Copper-Catalyzed Carbonylative Transformations of Indoles with Hexaketocyclohexane

Zechao Wang, Zhiping Yin and Xiao-Feng Wu*

Leibniz-Institut für Katalyse e.V. an der Universität Rostock, Albert-Einstein-Straße 29a, 18059 Rostock, Germany

List of the Contents:

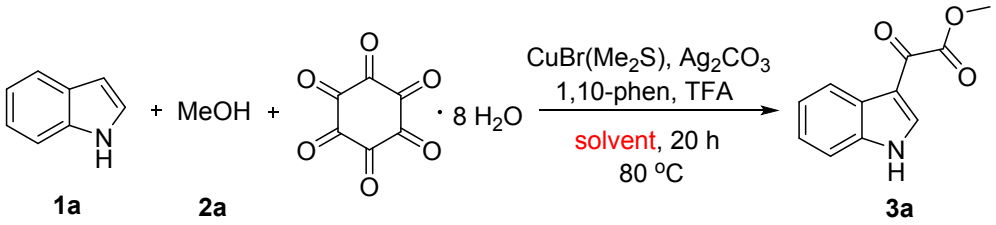
1. General experiment

All commercially available reagents and solvent were obtained from the commercial providers and used without further purification Nuclear Magnetic Resonance spectra were recorded on Bruker Avance 300 and Bruker ARX 400 spectrometers. All ^{1}H NMR experiments were reported in δ units, parts per million (ppm), and were measured relative to residual chloroform (7.26 ppm) or DMSO (2.5 ppm) in the deuterated solvent. All ^{13}C NMR spectra were reported in ppm relative to DMSO-d^6 (39.9 ppm), CD_3OD (48.0 ppm) and all were obtained with ^{1}H decoupling. Data for ^{1}H NMR are recorded as follows: chemical shift (δ, ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet or unresolved, br = broad singlet, coupling constant(s) in Hz, integration). Data for ^{13}C NMR are reported in terms of chemical shift (δ, ppm). Electron impact (EI) mass spectra were recorded on AMD 402 mass spectrometer (70 eV). High resolution mass spectra (HR-MS) were recorded on Agilent 6210. The data were given as mass units per charge (m/z). Gas chromatography analysis

was performed on an Agilent HP-5890 instrument with a FID detector and HP-5 capillary column (polydimethylsiloxane with 5 % phenyl groups, 30 m, 0.32 mm i.d., 0.25 μm film thickness) using argon as carrier gas. The products were isolated from the reaction mixture by column chromatography on silica gel 60, 0.063-0.2 mm, 70-230 mesh (Merck). To detect CO gas we used Micro III CO sensor device (0-500 ppm) which was produce by GFG company. 300 mL autoclave of the 4560 series from Parr Instruments®.

3. Optimization of reaction conditions

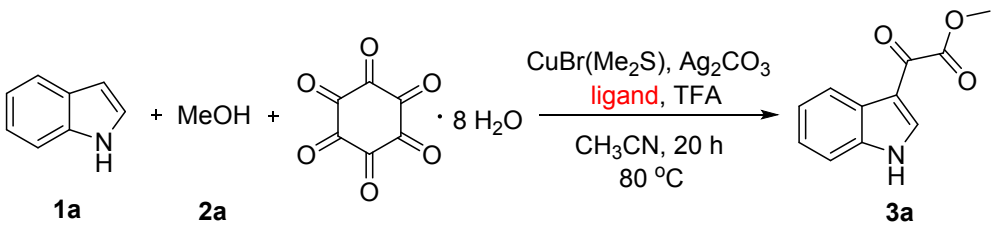
Table 1S. Optimization of solvents.[a]



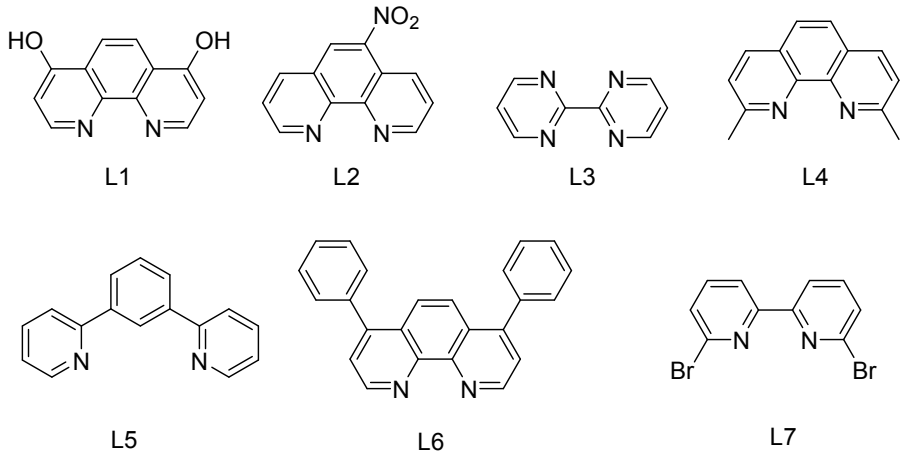
Solvent	Yield [%][b]
DCE	38
HFIP	0
H_2O	0
HOAc	0
DMSO	0
DMF	21
1,4-dioxane	43
Toluene	0
THF	51
CH_3CN	**69 (67)**

[a] Reaction conditions: Indole **1a** (0.2 mmol, 1 equiv.), methanol **2a** (6 mmol, 30 equiv.), $C_6O_6{\cdot}8H_2O$ (0.2 mmol, 1 equiv.), $CuBr(Me_2S)$ (0.03 mmol, 15 mol %), Ag_2CO_3 (1 mmol, 5 equiv.), 1,10-phen (0.06 mmol, 30 mol%), and TFA (0.8 mmol, 4 equiv.) in solvent (1 mL) for 20 h at 80 °C in sealed tubes under air. [b] Yields were determined by GC using n-hexadecane as the internal standard. Isolated yield is in parenthesis.

Table 2S. Optimization of ligands.[a]

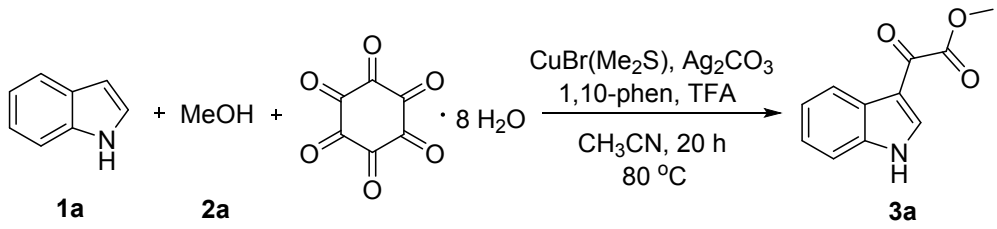


Ligand	Yield [%][b]
L1	60
L2	55
L3	58
L4	48
L5	50
L6	trace
L7	43
1,10-phen	**69 (67)**
Xantphos	51
PPh_3	48
PCy_3	52
DPPE	51
DPPF	43
1,10-phen (20 mol%)	61



[a] Reaction conditions: Indole **1a** (0.2 mmol, 1 equiv.), methanol **2a** (6 mmol, 30 equiv.), $C_6O_6{\cdot}8H_2O$ (0.2 mmol, 1 equiv.), $CuBr(Me_2S)$ (0.03 mmol, 15 mol %), Ag_2CO_3 (1 mmol, 5 equiv.), ligand (0.06 mmol, 30 mol%), and TFA (0.8 mmol, 4 equiv.) in CH_3CN (1 mL) for 20 h at 80 °C in sealed tubes under air. [b] Yields were determined by GC using n-hexadecane as the internal standard. Isolated yield is in parenthesis.

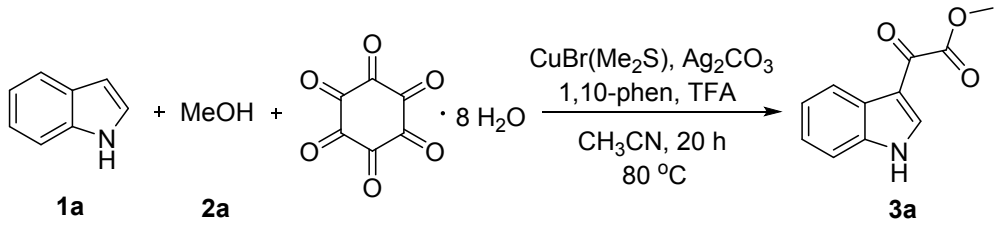
Table 3S. Screening the amount of MeOH.[a]



MeOH	Yield [%][b]
5 equiv.	trace
10 equiv.	58
20 equiv.	58
30 equiv.	**69 (67)**
40 equiv.	62
1 mL	45

[a] Reaction conditions: Indole **1a** (0.2 mmol, 1 equiv.), methanol **2a,** $C_6O_6{\cdot}8H_2O$ (0.2 mmol, 1 equiv.), CuBr(Me_2S) (0.03 mmol, 15 mol %), Ag_2CO_3 (1 mmol, 5 equiv.), 1,10-phen (0.06 mmol, 30 mol%), and TFA (0.8 mmol, 4 equiv.) in CH_3CN (1 mL) for 20 h at 80 °C in sealed tubes under air. [b] Yields were determined by GC using n-hexadecane as the internal standard. Isolated yield is in parenthesis.

Table 4S. Screening the amount of $C_6O_6{\cdot}8H_2O$.[a]



$C_6O_6{\cdot}8H_2O$	Yield [%][b]
0.5 equiv.	35
1.0 equiv.	**69 (67)**
1.5 equiv.	trace
2.0 equiv.	0

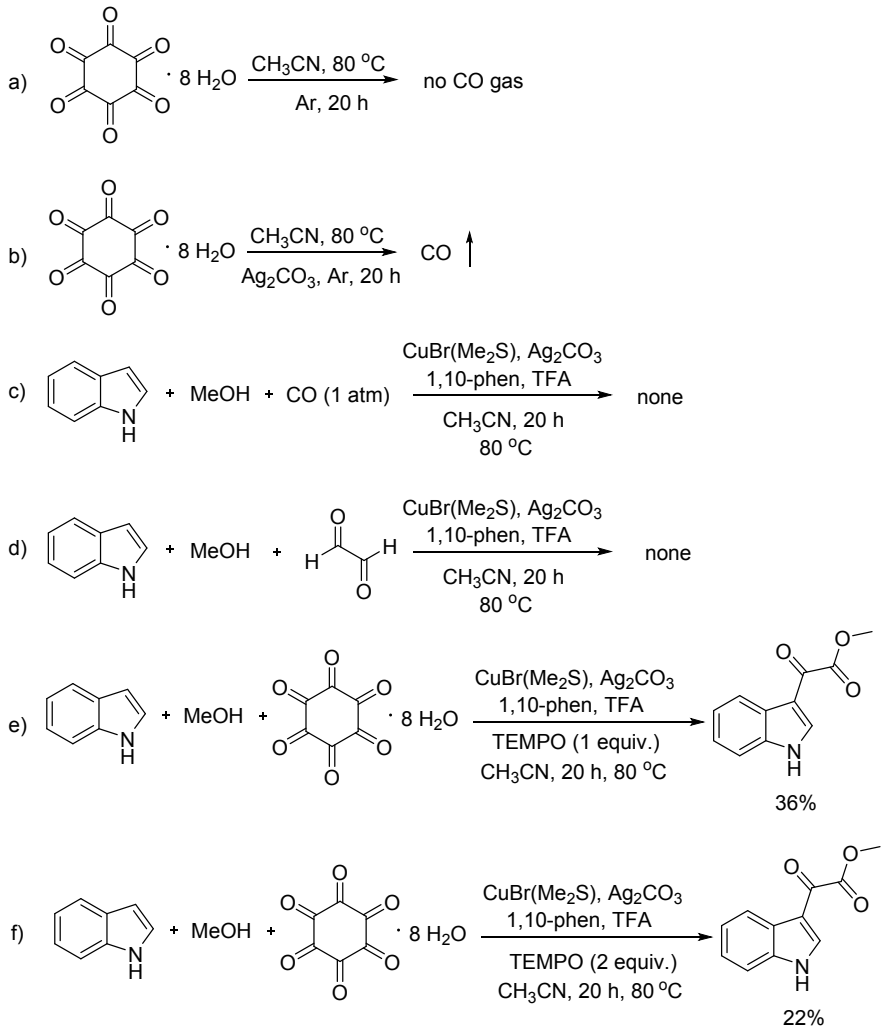
[a] Reaction conditions: Indole **1a** (0.2 mmol, 1 equiv.), methanol **2a** (6 mmol, 30 equiv.), $C_6O_6{\cdot}8H_2O$, CuBr(Me_2S) (0.03 mmol, 15 mol %), Ag_2CO_3 (1 mmol, 5 equiv.), 1,10-phen (0.06 mmol, 30 mol%), and TFA (0.8 mmol, 4 equiv.) in CH_3CN (1 mL) for 20 h at 80 °C in sealed tubes under air. [b] Yields were determined by GC using n-hexadecane as the internal standard. Isolated yield is in parenthesis.

4. General procedure for copper-catalyzed double carbonylation (3-4).

In a 25 mL sealed tube, a mixture of indoles **1** (0.2 mmol, 1 equiv.), alcohols **2** (6 mmol, 30 equiv.), $C_6O_6{\cdot}8H_2O$ (0.2 mmol, 1 equiv.), CuBr(Me_2S) (0.03 mmol, 15 mol %), Ag_2CO_3 (1 mmol, 5 equiv.), 1,10-phen (0.06 mmol, 30 mol%), and TFA (0.8 mmol, 4 equiv.) in CH_3CN (1 mL) was stirred at 80 °C under air. After 20 h, the

mixture was cooled to room temperature. The residue was diluted with H_2O solution (10 mL) and extracted with EtOAc (3×10 mL). The solvent was then evaporated under vacuum. The crude products were purified by using column chromatography on silica gel (pentane/ethyl acetate) to give the pure products.

5. Control Experiments.



a) In a 25 mL sealed tube, $C_6O_6 \cdot 8H_2O$ (0.2 mmol, 1 equiv.) in CH_3CN (1 mL) was stirred at 80 °C under argon. After 20 h, the mixture was cooled to room temperature. Then we use CO sensor device to detect CO gas.

b) In a 25 mL sealed tube, a mixture of $C_6O_6 \cdot 8H_2O$ (0.2 mmol, 1 equiv.) and Ag_2CO_3 (1 mmol, 5 equiv.) in CH_3CN (1 mL) was stirred at 80 °C under argon. After 20 h, the mixture was cooled to room temperature. Then we use CO sensor device to detect CO gas.

c) A mixture of indole **1a** (0.2 mmol, 1 equiv.), methanol **2a** (6 mmol, 30 equiv.), $CuBr(Me_2S)$ (0.03 mmol, 15 mol %), Ag_2CO_3 (1 mmol, 5 equiv.), 1,10-phen (0.06 mmol, 30 mol%), and TFA (0.8 mmol, 4 equiv.) in CH_3CN (1 mL) was transferred into a vial (5 mL reaction volume) equipped with a septum, a small cannula and a stirring

bar. Then, the vial was placed in an alloy plate, which was transferred into a 300 mL autoclave of the 4560 series from Parr Instruments® under air atmosphere. After flushing the autoclave three times with CO, a pressure of 1 bar was adjusted and the reaction was performed for 20 h at 80 °C. After the reaction, the autoclave was cooled down to room temperature and the pressure was released carefully. Yields were determined by GC using n-hexadecane as the internal standard.

d) In a 25 mL sealed tube, a mixture of indole **1a** (0.2 mmol, 1 equiv.), methanol **2a** (6 mmol, 30 equiv.), glyoxal (0.6 mmol, 3 equiv.), CuBr(Me_2S) (0.03 mmol, 15 mol %), Ag_2CO_3 (1 mmol, 5 equiv.), 1,10-phen (0.06 mmol, 30 mol%), and TFA (0.8 mmol, 4 equiv.) in CH_3CN (1 mL) was stirred at 80 °C under air. After 20 h, the mixture was cooled to room temperature. Yields were determined by GC using n-hexadecane as the internal standard.

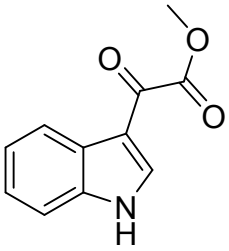
e) In a 25 mL sealed tube, a mixture of indole **1a** (0.2 mmol, 1 equiv.), methanol **2a** (6 mmol, 30 equiv.), $C_6O_6{\cdot}8H_2O$ (0.2 mmol, 1 equiv.), TEMPO (0.2 mmol, 1 equiv.), CuBr(Me_2S) (0.03 mmol, 15 mol %), Ag_2CO_3 (1 mmol, 5 equiv.), 1,10-phen (0.06 mmol, 30 mol%), and TFA (0.8 mmol, 4 equiv.) in CH_3CN (1 mL) was stirred at 80 °C under air. After 20 h, the mixture was cooled to room temperature. Yields were determined by GC using n-hexadecane as the internal standard.

f) In a 25 mL sealed tube, a mixture of indole **1a** (0.2 mmol, 1 equiv.), methanol **2a** (6 mmol, 30 equiv.), $C_6O_6{\cdot}8H_2O$ (0.2 mmol, 1 equiv.), TEMPO (0.4 mmol, 2 equiv.), CuBr(Me_2S) (0.03 mmol, 15 mol %), Ag_2CO_3 (1 mmol, 5 equiv.), 1,10-phen (0.06 mmol, 30 mol%), and TFA (0.8 mmol, 4 equiv.) in CH_3CN (1 mL) was stirred at 80 °C under air. After 20 h, the mixture was cooled to room temperature. Yields were determined by GC using n-hexadecane as the internal standard.

6. General procedure for monocarbonylation

In a 25 mL sealed tube, a mixture of 2-methyl-1*H*-indole (0.2 mmol, 1 equiv.), methanol **2a** (6 mmol, 30 equiv.), $C_6O_6{\cdot}8H_2O$ (0.2 mmol, 1 equiv.), CuBr(Me_2S) (0.03 mmol, 15 mol %), Ag_2CO_3 (1 mmol, 5 equiv.), 1,10-phen (0.06 mmol, 30 mol%), and TFA (0.8 mmol, 4 equiv.) in PhCl (1 mL) was stirred at 130 °C under air. After 20 h, the mixture was cooled to room temperature. The residue was diluted with H_2O solution (10 mL) and extracted with EtOAc (3×10 mL). The solvent was then evaporated under vacuum. The crude products were purified by using column chromatography on silica gel (pentane/ethyl acetate) to give the pure product **5a** in 46% yield.

7. Spectroscopic and analytical data of carbonylation products.

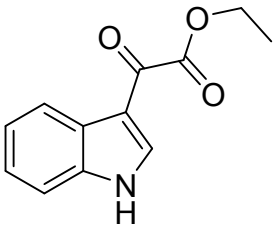


Methyl 2-(1*H*-indol-3-yl)-2-oxoacetate[1] **(3a) :** Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^6) δ 12.42 (s, 1H), 8.45 (d, J = 2.6 Hz, 1H), 8.30 – 8.08 (m, 1H), 7.60 – 7.52 (m, 1H), 7.35 – 7.24 (m, 2H), 3.90 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^6) δ 179.16, 164.43, 138.86, 137.16, 125.92, 124.31, 123.32, 121.59, 113.20, 112.87, 52.99.

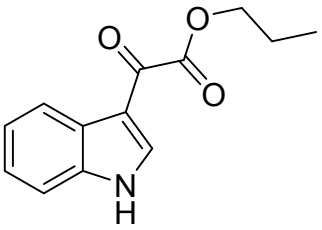
GC-MS (EI, 70ev): m/z (%) = 203 (M^+, 25), 144 (100), 116 (25), 89 (20), 44 (50).



Ethyl 2-(1*H*-indol-3-yl)-2-oxoacetate[2] **(3b):** Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^6) δ 12.40 (s, 1H), 8.43 (d, J = 3.3 Hz, 1H), 8.32 – 8.04 (m, 1H), 7.69 – 7.52 (m, 1H), 7.34 – 7.24 (m, 2H), 4.37 (q, J = 7.1 Hz, 2H), 1.35 (t, J = 7.1 Hz, 3H).

^{13}C NMR (75 MHz, DMSO-d^6) δ 179.55, 164.05, 138.67, 137.16, 125.92, 124.29, 123.30, 121.59, 113.19, 112.85, 62.08, 14.41.



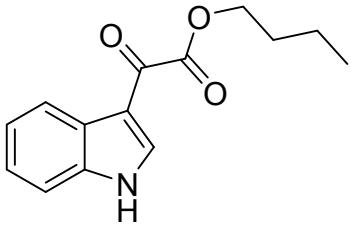
Propyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3c): Yellow solid.

^{1}H NMR (400 MHz, DMSO-d^6) δ 12.51 – 12.30 (m, 1H), 8.50 – 8.33 (m, 1H), 8.27 – 8.05 (m, 1H), 7.73 – 7.49 (m, 1H), 7.33 – 7.26 (m, 2H), 4.28 (t, J = 6.7 Hz, 2H), 1.78 – 1.70 (m, 2H), 0.96 (t, J = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, DMSO-d^6) δ 179.56, 164.16, 138.62, 137.16, 125.90, 124.31, 123.31, 121.57, 113.20, 112.86, 67.37, 21.86, 10.70.

GC-MS (EI, 70ev): m/z (%) = 231 (M^+, 10), 207 (72), 144 (100), 116 (20), 89 (20), 44 (64).

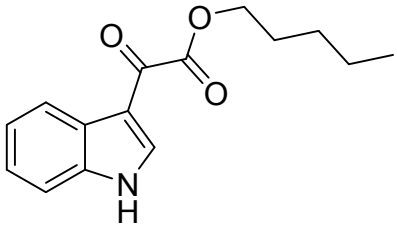
HR-MS (EI) calcd. for $C_{13}H_{13}NO_3$ $[M+H]^+$: 231.08899; found: 231.08922.



Butyl 2-(1*H*-indol-3-yl)-2-oxoacetate[3] **(3d):** Yellow solid.

^{1}H NMR (400 MHz, DMSO-d^{6}) δ 12.40 (s, 1H), 8.41 (d, J = 3.1 Hz, 1H), 8.23 – 8.10 (m, 1H), 7.64 – 7.51 (m, 1H), 7.32 – 7.24 (m, 2H), 4.33 (t, J = 6.6 Hz, 2H), 1.74 – 1.67 (m, 2H), 1.39 (dt, J = 14.7, 7.6 Hz, 2H), 0.93 (t, J = 7.4 Hz, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 179.55, 164.15, 138.58, 137.17, 125.92, 124.30, 123.30, 121.58, 113.20, 112.88, 65.66, 30.45, 19.09, 14.00.



