Supporting Information

Synthesis of benzoazepine derivatives via Rh(III)-catalyzed inert C(sp^2)−H functionalization and [4 + 3] annulation

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I. General experimental information

Commercial reagents were used without further purification. 2-Arylimidazoles (**1**),[1,2,3] methylene-oxetanones (**2**),[4,5] and $[RhCp^*Cl_2]_2$[6] were prepared based on literature procedures. Melting points were recorded with a micro melting point apparatus and uncorrected. The ^1H NMR spectra were recorded at 400 MHz or 600 MHz. The ^{13}C NMR spectra were recorded at 100 MHz or 150 MHz. Chemical shifts were expressed in parts per million (δ), and were reported as s (singlet), d (doublet), t (triplet), dd (doublet of doublet), m (multiplet), br s (broad singlet), etc. The coupling constants J were given in Hz. High resolution mass spectra (HRMS) were obtained *via* ESI mode by using a MicrOTOF mass spectrometer. All reactions were monitored by thin layer chromatography (TLC) using silica gel plates (silica gel 60 F254 0.25 mm), and components were visualized by observation under UV light (254 and 365 nm).

II. Experimental procedures and spectroscopic data

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

To a reaction tube equipped with a stir bar were added 2-phenyl-1*H*-imidazole (**1a**, 43.3 mg, 0.3 mmol), DCM (3 mL), 3-methylene-4-phenethyloxetan-2-one (**2a**, 84.7 mg, 0.45 mmol), $[RhCp^*Cl_2]_2$ (4.7 mg, 0.0075 mmol) and AgOAc (100.1 mg, 0.6 mmol) with stirring. The mixture was stirred at 100 °C for 10 h under air. Upon completion, the resulting mixture was cooled to room temperature, filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel chromatography using DCM/CH_3OH/HOAc (30:1:0.1) as eluent to afford **3a** in a yield of 73%. **3b-3kk** were obtained in a similar manner.

5-Phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3a)

White solid (72.4 mg, 73%), mp: 250-252 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.78-1.87 (m, 2H), 2.18-2.23 (m, 1H), 2.41-2.46 (m, 1H), 5.62 (t, J = 6.6 Hz, 1H), 6.96 (d, J = 7.2 Hz, 2H), 7.12 (t, J = 7.2 Hz, 1H), 7.17-7.18 (m, 3H), 7.45-7.48 (m, 2H), 7.54 (t, J = 7.8 Hz, 1H), 7.62 (d, J = 7.2 Hz, 1H), 7.87 (s, 1H), 8.17 (d, J = 7.8 Hz, 1H), 13.28 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.2, 34.4, 54.7, 124.0, 126.4, 128.4, 128.8, 128.9, 129.6, 130.3, 130.48, 130.51, 132.7, 133.4, 139.6, 140.8, 144.3, 167.3. HRMS calcd for $C_{21}H_{17}N_2O_2$: 329.1296 $[M-H]^-$, found: 329.1296.

9-Methyl-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3b)

White solid (70.3 mg, 68%), mp: 306-308 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.73-1.85 (m, 2H), 2.15-2.19 (m, 1H), 2.36 (s, 3H), 2.39-2.44 (m, 1H), 5.55-5.57 (m, 1H), 6.95 (d, J = 7.2 Hz, 2H), 7.10-7.12 (m, 2H), 7.18 (t, J = 7.8 Hz, 2H), 7.34 (d, J = 8.4 Hz, 1H), 7.39-7.41 (m, 2H), 7.78 (s, 1H), 8.03 (d, J = 7.8 Hz, 1H), 13.13 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 21.0, 32.2, 34.4, 54.6, 123.8, 126.4, 128.0, 128.4, 128.8, 129.4, 130.3, 131.3, 132.9, 133.1, 138.5, 139.8, 140.8, 144.4, 167.3. HRMS calcd for $C_{22}H_{19}N_2O_2$: 343.1452 $[M-H]^-$, found: 343.1450.

9-(*tert*-Butyl)-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3c)

White solid (77.7 mg, 67%), mp: 287-289 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.33 (s, 9H), 1.75-1.85 (m, 2H), 2.16-2.21 (m, 1H), 2.39-2.44 (m, 1H), 5.54-5.57 (m, 1H), 6.97 (d, J = 7.2 Hz, 2H), 7.10-7.13 (m, 2H), 7.19 (t, J = 7.2 Hz, 2H), 7.38 (s, 1H), 7.56 (dd, J_1 = 7.8 Hz, J_2= 1.8 Hz, 1H), 7.61 (d, J = 1.8 Hz, 1H), 7.87 (s, 1H), 8.07 (d, J = 8.4 Hz, 1H), 13.09 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 31.4, 32.2, 34.4, 34.9, 54.6, 123.8, 126.5, 127.6, 128.0, 128.5, 128.7, 128.8, 129.4, 129.5, 130.1, 132.7, 140.3, 140.8, 144.3, 151.5, 167.4. HRMS calcd for $C_{25}H_{25}N_2O_2$: 385.1922 $[M-H]^-$, 385.1920.

9-Methoxy-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3d)

White solid (68.1 mg, 63%), mp: 229-231 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.77-1.85 (m, 2H), 2.17-2.22 (m, 1H), 2.41-2.46 (m, 1H), 3.84 (s, 3H), 5.55-5.58 (m, 1H), 6.96 (d, J = 7.2 Hz, 2H), 7.11-7.13 (m, 3H), 7.19 (t, J = 7.2 Hz, 2H), 7.22 (d, J = 1.8 Hz, 1H), 7.39 (s, 1H), 7.84 (s, 1H), 8.05 (d, J = 9.0 Hz, 1H), 13.24 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.2, 34.2, 54.6, 55.9, 116.4, 117.1, 123.1, 123.5, 126.4, 128.4, 128.7, 128.8, 130.5, 132.0, 133.4, 139.7, 140.8, 144.2, 159.6, 167.3. HRMS calcd for $C_{22}H_{19}N_2O_3$: 359.1401 $[M-H]^-$, found: 359.1401.

9-Fluoro-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3e)

White solid (57.5 mg, 55%), mp: 239-240 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.76-1.90 (m, 2H), 2.19-2.24 (m, 1H), 2.42-2.48 (m, 1H), 5.61-5.64 (m, 1H), 6.97 (d, J = 7.2 Hz, 2H), 7.13 (t, J = 7.2 Hz, 1H), 7.17-7.21 (m, 3H), 7.40 (td, J_1 = 8.4 Hz, J_2 = 2.4 Hz, 1H), 7.45 (s, 1H), 7.56 (dd, J_1 = 9.6 Hz, J_2 = 2.4 Hz, 1H), 7.86 (s, 1H), 8.17-8.20 (m, 1H), 13.38 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.2, 34.4, 54.6, 117.6 (d, $^{2}J_{C\text{-}F}$ = 21.5 Hz), 118.4 (d, $^{2}J_{C\text{-}F}$ = 23.6 Hz), 124.0, 126.4, 127.2 (d, $^{4}J_{C\text{-}F}$ = 2.6 Hz), 128.4, 128.8, 129.6, 131.3 (d, $^{3}J_{C\text{-}F}$ = 8.0 Hz), 132.6 (d, $^{3}J_{C\text{-}F}$ = 9.3 Hz), 134.6, 138.4, 140.7, 143.6, 162.0 (d, $^{1}J_{C\text{-}F}$ = 244.5 Hz), 167.1. ^{19}F NMR (565 MHz, DMSO-d_6) δ: -113.43. HRMS calcd for $C_{21}H_{16}FN_2O_2$: 347.1207 $[M-H]^-$, found: 347.1197.

9-Chloro-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3f)

White solid (69.0 mg, 63%), mp: 270-271 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.73-1.87 (m, 2H), 2.14-2.21 (m, 1H), 2.39-2.47 (m, 1H), 5.58-5.62 (m, 1H), 6.96 (d, J = 7.2 Hz, 2H), 7.12 (t, J = 7.2 Hz, 1H), 7.17-7.21 (m, 3H), 7.47 (s, 1H), 7.57 (d, J = 6.4 Hz, 1H), 7.77 (d, J = 2.0 Hz, 1H), 7.82 (s, 1H), 8.12 (d, J = 6.0 Hz, 1H), 13.24 (br s, 1H). ^{13}C NMR (150 MHz, CF_3CO_2D) δ: 30.6, 31.2, 57.8, 119.0, 120.4, 124.0, 126.6, 127.5, 128.4, 127.9, 131.6, 132.2, 132.8, 132.9, 137.9, 140.7, 140.8, 141.5, 169.0. HRMS calcd for $C_{21}H_{16}ClN_2O_2$: 363.0906 $[M-H]^-$, found: 363.0904.

9-Bromo-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3g)

White solid (83.5 mg, 68%), mp: 292-293 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.74-1.88 (m, 2H), 2.14-2.22 (m, 1H), 2.39-2.47 (m, 1H), 5.57-5.61 (m, 1H), 6.97 (d, J = 7.2 Hz, 2H), 7.12 (t, J = 7.2 Hz, 1H), 7.17-7.21 (m, 3H), 7.46 (s, 1H), 7.70 (dd, J_1 = 8.4 Hz, J_2= 2.0 Hz, 1H), 7.82 (s, 1H), 7.90 (d, J = 2.0 Hz, 1H), 8.05 (d, J = 8.4 Hz, 1H), 13.26 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.1, 34.6, 54.7, 121.8, 124.4, 126.5, 128.4, 128.8, 129.6, 129.9, 130.7, 132.4, 133.0, 134.5, 134.8, 138.3, 140.7, 143.5, 167.1. HRMS calcd for $C_{21}H_{16}BrN_2O_2$: 407.0401 $[M-H]^-$, found: 407.0397.

5-Phenethyl-9-(trifluoromethyl)-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3h)

White solid (61.0 mg, 51%), mp: 265-267 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.75-1.78 (m, 1H), 1.85-1.89 (m, 1H), 2.18-2.21 (m, 1H), 2.42-2.47 (m, 1H), 5.64-5.66 (m, 1H), 6.97 (d, J = 7.2 Hz, 2H), 7.12 (t, J = 7.2 Hz, 1H), 7.19 (t, J = 7.2 Hz, 2H), 7.24 (s, 1H), 7.54 (s, 1H), 7.85 (d, J = 7.8 Hz, 1H), 7.96 (s, 1H), 8.07 (s, 1H), 8.33 (d, J = 7.8 Hz, 1H), 13.33 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.1, 34.8, 54.9, 124.3 (q, $^{1}J_{C-F}$ = 270.9 Hz), 125.0, 126.5, 128.4, 128.8, 128.9 (q, $^{2}J_{C-F}$ = 29.6 Hz), 129.7, 130.4, 131.0, 133.8, 134.8, 138.3, 140.6, 143.1, 167.1. ^{19}F NMR (376 MHz, DMSO-d_6) δ: -61.19. HRMS calcd for $C_{22}H_{16}F_3N_2O_2$: 397.1169 $[M-H]^-$, found: 397.1169.

10-Methyl-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3i)

White solid (48.6 mg, 47%), mp: 291-292 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.76-1.86 (m, 2H), 2.17-2.24 (m, 1H), 2.37-2.44 (m, 4H), 5.57 (t, J = 7.6 Hz, 1H), 6.96 (d, J = 7.2 Hz, 2H), 7.10-7.13 (m, 2H), 7.19 (t, J = 7.2 Hz, 2H), 7.28 (d, J = 8.0 Hz, 1H), 7.41 (s, 1H), 7.49 (d, J = 7.6 Hz, 1H), 7.81 (s, 1H), 7.96 (s, 1H), 13.07 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 21.5, 32.2, 34.4, 54.7, 123.9, 126.4, 127.9, 128.4, 128.8, 129.2, 129.5, 129.8, 130.4, 132.8, 139.6, 140.2, 140.8, 144.3, 167.4. HRMS calcd for $C_{22}H_{19}N_2O_2$: 343.1452 $[M-H]^-$, found: 343.1445.

10-Methoxy-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3j)

White solid (29.2 mg, 27%), mp: 230-232 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.77-1.84 (m, 2H), 2.16-2.24 (m, 1H), 2.37-2.45 (m, 1H), 3.87 (s, 3H), 5.55-5.59 (m, 1H), 6.97 (d, J = 7.2 Hz, 2H), 7.04 (dd, J_1 = 8.8 Hz, J_2 = 2.8 Hz, 1H), 7.10-7.14 (m, 2H), 7.19 (t, J = 7.2 Hz, 2H), 7.42 (s, 1H), 7.56 (d, J = 8.8 Hz, 1H), 7.64 (d, J = 2.8 Hz, 1H), 7.80 (s, 1H), 12.95 (br s, 1H). ^{13}C NMR (150 MHz, CF_3CO_2D) δ: 30.5, 31.3, 55.2, 58.0, 114.2, 118.5, 120.1, 122.4, 123.9, 124.2, 126.5, 127.5, 127.7, 128.4, 135.7, 138.2, 141.9, 142.3, 169.7. HRMS calcd for $C_{22}H_{19}N_2O_3$: 359.1401 $[M-H]^-$, found: 359.1402.

8-Methoxy-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3j')

White solid (30.3 mg, 28%), mp: 259-261 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.78-1.87 (m, 2H), 2.15-2.23 (m, 1H), 2.39-2.47 (m, 1H), 3.92 (s, 3H), 5.58-5.62 (m, 1H), 6.96 (d, J = 6.8 Hz, 2H), 7.10-7.20 (m, 5H), 7.43 (d, J = 0.8 Hz, 1H), 7.51 (t, J = 8.0 Hz, 1H), 7.75 (d, J = 8.0 Hz, 1H), 8.12 (s, 1H), 13.11 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.2, 33.7, 54.3, 56.6, 110.9, 119.4, 121.1, 123.9, 126.4, 128.4, 128.8, 129.5, 131.65, 131.69, 132.2, 133.5, 140.8, 144.0, 157.8, 167.4. HRMS calcd for $C_{22}H_{19}N_2O_3$: 359.1401 $[M-H]^-$, found: 359.1401.

8-Fluoro-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3k)

White solid (65.8 mg, 63%), mp: 253-254 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.77-1.92 (m, 2H), 2.18-2.23 (m, 1H), 2.42-2.47 (m, 1H), 5.64-5.67 (m, 1H), 6.97 (d, J = 7.8 Hz, 2H), 7.12 (t, J = 7.2 Hz, 1H),

7.18-7.20 (m, 3H), 7.35 (t, J = 9.6 Hz, 1H), 7.49 (s, 1H), 7.57-7.60 (m, 1H), 7.93 (s, 1H), 7.99 (d, J = 8.4 Hz, 1H), 13.38 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.1, 34.2, 54.6, 115.2 (d, $^2J_{C\text{-}F}$ = 22.7 Hz), 118.7 (d, $^2J_{C\text{-}F}$ = 14.3 Hz), 124.5, 124.8 (d, $^4J_{C\text{-}F}$ = 3.3 Hz), 126.5, 128.4, 128.8, 129.9, 130.2 (d, $^3J_{C\text{-}F}$ = 9.3 Hz), 132.17 (d, $^3J_{C\text{-}F}$ = 9.6 Hz), 132.20, 134.9, 140.7, 143.3 (d, $^4J_{C\text{-}F}$ = 2.1 Hz), 160.5 (d, $^1J_{C\text{-}F}$ = 248.7 Hz), 166.9. ^{19}F NMR (565 MHz, DMSO-d_6) δ: -113.75. HRMS calcd for $C_{21}H_{16}FN_2O_2$: 347.1201 $[M-H]^-$, found: 347.1200.

5-Phenethyl-10-(trifluoromethyl)-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3l)

White solid (35.9 mg, 30%), mp >300 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.74-1.92 (m, 2H), 2.19-2.26 (m, 1H), 2.41-2.46 (m, 1H), 5.63-5.67 (m, 1H), 6.96 (d, J = 7.2 Hz, 2H), 7.11 (t, J = 7.2 Hz, 1H), 7.16-7.20 (m, 3H), 7.52 (s, 1H), 7.79 (d, J = 8.0 Hz, 1H), 7.85-7.89 (m, 2H), 8.35 (s, 1H), 13.38 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.1, 34.8, 54.9, 124.3 (q, $^1J_{C\text{-}F}$ = 270.5 Hz), 124.8, 125.0 (q, $^3J_{C\text{-}F}$ = 3.6 Hz), 125.1 (q, $^3J_{C\text{-}F}$ = 2.9 Hz), 126.4, 128.4, 128.8, 130.0 (q, $^2J_{C\text{-}F}$ = 32.1 Hz), 130.2, 131.0, 133.87, 133.91, 136.0, 137.8, 140.6, 143.1, 167.1. ^{19}F NMR (565 MHz, DMSO-d_6) δ: -61.63. HRMS calcd for $C_{22}H_{16}F_3N_2O_2$: 397.1169 $[M-H]^-$, found: 397.1168.

11-Fluoro-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3m)

White solid (63.8 mg, 61%), mp: 229-230 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.77-1.85 (m, 2H), 2.24-2.28 (m, 1H), 2.41-2.46 (m, 1H), 5.58-5.61 (m, 1H), 6.96 (d, J = 7.8 Hz, 2H), 7.12 (t, J = 7.2 Hz, 1H), 7.18-7.21 (m, 3H), 7.39-7.43 (m, 2H), 7.47-7.51 (m, 2H), 7.83 (s, 1H), 13.26 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.2, 33.4, 54.3, 118.1 (d, $^2J_{C\text{-}F}$ = 22.8 Hz), 118.8 (d, $^3J_{C\text{-}F}$ = 11.6 Hz), 123.3, 126.5, 128.0, 128.36, 128.39, 128.4, 128.9, 129.7 (d, $^3J_{C\text{-}F}$ = 7.8 Hz), 130.2, 133.6, 135.7, 138.1 (d, $^4J_{C\text{-}F}$ = 5.3 Hz), 138.4 (d, $^2J_{C\text{-}F}$ = 14.9 Hz), 140.7, 159.7 (d, $^1J_{C\text{-}F}$ = 251.1 Hz), 166.9. ^{19}F NMR (376 MHz, DMSO-d_6) δ: -110.76. HRMS calcd for $C_{21}H_{16}FN_2O_2$: 347.1201 $[M-H]^-$, found: 347.1206.

5-Phenethyl-5*H*-imidazo[1,2-*a*]naphtho[1,2-*c*]azepine-6-carboxylic acid (3n)

Yellow solid (62.8 mg, 55%), mp: 151-153 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.76-1.80 (m, 2H), 2.26-2.31 (m, 1H), 2.42-2.47 (m, 1H), 5.69 (t, J = 7.8 Hz, 1H), 6.84 (d, J = 7.8 Hz, 2H), 7.04-7.10 (m, 3H), 7.30 (s, 1H), 7.47 (s, 1H), 7.59-7.64 (m, 2H), 7.67 (d, J = 8.4 Hz, 1H), 7.94 (s, 1H), 7.97-7.99 (m, 2H), 8.99 (d, J = 8.4 Hz, 1H), 13.17 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.0, 32.3, 54.8, 122.9, 126.4, 127.4, 127.8, 128.0, 128.3, 128.35, 128.38, 128.4, 128.5, 128.8, 129.0, 129.1, 129.3, 129.4, 129.6, 129.7, 131.3, 134.1, 135.8, 139.5, 139.6, 140.8, 142.1, 166.9. HRMS calcd for $C_{25}H_{19}N_2O_2$: 379.1452 $[M-H]^-$, found: 379.1450.

5-Phenethyl-5*H*-imidazo[1,2-*a*]pyrido[4,3-*c*]azepine-6-carboxylic acid (3o)

White solid (41.8 mg, 42%), mp: 257-258 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.72-1.79 (m, 1H), 1.84-1.90 (m, 1H), 2.14-2.18 (m, 1H), 2.41-2.46 (m, 1H), 5.66-5.69 (m, 1H), 6.97 (d, J = 7.8 Hz, 2H), 7.12 (t, J = 7.8 Hz, 1H), 7.19 (t, J = 7.2 Hz, 2H), 7.27 (s, 1H), 7.60 (s, 1H), 7.90 (s, 1H), 8.01 (d, J = 5.4 Hz, 1H), 8.62 (d, J = 4.8 Hz, 1H), 8.82 (s, 1H), 13.31 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.1, 35.3, 55.2, 121.3, 125.3, 125.7, 126.5, 128.4, 128.8, 130.8, 134.8, 136.4, 136.6, 140.6, 142.2, 150.5, 153.7, 167.0. HRMS calcd for $C_{20}H_{16}N_3O_2$: 330.1248 $[M-H]^-$, found: 330.1241.

2-Methyl-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3p)

White solid (67.2 mg, 65%), mp: 164-166 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.73-1.81 (m, 2H), 2.18-2.25 (m, 4H), 2.40-2.47 (m, 1H), 5.48-5.52 (m, 1H), 6.95 (d, J = 7.2 Hz, 2H), 7.11 (t, J = 7.2 Hz, 1H), 7.16-7.20 (m, 3H), 7.44-7.53 (m, 2H), 7.61 (d, J = 7.2 Hz, 1H), 7.82 (s, 1H), 8.06 (d, J = 6.8 Hz, 1H), 13.12 (br s, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ: 13.8, 32.2, 34.4, 54.6, 120.8, 126.4, 128.4, 128.7, 128.8, 129.0, 129.9, 130.3, 130.5, 132.8, 133.2, 137.4, 139.5, 140.8, 143.1, 167.2. HRMS calcd for $C_{22}H_{19}N_2O_2$: 343.1452 $[M-H]^-$, found: 343.1447.

5-Phenethyl-2-phenyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3q)

White solid (85.4 mg, 70%), mp: 220-221 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.82-1.91 (m, 2H), 2.24-2.31 (m, 1H), 2.45-2.49 (m, 1H), 5.62-5.66 (m, 1H), 6.96-6.98 (m, 2H), 7.09-7.13 (m, 1H), 7.16-7.20 (m, 2H), 7.25 (t, J = 7.2 Hz, 1H), 7.41 (t, J = 7.6 Hz, 2H), 7.50 (td, J_1 = 7.6 Hz, J_2= 1.2 Hz, 1H), 7.57 (td, J_1 = 7.6 Hz, J_2= 1.2 Hz, 1H), 7.65 (d, J = 7.2 Hz, 1H), 7.86-7.89 (m, 3H), 7.95 (s, 1H), 8.24 (dd, J_1 = 7.6 Hz, J_2= 0.8 Hz, 1H), 13.21 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.3, 34.4, 55.0, 120.4, 124.9, 126.5, 127.1, 128.4, 128.8, 129.03, 129.06, 129.1, 130.3, 130.4, 130.7, 132.8, 133.1, 134.6, 139.7, 140.7, 141.3, 144.5, 167.3. HRMS calcd for $C_{27}H_{21}N_2O_2$: 405.1609 $[M-H]^-$, found: 405.1600.

5-Phenethyl-2-(p-tolyl)-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3r)

White solid (90.8 mg, 72%), mp: 261-262 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.81-1.90 (m, 2H), 2.23-2.36 (m, 4H), 2.44-2.48 (m, 1H), 5.59-5.63 (m, 1H), 6.96-6.98 (m, 2H), 7.09-7.12 (m, 1H), 7.16-7.22 (m, 4H), 7.49 (td, J_1 = 7.2 Hz, J_2= 1.2 Hz, 1H), 7.56 (td, J_1 = 7.6 Hz, J_2 = 1.6 Hz, 1H), 7.63 (d, J = 7.2 Hz, 1H), 7.74 (d, J = 8.4 Hz, 2H), 7.87 (s, 1H), 7.88 (s, 1H), 8.22 (dd, J_1 = 7.6 Hz, J_2 = 1.2 Hz, 1H), 13.17 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 21.3, 32.3, 34.4, 54.9, 119.9, 124.9, 126.5, 128.4, 128.8, 129.0, 129.1, 129.6, 130.3, 130.4, 130.6, 131.8, 132.8, 133.1, 136.2, 139.7, 140.7, 141.4, 144.3, 167.3. HRMS calcd for $C_{28}H_{23}N_2O_2$: 419.1765 $[M-H]^-$, found: 419.1774.

2-(4-(*tert*-Butyl)phenyl)-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3s)

White solid (101.3 mg, 73%), mp: 259-261 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.30 (s, 9H), 1.81-1.89 (m, 2H), 2.24-2.29 (m, 1H), 2.45-2.49 (m, 1H), 5.60-5.63 (m, 1H), 6.97 (d, J = 7.2 Hz, 2H), 7.11 (t, J = 6.6 Hz, 1H), 7.18 (t, J = 7.2 Hz, 2H), 7.42 (d, J = 8.4 Hz, 2H), 7.49 (t, J = 7.2 Hz, 1H), 7.56 (t, J = 7.8 Hz, 1H), 7.63 (d, J = 7.8 Hz, 1H), 7.77 (d, J = 8.4 Hz, 2H), 7.87 (s, 1H), 7.88 (s, 1H), 8.23 (d, J = 7.8 Hz, 1H), 13.17 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 31.7, 32.2, 34.4, 34.7, 54.9, 120.0, 124.7, 125.8, 126.5, 128.4, 128.8, 129.0, 129.1, 130.3, 130.4, 130.6, 131.8, 132.8, 133.1, 139.7, 140.7, 141.4, 144.4, 149.5, 167.3. HRMS calcd for $C_{31}H_{29}N_2O_2$: 461.2235 $[M-H]^-$, found: 461.2239.

2-(4-Fluorophenyl)-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3t)

White solid (82.8 mg, 65%), mp: 225-226 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.84-1.91 (m, 2H), 2.26-2.33 (m, 1H), 2.46-2.52 (m, 1H), 5.64-5.68 (m, 1H), 6.97 (d, J = 6.8 Hz, 2H), 7.10-7.13 (m, 1H), 7.18 (t, J = 6.8 Hz, 2H), 7.26 (t, J = 8.8 Hz, 2H), 7.51 (td, J_1 = 7.6 Hz, J_2 = 1.2 Hz, 1H), 7.58 (td, J_1 = 7.2 Hz, J_2 = 1.2 Hz, 1H), 7.66 (d, J = 7.6 Hz, 1H), 7.90-7.95 (m, 4H), 8.26 (d, J = 7.6 Hz, 1H), 13.21 (br s, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ: 32.3, 34.3, 55.0, 115.9 (d, $^{2}J_{C\text{-}F}$ = 20.6 Hz), 120.1, 126.4, 126.8 (d, $^{3}J_{C\text{-}F}$ = 8.1 Hz), 128.4, 128.8, 129.0, 129.1, 130.2, 130.4, 130.7, 131.1 (d, $^{4}J_{C\text{-}F}$ = 2.7 Hz), 132.8, 133.1, 139.7, 140.4, 140.7, 144.6, 161.7 (d, $^{1}J_{C\text{-}F}$ = 242.1 Hz), 167.3. ^{19}F NMR (376 MHz, DMSO-d_6) δ: -115.85. HRMS calcd for $C_{27}H_{20}FN_2O_2$: 423.1514 $[M-H]^-$, found: 423.1520.

2-(4-Chlorophenyl)-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3u)

White solid (97.9 mg, 74%), mp: 250-252 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.80-1.91 (m, 2H), 2.24-2.31 (m, 1H), 2.45-2.49 (m, 1H), 5.61-5.65 (m, 1H), 6.96-6.98 (m, 2H), 7.09-7.12 (m, 1H), 7.16-7.19 (m, 2H), 7.45-7.47 (m, 2H), 7.50 (td, J_1 = 7.2 Hz, J_2= 1.6 Hz, 1H), 7.57 (td, J_1 = 7.6 Hz, J_2= 1.2 Hz, 1H), 7.65 (d, J = 7.2 Hz, 1H), 7.85-7.88 (m, 3H), 8.00 (s, 1H), 8.22 (dd, J_1 = 8.0 Hz, J_2= 1.2 Hz, 1H), 13.21 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 32.3, 34.3, 55.1, 120.8, 126.4, 126.6, 128.4, 128.8, 129.0, 129.1, 129.2, 130.1, 130.4, 130.7, 131.4, 132.8, 133.1, 133.5, 139.7, 140.1, 140.7, 144.7, 167.2. HRMS calcd for $C_{27}H_{20}ClN_2O_2$: 439.1219 $[M-H]^-$, found: 439.1227.

2-(4-Bromophenyl)-5-phenethyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3v)

White solid (104.8 mg, 72%), mp: 239-240 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.82-1.91 (m, 2H), 2.24-2.32 (m, 1H), 2.45-2.49 (m, 1H), 5.62-5.66 (m, 1H), 6.97 (d, J = 7.2 Hz, 2H), 7.11 (t, J = 7.2 Hz, 1H), 7.17 (t, J = 6.8 Hz, 2H), 7.51 (t, J = 7.2 Hz, 1H), 7.55-7.61 (m, 3H), 7.65 (d, J = 7.2 Hz, 1H), 7.82 (d, J = 8.4 Hz, 2H), 7.89 (s, 1H), 8.01 (s, 1H), 8.23 (d, J = 7.6 Hz, 1H), 13.26 (br s, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ: 32.3, 34.3, 55.1, 119.9, 120.8, 126.4, 126.9, 128.4, 128.8, 129.1, 129.2, 130.1, 130.4, 130.7,

132.0, 132.8, 133.2, 133.8, 139.6, 140.1, 140.7, 144.7, 167.3. HRMS calcd for $C_{27}H_{20}BrN_2O_2$: 483.0714 $[M-H]^-$, found: 483.0723.

5-Butyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3w)

White solid (55.9 mg, 66%), mp: 259-261 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 0.69 (t, J = 7.2 Hz, 3H), 0.86-0.91 (m, 1H), 1.03-1.15 (m, 3H), 1.46-1.52 (m, 2H), 5.50 (t, J = 8.4 Hz, 1H), 7.11 (s, 1H), 7.44-7.46 (m, 2H), 7.51 (t, J = 7.2 Hz, 1H), 7.60 (d, J = 7.2 Hz, 1H), 7.82 (s, 1H), 8.12 (d, J = 7.8 Hz, 1H), 13.14 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 14.1, 21.8, 28.3, 32.5, 54.9, 124.1, 128.76, 128.82, 128.9, 129.4, 129.5, 130.3, 130.4, 130.6, 132.70, 132.74, 133.5, 139.4, 139.5, 144.2, 167.4. HRMS calcd for $C_{17}H_{17}N_2O_2$: 281.1296 $[M-H]^-$, found: 281.1301.

5-Pentyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3x)

White solid (60.5 mg, 68%), mp: 239-240 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 0.73 (t, J = 6.8 Hz, 3H), 0.90-0.95 (m, 1H), 1.00-1.09 (m, 5H), 1.46-1.51 (m, 2H), 5.51 (t, J = 7.6 Hz, 1H), 7.11 (d, J = 0.4 Hz, 1H), 7.44-7.53 (m, 3H), 7.59-7.61 (m, 1H), 7.82 (s, 1H), 8.11-8.13 (m, 1H), 13.15 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 14.1, 22.2, 25.6, 30.7, 32.7, 54.9, 124.06, 124.10, 128.7, 128.8, 128.9, 129.4, 129.5, 130.3, 130.4, 130.6, 132.7, 133.5, 139.4, 139.5, 144.2, 167.3. HRMS calcd for $C_{18}H_{19}N_2O_2$: 295.1452 $[M-H]^-$, found: 295.1452.

5-Hexyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3y)

White solid (62.4 mg, 67%), mp: 194-196 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 0.76 (t, J = 7.2 Hz, 3H), 0.89-0.91 (m, 1H), 1.04-1.14 (m, 7H), 1.46-1.50 (m, 2H), 5.50 (t, J = 7.8 Hz, 1H), 7.11 (s, 1H), 7.44-7.47 (m, 2H), 7.51 (t, J = 7.2 Hz, 1H), 7.60 (d, J = 7.2 Hz, 1H), 7.81 (s, 1H), 8.11 (d, J = 7.8 Hz, 1H), 13.15 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 14.3, 22.2, 25.9, 28.2, 31.4, 32.7, 54.9, 124.0, 128.78, 128.84, 129.4, 130.2, 130.5, 130.6, 132.7, 133.6, 139.4, 144.2, 167.4. HRMS calcd for $C_{19}H_{21}N_2O_2$: 309.1609 $[M-H]^-$, found: 309.1600.

5-Octyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3z)

White solid (67.0 mg, 66%), mp: 209-210 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 0.81 (t, J = 6.8 Hz, 3H), 0.90-0.91 (m, 1H), 1.06-1.20 (m, 11H), 1.46-1.49 (m, 2H), 5.50 (t, J = 7.6 Hz, 1H), 7.11 (s, 1H), 7.44-7.53 (m, 3H), 7.60 (d, J = 7.2 Hz, 1H), 7.81 (s, 1H), 8.12 (d, J = 7.6 Hz, 1H), 13.15 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 14.4, 22.5, 25.9, 28.5, 28.8, 29.0, 31.6, 32.7, 54.9, 124.1, 128.8, 129.4, 129.5, 130.3, 130.4, 130.6, 132.7, 133.5, 139.4, 139.5, 144.2, 167.3. HRMS calcd for $C_{21}H_{25}N_2O_2$: 337.1922 $[M-H]^-$, found: 337.1922.

5-Undecyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3aa)

White solid (74.2 mg, 65%), mp: 150-152 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 0.82-0.91 (m, 4H), 1.05-1.25 (m, 17H), 1.45-1.49 (m, 2H), 5.50 (t, J = 7.6 Hz, 1H), 7.10 (s, 1H), 7.43-7.52 (m, 3H), 7.59 (d, J = 7.2 Hz, 1H), 7.81 (s, 1H), 8.12 (d, J = 7.6 Hz, 1H), 13.15 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 14.4, 22.5, 25.9, 28.5, 29.06, 29.14, 29.4, 31.7, 32.6, 54.9, 124.0, 128.7, 128.8, 129.4, 129.5, 130.2, 130.4, 130.6, 132.7, 133.5, 139.4, 139.5, 144.2, 167.3. HRMS calcd for $C_{24}H_{31}N_2O_2$: 379.2391 $[M-H]^-$, found: 379.2391.

5-(1-(4-Isopropylphenyl)propan-2-yl)-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3bb)

White solid (71.9 mg, 62%), mp: 181-183 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 0.33 (d, J = 6.6 Hz, 1.5H), 0.63 (d, J = 6.6 Hz, 1.5H), 1.09-1.12 (m, 6H), 1.78-1.86 (m, 1H), 1.91-1.93 (m, 0.5H), 2.03-2.07 (m, 0.5H), 2.13-2.17 (m, 0.5H), 2.60-2.63 (m, 0.5H), 2.71-2.79 (m, 1H), 5.33-5.36 (m, 1H), 6.58 (d, J = 7.8 Hz, 1H), 6.75 (d, J = 8.4 Hz, 1H), 6.98 (d, J = 8.4 Hz, 1H), 7.03 (d, J = 7.8 Hz, 1H), 7.11 (s, 0.5H), 7.15 (s, 0.5H), 7.46-7.52 (m, 2H), 7.55-7.58 (m, 1H), 7.60 (d, J = 7.8 Hz, 0.5H), 7.67-7.69 (m, 0.5H), 7.88 (s, 0.5H), 7.95 (s, 0.5H), 8.07-8.09 (m, 0.5H), 8.17 (d, J = 7.8 Hz, 0.5H), 13.19 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 15.8, 16.1, 24.29, 24.31, 24.34, 33.37, 33.40, 38.3, 38.6, 38.7, 39.2, 59.6, 59.7, 124.6, 124.7, 126.6, 126.7, 128.6, 128.7, 128.8, 128.90, 128.93, 129.3, 129.5, 130.3, 130.6, 130.68,

130.74, 130.8, 132.3, 132.4, 133.2, 133.4, 137.2, 137.5, 139.3, 139.6, 146.4, 146.5, 167.7, 167.8. HRMS calcd for $C_{25}H_{25}N_2O_2$: 385.1922 $[M-H]^-$, found: 385.1922.

5-Cyclopentyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3cc)

White solid (58.3 mg, 66%), mp: >300 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 1.01-1.05 (m, 1H), 1.12-1.18 (m, 1H), 1.24-1.43 (m, 4H), 1.52-1.58 (m, 2H), 2.04-2.10 (m, 1H), 5.31 (d, J = 10.8 Hz, 1H), 7.12 (s, 1H), 7.46 (t, J = 7.8 Hz, 1H), 7.50-7.53 (m, 2H), 7.62 (d, J = 7.2 Hz, 1H), 7.88 (s, 1H), 8.13 (d, J = 7.2 Hz, 1H), 13.20 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 24.4, 24.9, 29.2, 30.1, 42.9, 58.8, 124.2, 128.78, 128.82, 129.2, 130.3, 130.6, 130.7, 132.7, 133.2, 139.5, 144.2, 167.8. HRMS calcd for $C_{18}H_{17}N_2O_2$: 293.1296 $[M-H]^-$, found: 293.1293.

5-Benzyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3dd)

White solid (52.2 mg, 55%), mp: 261-262 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 2.72 (dd, J_1 = 13.2 Hz, J_2 = 9.2 Hz, 1H), 2.81 (dd, J_1 = 13.2 Hz, J_2= 6.4 Hz, 1H), 5.70-5.74 (m, 1H), 6.82 (dd, J_1 = 7.6 Hz, J_2 = 1.6 Hz, 2H), 6.93 (d, J = 0.8 Hz, 1H), 7.03 (d, J = 0.8 Hz, 1H), 7.12-7.19 (m, 3H), 7.51 (td, J_1 = 7.2 Hz, J_2 = 1.2 Hz, 1H), 7.58 (td, J_1 = 7.6 Hz, J_2 = 1.6 Hz, 1H), 7.68 (d, J = 7.2 Hz, 1H), 7.88 (s, 1H), 8.20 (dd, J_1 = 7.6 Hz, J_2 = 1.2 Hz, 1H), 13.04 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 38.6, 56.5, 123.8, 127.1, 128.7, 128.9, 129.0, 129.2, 130.47, 130.50, 130.9, 132.8, 136.9, 139.7, 144.3, 167.1. HRMS calcd for $C_{20}H_{15}N_2O_2$: 315.1139 $[M-H]^-$, found: 315.1121.

5-(4-Cyanophenyl)-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3ee)

White solid (40.3 mg, 41%), mp: 180-181 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 6.90 (d, J = 8.0 Hz, 2H), 7.02 (s, 1H), 7.25 (d, J = 1.2 Hz, 1H), 7.36 (td, J_1 = 7.6 Hz, J_2= 1.6 Hz, 1H), 7.43 (td, J_1 = 7.6 Hz, J_2= 1.6 Hz, 1H), 7.53 (d, J = 6.8 Hz, 1H), 7.65 (d, J = 8.4 Hz, 2H), 7.83 (d, J = 1.2 Hz, 1H), 8.02-8.05 (m, 2H), 13.52 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 56.3, 110.9, 118.8, 124.5, 126.8, 128.8, 129.0, 130.2,

130.3, 130.7, 132.1, 132.8, 132.9, 141.5, 144.6, 145.1, 167.7. HRMS calcd for $C_{20}H_{12}N_3O_2$: 326.0935 $[M-H]^-$, found: 326.0930.

9-Methyl-5-pentyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3ff)

White solid (56.8 mg, 61%), mp: 258-259 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 0.73 (t, J = 6.8 Hz, 3H), 0.88-0.92 (m, 1H), 1.02-1.08 (m, 5H), 1.44-1.48 (m, 2H), 2.37 (s, 3H), 5.47 (t, J = 7.6 Hz, 1H), 7.07 (s, 1H), 7.33 (d, J = 8.0 Hz, 1H), 7.40-7.42 (m, 2H), 7.75 (s, 1H), 8.00 (d, J = 8.0 Hz, 1H), 13.02 (br s, 1H). ^{13}C NMR (150 MHz, CF_3CO_2D) δ: 11.8, 19.6, 21.4, 25.1, 30.1, 30.5, 58.2, 118.0, 119.8, 123.6, 128.1, 130.5, 131.5, 132.5, 133.8, 142.4, 142.7, 145.8, 169.8. HRMS calcd for $C_{19}H_{21}N_2O_2$: 309.1609 $[M-H]^-$, found: 309.1613.

5-Cyclopentyl-9-methyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3gg)

White solid (37.0 mg, 40%), mp >300 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.01-1.55 (m, 8H), 2.06-2.08 (m, 1H), 2.37 (s, 3H), 5.26 (d, J = 10.8 Hz, 1H), 7.06 (s, 1H), 7.32 (d, J = 7.6 Hz, 1H), 7.42 (s, 1H), 7.46 (s, 1H), 7.80 (s, 1H), 8.01 (d, J = 8.0 Hz, 1H), 13.08 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 21.0, 24.4, 24.9, 29.2, 30.1, 42.8, 58.7, 123.9, 128.3, 128.8, 129.1, 130.5, 131.2, 132.9, 133.0, 138.3, 139.6, 144.3, 167.8. HRMS calcd for $C_{19}H_{19}N_2O_2$: 307.1452 $[M-H]^-$, found: 307.1449.

9-Fluoro-5-pentyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3hh)

White solid (50.0 mg, 53%), mp: 251-252 ºC. ^{1}H NMR (600 MHz, DMSO-d_6) δ: 0.73 (t, J = 7.2 Hz, 3H), 0.90-0.92 (m, 1H), 1.03-1.10 (m, 5H), 1.47-1.50 (m, 2H), 5.50 (t, J = 7.8 Hz, 1H), 7.10 (s, 1H), 7.36-7.39 (m, 1H), 7.46 (s, 1H), 7.55 (d, J = 9.6 Hz, 1H), 7.80 (s, 1H), 8.12-8.15 (m, 1H), 13.18 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 14.1, 22.2, 25.6, 30.7, 32.7, 54.8, 117.6 (d, $^2J_{C\text{-}F}$ = 21.5 Hz), 118.4 (d, $^2J_{C\text{-}F}$ = 22.4 Hz), 124.0, 127.3, 129.5, 131.3 (d, $^3J_{C\text{-}F}$ = 9.3 Hz), 132.6 (d, $^3J_{C\text{-}F}$ = 6.9 Hz), 134.7, 138.3, 143.6, 161.9 (d, $^1J_{C\text{-}F}$ = 245.1 Hz), 167.2. ^{19}F NMR (376 MHz, DMSO-d_6) δ: -113.63. HRMS calcd for $C_{18}H_{18}FN_2O_2$: 313.1358 $[M-H]^-$, found: 313.1358.

5-Cyclopentyl-9-fluoro-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3ii)

White solid (45.9 mg, 49%), mp >300 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 0.99-1.06 (m, 1H), 1.11-1.46 (m, 5H), 1.50-1.62 (m, 2H), 2.03-2.10 (m, 1H), 5.30 (d, J = 10.8 Hz, 1H), 7.10 (d, J = 0.8 Hz, 1H), 7.37 (td, J_1 = 8.4 Hz, J_2 = 2.8 Hz, 1H), 7.50 (d, J = 0.8 Hz, 1H), 7.56 (dd, J_1 = 10.0 Hz, J_2 = 2.4 Hz, 1H), 7.85 (s, 1H), 8.13-8.16 (m, 1H), 13.28 (br s, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ: 24.4, 24.9, 29.2, 30.1, 43.0, 58.6, 117.6 (d, $^{2}J_{C\text{-}F}$ = 21.4 Hz), 118.4 (d, $^{2}J_{C\text{-}F}$ = 22.9 Hz), 124.1, 127.5 (d, $^{4}J_{C\text{-}F}$ = 2.6 Hz), 129.3, 131.2 (d, $^{3}J_{C\text{-}F}$ = 8.4 Hz), 132.7 (d, $^{3}J_{C\text{-}F}$ = 9.2 Hz), 134.4, 138.3, 143.6, 161.9 (d, $^{1}J_{C\text{-}F}$ = 243.4 Hz), 167.6. ^{19}F NMR (376 MHz, DMSO-d_6) δ: -113.66. HRMS calcd for $C_{18}H_{16}FN_2O_2$: 311.1201 $[M-H]^-$, found: 311.1201.

