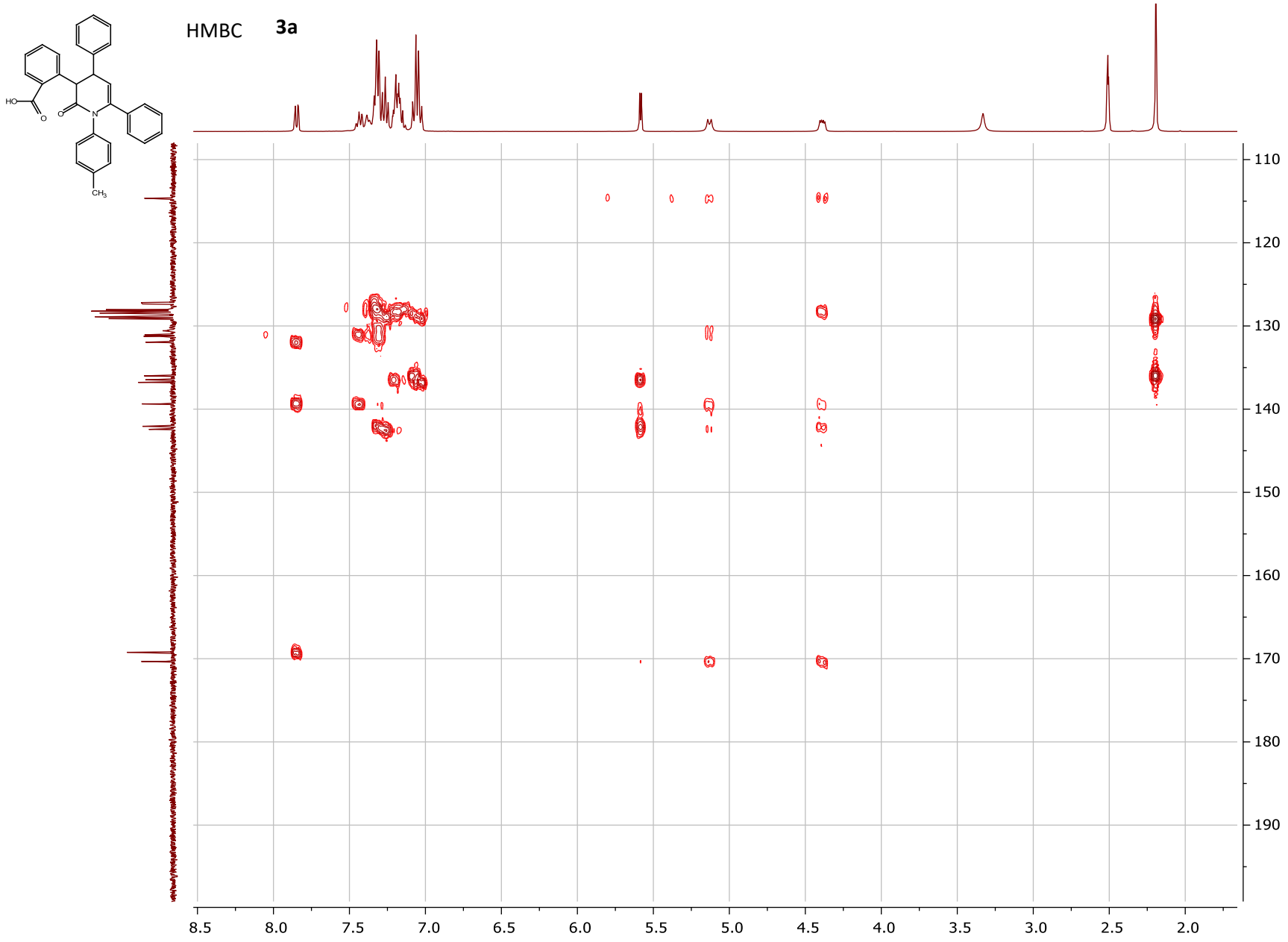
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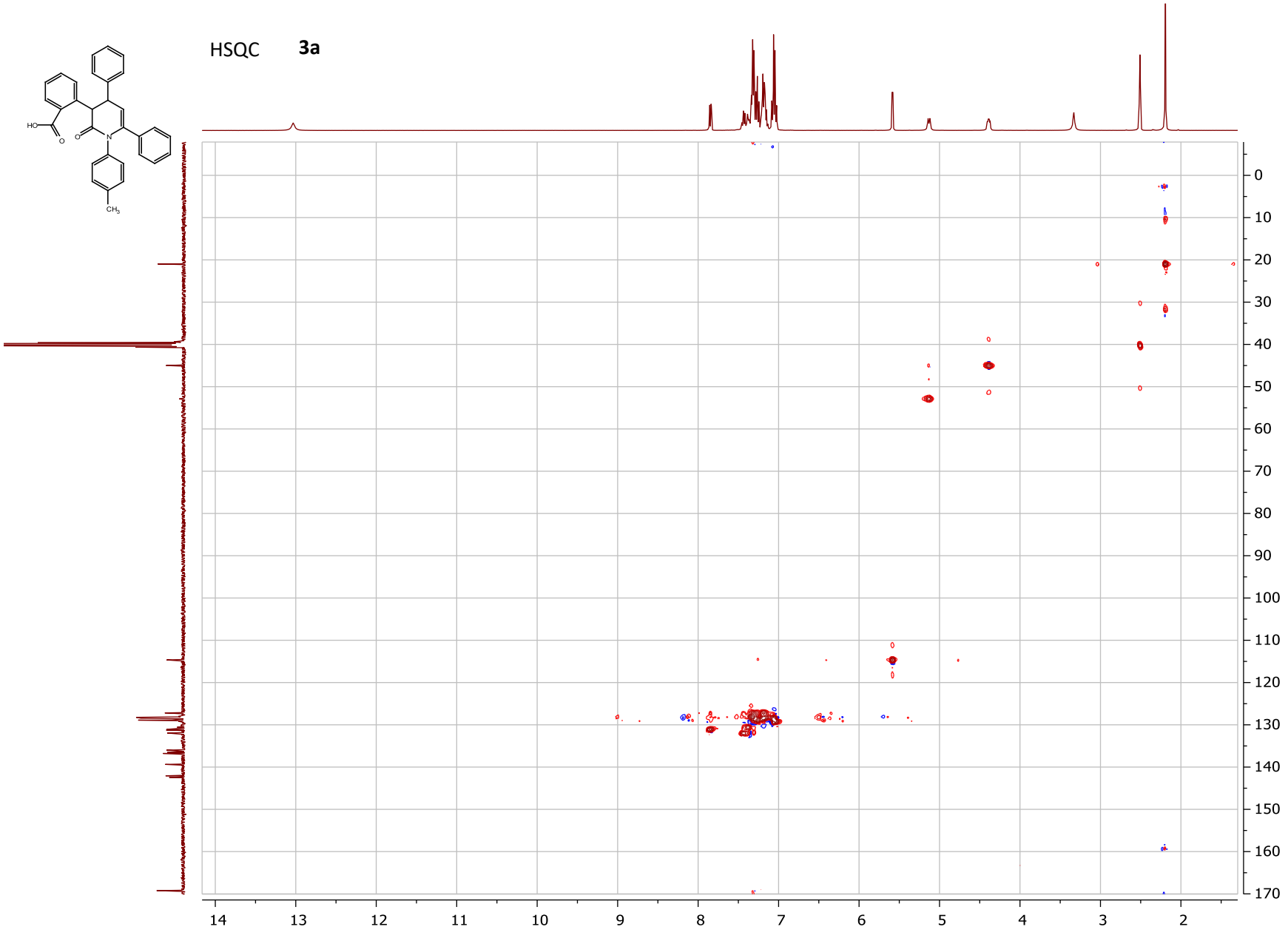
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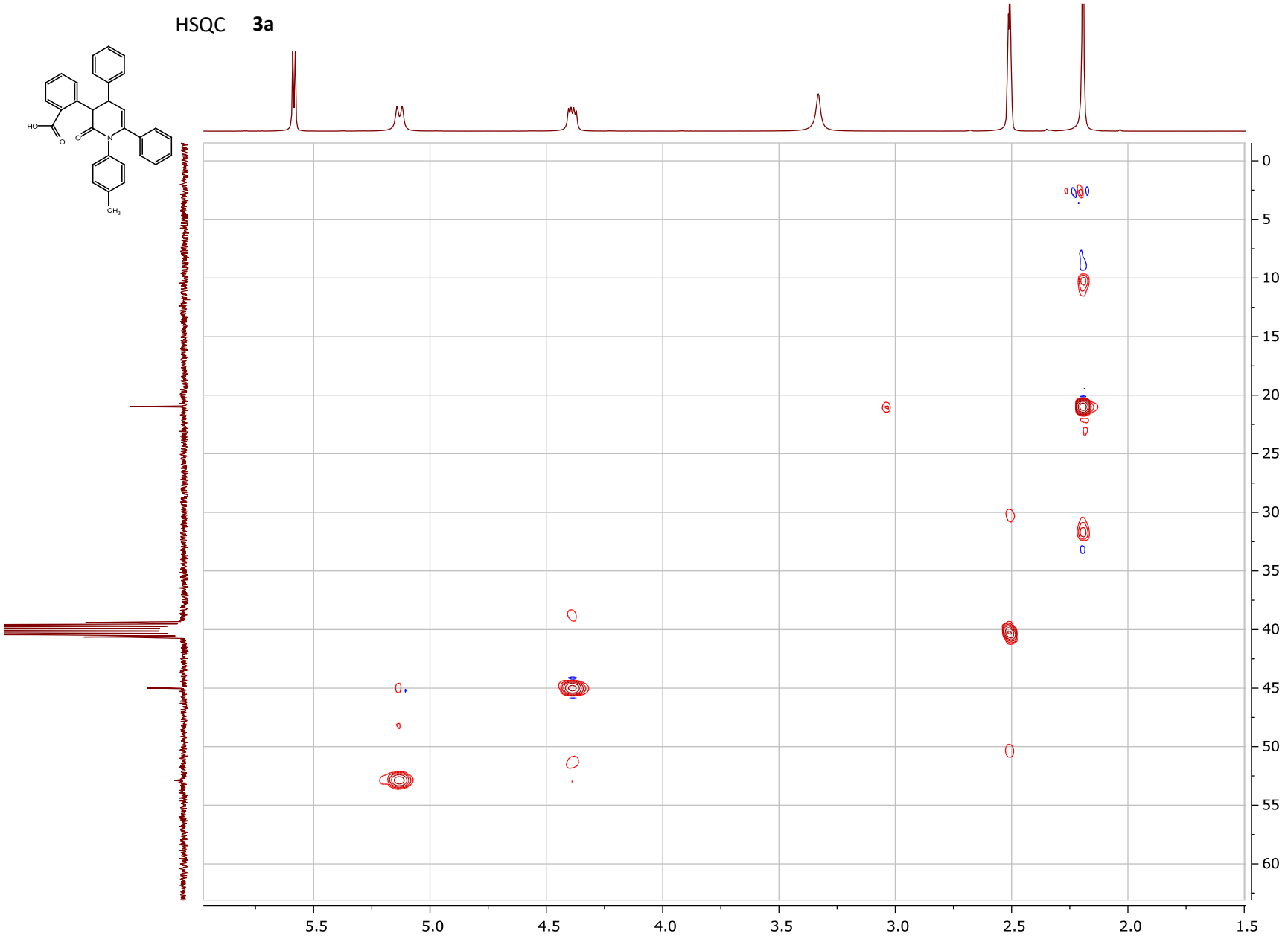
170

HSQC **3a**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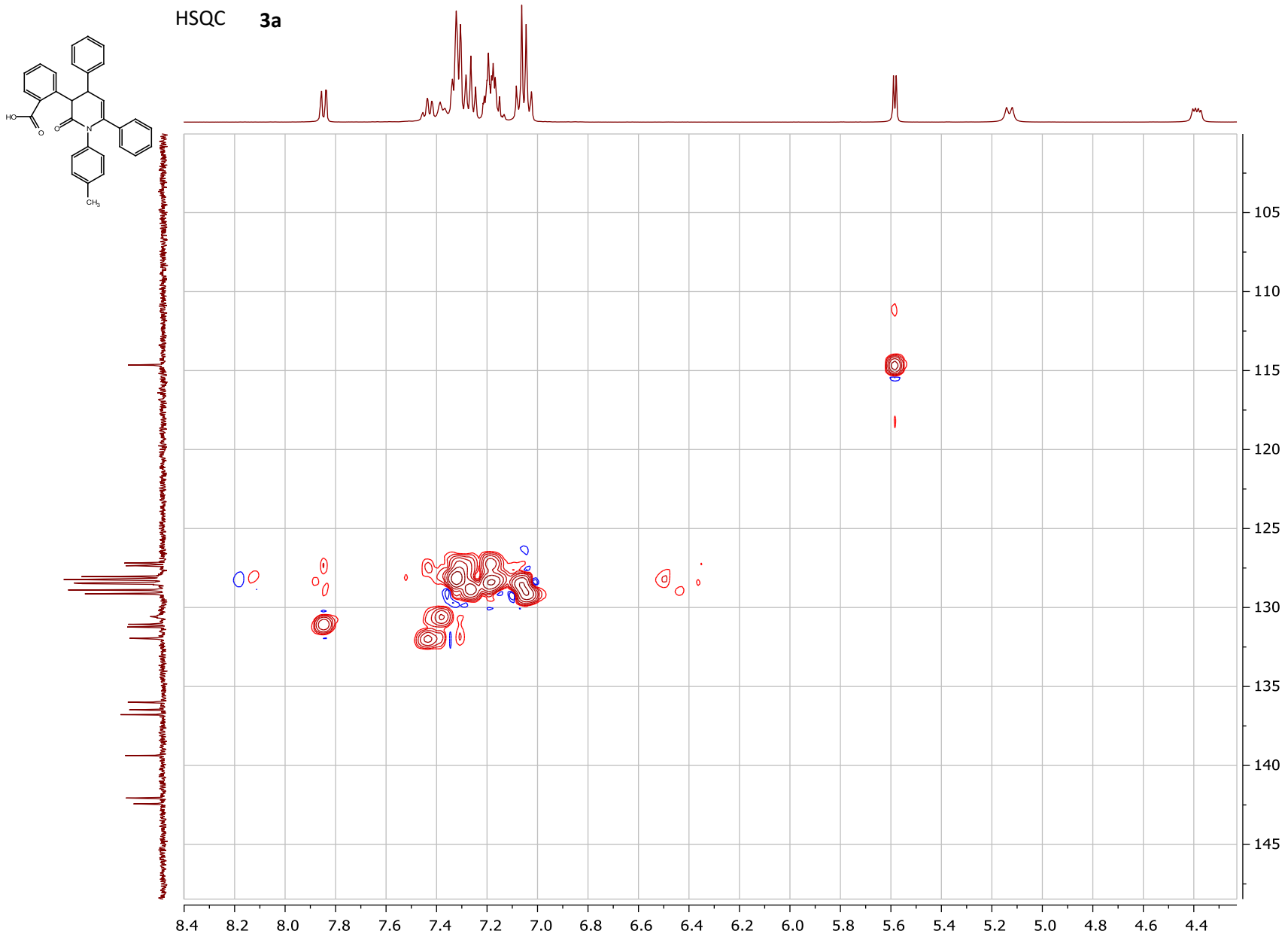
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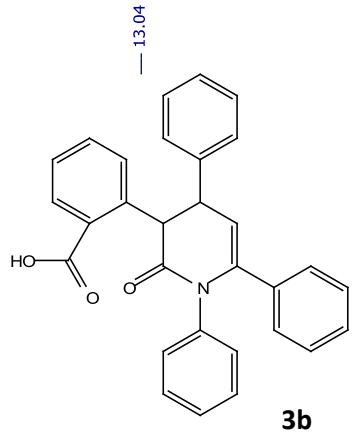
4.4


13.04
HO
O
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N

3b


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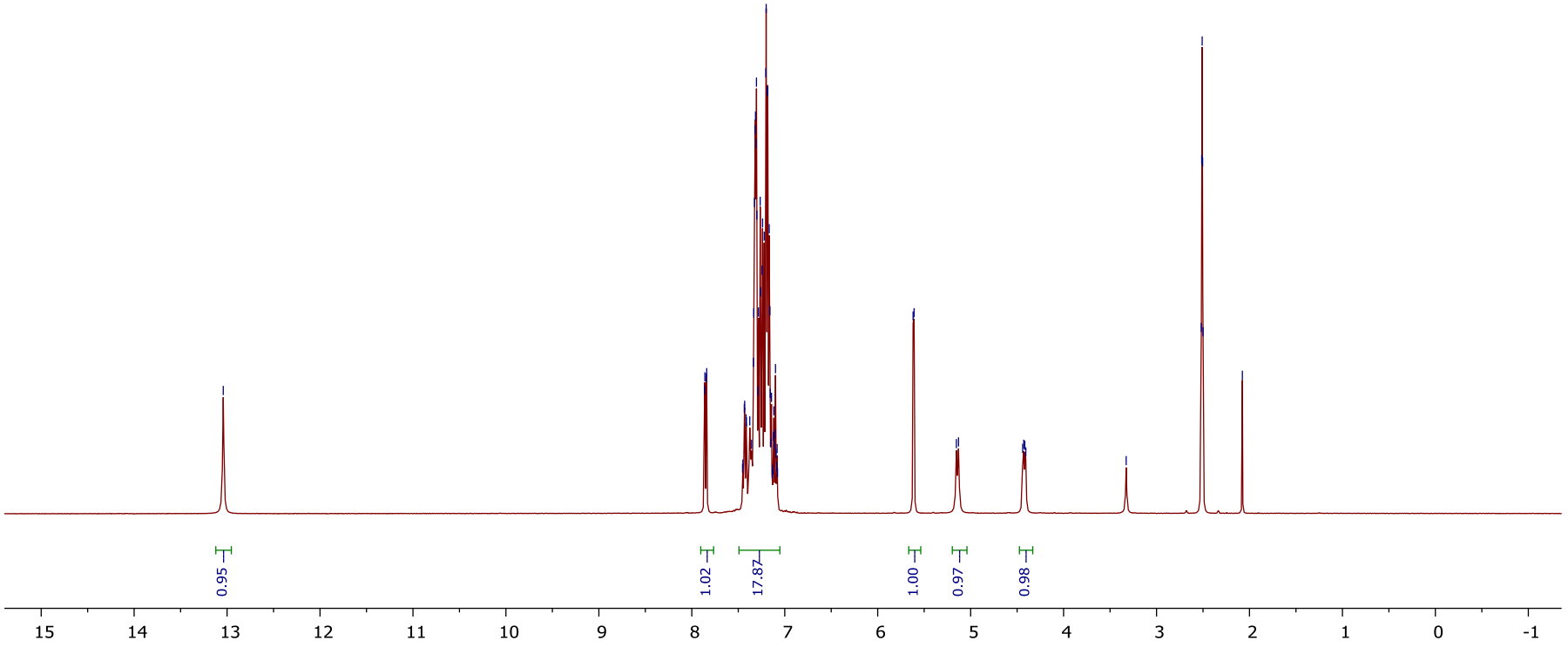
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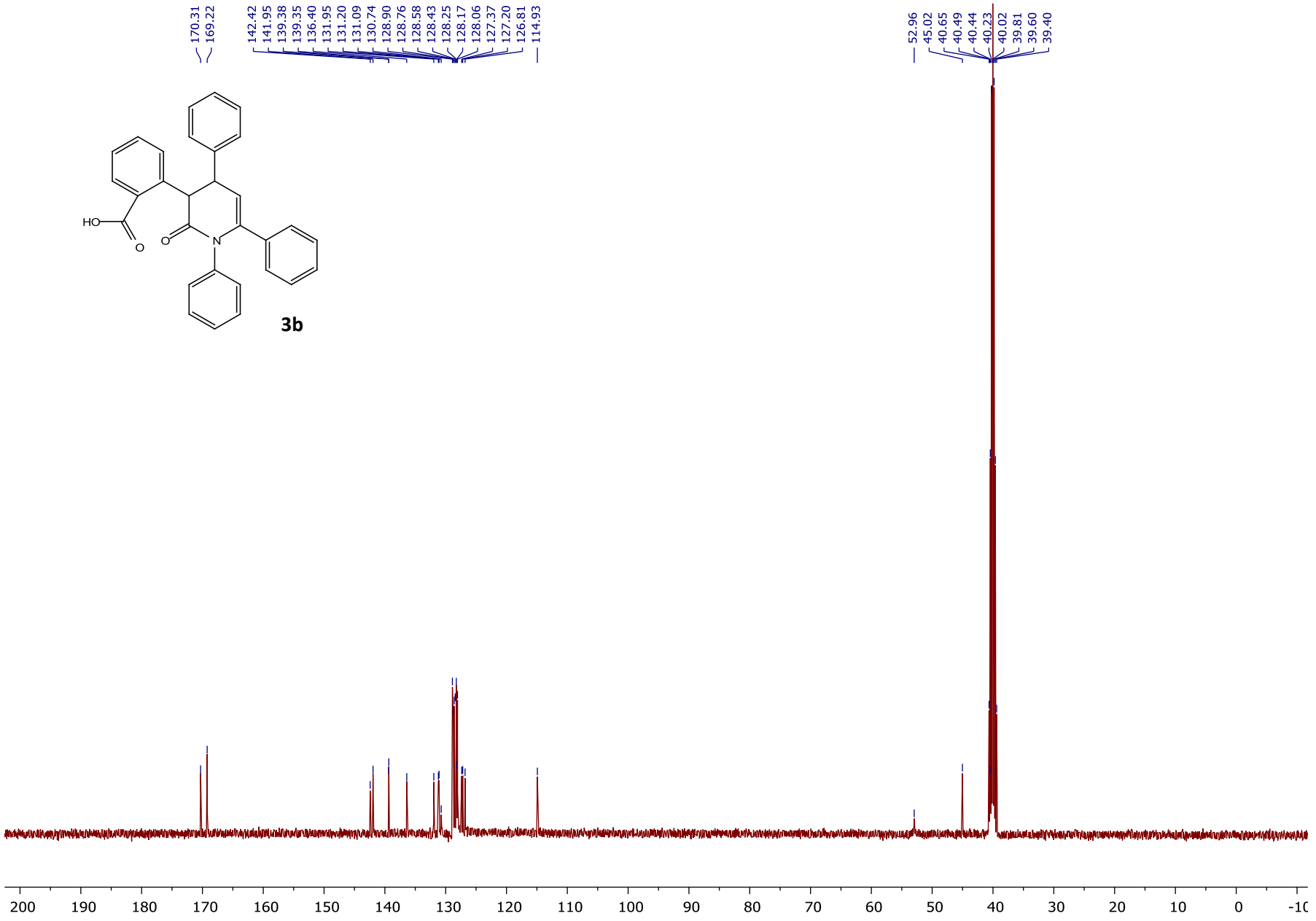
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128.06
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126.81
114.93
52.96
45.02
40.65
40.49
40.44
40.23
40.02
39.81
39.60
39.40
HO
O
O
N
3b
200
190
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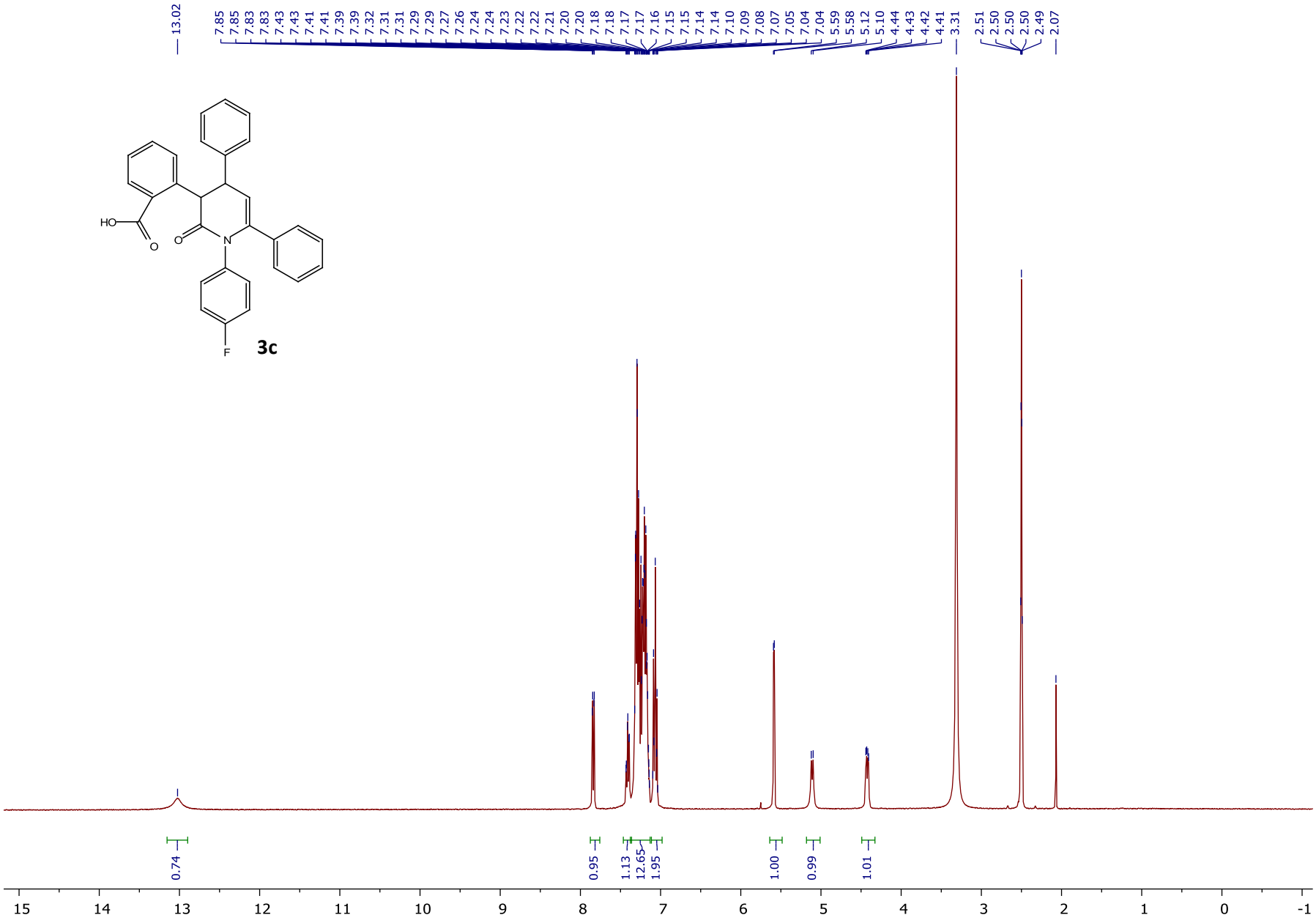
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2.07