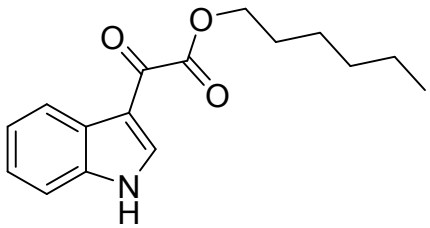
Pentyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3e): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.40 (s, 1H), 8.41 (d, J = 3.2 Hz, 1H), 8.30 – 8.06 (m, 1H), 7.58 – 7.54 (m, 1H), 7.35 – 7.27 (m, 2H), 4.32 (t, J = 6.6 Hz, 2H), 1.80 – 1.64 (m, 2H), 1.40 – 1.31 (m, 4H), 0.92 – 0.86 (m, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 179.55, 164.14, 138.59, 137.16, 125.91, 124.30, 123.30, 121.57, 113.20, 112.87, 65.94, 28.10, 28.00, 22.22, 14.31.

GC-MS (EI, 70ev): m/z (%) = 259 (M^{+}, 10), 144 (100), 116 (20), 89 (15).

HR-MS (EI) calcd. for $C_{15}H_{17}NO_3$ $[M+H]^{+}$: 259.12029; found: 259.12030.



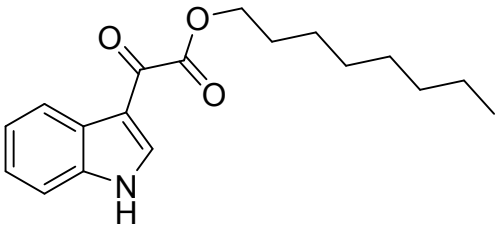
Hexyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3f): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.40 (s, 1H), 8.41 (d, J = 3.3 Hz, 1H), 8.30 – 8.04 (m, 1H), 7.59 – 7.55 (m, 1H), 7.34 – 7.27 (m, 2H), 4.32 (t, J = 6.6 Hz, 2H), 1.83 – 1.63 (m, 2H), 1.31 (d, J = 2.5 Hz, 2H), 1.19 (q, J = 3.1, 2.3 Hz, 2H), 0.91 – 0.79 (m, 5H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 179.54, 164.14, 138.57, 137.17, 125.92, 124.29, 123.29, 121.58, 113.19, 112.88, 65.94, 31.30, 28.37, 25.48, 22.46, 14.33.

GC-MS (EI, 70ev): m/z (%) = 273 (M^{+}, 10), 144 (100), 116 (20), 89 (15), 44 (10).

HR-MS (EI) calcd. for $C_{16}H_{19}NO_3$ $[M+H]^{+}$: 273.13594; found: 273.13597.



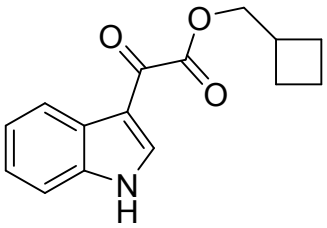
Octyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3g): Yellow solid.

^{1}H NMR (400 MHz, DMSO-d^{6}) δ 12.40 (s, 1H), 8.40 (d, J = 3.3 Hz, 1H), 8.23 – 8.08 (m, 1H), 7.63 – 7.49 (m, 1H), 7.33 – 7.26 (m, 2H), 4.31 (t, J = 6.6 Hz, 2H), 1.76 – 1.67 (m, 2H), 1.37 – 1.21 (m, 10H), 0.88 – 0.83 (m, 3H).

^{13}C NMR (101 MHz, DMSO-d^{6}) δ 179.55, 164.14, 138.60, 137.15, 125.90, 124.31, 123.31, 121.56, 113.20, 112.85, 65.95, 31.66, 29.05 (2C), 28.39, 25.82, 22.53, 14.41.

GC-MS (EI, 70ev): m/z (%) = 301 (M^{+}, 10), 144 (100), 116 (10), 89 (10), 44 (36).

HR-MS (EI) calcd. for $C_{18}H_{23}NO_3$ $[M+H]^{+}$: 301.16725; found: 301.16757.



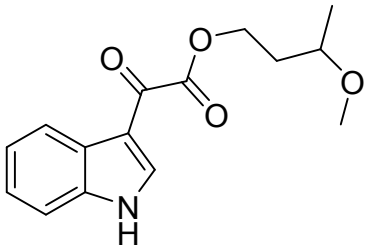
Cyclobutylmethyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3h): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.44 (s, 1H), 8.43 (d, J = 3.3 Hz, 1H), 8.25 – 8.18 (m, 1H), 7.62 – 7.59 (m, 1H), 7.37 – 7.30 (m, 2H), 4.36 (d, J = 6.8 Hz, 2H), 2.82 – 2.72 (m, 1H), 2.15 – 2.06 (m, 2H), 1.94 – 1.84 (m, 4H).

^{13}C NMR (75 MHz, DMSO-d^6) δ 179.56, 164.22, 138.55, 137.16, 125.90, 124.32, 123.32, 121.56, 113.20, 112.89, 69.37, 33.81, 24.68, 18.37.

GC-MS (EI, 70ev): m/z (%) = 257 (M^+, 10), 144 (100), 116 (15), 89 (10).

HR-MS (EI) calcd. for $C_{15}H_{15}NO_3$ $[M+H]^+$: 257.10464; found: 257.10480.



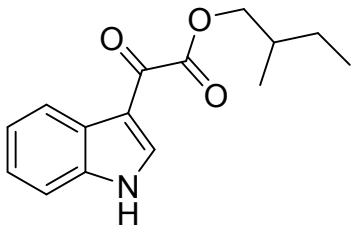
3-Methoxybutyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3i): Yellow solid.

^{1}H NMR (400 MHz, DMSO-d^6) δ 12.41 (s, 1H), 8.43 (d, J = 3.2 Hz, 1H), 8.19 – 8.15 (m, 1H), 7.57 – 7.54 (m, 1H), 7.32 – 7.27 (m, 2H), 4.38 (t, J = 6.7 Hz, 2H), 3.49 – 3.39 (m, 1H), 3.24 (s, 3H), 1.89 – 1.84 (m, 2H), 1.13 (d, J = 6.2 Hz, 3H).

^{13}C NMR (101 MHz, DMSO-d^6) δ 179.43, 164.05, 138.70, 137.15, 125.91, 124.31, 123.32, 121.57, 113.20, 112.85, 73.51, 63.05, 55.86, 35.17, 19.33.

GC-MS (EI, 70ev): m/z (%) = 275 (M^+, 10), 144 (100), 116 (20), 89 (16), 44 (20).

HR-MS (EI) calcd. for $C_{15}H_{17}NO_4$ $[M+H]^+$: 275.11521; found: 275.11540.



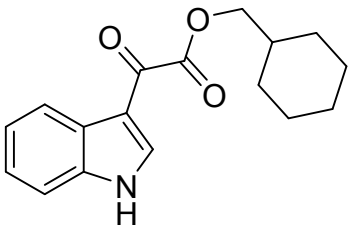
2-Methylbutyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3j): Yellow solid.

^{1}H NMR (400 MHz, DMSO-d^6) δ 12.55 – 12.26 (m, 1H), 8.40 (d, J = 3.3 Hz, 1H), 8.27 – 8.09 (m, 1H), 7.64 – 7.48 (m, 1H), 7.34 – 7.23 (m, 2H), 4.28 – 4.10 (m, 2H), 1.89 – 1.76 (m, 1H), 1.54 – 1.38 (m, 1H), 1.22 (dt, J = 13.5, 7.6 Hz, 1H), 0.97 – 0.87 (m, 6H).

^{13}C NMR (101 MHz, DMSO-d^6) δ 179.55, 164.20, 138.55, 137.16, 125.89, 124.32, 123.32, 121.56, 113.21, 112.86, 70.13, 33.99, 25.88, 16.57, 11.51.

GC-MS (EI, 70ev): m/z (%) = 259 (M^+, 10), 144 (100), 116 (15), 89 (10), 44 (10).

HR-MS (EI) calcd. for $C_{15}H_{17}NO_3$ $[M+H]^+$: 259.12029; found: 259.12067.



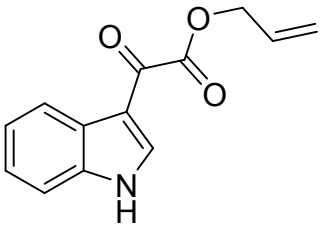
Cyclohexylmethyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3k): Yellow solid.

^{1}H NMR (400 MHz, DMSO-d^6) δ 12.40 (s, 1H), 8.39 (d, J = 3.3 Hz, 1H), 8.22 – 8.07 (m, 1H), 7.57 – 7.54 (m, 1H), 7.33 – 7.27 (m, 2H), 4.15 (d, J = 6.1 Hz, 2H), 3.96 – 3.88 (m, 1H), 1.74 – 1.64 (m, 5H), 1.28 – 1.17 (m, 3H), 1.07 – 0.98 (m, 2H).

^{13}C NMR (101 MHz, DMSO-d^6) δ 179.55, 164.18, 138.55, 137.16, 125.90, 124.31, 123.31, 121.56, 113.20, 112.87, 70.55, 36.92, 29.45, 26.29, 25.57.

GC-MS (EI, 70ev): m/z (%) = 285 (M^+, 10), 144 (100), 116 (10), 89 (10), 44 (15).

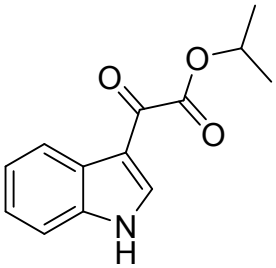
HR-MS (EI) calcd. for $C_{17}H_{19}NO_3$ $[M+H]^+$: 285.13594; found: 285.13573.



Allyl 2-(1*H*-indol-3-yl)-2-oxoacetate[4] **(3l):** Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^6) δ 12.42 (s, 1H), 8.43 (d, J = 3.3 Hz, 1H), 8.30 – 8.04 (m, 1H), 7.62 – 7.53 (m, 1H), 7.34 – 7.25 (m, 2H), 6.07 (ddt, J = 17.2, 10.4, 5.7 Hz, 1H), 5.52 – 5.27 (m, 2H), 4.85 (dt, J = 5.7, 1.4 Hz, 2H).

^{13}C NMR (75 MHz, DMSO-d^6) δ 179.13, 163.62, 138.75, 137.17, 132.40, 125.90, 124.35, 123.35, 121.59, 119.44, 113.23, 112.84, 66.29.



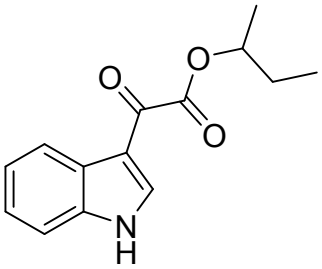
Isopropyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3m): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.37 (s, 1H), 8.38 (d, J = 3.3 Hz, 1H), 8.28 – 8.04 (m, 1H), 7.69 – 7.52 (m, 1H), 7.36 – 7.23 (m, 2H), 5.18 (h, J = 6.3 Hz, 1H), 1.36 (d, J = 6.3 Hz, 6H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 179.90, 163.68, 138.44, 137.15, 125.91, 124.28, 123.29, 121.56, 113.20, 112.79, 70.12, 21.93.

GC-MS (EI, 70ev): m/z (%) = 231 (M^{+}, 20), 191 (10), 144 (100), 129 (10), 116 (18), 89 (15), 44 (45).

HR-MS (EI) calcd. for $C_{13}H_{13}NO_3$ $[M+H]^{+}$: 231.08899; found: 231.08937.



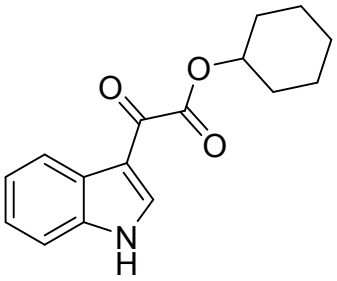
***sec*-Butyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3n):** Yellow solid.

^{1}H NMR (400 MHz, DMSO-d^{6}) δ 12.37 (s, 1H), 8.36 (d, J = 3.2 Hz, 1H), 8.20 – 8.12 (m, 1H), 7.58 – 7.53 (m, 1H), 7.32 – 7.26 (m, 2H), 5.04 (h, J = 6.3 Hz, 1H), 1.72 – 1.64 (m, 2H), 1.33 (d, J = 6.3 Hz, 3H), 0.92 (t, J = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, DMSO-d^{6}) δ 179.91, 163.87, 138.35, 137.15, 125.88, 124.30, 123.30, 121.55, 113.21, 112.79, 74.41, 28.57, 19.55, 9.95.

GC-MS (EI, 70ev): m/z (%) = 245 (M^{+}, 10), 144 (100), 116 (15), 89 (12), 44 (10).

HR-MS (EI) calcd. for $C_{14}H_{15}NO_3$ $[M+H]^{+}$: 245.10464; found: 245.10510.



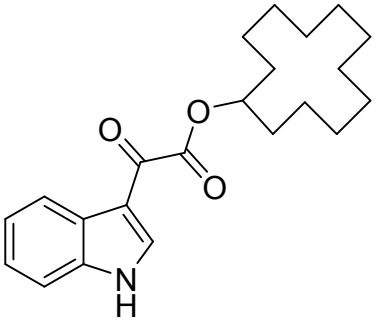
Cyclohexyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3o): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^6) δ 12.38 (s, 1H), 8.37 (d, J = 3.3 Hz, 1H), 8.16 (ddt, J = 5.9, 2.7, 0.7 Hz, 1H), 7.61 – 7.52 (m, 1H), 7.34 – 7.25 (m, 2H), 4.97 (tt, J = 9.0, 3.9 Hz, 1H), 2.01 – 1.89 (m, 2H), 1.76 – 1.67 (m, 2H), 1.57 – 1.51 (m, 2H), 1.43 (m, 2H), 1.28 (m, 2H).

^{13}C NMR (75 MHz, DMSO-d^6) δ 179.92, 163.59, 138.41, 137.15, 125.88, 124.29, 123.29, 121.54, 113.20, 112.80, 74.60, 31.35, 25.19, 23.65.

GC-MS (EI, 70ev): m/z (%) = 271 (M^+, 10), 144 (100), 116 (15), 89 (15), 55 (12).

HR-MS (EI) calcd. for $C_{16}H_{17}NO_3$ $[M+H]^+$: 271.12029; found: 271.12023.



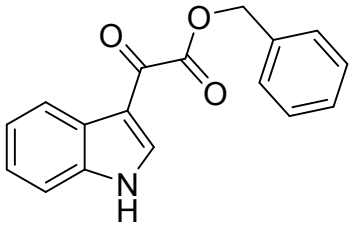
Cyclododecyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3p): Yellow solid.

^{1}H NMR (400 MHz, DMSO-d^6) δ 12.36 (s, 1H), 8.36 (d, J = 2.9 Hz, 1H), 8.18 – 8.13 (m, 1H), 7.58 – 7.54 (m, 1H), 7.32 – 7.26 (m, 2H), 5.20 (ddd, J = 7.2, 4.8, 2.3 Hz, 1H), 1.83 (dd, J = 13.8, 7.0 Hz, 2H), 1.62 (dd, J = 14.0, 5.2 Hz, 2H), 1.42 – 1.31 (m, 18H).

^{13}C NMR (101 MHz, DMSO-d^6) δ 179.78, 163.87, 138.35, 137.15, 125.90, 124.30, 123.30, 121.54, 113.21, 112.80, 74.08, 29.03, 24.04, 23.40, 23.19, 20.93.

GC-MS (EI, 70ev): m/z (%) = 355 (M^+, 10), 253 (10), 144 (100), 116 (10), 89 (10), 55 (16).

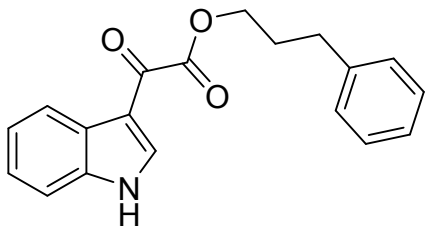
HR-MS (EI) calcd. for $C_{22}H_{29}NO_3$ $[M+H]^+$: 355.21420; found: 355.21414.



Benzyl 2-(1*H*-indol-3-yl)-2-oxoacetate[4] **(3q):** Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.42 (s, 1H), 8.48 – 8.38 (m, 1H), 8.20 – 8.10 (m, 1H), 7.58 – 7.53 (m, 1H), 7.50 (dd, J = 8.0, 1.8 Hz, 2H), 7.47 – 7.38 (m, 3H), 7.33 – 7.25 (m, 2H), 5.40 (s, 2H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 179.14, 163.77, 138.70, 137.15, 135.74, 129.05, 128.98, 128.93, 125.90, 124.36, 123.37, 121.58, 113.22, 112.88, 67.43.



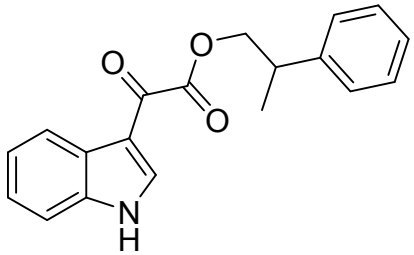
3-Phenylpropyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3r): Yellow solid.

^{1}H NMR (400 MHz, DMSO-d^{6}) δ 12.41 (s, 1H), 8.42 (d, J = 3.1 Hz, 1H), 8.21 – 8.16 (m, 1H), 7.59 – 7.54 (m, 1H), 7.33 – 7.17 (m, 7H), 4.32 (t, J = 6.6 Hz, 2H), 2.71 (dd, J = 8.7, 6.7 Hz, 2H), 2.08 – 1.99 (m, 2H).

^{13}C NMR (101 MHz, DMSO-d^{6}) δ 179.43, 164.08, 141.42, 138.71, 137.16, 128.85, 128.78, 126.42, 125.92, 124.32, 123.33, 121.58, 113.21, 112.86, 65.32, 31.81, 30.03.

GC-MS (EI, 70ev): m/z (%) = 307 (M^{+}, 10), 144 (100), 116 (20), 91 (15).

HR-MS (EI) calcd. for $C_{19}H_{17}NO_3$ $[M+H]^{+}$: 307.12029; found: 307.12110.



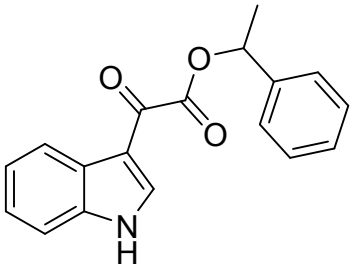
2-Phenylpropyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3s): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.35 (s, 1H), 8.18 – 8.12 (m, 1H), 8.03 (d, J = 3.3 Hz, 1H), 7.57 – 7.51 (m, 1H), 7.38 – 7.33 (m, 4H), 7.31 – 7.26 (m, 3H), 4.54 – 4.40 (m, 2H), 3.29 – 3.21 (m, 1H), 1.31 (d, J = 7.0 Hz, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 179.34, 163.89, 143.44, 138.41, 137.14, 128.96, 127.82, 127.18, 125.83, 124.34, 123.33, 121.57, 113.18, 112.81, 70.34, 38.68, 18.52.

GC-MS (EI, 70ev): m/z (%) = 307 (M^{+}, 10), 144 (100), 116 (20), 89 (15).

HR-MS (EI) calcd. for $C_{19}H_{17}NO_3$ $[M+H]^{+}$: 307.12029; found: 307.12098.



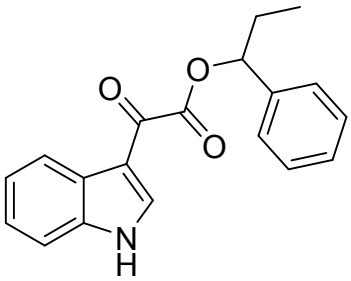
1-Phenylethyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3t): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.39 (s, 1H), 8.33 (d, J = 3.3 Hz, 1H), 8.21 – 8.09 (m, 1H), 7.60 – 7.53 (m, 1H), 7.51 – 7.46 (m, 2H), 7.45 – 7.35 (m, 3H), 7.32 – 7.27 (m, 2H), 6.10 (q, J = 6.6 Hz, 1H), 1.66 (d, J = 6.6 Hz, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 179.38, 163.28, 141.25, 138.43, 137.15, 129.05, 128.61, 126.58, 125.89, 124.35, 123.36, 121.56, 113.23, 112.79, 74.30, 22.30.

GC-MS (EI, 70ev): m/z (%) = 293 (M^{+}, 10), 144 (100), 116 (20), 89 (15).

HR-MS (EI) calcd. for $C_{18}H_{15}NO_3$ $[M+H]^{+}$: 293.10538; found: 293.10566.



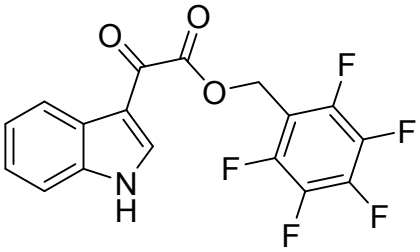
1-Phenylpropyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3u): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.39 (s, 1H), 8.28 (d, J = 3.3 Hz, 1H), 8.18 – 8.13 (m, 1H), 7.59 – 7.53 (m, 1H), 7.45 – 7.41 (m, 3H), 7.40 – 7.34 (m, 2H), 7.32 – 7.27 (m, 2H), 5.93 – 5.87 (m, 1H), 2.05 – 1.91 (m, 2H), 0.90 (t, J = 7.4 Hz, 3H).

^{13}C NMR (75 MHz, DMSO-d^6) δ 179.37, 163.46, 140.01, 138.27, 137.16, 128.99, 128.60, 126.93, 125.86, 124.37, 123.37, 121.54, 113.24, 112.79, 79.07, 29.08, 10.20.

GC-MS (EI, 70ev): m/z (%) = 307 (M^+, 10), 144 (100), 116 (20), 91 (15).

HR-MS (EI) calcd. for $C_{19}H_{17}NO_3$ $[M+H]^+$: 307.12029; found: 307.12092.



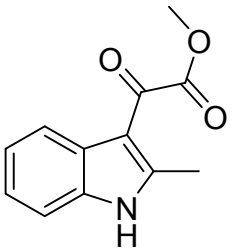
(Perfluorophenyl)methyl 2-(1*H*-indol-3-yl)-2-oxoacetate (3v): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^6) δ 12.45 (s, 1H), 8.43 (d, J = 3.3 Hz, 1H), 8.27 – 8.04 (m, 1H), 7.61 – 7.50 (m, 1H), 7.29 (tdd, J = 8.7, 4.7, 2.1 Hz, 2H), 5.52 (s, 2H).