5-Pentyl-2-phenyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3jj)

White solid (82.7 mg, 74%), mp: 117-119 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 0.72 (t, J = 6.4 Hz, 3H), 1.01-1.18 (m, 6H), 1.54-1.57 (m, 2H), 5.61 (t, J = 7.2 Hz, 1H), 7.25 (t, J = 7.2 Hz, 1H), 7.41 (t, J = 7.2 Hz, 2H), 7.50 (t, J = 7.2 Hz, 1H), 7.58 (t, J = 7.2 Hz, 1H), 7.65 (d, J = 7.6 Hz, 1H), 7.89-7.92 (m, 3H), 7.98 (s, 1H), 8.30 (d, J = 7.6 Hz, 1H), 13.23 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 14.1, 22.2, 25.7, 30.8, 32.6, 55.3, 120.4, 124.9, 127.0, 129.0, 130.3, 130.4, 130.7, 132.8, 133.3, 134.6, 139.5, 141.2, 144.5, 167.4. HRMS calcd for $C_{24}H_{23}N_2O_2$: 371.1765 $[M-H]^-$, found: 371.1765.

5-Cyclopentyl-2-phenyl-5*H*-benzo[*c*]imidazo[1,2-*a*]azepine-6-carboxylic acid (3kk)

White solid (62.2 mg, 56%), mp: 274-275 ºC. ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.09-1.15 (m, 1H), 1.18-1.45 (m, 5H), 1.54-1.58 (m, 2H), 2.09-2.16 (m, 1H), 5.33 (d, J = 11.2 Hz, 1H), 7.23 (t, J = 7.2 Hz, 1H), 7.39 (t, J = 7.6 Hz, 2H), 7.47-7.51 (m, 1H), 7.54-7.58 (m, 1H), 7.65 (d, J = 7.2 Hz, 1H), 7.84 (d, J = 7.6 Hz, 2H), 7.91 (s, 1H), 8.03 (s, 1H), 8.23 (d, J = 7.2 Hz, 1H), 13.18 (br s, 1H). ^{13}C NMR (150 MHz, DMSO-d_6) δ: 24.4, 24.9, 29.3, 30.2, 59.1, 120.6, 124.8, 127.0, 128.98, 129.02, 130.4, 130.5, 130.8, 132.8,

133.0, 134.6, 139.5, 141.1, 144.5, 167.8. HRMS calcd for $C_{24}H_{21}N_2O_2$: 369.1609 $[M-H]^-$, found: 369.1608.

2. Structural elaborations of 3a and 3dd

2.1. Synthesis of 5 from the reaction of 3a

To a reaction tube equipped with a stir bar were added **3a** (66.1 mg, 0.2 mmol) and poly(phosphoric acid) (PPA, 1 mL) with stirring. The tube was then sealed, and the mixture was stirred at 160 °C for 12 h. Upon completion, the resulting mixture was diluted with saturated $NaHCO_3$ solution (5 mL) and extracted with ethyl acetate (10 mL × 3). The combined organic layers were washed with water (5 mL) and brine (5 mL), dried over anhydrous $MgSO_4$, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel with DCM/CH_3OH (100:1) as the eluent to afford **5** in a yield of 90%.

15,15a-dihydrobenzo[*c*]benzo[5,6]cyclohepta[1,2-*f*]imidazo[1,2-*a*]azepin-9(14*H*)-one (5)

Yellow solid (56.2 mg, 90%), mp: 247-248 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 2.08-2.18 (m, 1H), 2.28-2.36 (m, 1H), 2.73 (dd, J_1 = 14.0 Hz, J_2 = 5.6 Hz, 1H), 3.00-3.08 (m, 1H), 5.01-5.06 (m, 1H), 6.83 (d, J = 0.8 Hz, 1H), 7.18 (d, J = 0.8 Hz, 1H), 7.23 (d, J = 7.2 Hz, 1H), 7.39-7.56 (m, 5H), 7.65 (s, 1H), 7.89 (dd, J_1 = 7.6 Hz, J_2 = 1.2 Hz, 1H), 8.32 (d, J = 8.0 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 30.4, 32.3, 57.1, 122.1, 127.9, 128.9, 129.4, 129.8, 130.0, 130.1, 130.4, 133.4, 133.7, 136.8, 137.8, 138.4, 138.6, 145.1, 193.3. HRMS calcd for $C_{21}H_{17}N_2O$: 313.1335 $[M+H]^+$, found: 313.1335.

2.2. Synthesis of 6 from the reaction of 3dd

To a reaction tube equipped with a stir bar were added **3dd** (63.3 mg, 0.2 mmol) and poly(phosphoric acid) (PPA, 1 mL) with stirring. The tube was then sealed, and the mixture was stirred at 160 °C for 12 h. Upon completion, the resulting mixture was diluted with saturated $NaHCO_3$ solution (5 mL) and extracted with ethyl acetate (10 mL × 3). The combined organic layers were washed with water (5 mL)

and brine (5 mL), dried over anhydrous $MgSO_4$, and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel with DCM/CH_3OH (100:1) as the eluent to afford **6** in a yield of 85%.

14,14a-dihydro-9*H*-benzo[*c*]imidazo[1,2-*a*]naphtho[2,3-*f*]azepin-9-one (6)

Yellow solid (50.7 mg, 85%), mp: 211-212 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 3.59 (dd, J_1 = 17.2 Hz, J_2 = 1.2 Hz, 1H), 3.70 (dd, J_1 = 17.2 Hz, J_2 = 6.4 Hz, 1H), 4.93 (d, J = 6.0 Hz, 1H), 6.98 (s, 1H), 7.12 (s, 1H), 7.44-7.66 (m, 6H), 8.04 (d, J = 7.6 Hz, 1H), 8.08 (s, 1H), 8.18 (d, J = 7.6 Hz, 1H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 29.8, 49.6, 115.7, 128.2, 128.29, 128.32, 128.7, 129.7, 129.9, 130.2, 130.7, 131.7, 131.8, 133.3, 133.9, 134.4, 138.3, 140.9, 146.8, 183.7. HRMS calcd for $C_{20}H_{15}N_2O$: 299.1179 $[M+H]^+$, found: 299.1179.

3. Gram-scale synthesis of 3a

To a reaction tube equipped with a stir bar were added 2-phenyl-1*H*-imidazole (**1a**, 0.72 g, 5 mmol), DCM (30 mL), 3-methylene-4-phenethyloxetan-2-one (**2a**, 1.41 g, 7.5 mmol), $[RhCp^*Cl_2]_2$ (77.3 mg, 0.125 mmol) and AgOAc (1.67 g, 10 mmol) with stirring. The mixture was stirred at 100 °C for 10 h under air in an oil bath. Upon completion, it was cooled to room temperature. The resulting mixture was filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel chromatography using DCM/CH_3OH/HOAc (30:1:0.1) as eluent to afford **3a** in a yield of 52% (859mg).

III. Mechanism studies

1. Study on the reversibility of C−H bond activation

To a reaction tube equipped with a stir bar were added 2-phenyl-1*H*-imidazole (**1a**, 43.3 mg, 0.3 mmol), DCM (3 mL), CD_3OD (0.15 mL, 3.6 mmol), $[RhCp^*Cl_2]_2$ (4.7 mg, 0.0075 mmol) and AgOAc (100.1 mg, 0.6 mmol) with stirring. The mixture was stirred at 100 °C under air for 2 h. Upon completion, the resulting mixture was cooled to room temperature, filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel chromatography using petroleum ether/ethyl acetate (1:1) as eluent to give a mixture of **1a** and **1a**-d_n. Upon analyzing the ^{1}H NMR spectrum of the mixture as shown in Figure S1, the deuteration percentage was determined as 26%.

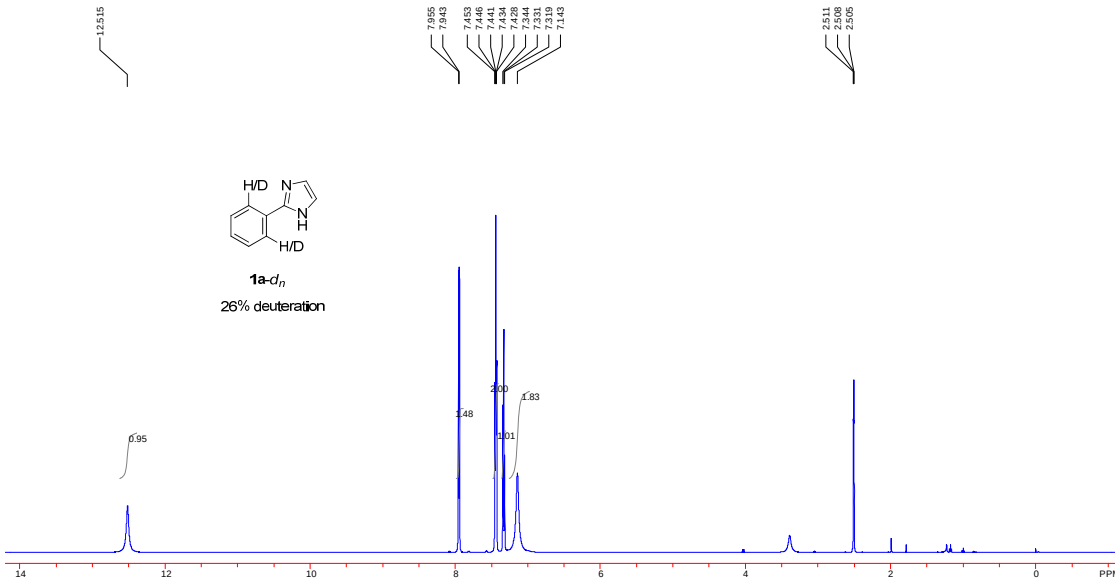


Figure S1. The ^{1}H NMR spectrum of the products obtained from the reversibility of C−H bond activation experiment

2. Intermolecular kinetic isotope effect study (I)

To a reaction tube equipped with a stir bar were added **1a** (21.6 mg, 0.15 mmol), **1a**-d_5 (22.4 mg, 0.15 mmol), DCM (3 mL), **2a** (56.5 mg, 0.3 mmol), $[RhCp^*Cl_2]_2$ (4.7 mg, 0.0075 mmol) and AgOAc (100.1 mg, 0.6 mmol) with stirring. The mixture was stirred at 100 °C under air for 80 min. Upon completion,

the resulting mixture was cooled to room temperature, filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel chromatography using DCM/CH_3OH/HOAc (30:1:0.1) as eluent to afford a mixture of **3a** and **3a**-d_4. Upon analyzing the ^{1}H NMR spectrum of the mixture as shown in Figure S2, the ratio of **3a** and **3a**-d_4 was determined as 0.57:0.43. Accordingly, the intermolecular KIE (k_H/k_D) was calculated as 1.33.

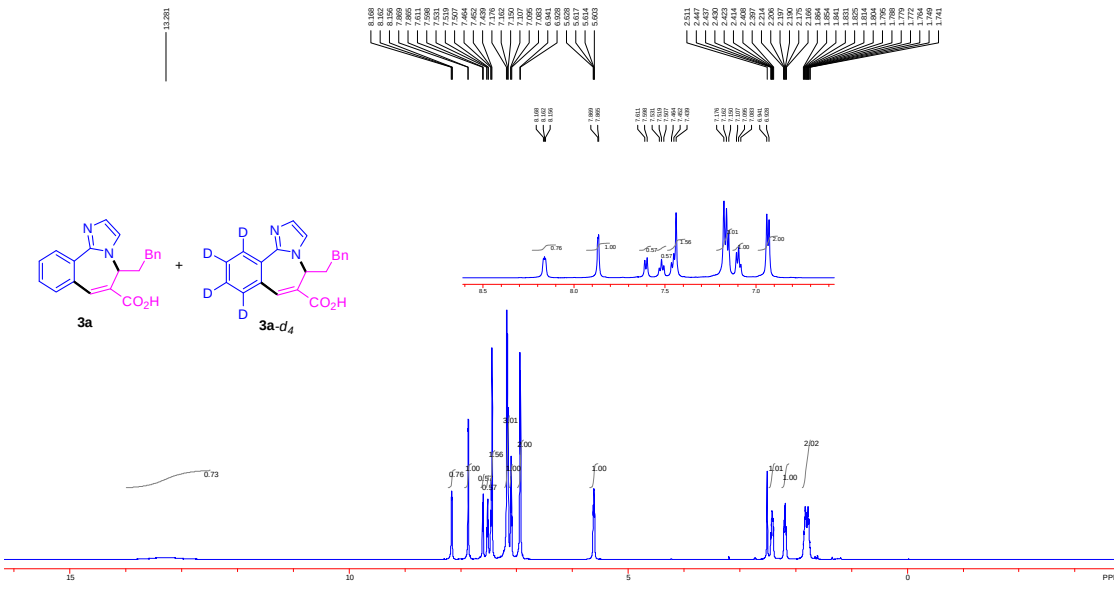


Figure S2. The ^{1}H NMR spectrum of the products obtained from the intermolecular KIE experiment

3. Intermolecular kinetic isotope effect study (II)

To a reaction tube equipped with a stir bar were added **1a** (21.6 mg, 0.15 mmol), **1a**-d_5 (22.4 mg, 0.15 mmol), DCM (3 mL), **2a** (28.2 mg, 0.15 mmol), $[RhCp^*Cl_2]_2$ (4.7 mg, 0.0075 mmol) and AgOAc (100.1 mg, 0.6 mmol) with stirring. The mixture was stirred at 100 °C under air for 10 h. Upon completion, the resulting mixture was cooled to room temperature, filtered through a pad of celite and concentrated under reduced pressure. The residue was purified by silica gel chromatography using DCM/CH_3OH/HOAc (30:1:0.1) as eluent to afford a mixture of **3a** and **3a**-d_4. Upon analyzing the ^{1}H NMR spectrum of the mixture as shown in Figure S3, the ratio of **3a** and **3a**-d_4 was determined as 0.59:0.41. Accordingly, the intermolecular KIE (k_H/k_D) was calculated as 1.44.

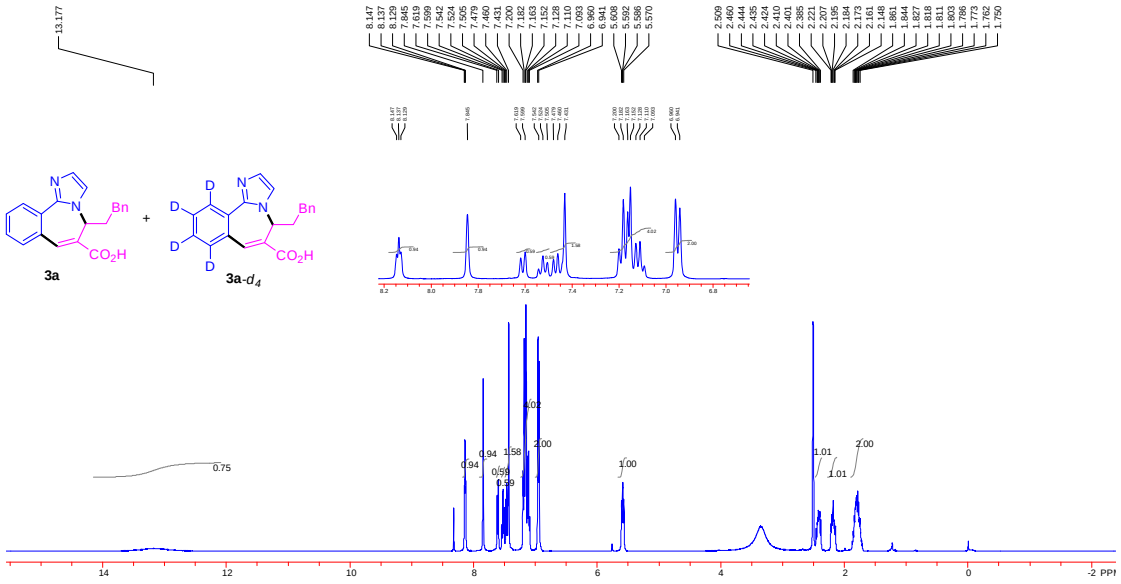
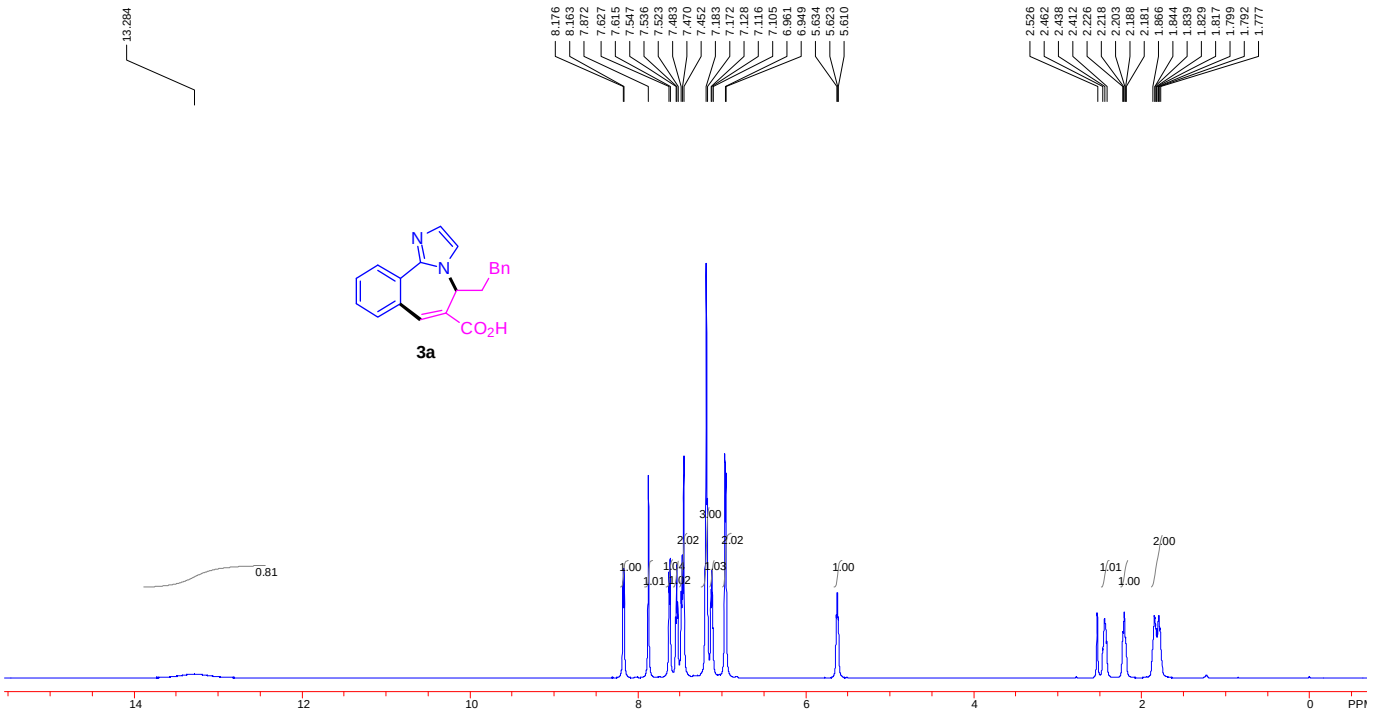


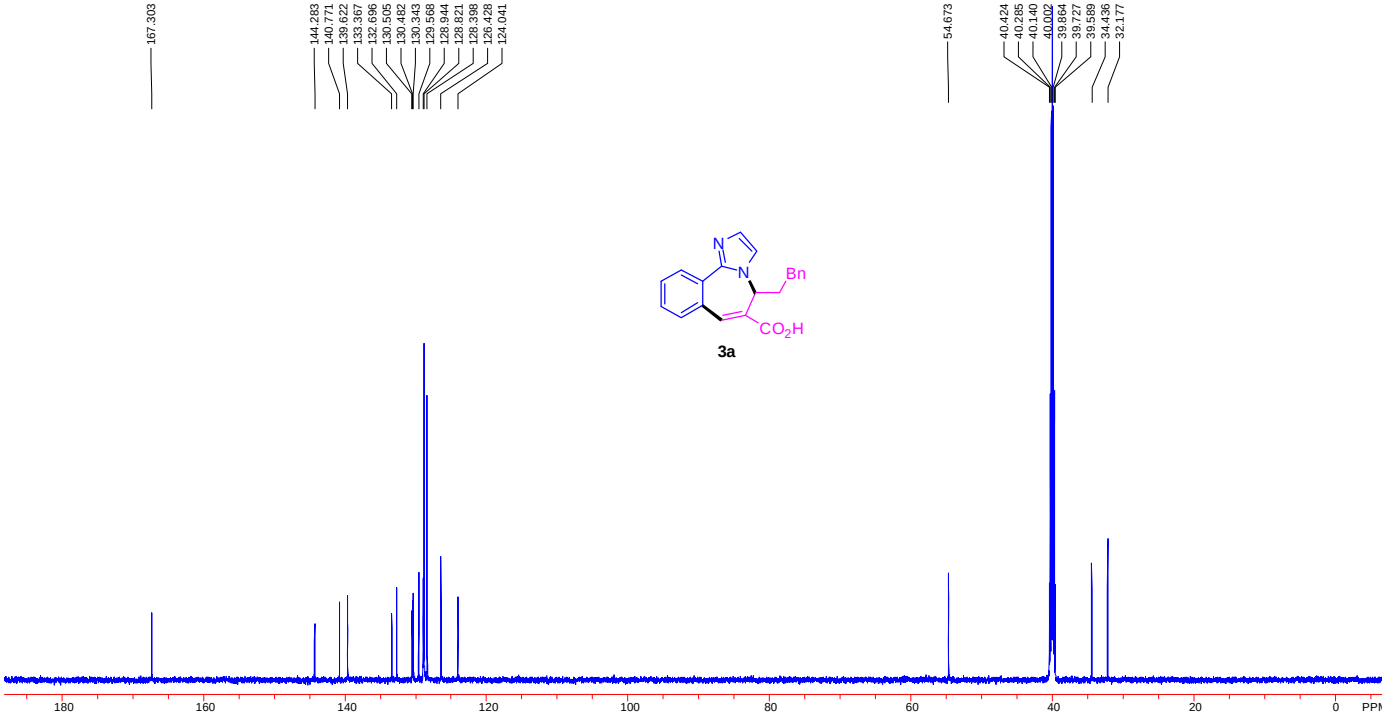
Figure S3. The ^{1}H NMR spectrum of the products obtained from the intermolecular KIE experiment

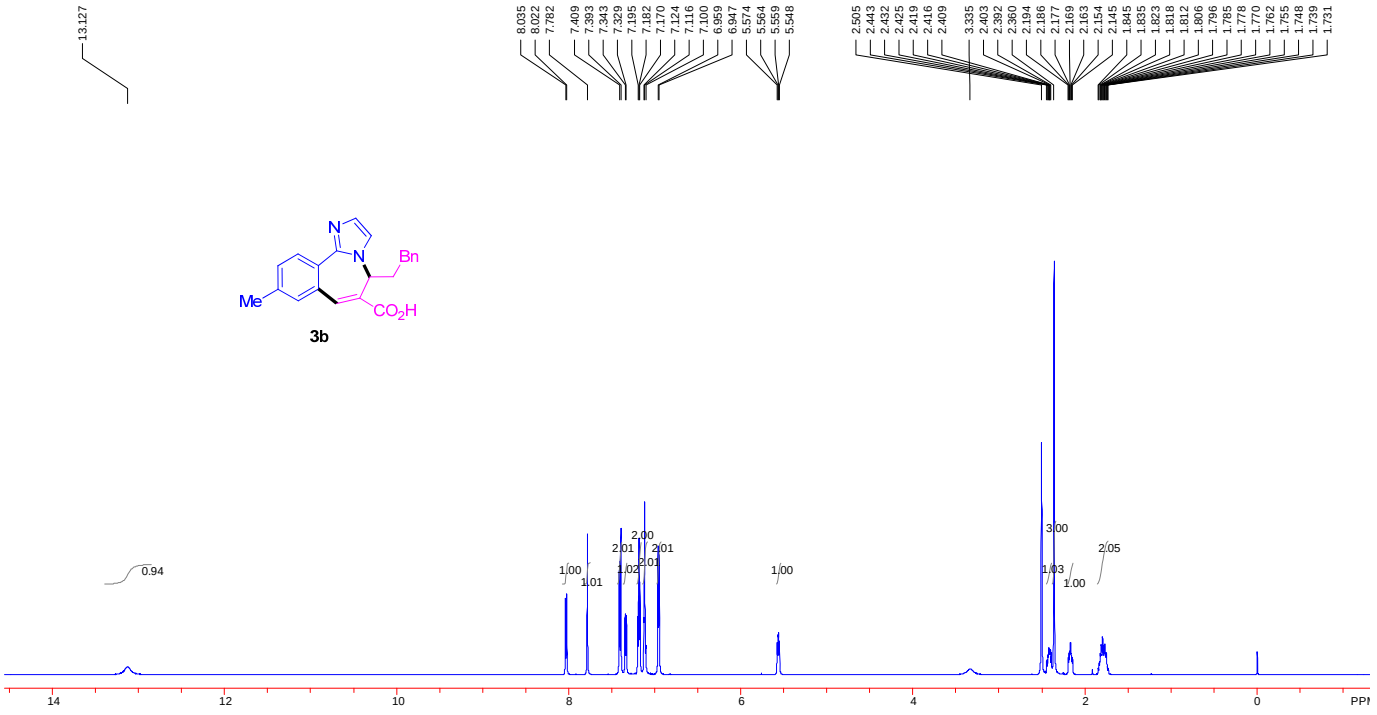
4. Control experiment with 3-hydroxy-2-methylene-5-phenylpentanoic acid (4) as possible coupling partner

To a reaction tube equipped with a stir bar were added **1a** (14.4 mg, 0.1 mmol), DCM (1 mL), 3-hydroxy-2-methylene-5-phenylpentanoic acid (**4**, 30.9 mg, 0.15 mmol), $[RhCp^*Cl_2]_2$ (1.6 mg, 0.0025 mmol) and AgOAc (33.4 mg, 0.2 mmol) with stirring. The mixture was stirred at 100 °C under air for 10 h. TLC analysis of the resulting mixture showed that the formation of **3a** was not observed, and most of the starting materials remained intact.