HO
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O
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F
3c
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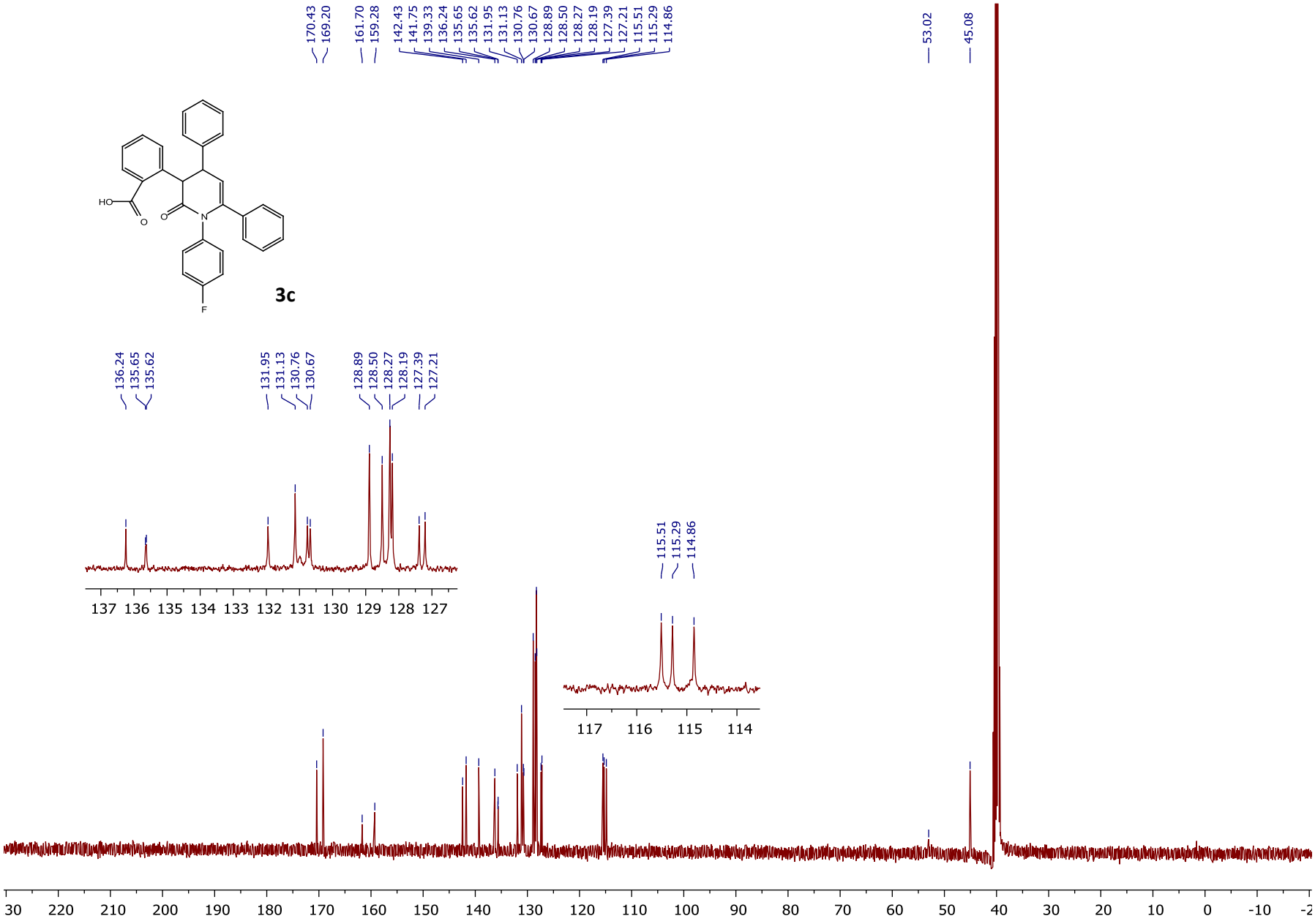
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115.29
114.86
53.02
45.08
HO
O
O
N
F
3c
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137 136 135 134 133 132 131 130 129 128 127
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115.29
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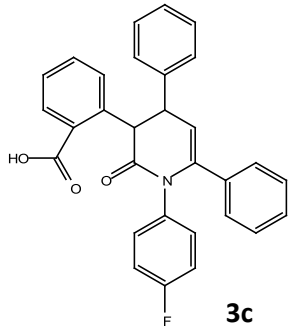
HO
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F

3c

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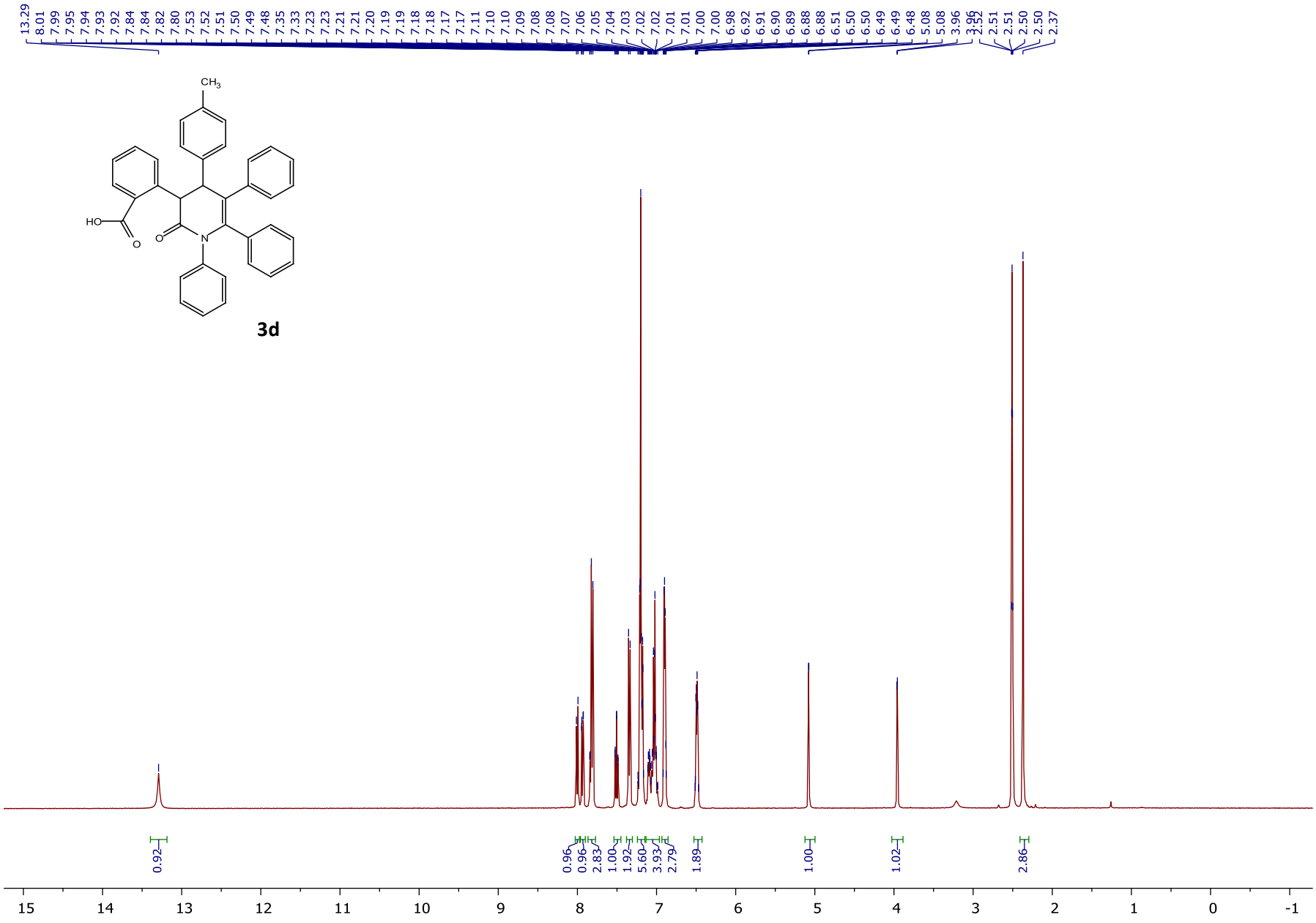
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7.02
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CH3
HO
O
O
N
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1.00
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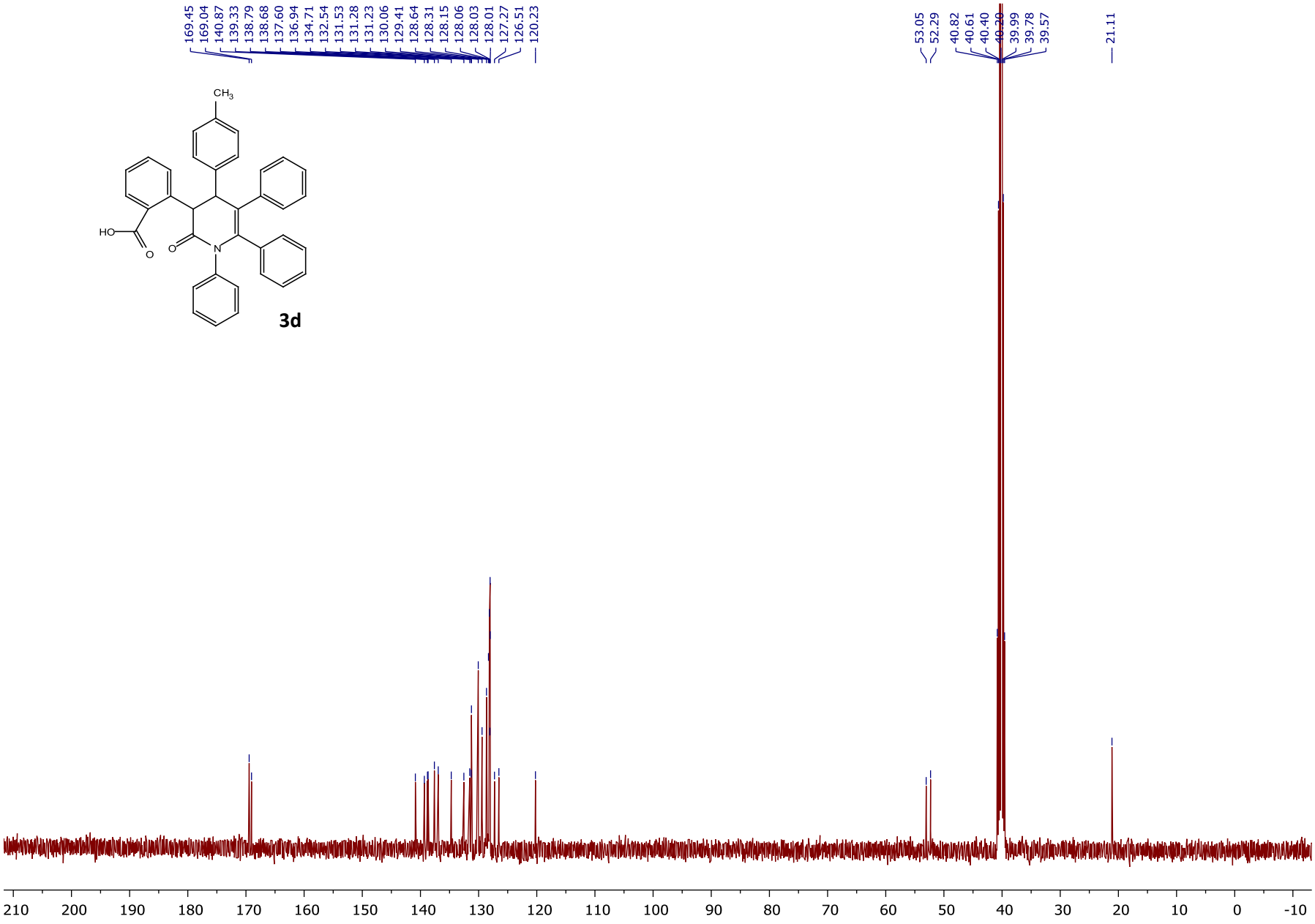
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CH3
HO
O
O
N
3d