^{19}F NMR (282 MHz, DMSO-d^6) δ 141.51–142.40 (dd, J = 22.4, 2F), -152.94 (t, J = 22.4 Hz, 1F), 162.26 (ddd, J = 46.2, 23.2, 7.8 Hz, 2F).

GC-MS (EI, 70ev): m/z (%) = 369 (M^+, 10), 181 (18), 144 (100), 116 (20), 89 (18).

HR-MS (EI) calcd. for $C_{17}H_8NO_3F_5$ $[M+H]^+$: 369.04250; found: 369.04281.



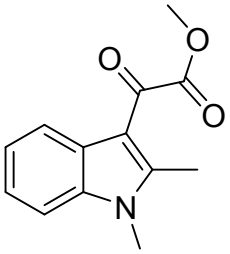
Methyl 2-(2-methyl-1*H*-indol-3-yl)-2-oxoacetate (4a): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^6) δ 12.39 (s, 1H), 7.89 – 7.83 (m, 1H), 7.47 – 7.43 (m, 1H), 7.25 – 7.20 (m, 2H), 3.93 (s, 3H), 2.58 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^6) δ 181.56, 166.96, 148.44, 135.59, 126.78, 123.48, 122.98, 120.11, 112.29, 108.83, 53.01, 13.94.

GC-MS (EI, 70ev): m/z (%) = 217 (M^+, 20), 158 (100), 130 (20), 103 (18), 77 (18).

HR-MS (EI) calcd. for $C_{12}H_{11}NO_3$ $[M+H]^+$: 217.07334; found: 217.07357.



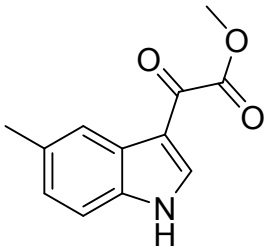
Methyl 2-(1,2-dimethyl-1*H*-indol-3-yl)-2-oxoacetate (4b): Red solid.

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.92 – 7.85 (m, 1H), 7.33 – 7.26 (m, 3H), 3.99 (s, 3H), 3.70 (s, 3H), 2.68 (s, 3H).

^{13}C NMR (75 MHz, $CDCl_3$) δ 181.39, 166.58, 147.77, 136.92, 126.04, 123.11, 123.06, 120.18, 109.66, 109.54, 52.55, 29.83, 12.32.

GC-MS (EI, 70ev): m/z (%) = 231(M^+, 12), 172 (100), 143 (10), 115 (10).

HR-MS (EI) calcd. for $C_{13}H_{13}NO_3$ $[M+H]^+$: 231.08899; found: 231.08930.



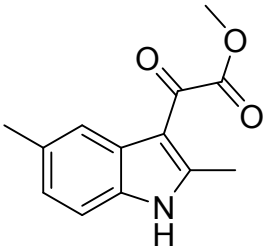
Methyl 2-(5-methyl-1*H*-indol-3-yl)-2-oxoacetate (4c): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^6) δ 12.31 (s, 1H), 8.38 (d, J = 2.6 Hz, 1H), 7.98 (dp, J = 1.6, 0.7 Hz, 1H), 7.43 (ddd, J = 8.3, 0.8, 0.4 Hz, 1H), 7.12 (ddd, J = 8.3, 1.8, 0.7 Hz, 1H), 3.89 (s, 3H), 2.43 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^6) δ 179.09, 164.54, 138.76, 135.45, 132.37, 126.20, 125.73, 121.36, 112.82, 112.52, 52.94, 21.74.

GC-MS (EI, 70ev): m/z (%) = 217 (M^+, 18), 158 (100), 130 (15), 103 (12), 77 (12), 44 (10).

HR-MS (EI) calcd. for $C_{12}H_{11}NO_3$ $[M+H]^+$: 217.07334; found: 217.07355.



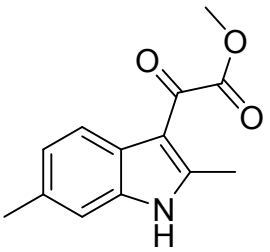
Methyl 2-(2,5-dimethyl-1*H*-indol-3-yl)-2-oxoacetate (4d): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.28 (s, 1H), 7.67 (d, J = 1.5 Hz, 1H), 7.32 (ddd, J = 8.2, 0.4 Hz, 1H), 7.05 (ddd, J = 8.2, 1.7, 0.6 Hz, 1H), 3.92 (s, 3H), 2.53 (s, 3H), 2.40 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 181.46, 167.01, 148.22, 133.84, 131.91, 127.11, 124.82, 120.08, 111.93, 108.55, 52.97, 21.82, 13.90.

GC-MS (EI, 70ev): m/z (%) = 231 (M^{+}, 15), 191 (10), 172 (100), 143 (10), 115 (10), 73 (10), 44 (63).

HR-MS (EI) calcd. for $C_{13}H_{13}NO_3$ $[M+H]^{+}$: 231.08899; found: 231.08920.



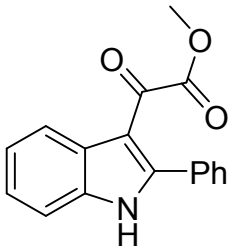
Methyl 2-(2,6-dimethyl-1*H*-indol-3-yl)-2-oxoacetate (4e): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.24 (s, 1H), 7.72 (d, J = 8.1 Hz, 1H), 7.23 (dt, J = 1.6, 0.8 Hz, 1H), 7.04 (ddd, J = 8.1, 1.5, 0.6 Hz, 1H), 3.92 (s, 3H), 2.54 (s, 3H), 2.40 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 181.40, 167.01, 147.96, 135.99, 132.83, 124.53, 124.47, 119.86, 112.12, 108.78, 52.98, 21.63, 13.90.

GC-MS (EI, 70ev): m/z (%) = 231 (M^{+}, 15), 172 (100), 143 (10), 115 (12), 44 (25).

HR-MS (EI) calcd. for $C_{13}H_{13}NO_3$ $[M+H]^{+}$: 231.08899; found: 231.08914.



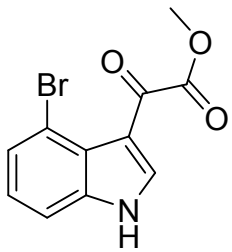
Methyl 2-oxo-2-(2-phenyl-1*H*-indol-3-yl)acetate (4f): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.57 (s, 1H), 8.19 – 7.98 (m, 1H), 7.48 – 7.41 (m, 6H), 7.27 – 7.20 (m, 2H), 3.12 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 182.67, 165.42, 149.37, 136.24, 130.96, 130.37, 130.16, 128.89, 127.30, 124.44, 123.44, 121.43, 112.73, 109.57, 52.04.

GC-MS (EI, 70ev): m/z (%) = 279 (M^{+}, 10), 220 (100), 191 (10), 165 (16), 44 (10).

HR-MS (EI) calcd. for $C_{17}H_{13}NO_3$ $[M+H]^{+}$: 279.08899; found: 279.08910.



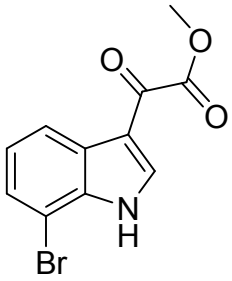
Methyl 2-(4-bromo-1*H*-indol-3-yl)-2-oxoacetate (4g): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.68 (s, 1H), 8.41 (s, 1H), 7.58 (dd, J = 8.1, 0.9 Hz, 1H), 7.48 (dd, J = 7.7, 0.9 Hz, 1H), 7.21 (dd, J = 7.7 Hz, 1H), 3.89 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 179.28, 165.47, 140.00, 139.35, 127.85, 125.41, 124.95, 113.78, 113.27, 112.78, 53.12.

GC-MS (EI, 70ev): m/z (%) = 281 (M^{+}, 26), 269 (32), 178 (20), 144 (35), 115 (48), 89 (20), 44 (68).

HR-MS (EI) calcd. for $C_{11}H_8NO_3{}^{79}Br$ $[M+H]^{+}$: 280.96821; found: 280.96921; calcd. for $C_{11}H_8NO_3{}^{81}Br$ $[M+H]^{+}$: 282.96616; found: 282.96721.



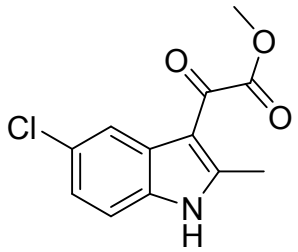
Methyl 2-(7-bromo-1*H*-indol-3-yl)-2-oxoacetate (4h): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.69 (s, 1H), 8.47 (d, J = 3.4 Hz, 1H), 8.19 (ddd, J = 7.9, 0.5 Hz, 1H), 7.54 (dd, J = 7.7, 0.9 Hz, 1H), 7.24 (t, J = 7.8 Hz, 1H), 3.91 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 179.21, 163.88, 139.34, 135.61, 127.66, 127.04, 124.86, 121.04, 113.72, 105.59, 53.18.

GC-MS (EI, 70ev): m/z (%) = 281 (M^{+}, 25), 224 (100), 193 (20), 143 (25), 115 (25), 88 (16), 44 (75).

HR-MS (EI) calcd. for $C_{11}H_8NO_3{}^{79}Br$ $[M+H]^{+}$: 280.96821; found: 280.96925; calcd. for $C_{11}H_8NO_3{}^{81}Br$ $[M+H]^{+}$: 282.96616; found: 282.96725.



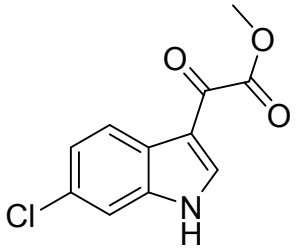
Methyl 2-(5-chloro-2-methyl-1*H*-indol-3-yl)-2-oxoacetate (4i): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.58 (s, 1H), 7.89 (d, J = 2.1 Hz, 1H), 7.47 (dd, J = 8.6, 0.6 Hz, 1H), 7.26 (dd, J = 8.6, 2.1 Hz, 1H), 3.93 (s, 3H), 2.55 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 181.41, 166.55, 149.72, 134.18, 128.11, 127.66, 123.56, 119.62, 113.92, 108.65, 53.16, 13.88.

GC-MS (EI, 70ev): m/z (%) = 251 (M^{+}, 10), 192 (100), 164 (10), 128 (10), 101 (10), 44 (25).

HR-MS (EI) calcd. for $C_{12}H_{10}NO_3{}^{35}Cl$ $[M+H]^{+}$: 251.01872; found: 251.01835; calcd. for $C_{12}H_{10}NO_3{}^{37}Cl$ $[M+H]^{+}$: 253.01577; found: 253.01589.



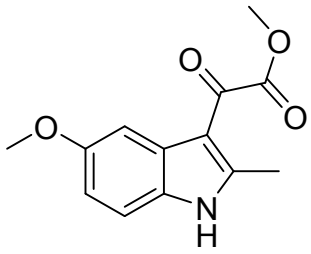
Methyl 2-(6-chloro-1*H*-indol-3-yl)-2-oxoacetate (4j): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^{6}) δ 12.49 (s, 1H), 8.51 (s, 1H), 8.15 (dd, J = 8.5, 0.6 Hz, 1H), 7.61 (dd, J = 1.9, 0.6 Hz, 1H), 7.31 (dd, J = 8.5, 1.9 Hz, 1H), 3.90 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 179.02, 164.00, 139.77, 137.66, 128.78, 124.75, 123.59, 122.90, 113.00, 112.81, 53.09.

GC-MS (EI, 70ev): m/z (%) = 237 (M^+, 18), 178 (100), 150 (15), 123 (15).

HR-MS (EI) calcd. for $C_{11}H_8NO_3{}^{35}Cl$ $[M+H]^+$: 237.01872; found: 237.01837; calcd. for $C_{11}H_8NO_3{}^{37}Cl$ $[M+H]^+$: 239.01577; found: 239.01591.



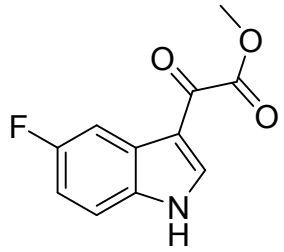
Methyl 2-(5-methoxy-2-methyl-1*H*-indol-3-yl)-2-oxoacetate (4k): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d6) δ 12.27 (s, 1H), 7.40 (d, J = 2.5 Hz, 1H), 7.34 (dd, J = 8.8, 0.5 Hz, 1H), 6.86 (dd, J = 8.8, 2.5 Hz, 1H), 3.92 (s, 3H), 3.78 (s, 3H), 2.52 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^{6}) δ 181.37, 167.00, 156.31, 148.23, 130.29, 127.80, 113.02, 112.57, 108.87, 102.87, 55.75, 52.99, 13.89.

GC-MS (EI, 70ev): m/z (%) = 247 (M^+, 18), 188 (100), 173 (15), 145 (10), 117 (10), 44 (35).

HR-MS (EI) calcd. for $C_{13}H_{13}NO_4$ $[M+H]^+$: 247.08391; found: 247.08391.



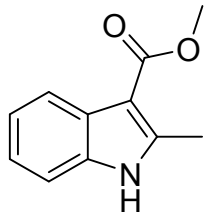
Methyl 2-(5-fluoro-1*H*-indol-3-yl)-2-oxoacetate (4l): Yellow solid.

^{1}H NMR (300 MHz, DMSO-d^6) δ 12.52 (s, 1H), 8.52 (s, 1H), 7.84 (ddd, J = 9.6, 2.7, 0.5 Hz, 1H), 7.58 (ddd, J = 8.9, 4.6, 0.5 Hz, 1H), 7.17 (dddd, J = 9.3, 8.9, 2.7, 0.3 Hz, 1H), 3.90 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^6) δ 178.89, 164.06, 140.14, 133.73, 126.72 (d, J = 11.0 Hz), 114.69, 114.56, 112.94, 112.45 (d, J = 26.0 Hz), 106.63 (d, J = 25.0 Hz), 53.07.

GC-MS (EI, 70ev): m/z (%) = 221 (M^+, 15), 162 (100), 134 (23), 107 (20).

HR-MS (EI) calcd. for $C_{11}H_8NO_3F$ $[M+H]^+$: 221.04827; found: 221.04771.



Methyl 2-methyl-1H-indole-3-carboxylate[5] **(5a) :** White solid.

^{1}H NMR (300 MHz, DMSO-d^6) δ 11.83 (s, 1H), 8.05 – 7.83 (m, 1H), 7.46 – 7.29 (m, 1H), 7.20 – 7.04 (m, 2H), 3.81 (s, 3H), 2.64 (s, 3H).

^{13}C NMR (75 MHz, DMSO-d^6) δ 165.96, 145.09, 135.22, 127.20, 122.09, 121.35, 120.77, 111.64, 103.01, 50.88, 14.18.

GC-MS (EI, 70ev): m/z (%) = 189 (M^+, 75), 158(100), 130 (20), 103 (10), 77 (20), 44 (25).

8. Reference

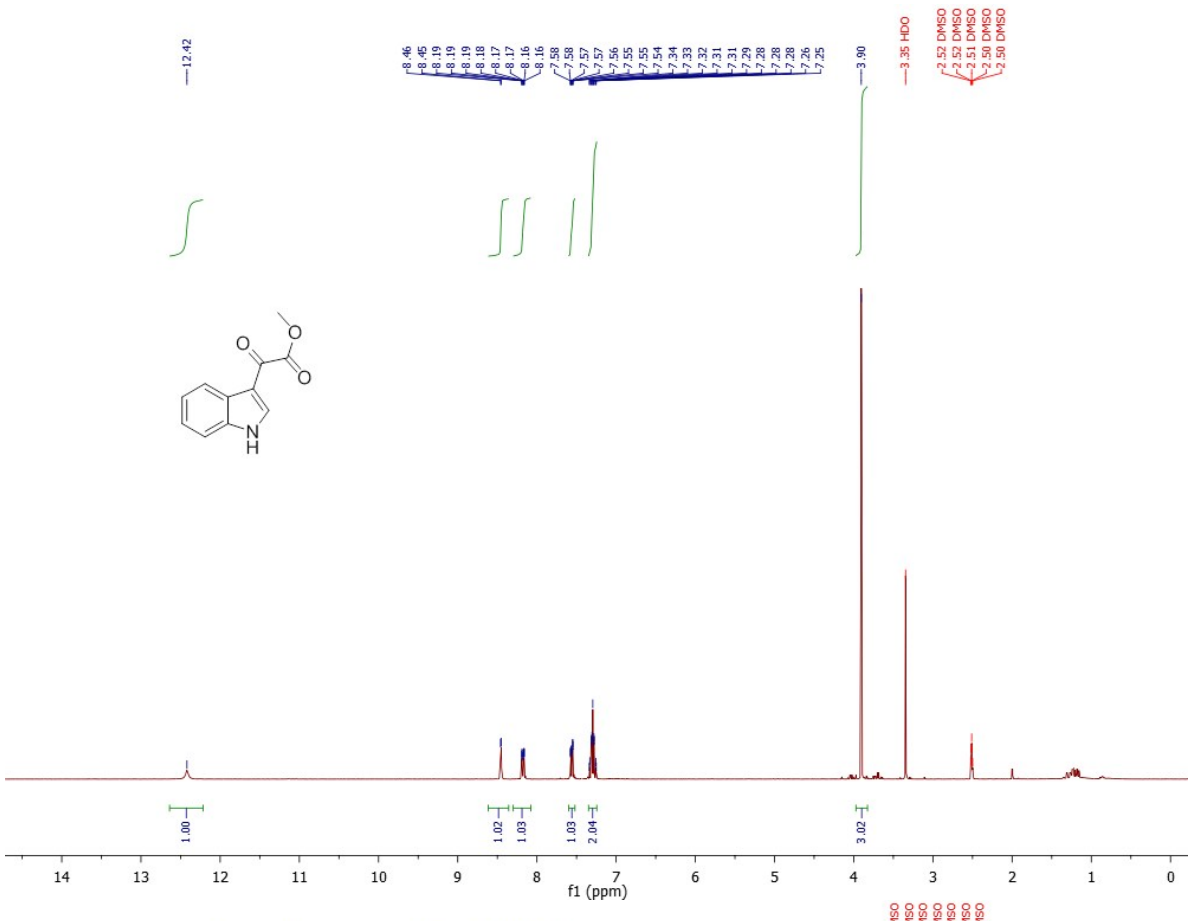
(1) Piers, E.; Britton, R..; Andersen, R. J. *J. Org. Chem.* **2000**, *65*, 530-535.

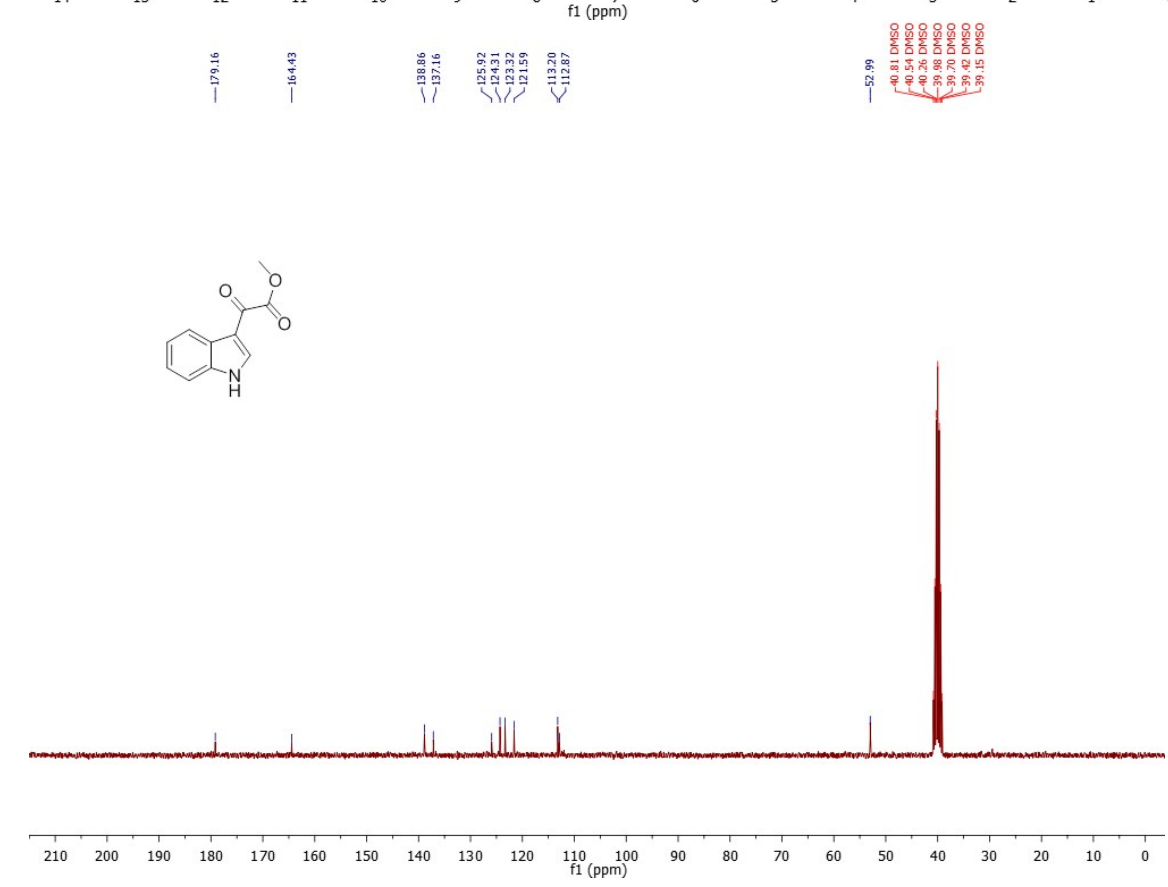
(2) Kumar, Y.; Jaiswal, Y.; Kumar, A. *J. Org. Chem.* **2016**, *81*, 12247-12257.