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



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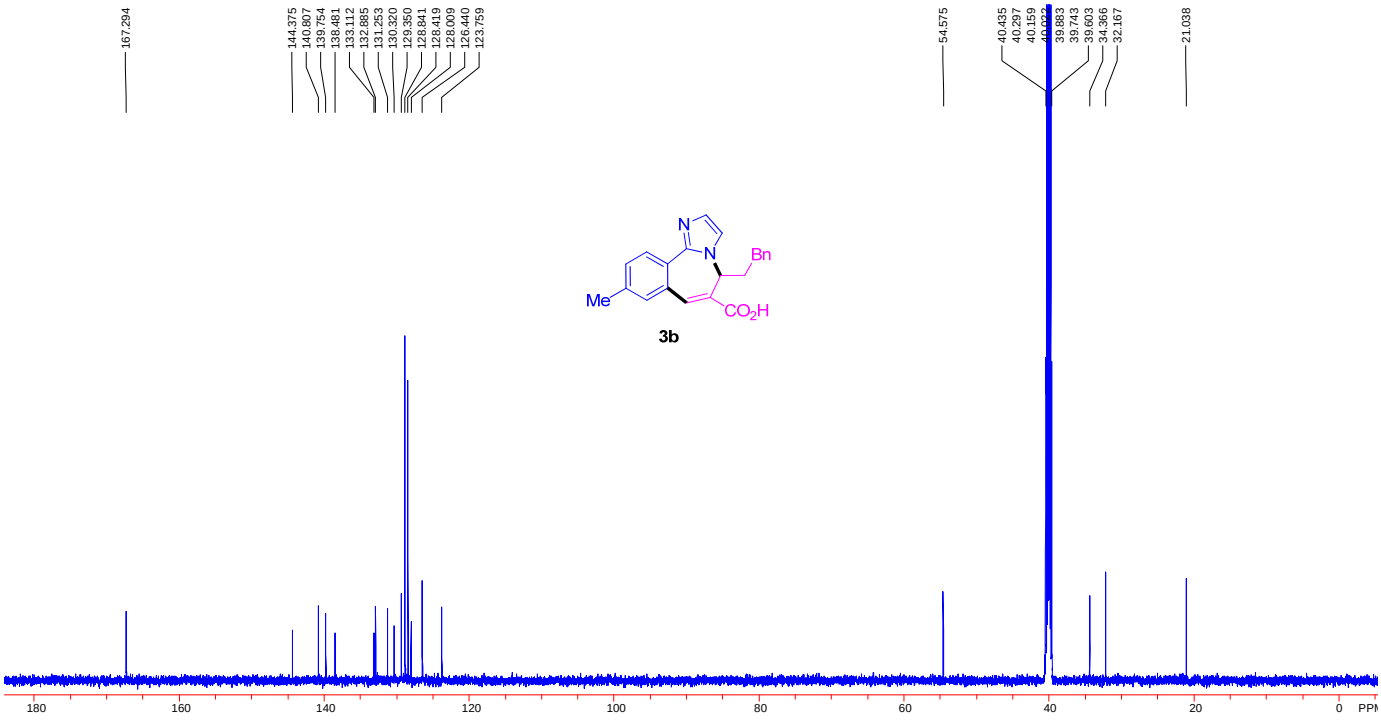
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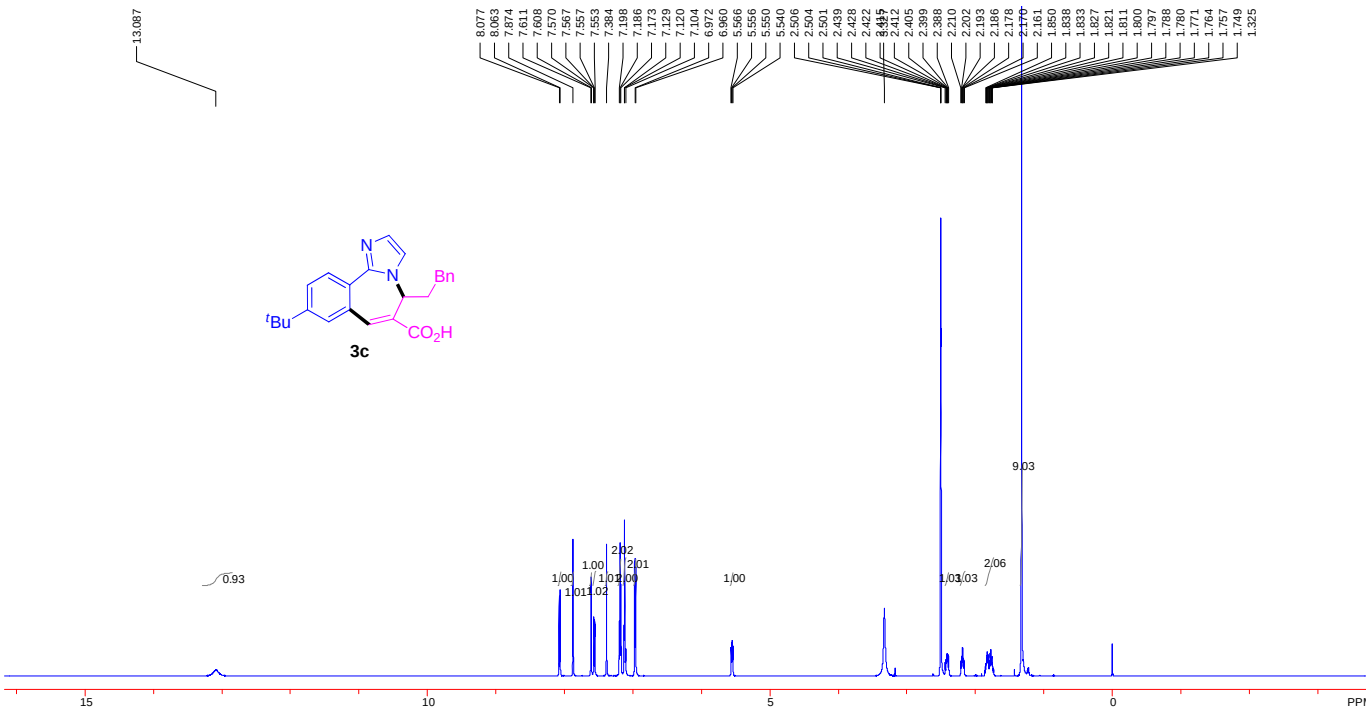
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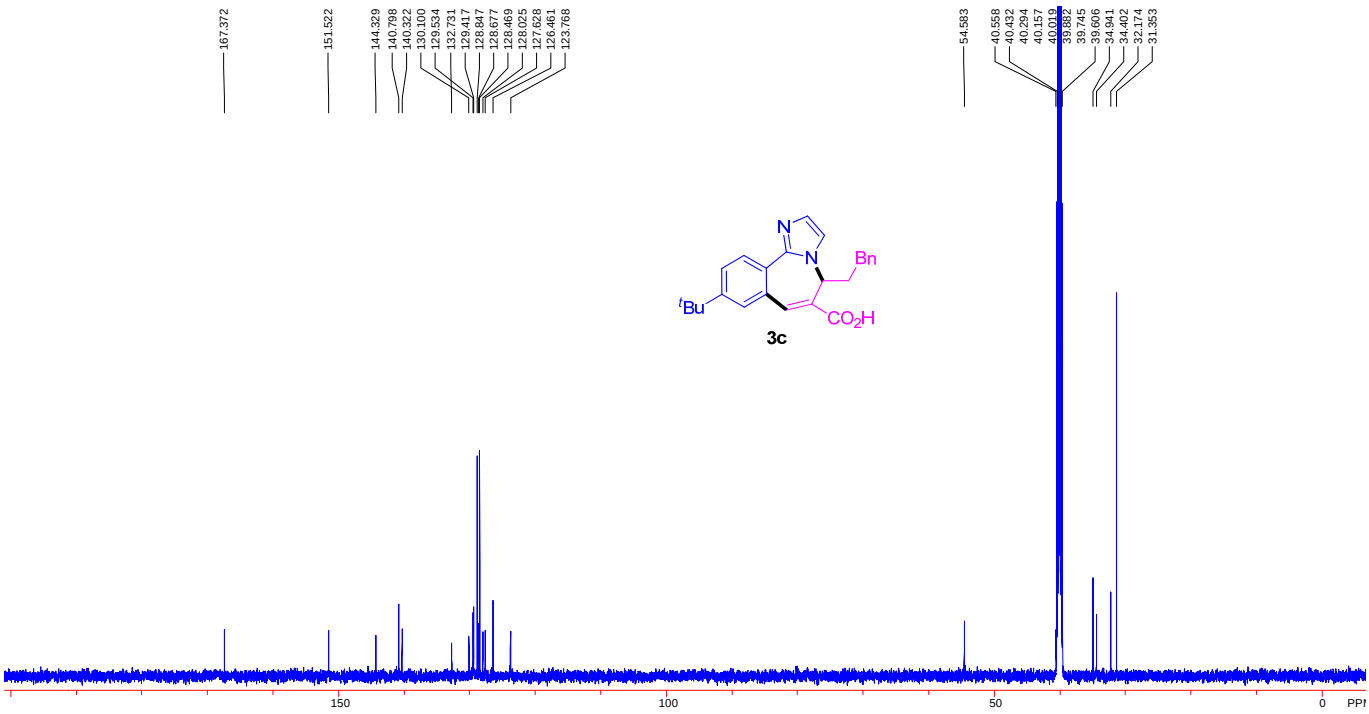
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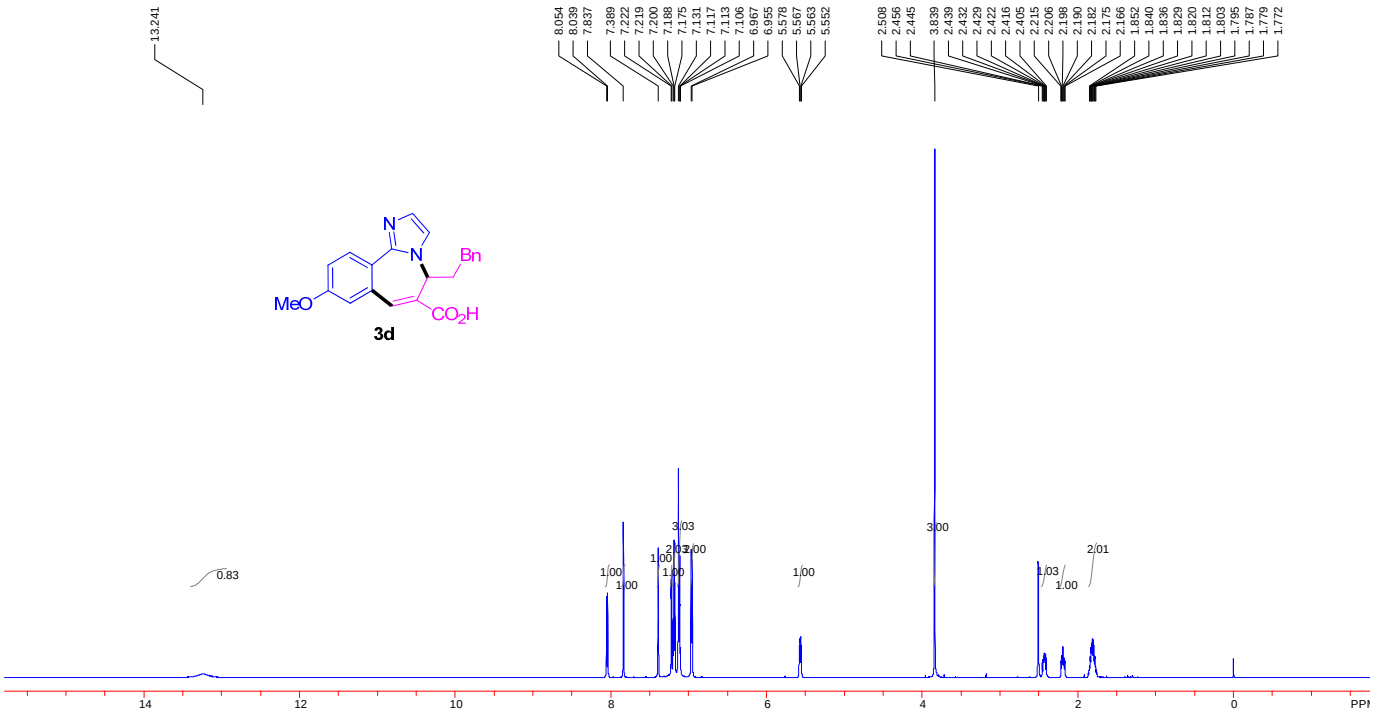
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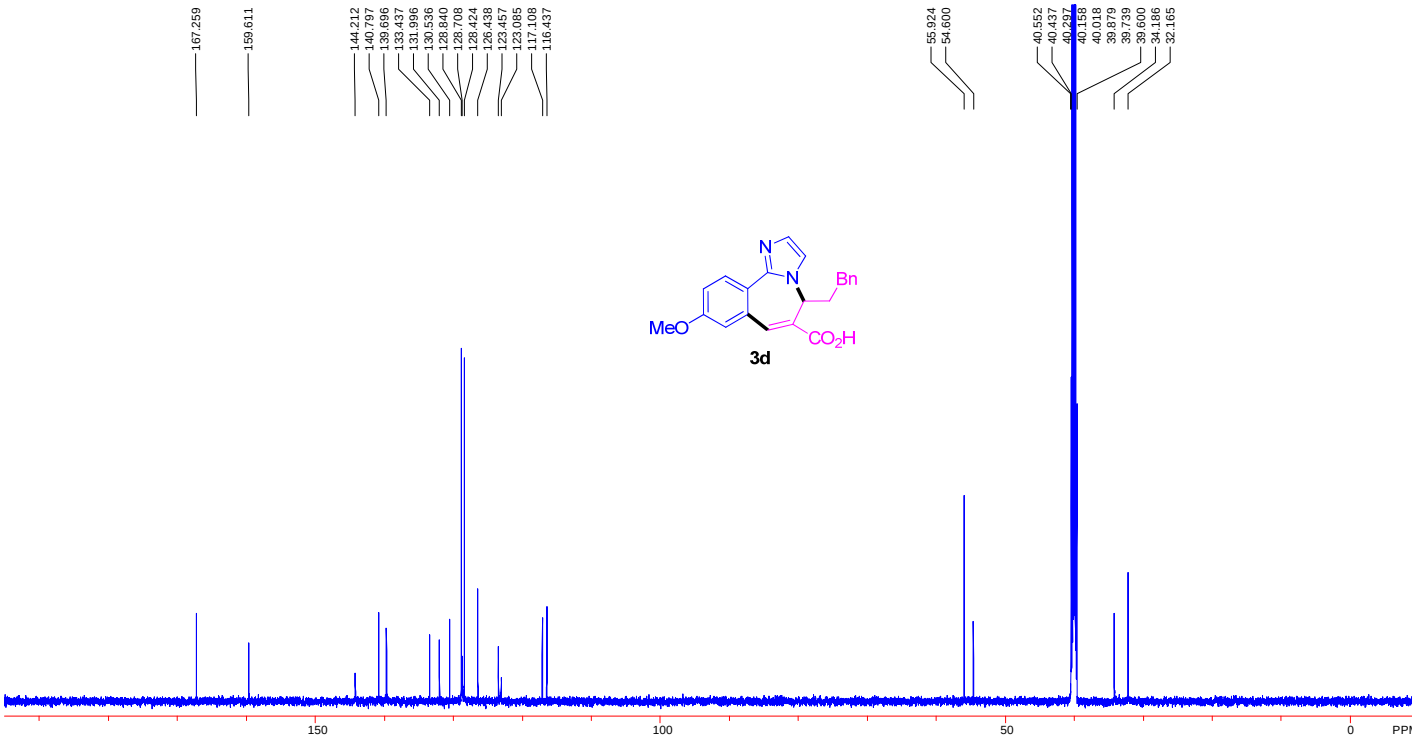
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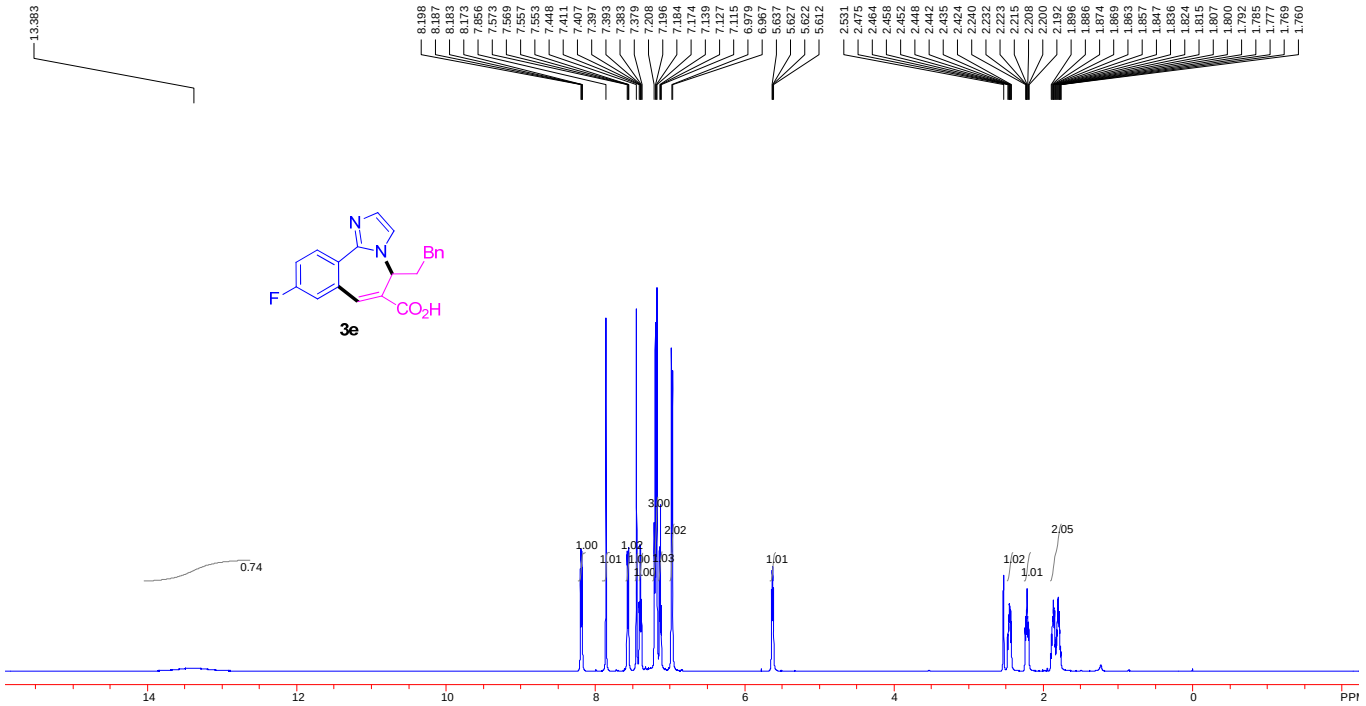
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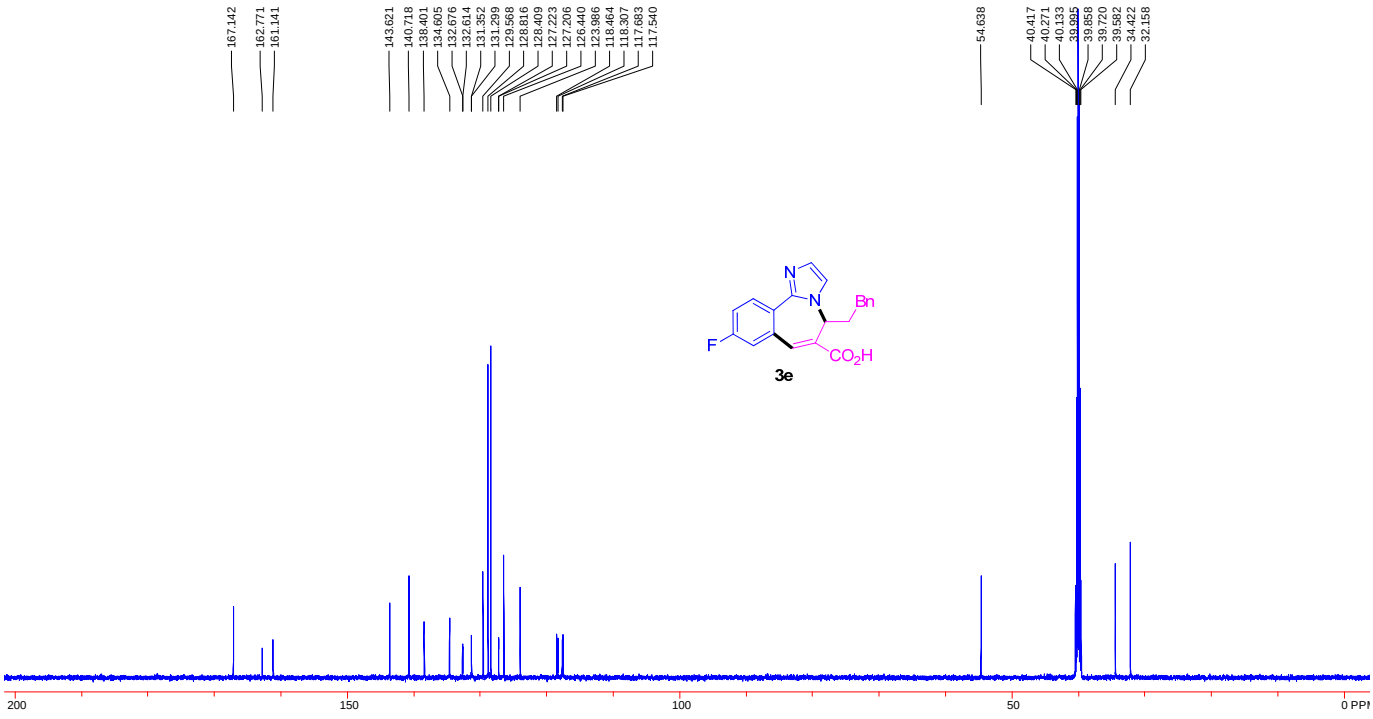
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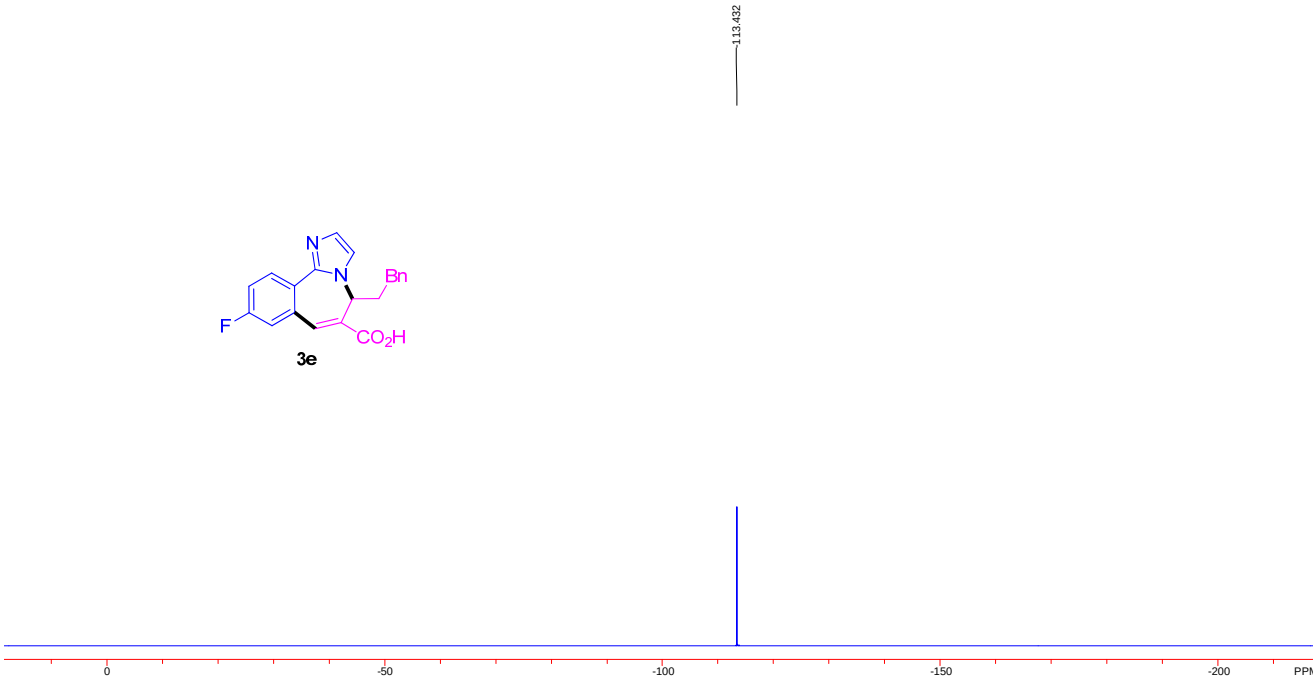
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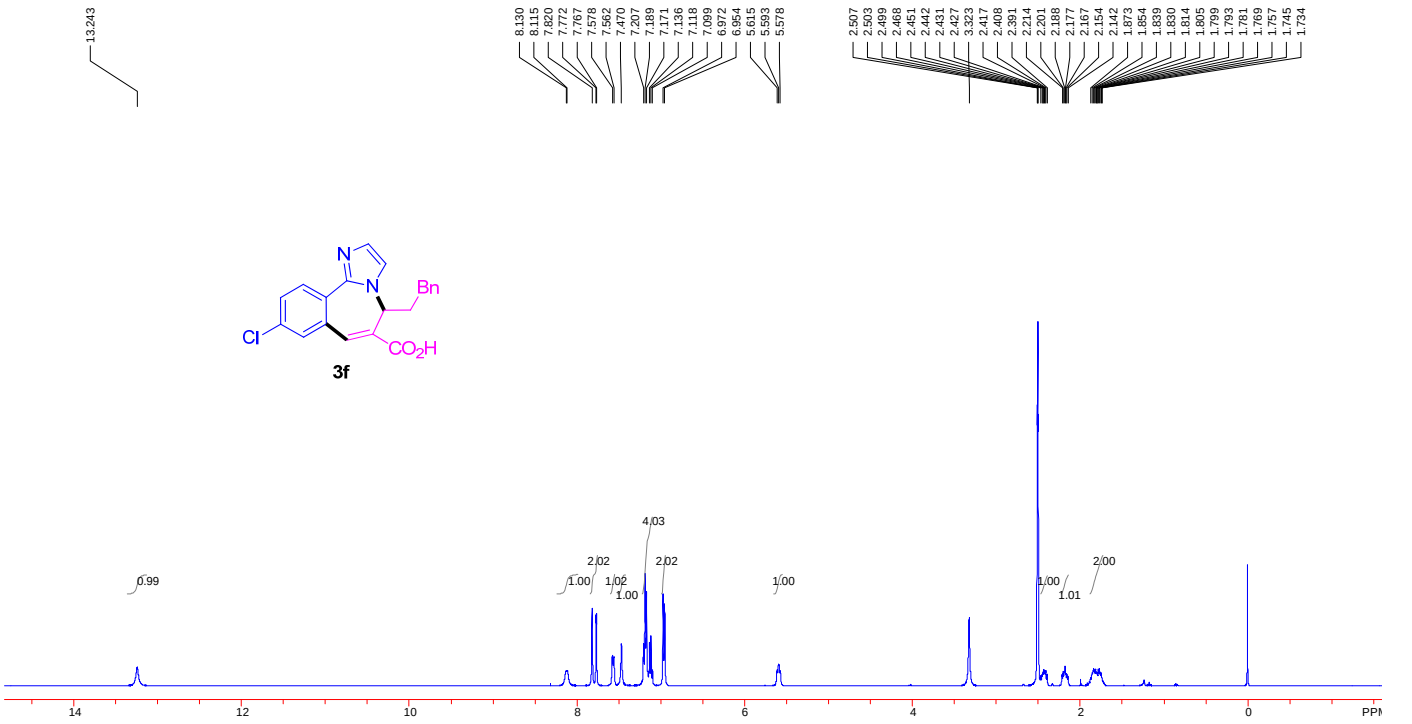
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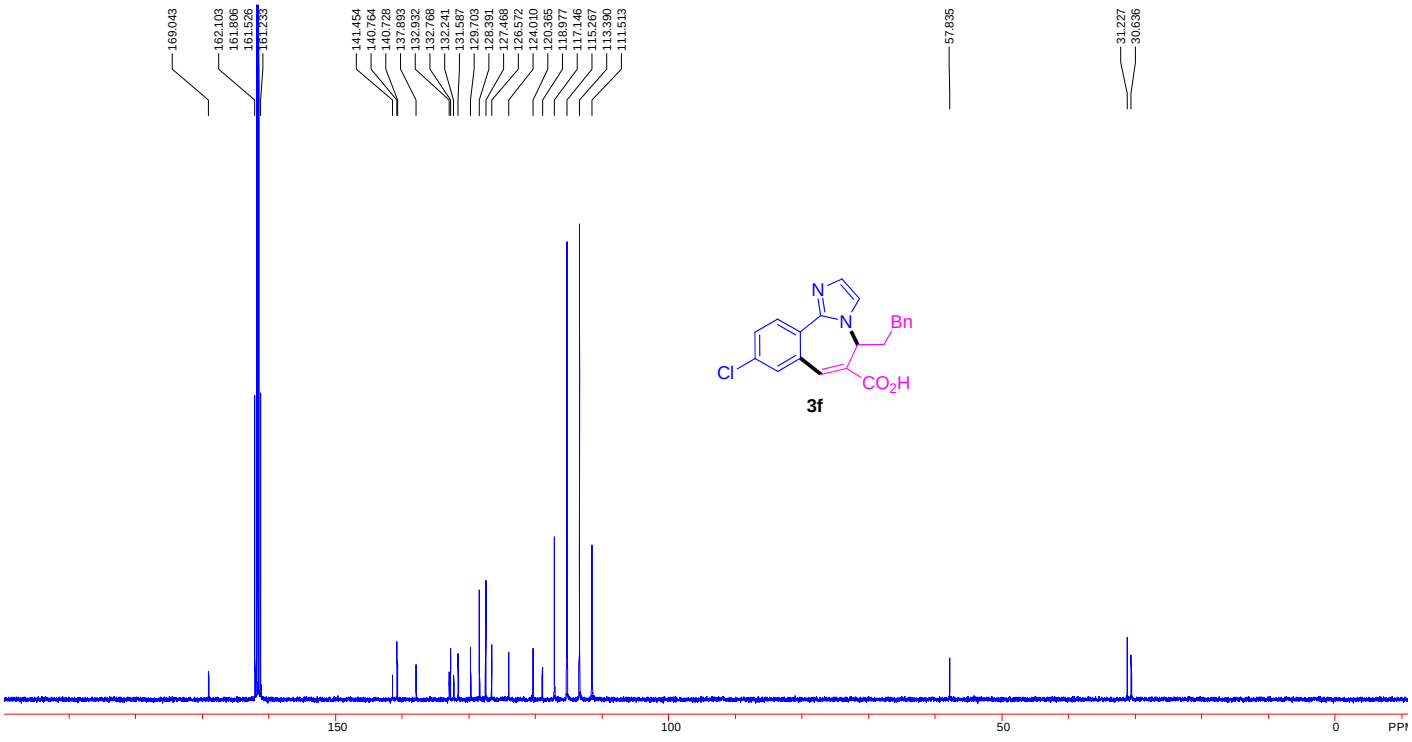
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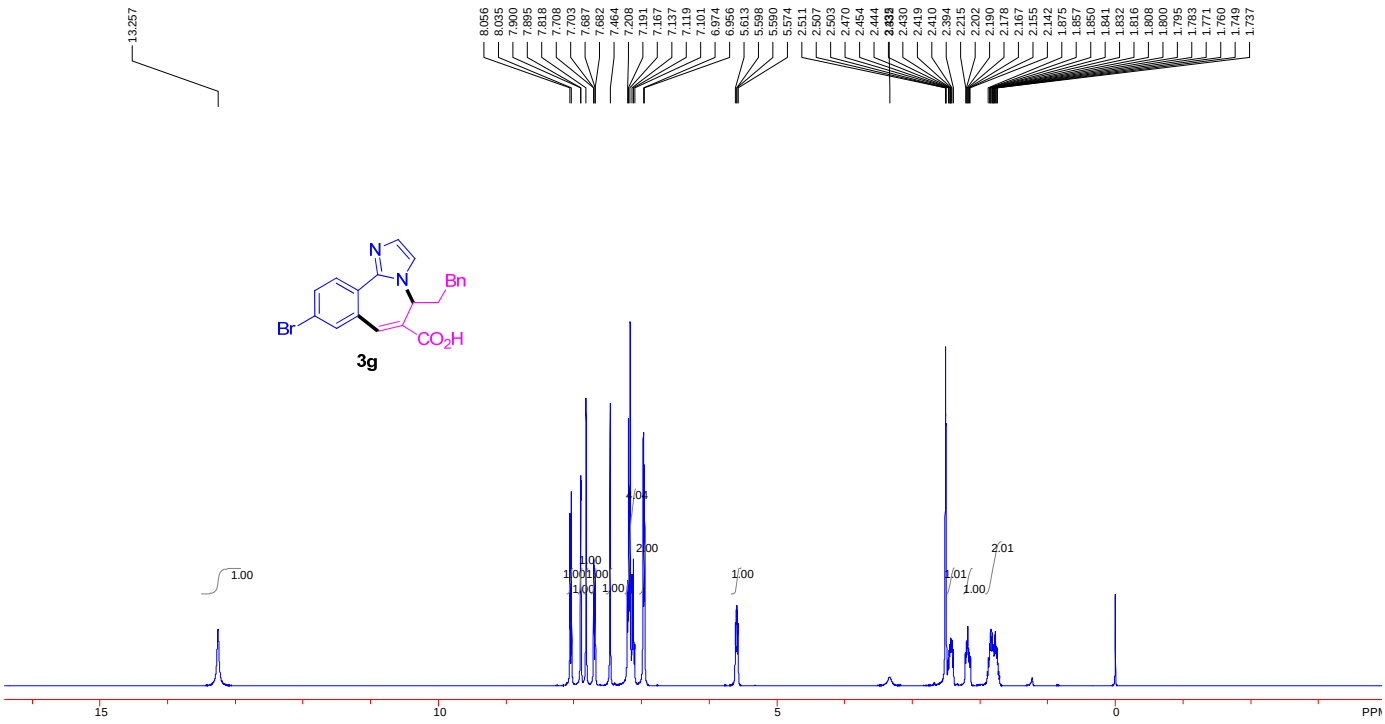
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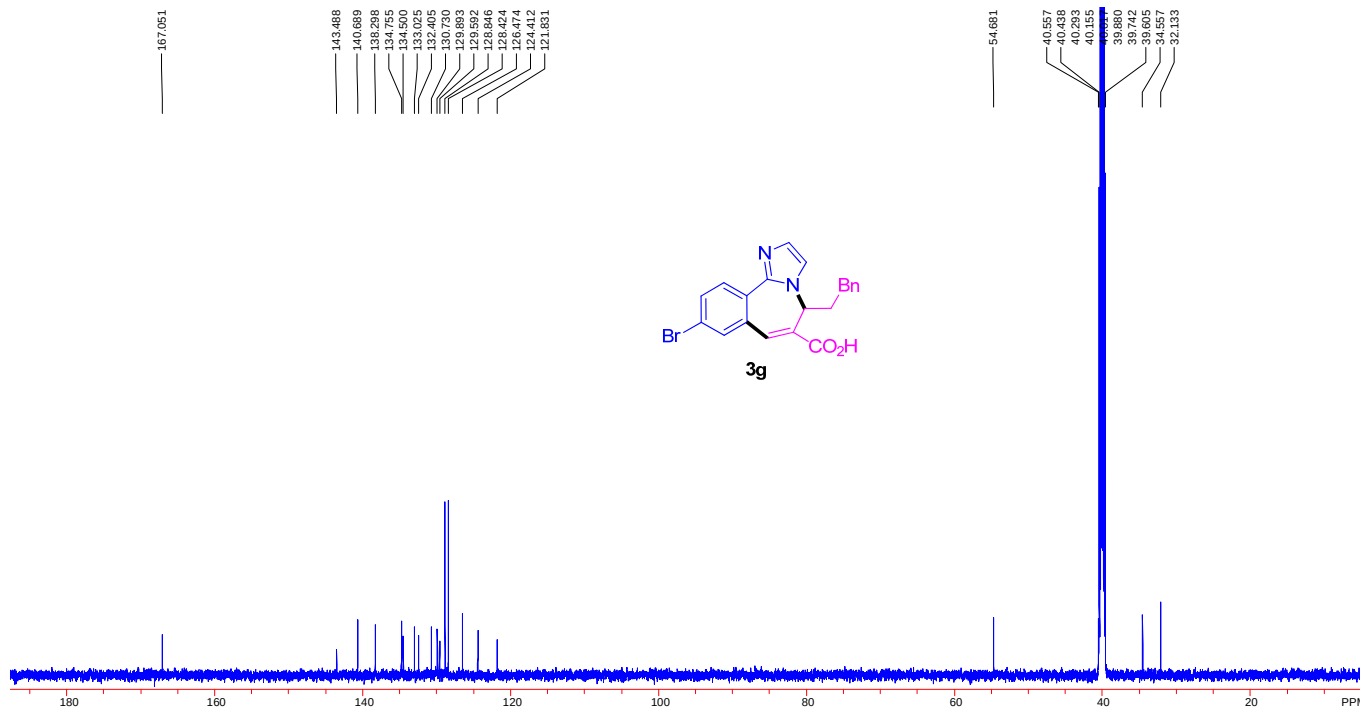
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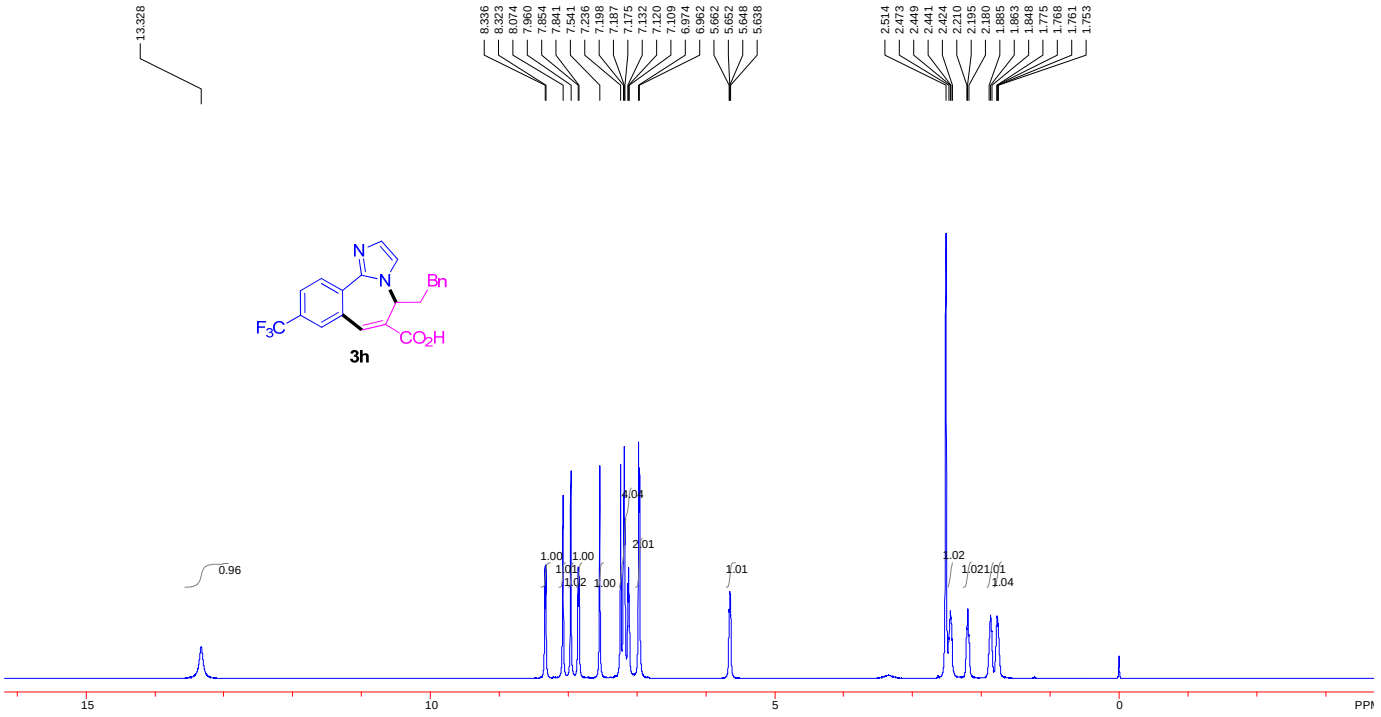
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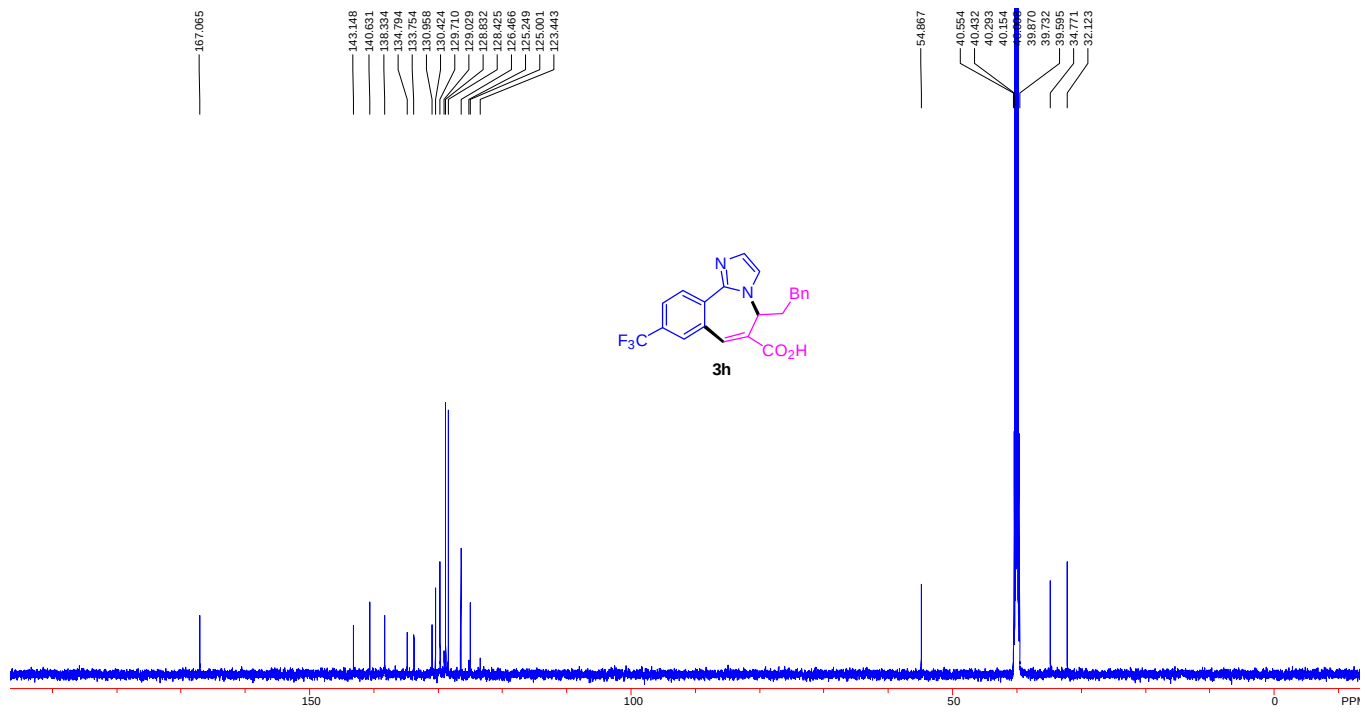
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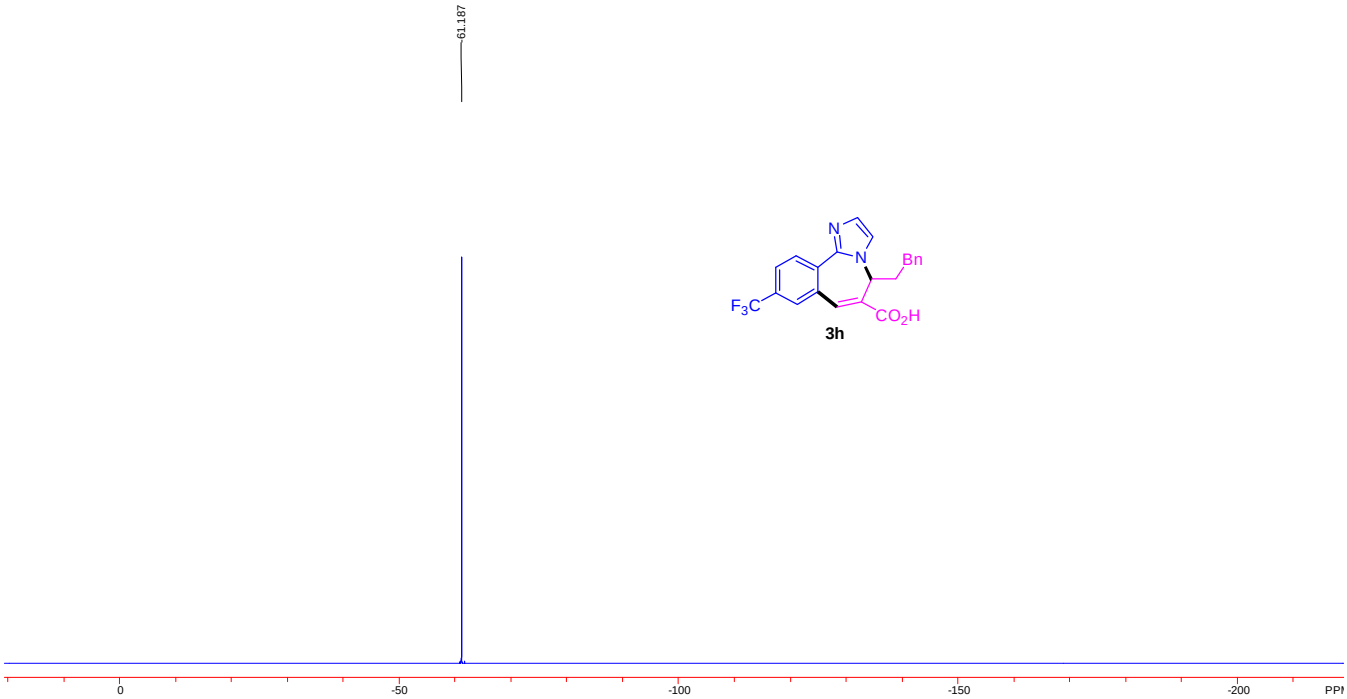
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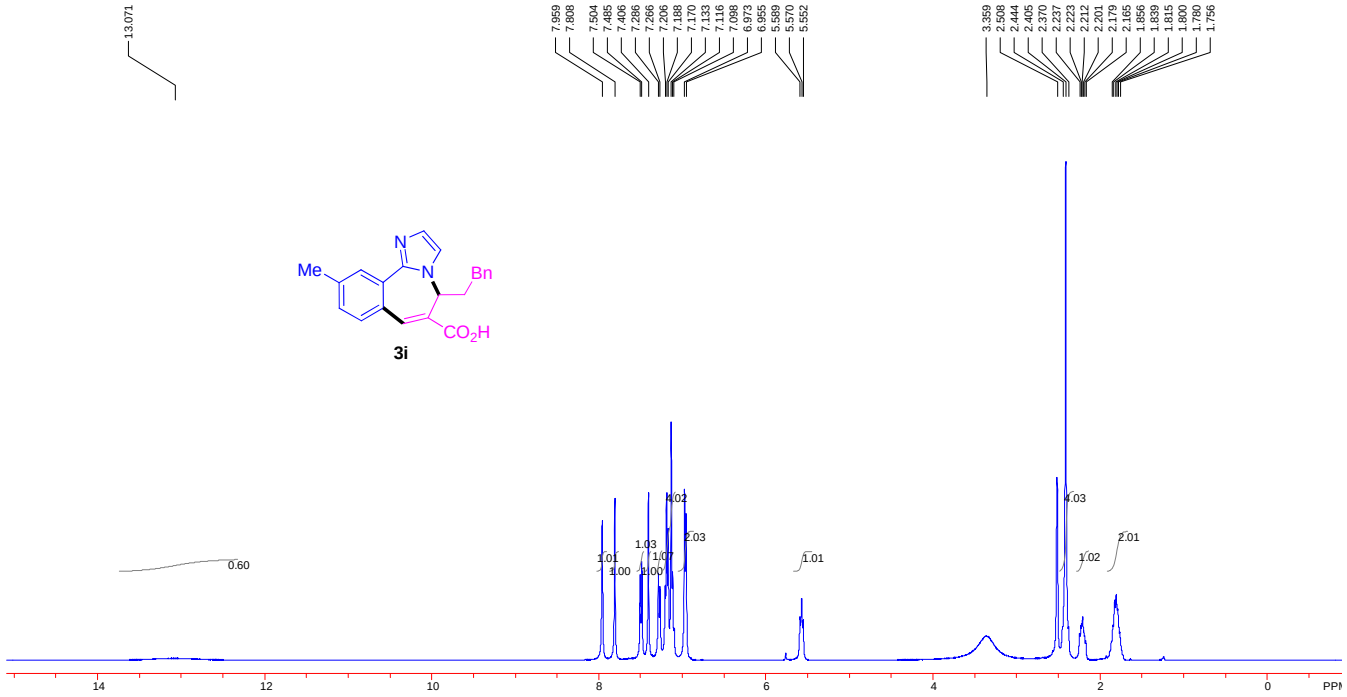
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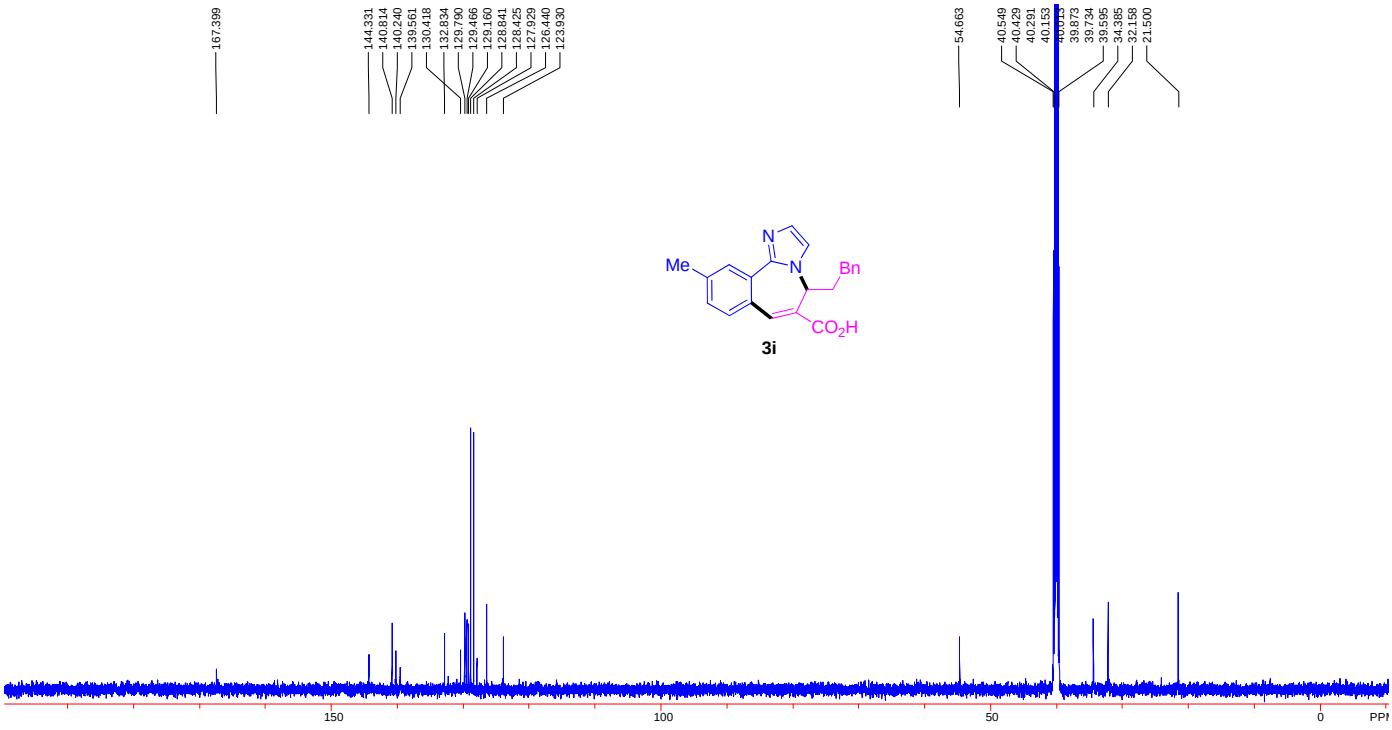
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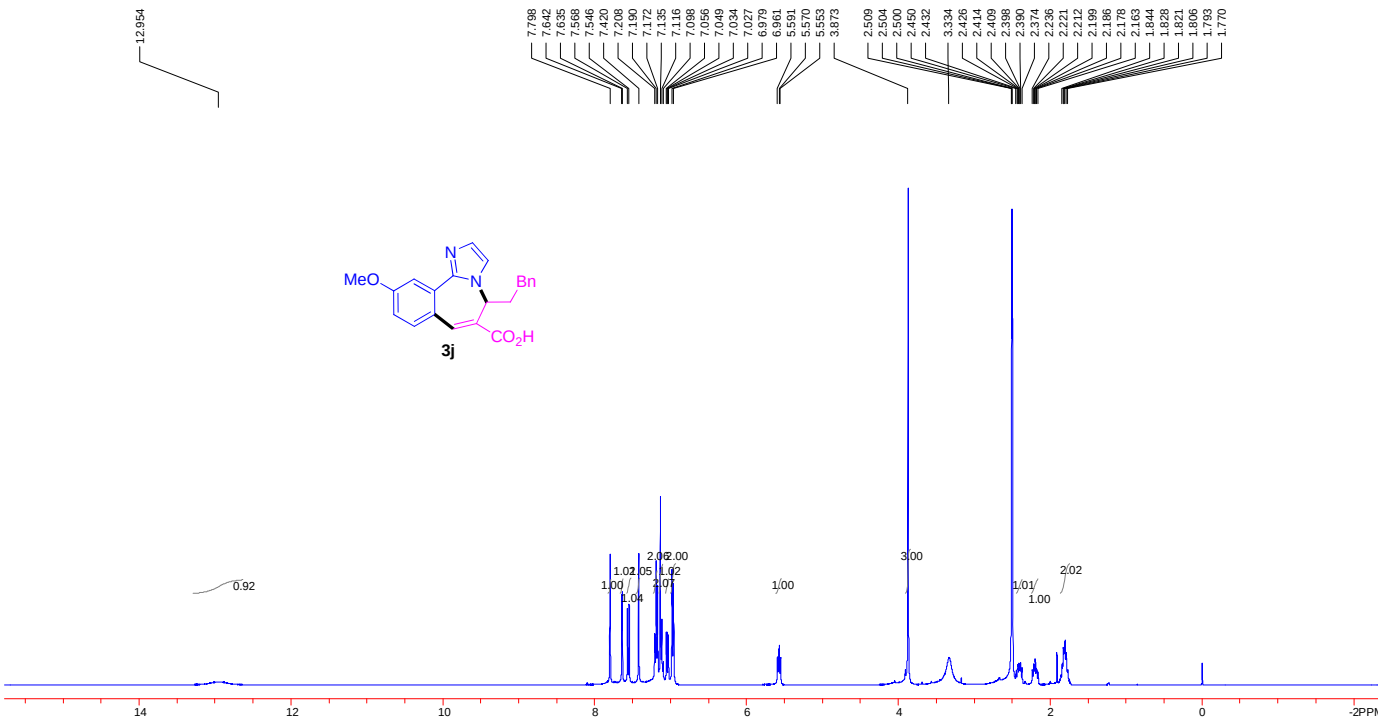
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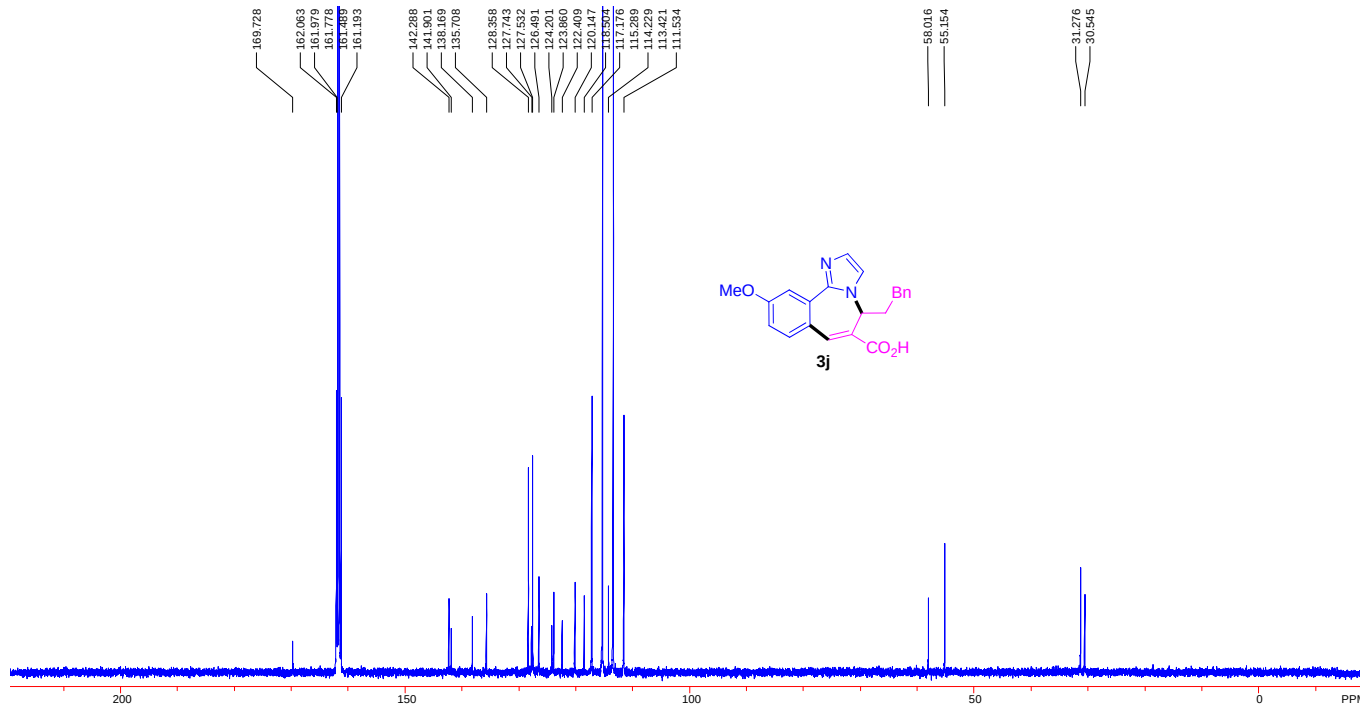
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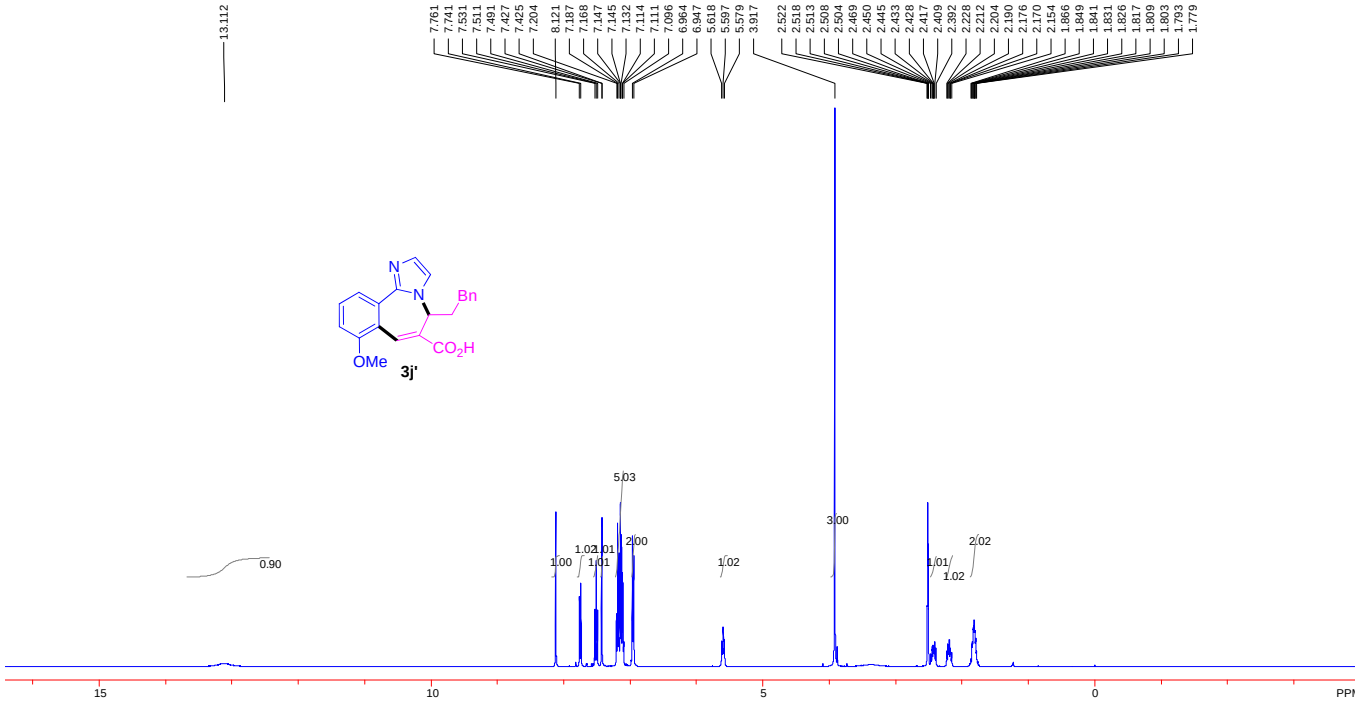
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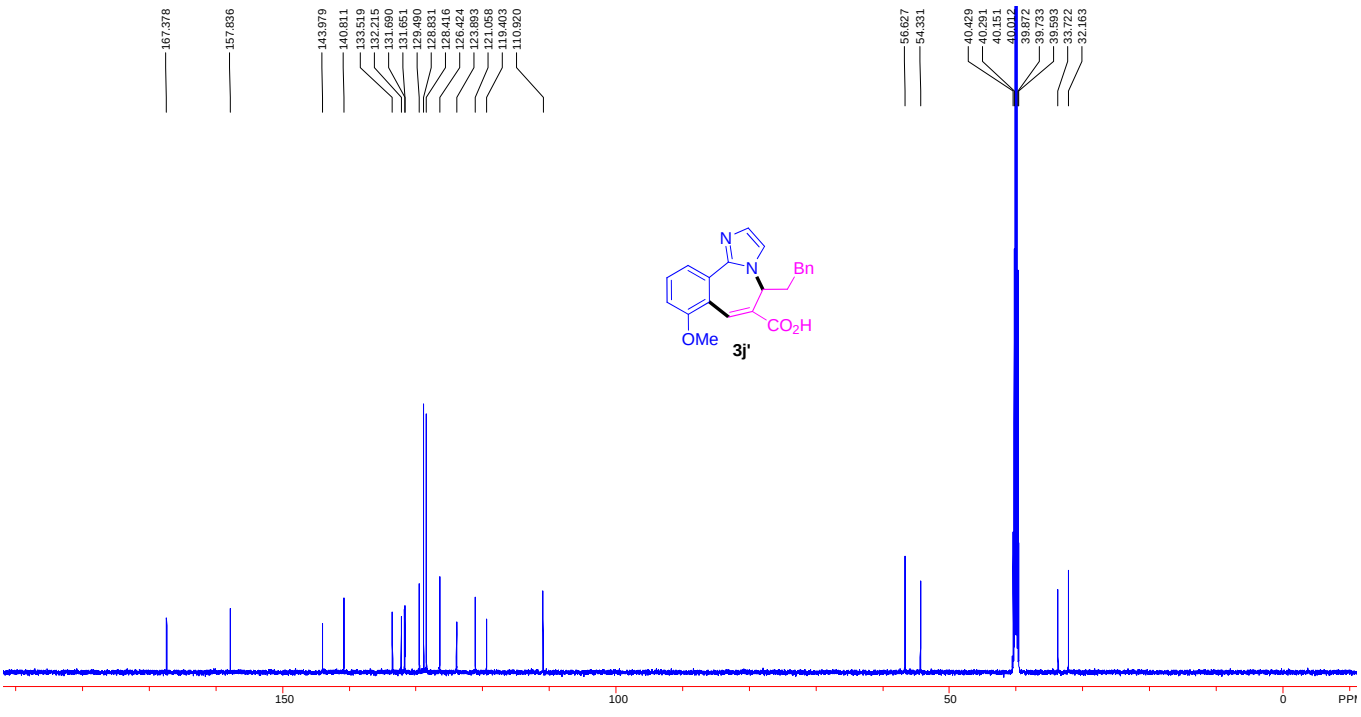
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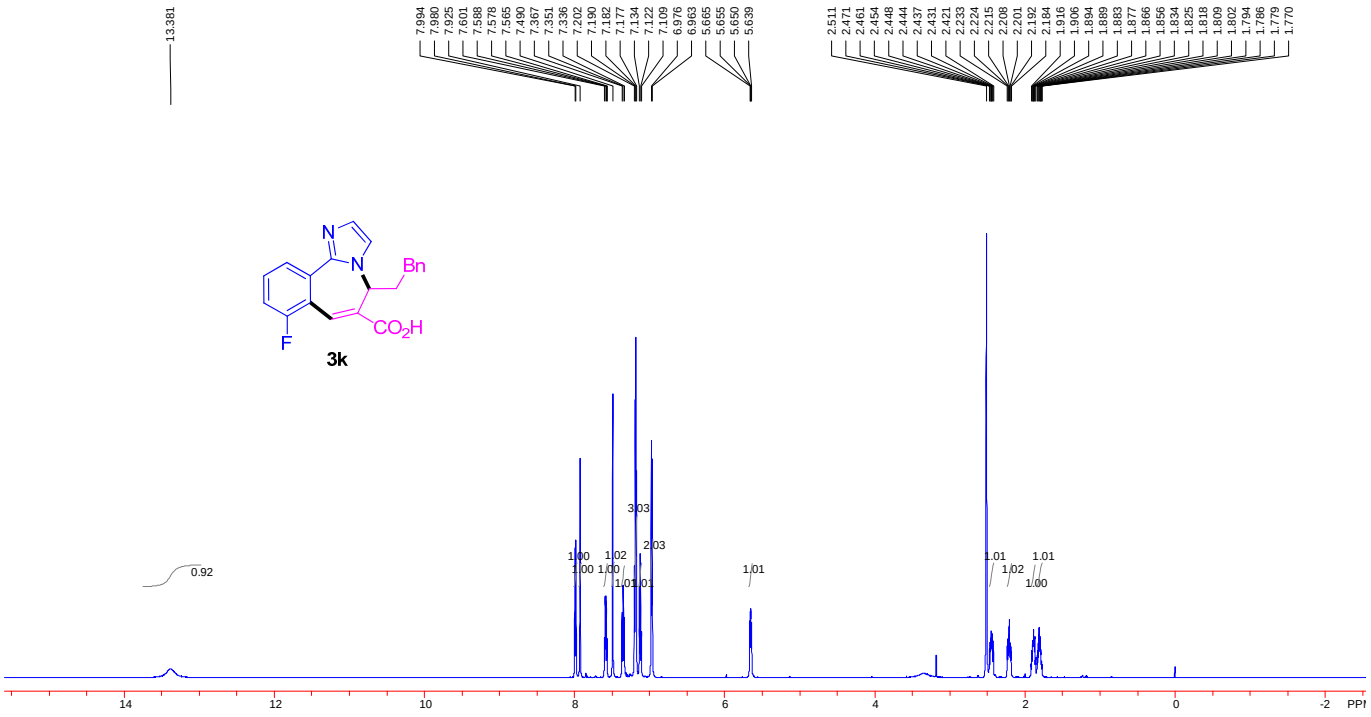
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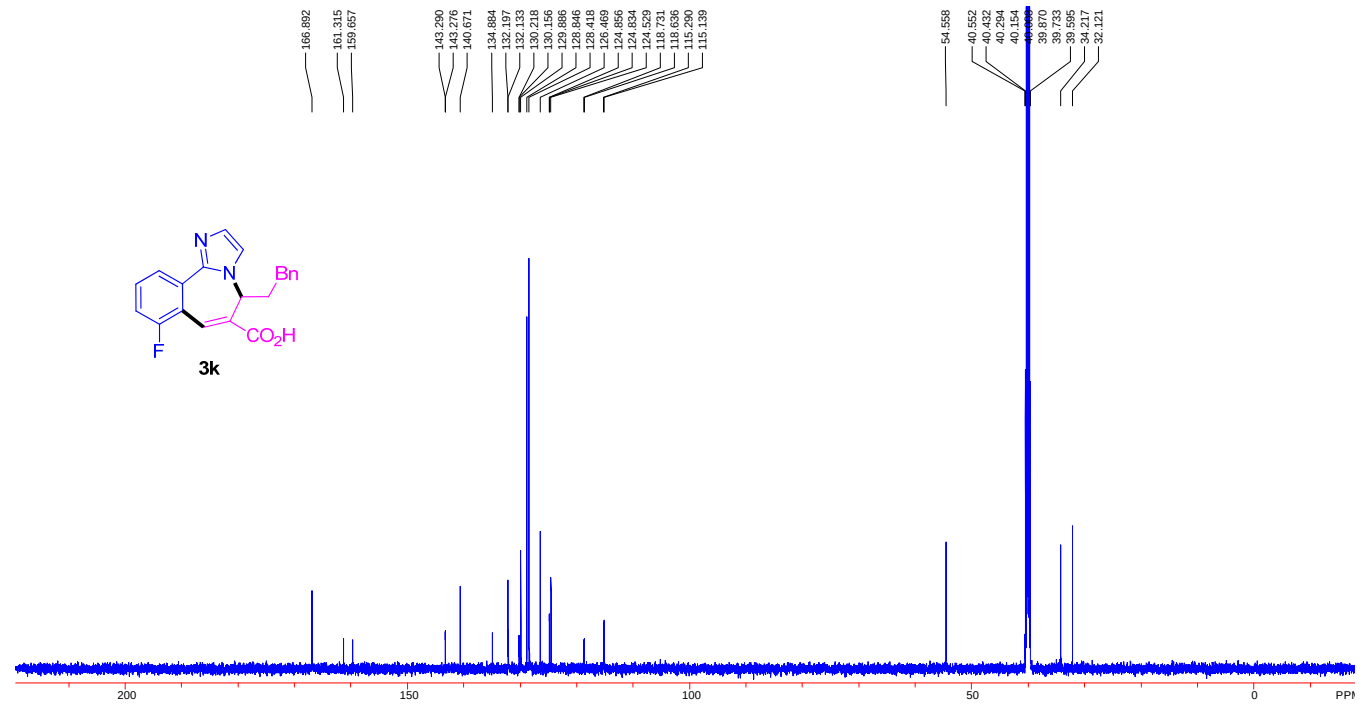
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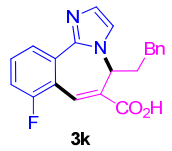