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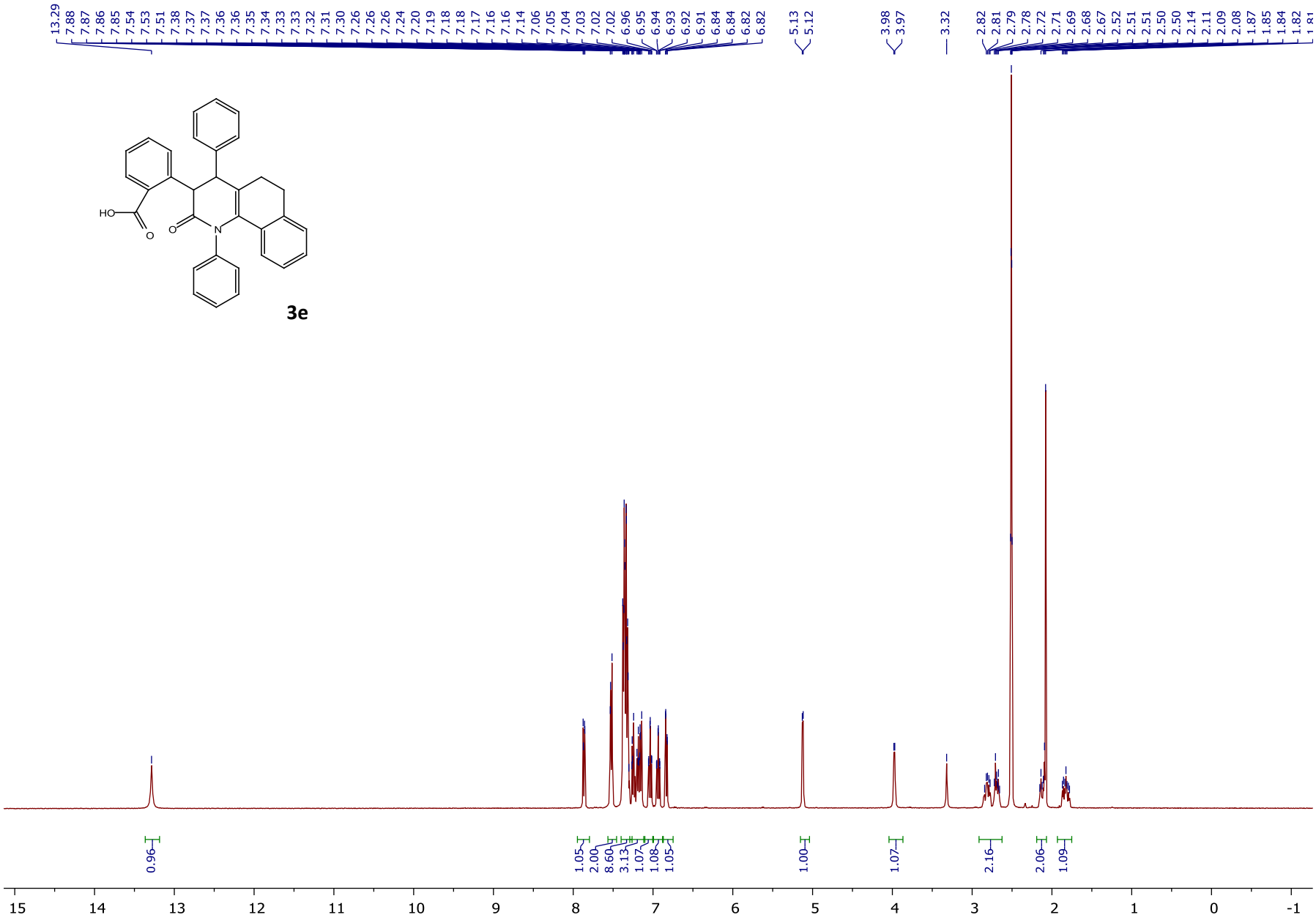
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2.08
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1.82
HO
O
O
N
3e
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1.08
1.05
1.00
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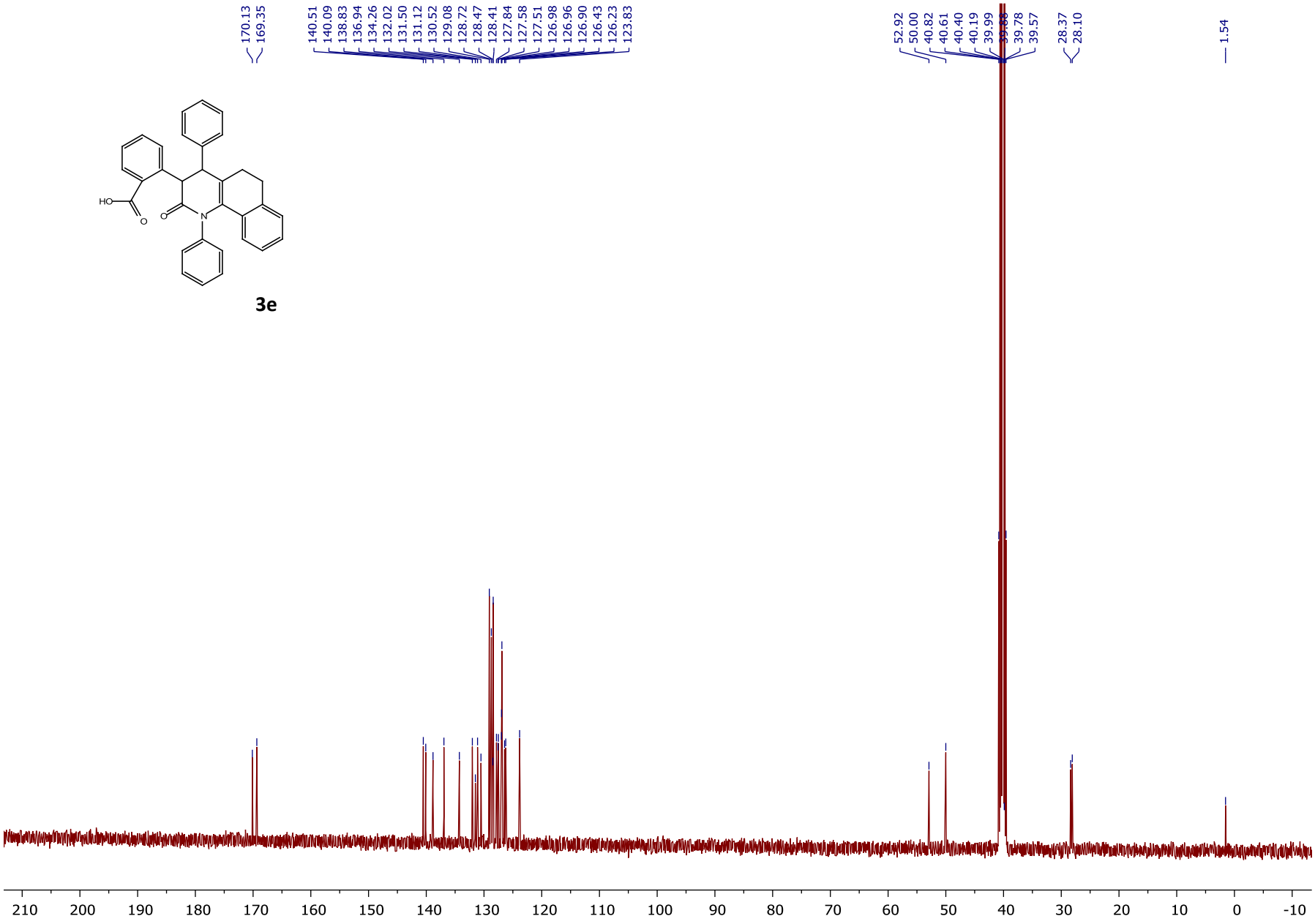
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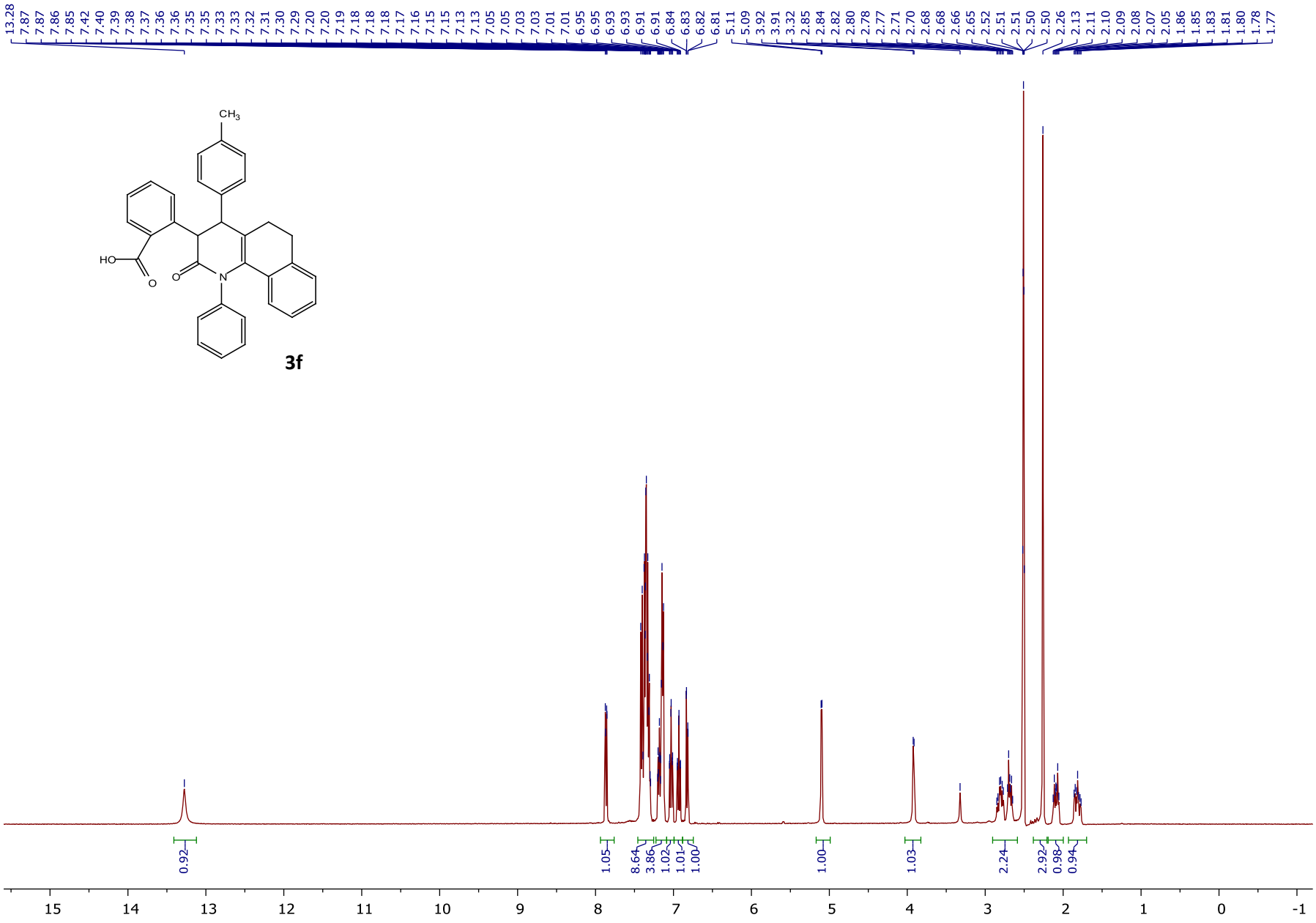
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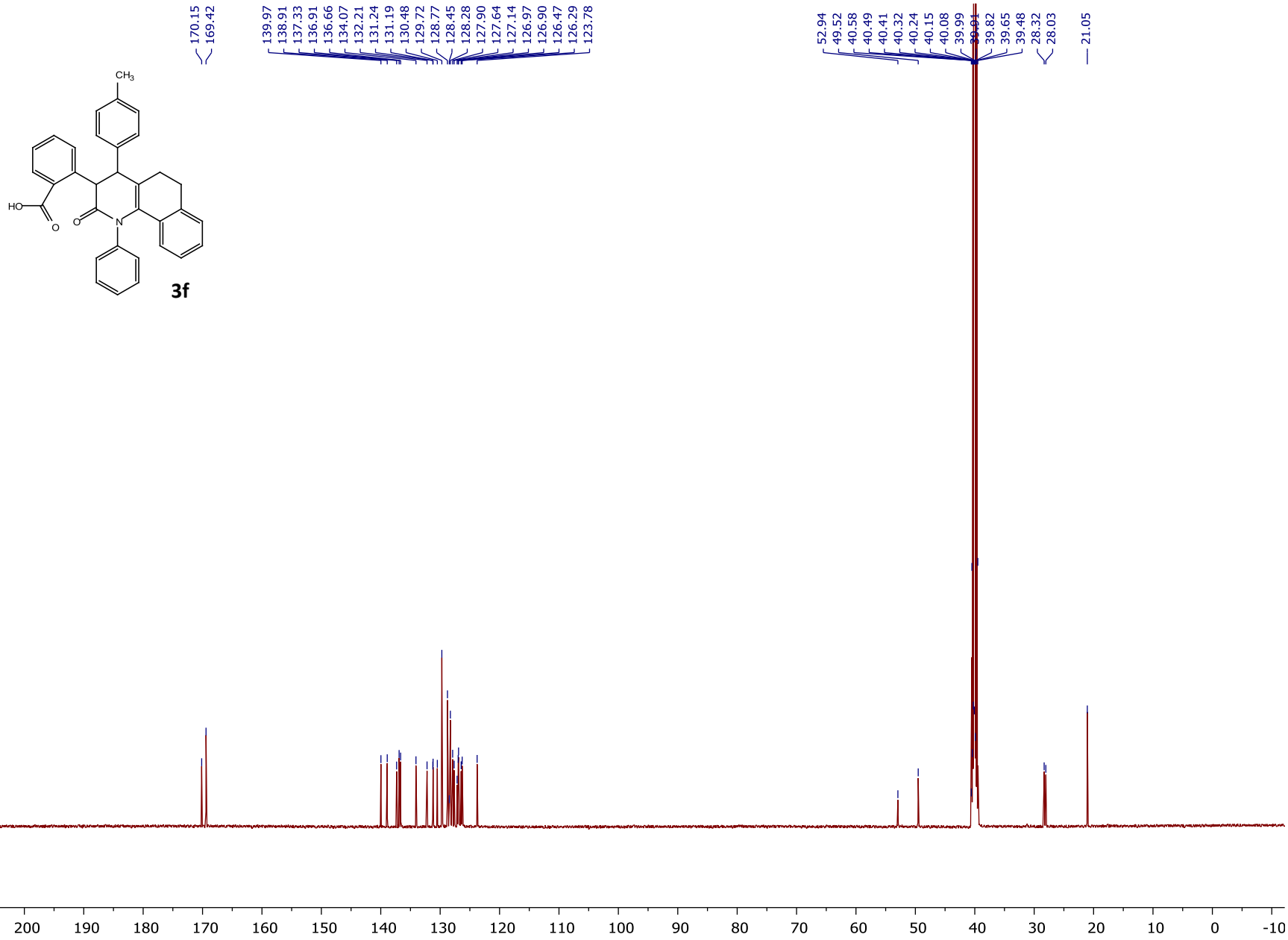
CH3
HO
O
O
N
0.92 1.05 8.64 3.86 1.02 1.01 1.00 1.00 1.03 2.24 2.92 0.98 0.94
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1

3f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28.03
21.05
CH3
HO
O
O
N
3f
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200
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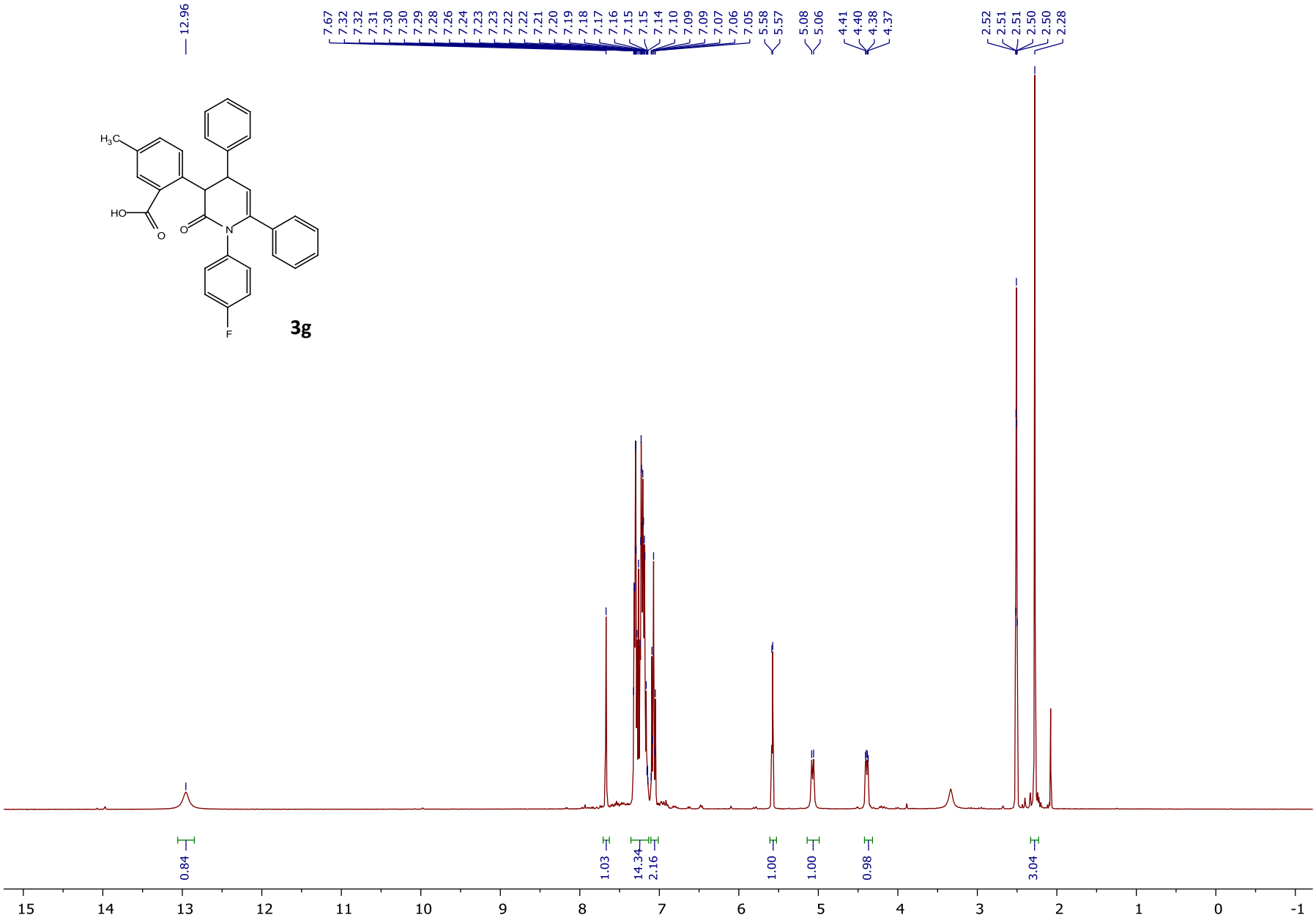
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H3C
HO
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N
F