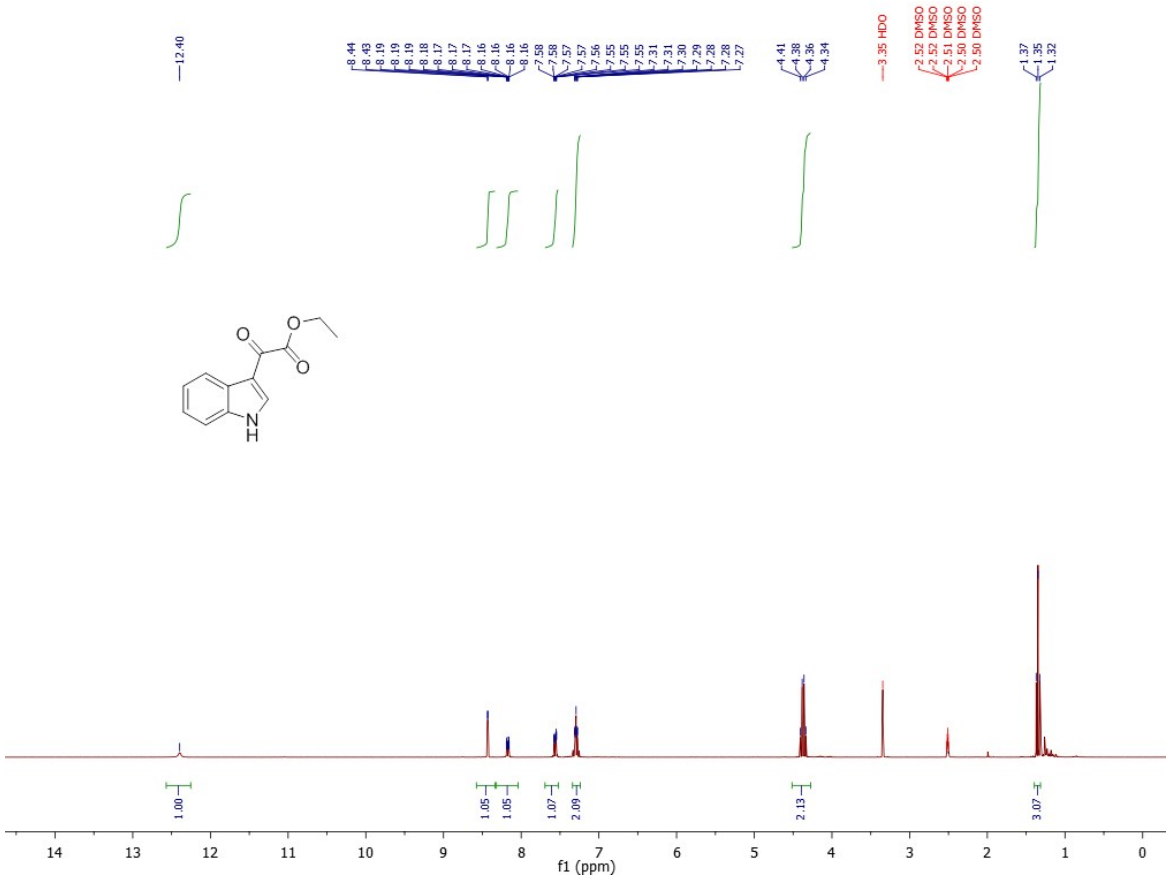
(3) Cordero-Pérez, J. J.; Ita-Gutiérrez, S. L.; Trejo-Carbajal, N.; Meléndez-Rodríguez, M.; Sánchez-Zavala, M.; Pérez-Hernández, N.; Morales-Ríos, M. S.; Joseph-Nathan, P.; Suárez-Castillo, O. R. *Magn. Reson. Chem.* **2014**, *52*, 789-794.

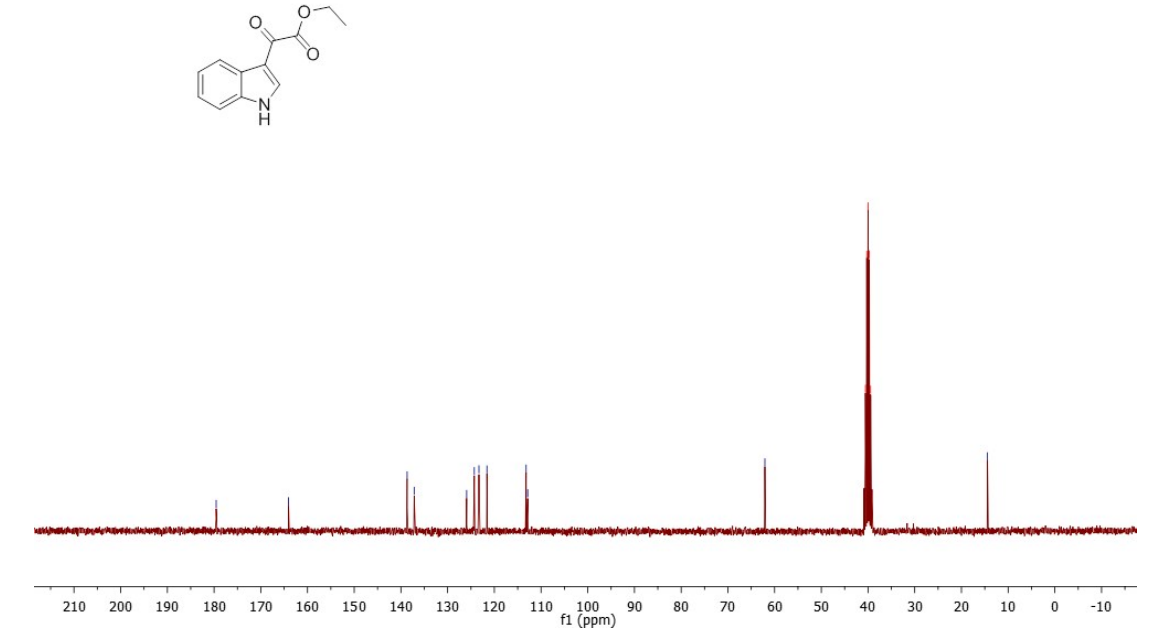
(4) Stefani, H. A.; Vasconcelos, S. N. S.; Souza, F. B.; Manarin, F.; Zukerman-Schpector, J. *Tetrahedron Lett.* **2013**, *54*, 5821-5825.

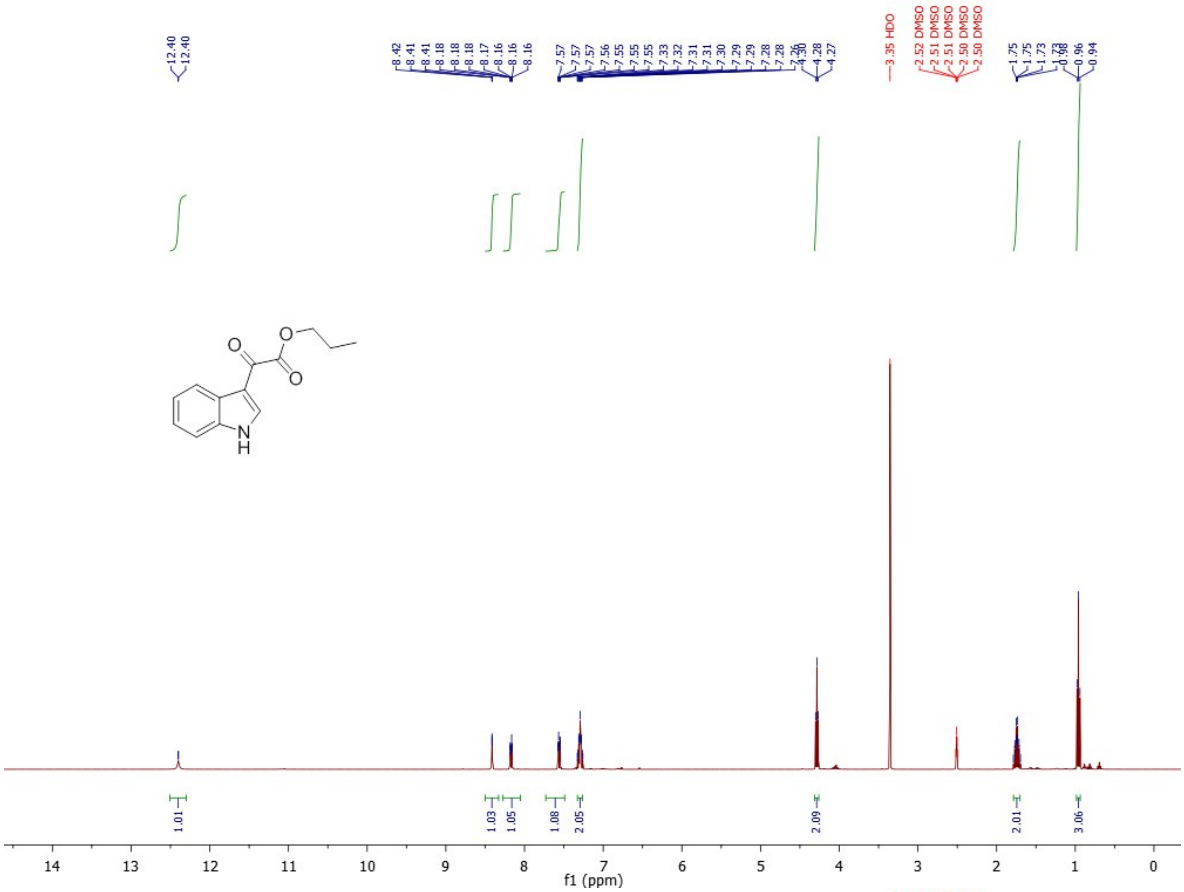
(5) Li, Y.; Qi, Z.; Wang, H.; Yang, X.; Li, X. *Angew. Chem. Int. Ed.* **2016**, *55*, 11877-11881.

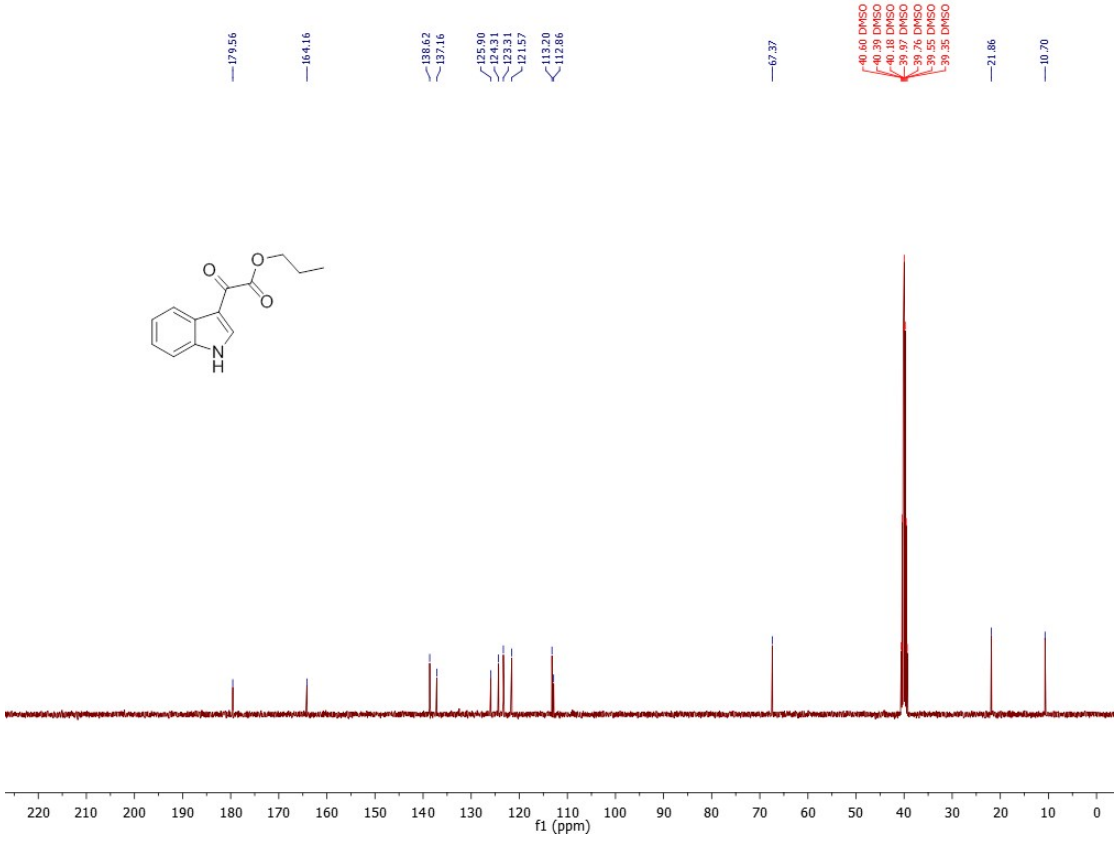

12.42
8.46
8.45
8.19
8.19
8.19
8.18
8.17
8.17
8.16
8.16
7.58
7.57
7.57
7.56
7.55
7.55
7.54
7.34
7.33
7.32
7.31
7.31
7.29
7.28
7.28
7.28
7.26
7.25
3.90
3.35 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.00
1.02
1.03
1.03
2.04
3.02
f1 (ppm)

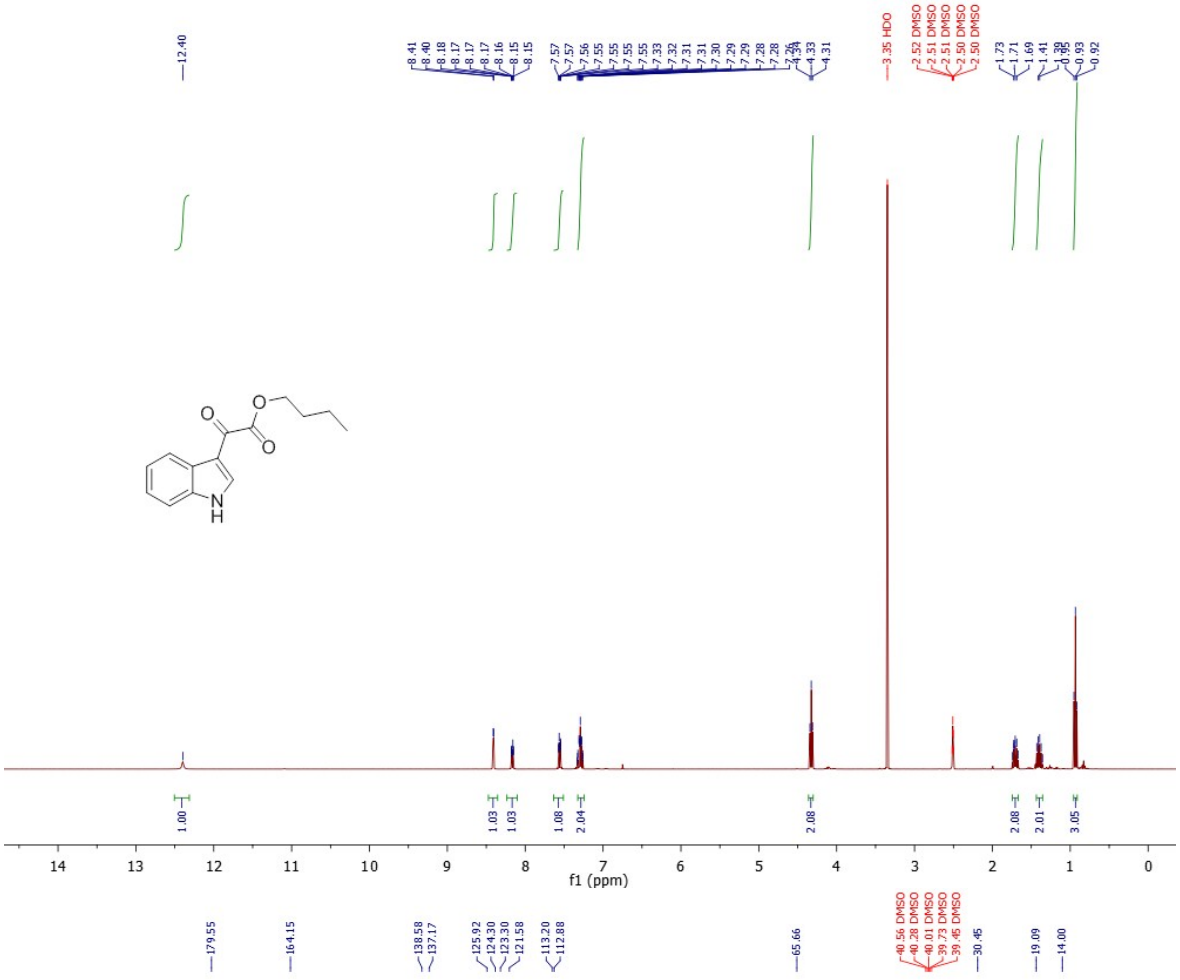

179.16
164.43
138.86
137.16
125.92
124.31
123.32
121.59
113.20
112.87
52.99
40.81 DMSO
40.54 DMSO
40.26 DMSO
39.98 DMSO
39.70 DMSO
39.42 DMSO
39.15 DMSO
f1 (ppm)

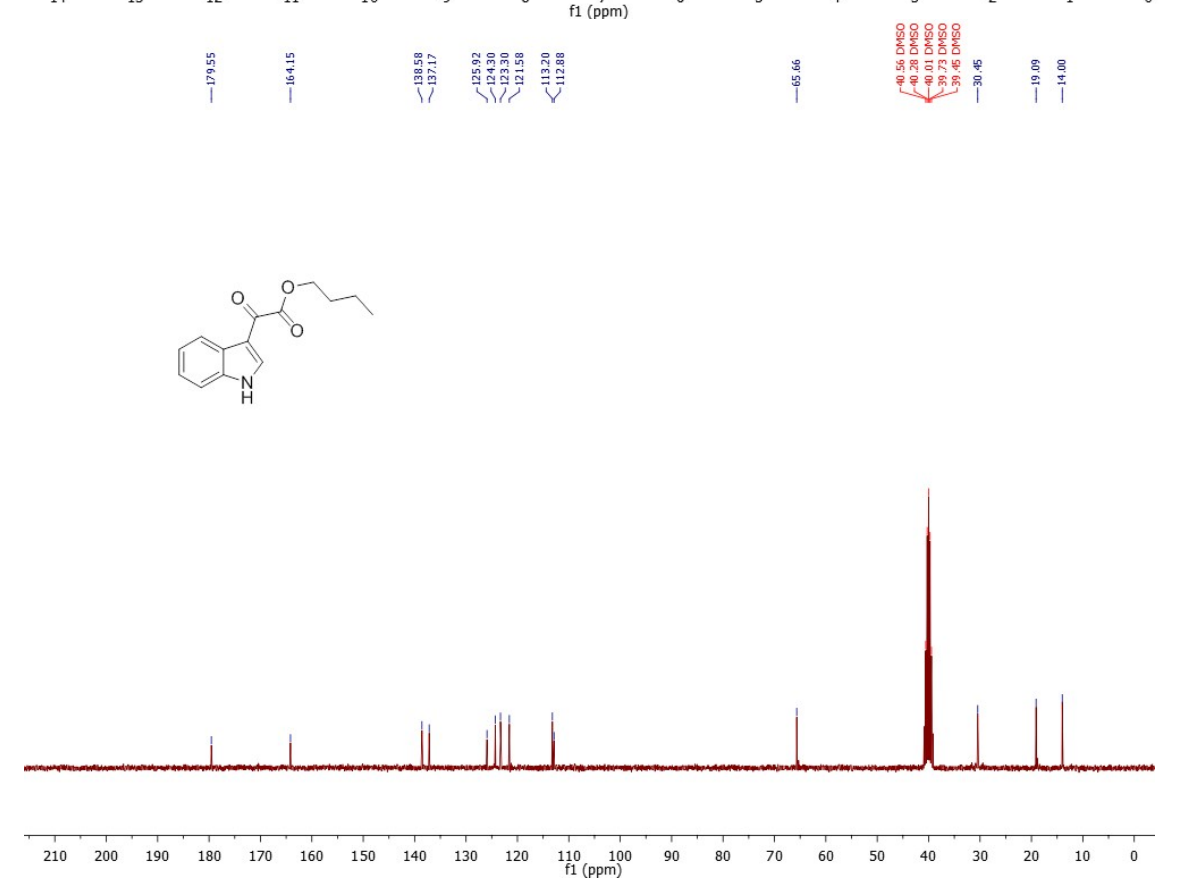

12.40
8.44
8.43
8.19
8.19
8.19
8.18
8.17
8.17
8.17
8.16
8.16
8.16
8.16
7.58
7.58
7.57
7.57
7.56
7.55
7.55
7.55
7.31
7.31
7.30
7.29
7.28
7.28
7.27
4.41
4.38
4.36
4.34
3.35 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.37
1.35
1.32
1.00
1.05
1.05
1.07
2.09
2.13
3.07
f1 (ppm)

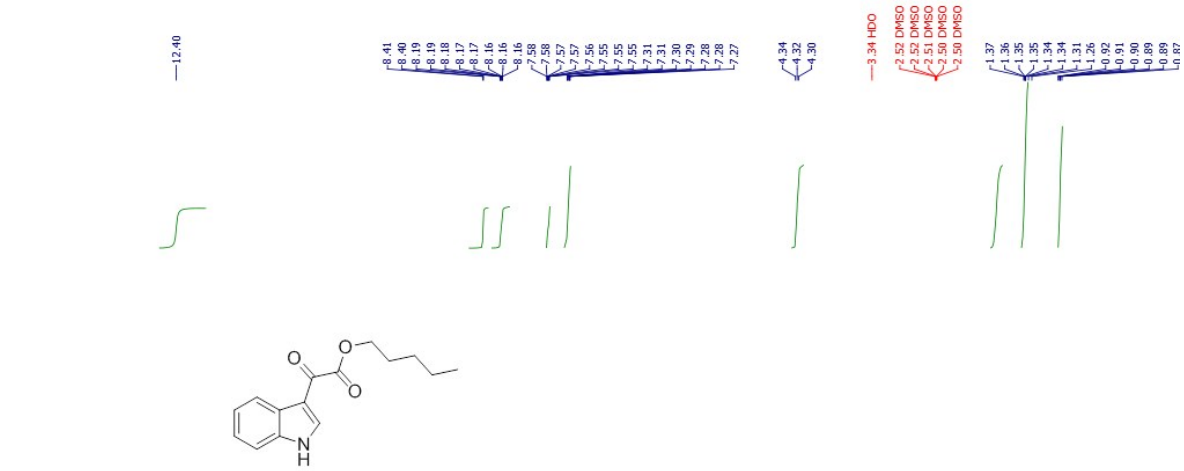

179.55
164.05
138.67
137.16
125.92
124.29
123.30
121.59
113.19
112.85
62.08
40.55 DMSO
40.27 DMSO
39.99 DMSO
39.72 DMSO
39.44 DMSO
14.41
f1 (ppm)