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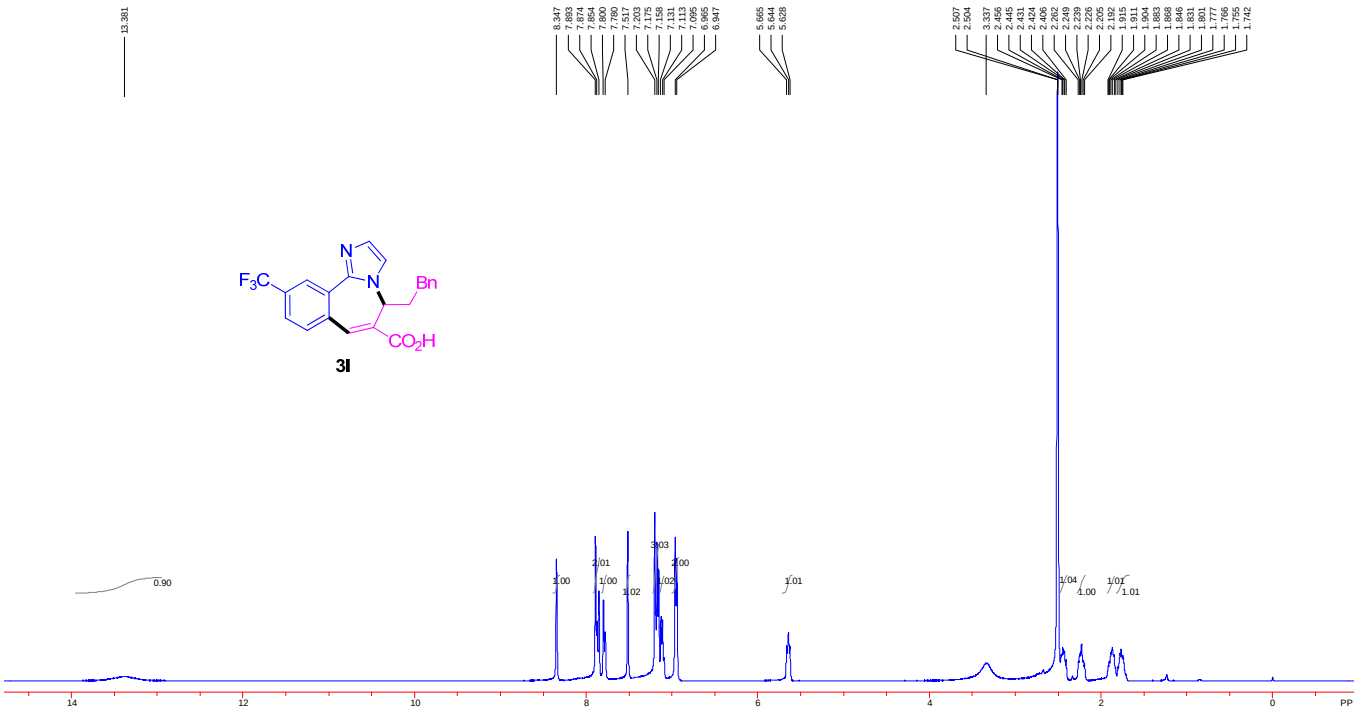
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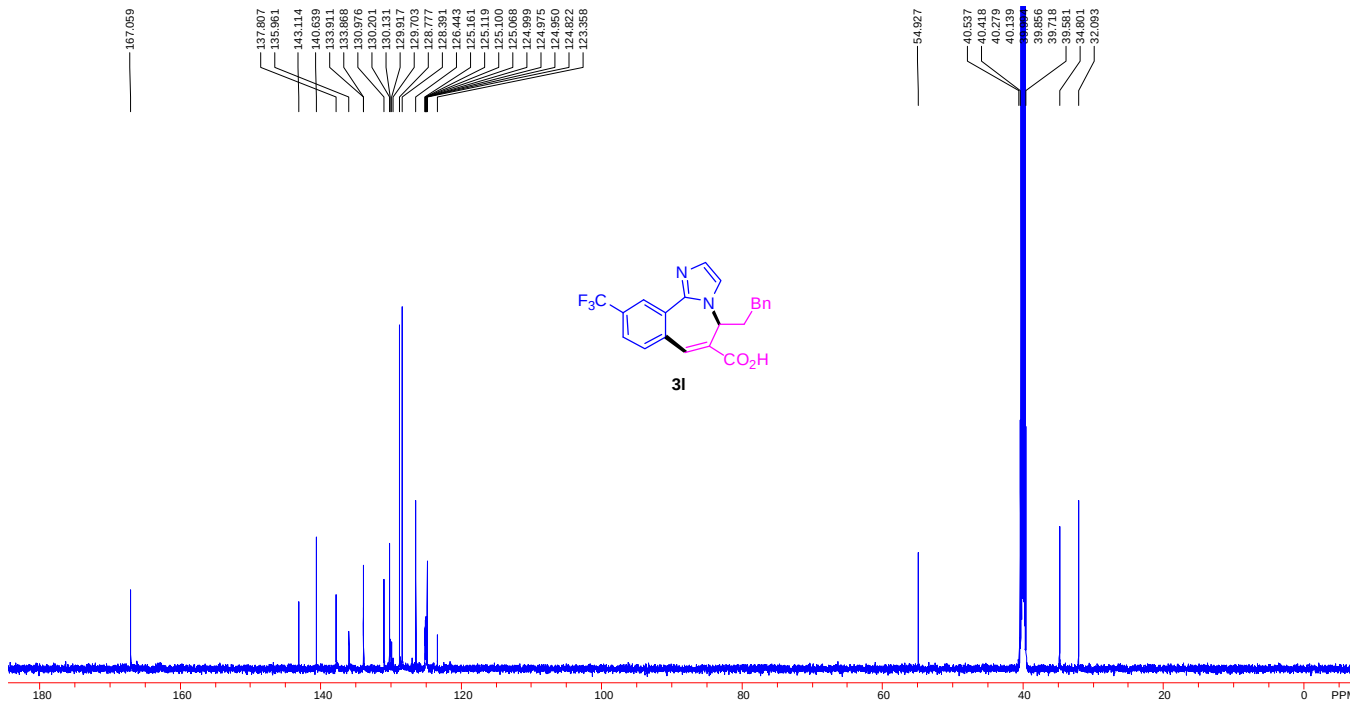
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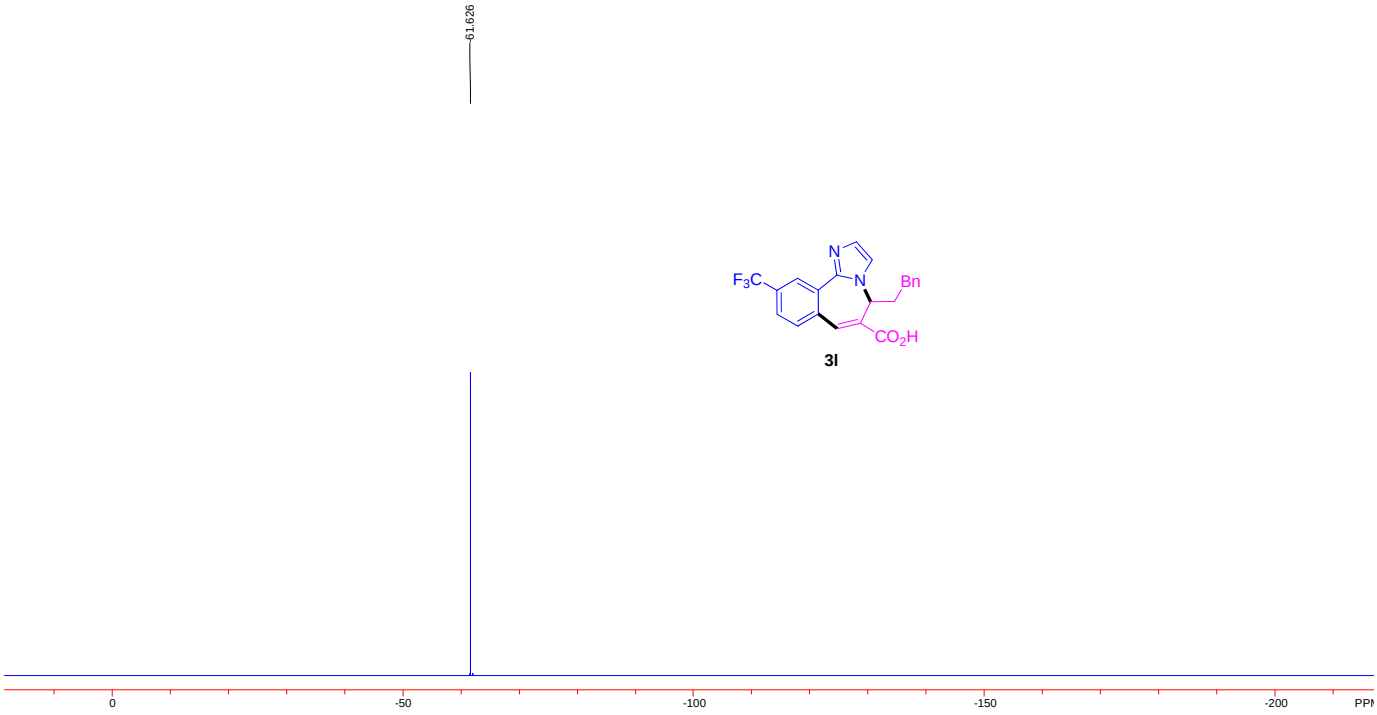

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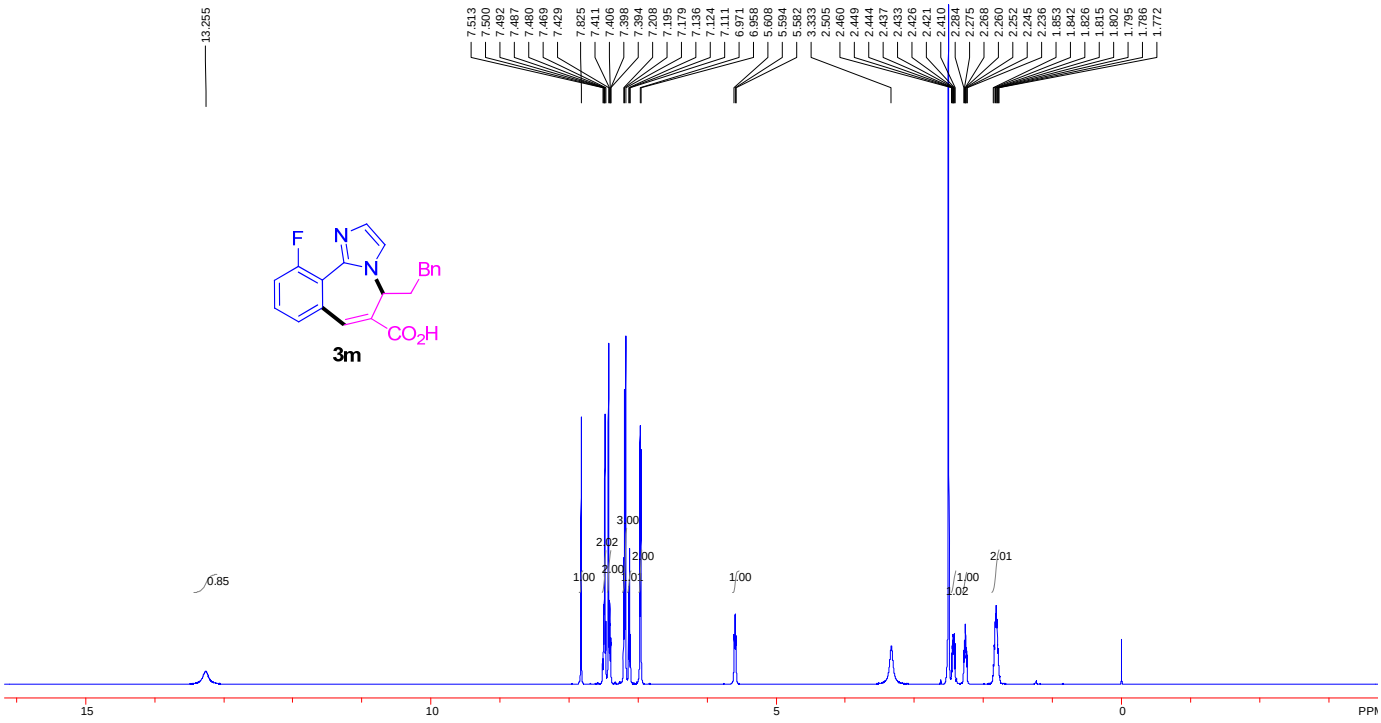
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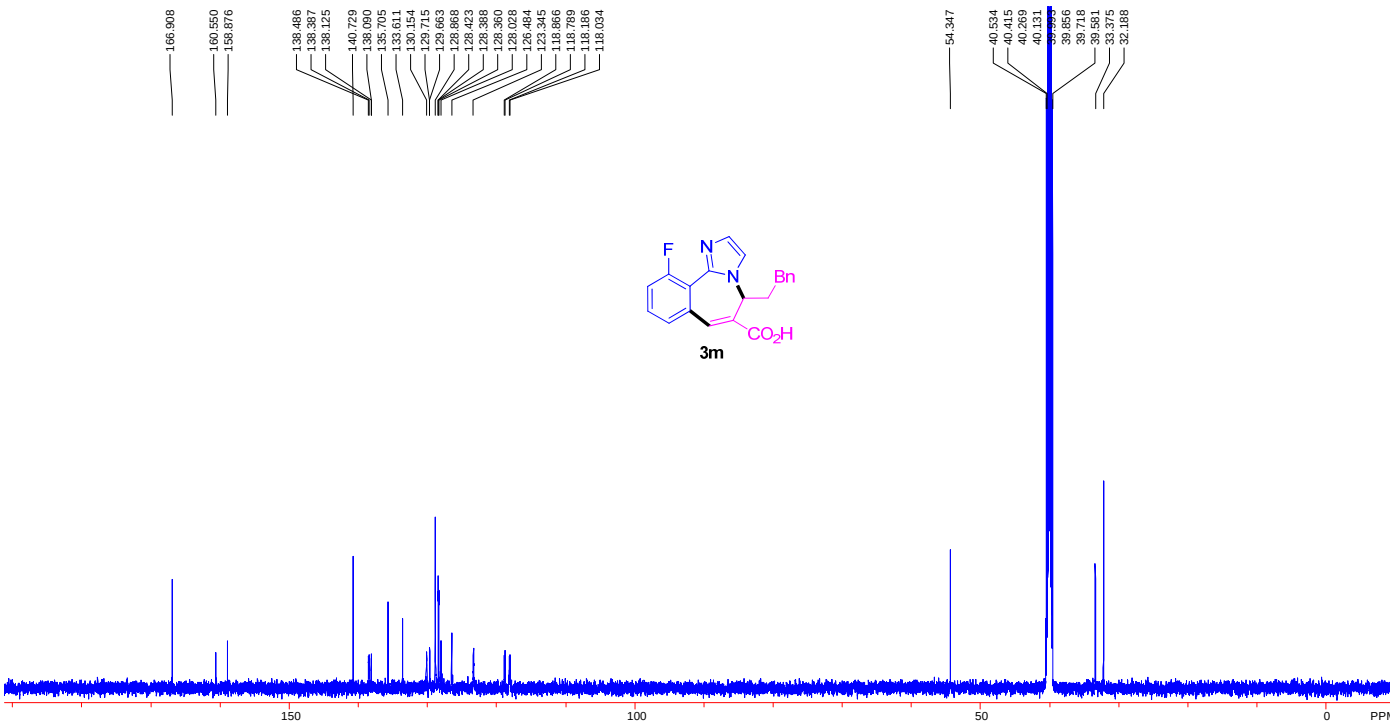
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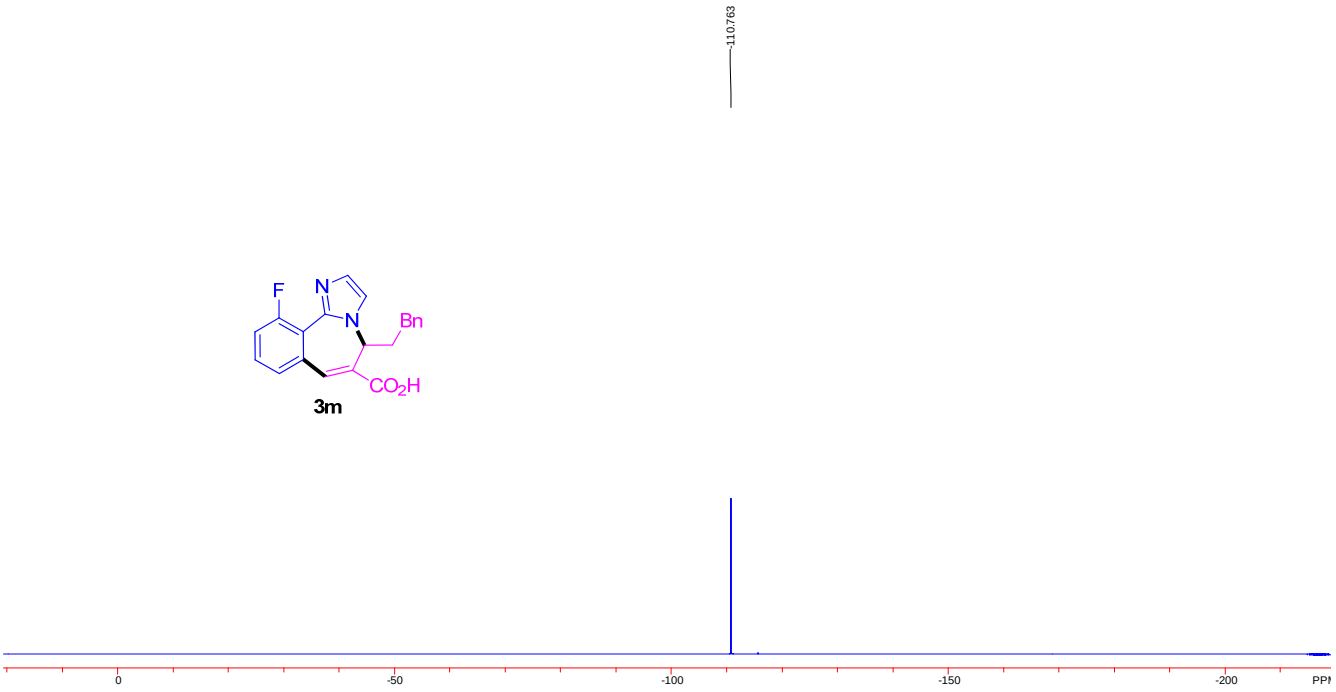
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CO2H
3m
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-200
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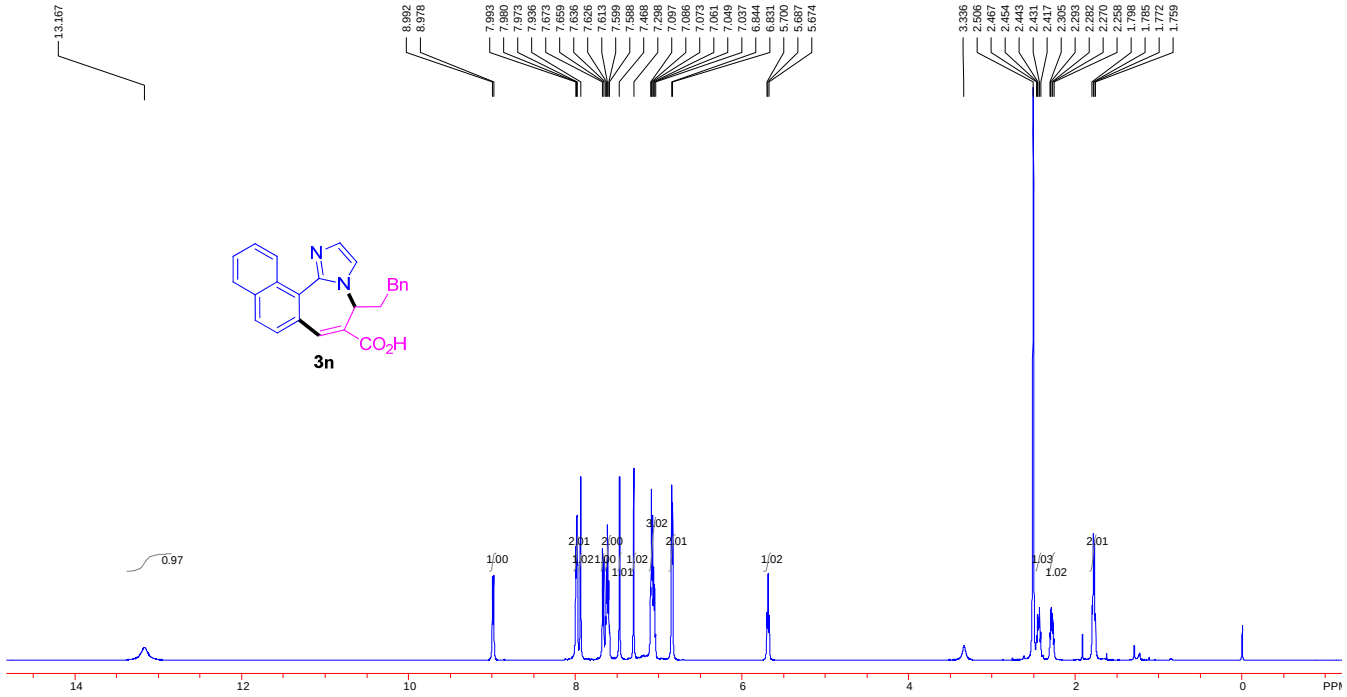
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7.626
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7.588
7.468
7.298
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7.086
7.073
7.061
7.049
7.037
6.844
6.831
5.700
5.687
5.674
3.336
2.506
2.467
2.454
2.443
2.431
2.417
2.305
2.293
2.282
2.270
2.258
1.798
1.785
1.772
1.759
N
N
Bn
CO2H
3n
0.97
1.00
2.01
1.02
2.00
1.00
1.02
1.01
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2.01
1.02
1.03
1.02
2.01
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12
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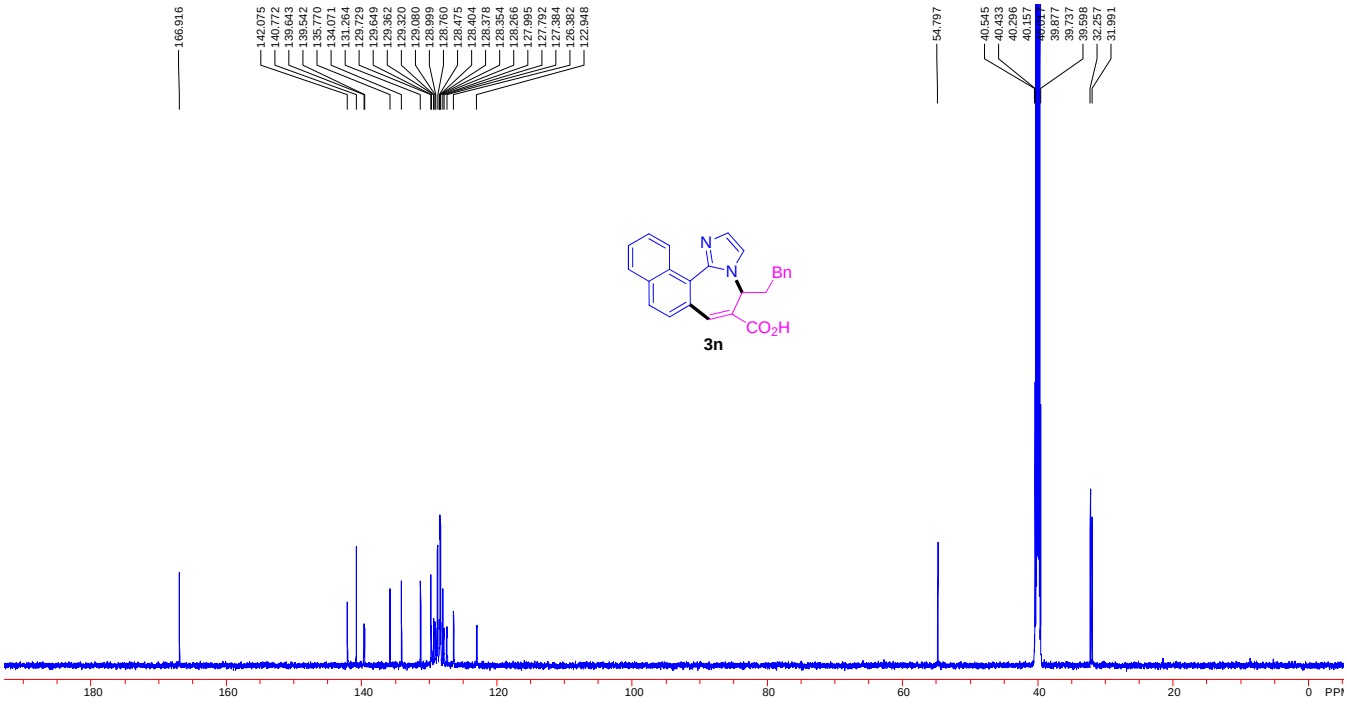
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129.320
129.080
128.999
128.760
128.475
128.404
128.378
128.354
128.266
127.995
127.792
127.384
126.382
122.948
54.797
40.545
40.433
40.296
40.157
39.877
39.737
39.598
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N
Bn
CO2H
3n
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120
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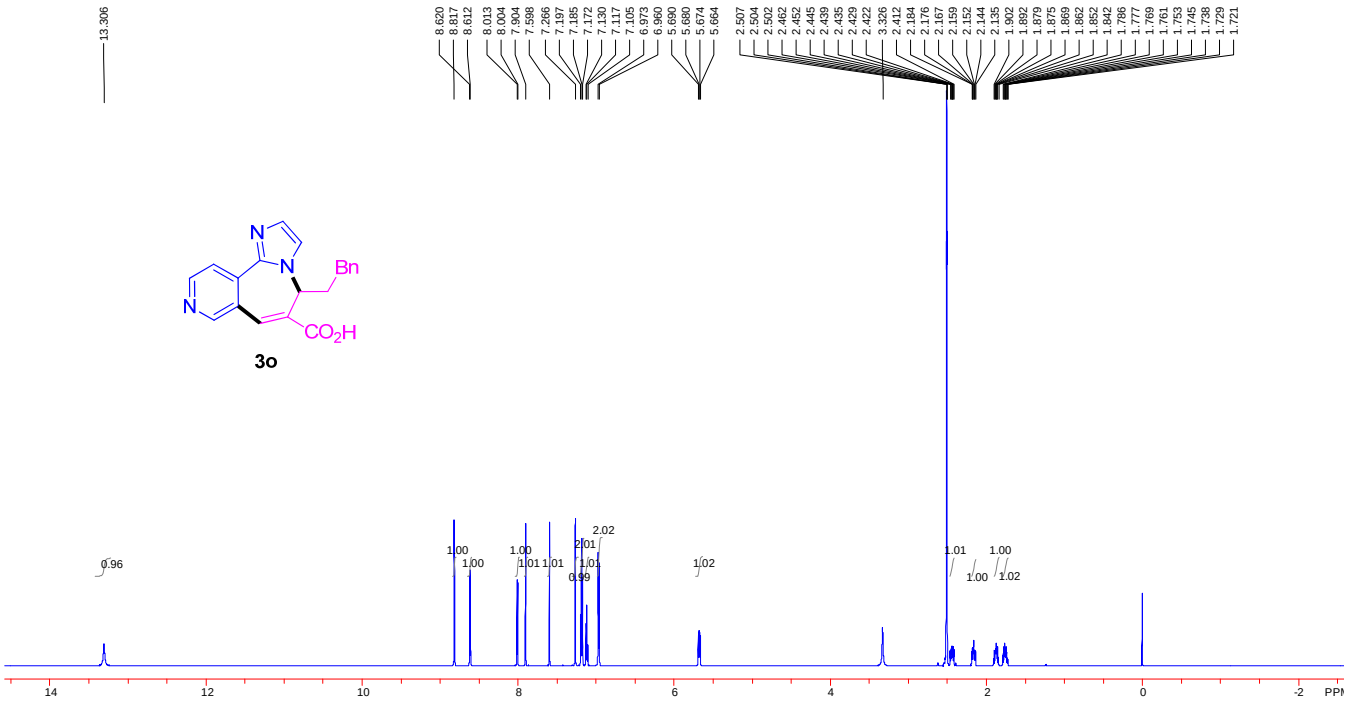
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7.598
7.266
7.197
7.185
7.172
7.130
7.117
7.105
6.973
6.960
5.690
5.680
5.674
5.664
2.507
2.504
2.502
2.462
2.452
2.445
2.439
2.435
2.429
2.422
3.326
2.412
2.184
2.176
2.167
2.159
2.152
2.144
2.135
1.902
1.892
1.879
1.875
1.869
1.862
1.852
1.842
1.786
1.777
1.769
1.761
1.753
1.745
1.738
1.729
1.721
N
N
N
Bn
CO2H
3o
0.96
1.00
1.00
1.00
1.01
1.01
2.01
1.01
0.99
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1.00
1.00
1.02
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8
6
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0
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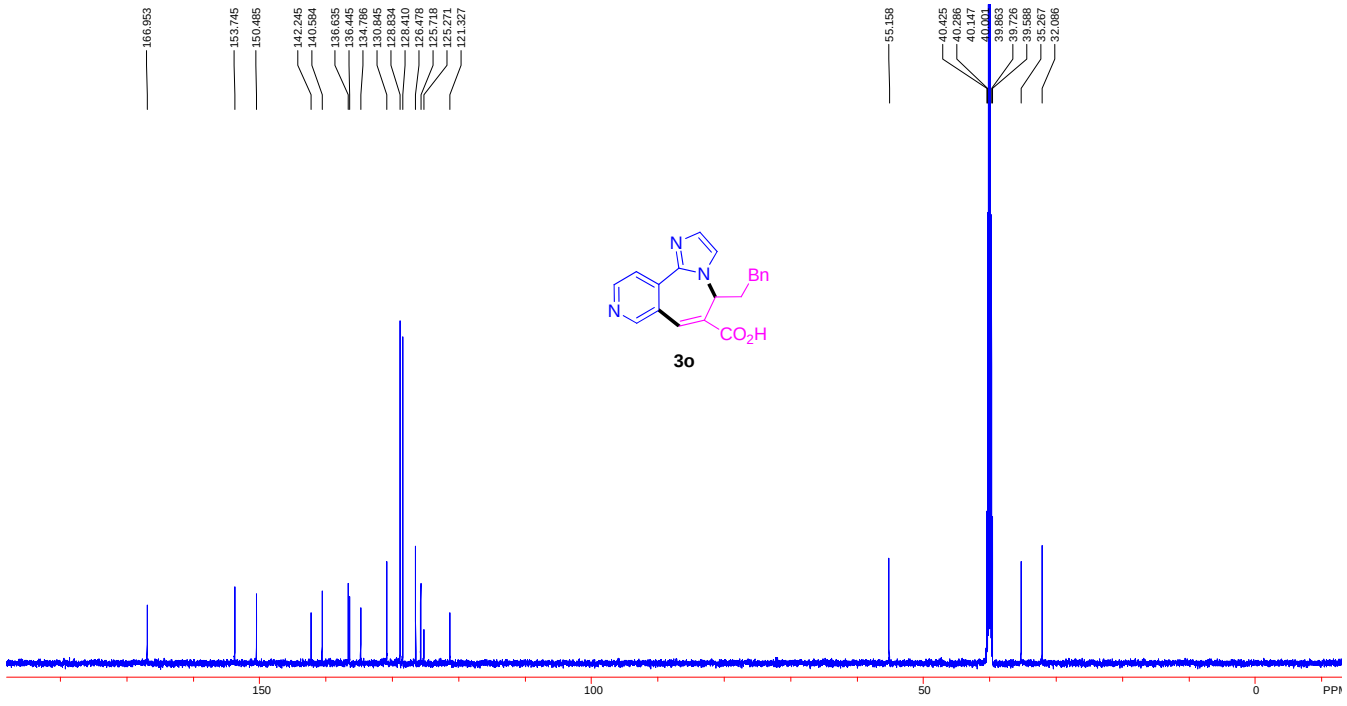
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150.485
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140.584
136.635
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134.786
130.845
128.834
128.410
126.478
125.718
125.271
121.327
55.158
40.425
40.286
40.147
40.001
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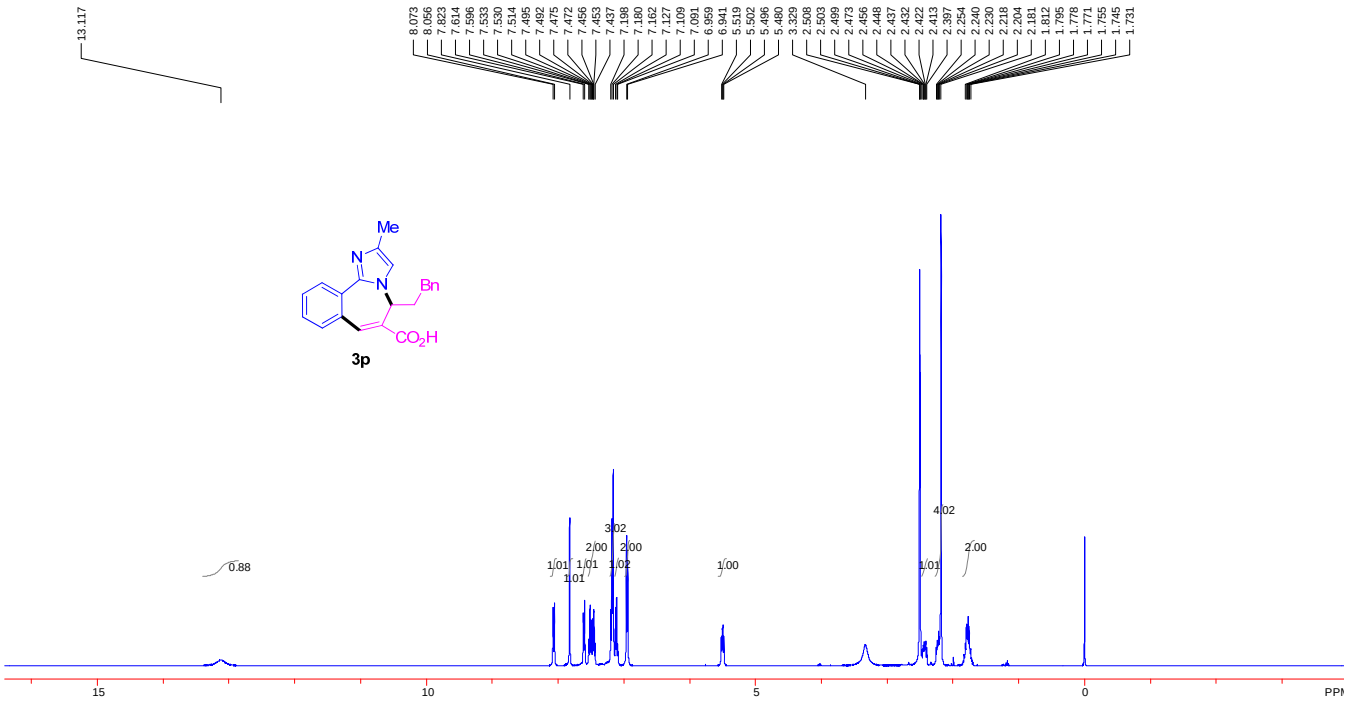
32.086
N
N
N
Bn
CO2H
3o
150
100
50
0
PPM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7.530
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7.492
7.475
7.472
7.456
7.453
7.437
7.198
7.180
7.162
7.127
7.109
7.091
6.959
6.941
5.519
5.502
5.496
5.480
3.329
2.508
2.503
2.499
2.473
2.456
2.448
2.437
2.432
2.422
2.413
2.397
2.254
2.240
2.230
2.218
2.204
2.181
1.812
1.795
1.778
1.771
1.755
1.745
1.731
Me
N
N
Bn
CO2H
3p
0.88
1.01
1.01
1.01
1.02
3.02
2.00
2.00
1.00
1.01
4.02
2.00
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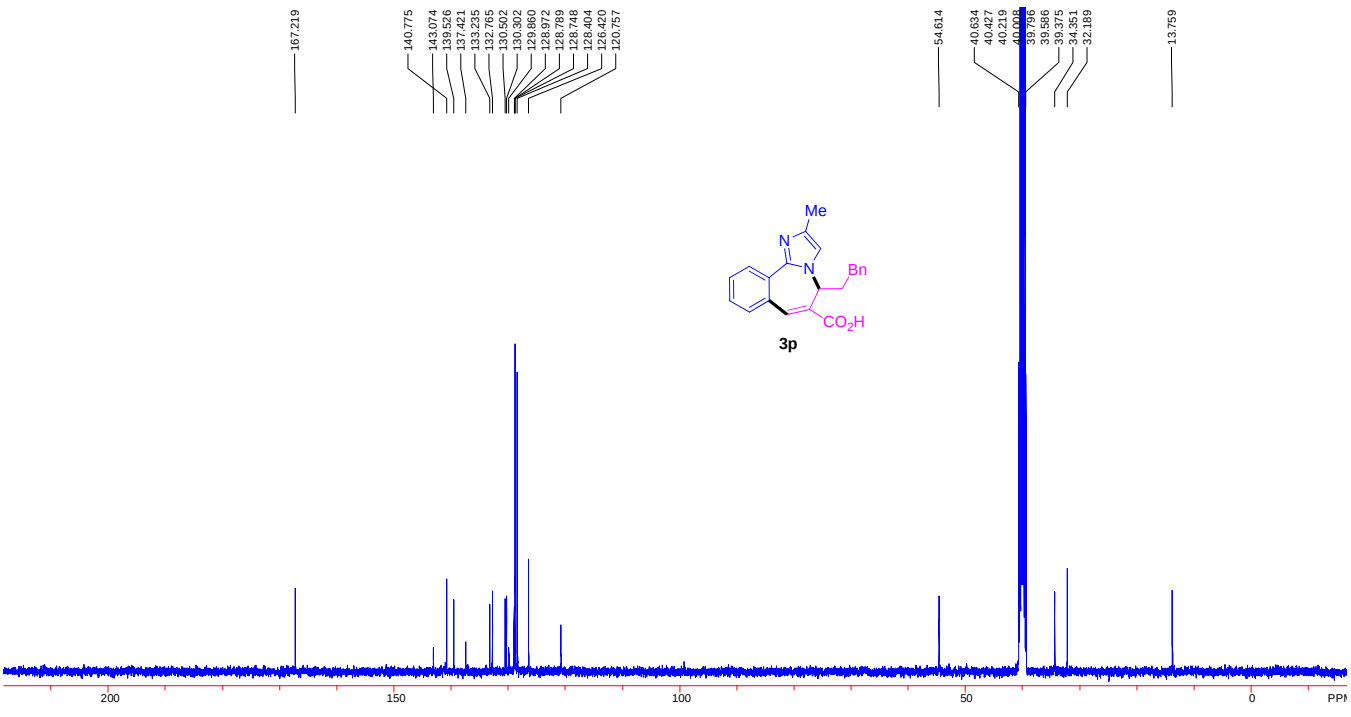
10
5
0
PPM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128.748
128.404
126.420
120.757
54.614
40.634
40.427
40.219
40.012
39.796
39.586
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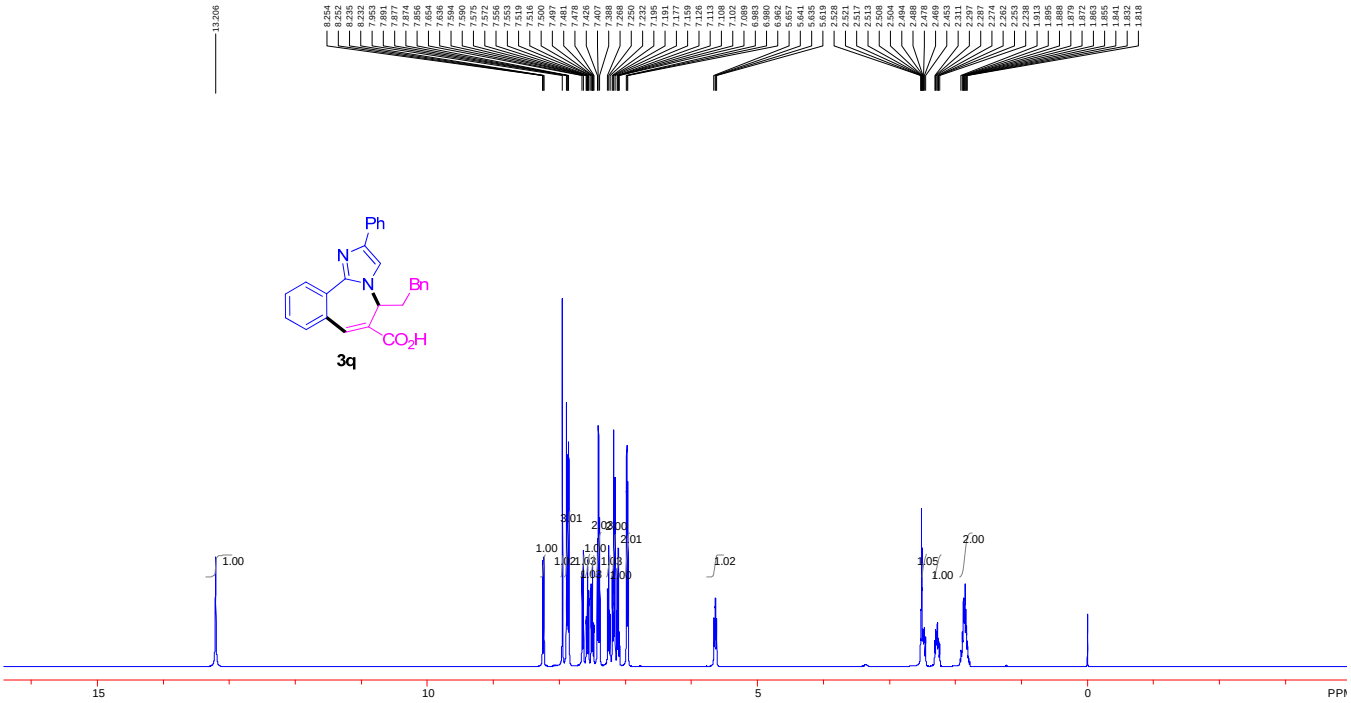
34.351
32.189
13.759
Me
N
N
Bn
CO2H
3p
200
150
100
50
0
PPM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8.254 8.252 8.235 8.232 7.883 7.881 7.877 7.874 7.856 7.854 7.836 7.594 7.590 7.575 7.572 7.556 7.553 7.519 7.516 7.500 7.497 7.481 7.478 7.426 7.407 7.388 7.268 7.250 7.232 7.195 7.191 7.177 7.159 7.126 7.113 7.108 7.102 7.089 6.983 6.980 6.962 6.957 5.641 5.635 5.619 2.528 2.521 2.517 2.513 2.508 2.504 2.484 2.478 2.469 2.453 2.311 2.297 2.287 2.274 2.262 2.253 2.238 1.913 1.895 1.888 1.879 1.872 1.863 1.855 1.841 1.832 1.818
Ph
N
N
Bn
CO2H
3q
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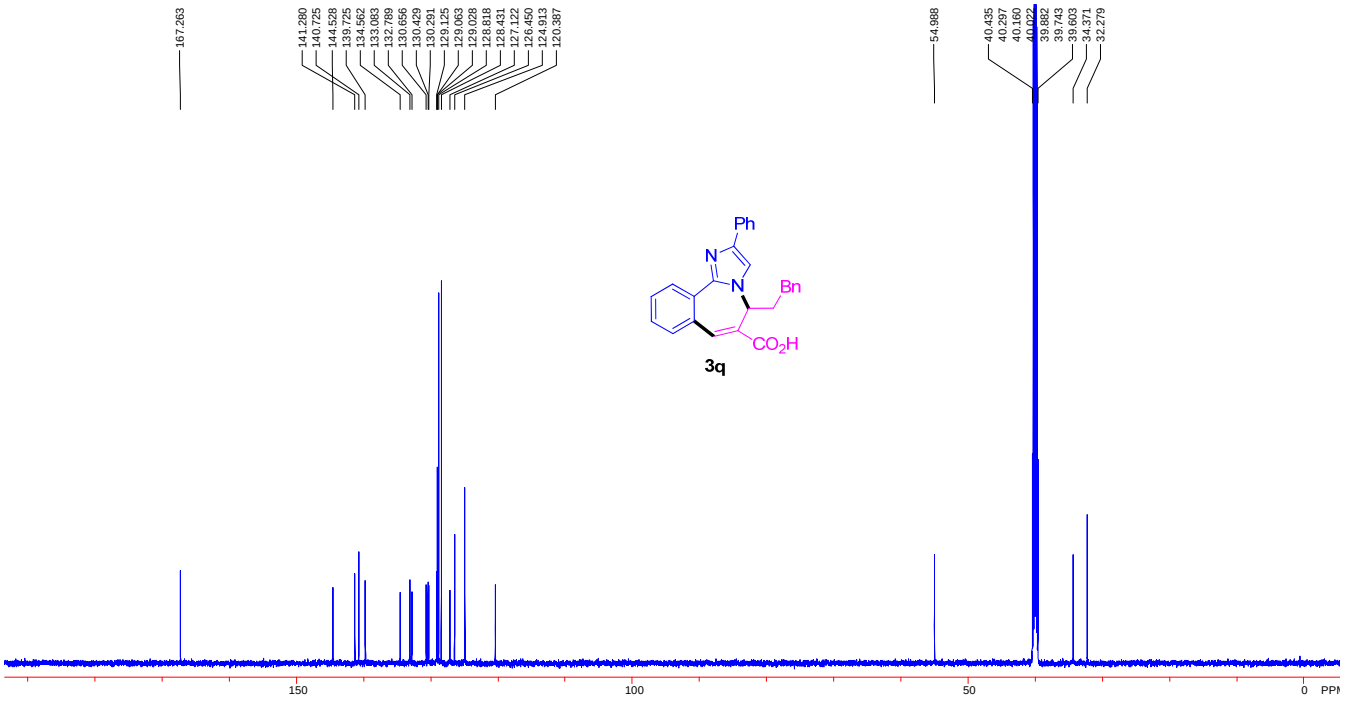
1.00
1.02
1.00
1.05
1.00
2.00
15
10
5
0
PPM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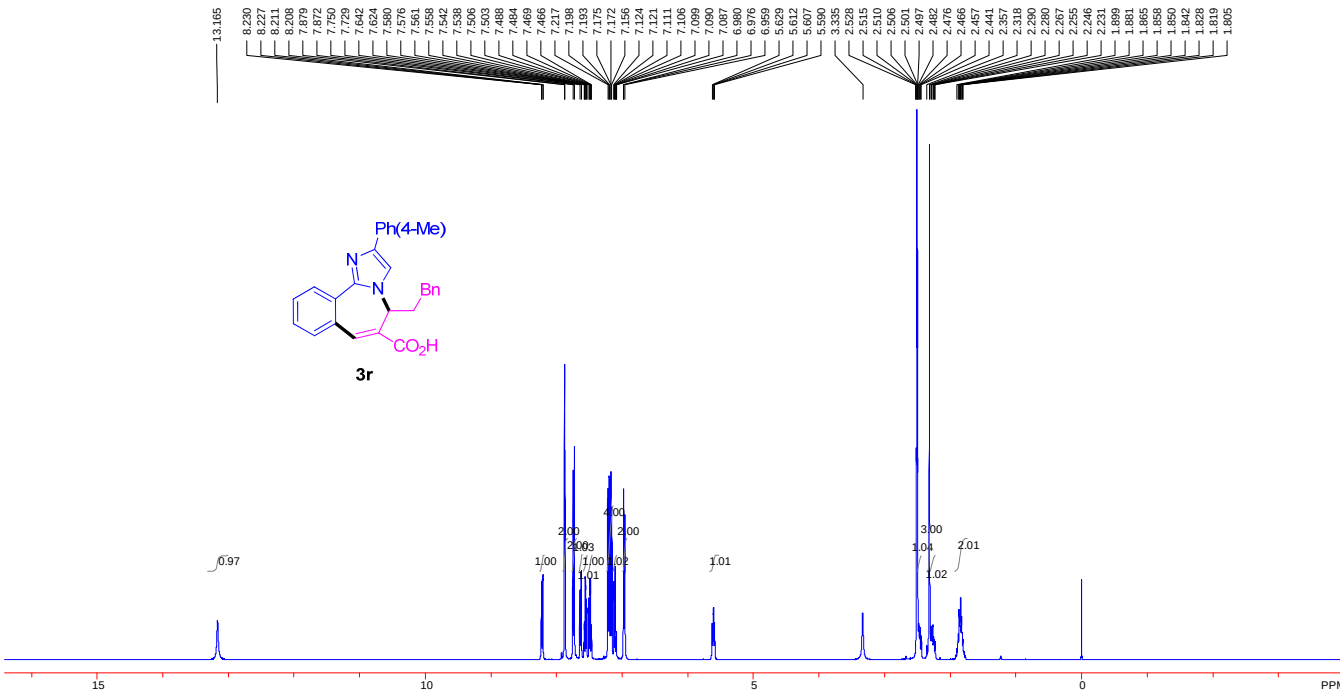
141.280 140.725 144.528 139.725 134.562 133.083 132.789 130.656 130.429 130.291 129.125 129.063 129.028 128.818 128.431 127.122 126.450 124.913 120.387
54.988
40.435 40.297 40.160 40.022 39.882 39.743 39.603 34.371 32.279
Ph
N
N
Bn
CO2H
3q
150
100
50
0
PPM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N
Bn
CO2H
3r
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8.227
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8.208
8.879
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7.750
7.729
7.642
7.624
7.580
7.576
7.561
7.558
7.542
7.538
7.506
7.503
7.488
7.484
7.469
7.466
7.217
7.198
7.193
7.175
7.172
7.156
7.124
7.121
7.111
7.106
7.099
7.090
7.087
6.980
6.976
6.959
5.629
5.612
5.607
5.590
3.335
2.528
2.515
2.510
2.506
2.501
2.497
2.482
2.476
2.466
2.457
2.441
2.357
2.318
2.290
2.280
2.267
2.255
2.246
2.231
1.899
1.881
1.865
1.858
1.850
1.842
1.828
1.819
1.805
0.97
1.00
2.00
2.00
2.00
1.00
1.01
4.00
2.00
1.02
1.01
3.00
1.04
1.02
2.01
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10
5
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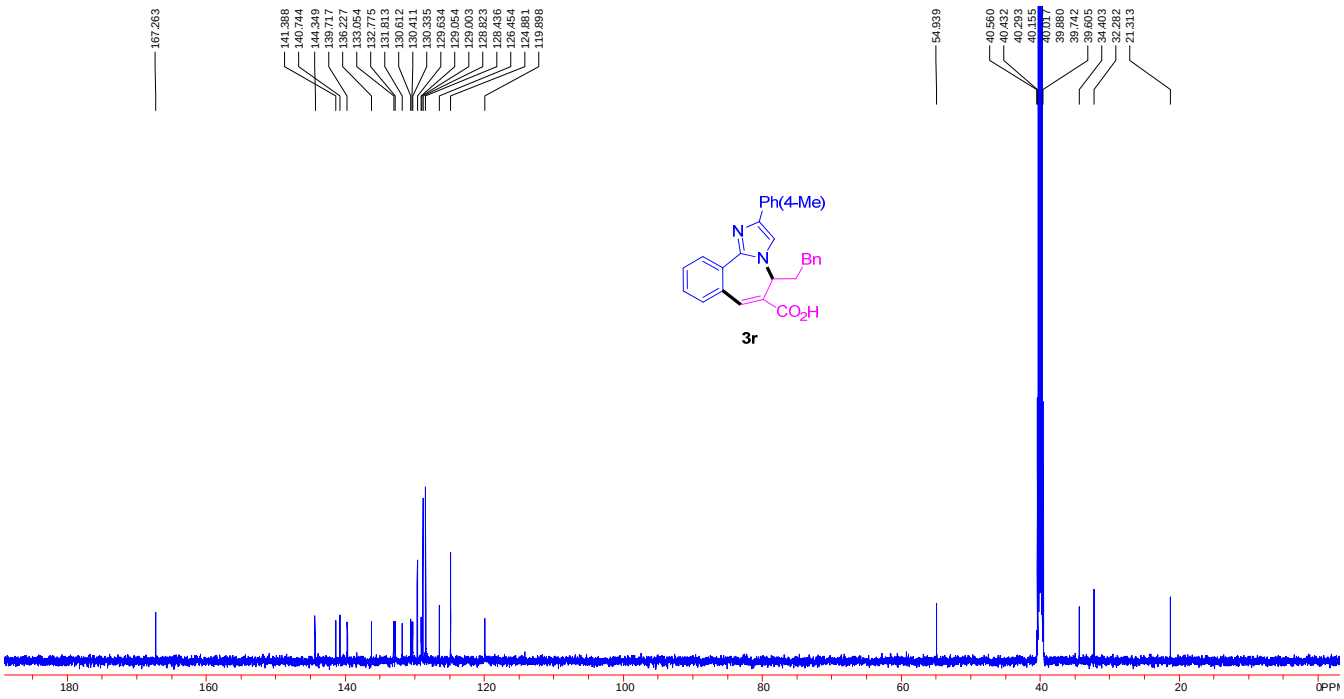
PPM