3g
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14.34
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1.00
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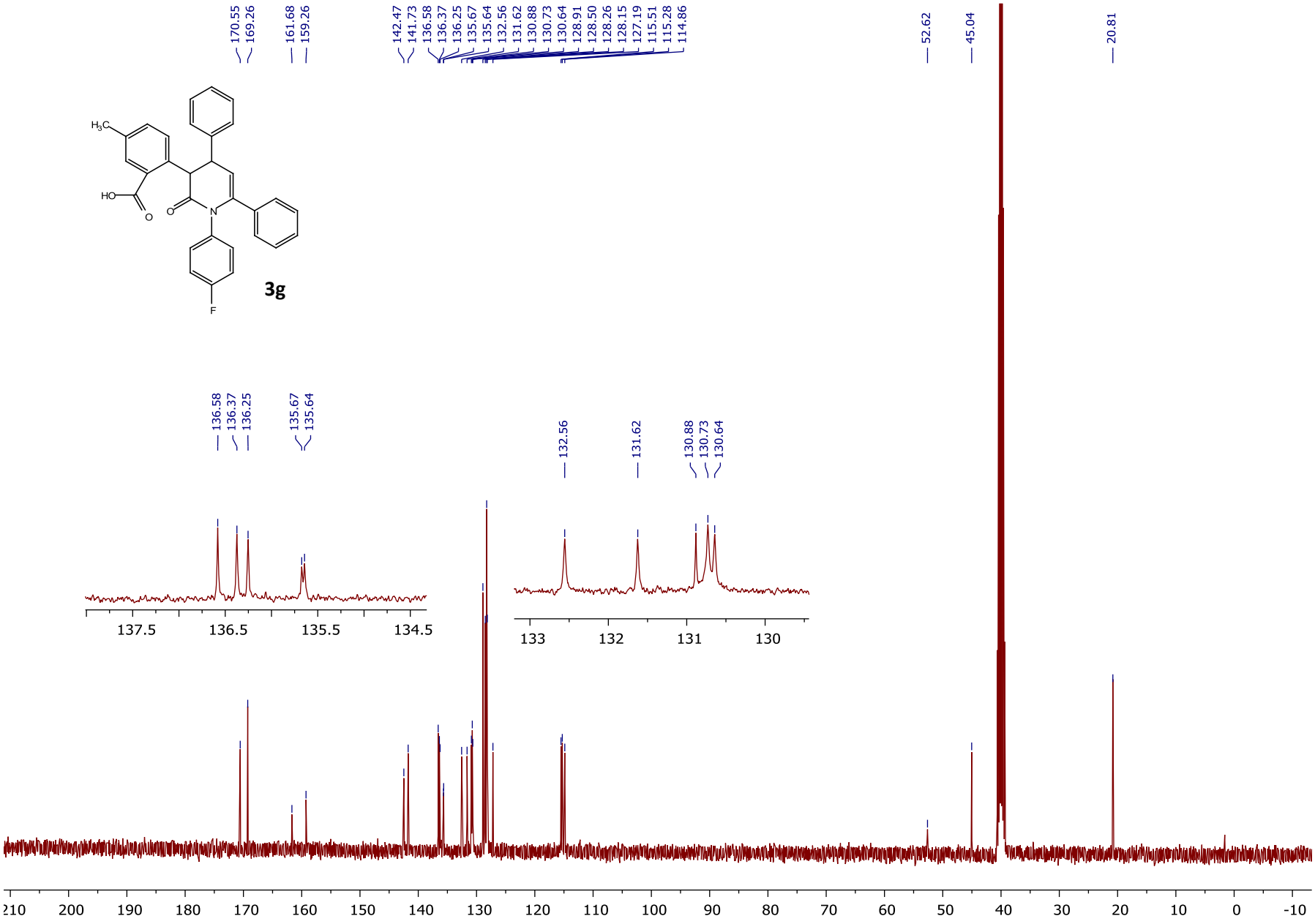
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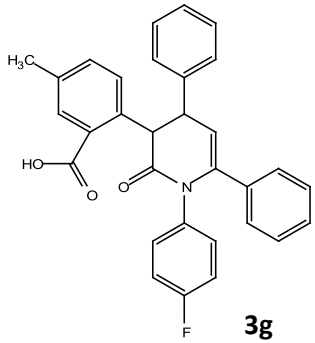
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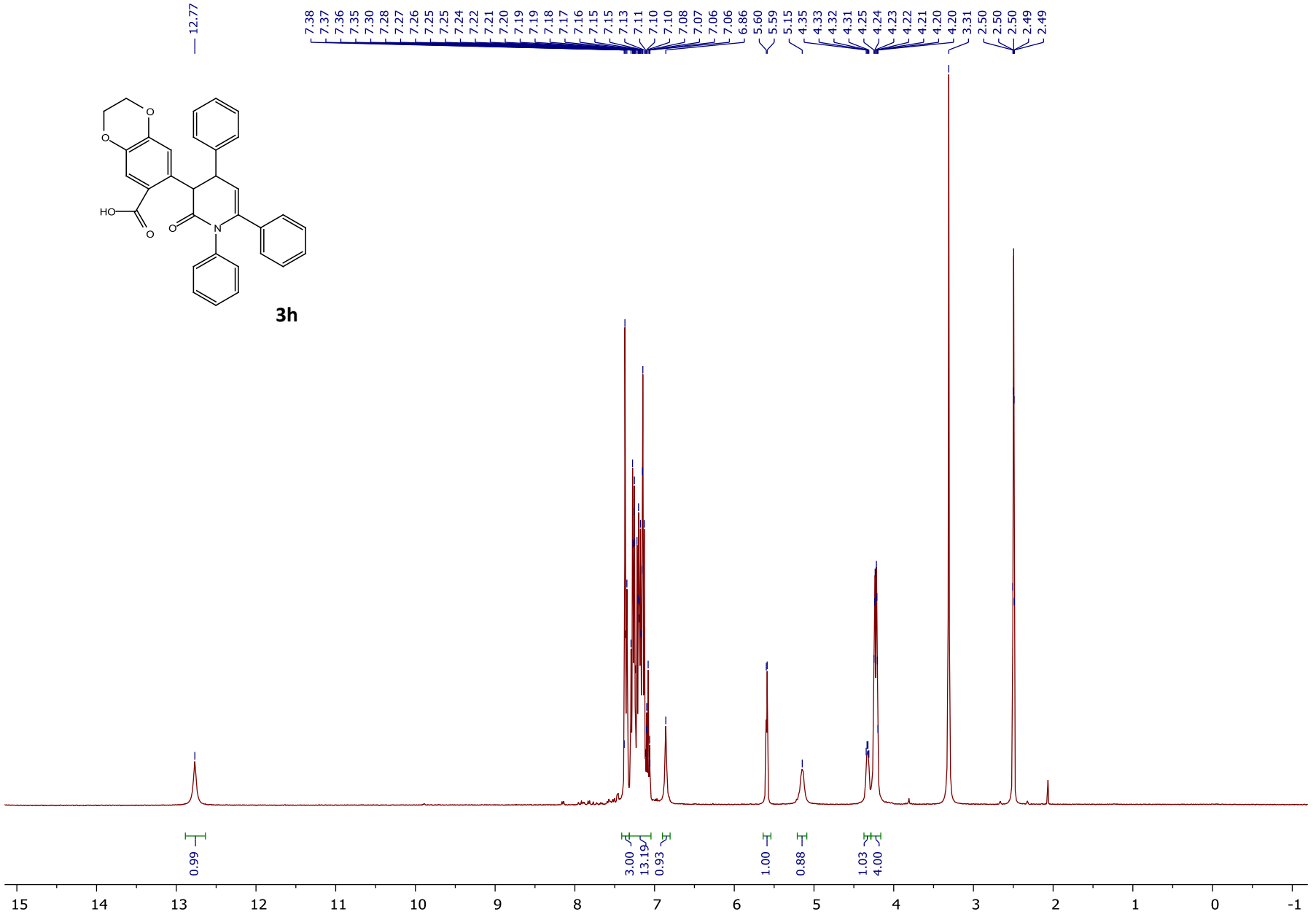
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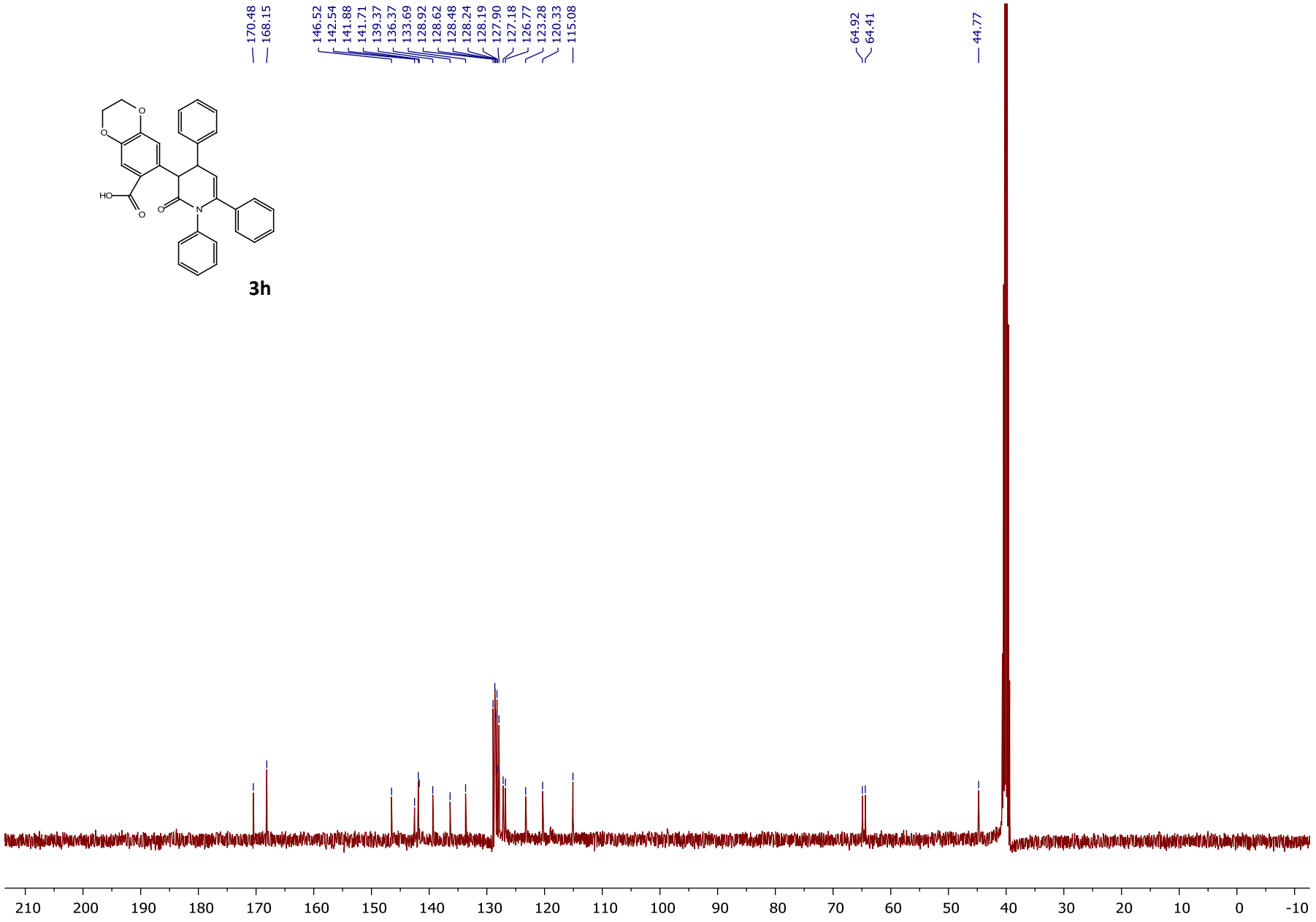
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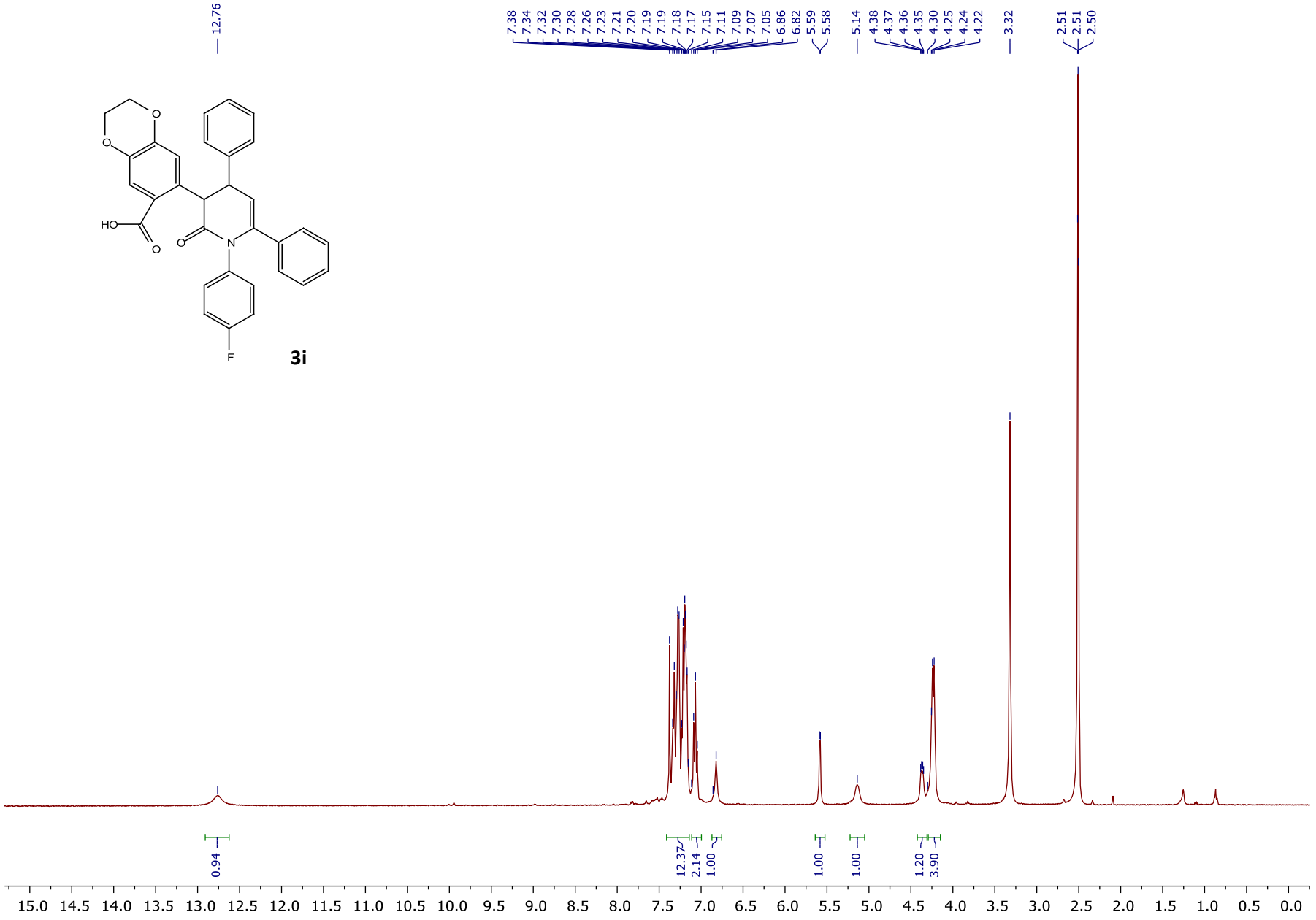
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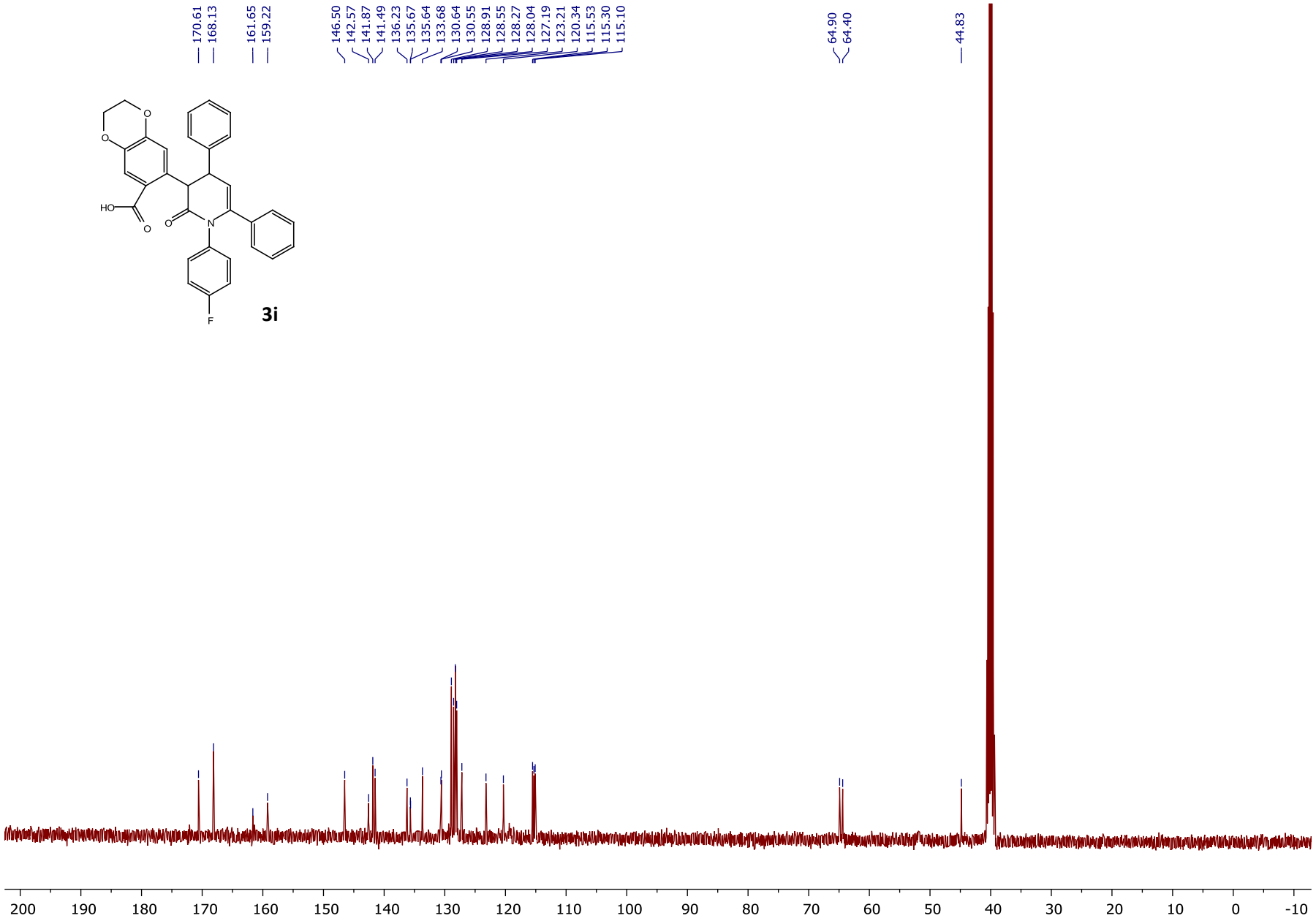
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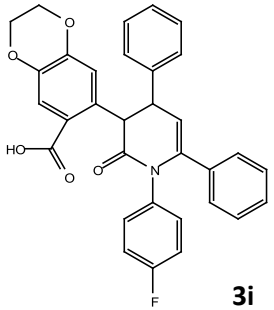
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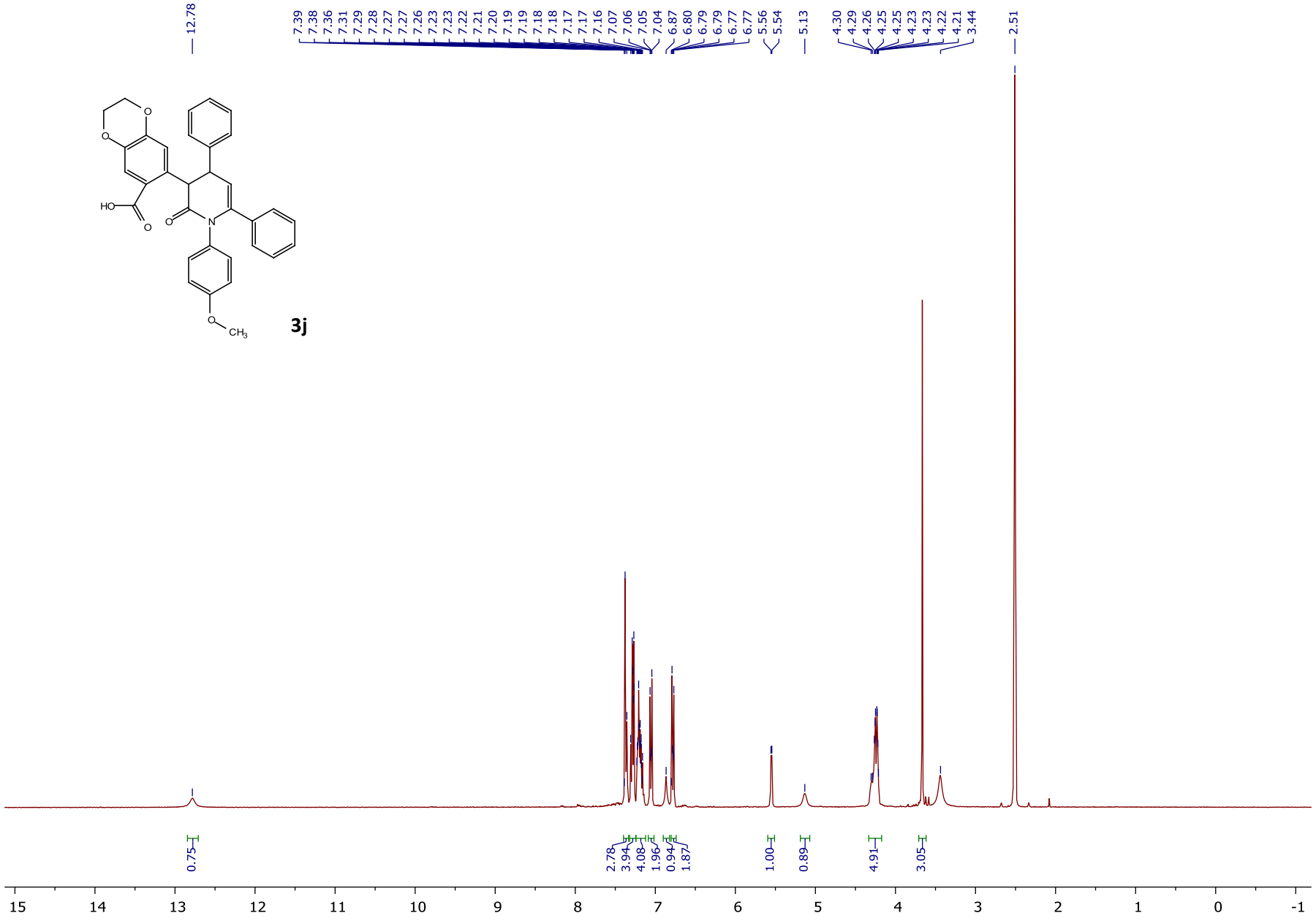
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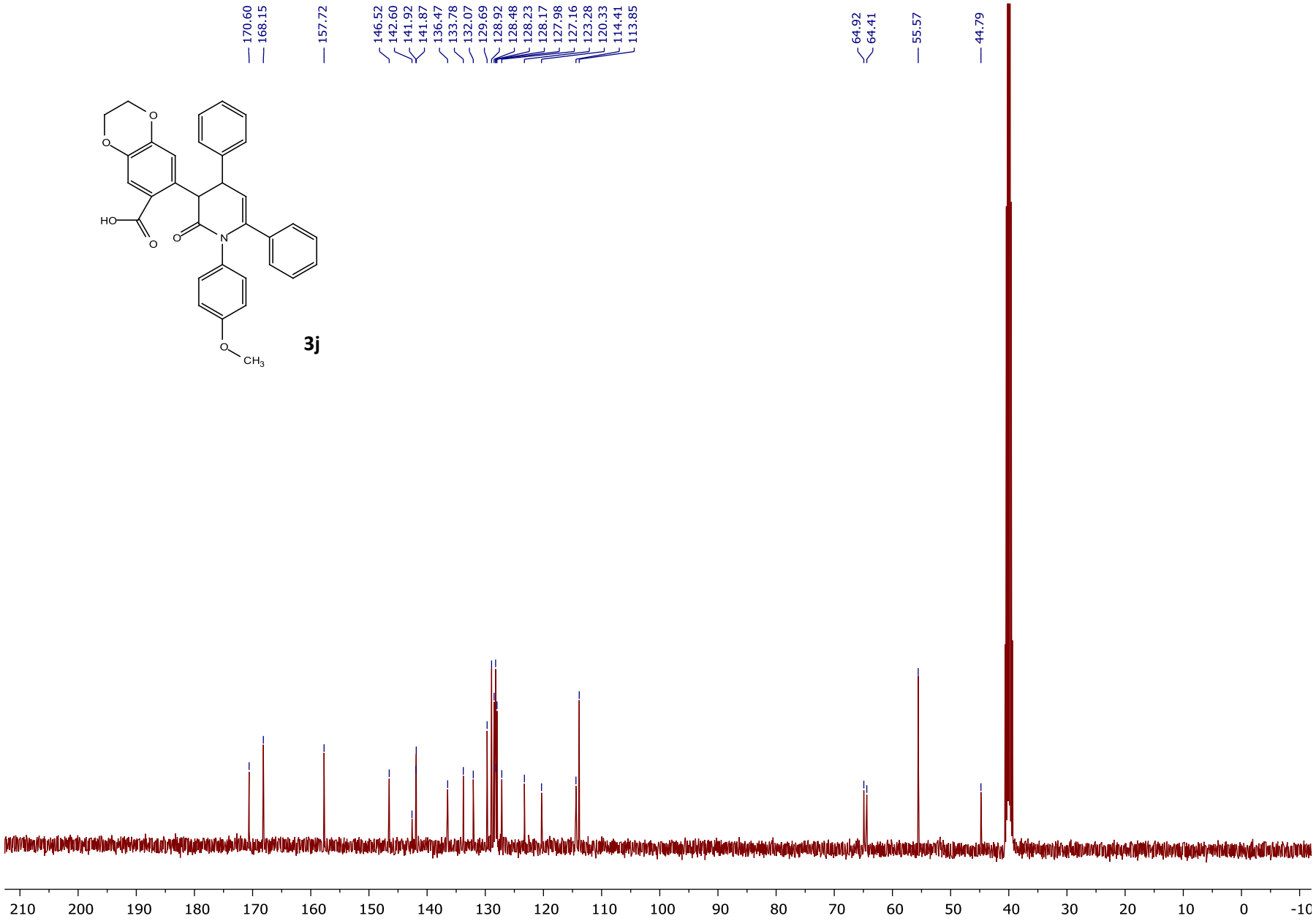
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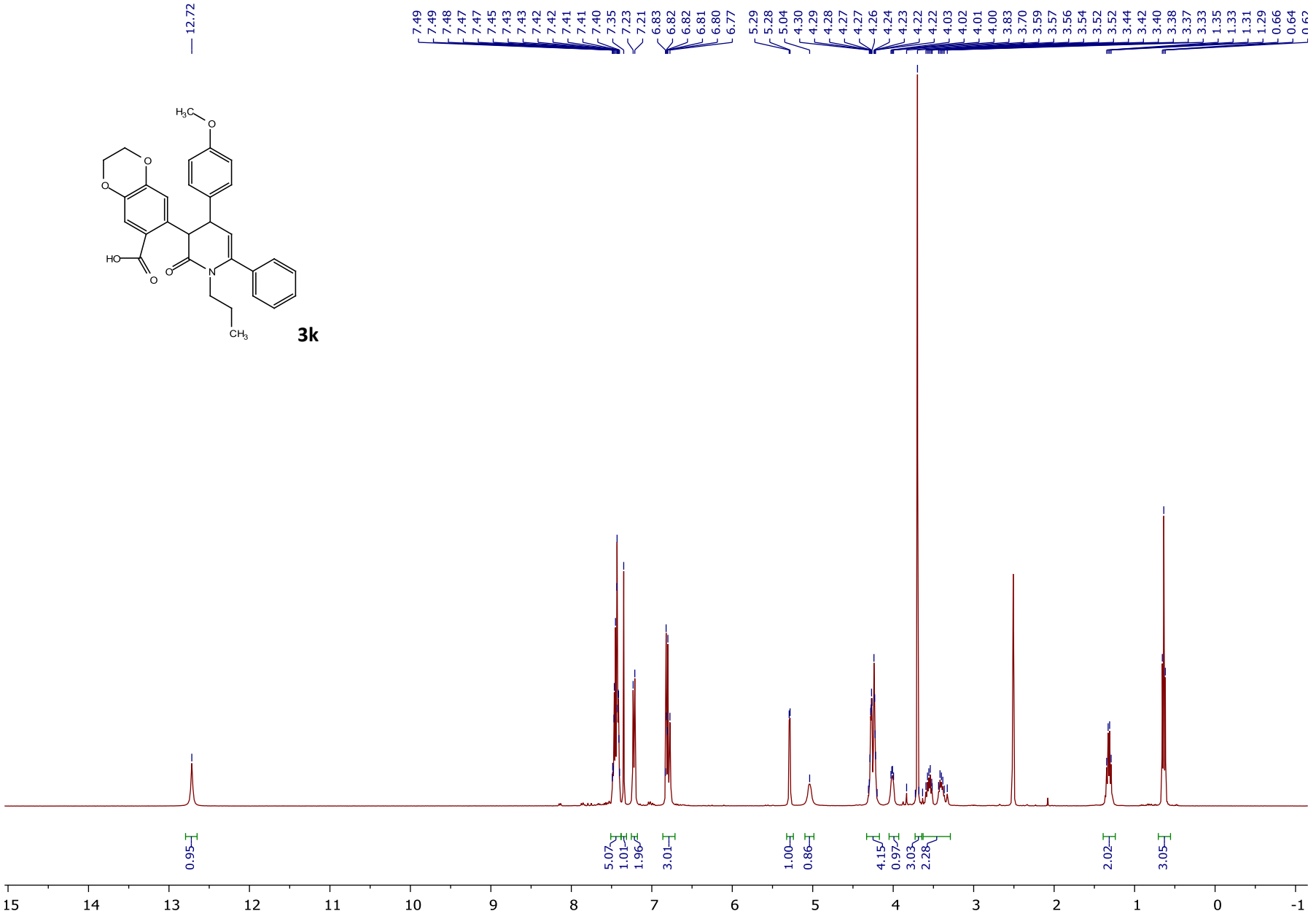