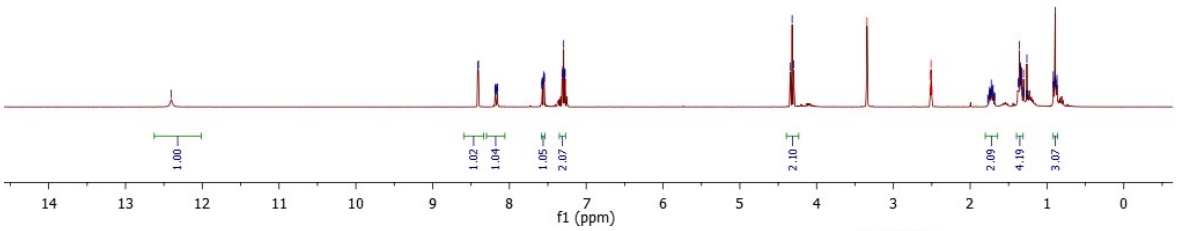

12.40
8.42
8.41
8.18
8.17
8.16
7.57
7.56
7.55
7.33
7.32
7.31
7.30
7.29
7.28
4.28
4.27
3.35 HDO
2.52 DMSO
2.51 DMSO
2.50 DMSO
1.75
1.73
0.96
0.94
1.01
1.03
1.05
1.08
2.05
2.09
2.01
3.06
f1 (ppm)


179.56
164.16
138.62
137.16
125.90
124.31
123.31
121.57
113.20
112.86
67.37
40.60 DMSO
40.39 DMSO
40.18 DMSO
39.97 DMSO
39.76 DMSO
39.55 DMSO
39.35 DMSO
21.86
10.70
f1 (ppm)

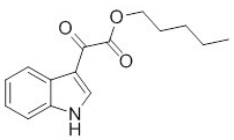

12.40
8.41
8.40
8.18
8.17
8.17
8.17
8.16
8.15
8.15
7.57
7.57
7.56
7.55
7.55
7.55
7.55
7.33
7.32
7.31
7.31
7.30
7.29
7.29
7.28
7.28
4.34
4.33
4.31
3.35 HDO
2.52 DMSO
2.51 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.73
1.71
1.69
1.41
1.39
0.95
0.93
0.92
1.00
1.03
1.03
1.08
2.04
2.08
2.08
2.01
3.05
f1 (ppm)

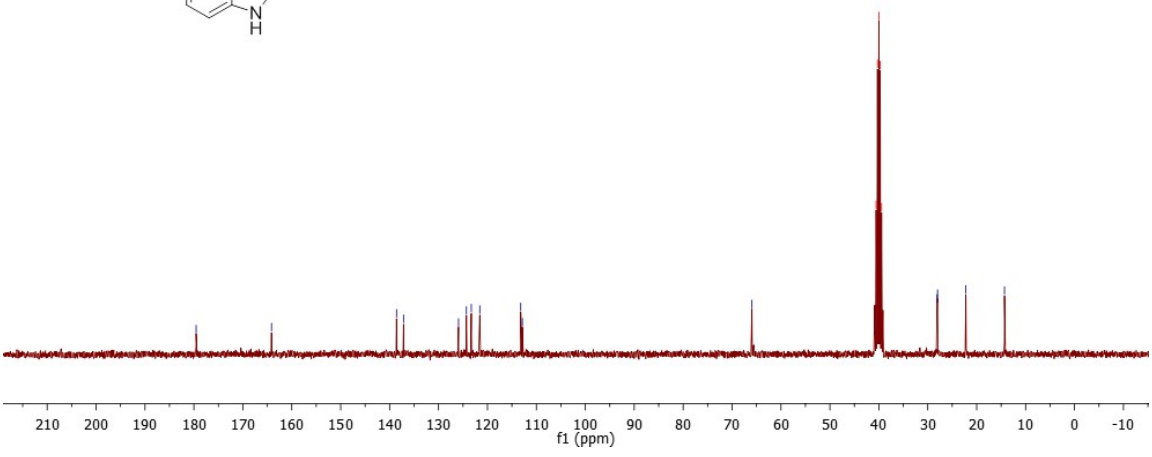

179.55
164.15
138.58
137.17
125.92
124.30
123.30
121.58
113.20
112.88
65.66
40.56 DMSO
40.26 DMSO
40.01 DMSO
39.77 DMSO
39.49 DMSO
30.45
19.09
14.00
f1 (ppm)

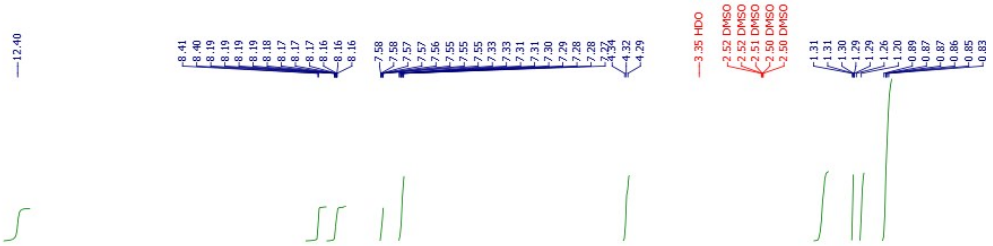

12.40
8.41
8.40
8.19
8.19
8.18
8.17
8.17
8.16
8.16
8.16
7.58
7.58
7.57
7.57
7.56
7.55
7.55
7.55
7.31
7.31
7.30
7.29
7.28
7.28
7.27
4.34
4.32
4.30
3.34 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.37
1.36
1.35
1.35
1.34
1.34
1.31
1.26
0.92
0.91
0.90
0.89
0.89
0.87

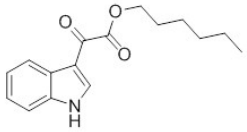

1.00
1.02
1.04
1.05
2.07
2.10
2.09
4.19
3.07
f1 (ppm)

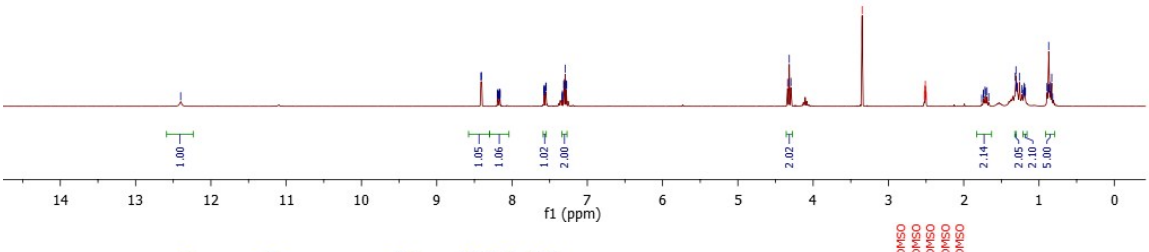

179.55
164.14
138.59
137.16
125.91
124.30
123.30
121.57
113.20
112.87
65.94
40.55 DMSO
40.27 DMSO
40.00 DMSO
39.72 DMSO
39.44 DMSO
28.10
28.00
22.22
14.31

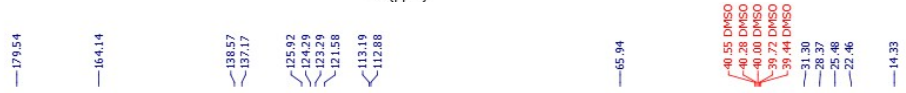


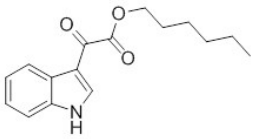

f1 (ppm)

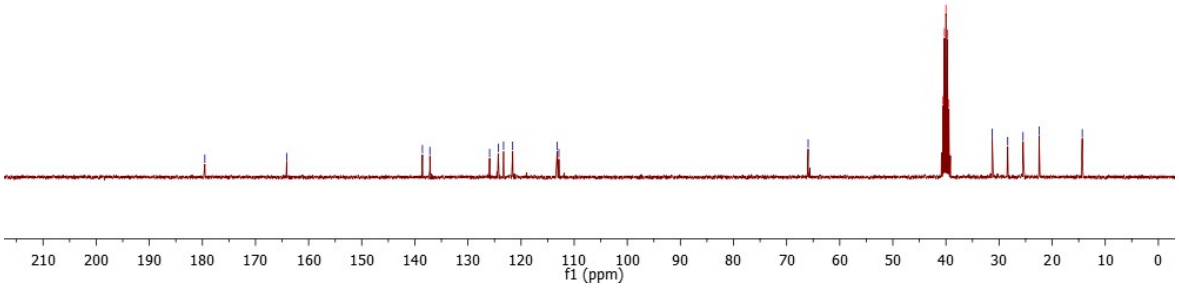

12.40
8.41
8.40
8.19
8.19
8.19
8.19
8.18
8.17
8.17
8.17
8.16
8.16
8.16
7.58
7.58
7.57
7.57
7.56
7.55
7.55
7.55
7.33
7.33
7.31
7.31
7.30
7.29
7.28
7.28
4.34
4.32
4.29
3.35 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.31
1.31
1.30
1.29
1.29
1.26
1.20
0.89
0.87
0.86
0.85
0.83

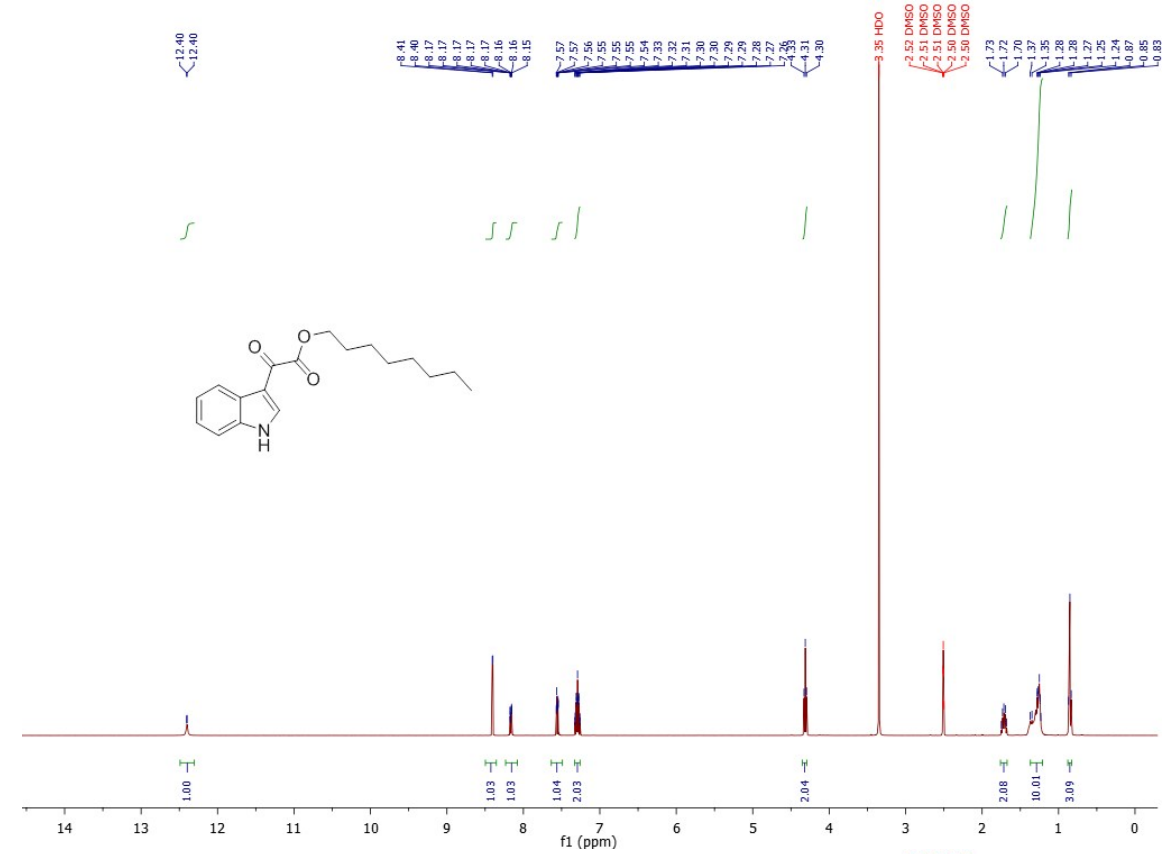


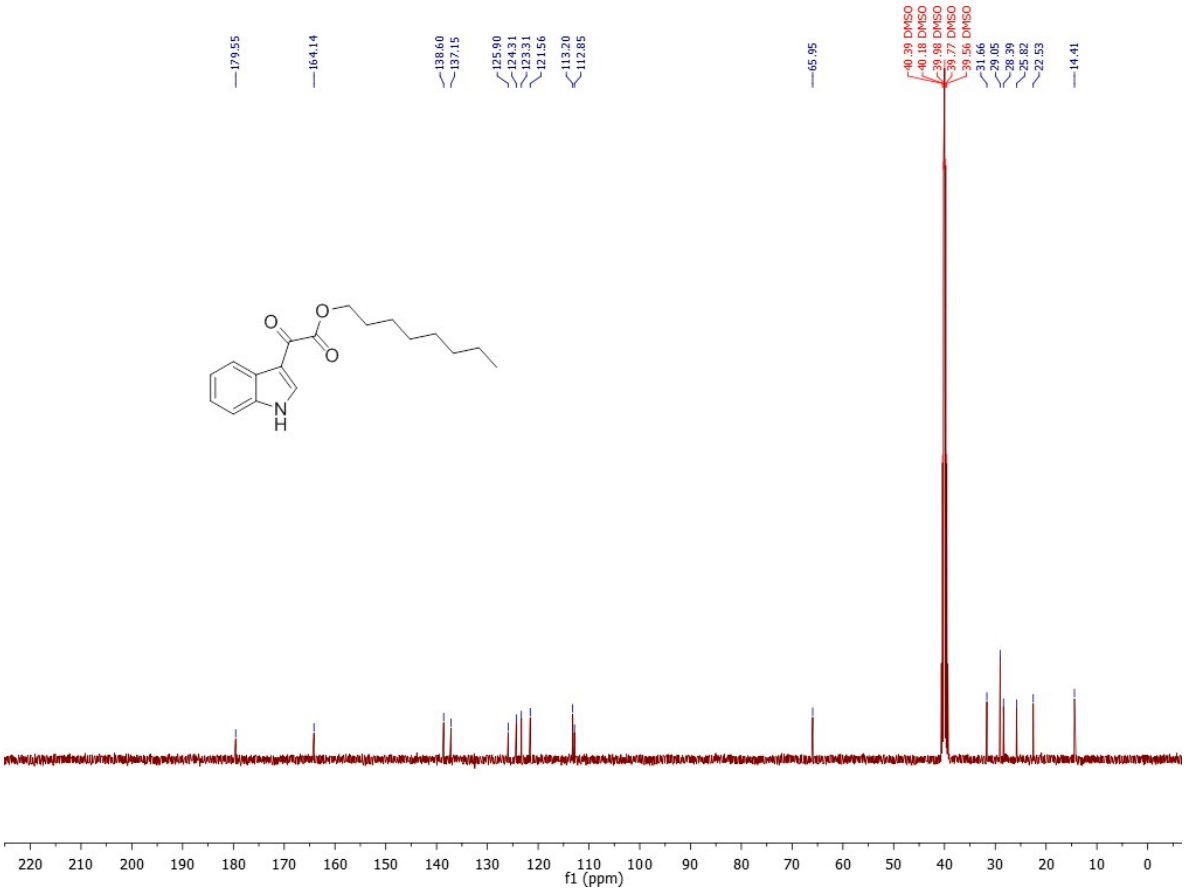

1.00
1.05
1.06
1.02
2.00
2.02
2.14
2.05
2.10
5.00
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

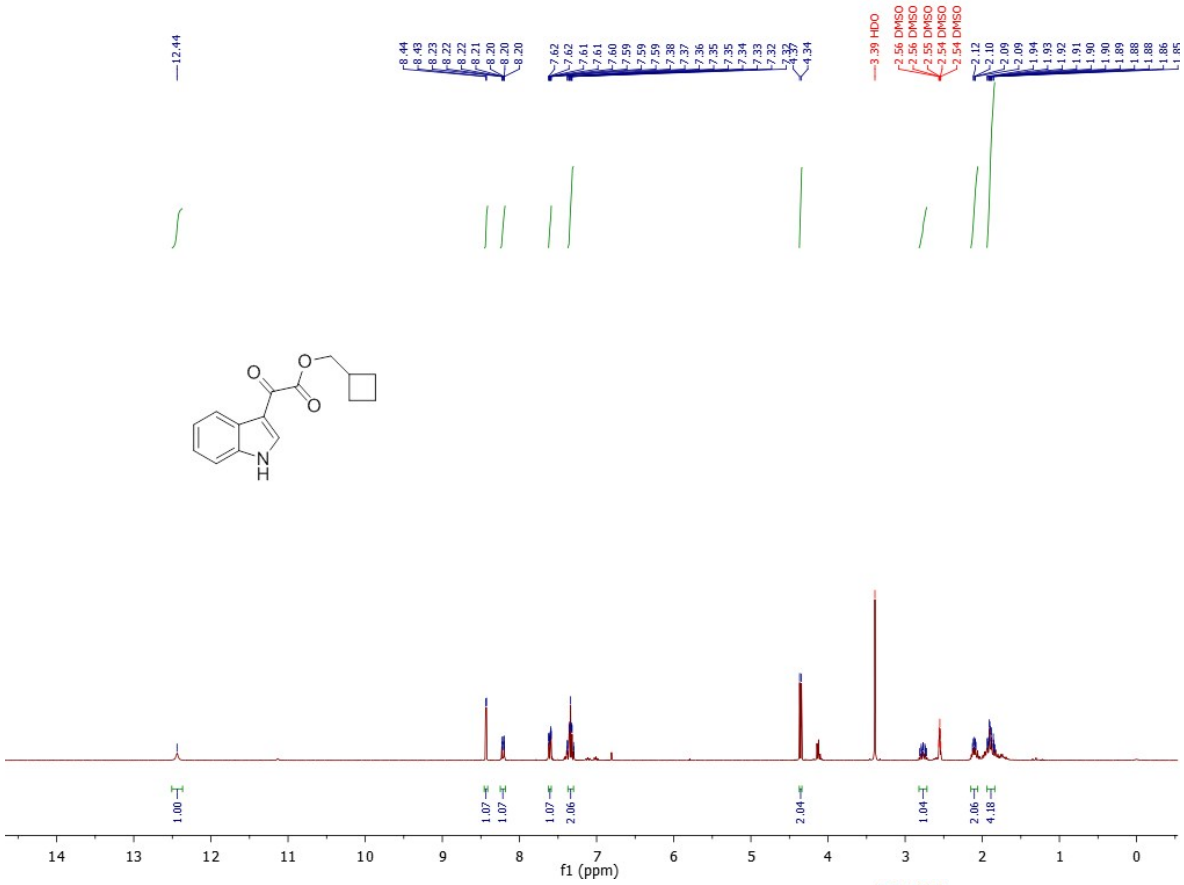

179.54
164.14
138.57
137.17
125.92
124.29
123.29
121.58
113.19
112.88
65.94
40.55 DMSO
40.28 DMSO
40.00 DMSO
39.72 DMSO
39.44 DMSO
31.30
28.37
25.48
22.46
14.33