Ph(4-Me)
N
N
Bn
CO2H
3r
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140.744
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139.717
136.227
133.054
132.775
131.813
130.612
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130.335
129.634
129.054
129.003
128.823
128.436
126.454
124.881
119.898
54.939
40.560
40.432
40.293
40.155
40.017
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34.403
32.282
21.313
180
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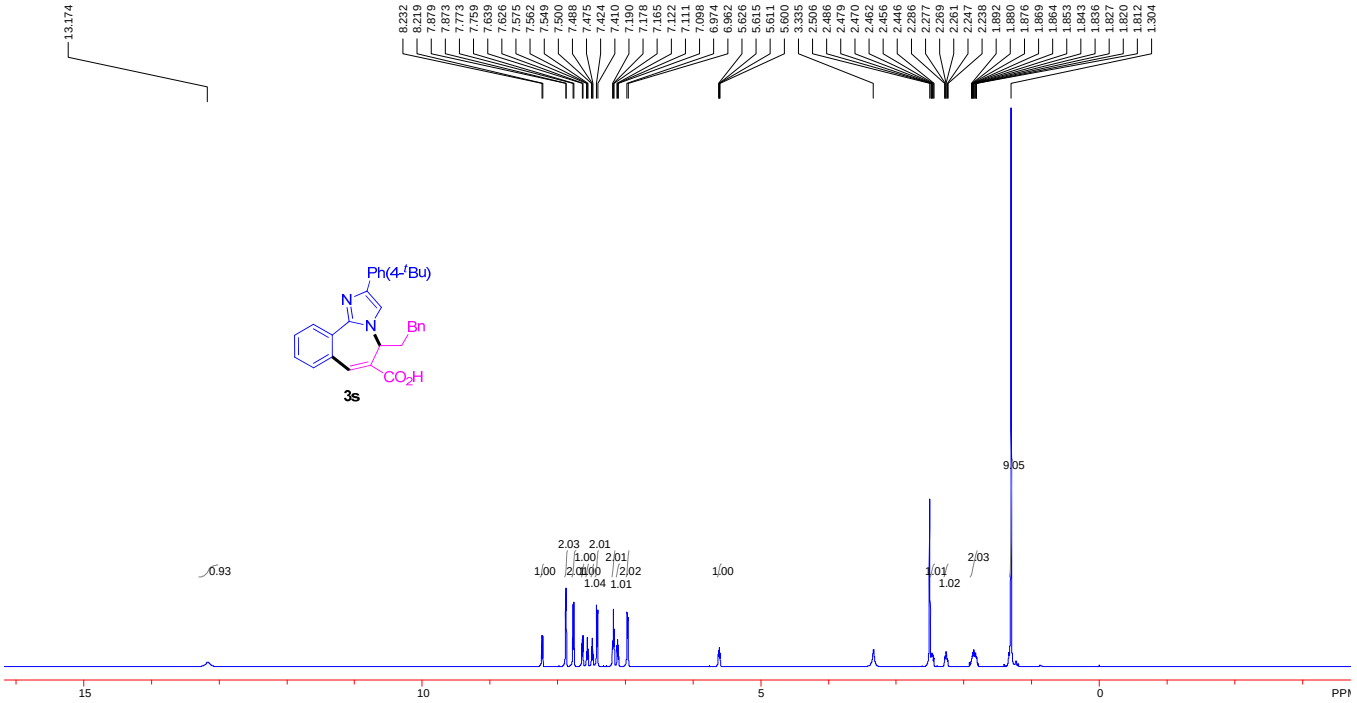
140
120
100
80
60
40
20
0PPM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7.575
7.562
7.549
7.500
7.488
7.475
7.424
7.410
7.190
7.178
7.165
7.122
7.111
7.098
6.974
6.962
5.626
5.615
5.611
5.600
3.335
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2.479
2.470
2.462
2.456
2.446
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2.277
2.269
2.261
2.247
2.238
1.892
1.880
1.876
1.869
1.864
1.853
1.843
1.836
1.827
1.820
1.812
1.304
Ph(4-tBu)
N
N
Bn
CO2H
3s
9.05
2.03
2.01
1.00
2.01
1.00
2.00
1.00
1.04
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1.01
1.00
1.01
1.02
2.03
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5
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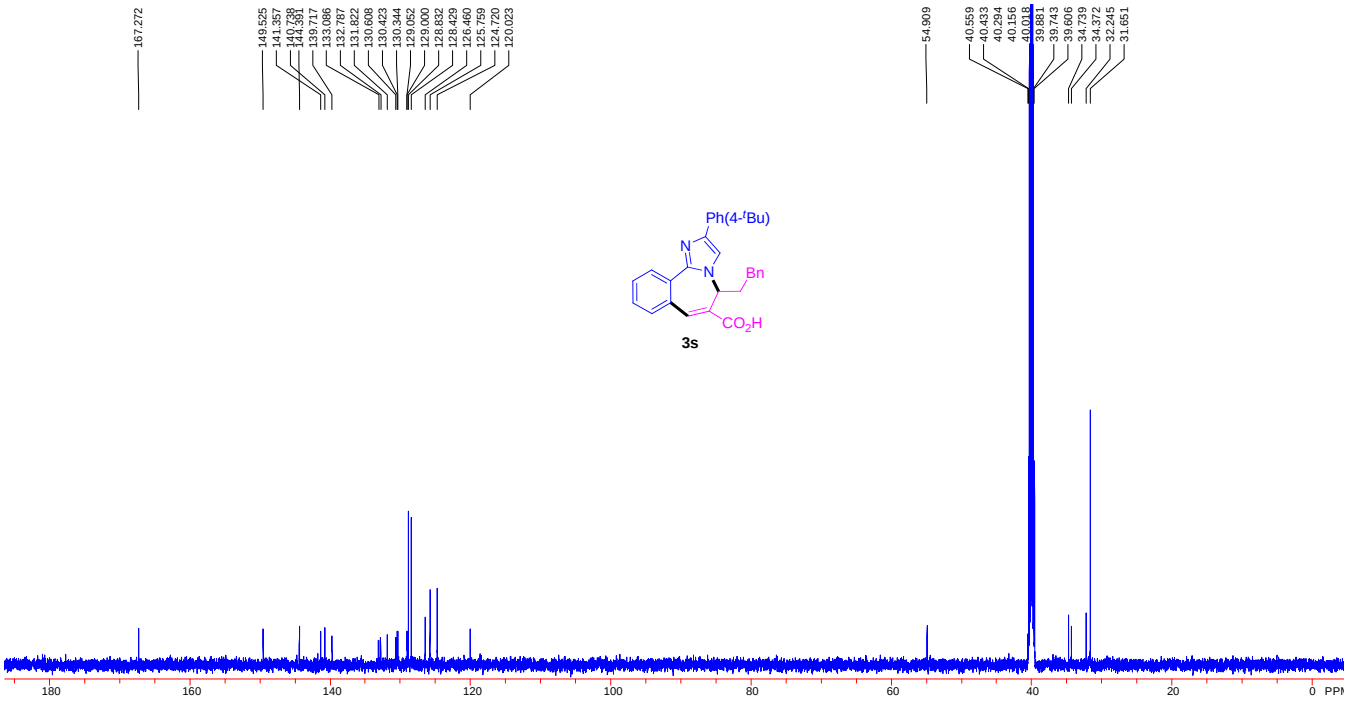
PPM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132.787
131.822
130.608
130.423
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129.052
129.000
128.832
128.426
126.460
125.759
124.720
120.023
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40.559
40.433
40.294
40.156
40.018
39.881
39.743
39.606
34.739
34.372
32.245
31.651
Ph(4-tBu)
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N
Bn
CO2H
3s
180
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120
100
80
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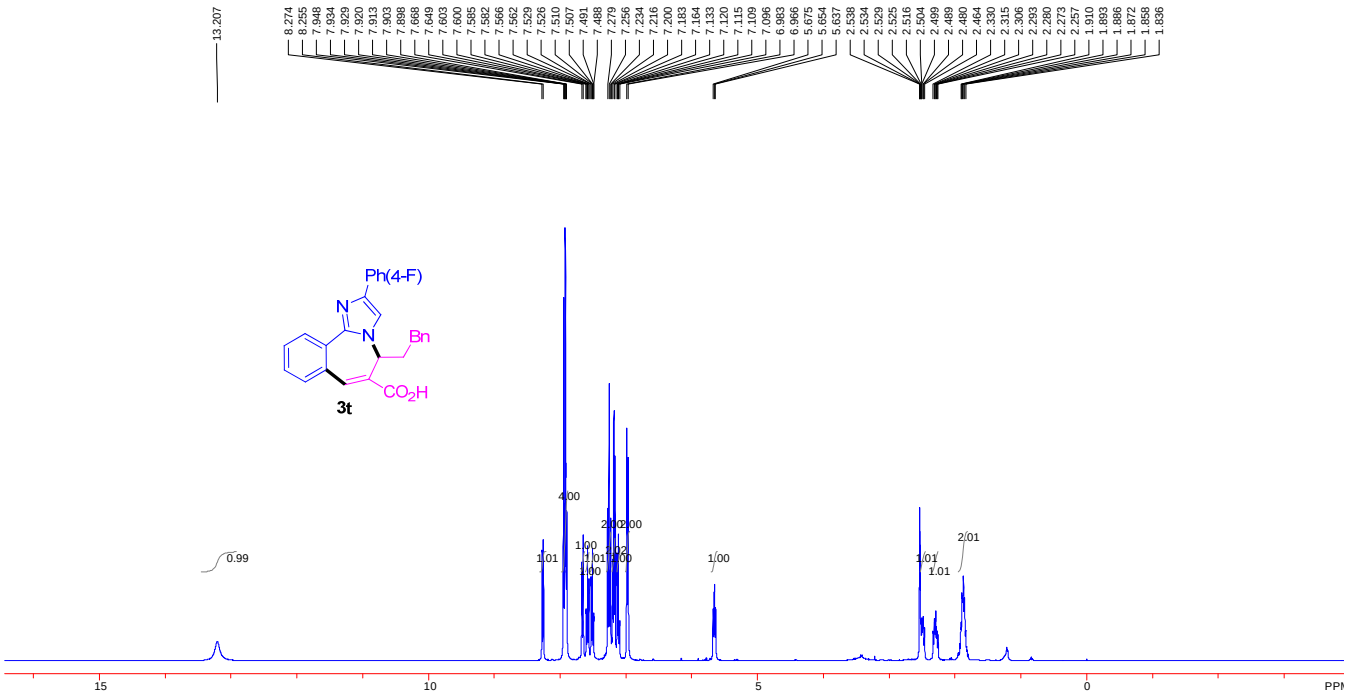
40
20
0
PPM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7.582
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7.529
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7.510
7.507
7.491
7.488
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7.216
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7.133
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7.115
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7.096
6.983
6.966
5.675
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5.637
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2.529
2.525
2.516
2.504
2.499
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2.480
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2.330
2.315
2.306
2.293
2.280
2.273
2.257
1.910
1.893
1.886
1.872
1.858
1.836
Ph(4-F)
N
N
Bn
CO2H
3t
0.99
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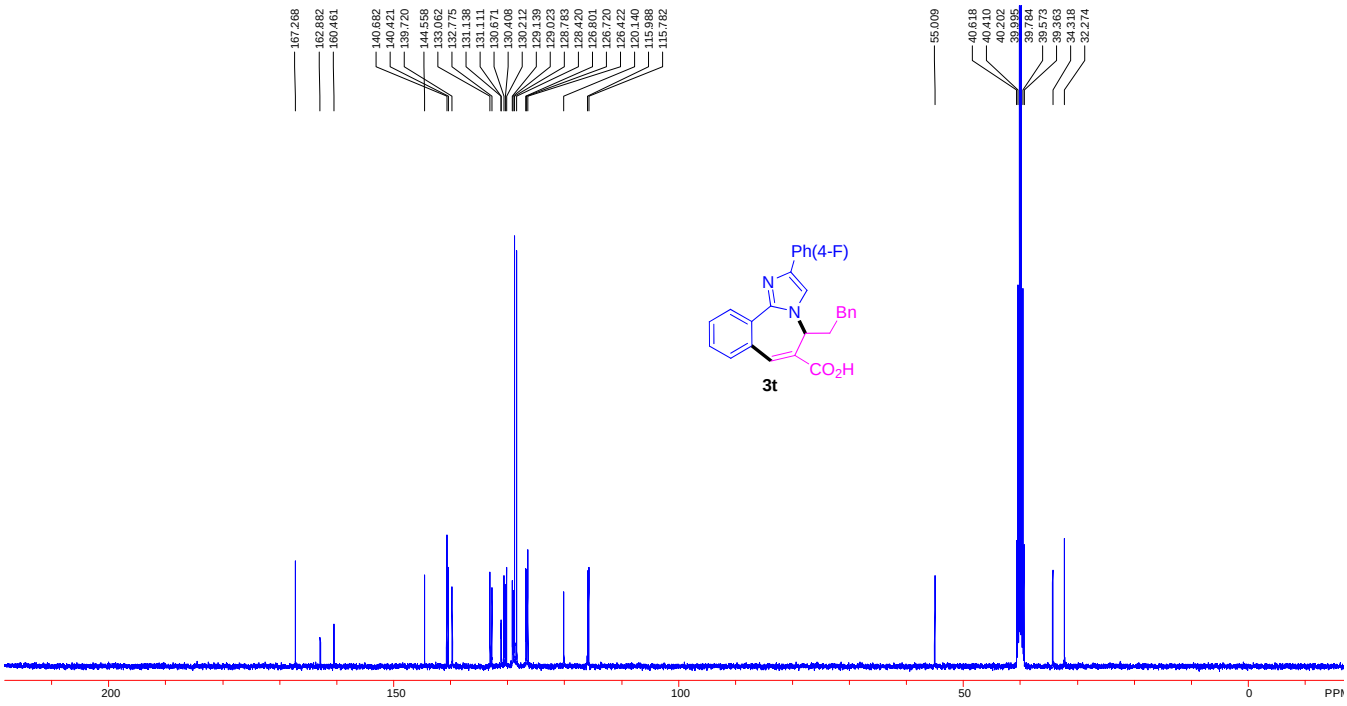
2.02
2.00
1.00
1.01
1.01
2.01
15
10
5
0
PPM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115.988
115.782
55.009
40.618
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39.784
39.573
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Ph(4-F)
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N
Bn
CO2H
3t
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100
50
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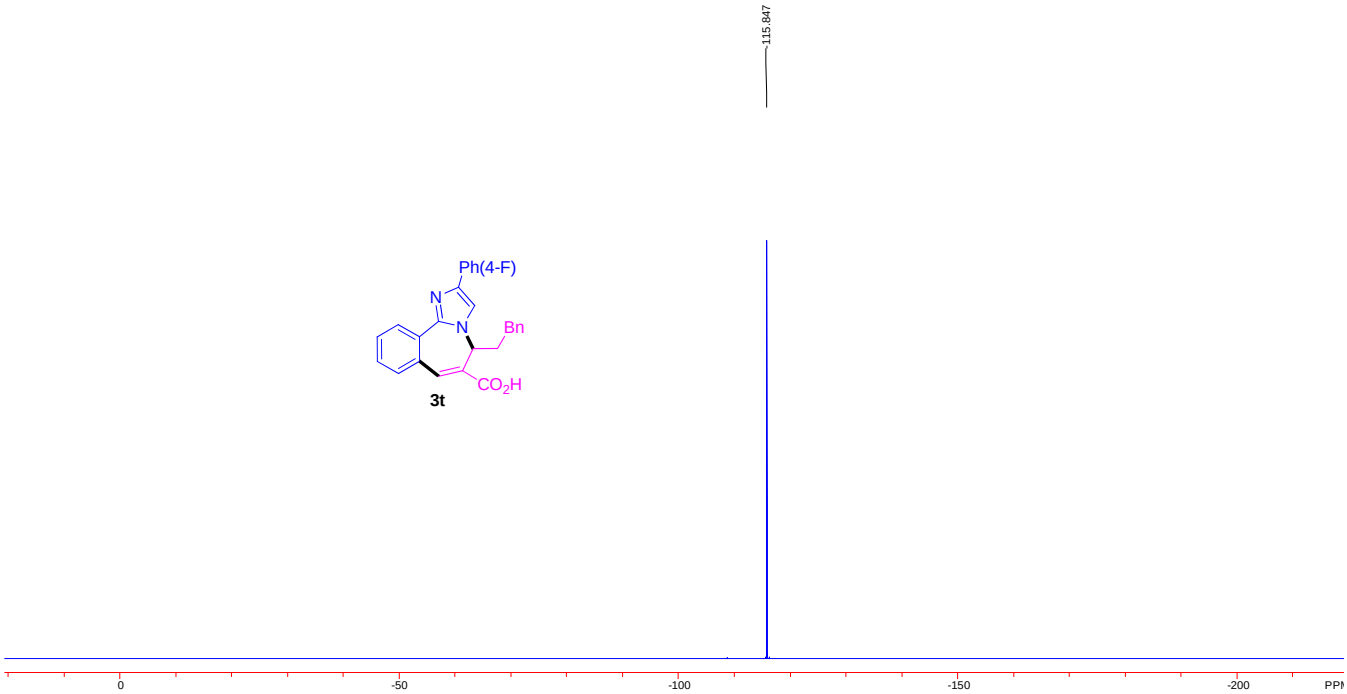
PPM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-200
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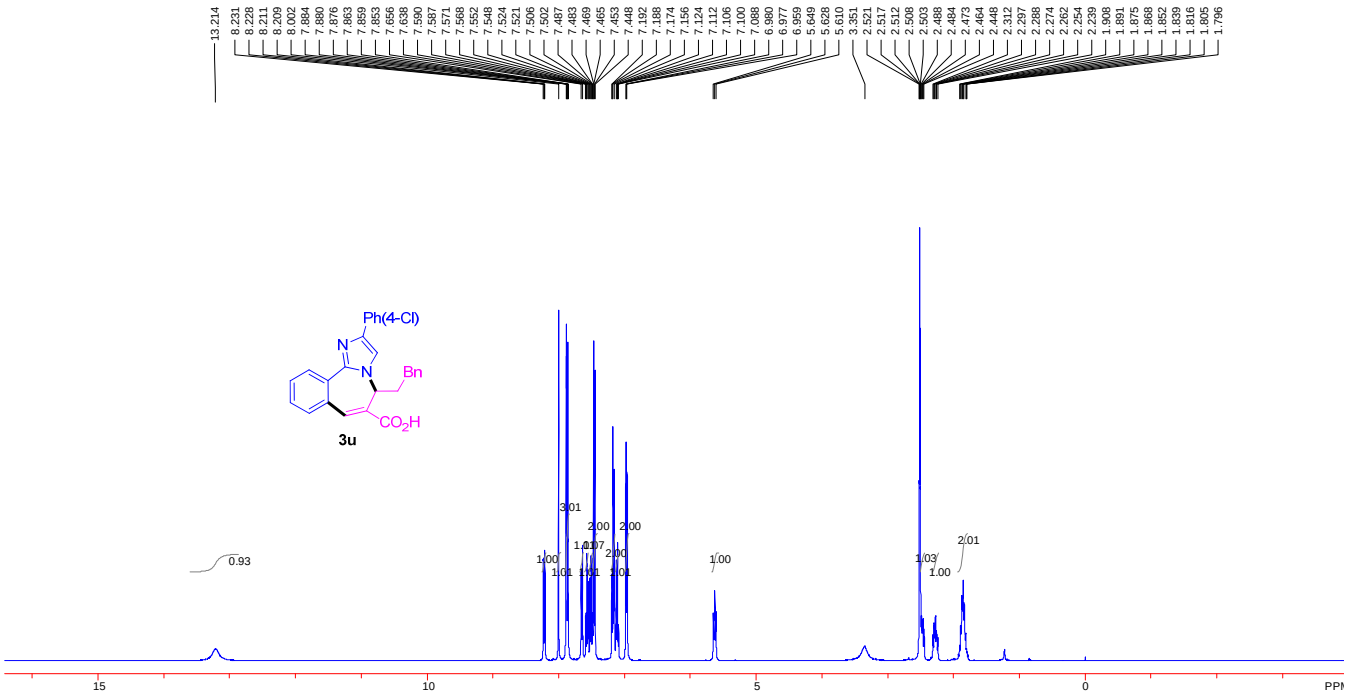
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7.590
7.587
7.571
7.568
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7.548
7.524
7.521
7.506
7.502
7.487
7.483
7.469
7.465
7.453
7.448
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7.174
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7.124
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7.106
7.100
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5.610
3.351
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2.512
2.508
2.503
2.488
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2.473
2.464
2.448
2.312
2.297
2.288
2.274
2.262
2.254
2.239
1.908
1.891
1.875
1.868
1.852
1.839
1.816
1.805
1.796
Ph(4-Cl)
N
N
Bn
CO2H
3u
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1.01
3.01
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1.00
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1.00
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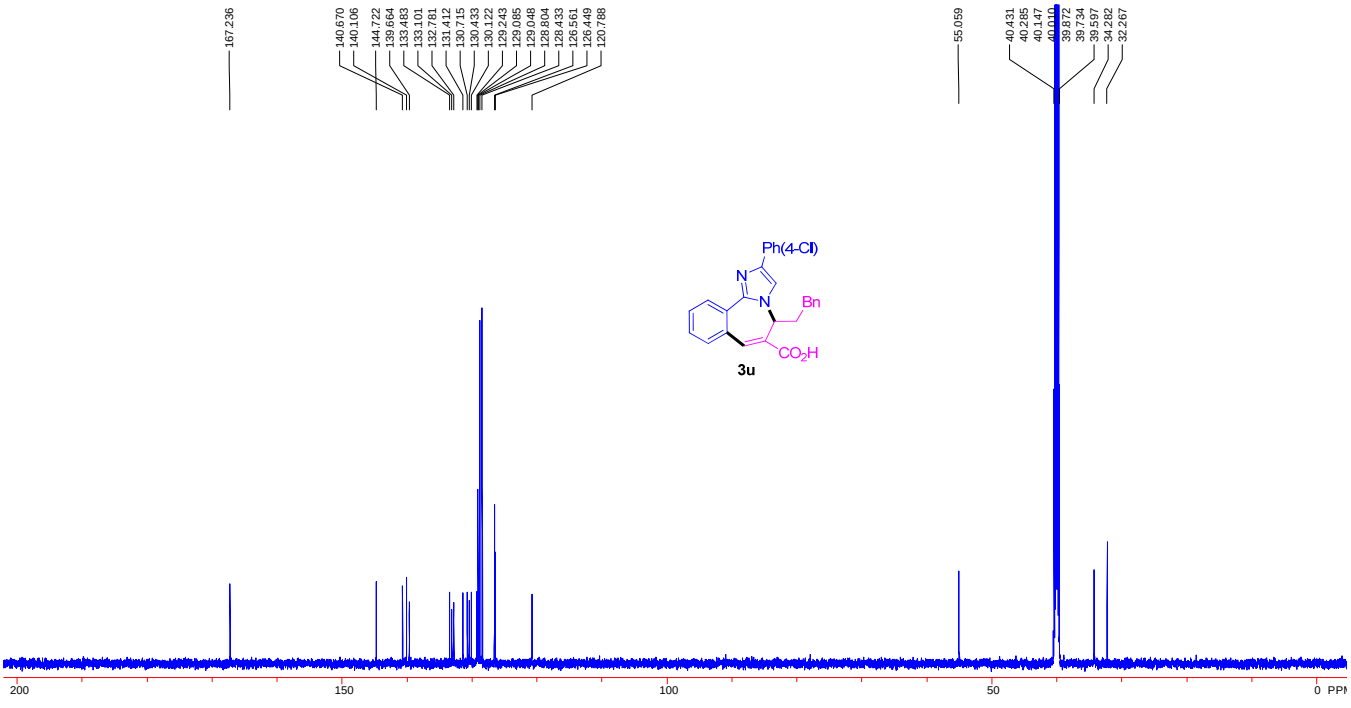
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132.781
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130.715
130.433
130.122
129.243
129.085
129.048
128.804
128.433
126.561
126.449
120.788
55.059
40.431
40.285
40.147
40.010
39.872
39.734
39.597
34.282
32.267
Ph(4-Cl)
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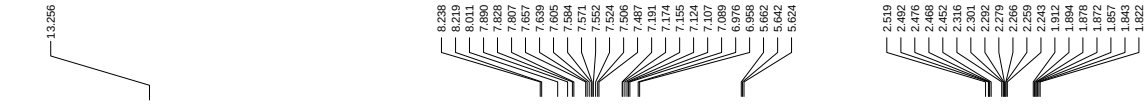
Bn
CO2H
3u
200
150
100
50
0 PPM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7.571
7.552
7.524
7.506
7.487
7.191
7.174
7.155
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5.624
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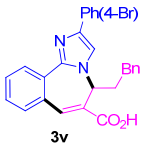
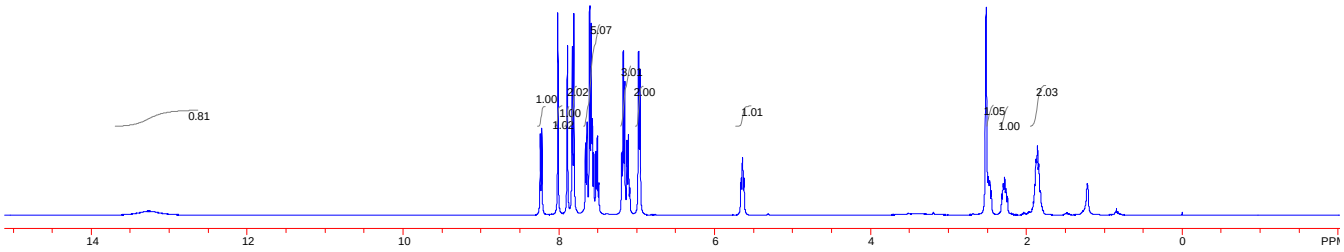
1.822