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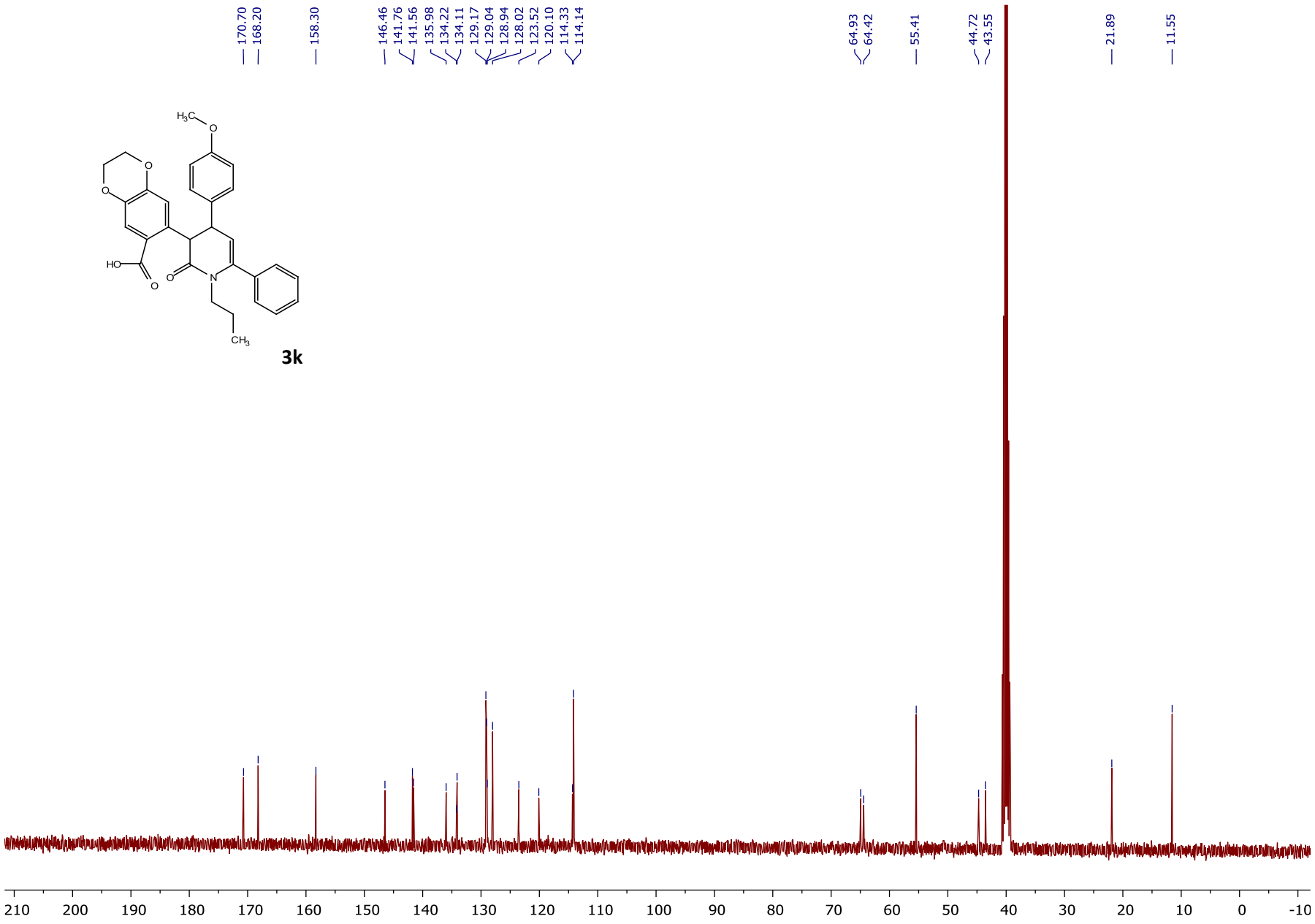
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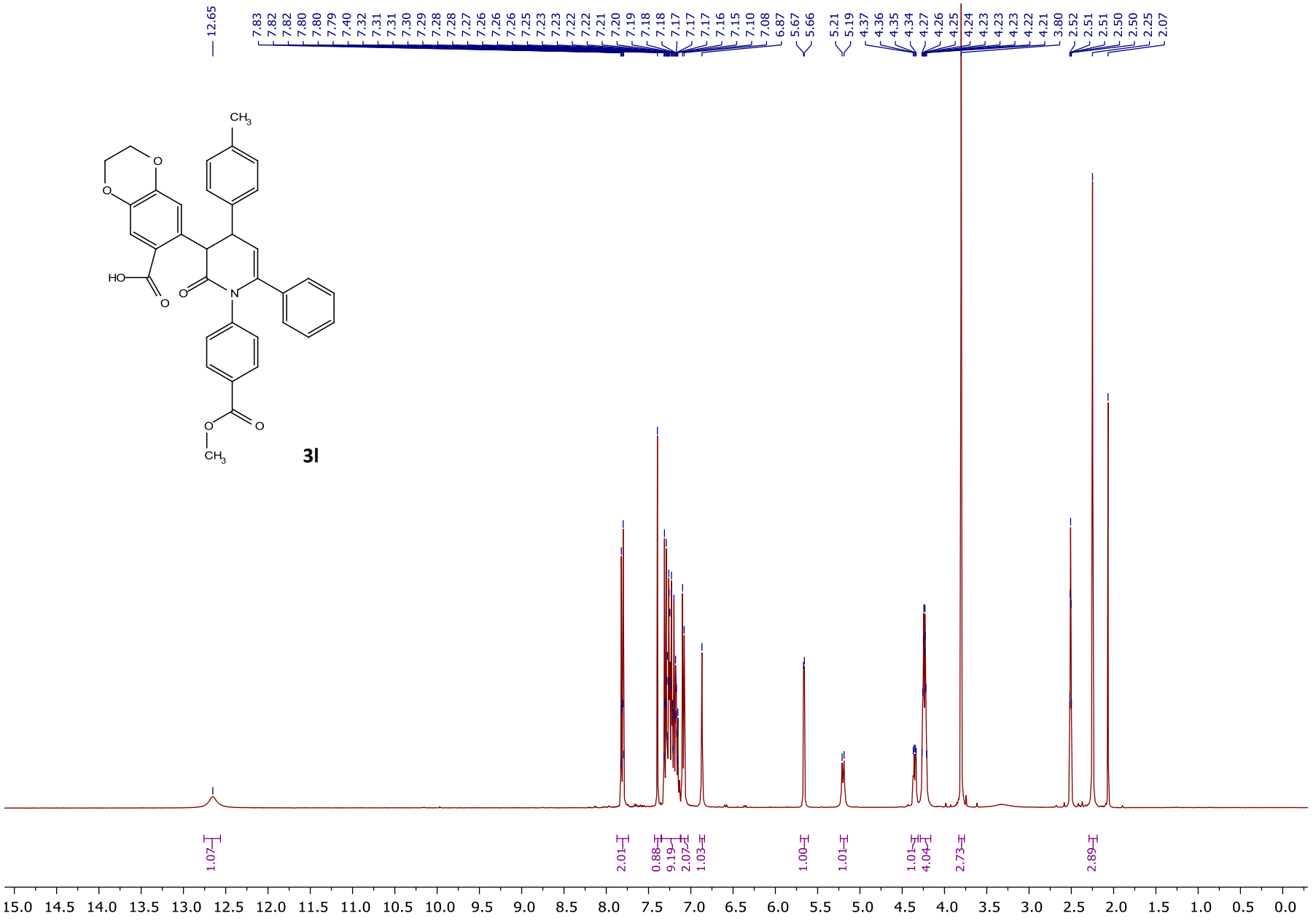
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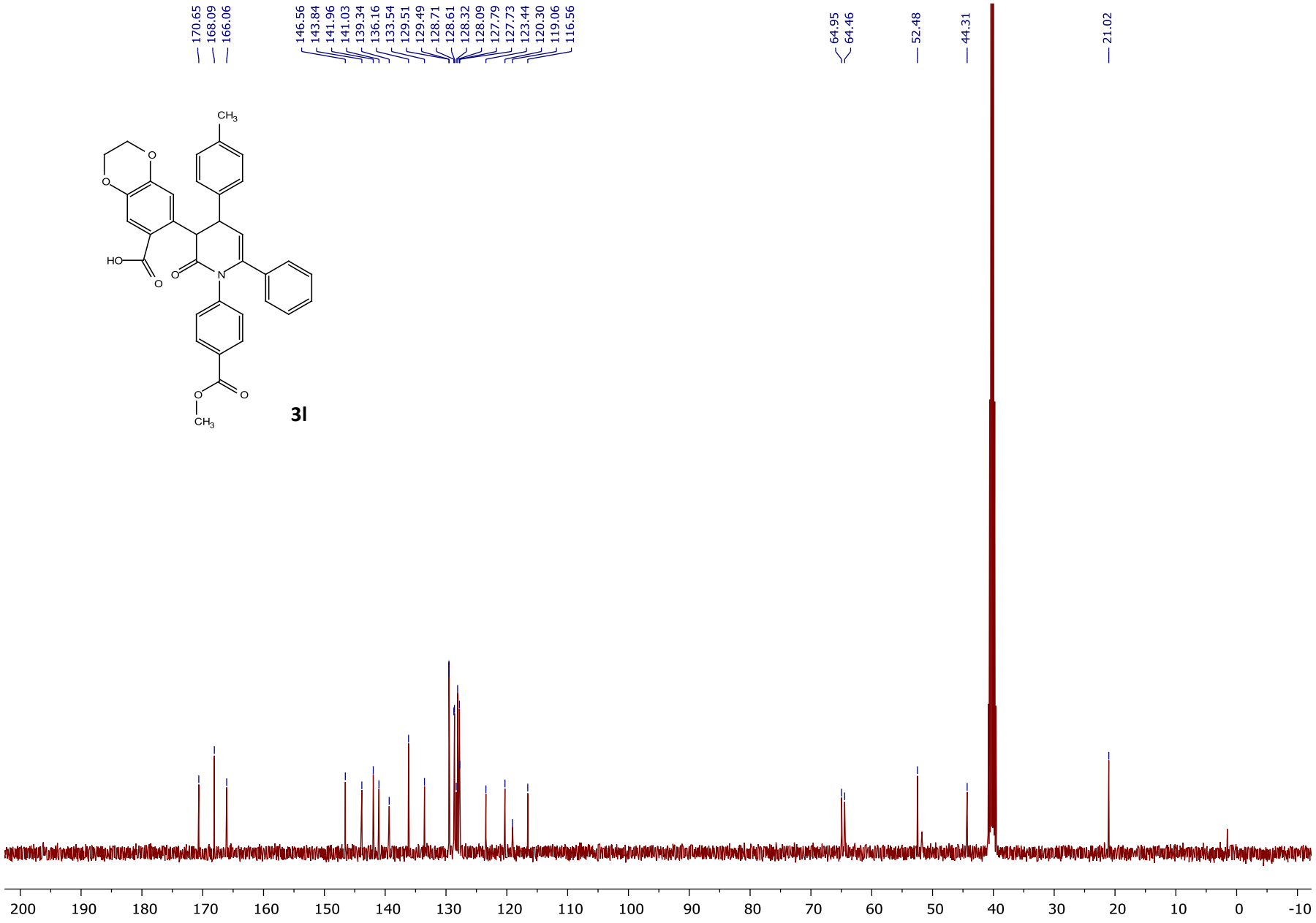
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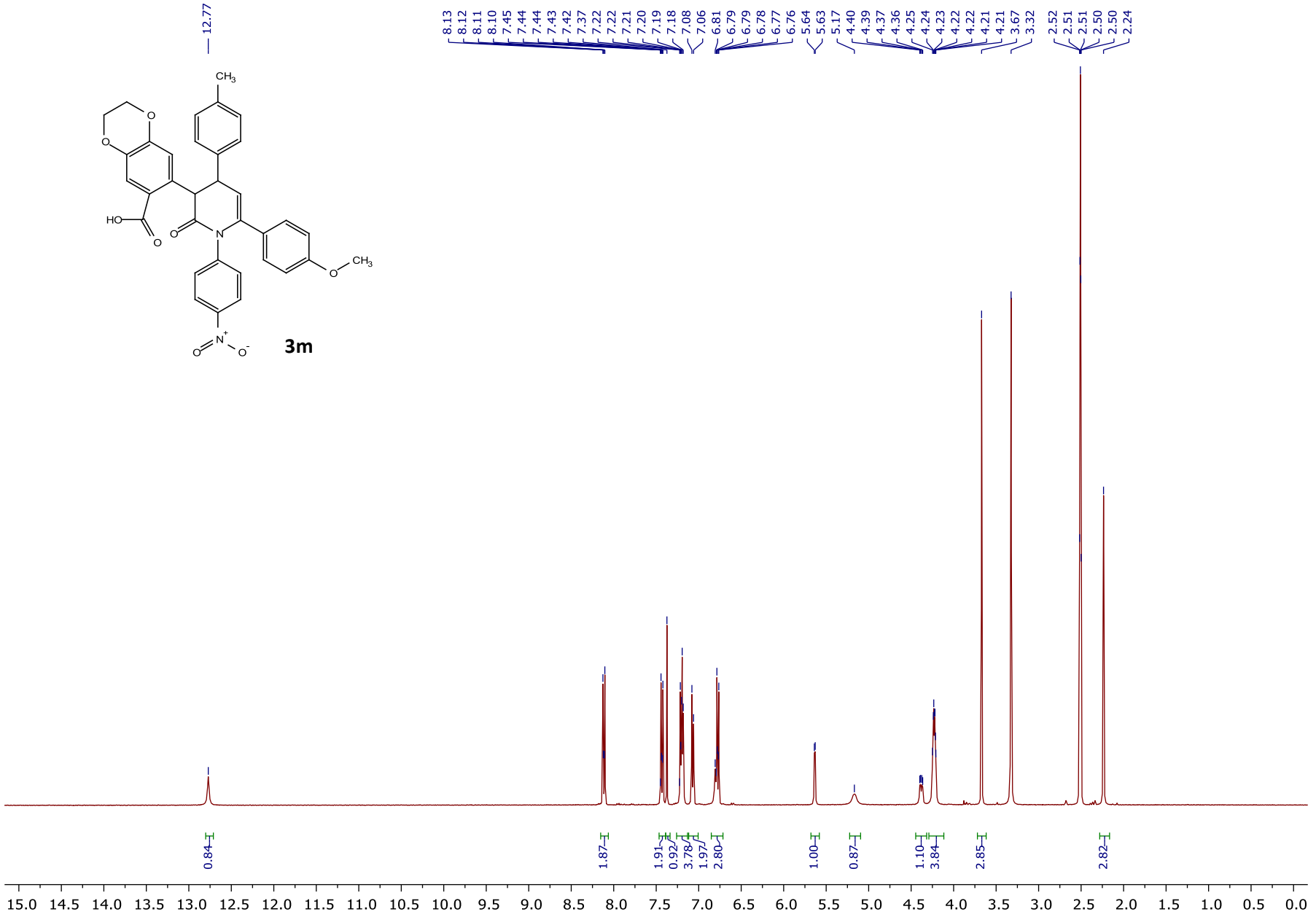
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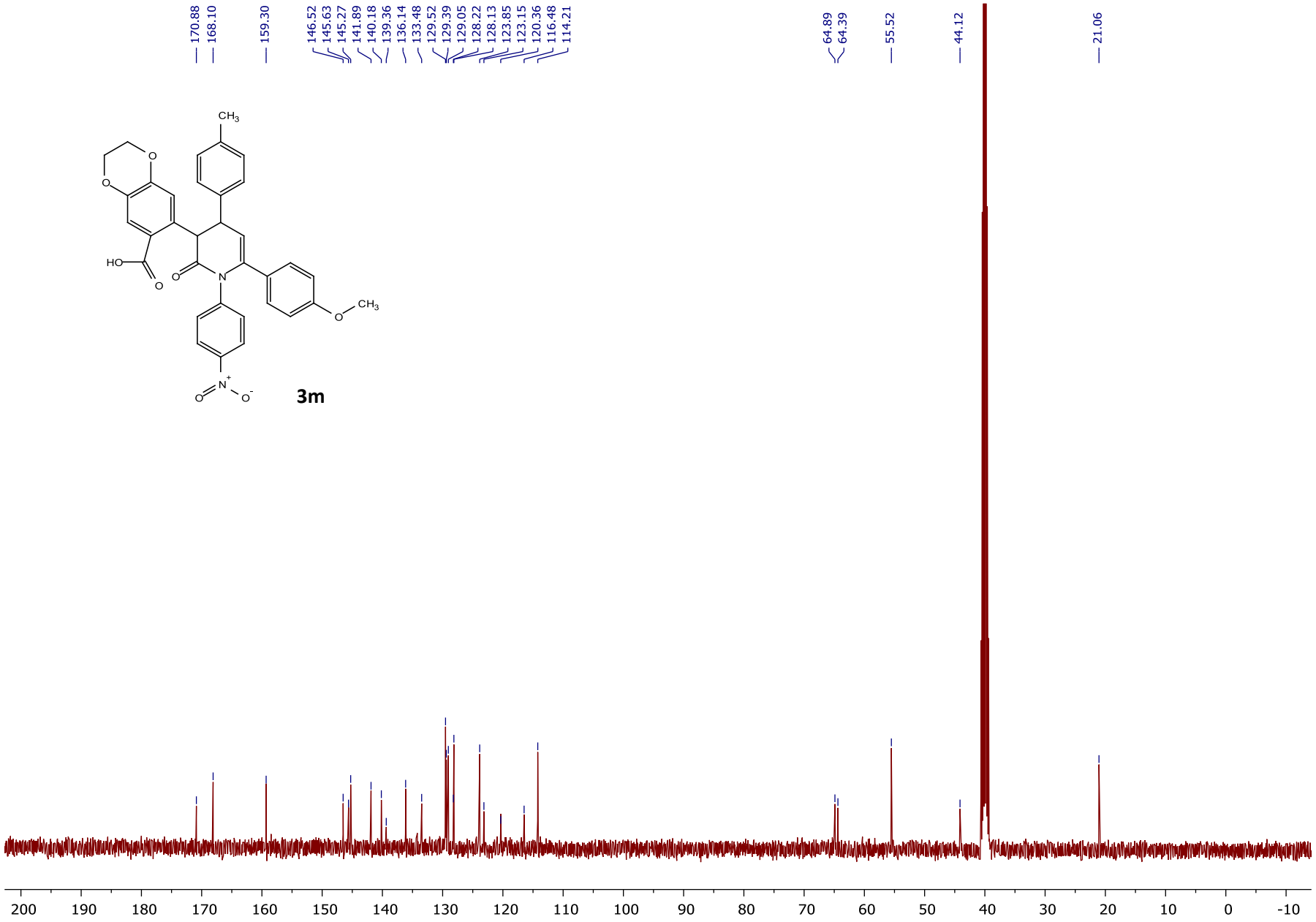
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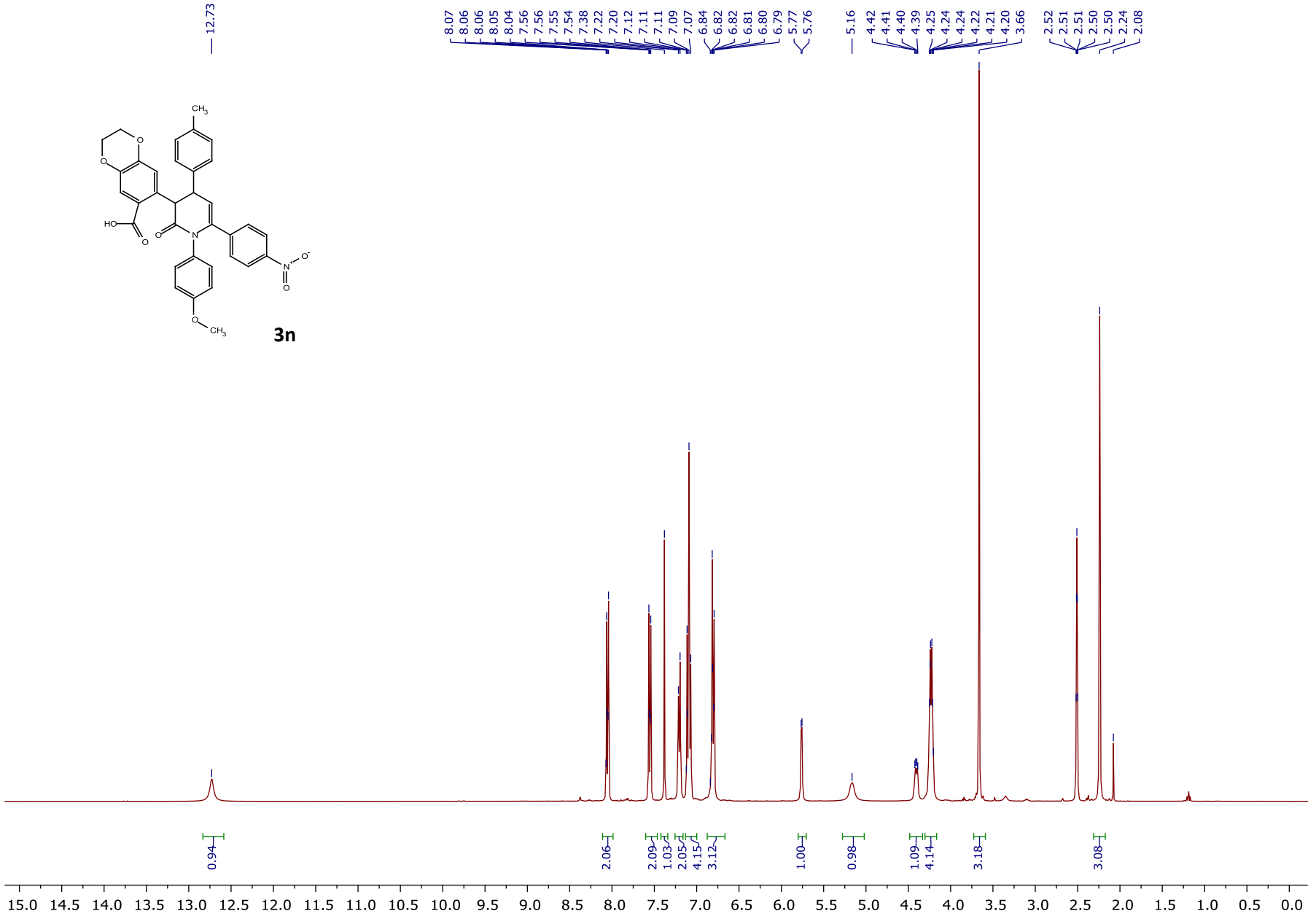
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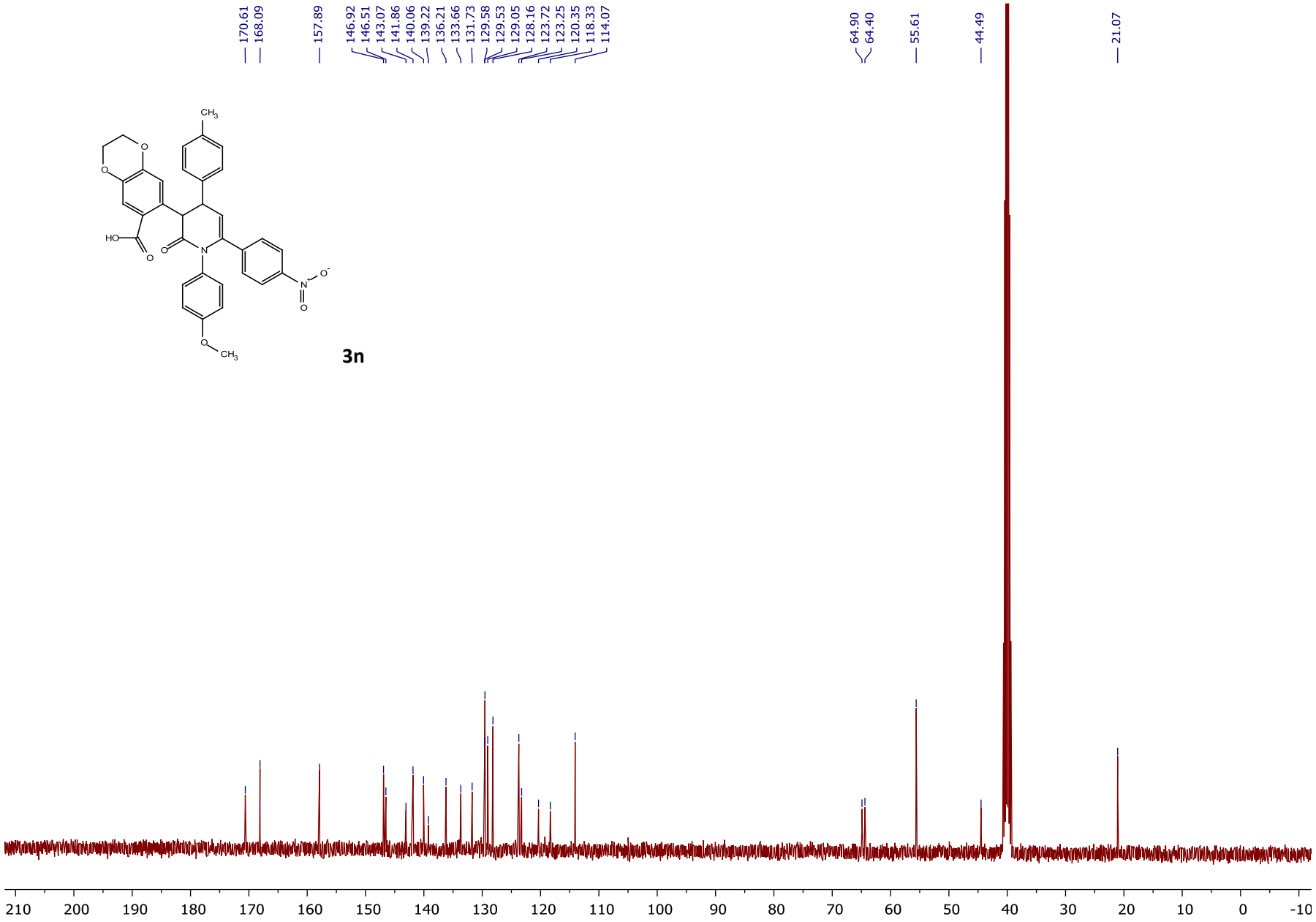
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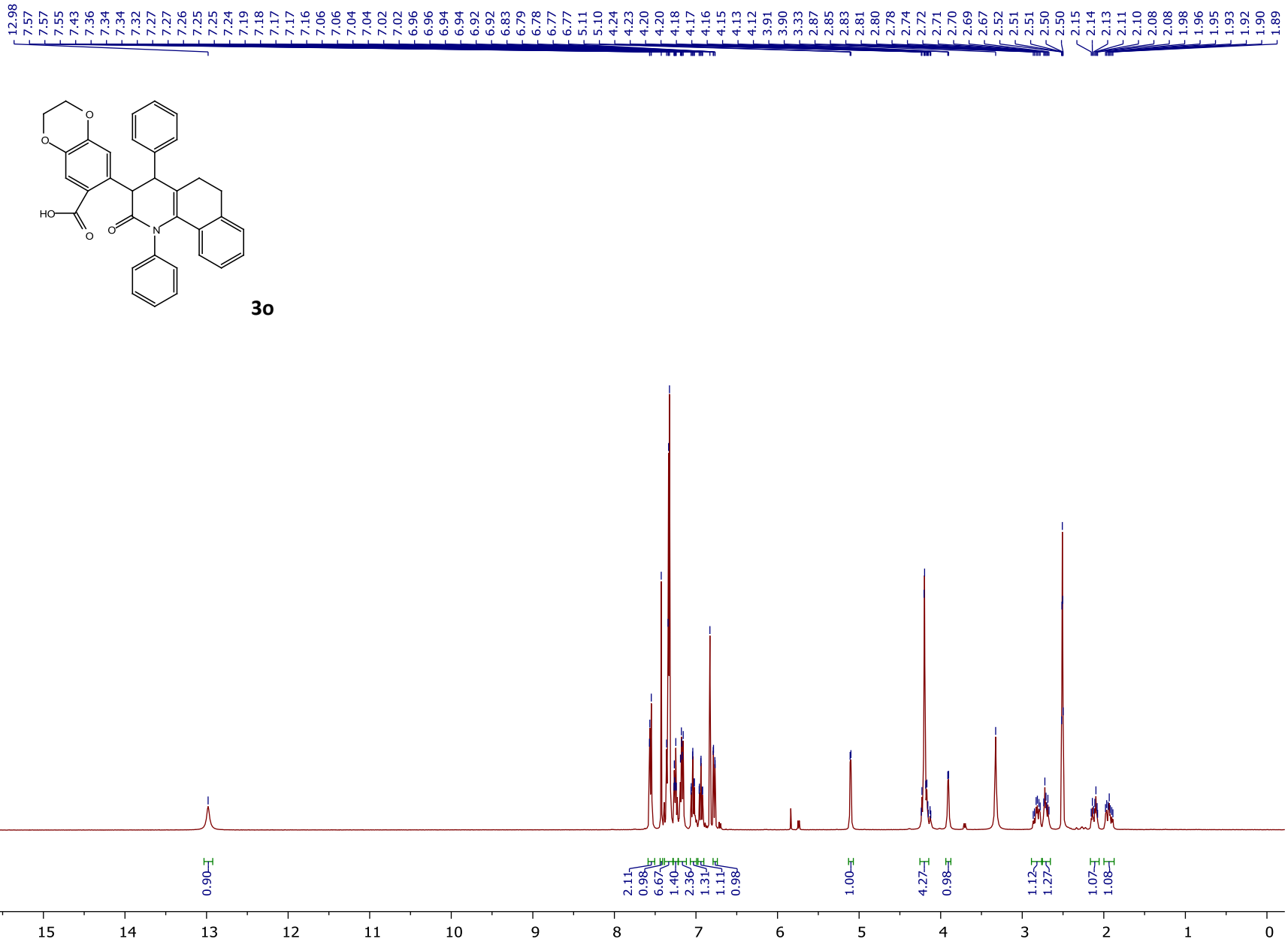
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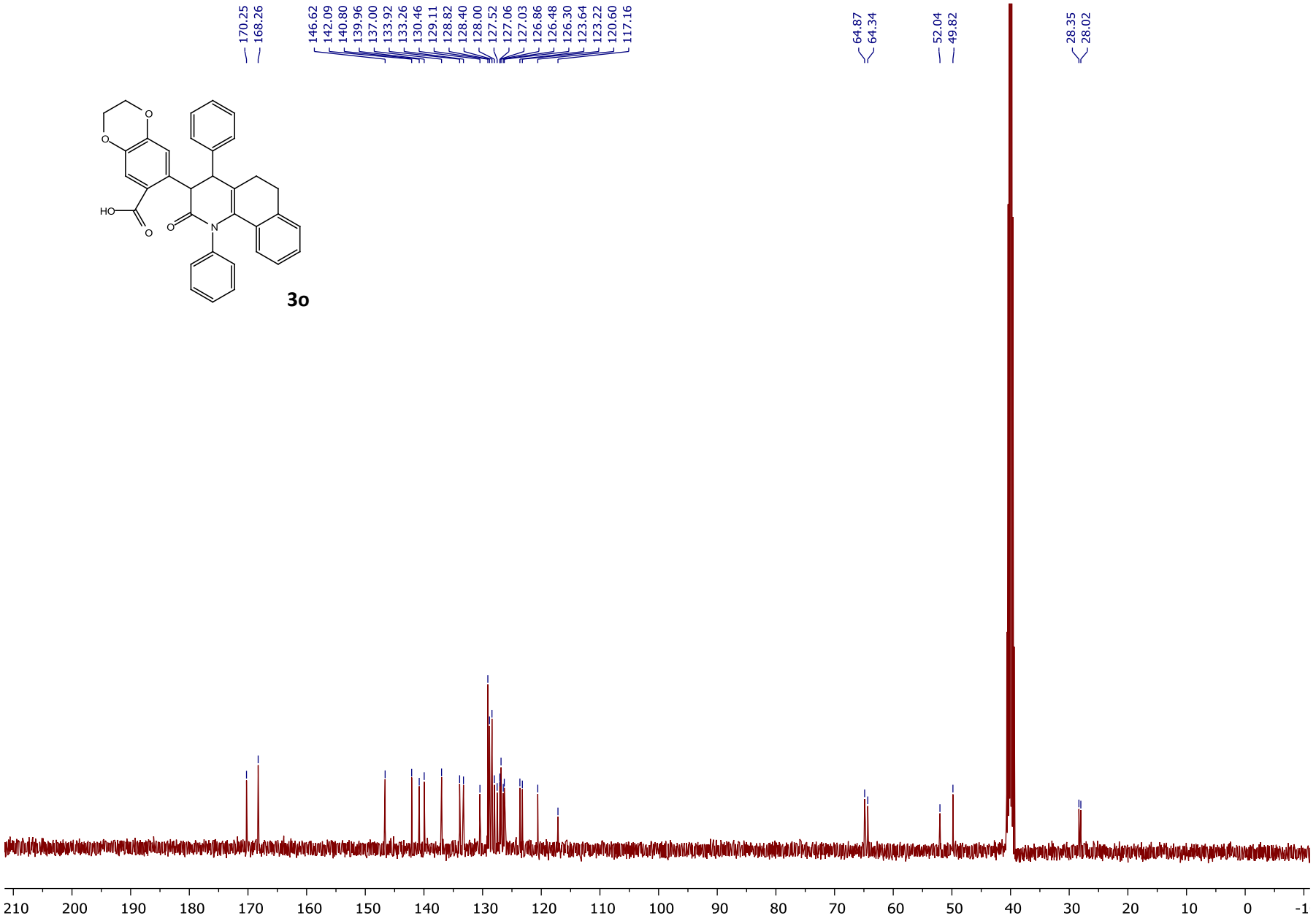
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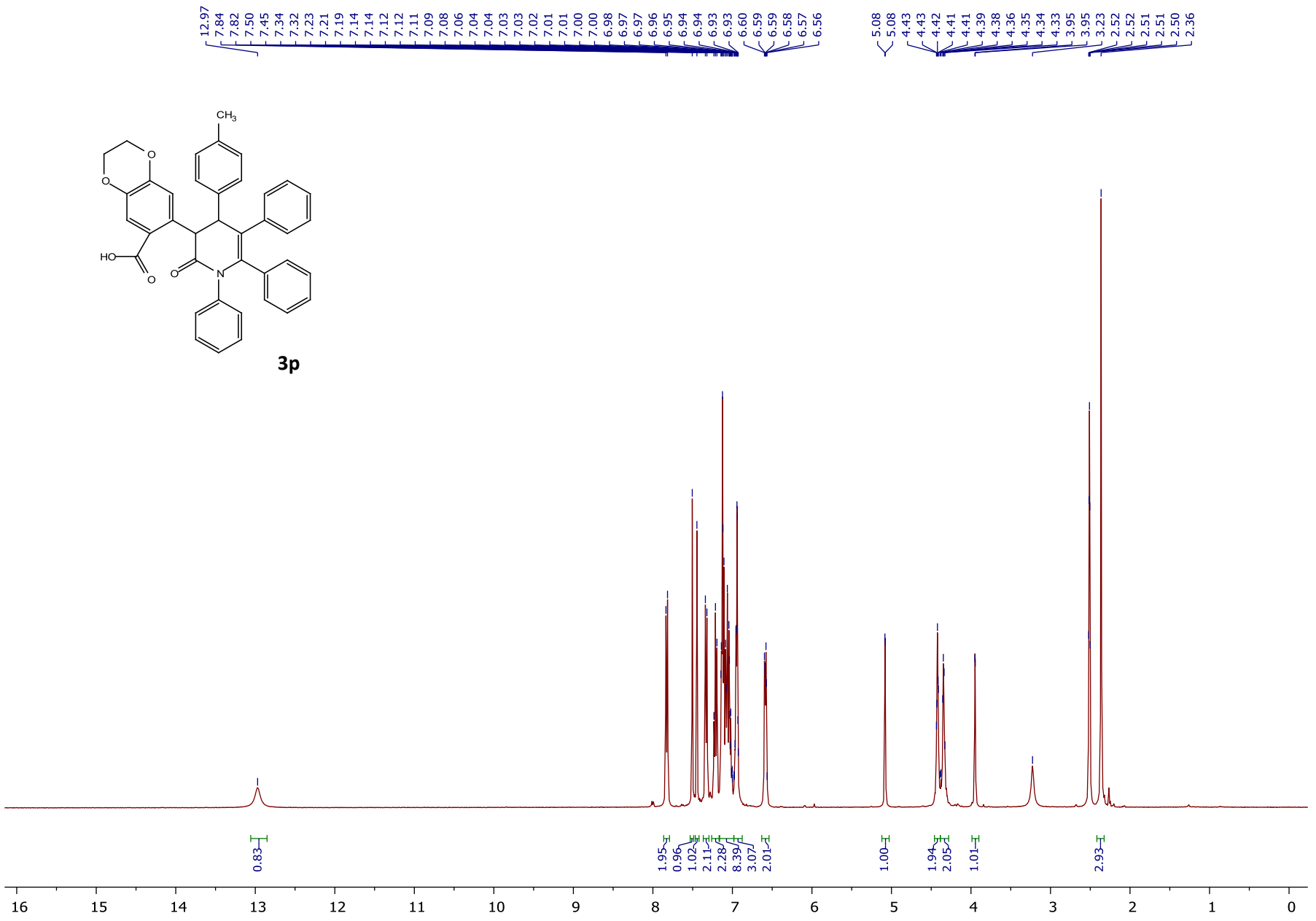
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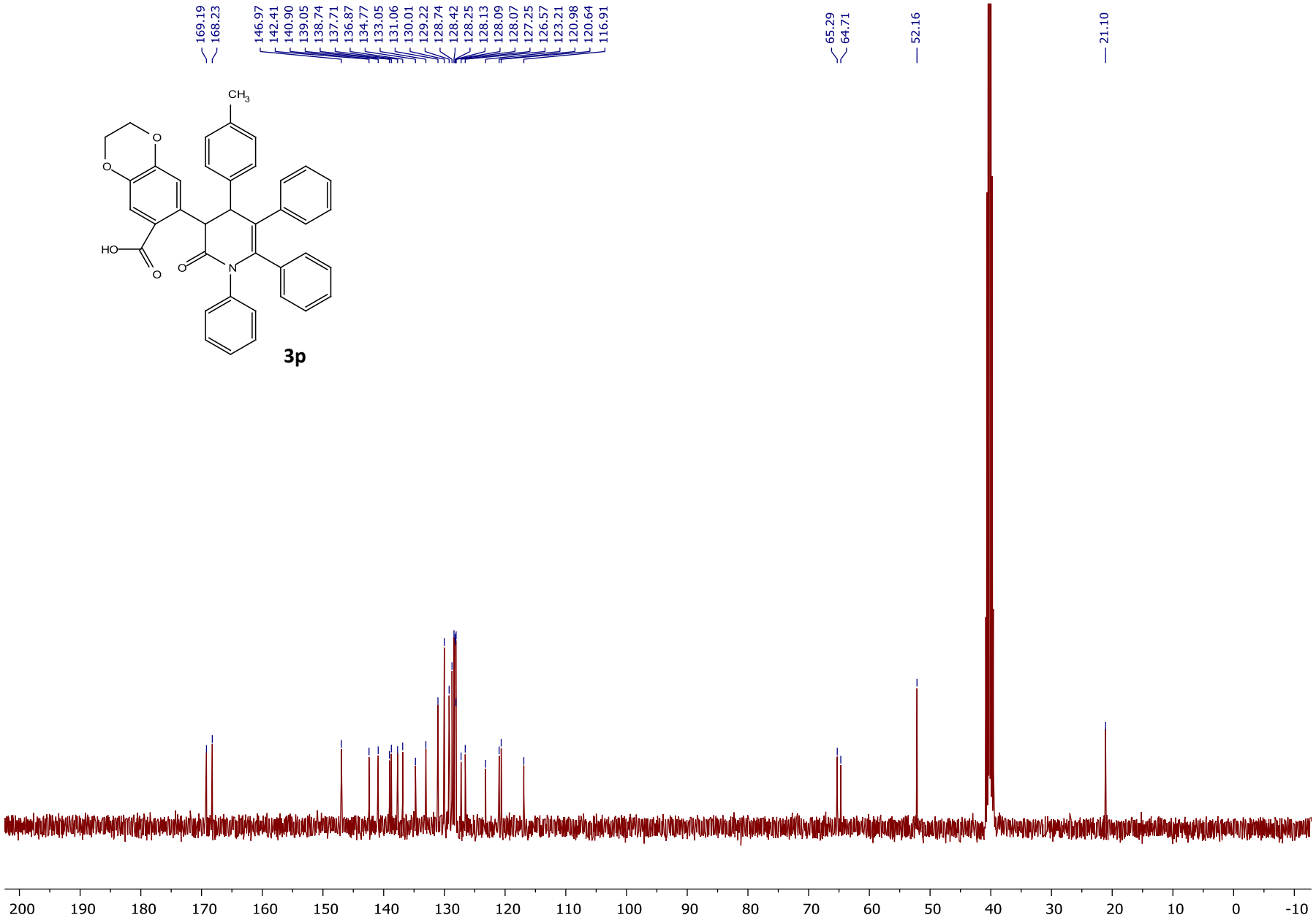