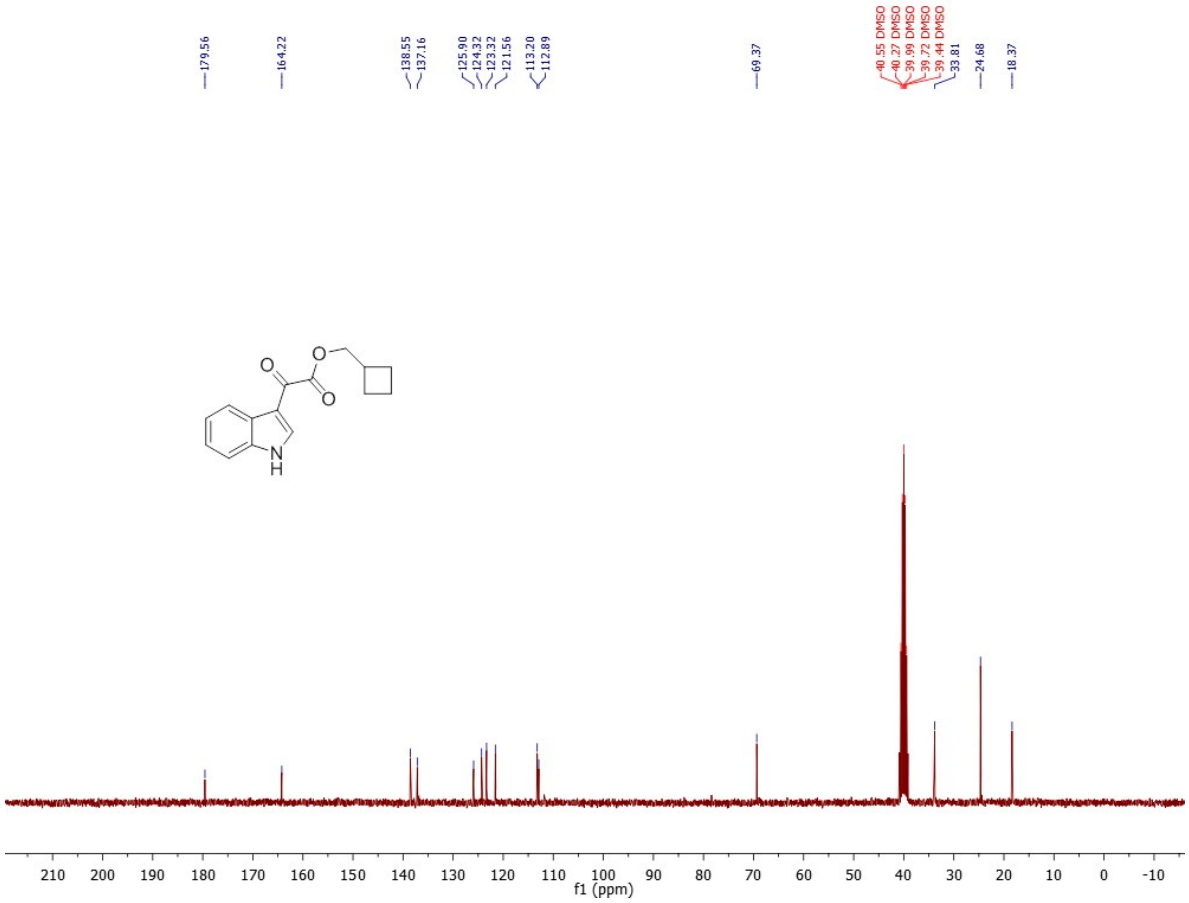


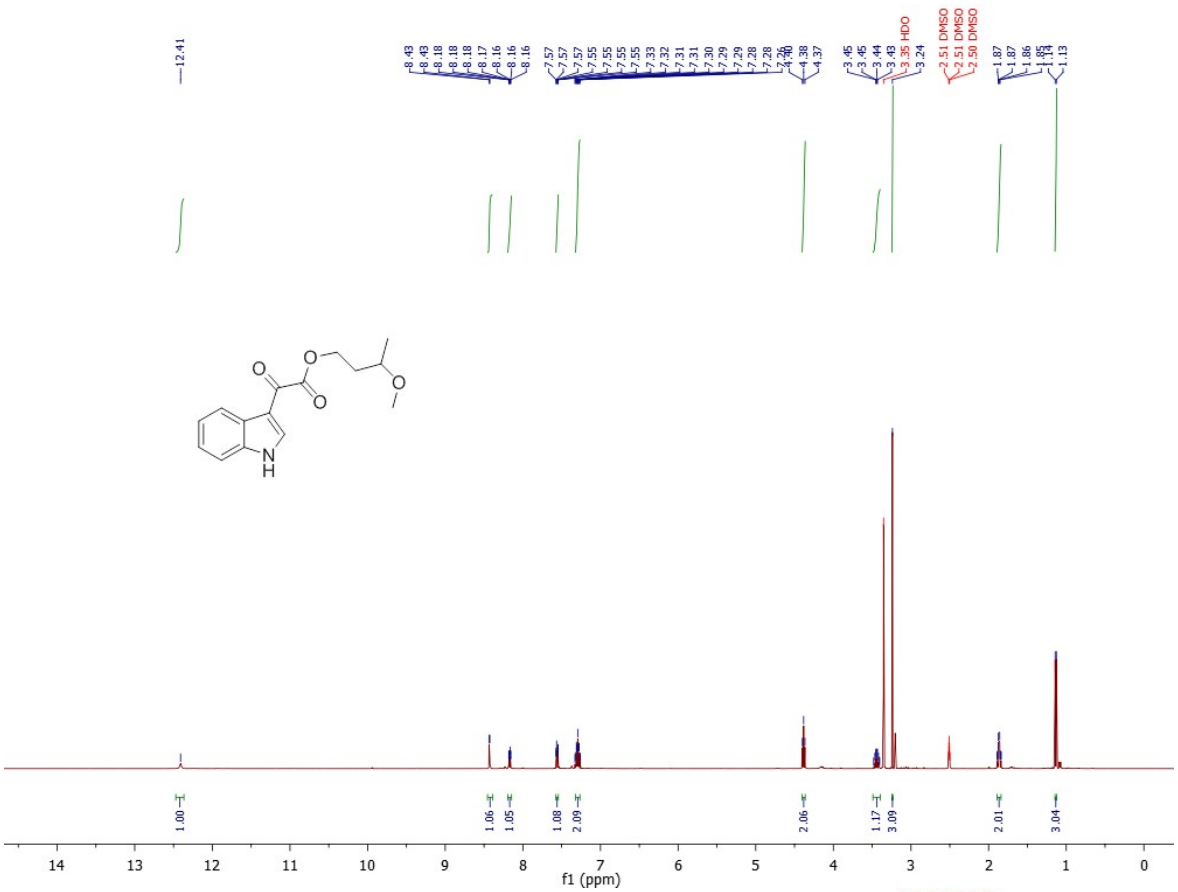

210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

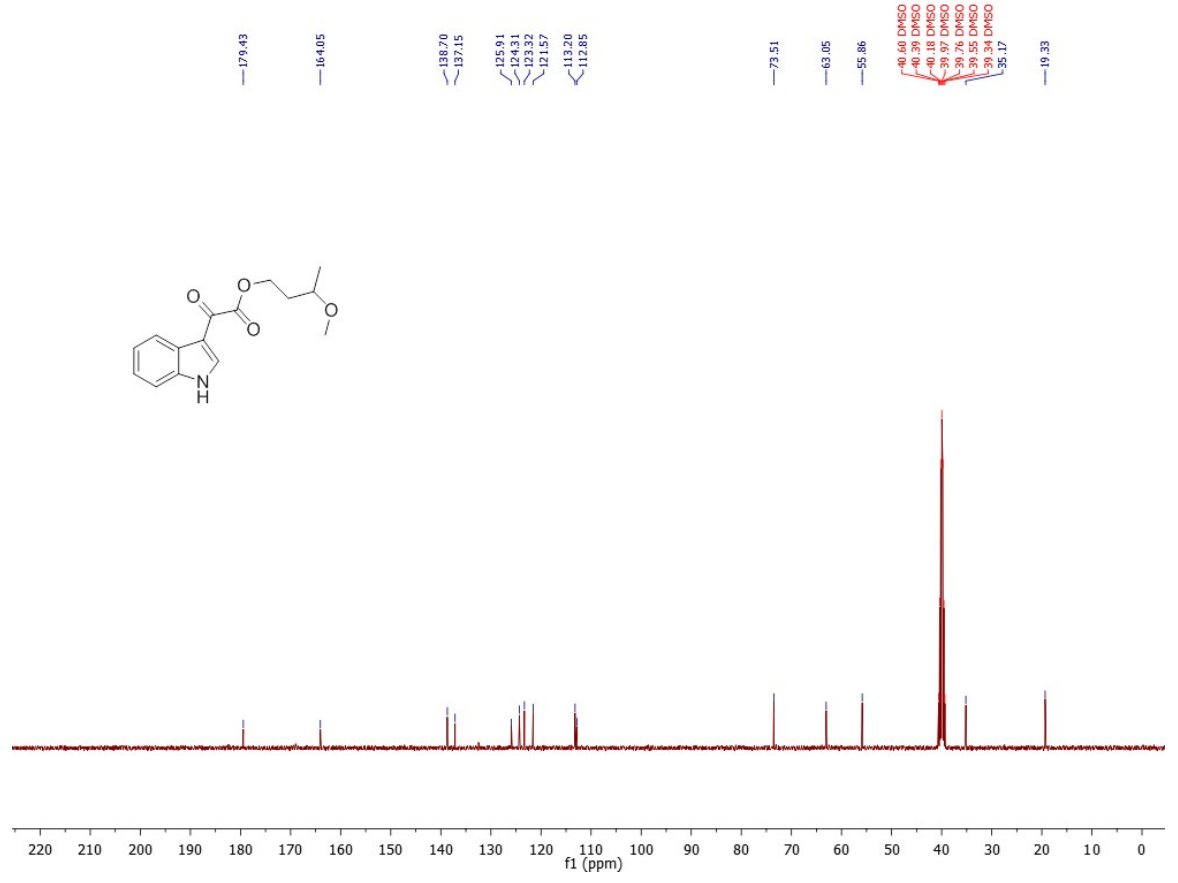

12.40
8.41
8.40
8.17
8.17
8.17
8.17
8.17
8.16
8.16
8.15
7.57
7.57
7.56
7.55
7.55
7.55
7.54
7.33
7.32
7.31
7.30
7.30
7.29
7.29
7.28
7.27
4.31
4.30
3.35 HDO
2.52 DMSO
2.51 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.73
1.72
1.70
1.37
1.35
1.28
1.28
1.27
1.25
1.24
0.87
0.85
0.83
1.00
1.03
1.03
1.04
2.03
2.04
2.08
10.01
3.09
f1 (ppm)

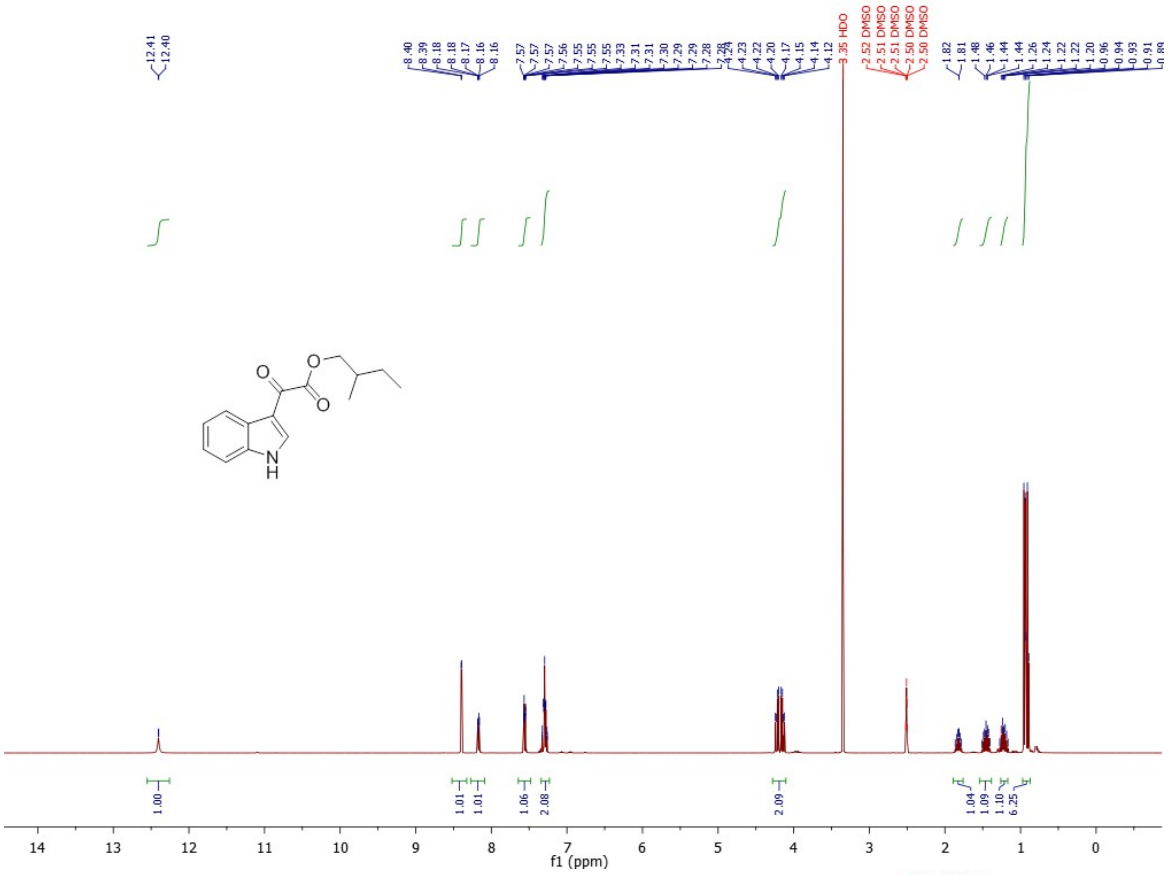

179.55
164.14
138.60
137.15
125.90
124.31
123.31
121.56
113.20
112.85
65.95
40.39 DMSO
40.18 DMSO
39.98 DMSO
39.77 DMSO
39.56 DMSO
31.66
29.05
28.39
25.82
22.53
14.41
f1 (ppm)

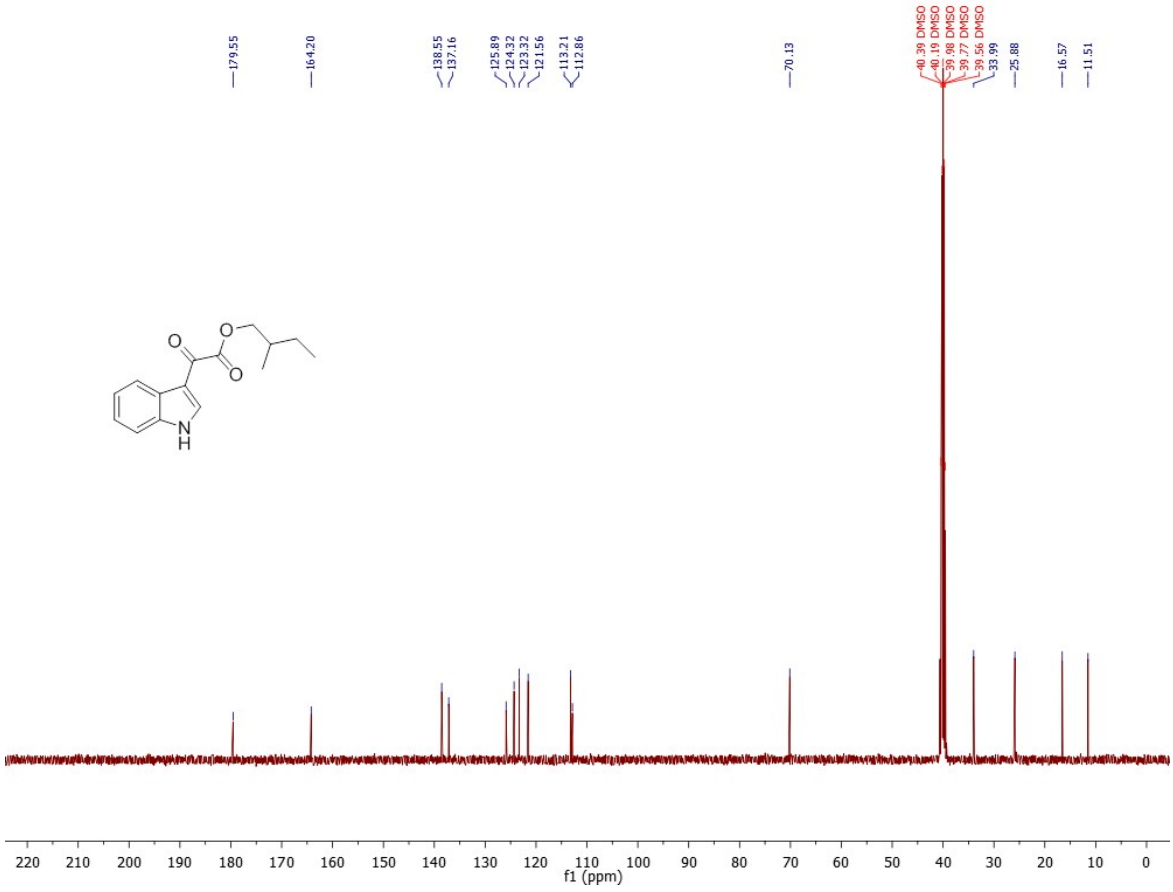

12.44
8.44
8.43
8.23
8.22
8.22
8.21
8.20
8.20
8.20
7.62
7.62
7.61
7.61
7.60
7.59
7.59
7.59
7.38
7.37
7.36
7.35
7.35
7.34
7.33
7.32
7.32
4.37
4.34
3.39 HDO
2.56 DMSO
2.56 DMSO
2.55 DMSO
2.54 DMSO
2.54 DMSO
2.12
2.10
2.09
2.09
1.94
1.93
1.92
1.91
1.90
1.90
1.89
1.88
1.88
1.86
1.85
O
O
O
N
H
1.00
1.07
1.07
1.07
2.06
2.04
1.04
2.06
4.18
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

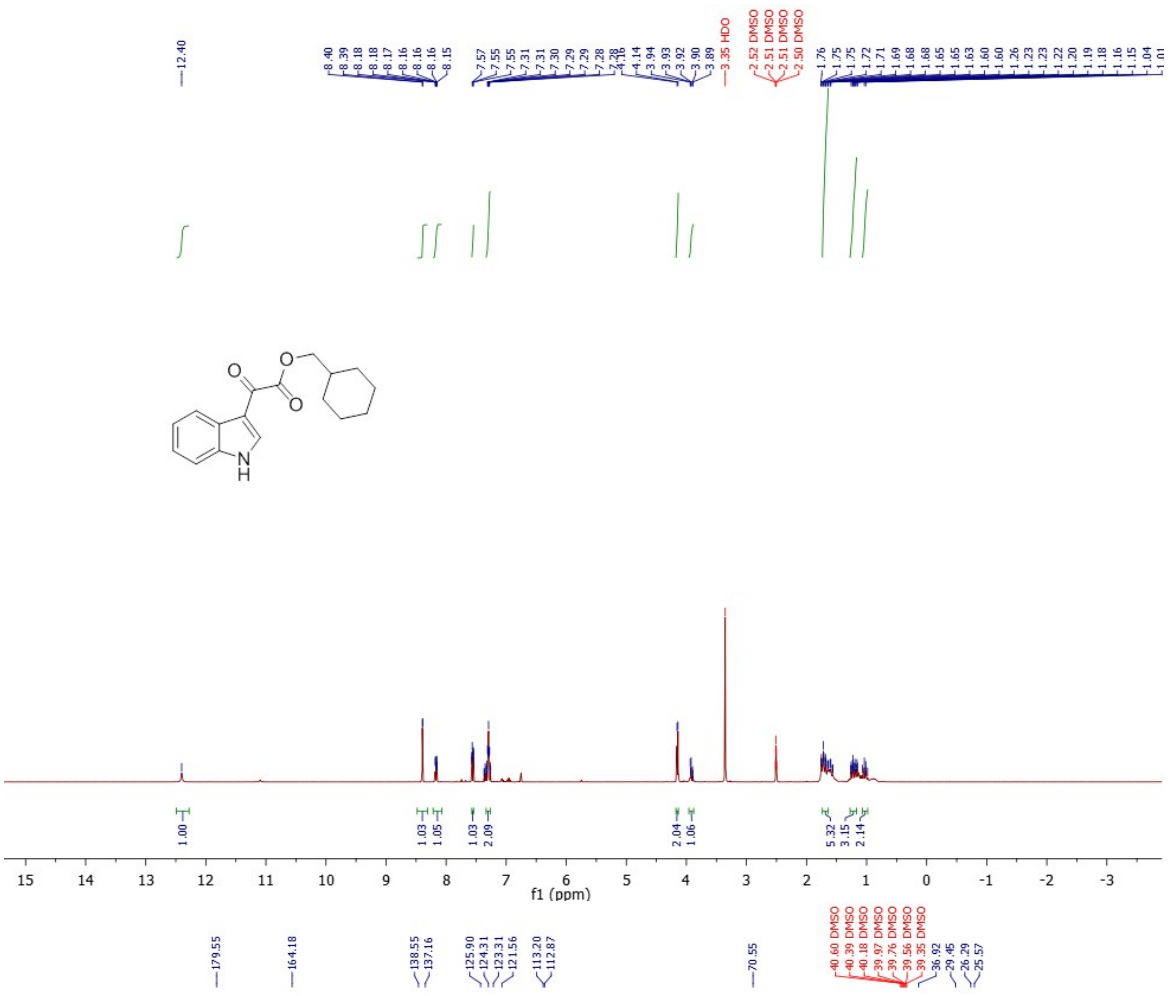

179.56
164.22
138.55
137.16
125.90
124.32
123.32
121.56
113.20
112.89
69.37
40.55 DMSO
40.27 DMSO
39.99 DMSO
39.72 DMSO
39.44 DMSO
33.81
24.68
18.37
O
O
O
N
H
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

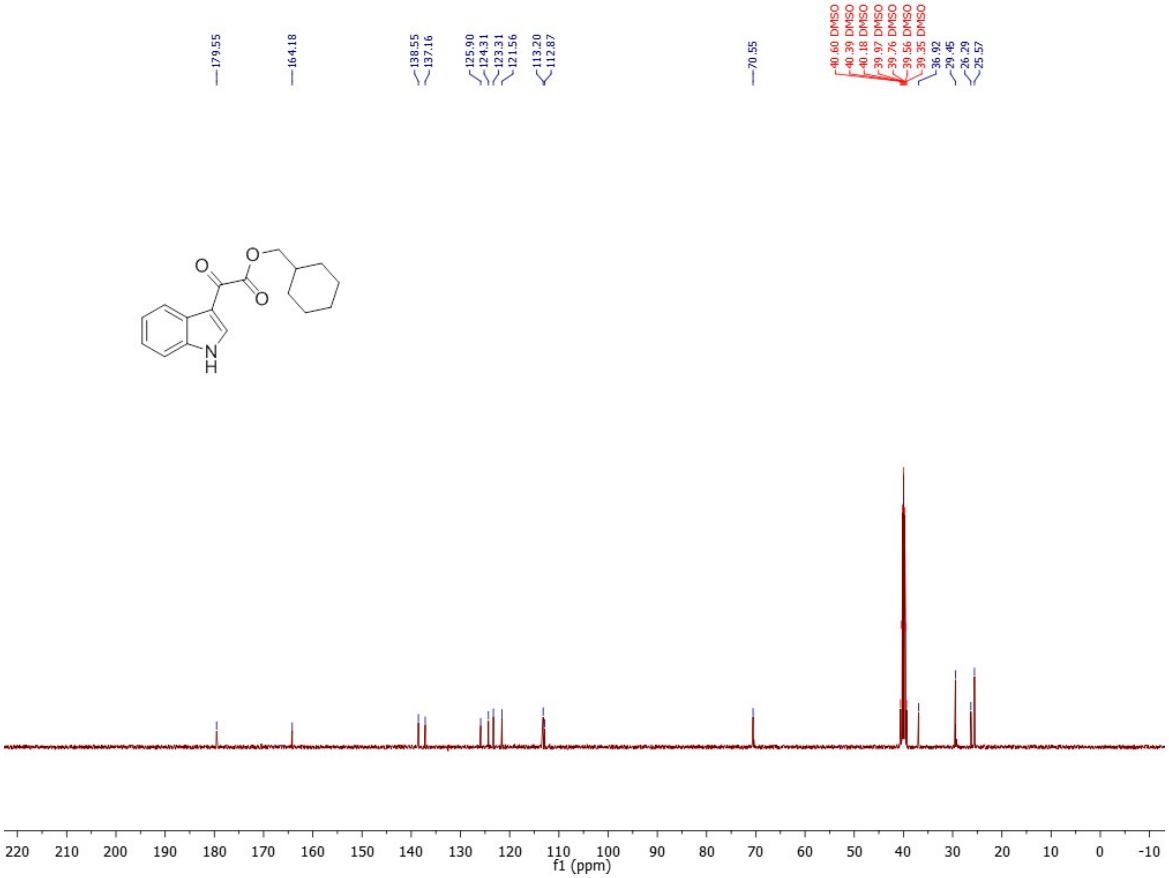

12.41
8.43
8.43
8.18
8.18
8.18
8.17
8.16
8.16
8.16
7.57
7.57
7.57
7.55
7.55
7.55
7.55
7.33
7.32
7.31
7.31
7.30
7.29
7.29
7.28
7.28
4.38
4.37
3.45
3.45
3.44
3.43
3.35 HDO
3.24
2.51 DMSO
2.51 DMSO
2.50 DMSO
1.87
1.87
1.86
1.13
1.00
1.06
1.05
1.08
2.09
2.06
1.17
3.09
2.01
3.04
f1 (ppm)