Ph(4-Br)
N
N
Bn
CO2H

3v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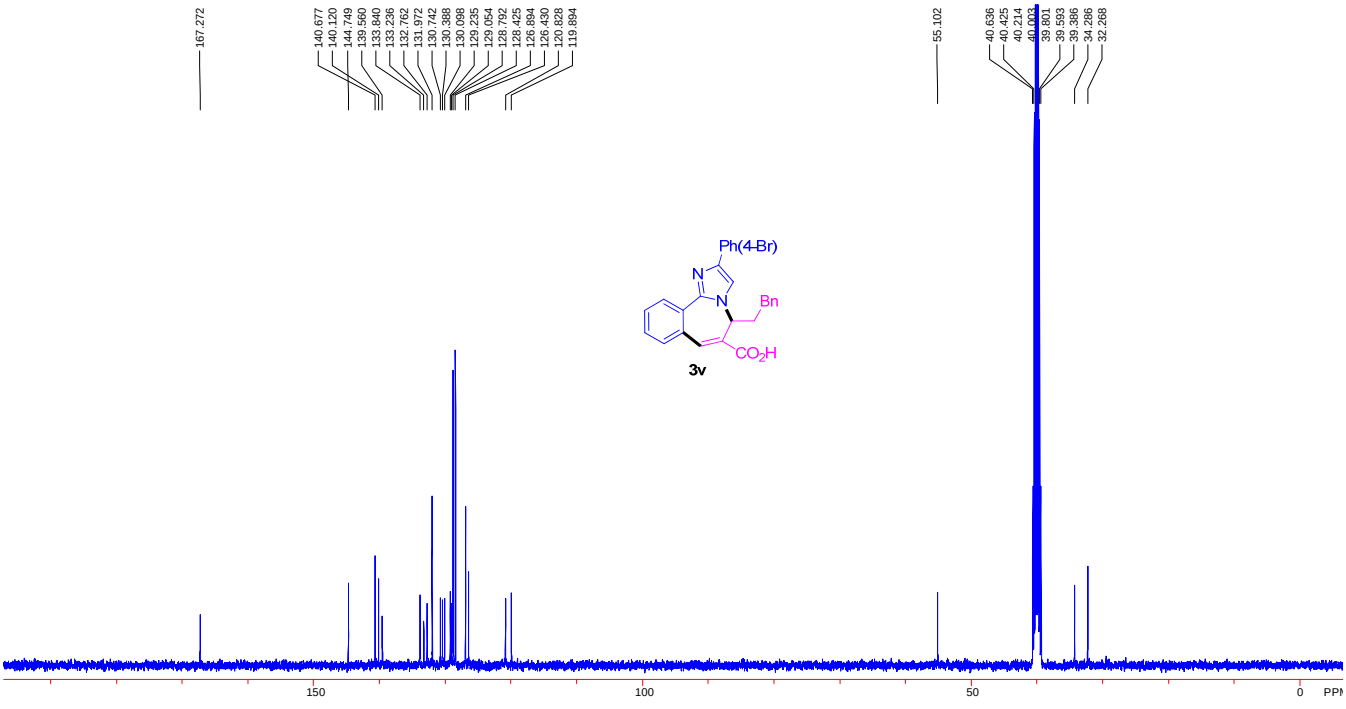
2.02
1.00
1.02
5.07
3.01
2.00
1.01
1.05
1.00
2.03
14
12
10
8
6
4
2
0
PPM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140.120
144.749
139.560
133.840
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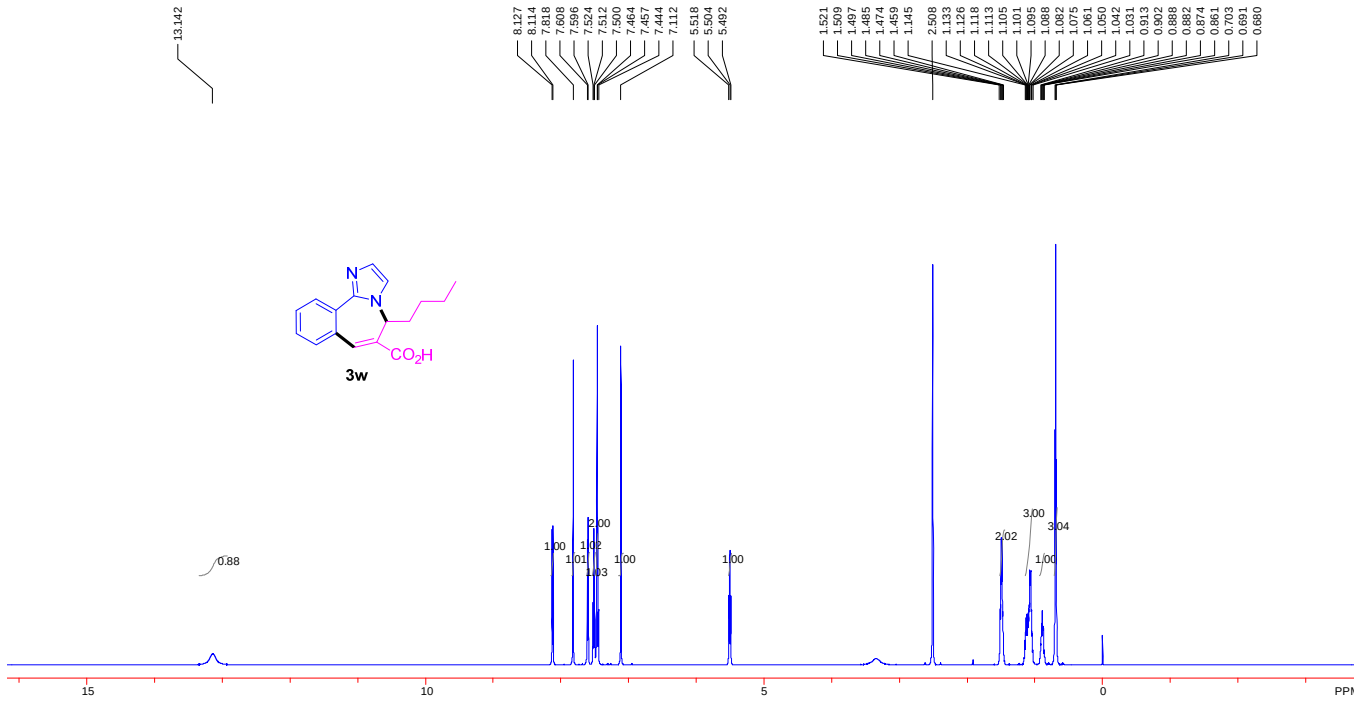
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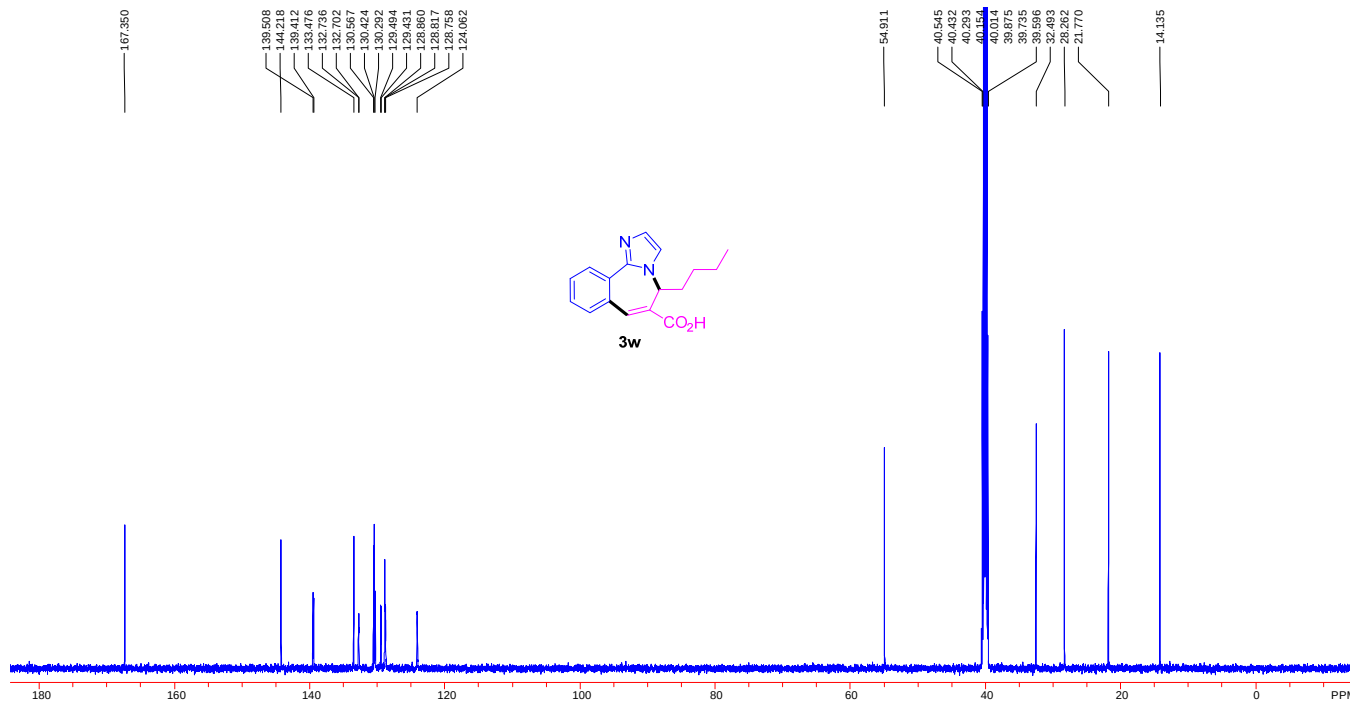
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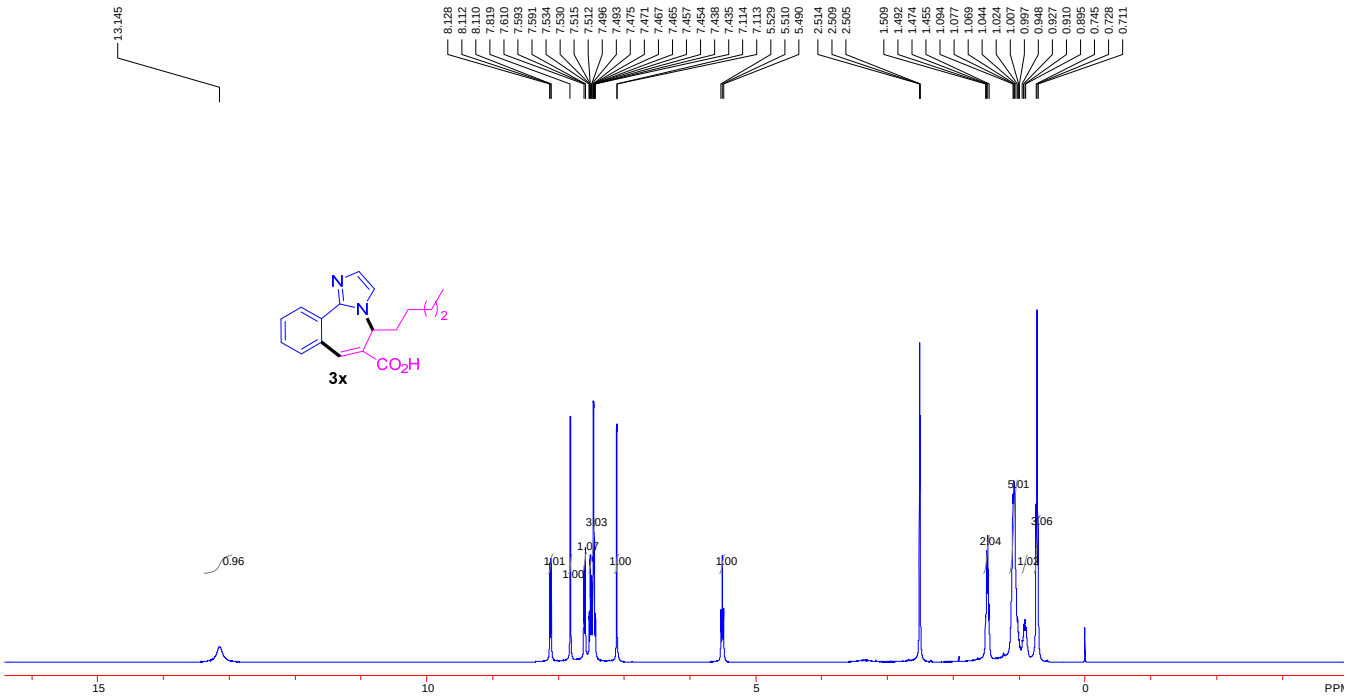
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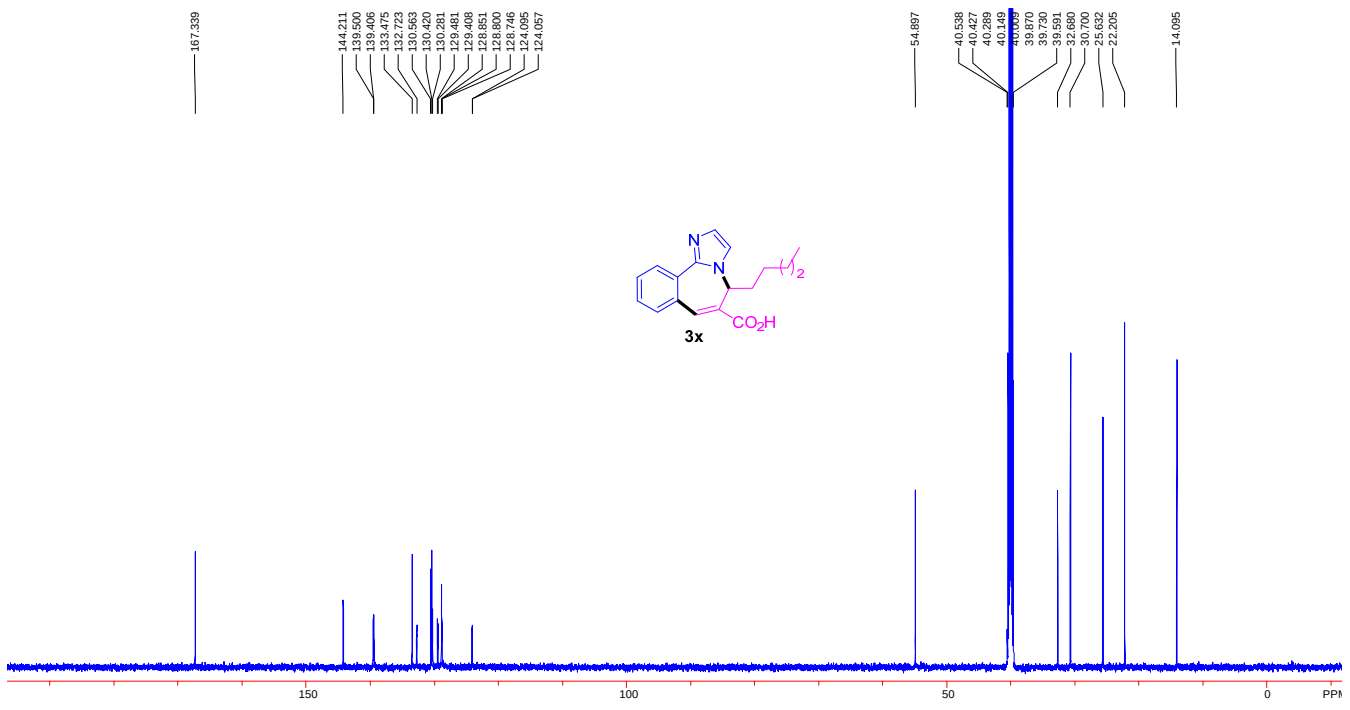
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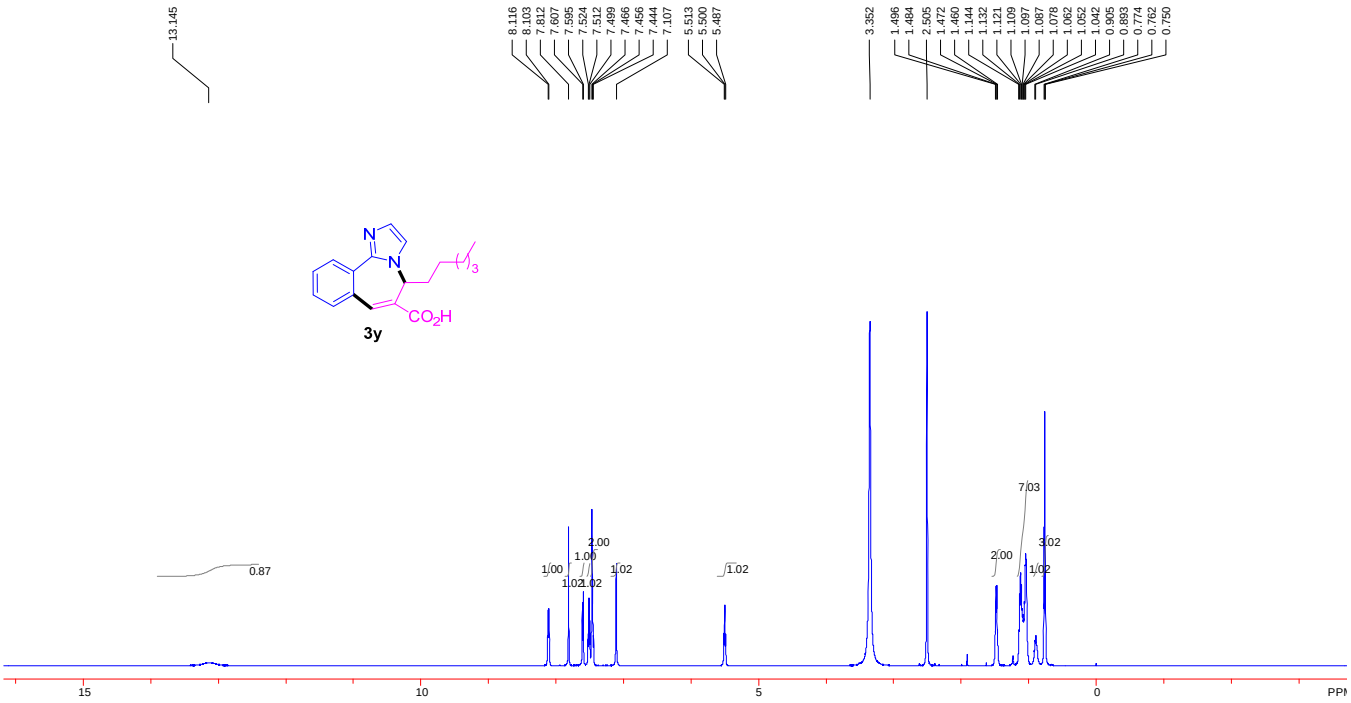
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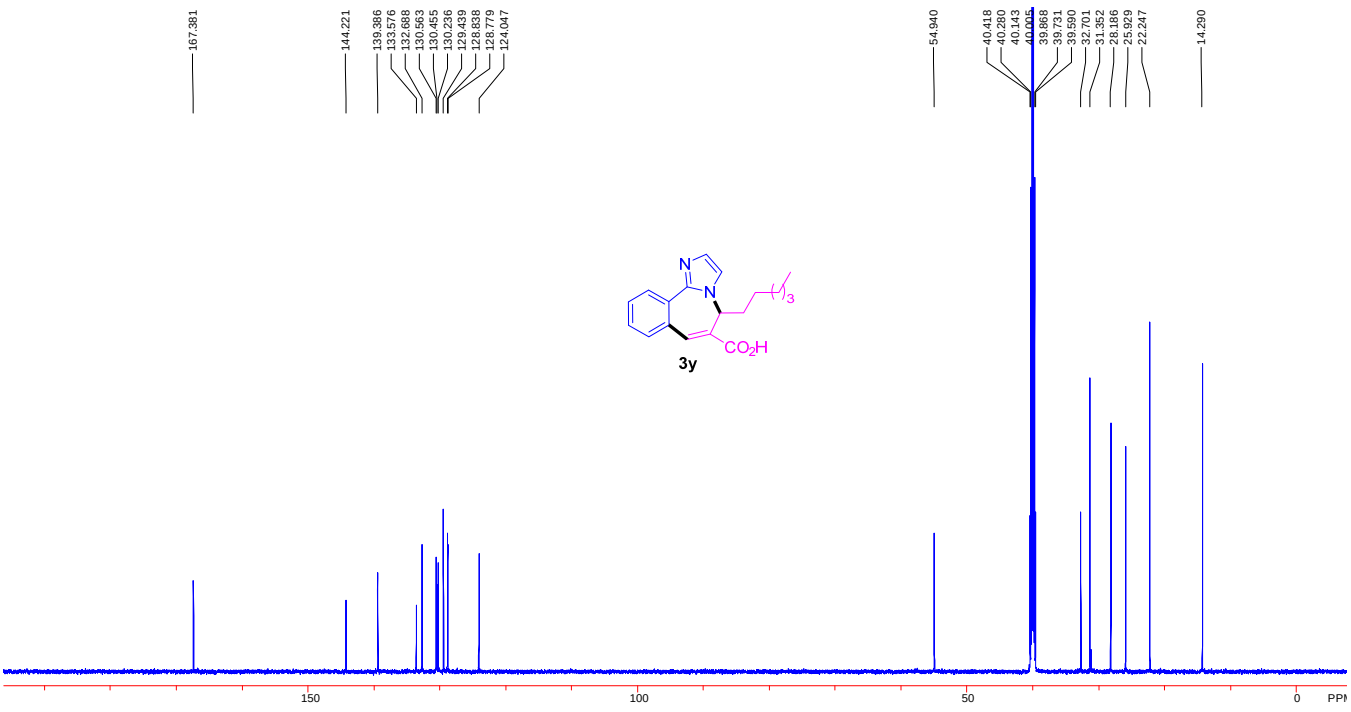
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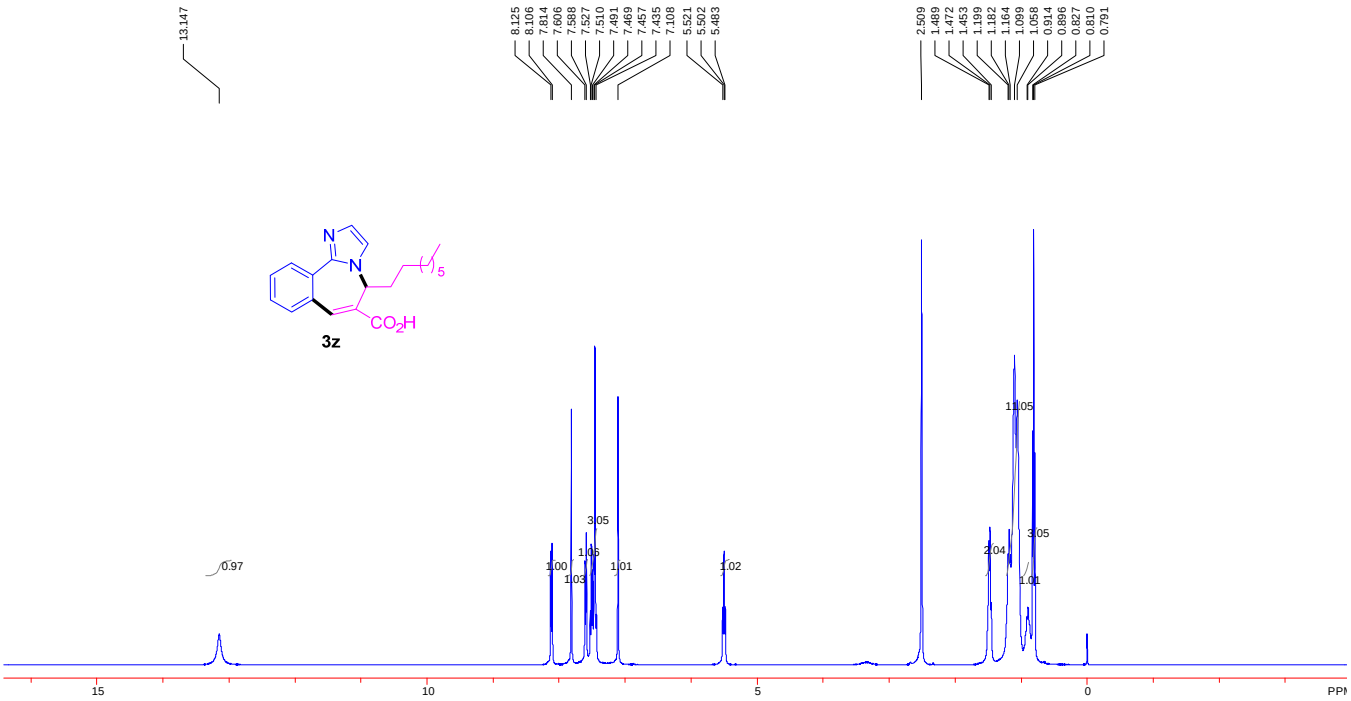
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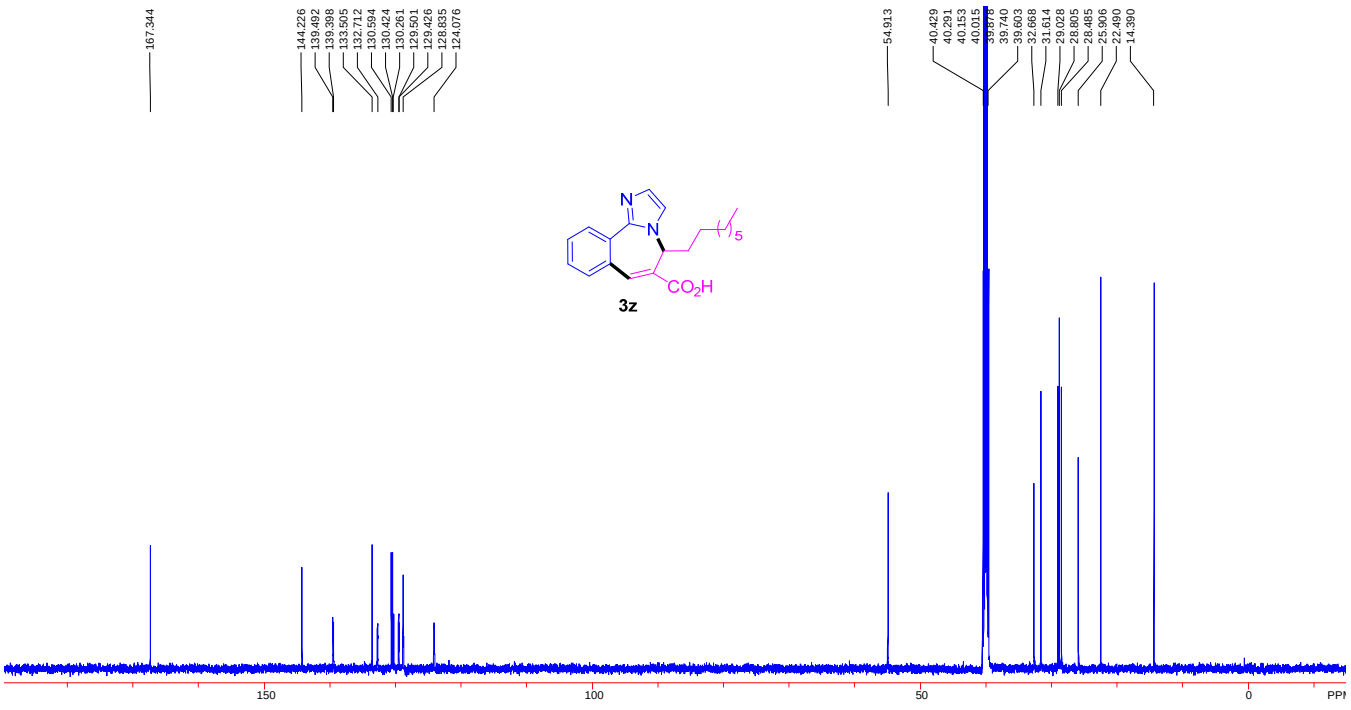
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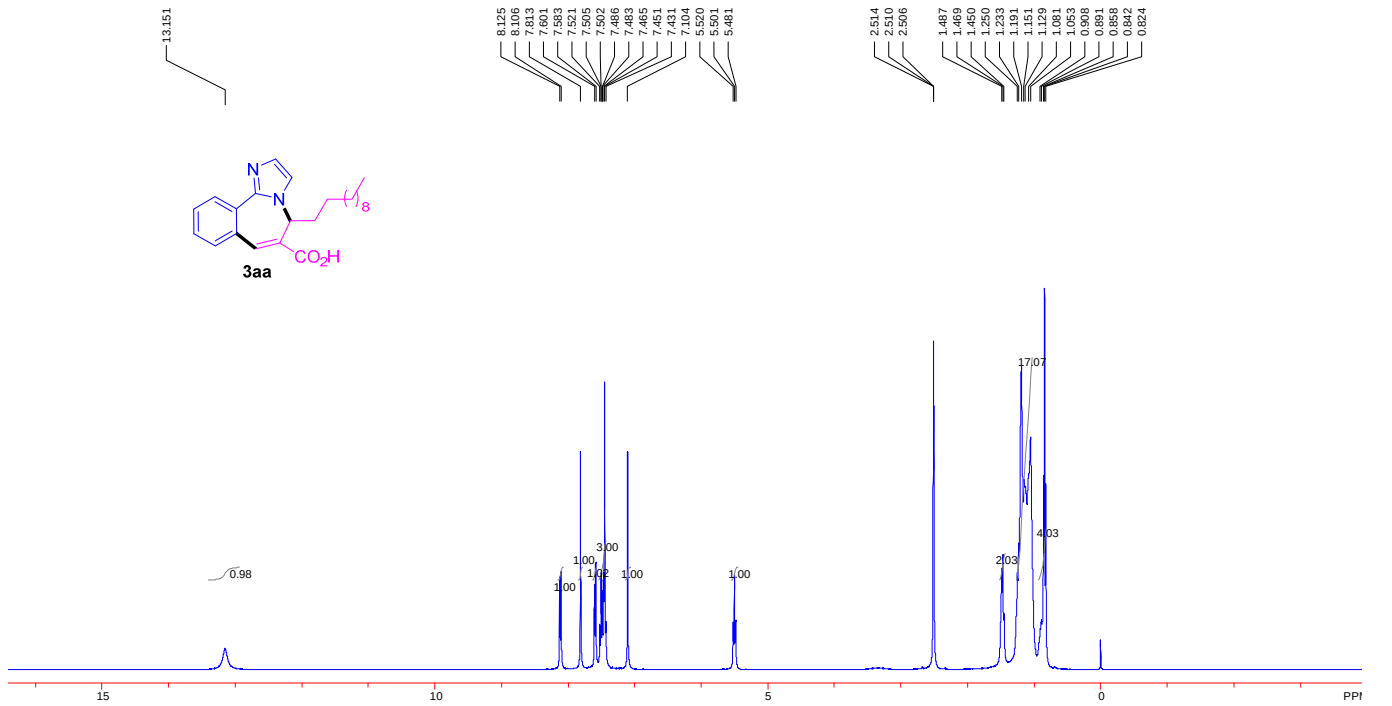
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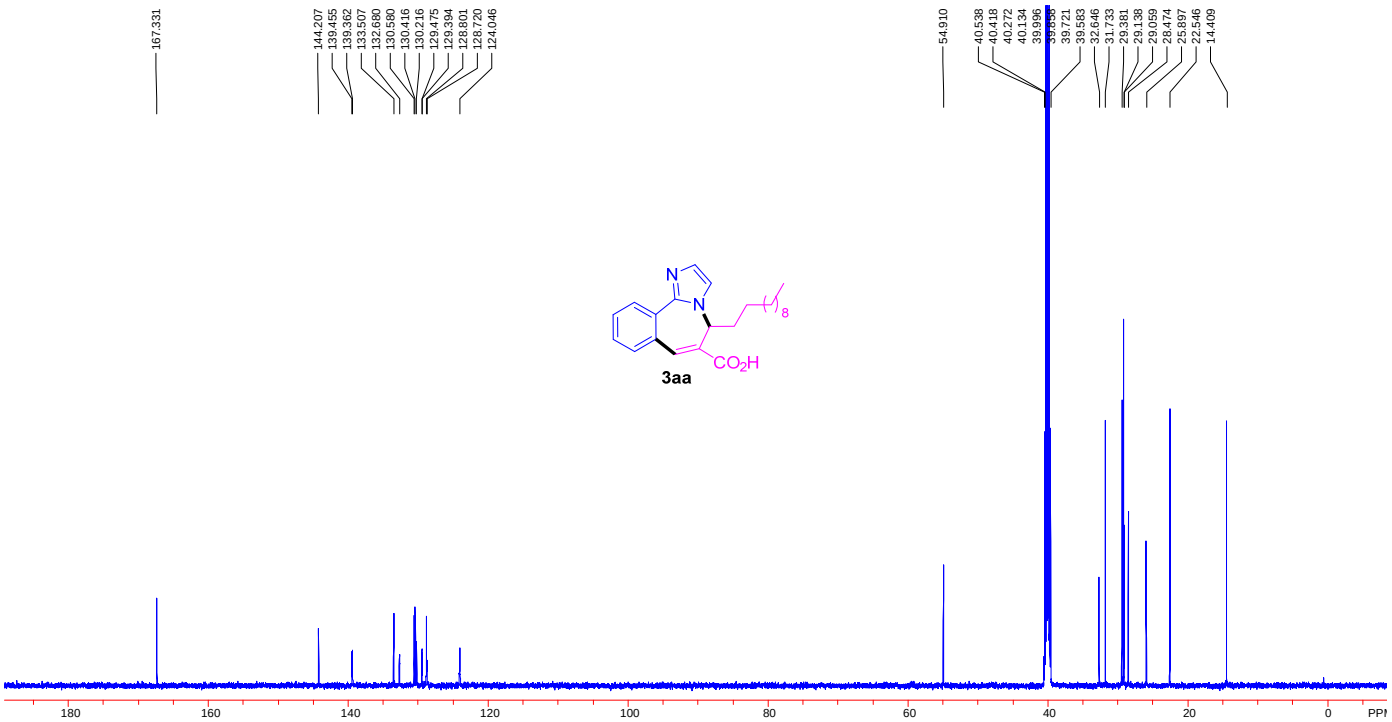
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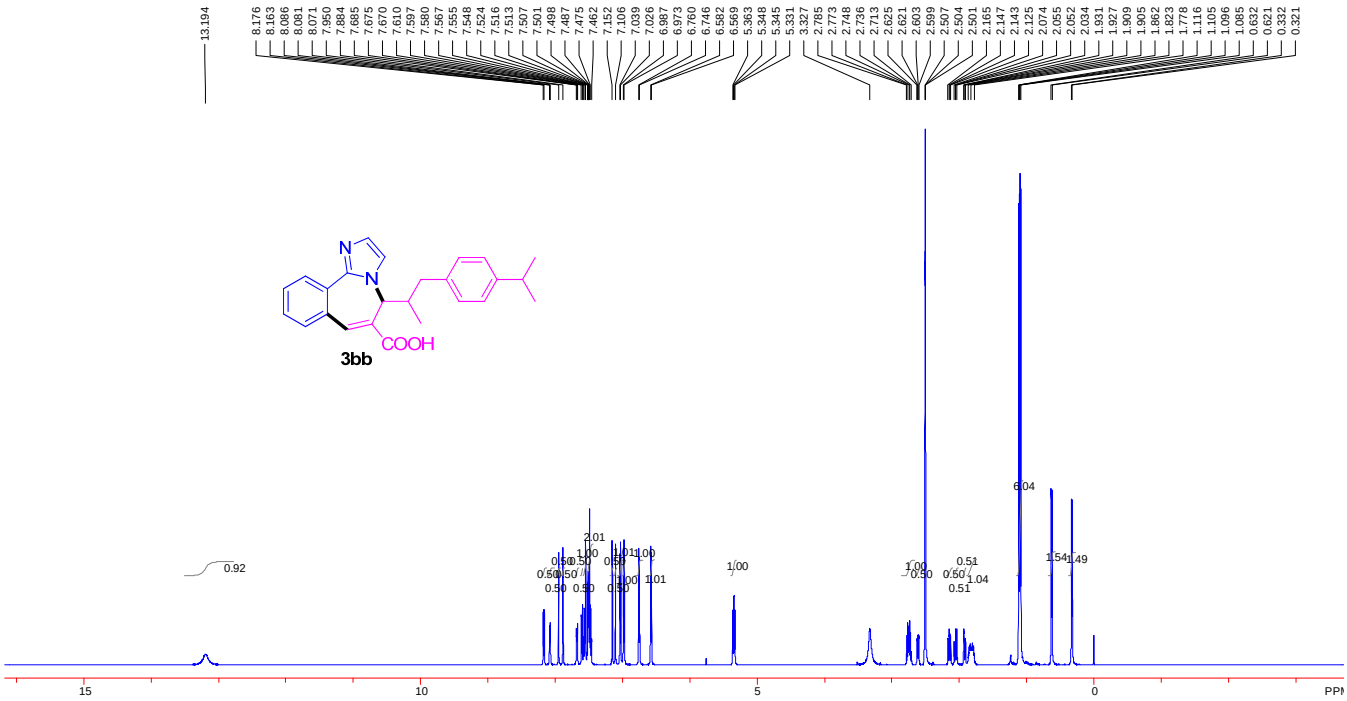
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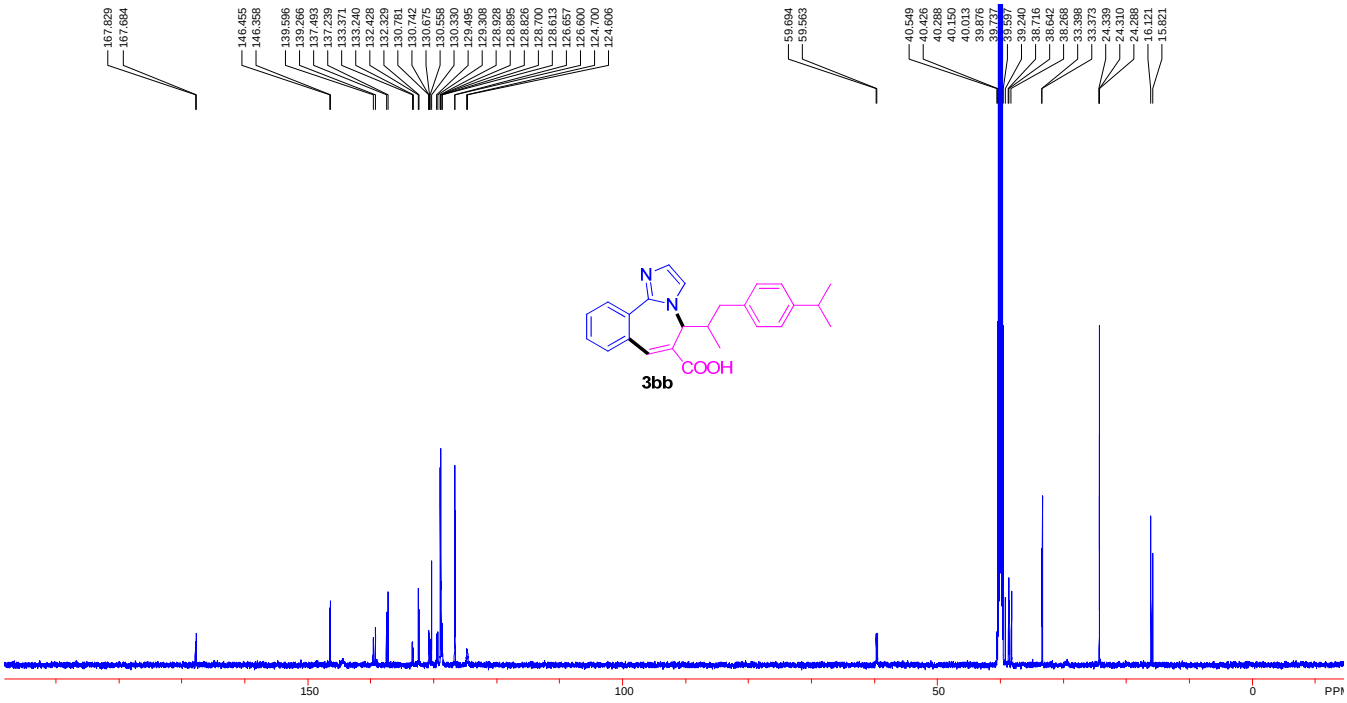
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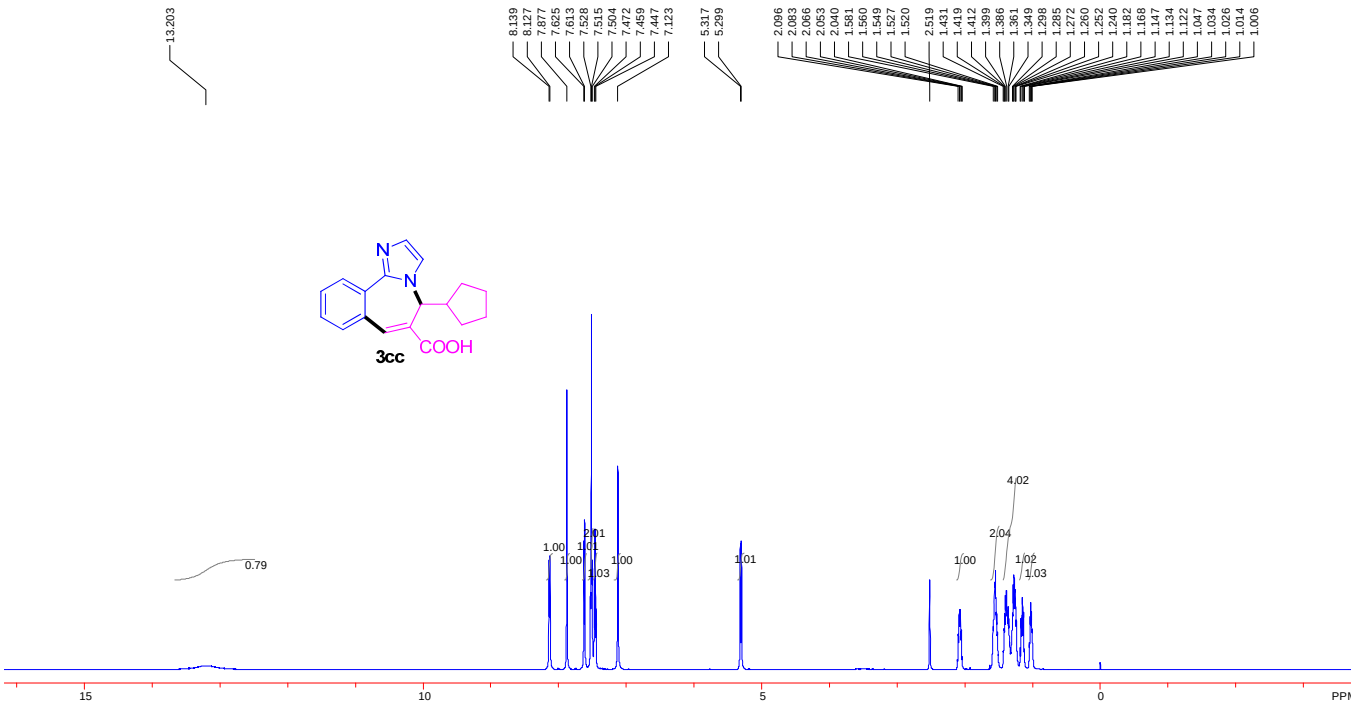
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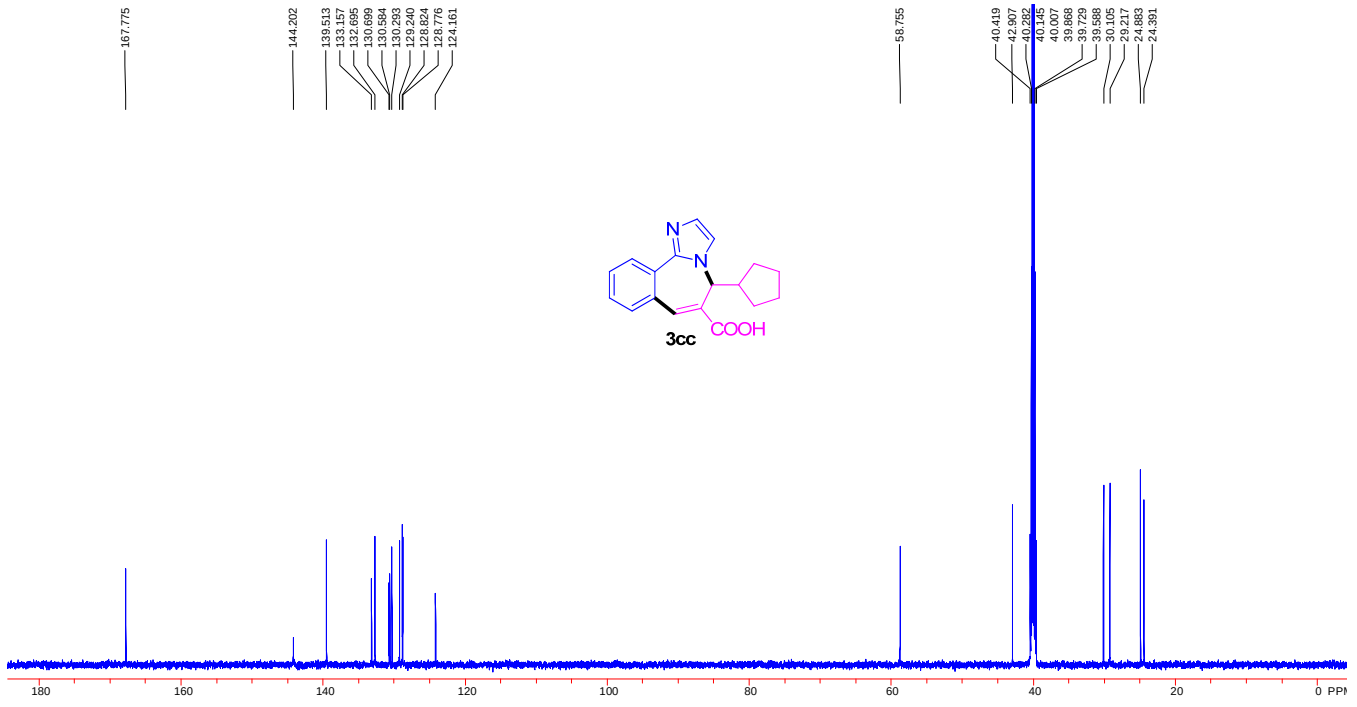