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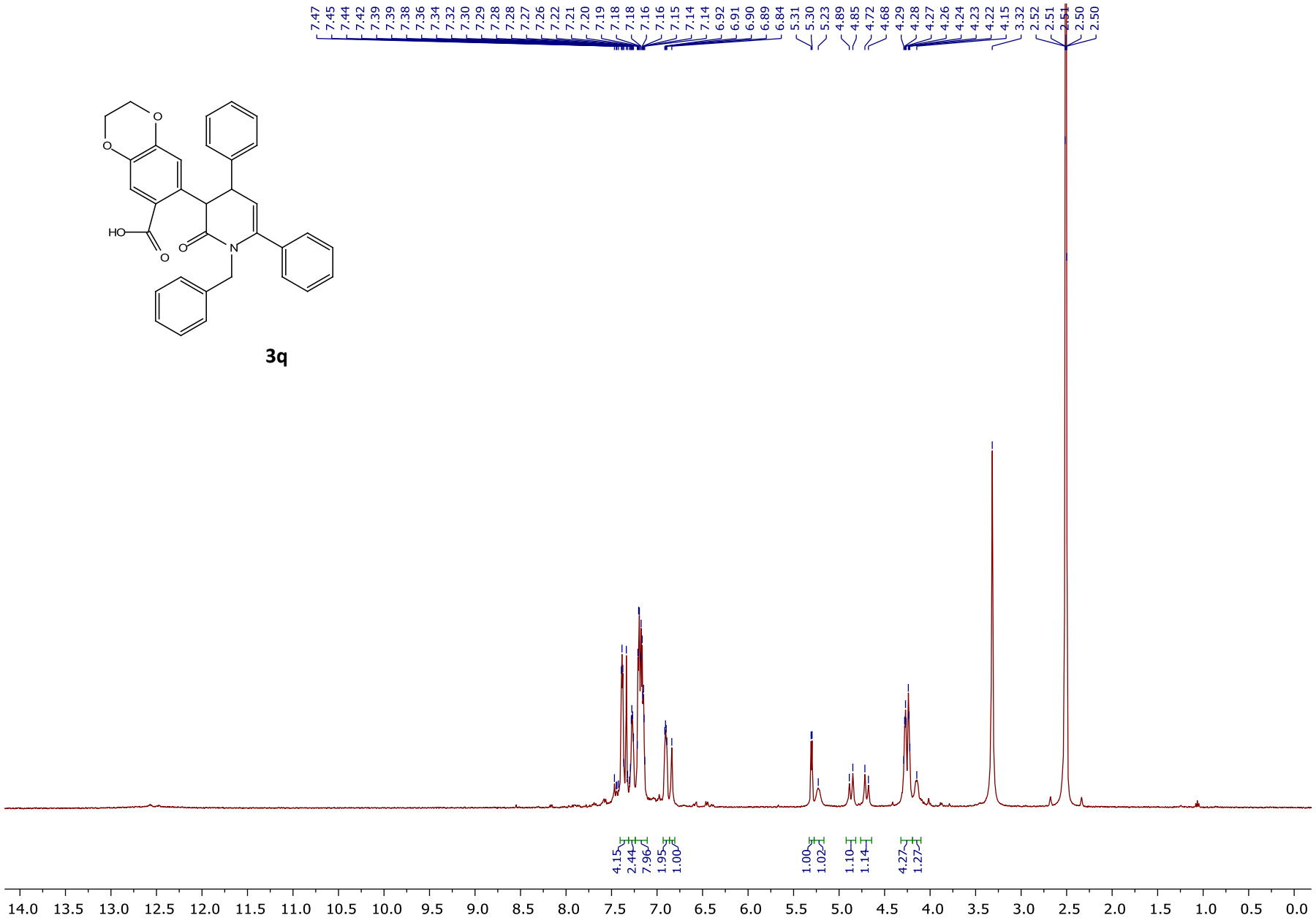
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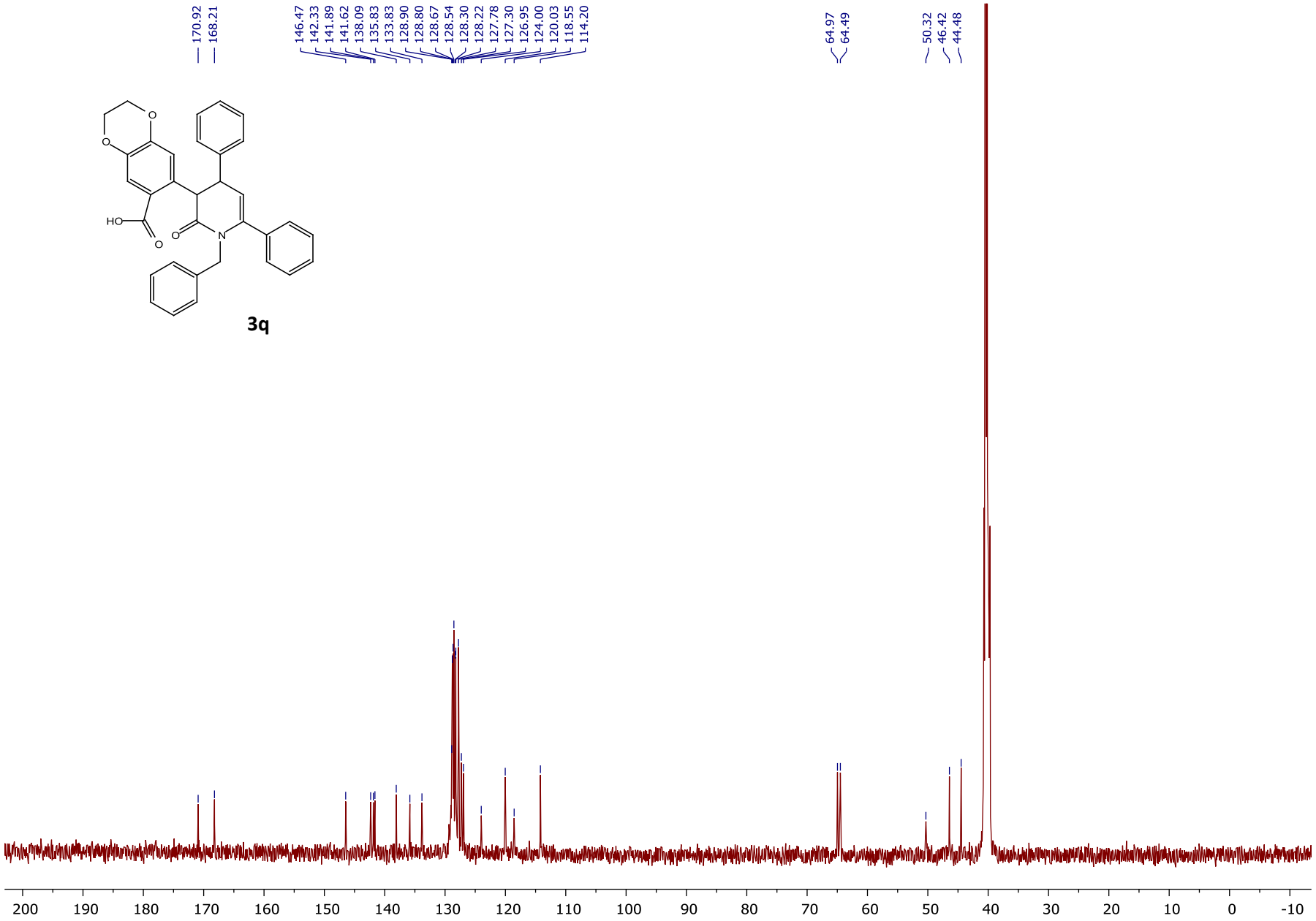
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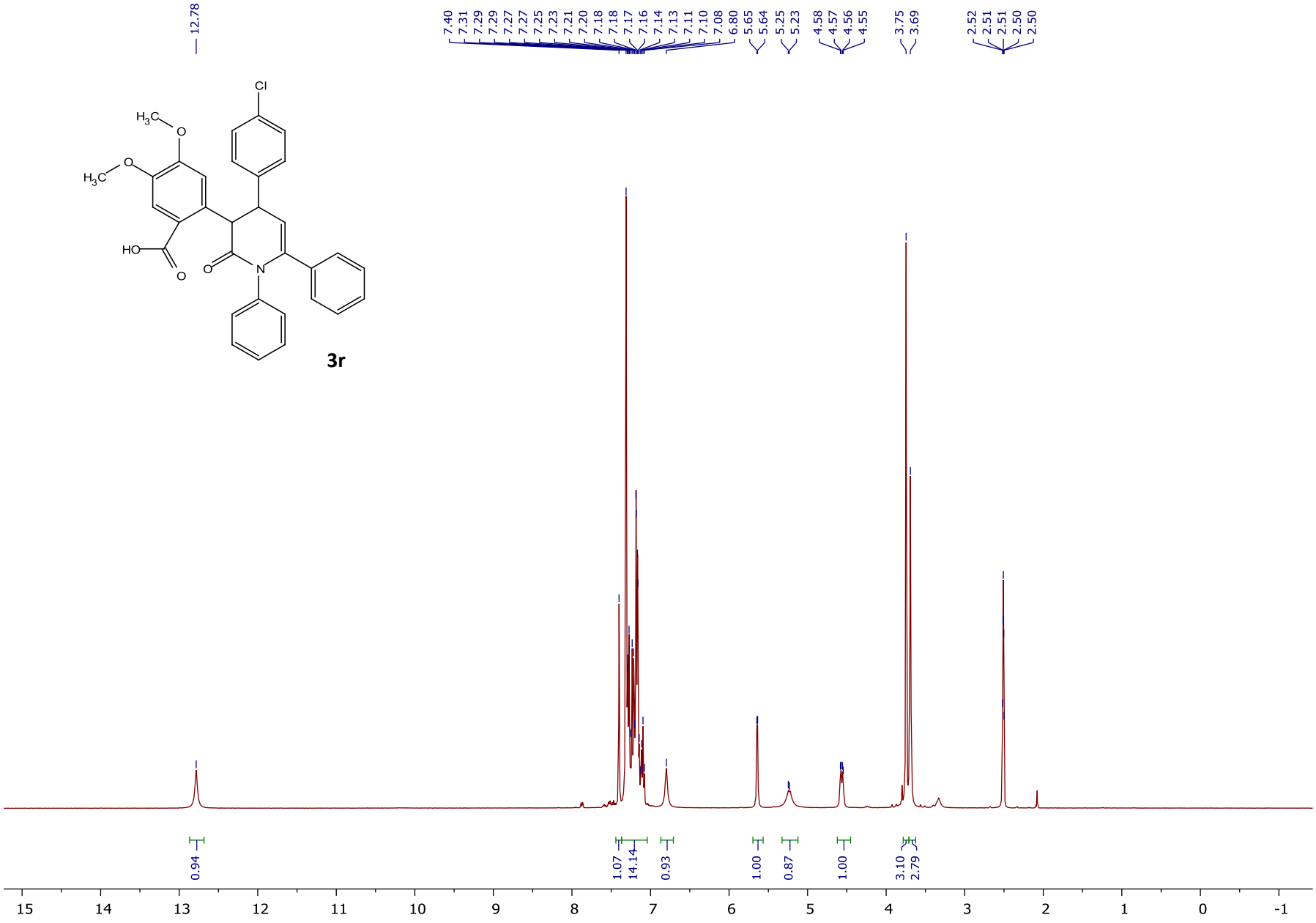
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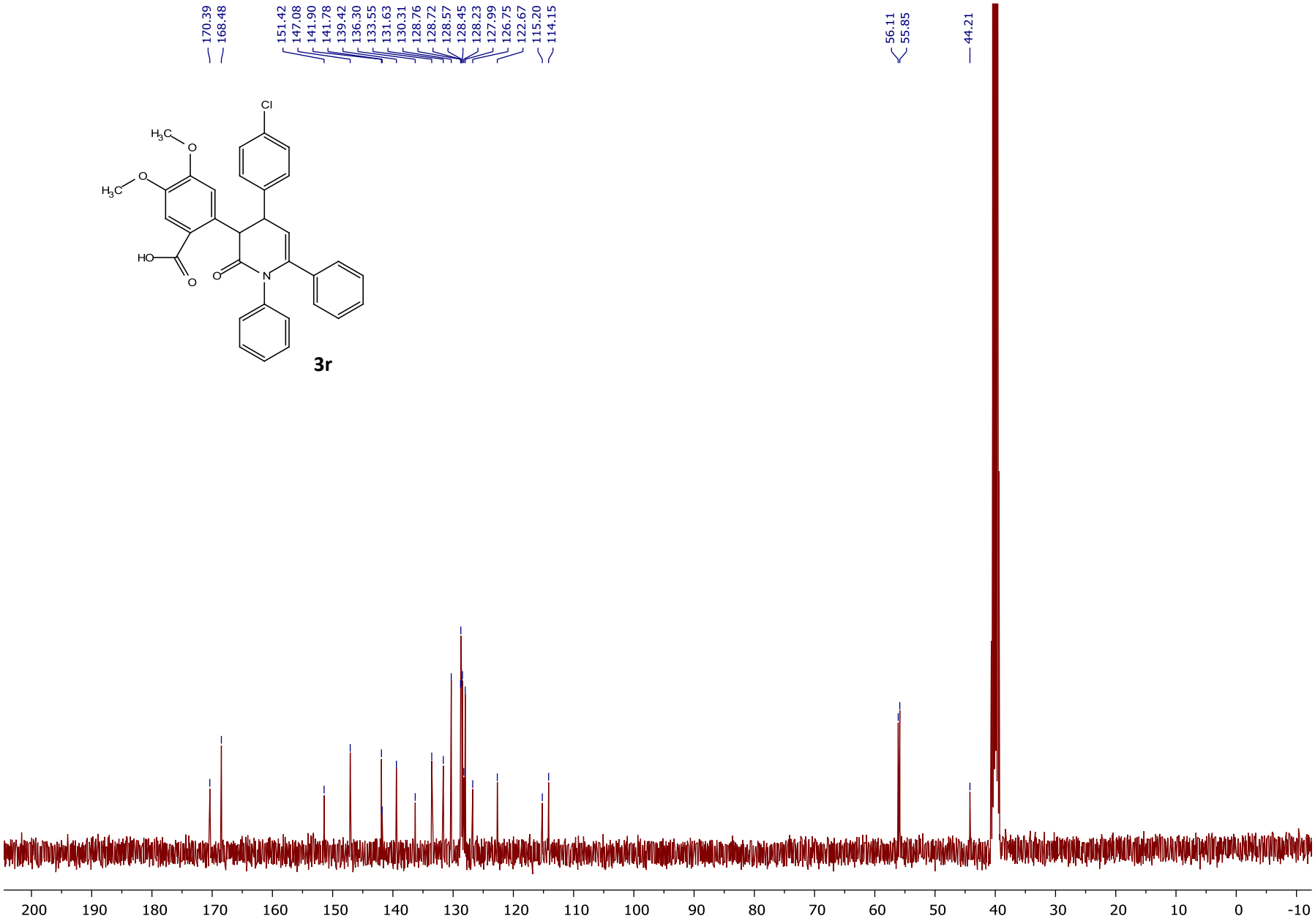
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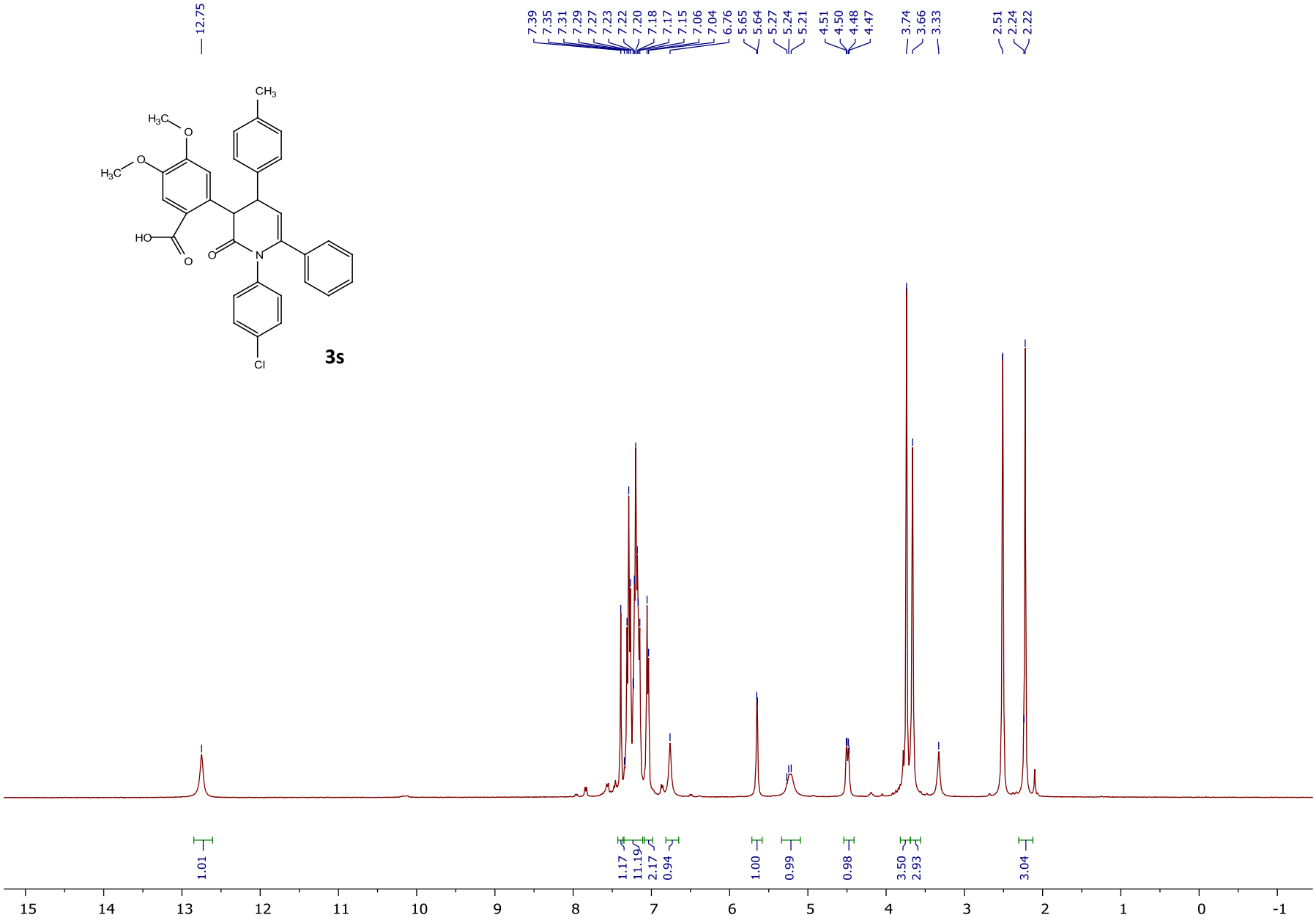
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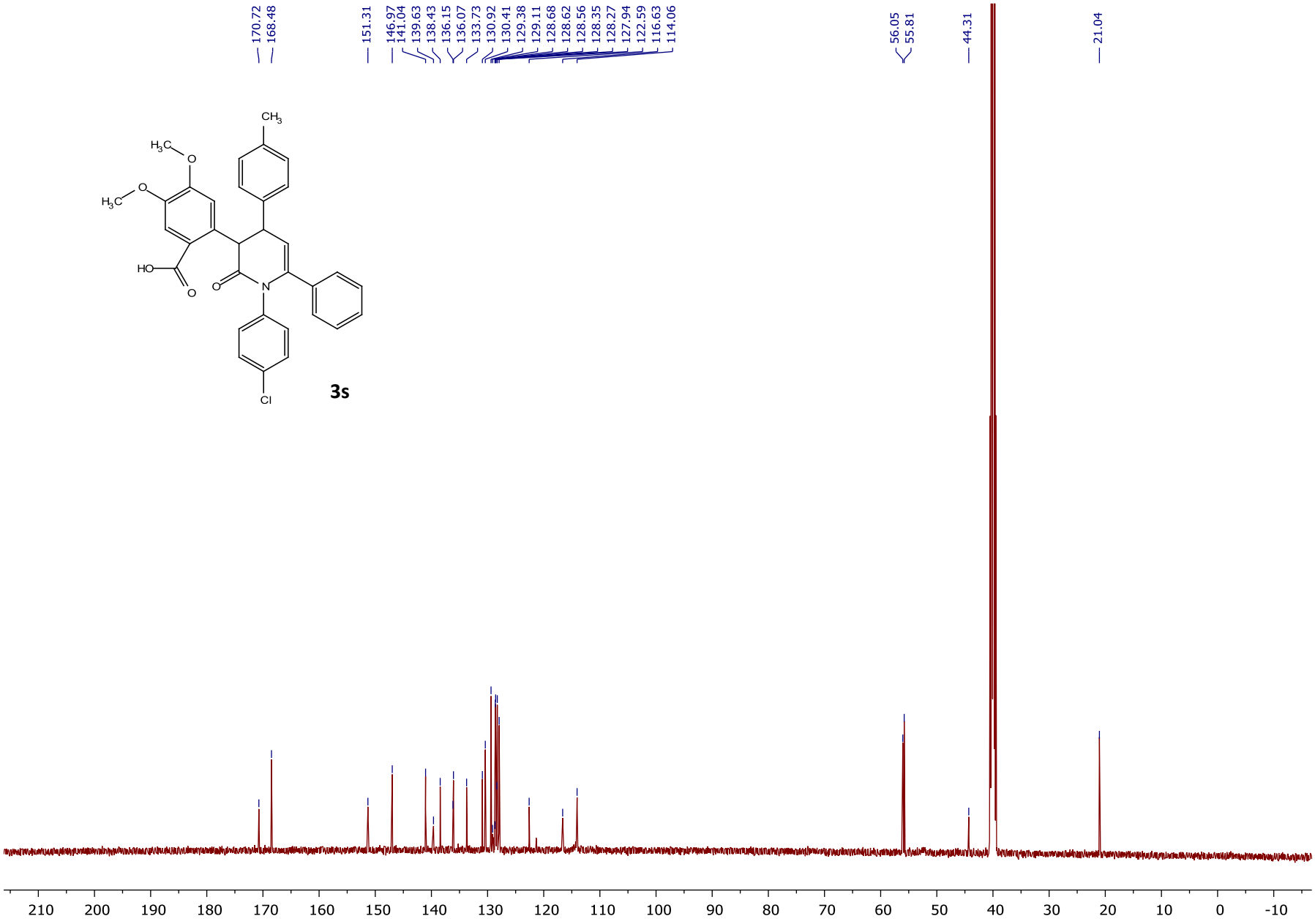
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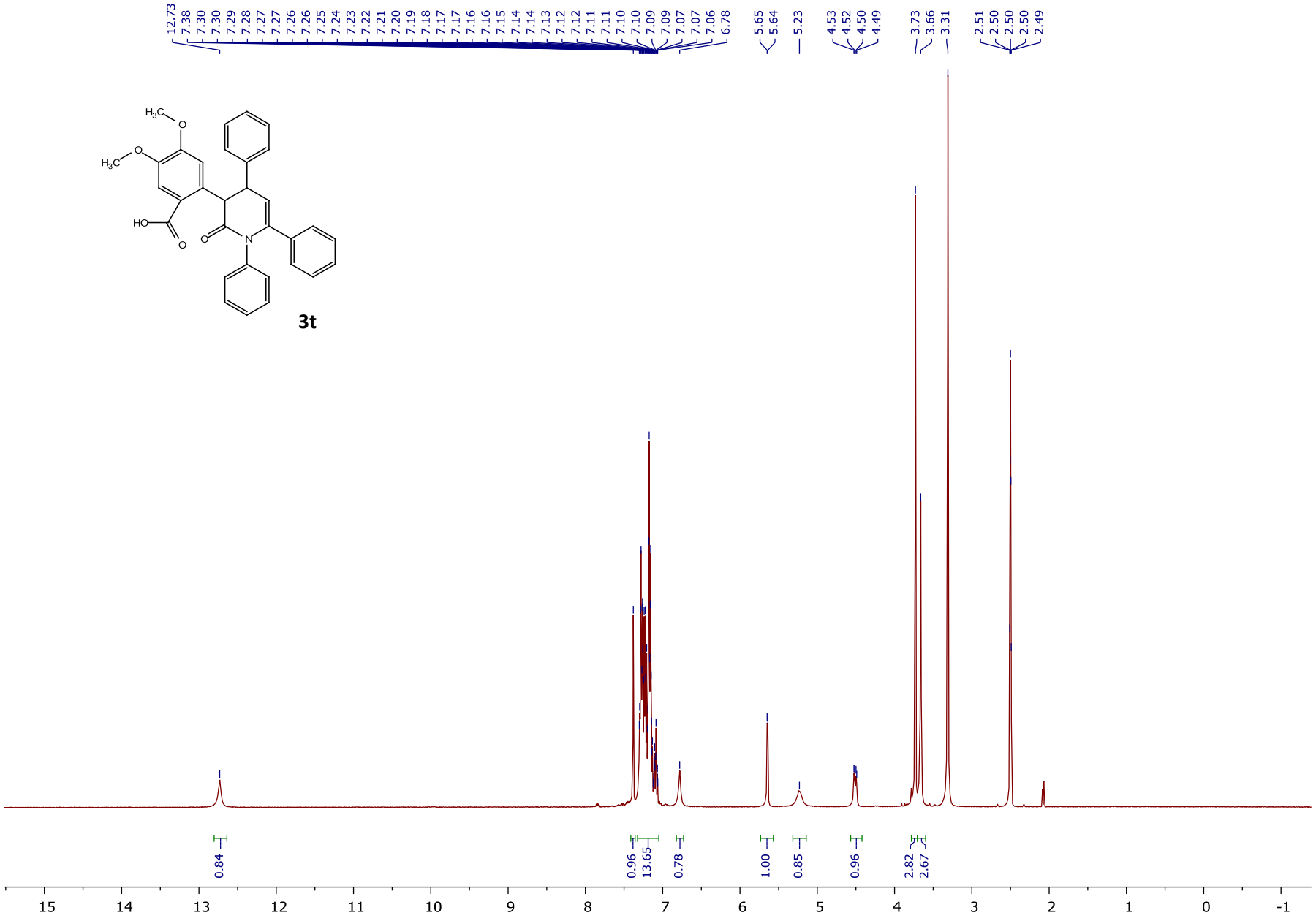
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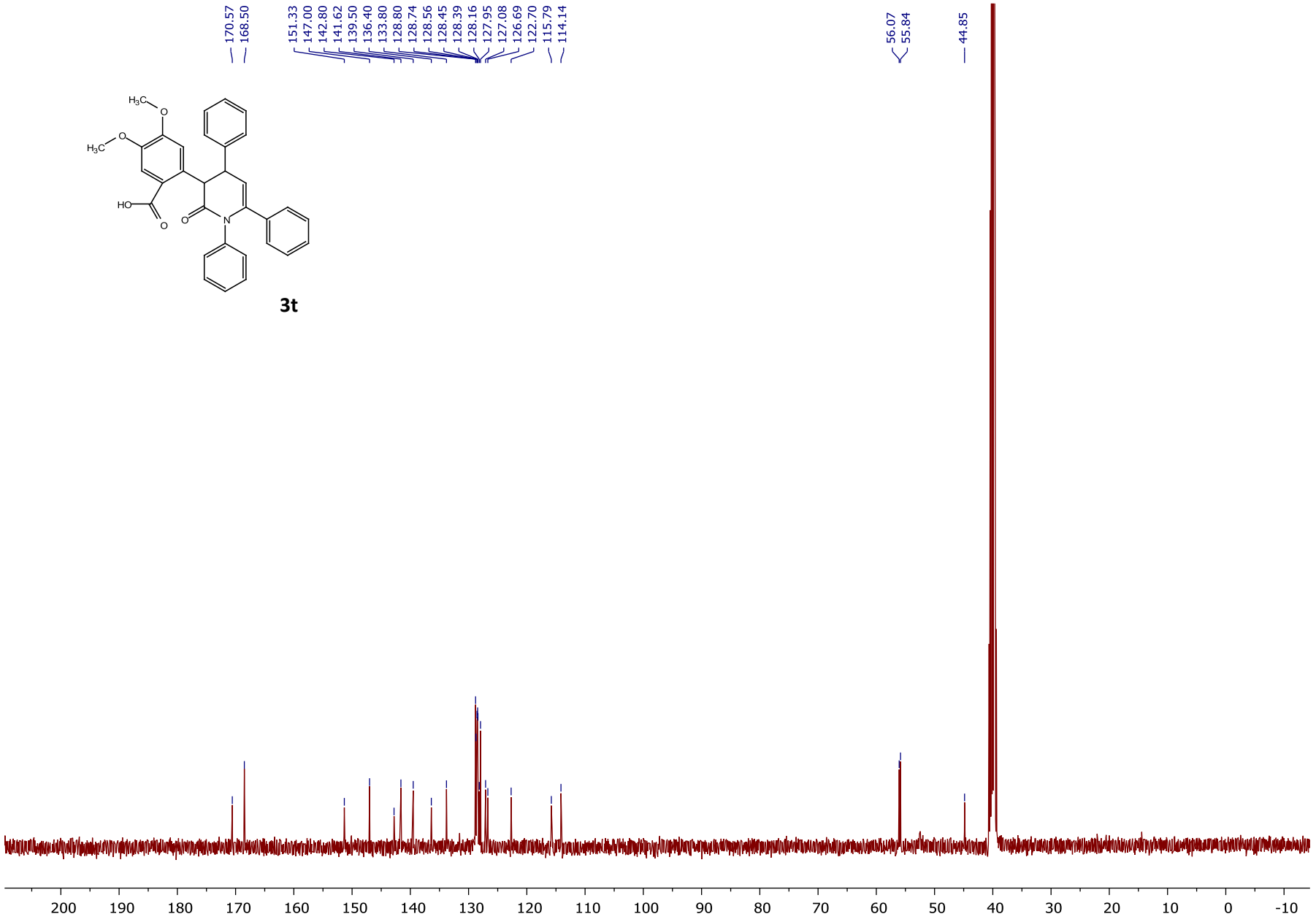
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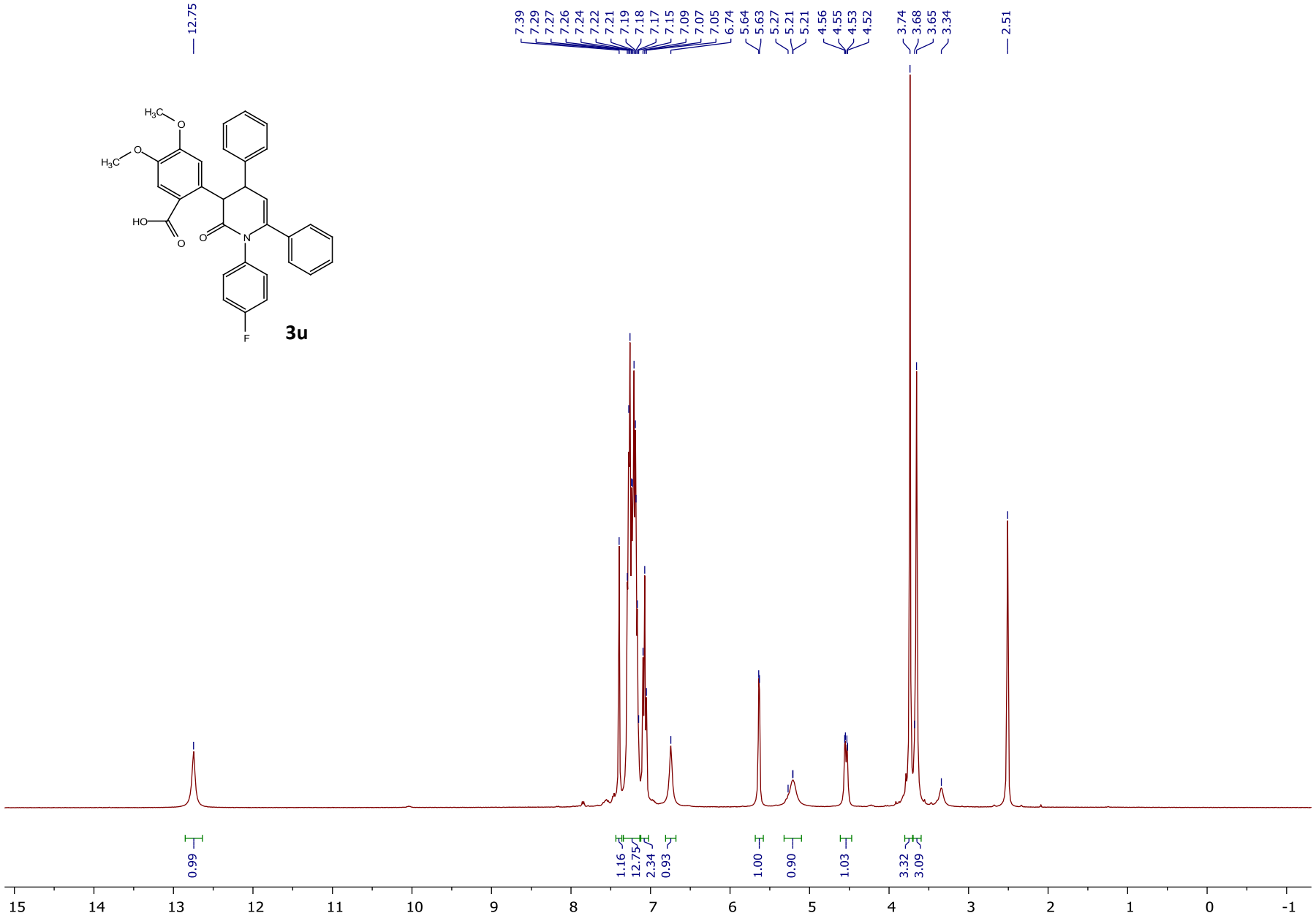
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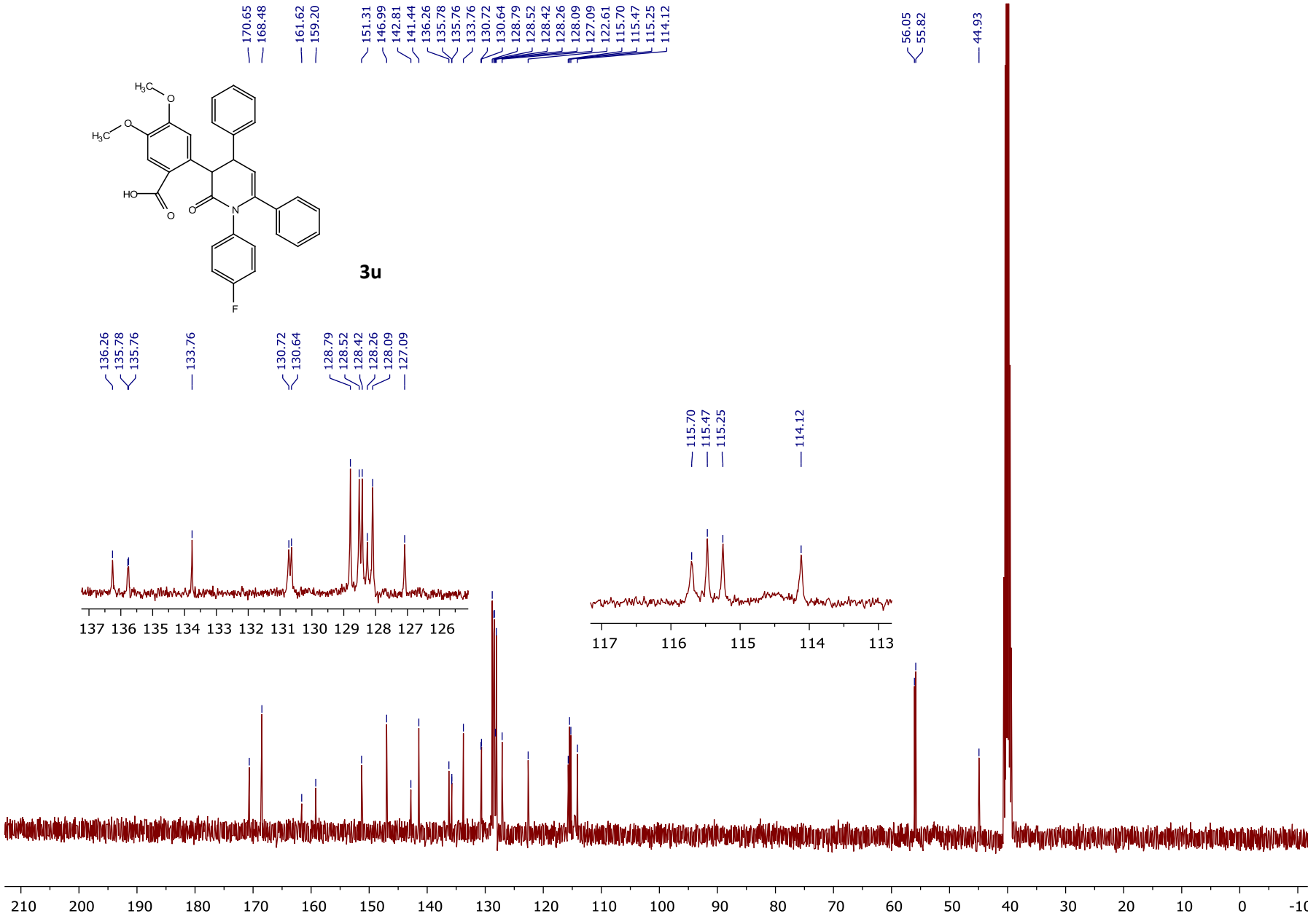
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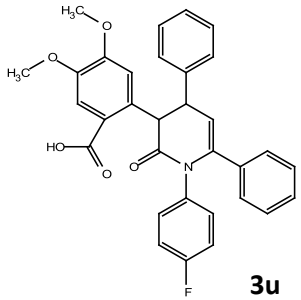