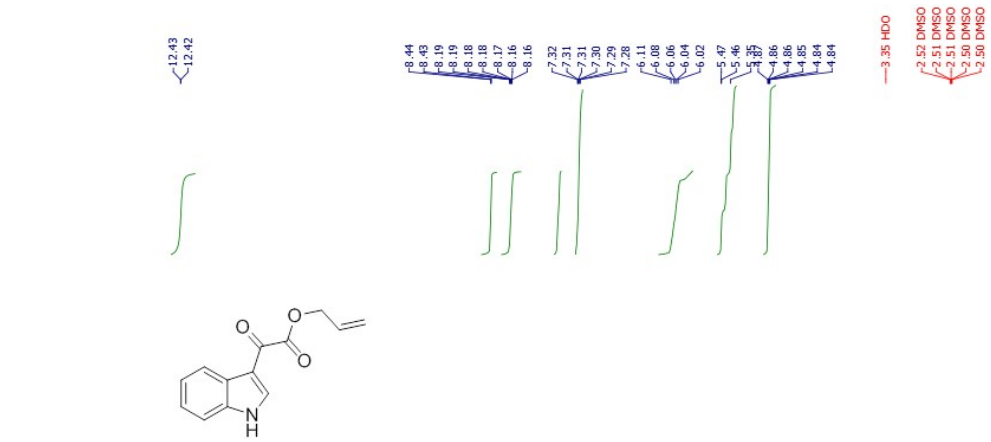

179.43
164.05
138.70
137.15
125.91
124.31
123.32
121.57
113.20
112.85
79.51
63.05
55.86
40.60 DMSO
40.39 DMSO
40.18 DMSO
39.97 DMSO
39.76 DMSO
39.55 DMSO
39.34 DMSO
35.17
19.33
f1 (ppm)

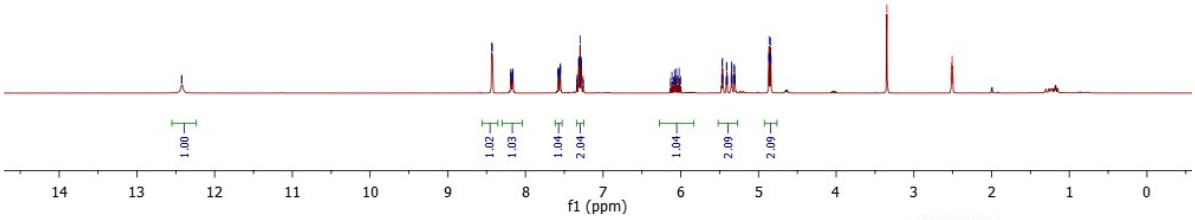

12.41
12.40
8.40
8.39
8.18
8.18
8.17
8.16
8.16
7.57
7.57
7.56
7.55
7.55
7.55
7.33
7.31
7.31
7.30
7.29
7.29
7.28
4.23
4.22
4.20
4.17
4.15
4.14
4.12
3.35 HDO
2.52 DMSO
2.51 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.82
1.81
1.48
1.46
1.44
1.44
1.26
1.24
1.22
1.22
1.20
0.96
0.94
0.93
0.91
0.89
1.00
1.01
1.01
1.06
2.08
2.09
1.04
1.09
1.10
6.25
f1 (ppm)


179.55
164.20
138.55
137.16
125.89
124.32
123.32
121.56
113.21
112.86
70.13
40.39 DMSO
40.19 DMSO
39.98 DMSO
39.77 DMSO
39.56 DMSO
33.99
25.88
16.57
11.51
f1 (ppm)

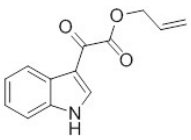

12.40
8.40
8.39
8.18
8.18
8.17
8.16
8.16
8.16
8.15
7.57
7.55
7.55
7.31
7.31
7.30
7.29
7.29
7.28
7.28
4.14
3.94
3.93
3.92
3.90
3.89
3.35 HDO
2.52 DMSO
2.51 DMSO
2.51 DMSO
2.50 DMSO
1.76
1.75
1.75
1.72
1.71
1.69
1.68
1.68
1.65
1.65
1.63
1.60
1.60
1.26
1.23
1.23
1.22
1.20
1.19
1.18
1.16
1.15
1.04
1.01
O
O
O
N
H
1.00
1.03
1.05
1.03
2.09
2.04
1.06
5.32
3.15
2.14
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2 -3
f1 (ppm)

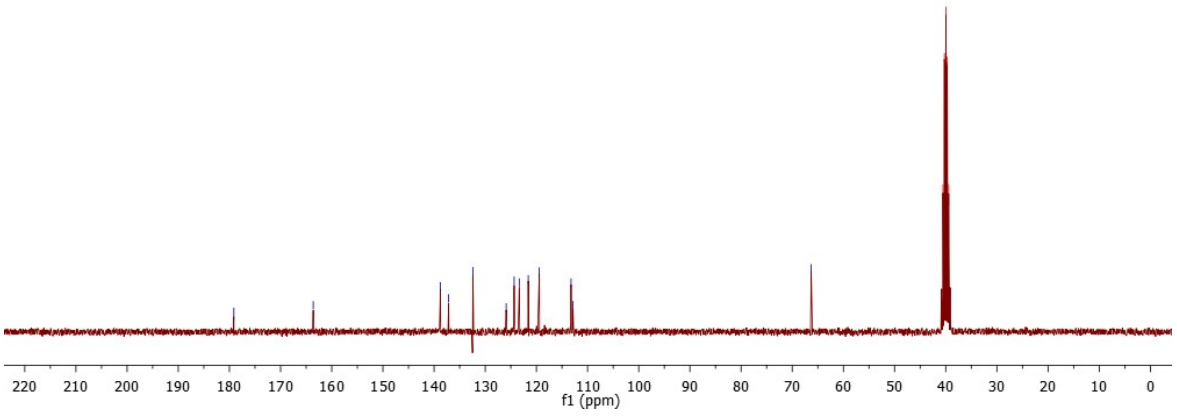

179.55
164.18
138.55
137.16
125.90
124.31
123.31
121.56
113.20
112.87
70.55
40.60 DMSO
40.39 DMSO
40.18 DMSO
39.97 DMSO
39.76 DMSO
39.56 DMSO
39.35 DMSO
36.92
29.46
26.29
25.57
O
O
O
N
H
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

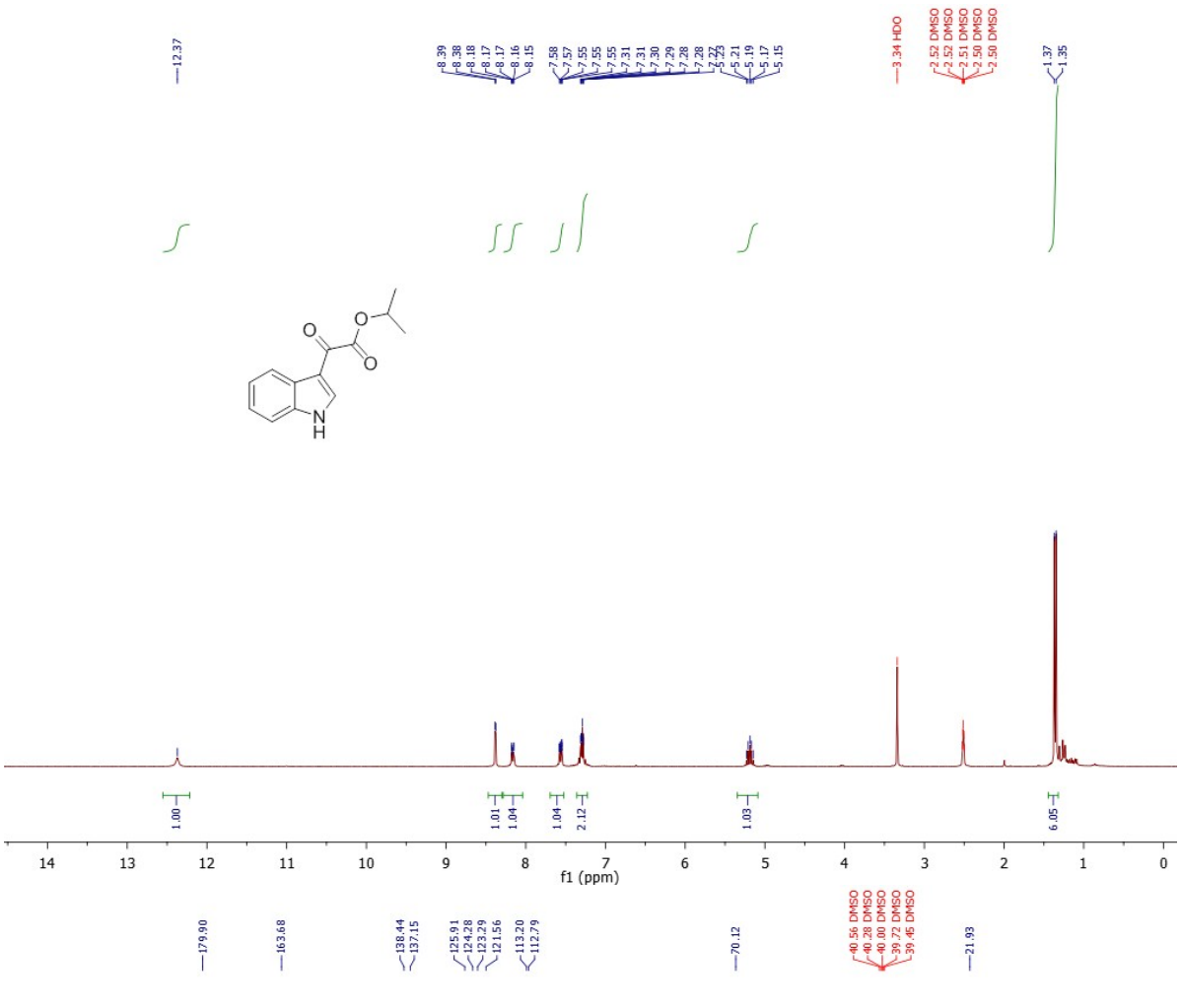

12.43
12.42
8.44
8.43
8.19
8.19
8.18
8.18
8.17
8.16
8.16
7.32
7.31
7.31
7.30
7.29
7.28
6.11
6.08
6.06
6.04
6.02
5.47
5.46
5.35
4.87
4.86
4.86
4.85
4.84
4.84
3.35 HDO
2.52 DMSO
2.51 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
O
O
O
N
H

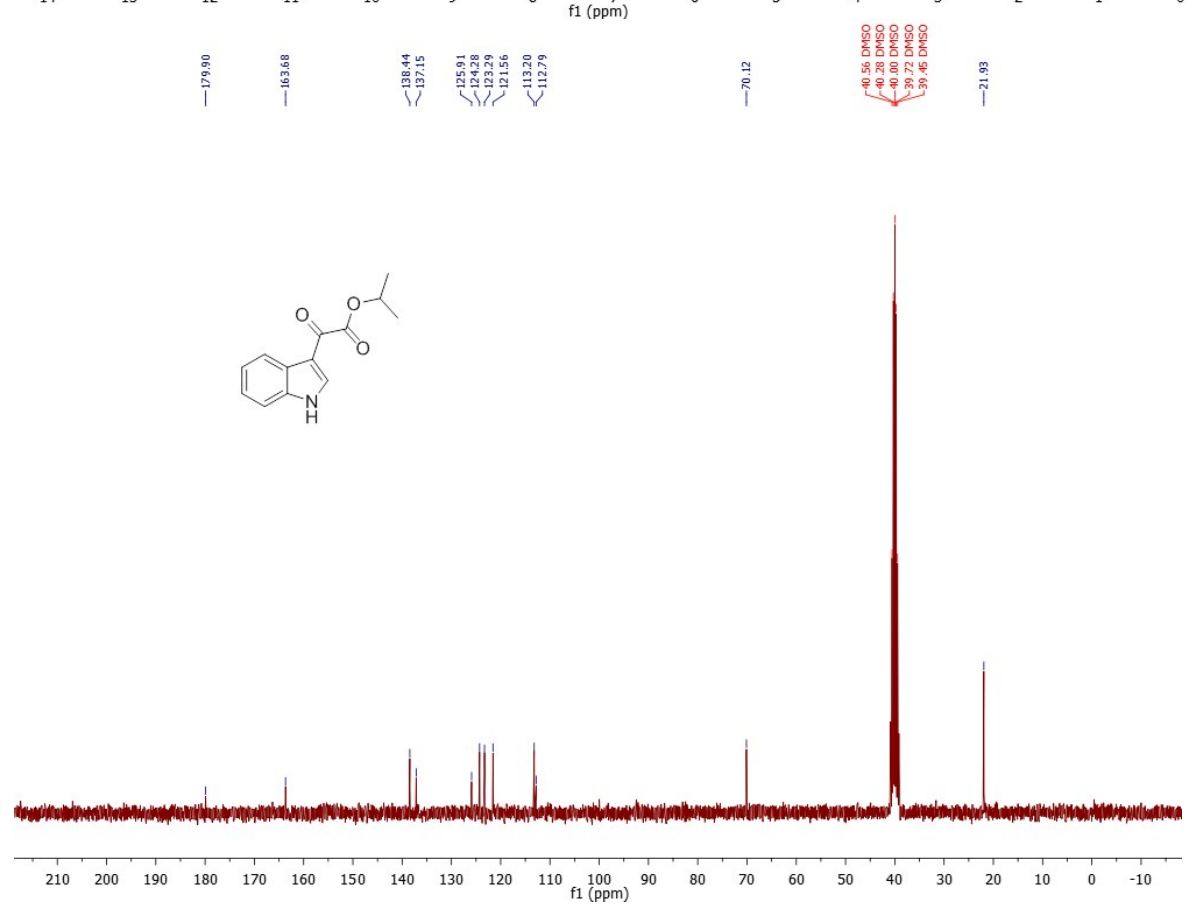

1.00
1.02
1.03
1.04
2.04
1.04
2.09
2.09
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

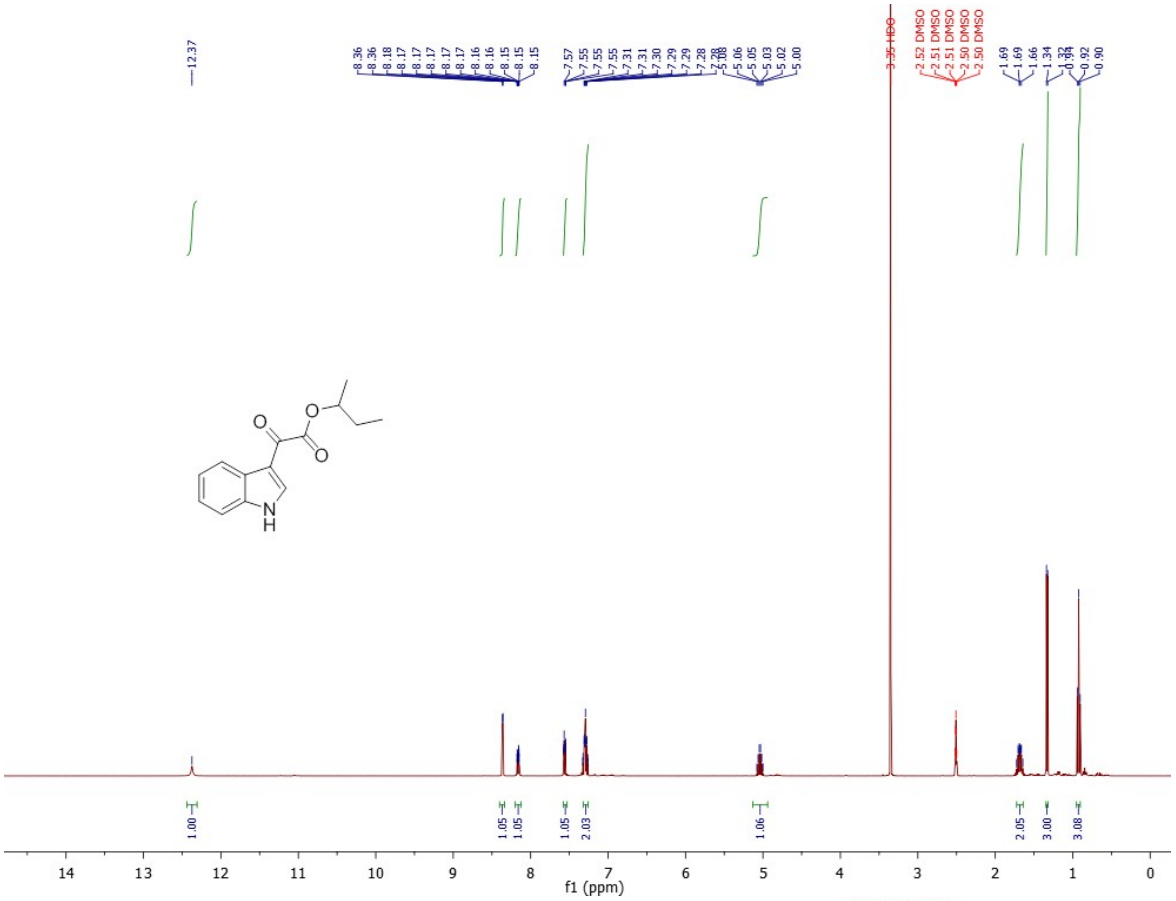

179.13
163.62
138.75
137.17
132.40
125.90
124.35
123.35
121.59
119.44
113.23
112.84
66.29
40.53 DMSO
40.26 DMSO
39.98 DMSO
39.70 DMSO
39.42 DMSO

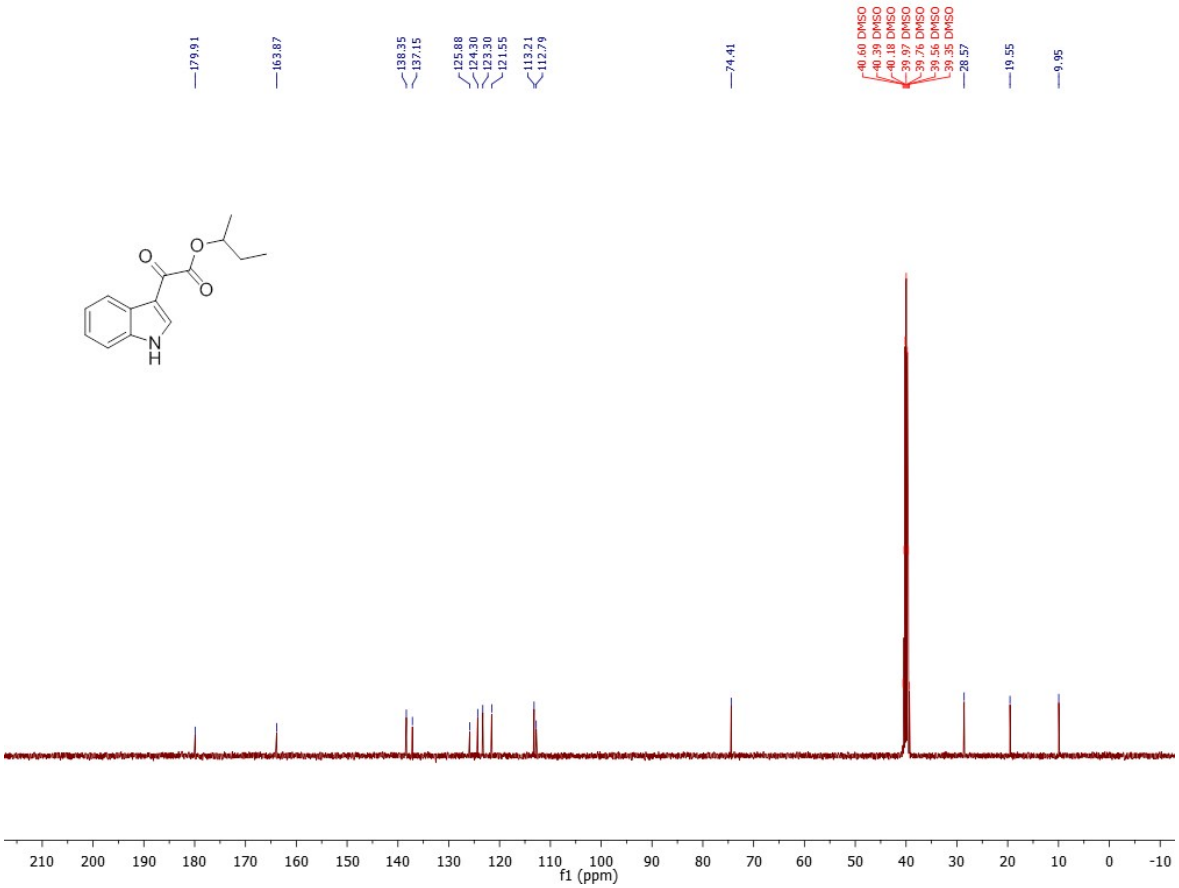

O
O
O
N
H

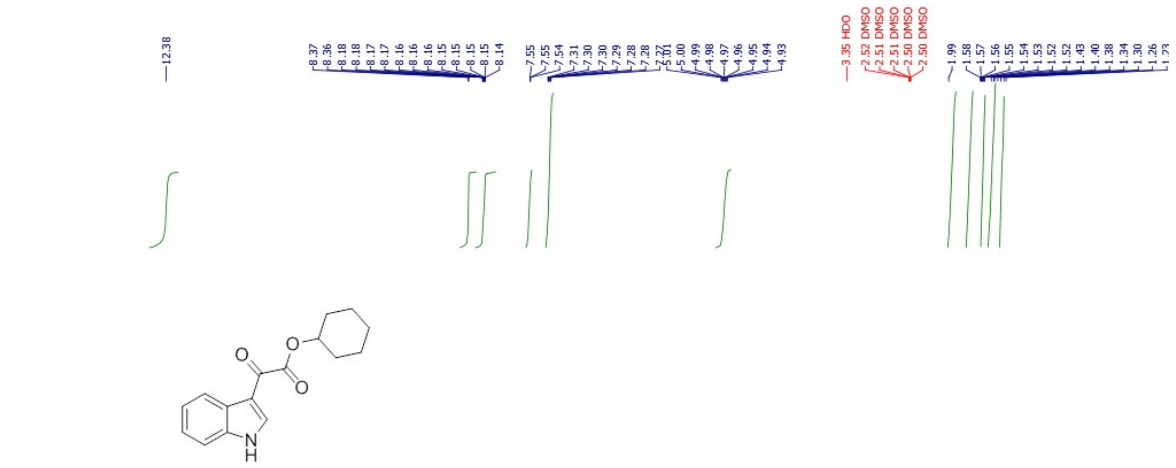

220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

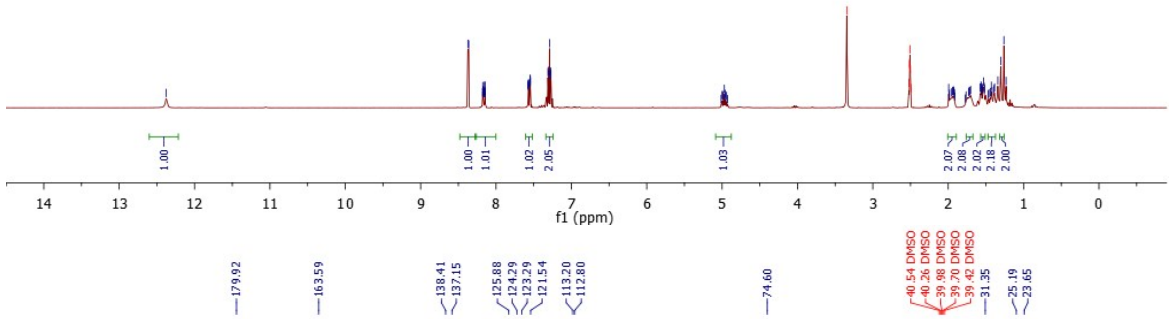

12.37
8.39
8.38
8.18
8.17
8.17
8.16
8.15
7.58
7.57
7.55
7.55
7.55
7.31
7.31
7.30
7.29
7.28
7.28
5.23
5.21
5.19
5.17
5.15
3.34 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.37
1.35
O
O
O
N
H
1.00
1.01
1.04
1.04
2.12
1.03
6.05
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