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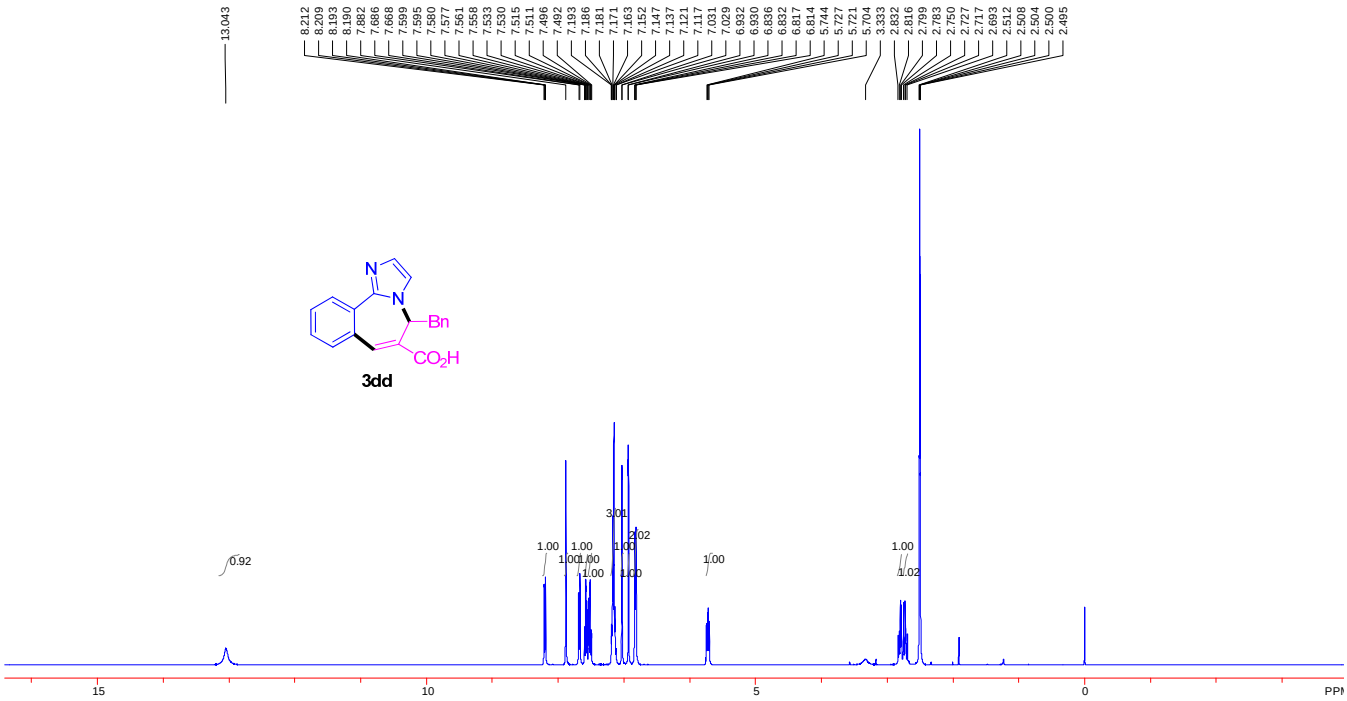
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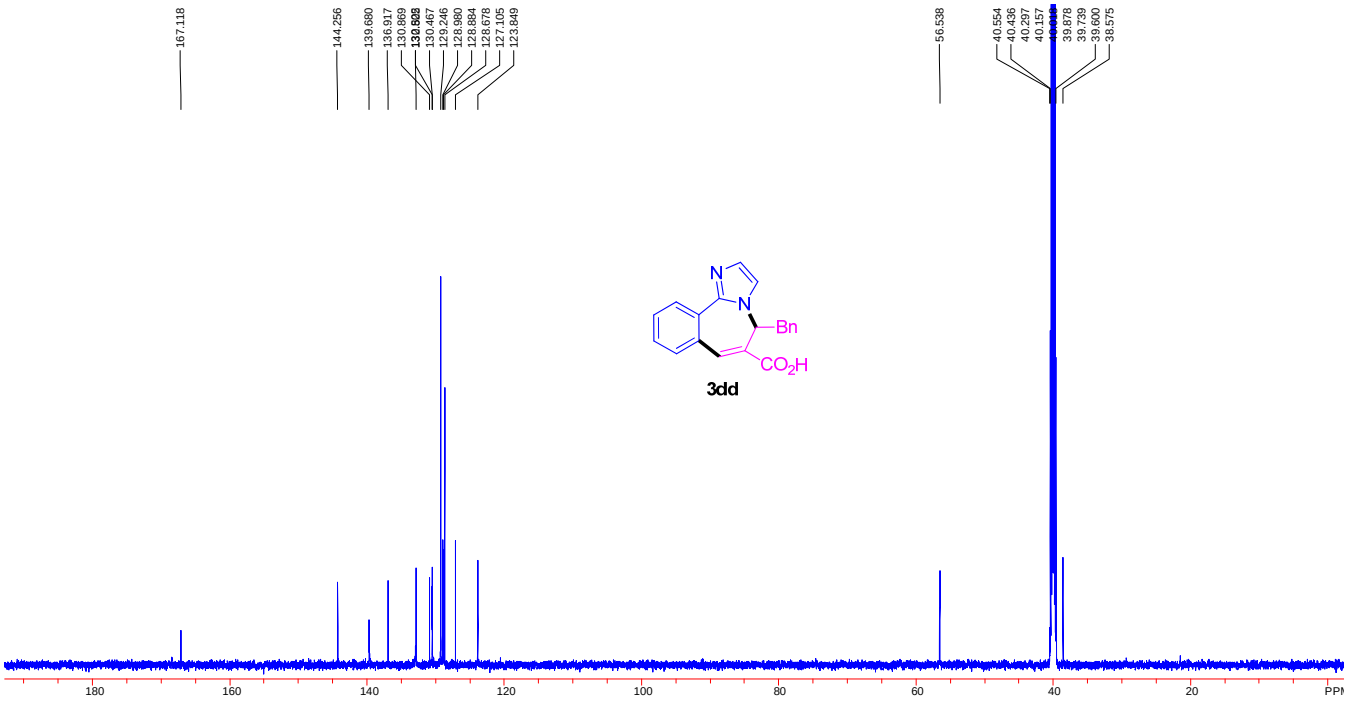
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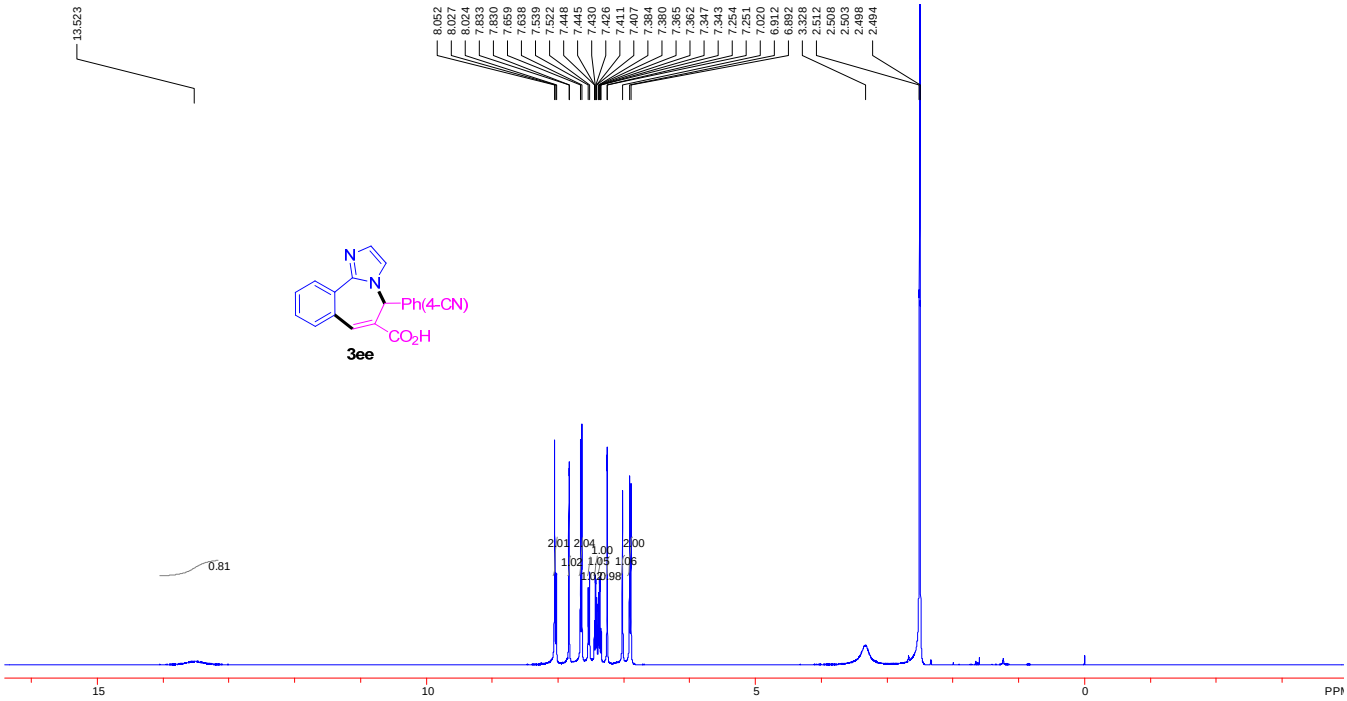
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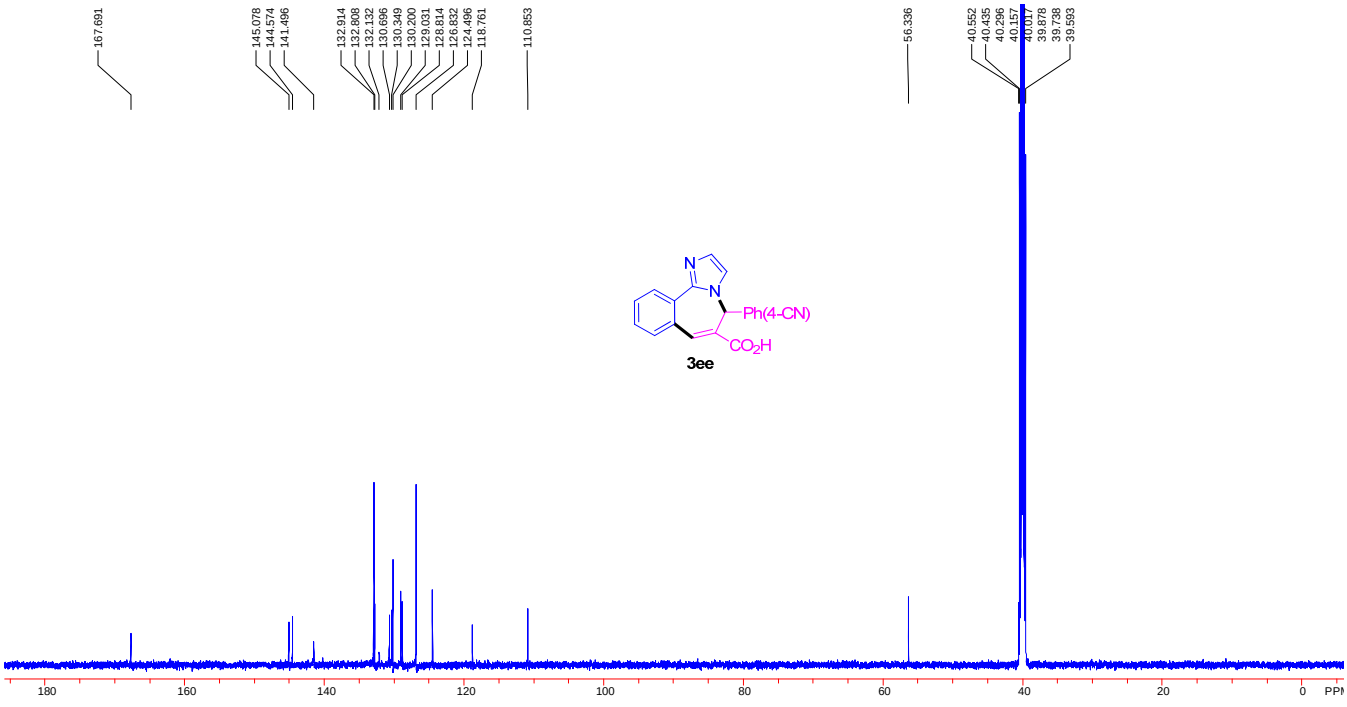
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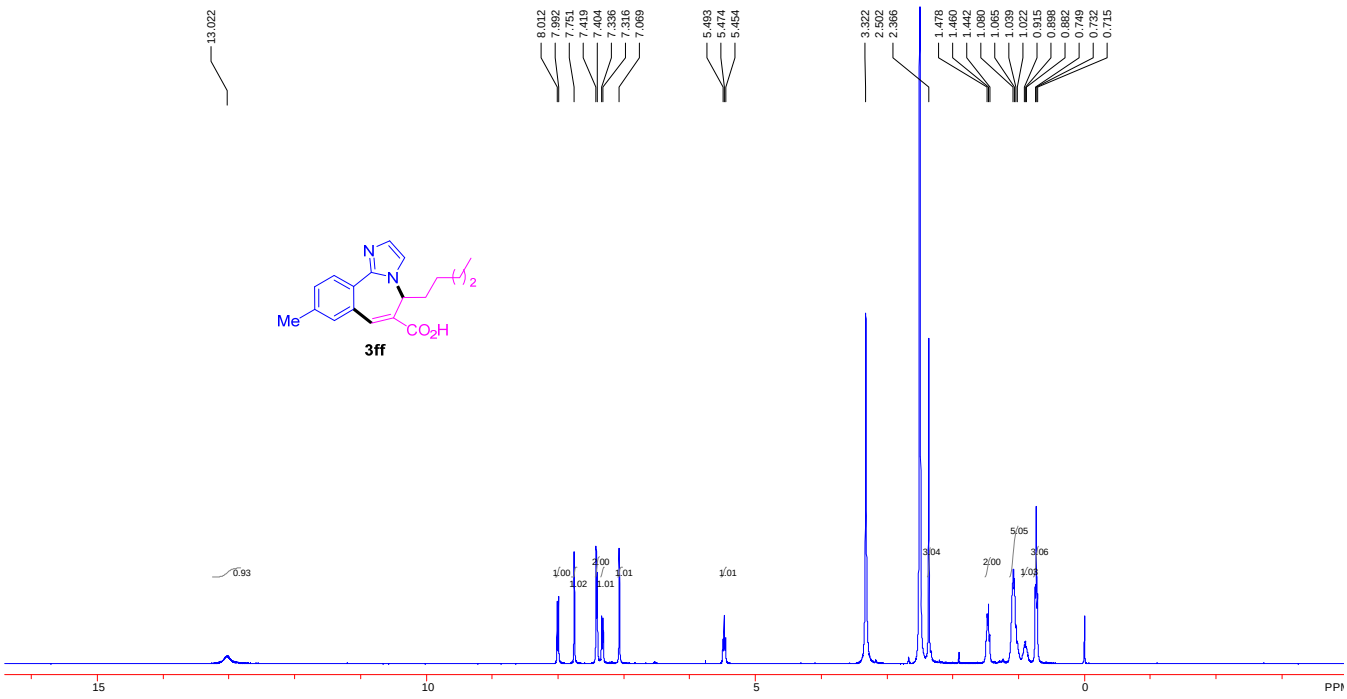
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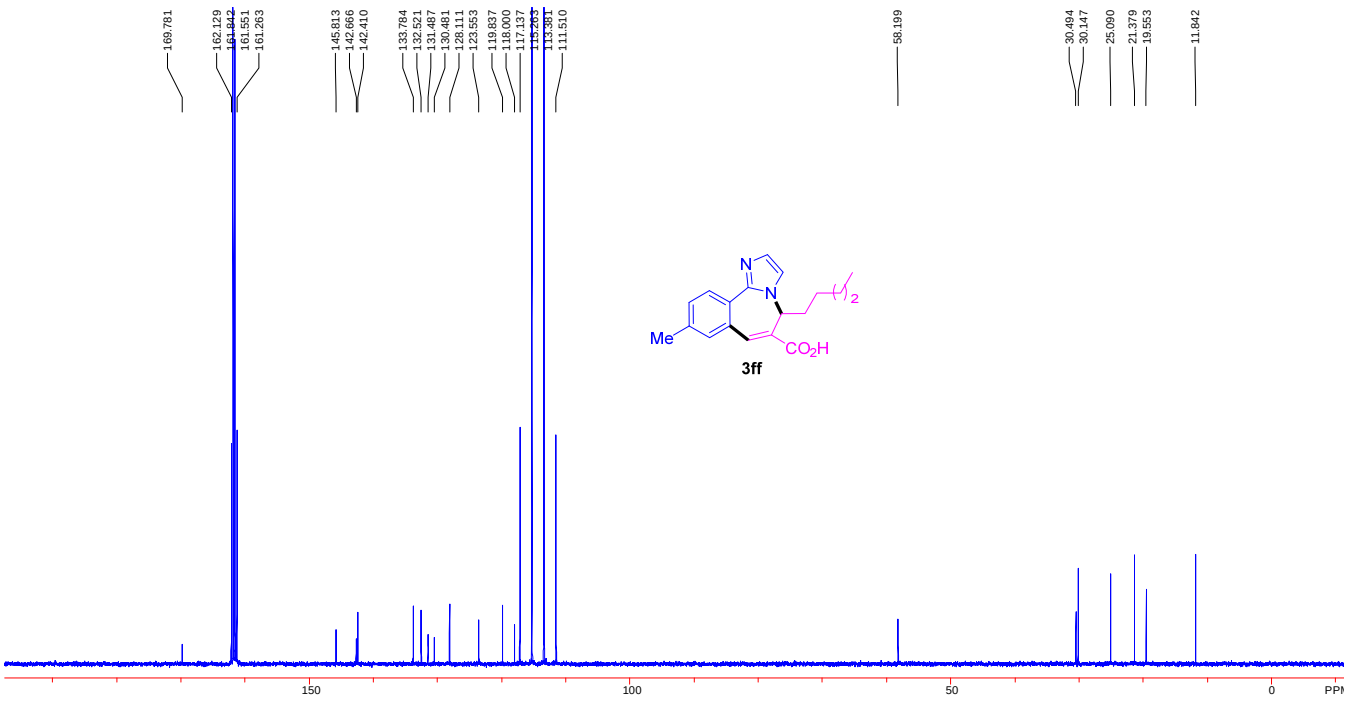
Me
CO2H
3ff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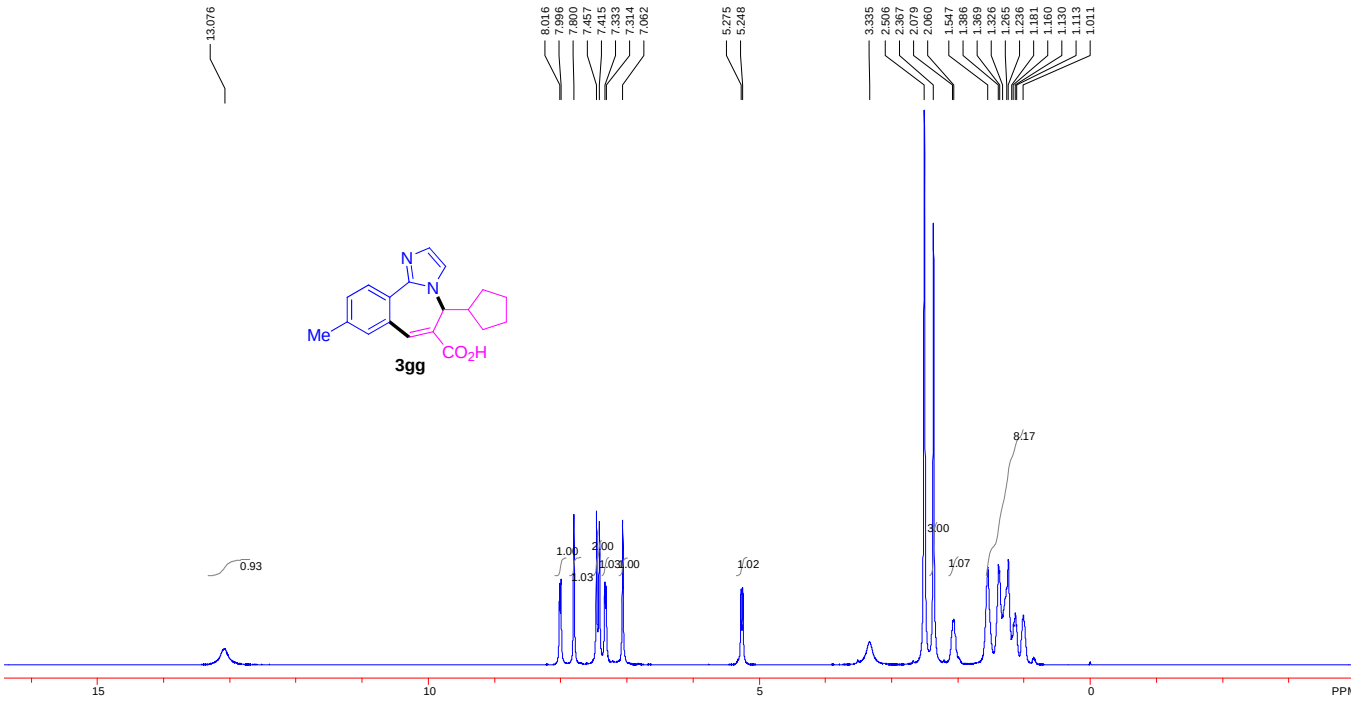
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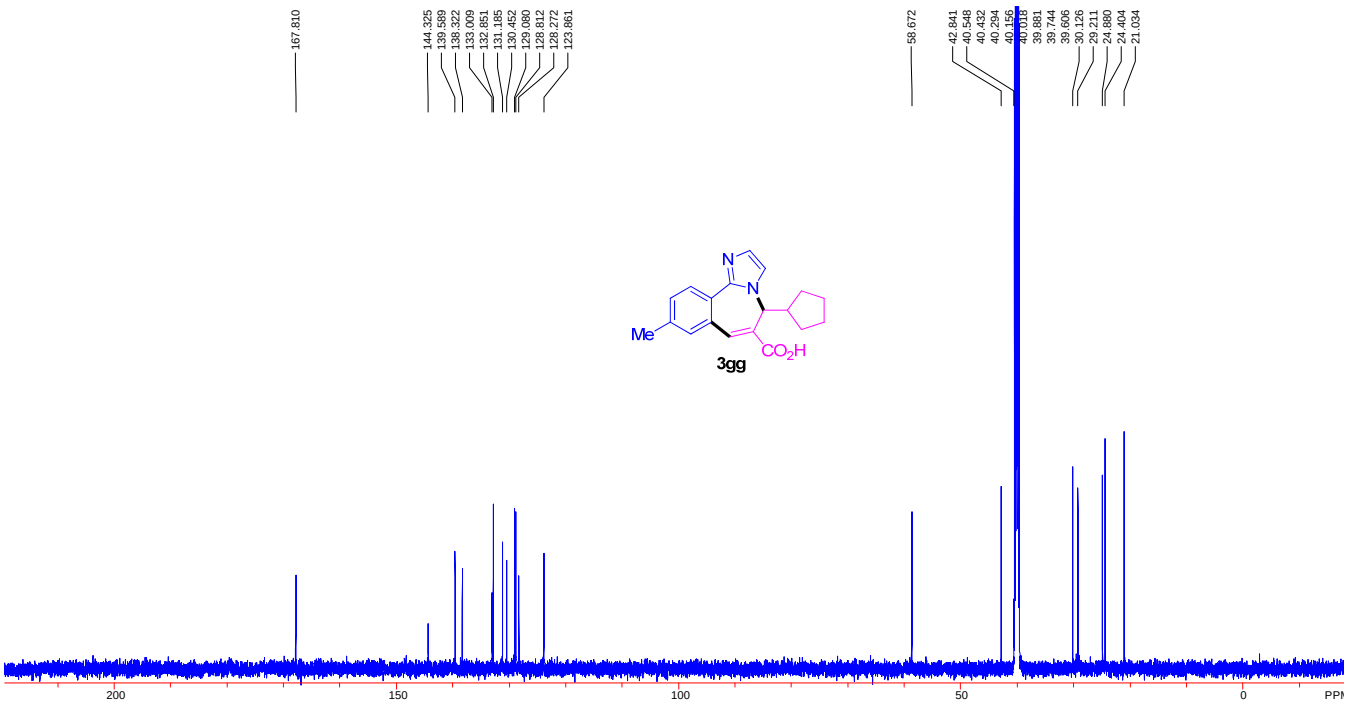
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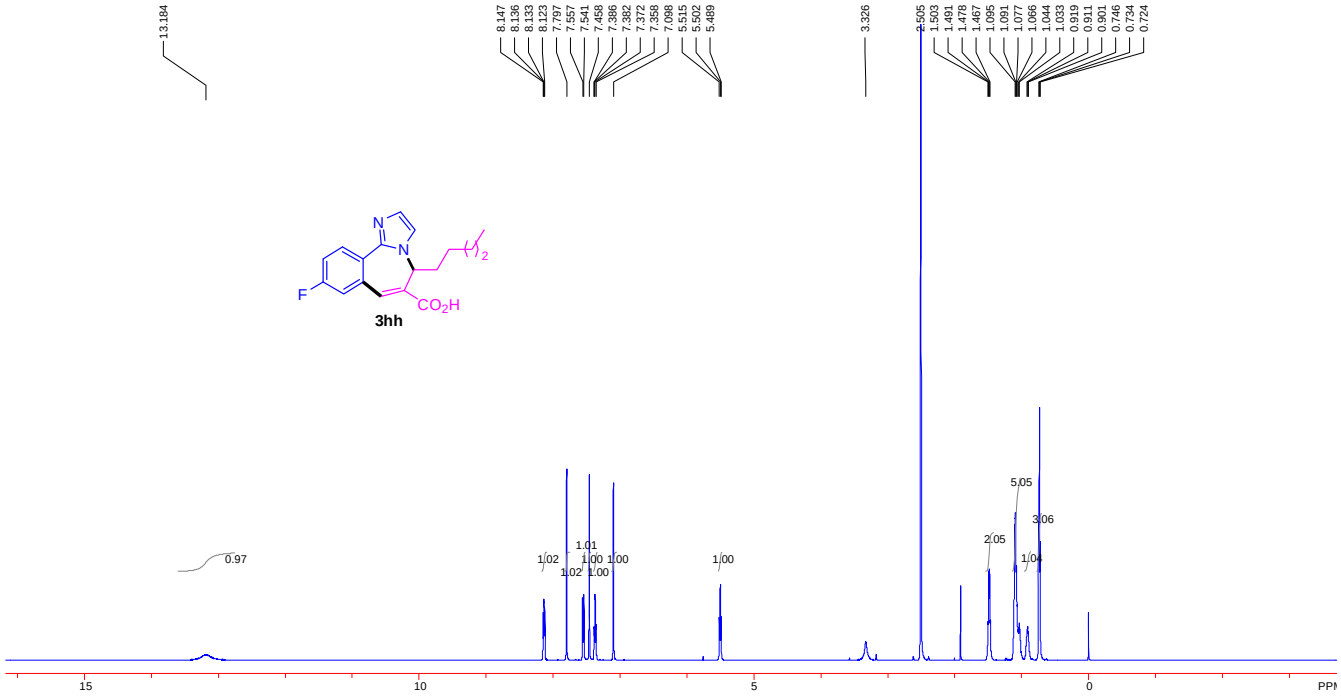
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0.724
3hh
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1.01
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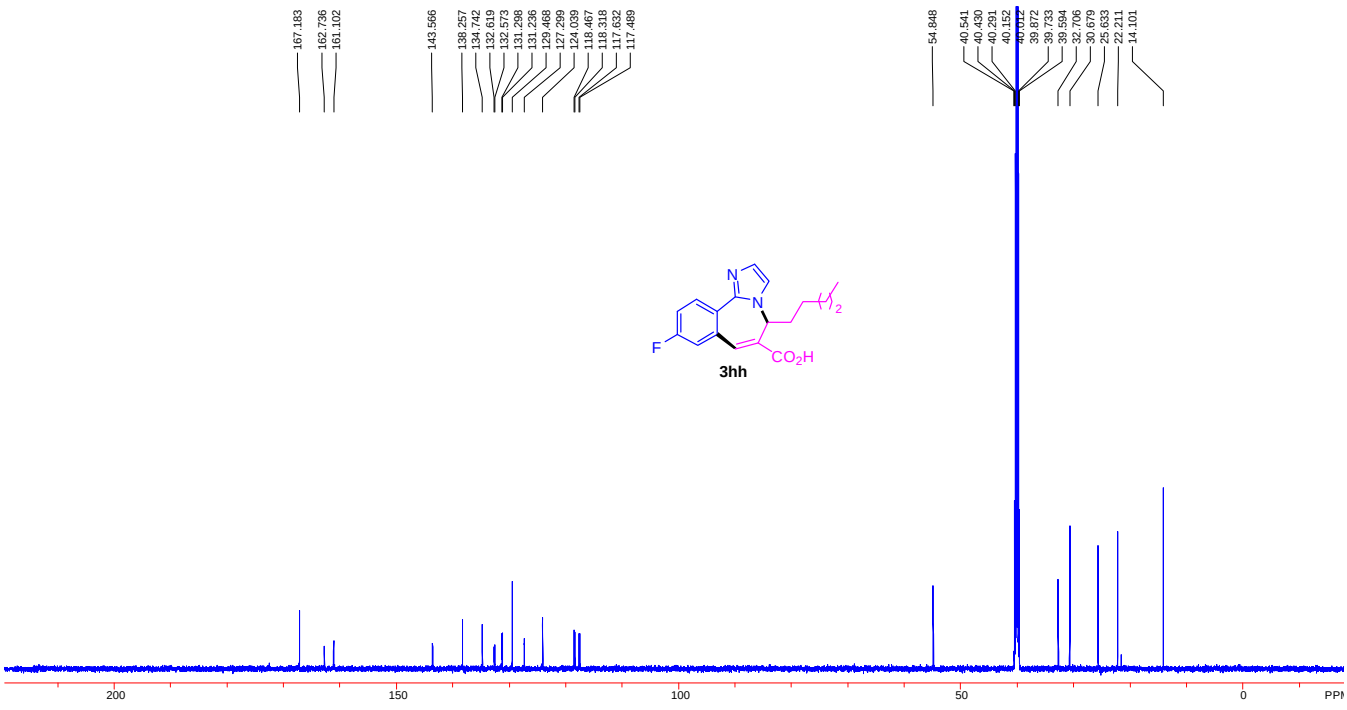
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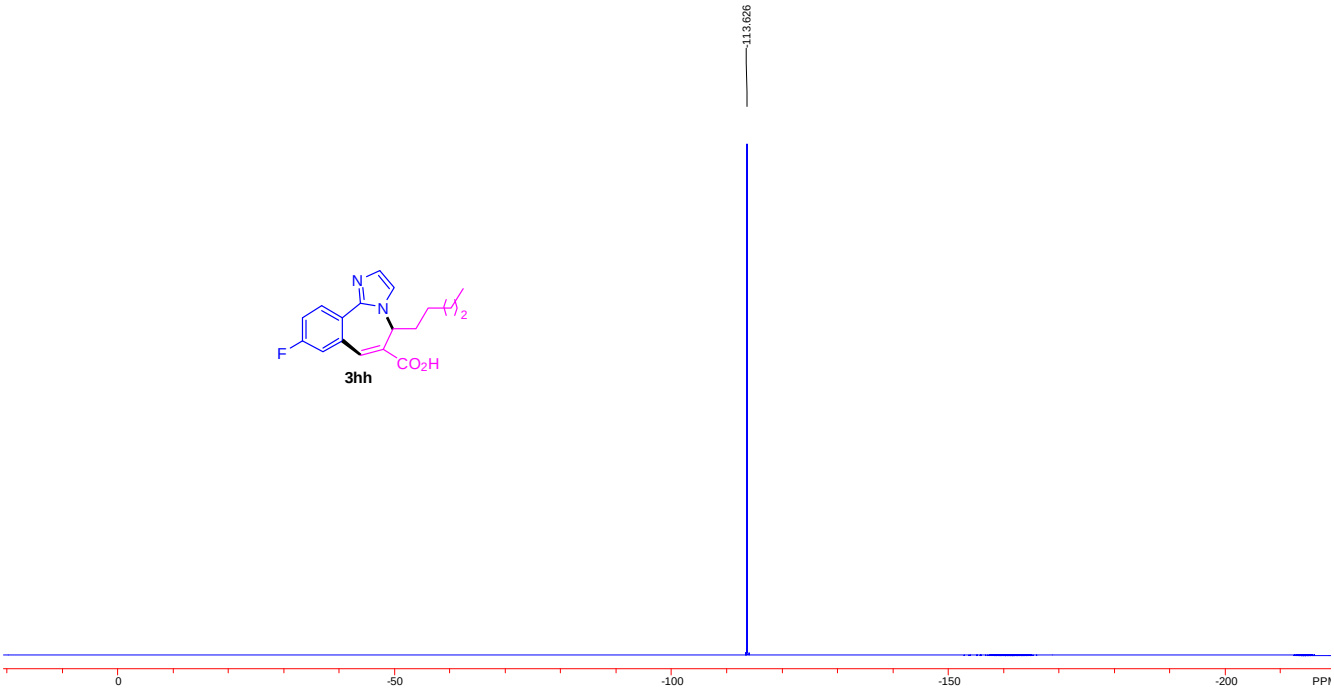
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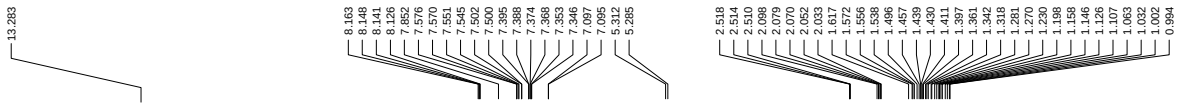
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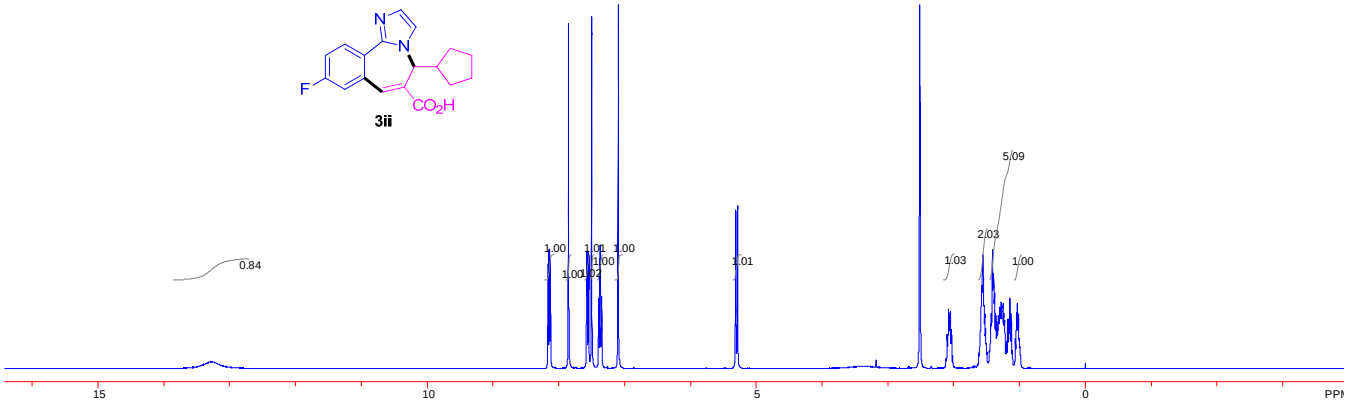
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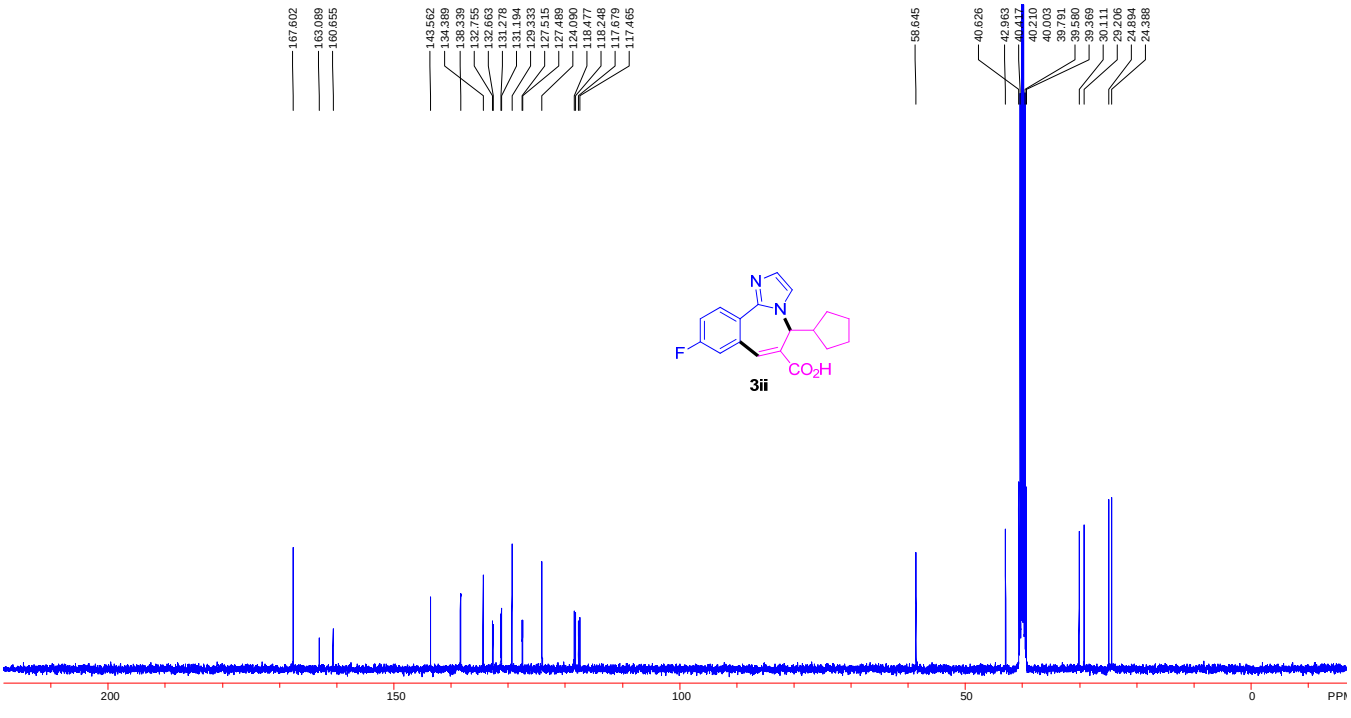
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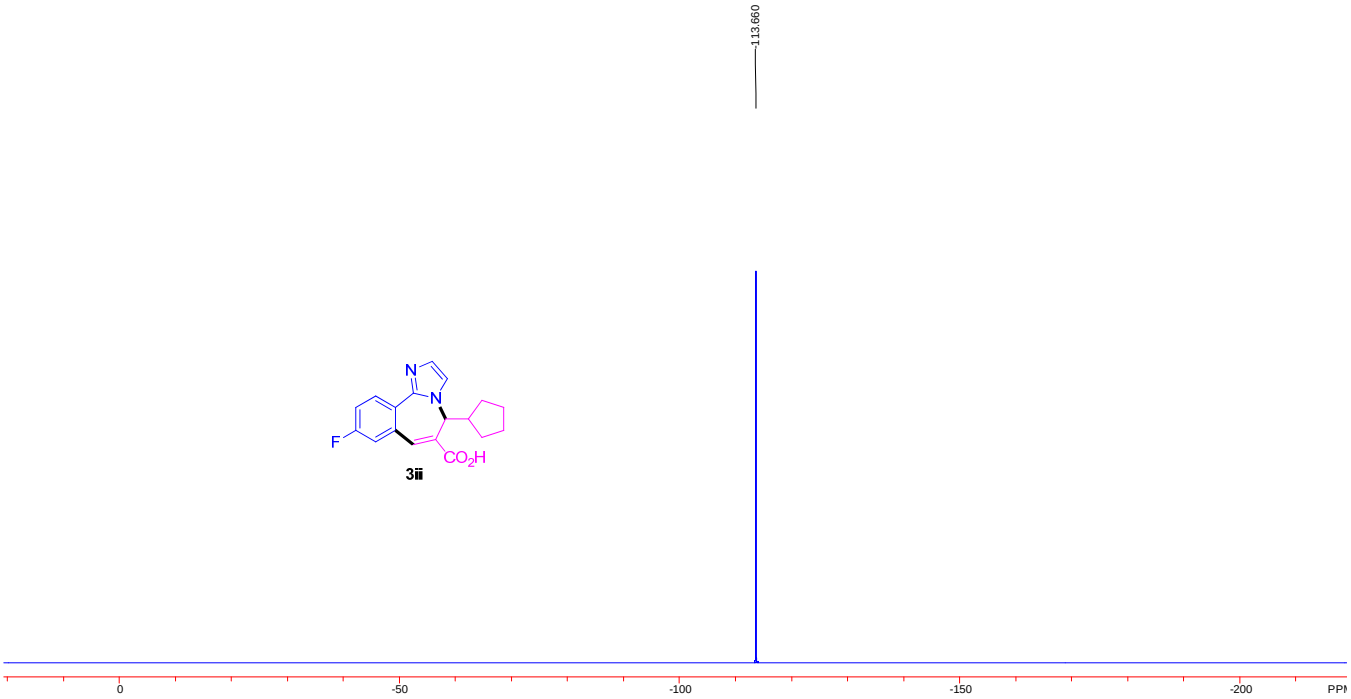