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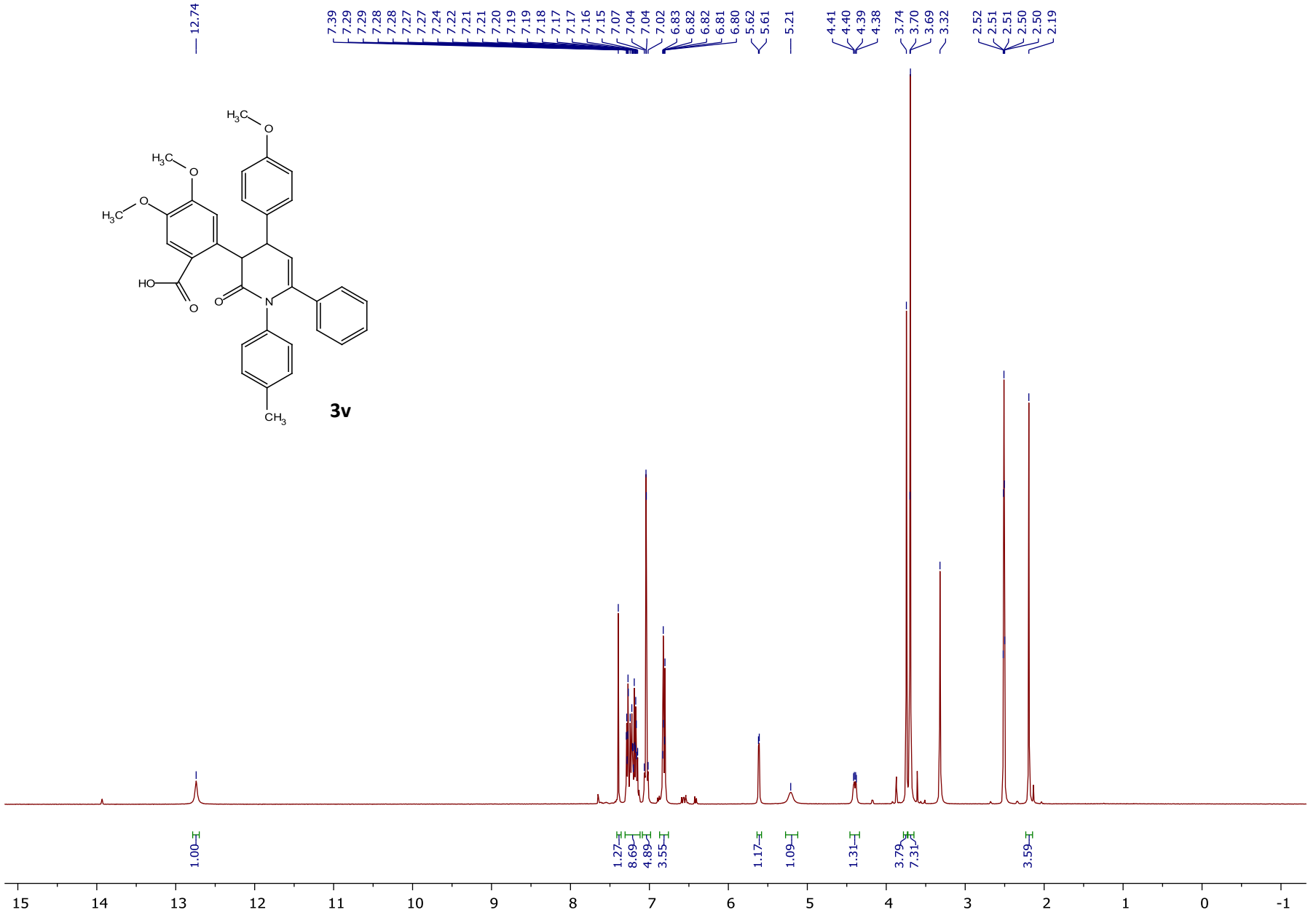
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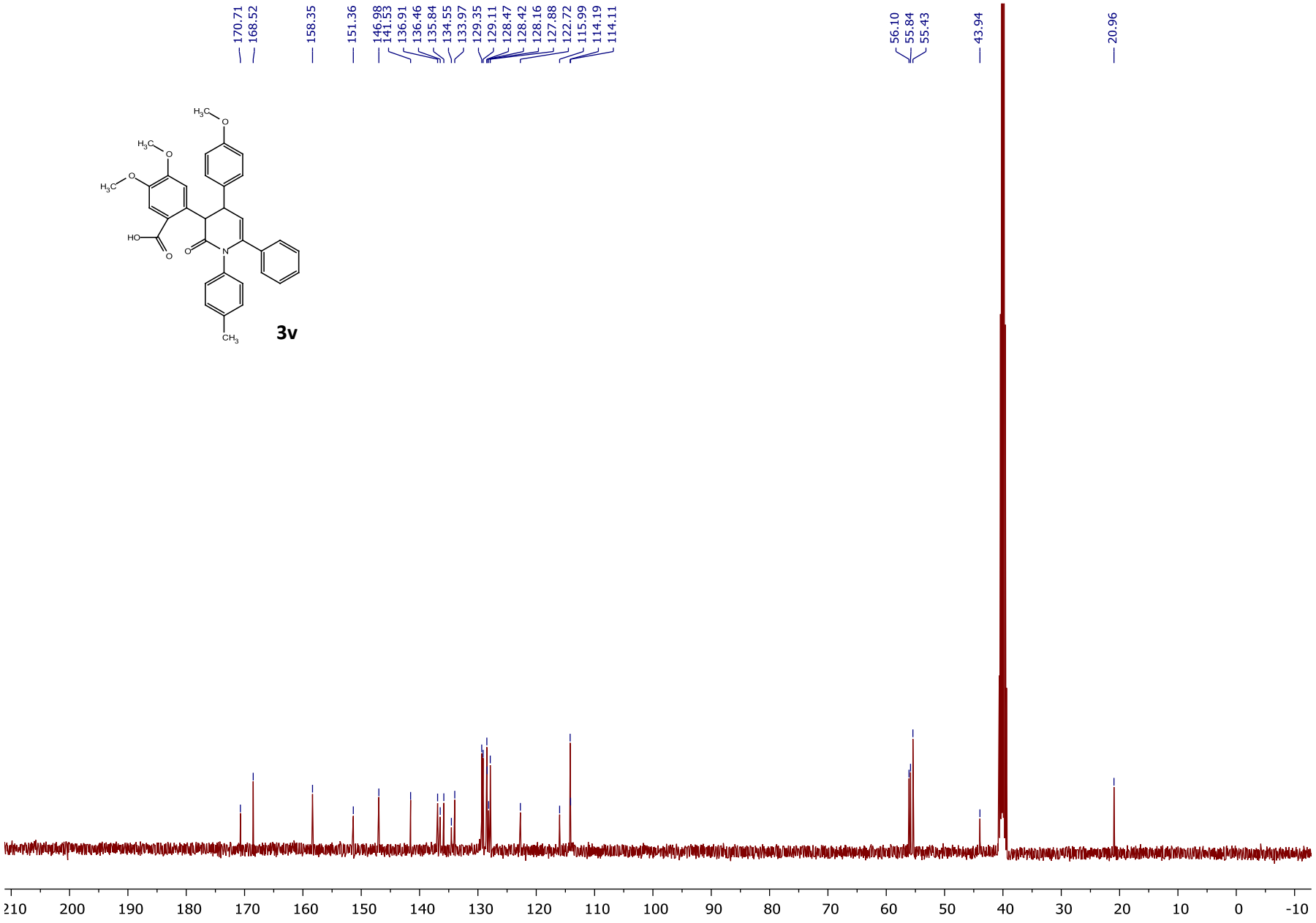
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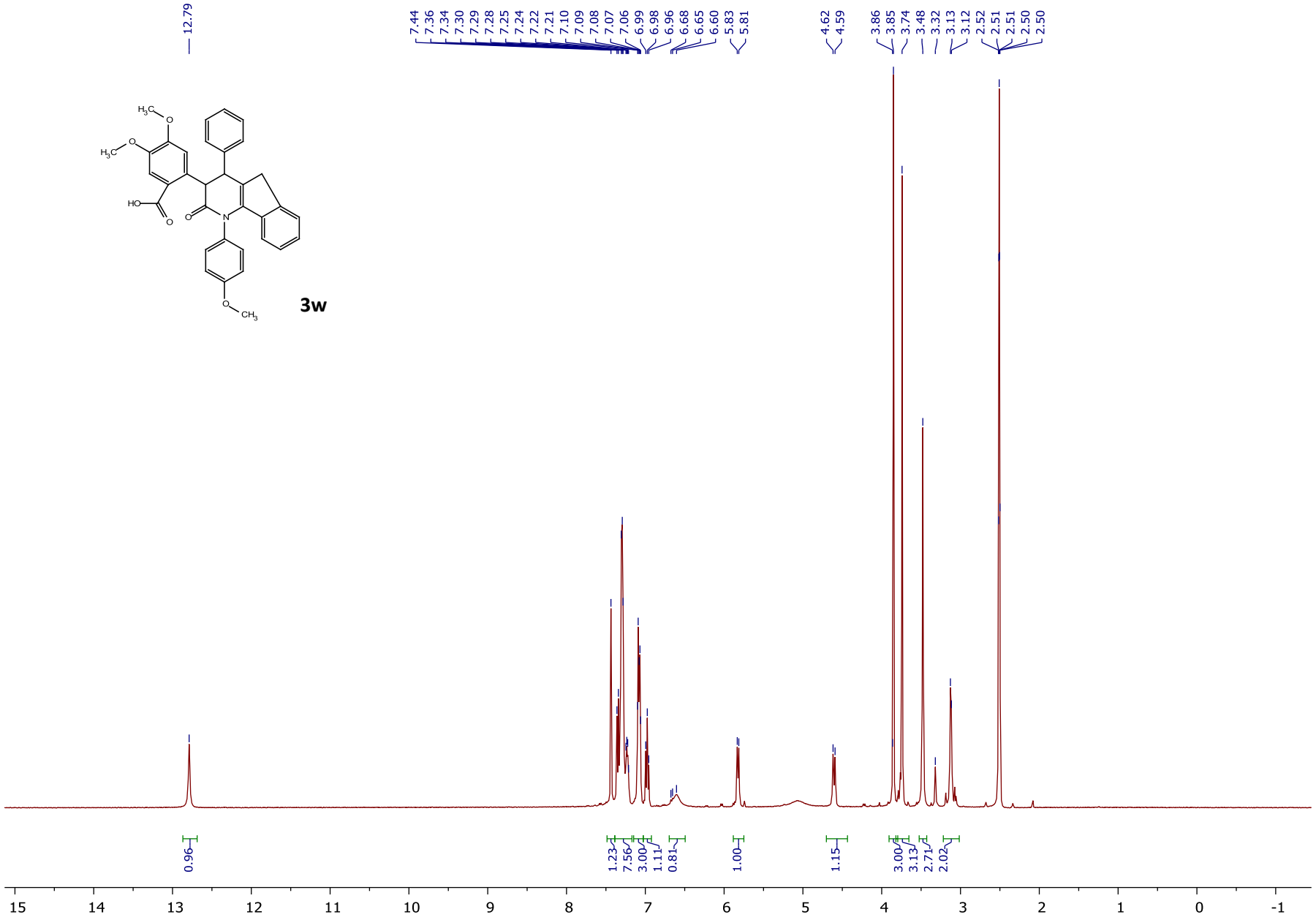
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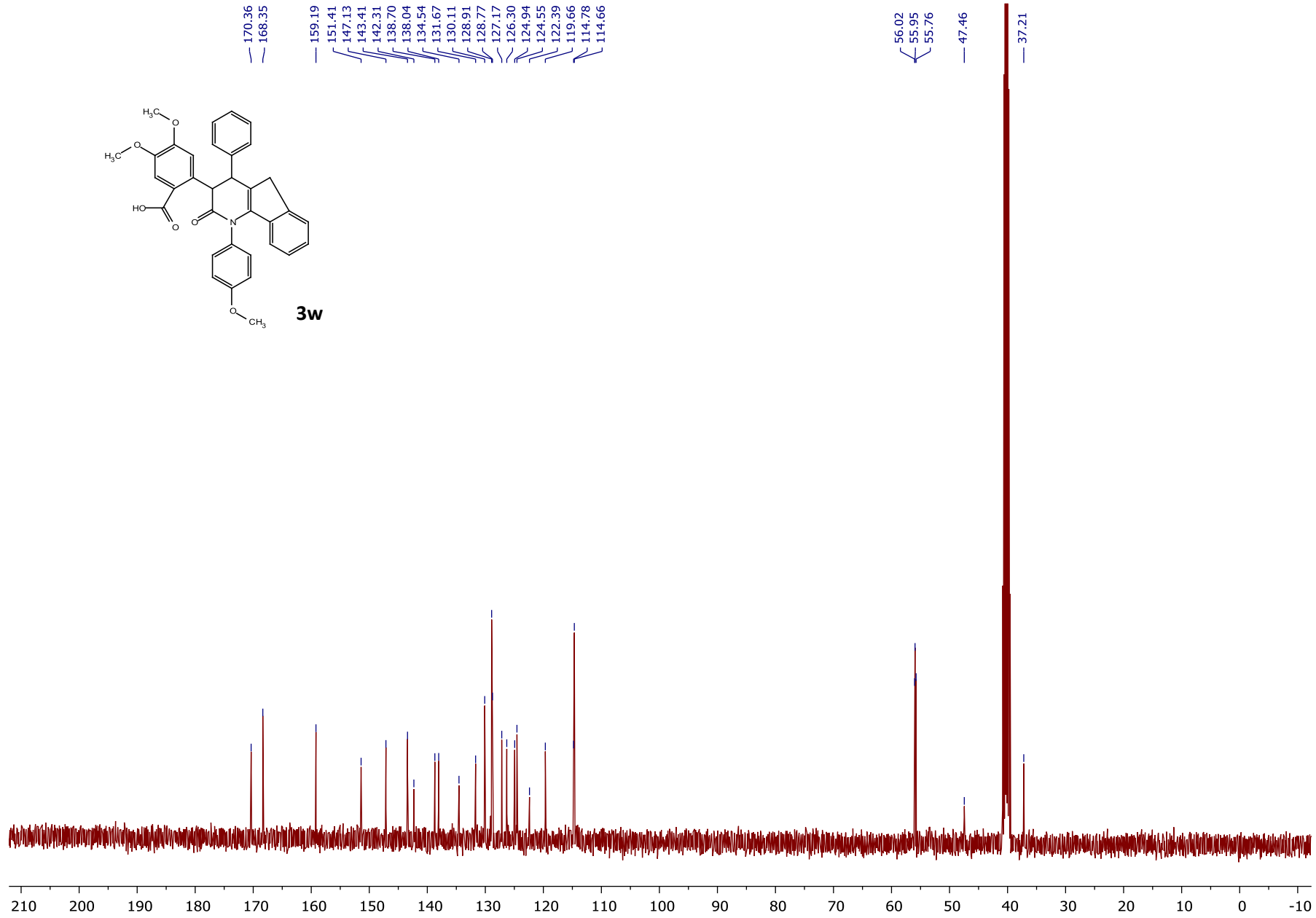
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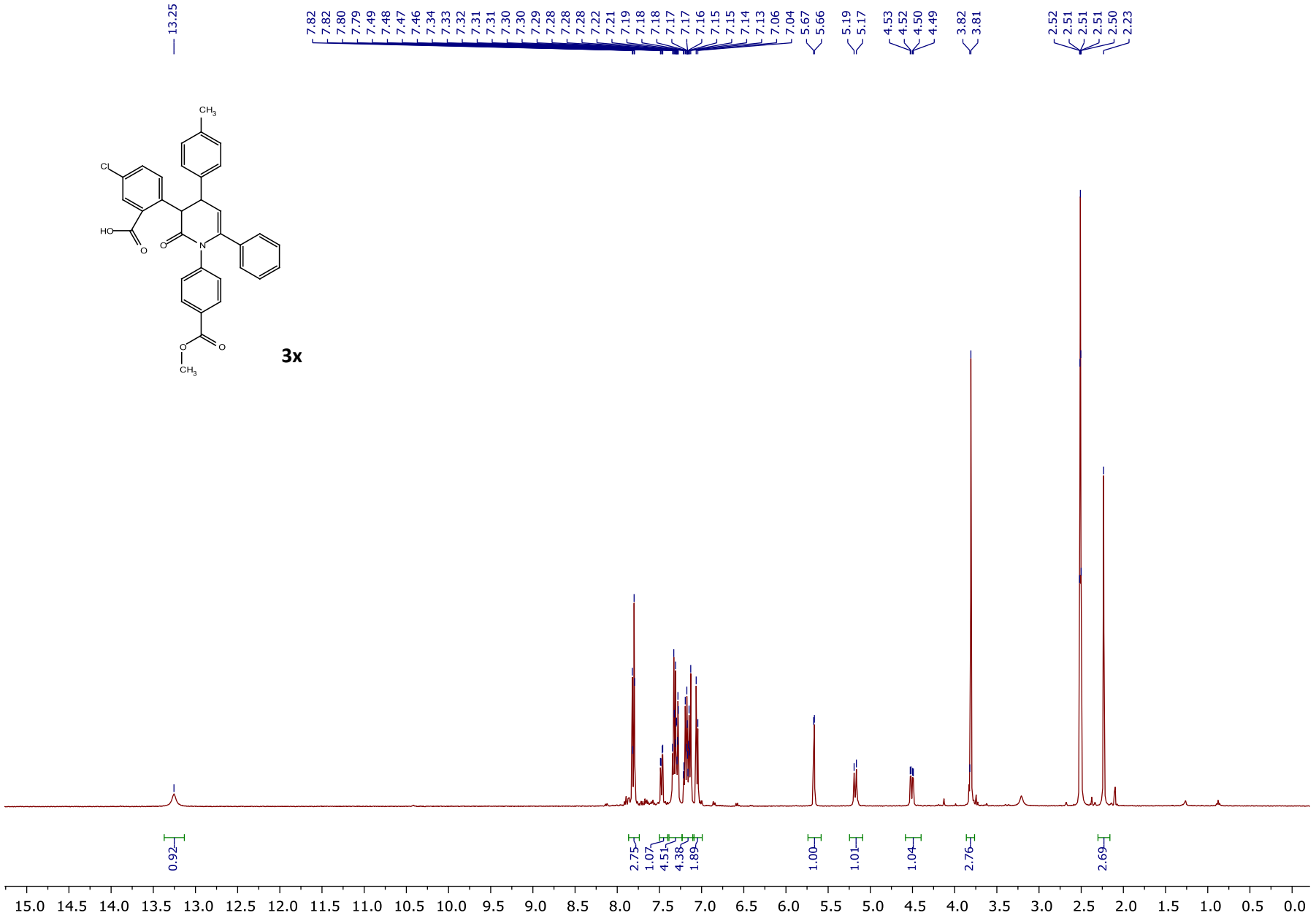
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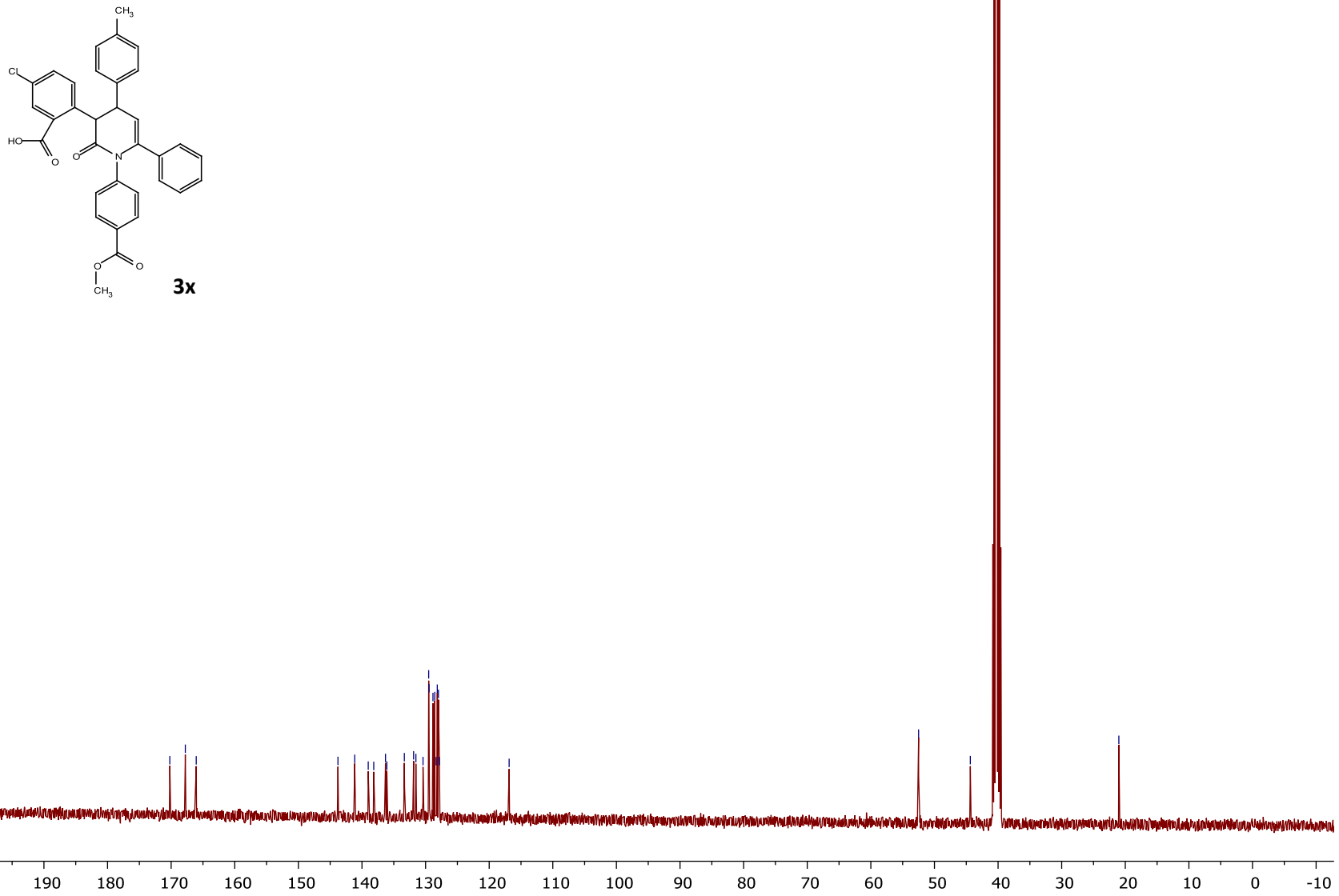
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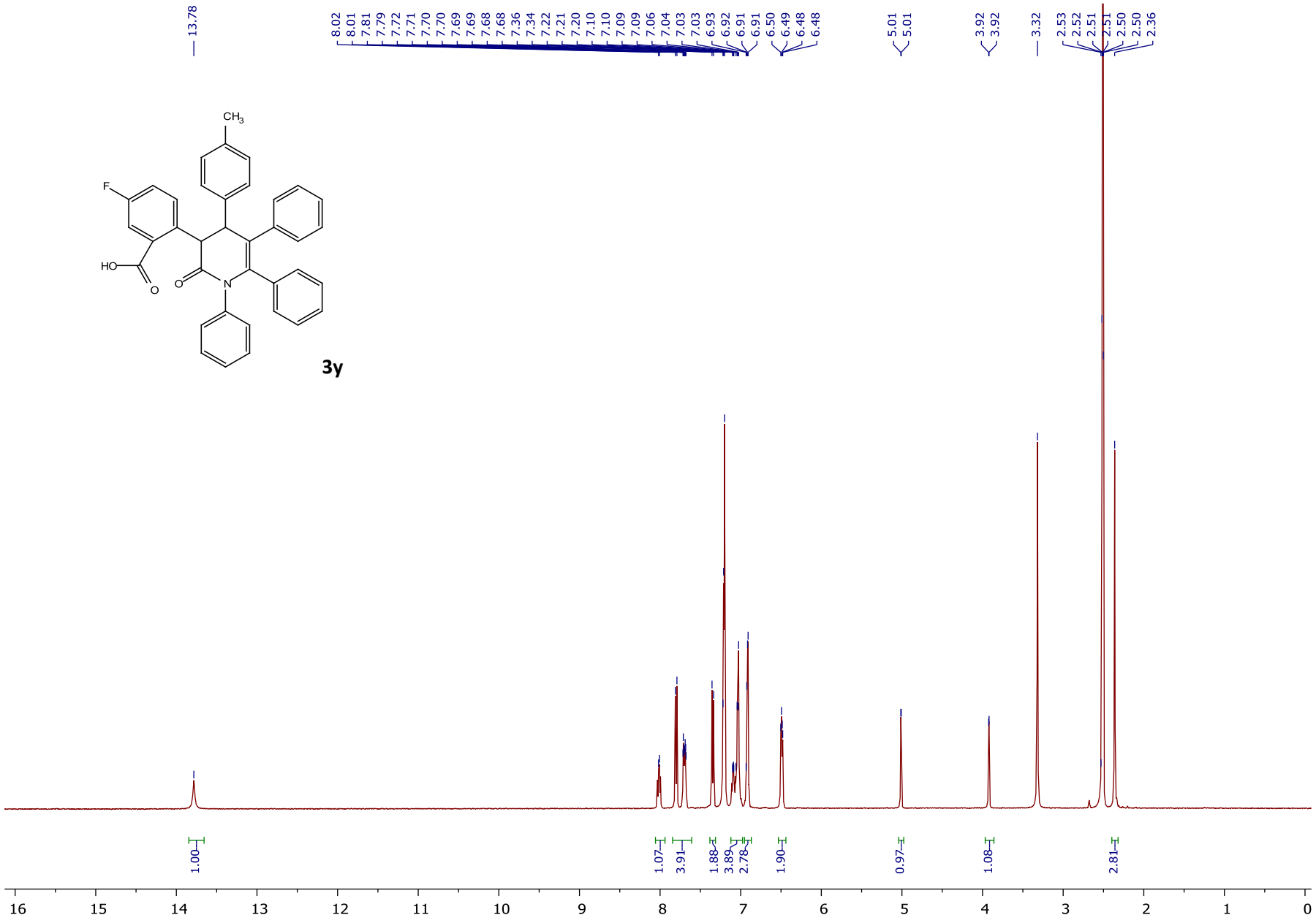
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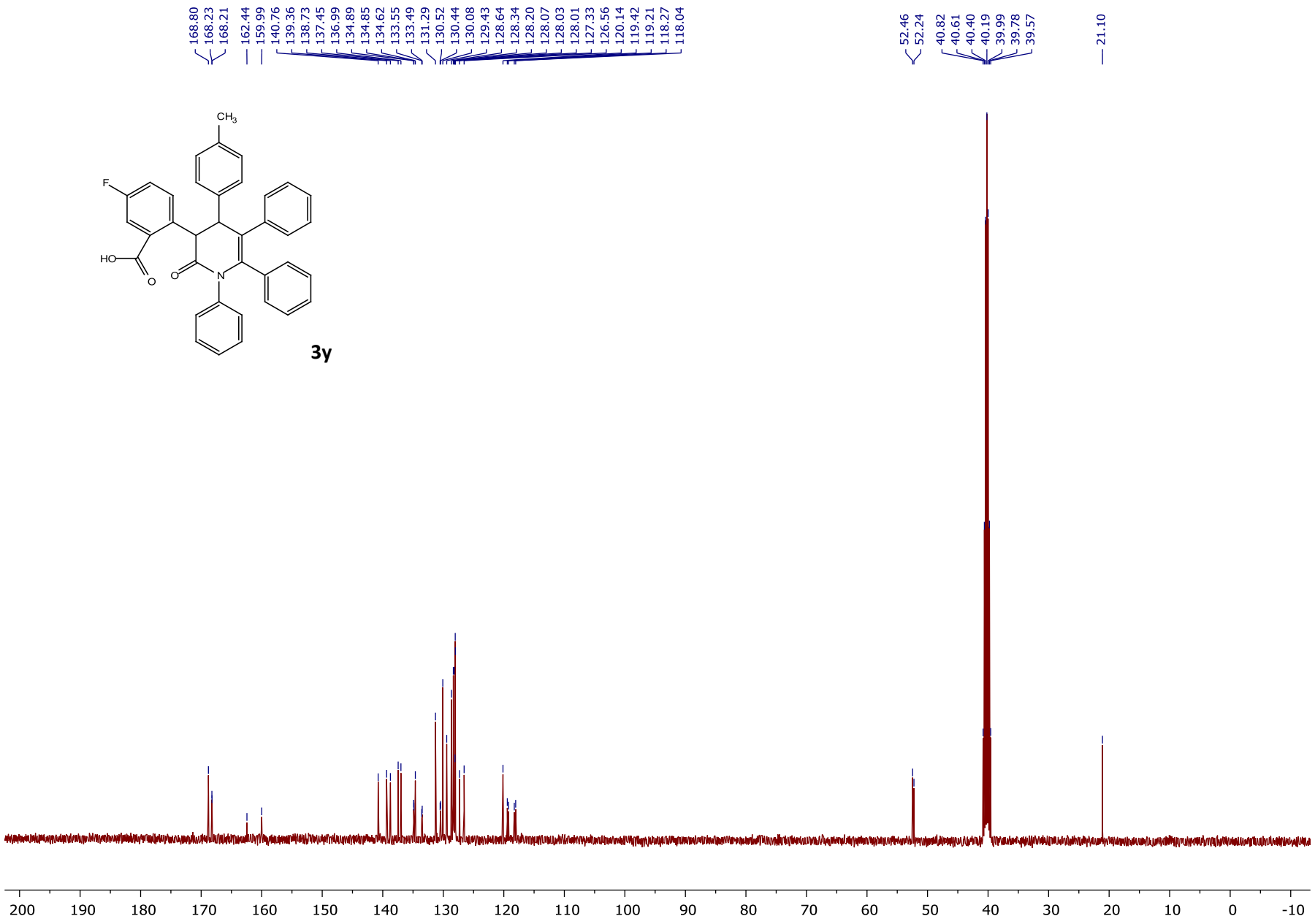
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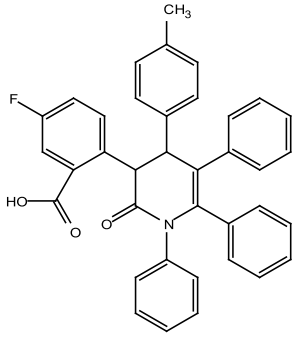
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3y

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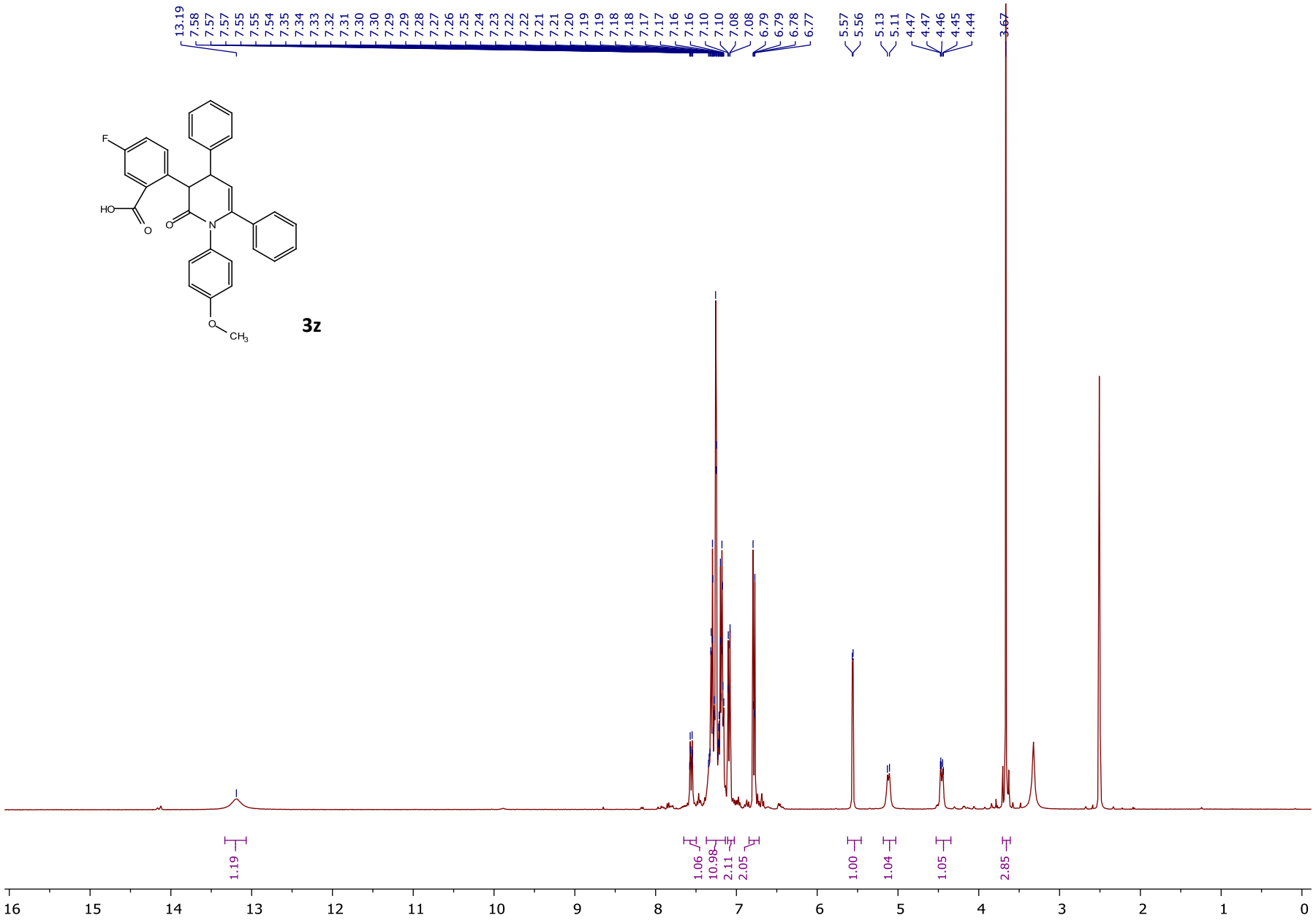
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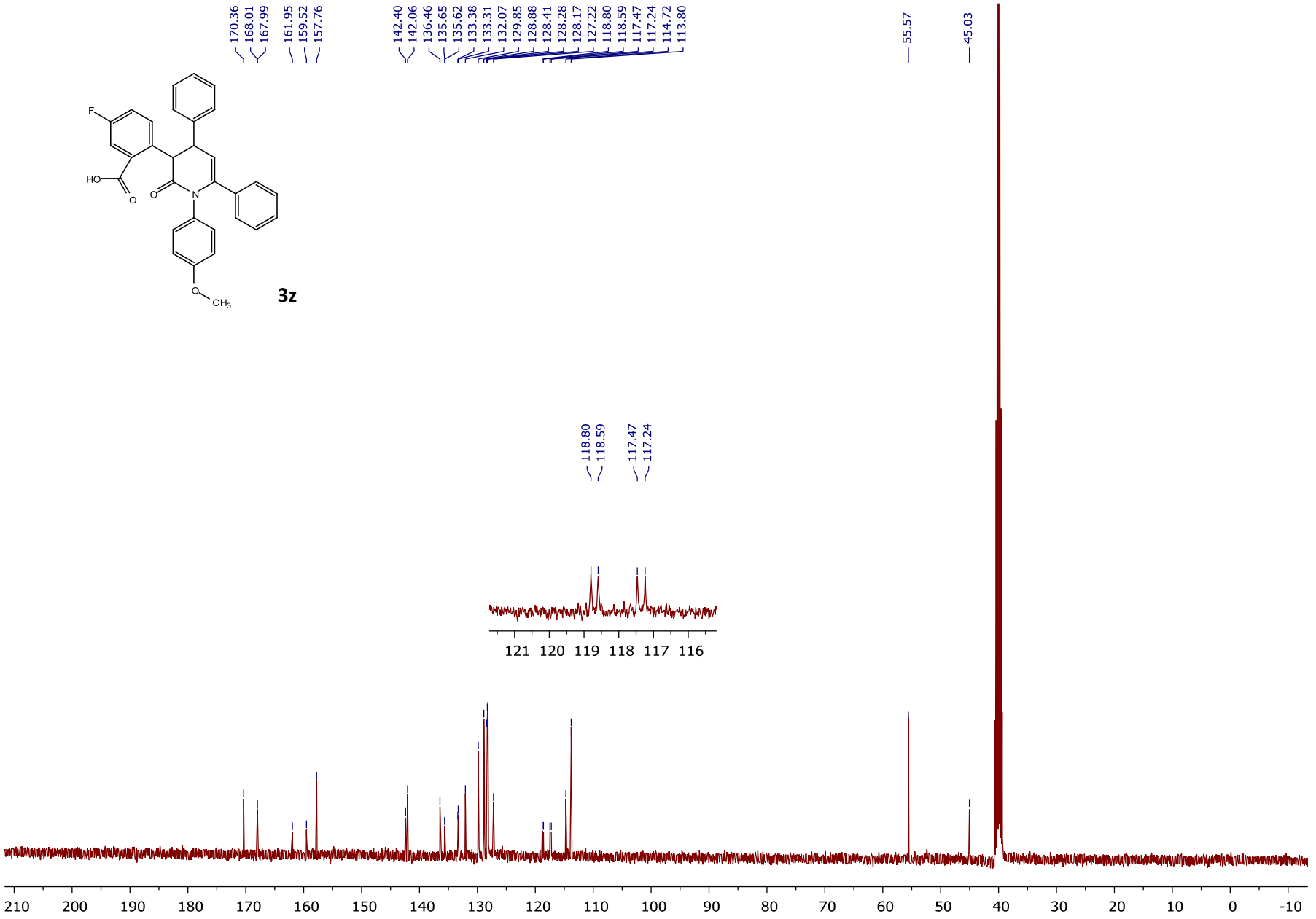