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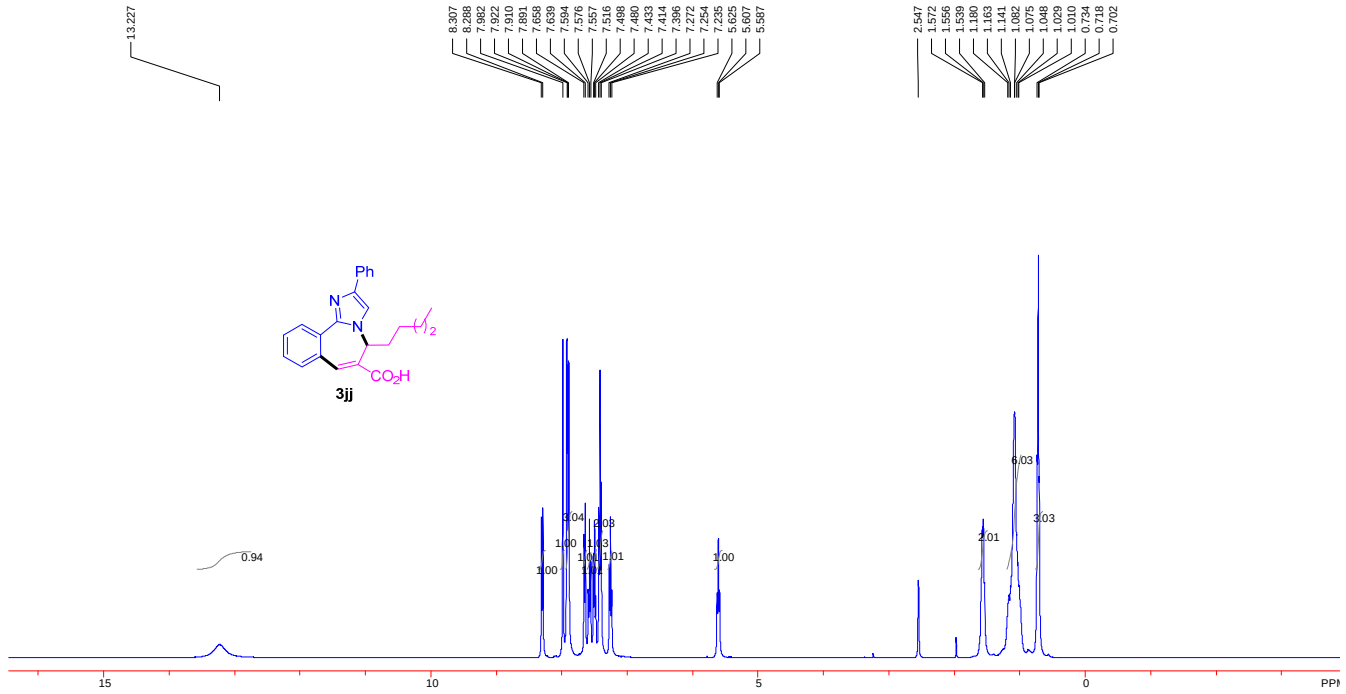
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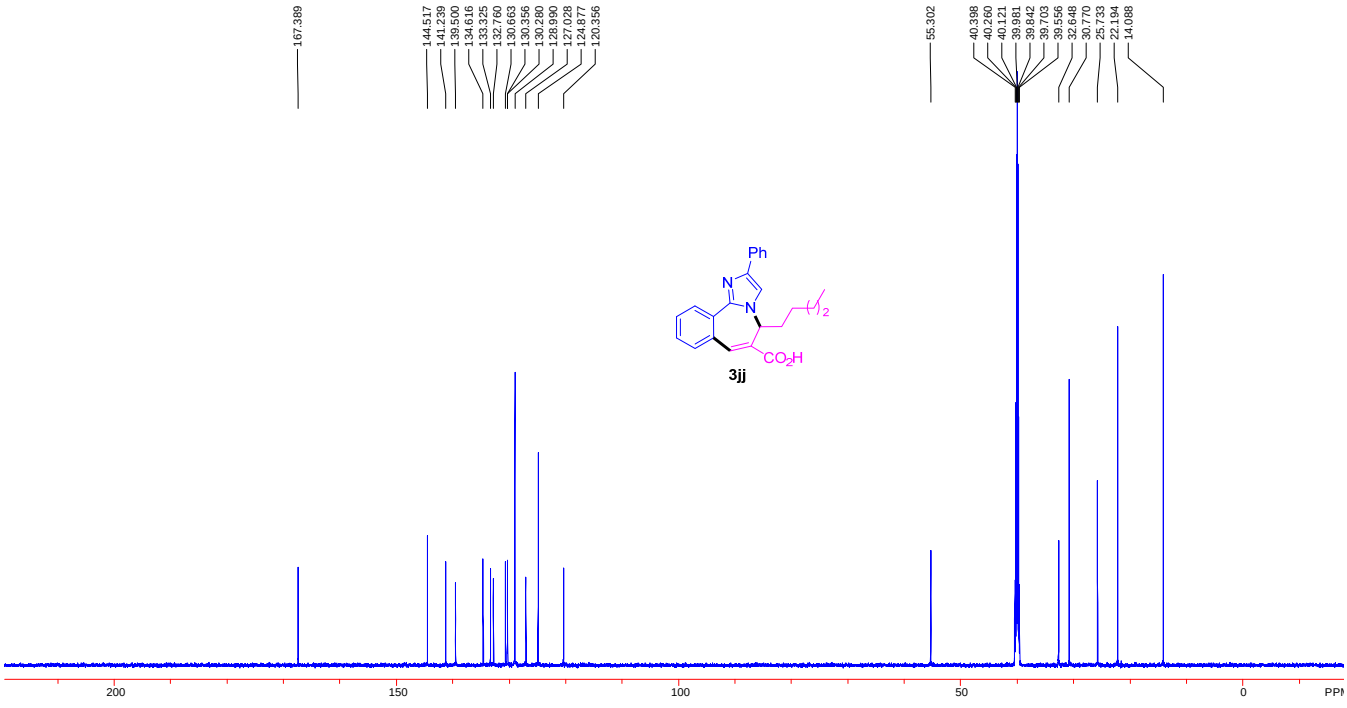
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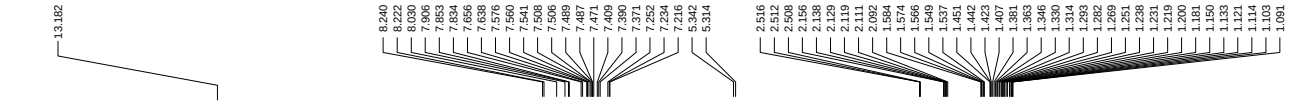
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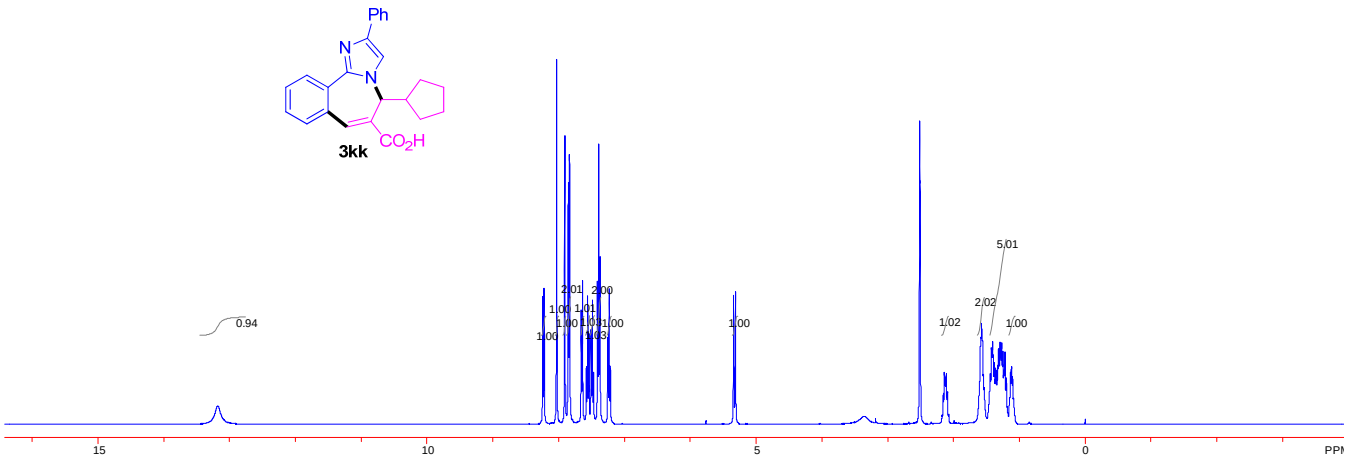
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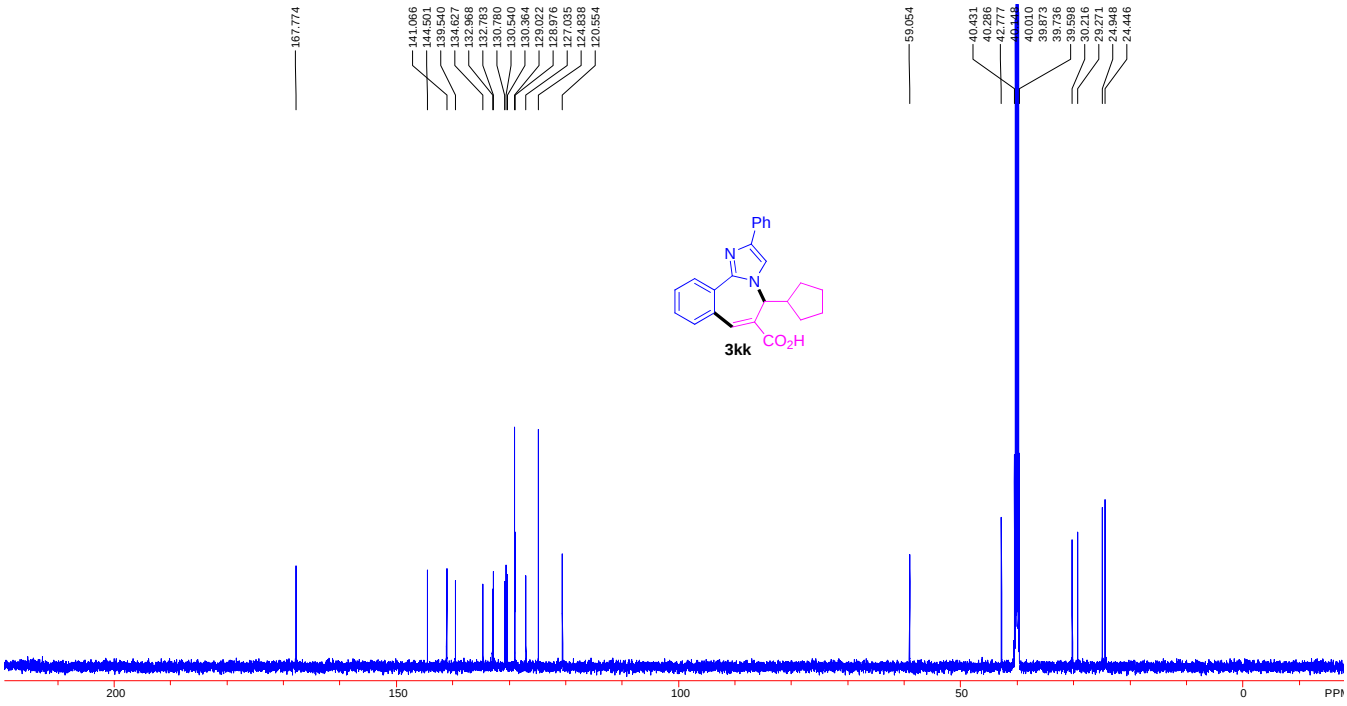
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Ph
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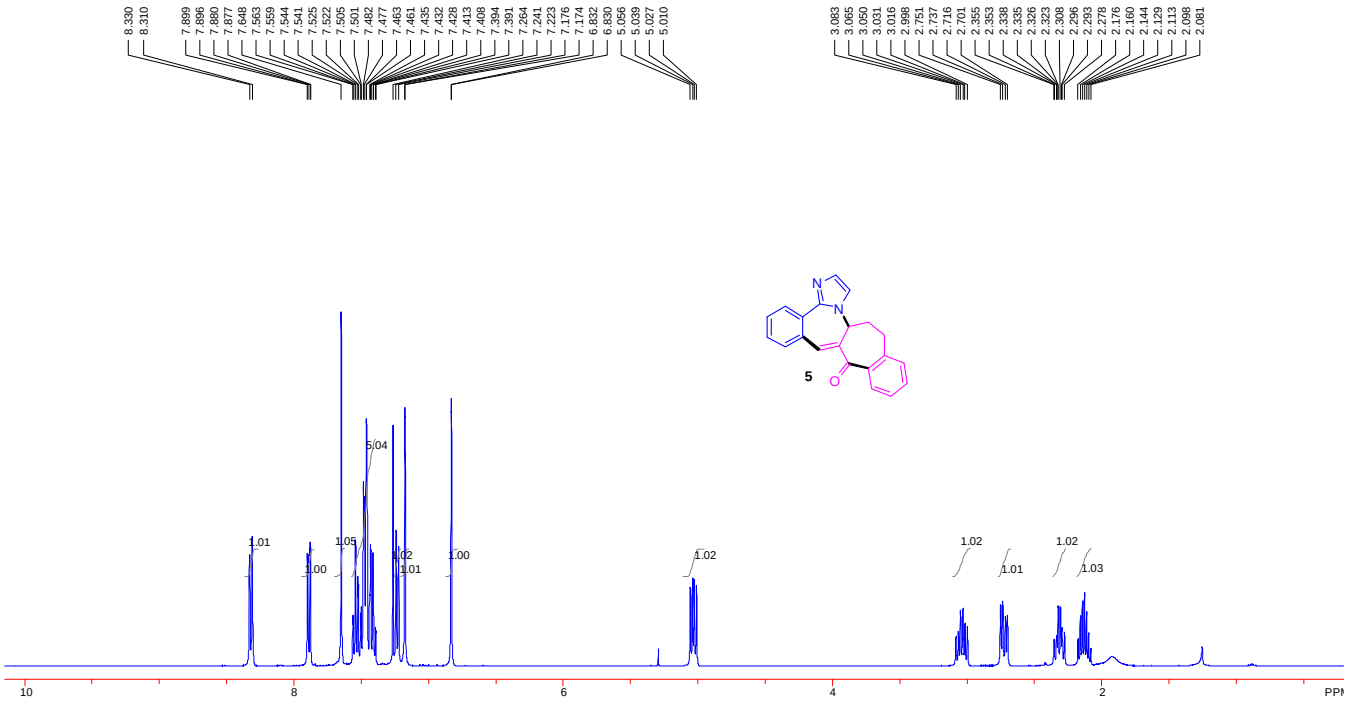
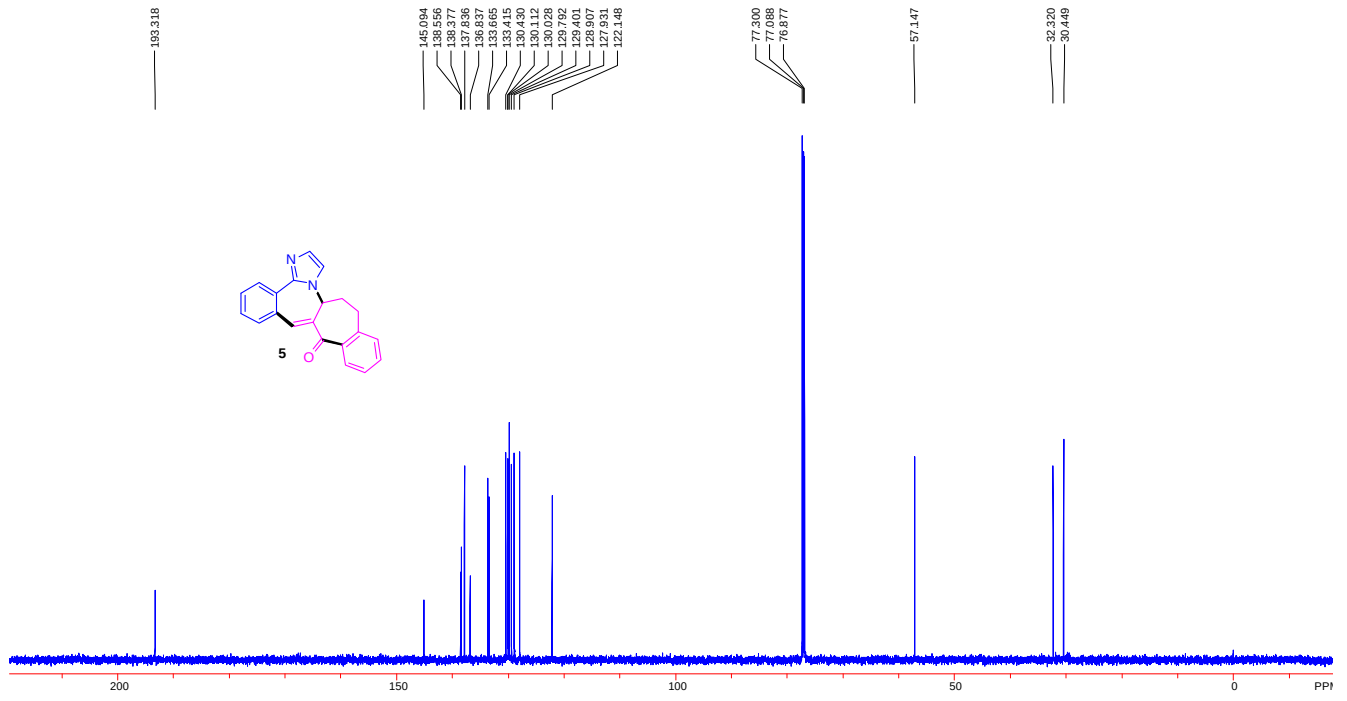
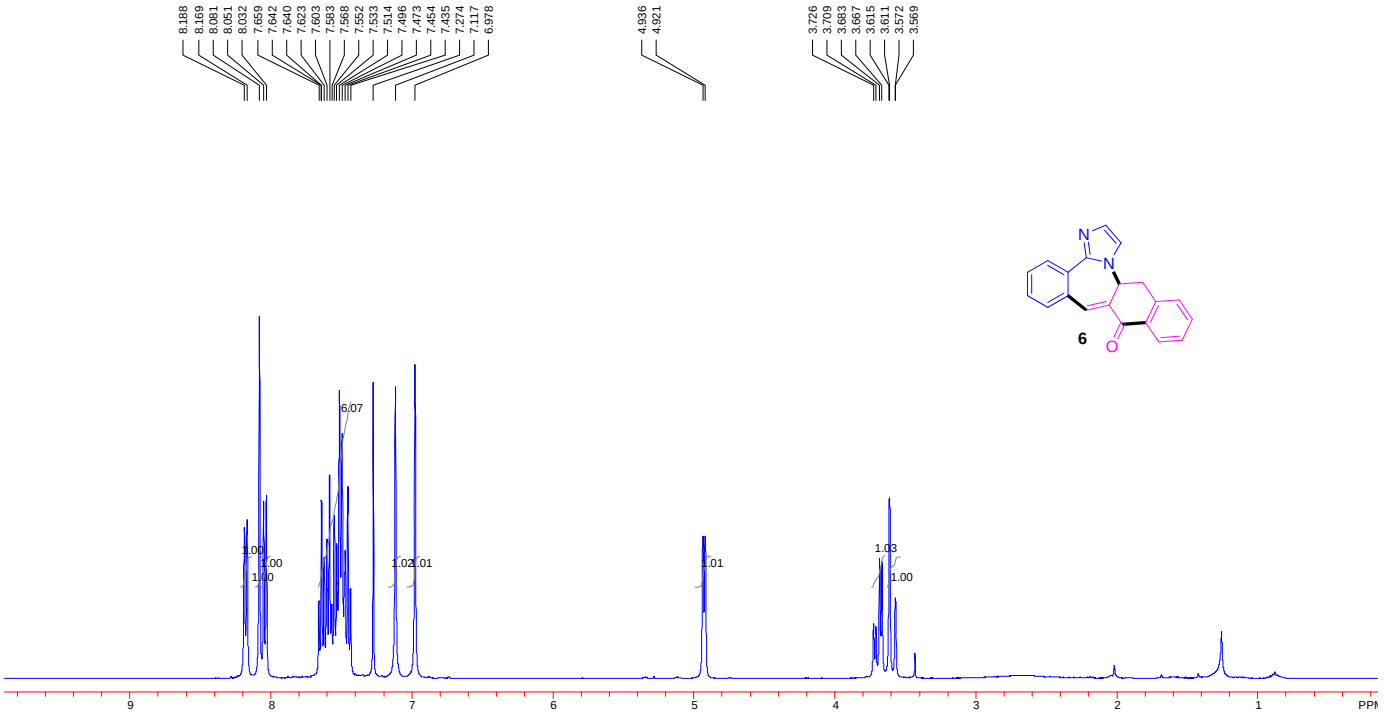
V. Copies of NMR spectra of 5 and 6



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3.709
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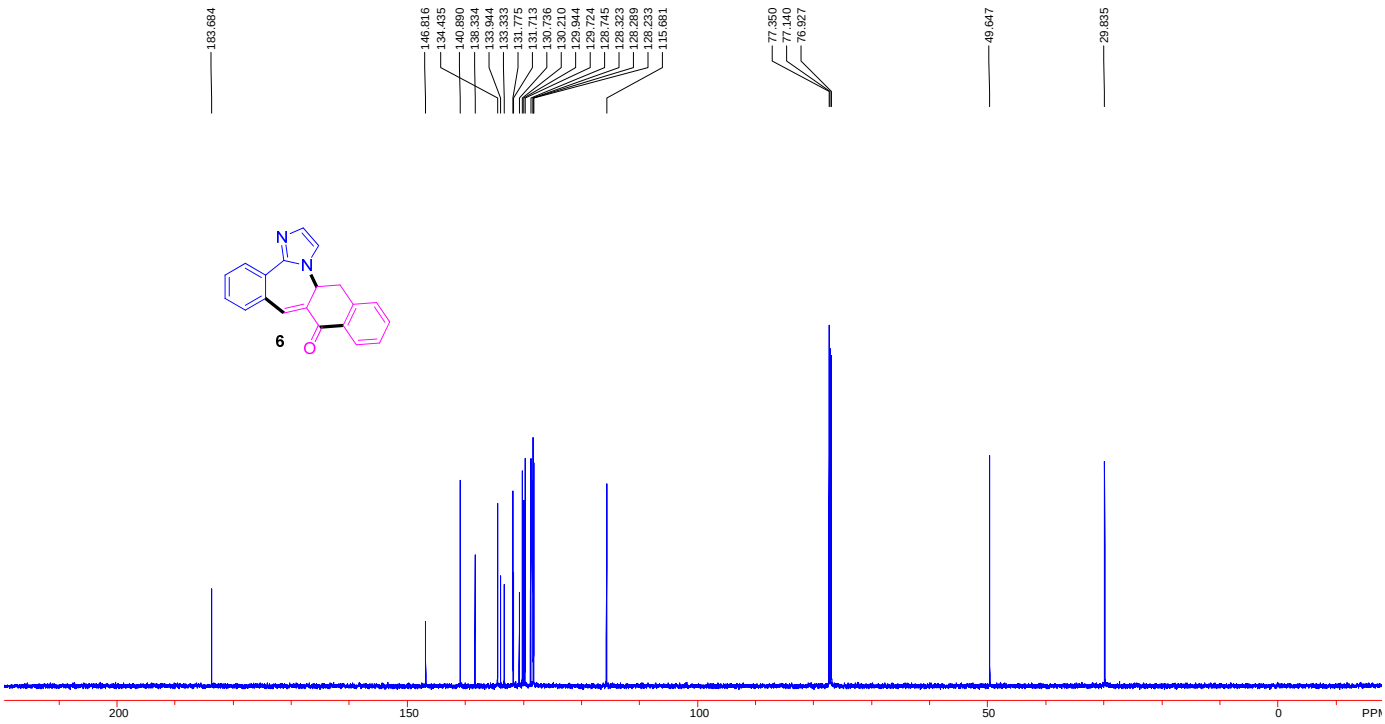
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77.140
76.927
49.647
29.835
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N
O
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100
50
0
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VI. X-ray crystal structures and data of 3g, 3k, 3bb and 5

1. X-ray crystal structure and data of 3g

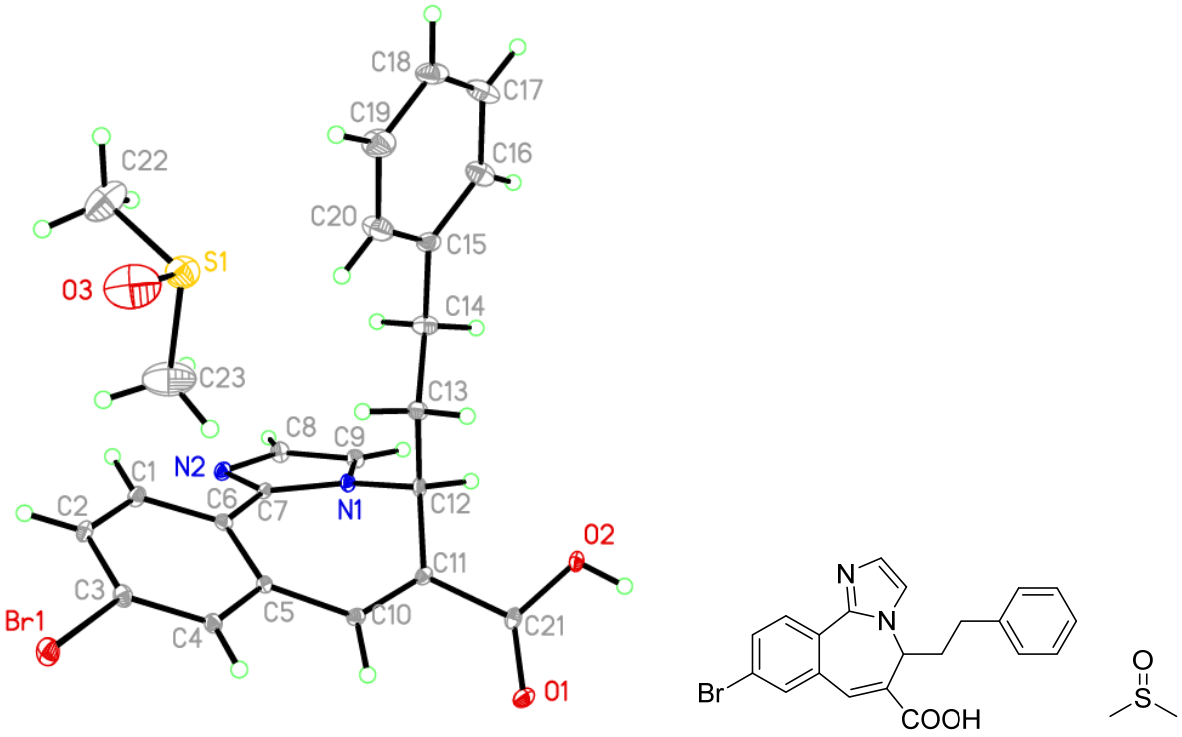

Figure S3. X-ray structure of **3g** with 30% ellipsoid probability

X-ray structure determination. Single crystals suitable for X-ray diffraction were obtained by slow evaporation of the solvent from a dimethyl sulfoxide/ethyl acetate (1:1) solution of **3g**. Crystal data collection and refinement parameters of **3g** are summarized in Table S1. Intensity data were collected at 170 K on a SuperNova Dual diffractometer using mirror-monochromated Mo Kα radiation, λ = 0.71073 Å. The data were corrected for decay, Lorentz, and polarization effects as well as absorption and beam corrections based on the multi-scan technique. The structure was solved by a combination of direct methods in SHELXTL and the difference Fourier technique, and refined by full-matrix least-squares procedures. Nonhydrogen atoms were refined with anisotropic displacement parameters. The H-atoms were either located or calculated and subsequently treated with a riding model.

Table S1 Crystallographic data and structure refinement results of **3g**

Empirical formula	$C_{23}H_{23}BrN_2O_3S$
Formula weight	487.40
Temp, K	169.99 (10)
Crystal system	Monoclinic
Space group	P21/c
a, Å	8.7087(6)
b, Å	24.8530(16)
c, Å	10.4060(8)
α (°)	90
β (°)	110.876(8)
γ (°)	90
Volume, Å^3	2104.4(3)
Z	4
d_{calc}, g cm^{-3}	1.538
λ, Å	0.71073
μ, mm^{-1}	2.081
No. of data collected	13912
No. of unique data	4931
R_{int}	0.0304
Goodness-of-fit on F^2	1.056
R_1, wR_2 ($I > 2\sigma(I)$)	0.0402, 0.0884
R_1, wR_2 (all data)	0.0532, 0.0936

2. X-ray crystal structure and data of 3k

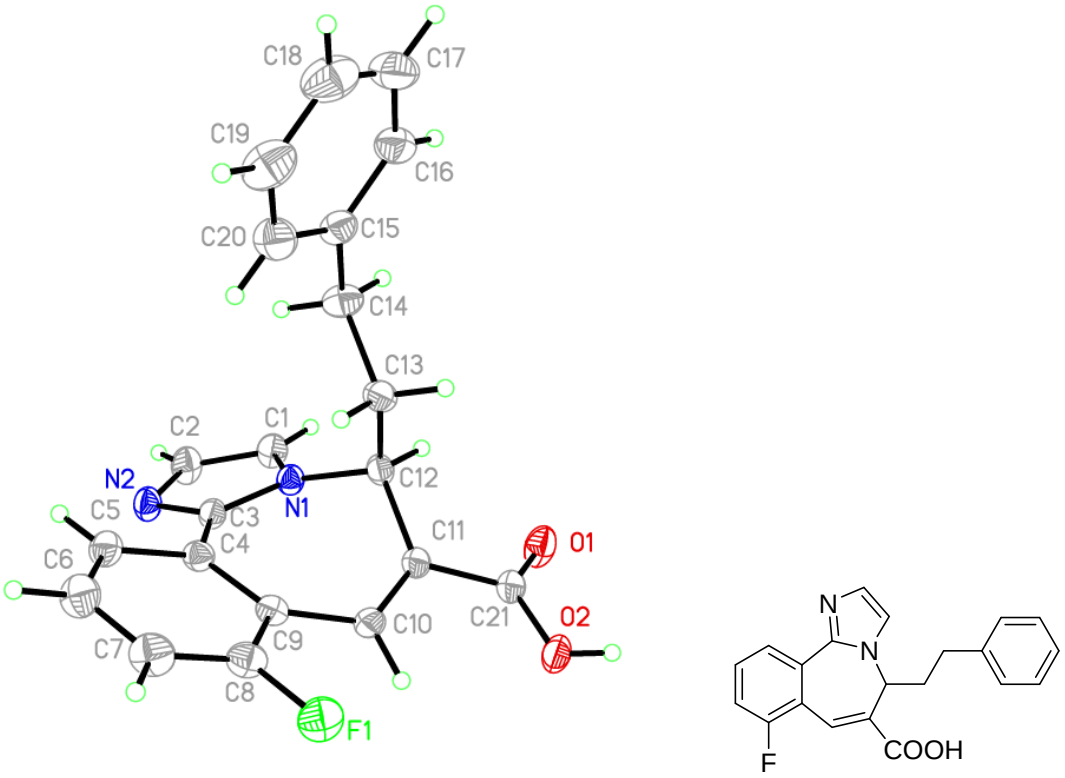

Figure S4. X-ray structure of **3k** with 30% ellipsoid probability

X-ray structure determination. Single crystals suitable for X-ray diffraction were obtained by slow evaporation of the solvent from a methanol solution of **3k**. Crystal data collection and refinement parameters of **3k** are summarized in Table S2. Intensity data were collected at 297 K on a SuperNova Dual diffractometer using mirror-monochromated Cu Kα radiation, λ = 1.54184 Å. The data were corrected for decay, Lorentz, and polarization effects as well as absorption and beam corrections based on the multi-scan technique. The structure was solved by a combination of direct methods in SHELXTL and the difference Fourier technique, and refined by full-matrix least-squares procedures. Nonhydrogen atoms were refined with anisotropic displacement parameters. The H-atoms were either located or calculated and subsequently treated with a riding model.

Table S2 Crystallographic data and structure refinement results of **3k**

Empirical formula	$C_{21}H_{17}FN_2O_2$
Formula weight	348.36
Temp, K	296.93(13)
Crystal system	orthorhombic
Space group	P212121
a, Å	8.7924(3)
b, Å	10.9272(3)
c, Å	18.0980(7)
α (°)	90
β (°)	90
γ (°)	90
Volume, Å^3	1738.79(10)
Z	4
d_{calc}, g cm^{-3}	1.331
λ, Å	1.54184
μ, mm^{-1}	0.771
No. of data collected	5171
No. of unique data	3045
R_{int}	0.0238
Goodness-of-fit on F^2	1.019
R_1, wR_2 ($I > 2\sigma(I)$)	0.0334, 0.0774
R_1, wR_2 (all data)	0.0412, 0.0822
Flack parameter	0.08 (11)

3. X-ray crystal structure and data of 3bb

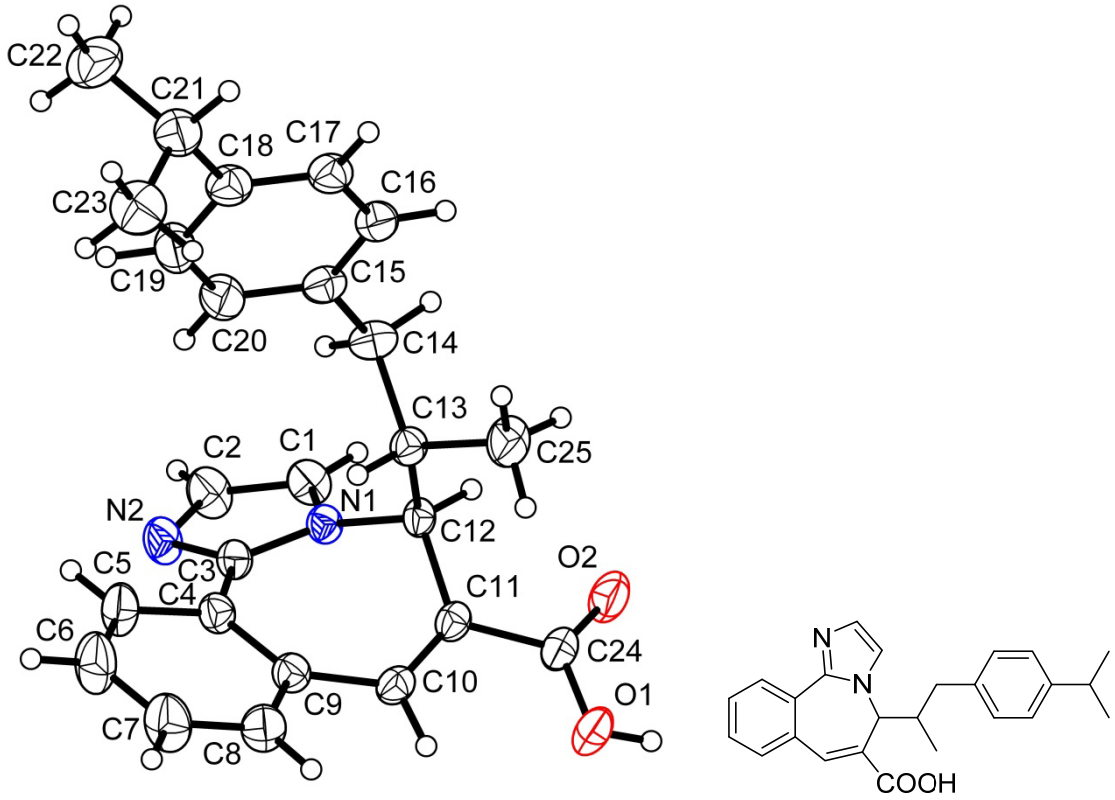

Figure S5. X-ray structure of **3bb** with 30% ellipsoid probability

X-ray structure determination. Single crystals suitable for X-ray diffraction were obtained by slow evaporation of the solvent from a dimethyl sulfoxide solution of **3bb**. Crystal data collection and refinement parameters of **3bb** are summarized in Table S3. Intensity data were collected at 289 K on a SuperNova Dual diffractometer using mirror-monochromated Cu Kα radiation, λ = 1.54184 Å. The data were corrected for decay, Lorentz, and polarization effects as well as absorption and beam corrections based on the multi-scan technique. The structure was solved by a combination of direct methods in SHELXTL and the difference Fourier technique, and refined by full-matrix least-squares procedures. Nonhydrogen atoms were refined with anisotropic displacement parameters. The H-atoms were either located or calculated and subsequently treated with a riding model.

Table S3 Crystallographic data and structure refinement results of **3bb**

Empirical formula	$C_{50}H_{52}N_4O_4$
Formula weight	772.95
Temp, K	289(3)
Crystal system	triclinic
Space group	P-1
a, Å	12.8963(5)
b, Å	13.1501(3)
c, Å	17.1010(5)
α (°)	92.305(2)
β (°)	111.817(3)
γ (°)	103.594(3)
Volume, Å^3	2590.69(15)
Z	2
d_{calc}, g cm^{-3}	0.991
λ, Å	1.54184
μ, mm^{-1}	0.497
No. of data collected	24264
No. of unique data	9887
R_{int}	0.0210
Goodness-of-fit on F^2	1.067
R_1, wR_2 ($I > 2\sigma(I)$)	0.0537, 0.1524
R_1, wR_2 (all data)	0.0637, 0.1603

4. X-ray crystal structure and data of 5

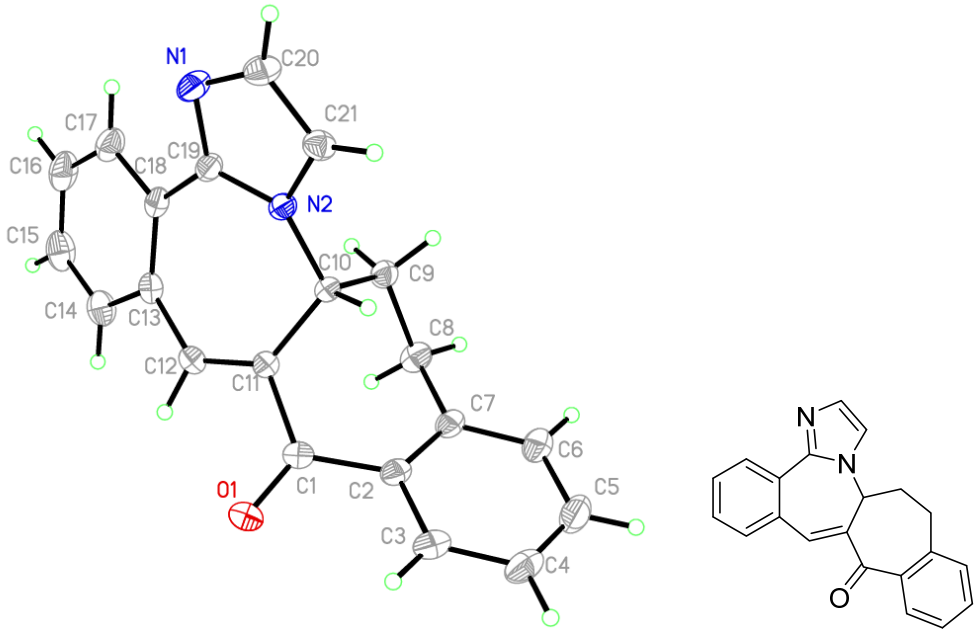

Figure S6. X-ray structure of **5** with 30% ellipsoid probability

X-ray structure determination. Single crystals suitable for X-ray diffraction were obtained by slow evaporation of the solvent from a methanol solution of **5**. Crystal data collection and refinement parameters of **5** are summarized in Table S4. Intensity data were collected at 295 K on a SuperNova Dual diffractometer using mirror-monochromated Mo Kα radiation, λ = 0.71073 Å. The data were corrected for decay, Lorentz, and polarization effects as well as absorption and beam corrections based on the multi-scan technique. The structure was solved by a combination of direct methods in SHELXTL and the difference Fourier technique, and refined by full-matrix least-squares procedures. Nonhydrogen atoms were refined with anisotropic displacement parameters. The H-atoms were either located or calculated and subsequently treated with a riding model.

Table S4 Crystallographic data and structure refinement results of **5**

Empirical formula	$C_{21}H_{16}N_2O$
Formula weight	312.36
Temp, K	295.01 (13)
Crystal system	orthorhombic
Space group	Pbca

a, Å	11.2543(4)
b, Å	11.6498(3)
c, Å	23.6897(7)
α (°)	90
β (°)	90
γ (°)	90
Volume, Å^3	3105.97(16)
Z	8
d_{calc}, g cm^{-3}	1.336
λ, Å	0.71073
μ, mm^{-1}	0.083
No. of data collected	14916
No. of unique data	3768
R_{int}	0.0384
Goodness-of-fit on F^2	1.059
R_1, wR_2 ($I > 2\sigma(I)$)	0.0522, 0.1143
R_1, wR_2 (all data)	0.0828, 0.1336

VII. References

(1) X. P. Wu, S. Song, S. B. Xu, C. Jiang, *Adv. Synth. Catal*., 2018, **360**, 1111.

(2) M. E. Voss, C. M. Beer, S. A. Mitchell, P. A. Blomgren, P. E. Zhichkin*, Tetrahedron,* 2008, **64**, 645.

(3) N. Naresh Kumar Reddy, S. N. Rao, C. Ravi, S. Adimurthy, *ACS Omega*, 2017, **2**, 5235.

(4) C. A. Malapit, D. R. Caldwell, N. Sassu, S. Milbin, A. R. Howell, *Org. Lett*., 2017, **19**, 1966.

(5) Z. Zhou, M. Y. Bian, L. X. Zhao, H. Gao, J. J. Huang, X. Liu, X. Yu, X. Li, W. Yi, *Org. Lett*., 2018, **20**, 3892.

(6) K.-i. Fujita, Y. Takahashi, M. Owaki, K. Yamamoto, R. Yamaguchi, *Org. Lett*., 2004, **6**, 2785.