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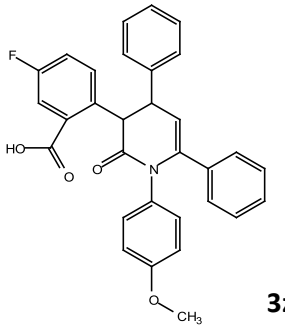
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3z

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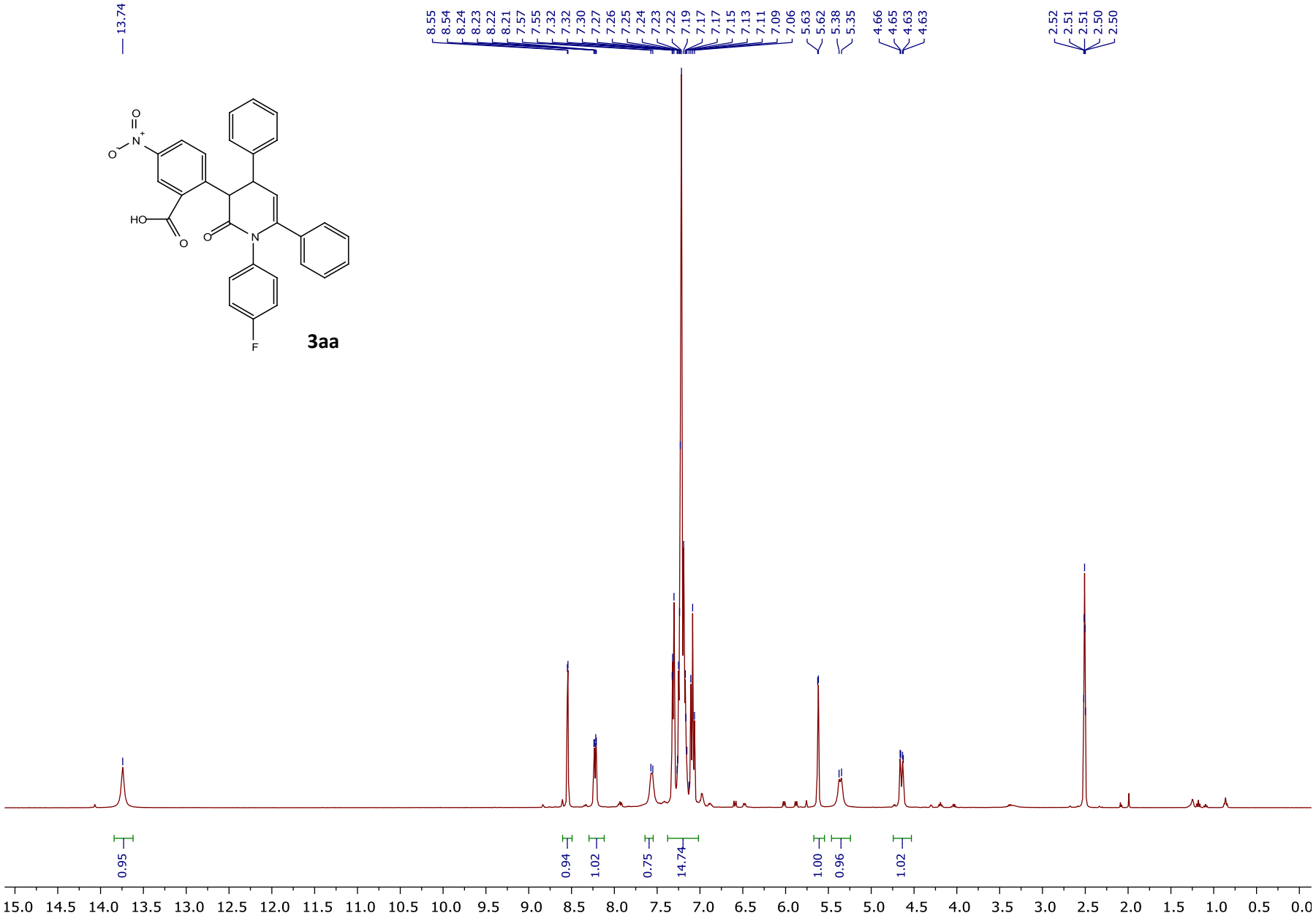
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O
N
O
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0.94
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0.75
14.74
1.00
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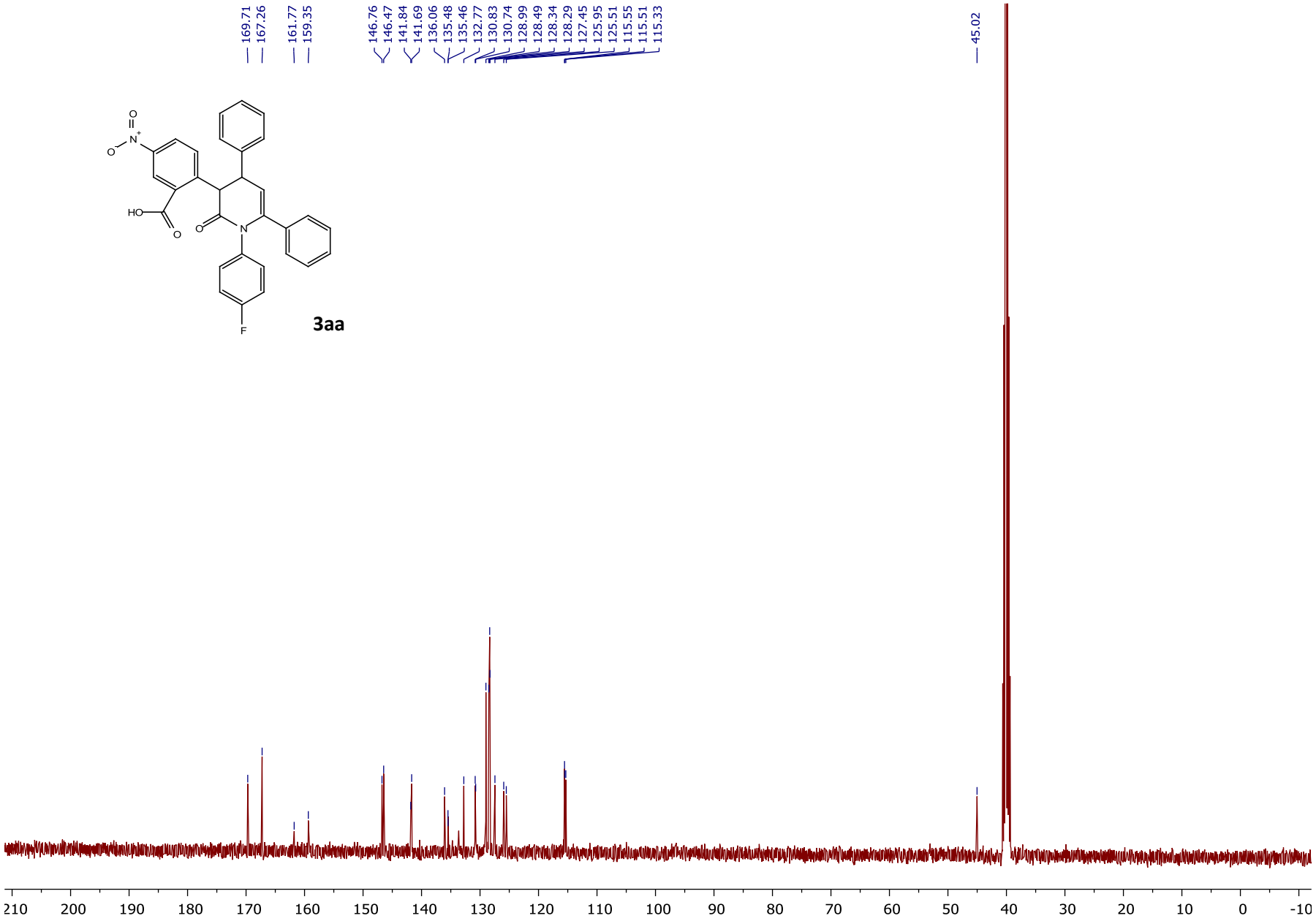
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45.02
HO
O
O
N
O
O
N+
O-
F
3aa
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200
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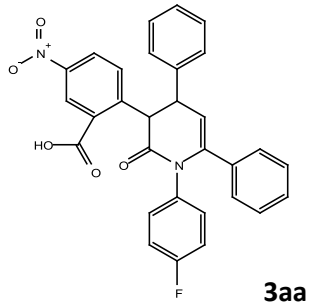
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F

3aa

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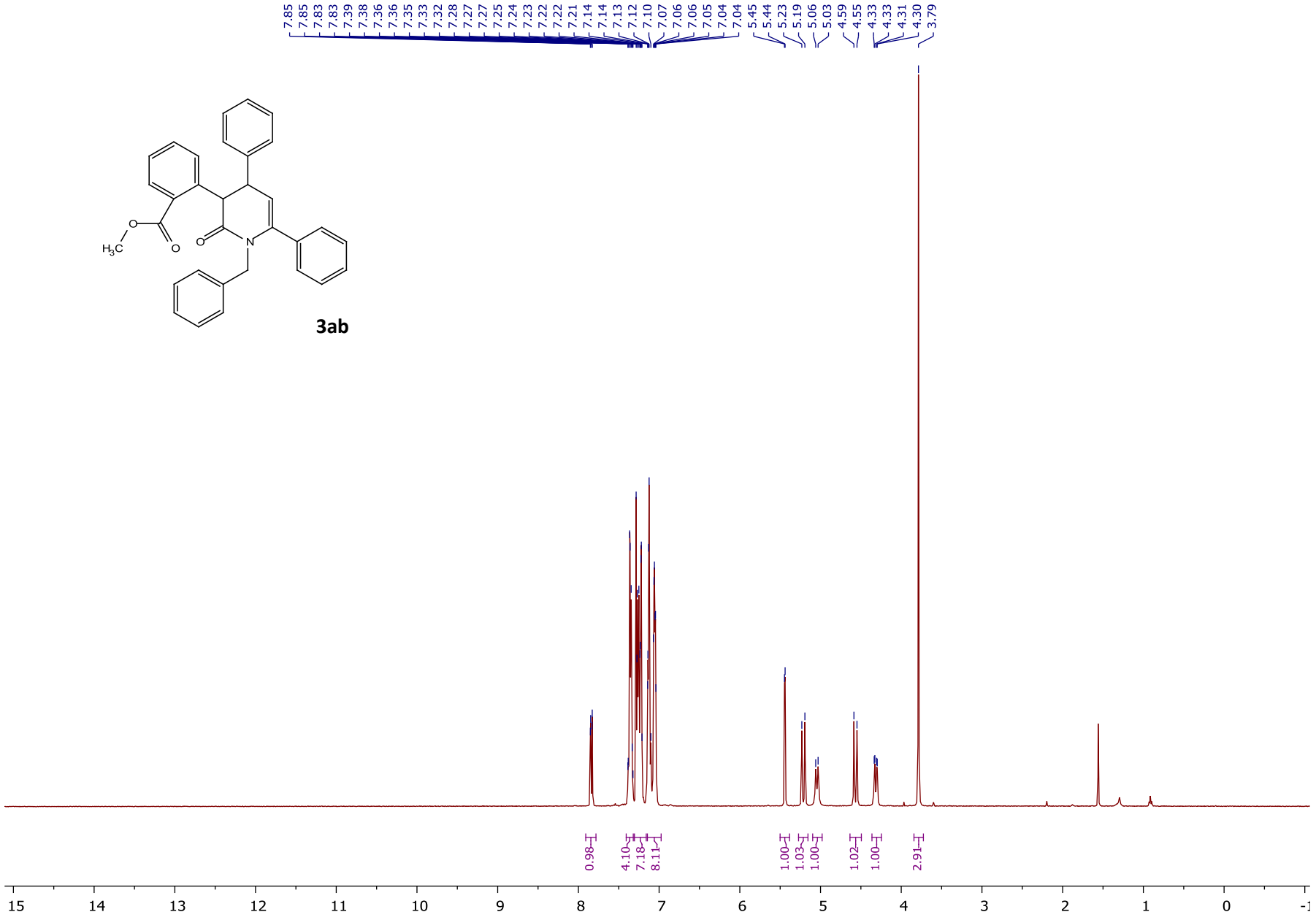
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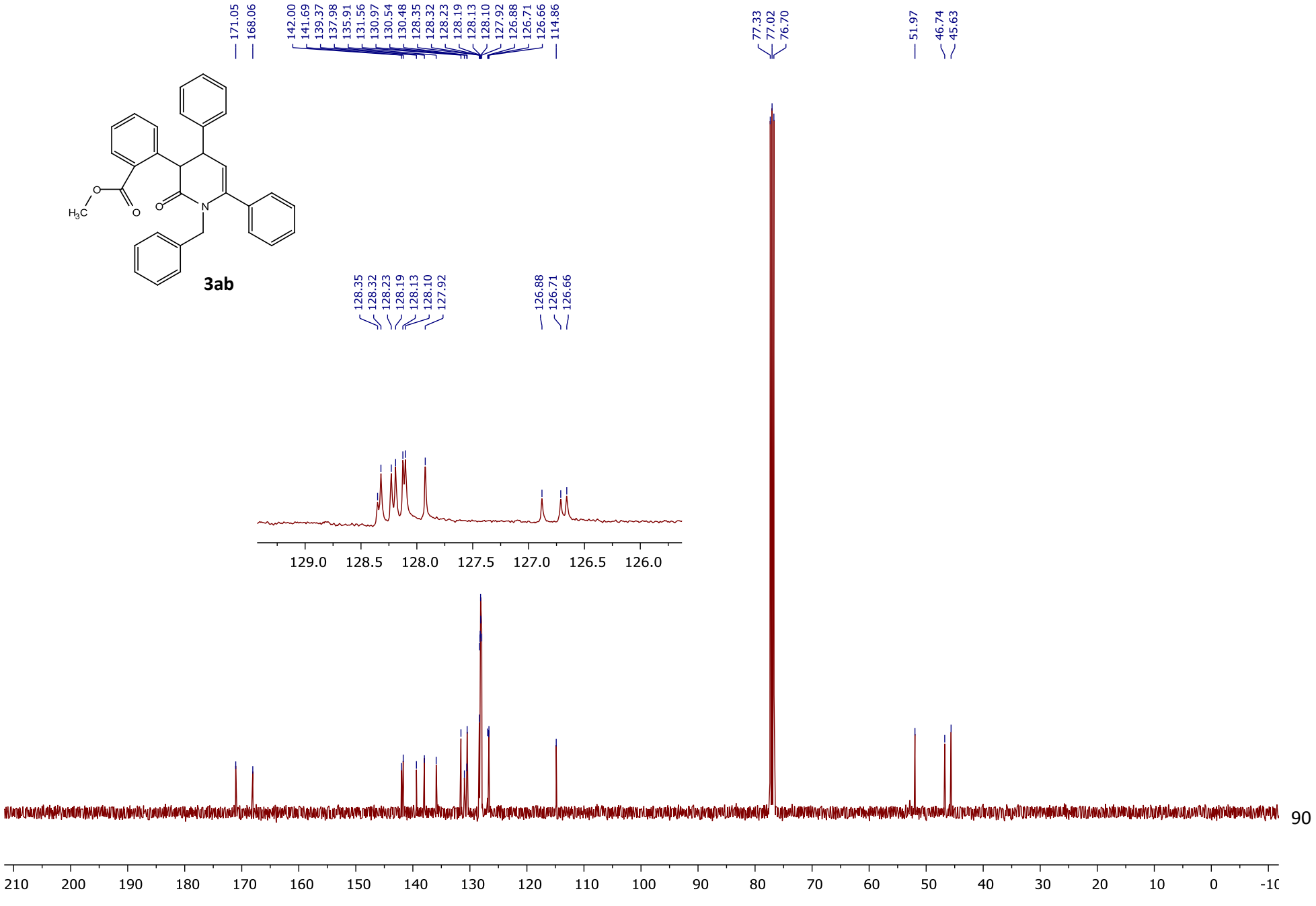
3ab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