179.90
163.68
138.44
137.15
125.91
124.28
123.29
121.56
113.20
112.79
70.12
40.56 DMSO
40.28 DMSO
40.00 DMSO
39.72 DMSO
39.45 DMSO
21.93
O
O
O
N
H
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

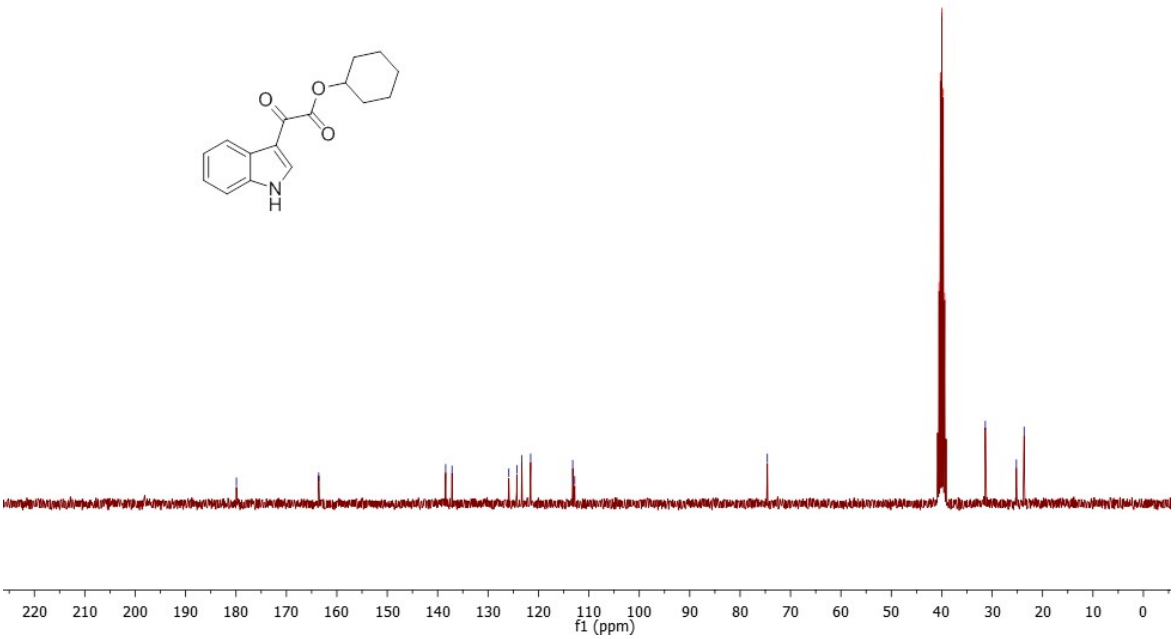

12.37
8.36
8.36
8.18
8.17
8.17
8.17
8.17
8.16
8.16
8.15
8.15
8.15
7.57
7.55
7.55
7.55
7.31
7.31
7.30
7.29
7.29
7.28
5.06
5.05
5.03
5.02
5.00
3.35 HDO
2.52 DMSO
2.51 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.69
1.69
1.66
1.34
0.92
0.90
1.00
1.05
1.05
1.05
2.03
1.06
2.05
3.00
3.08
f1 (ppm)

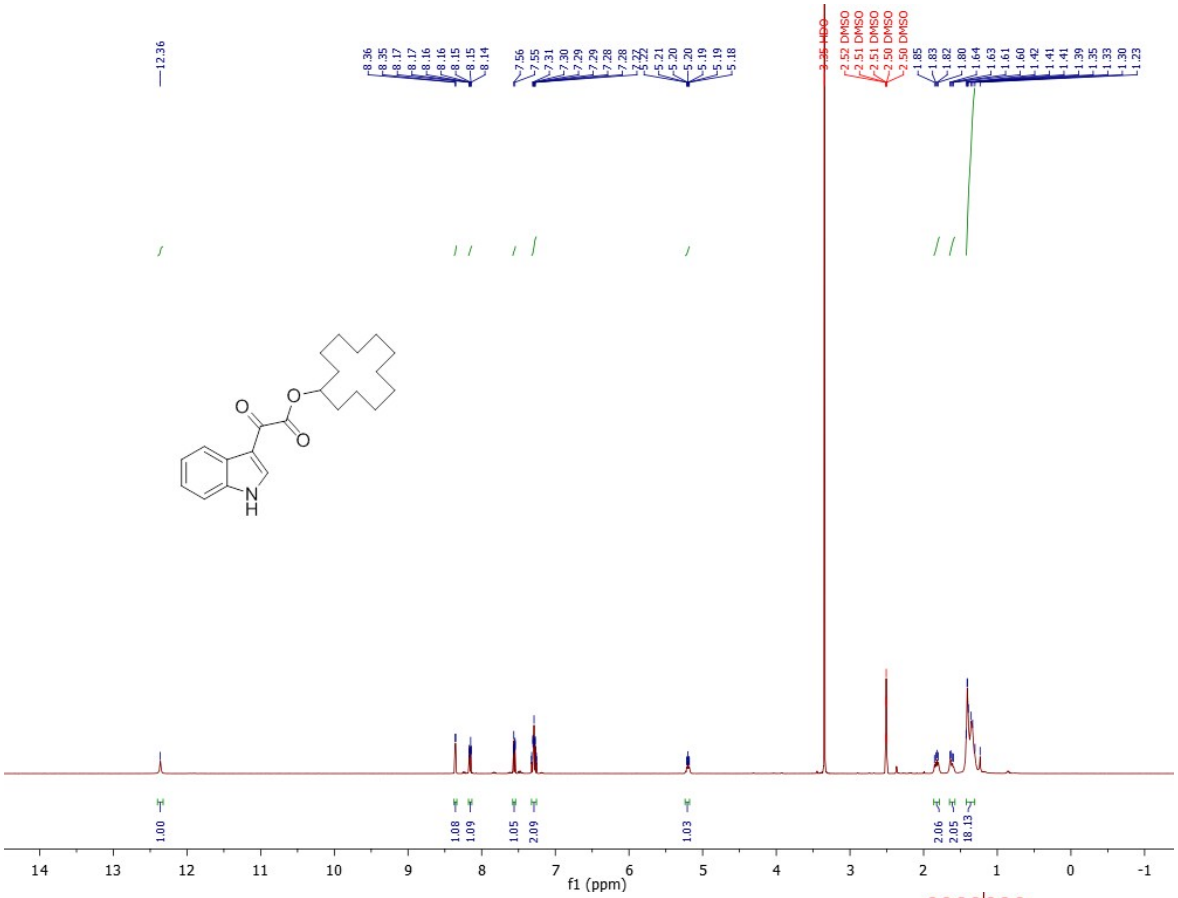

179.91
163.87
138.35
137.15
125.88
124.30
123.30
121.55
113.21
112.79
74.41
40.60 DMSO
40.39 DMSO
40.18 DMSO
39.97 DMSO
39.76 DMSO
39.56 DMSO
39.35 DMSO
28.57
19.55
9.95
f1 (ppm)

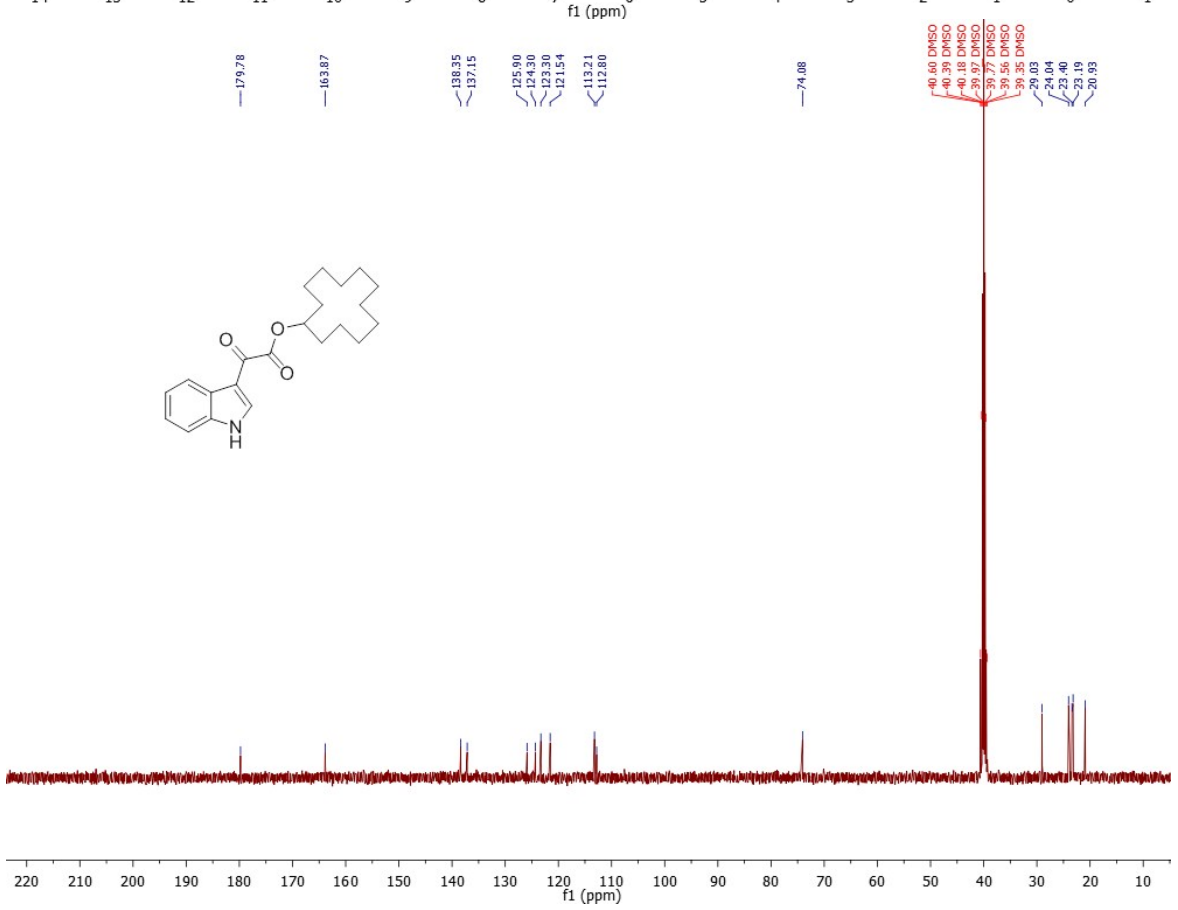

12.38
8.37
8.36
8.18
8.18
8.17
8.17
8.16
8.16
8.16
8.15
8.15
8.15
8.15
8.14
7.55
7.55
7.54
7.31
7.30
7.30
7.29
7.28
7.28
7.27
5.01
5.00
4.99
4.98
4.97
4.96
4.95
4.94
4.93
3.35 HDO
2.52 DMSO
2.51 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.99
1.58
1.57
1.56
1.55
1.54
1.53
1.52
1.52
1.48
1.40
1.38
1.34
1.30
1.26
O
O
O
N
H

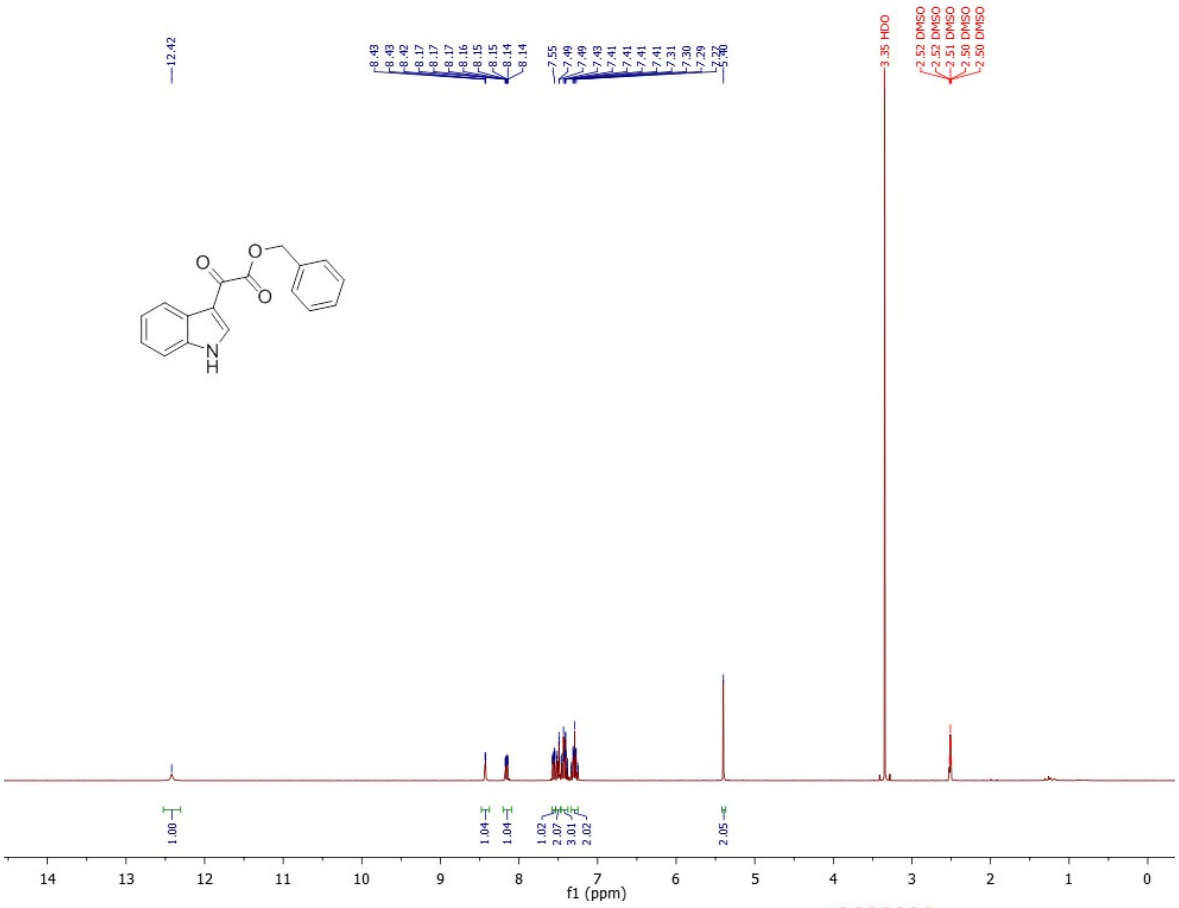

1.00
1.00
1.01
1.02
2.05
1.03
2.07
2.08
2.02
2.18
2.00
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

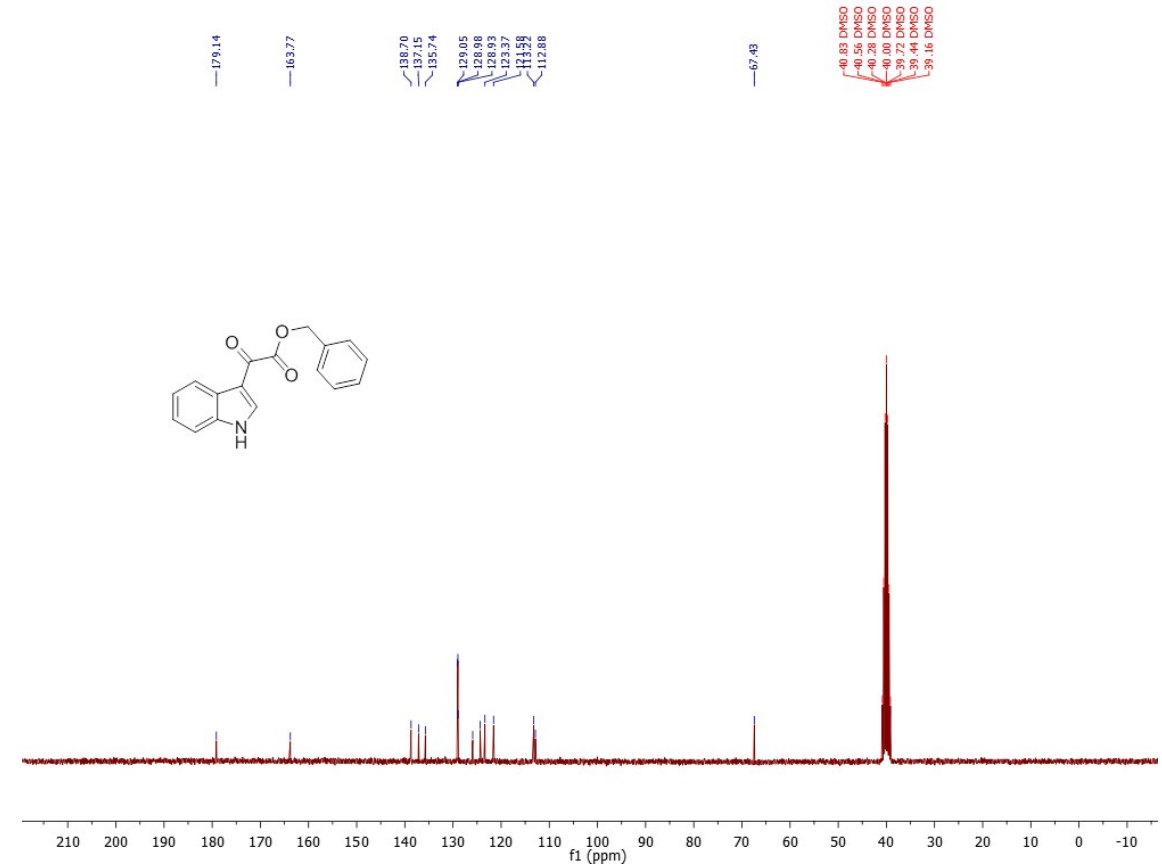
179.92
163.59
138.41
137.15
125.88
124.29
123.29
121.54
113.20
112.80
74.60
40.54 DMSO
40.26 DMSO
39.98 DMSO
39.70 DMSO
39.42 DMSO
31.35
25.19
23.65

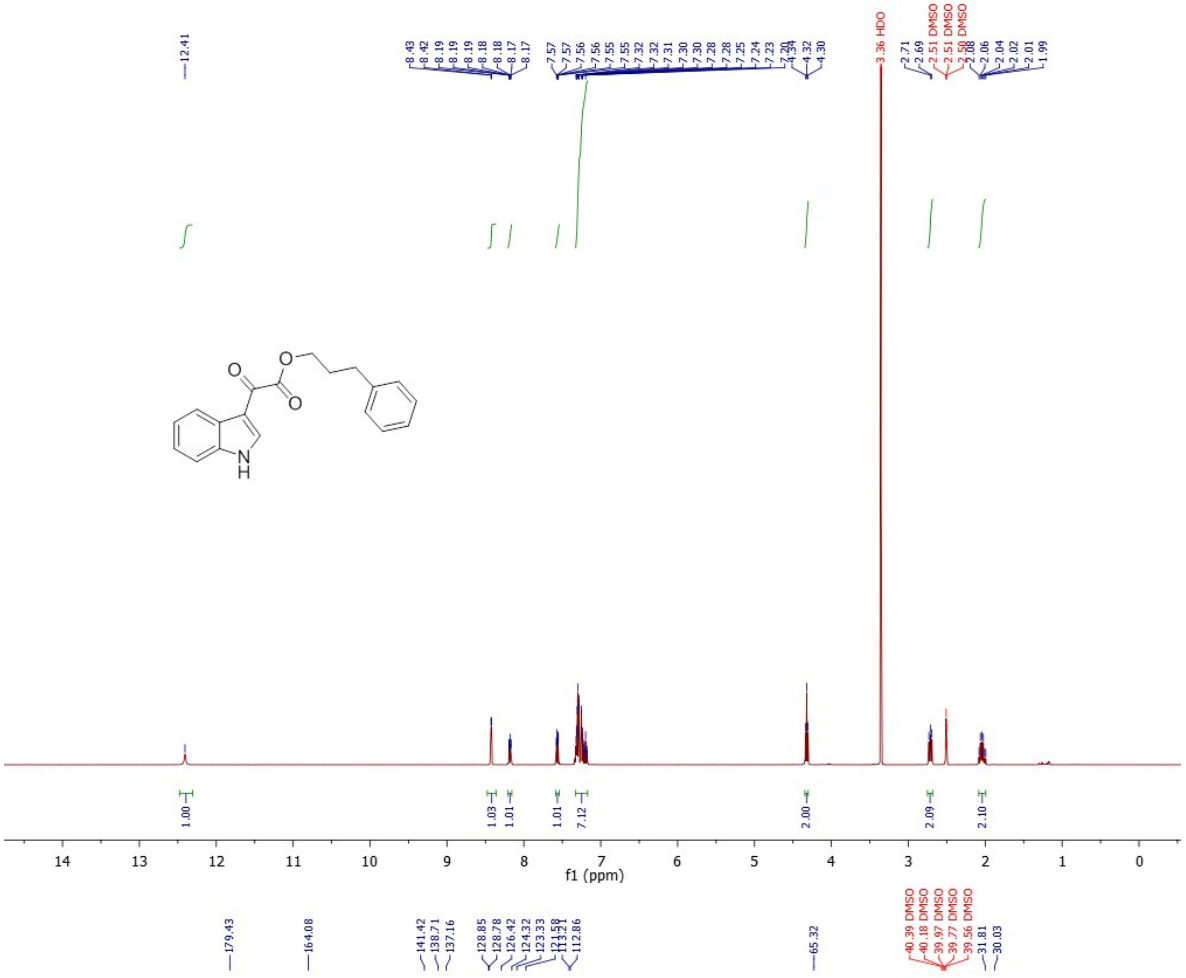

O
O
O
N
H
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

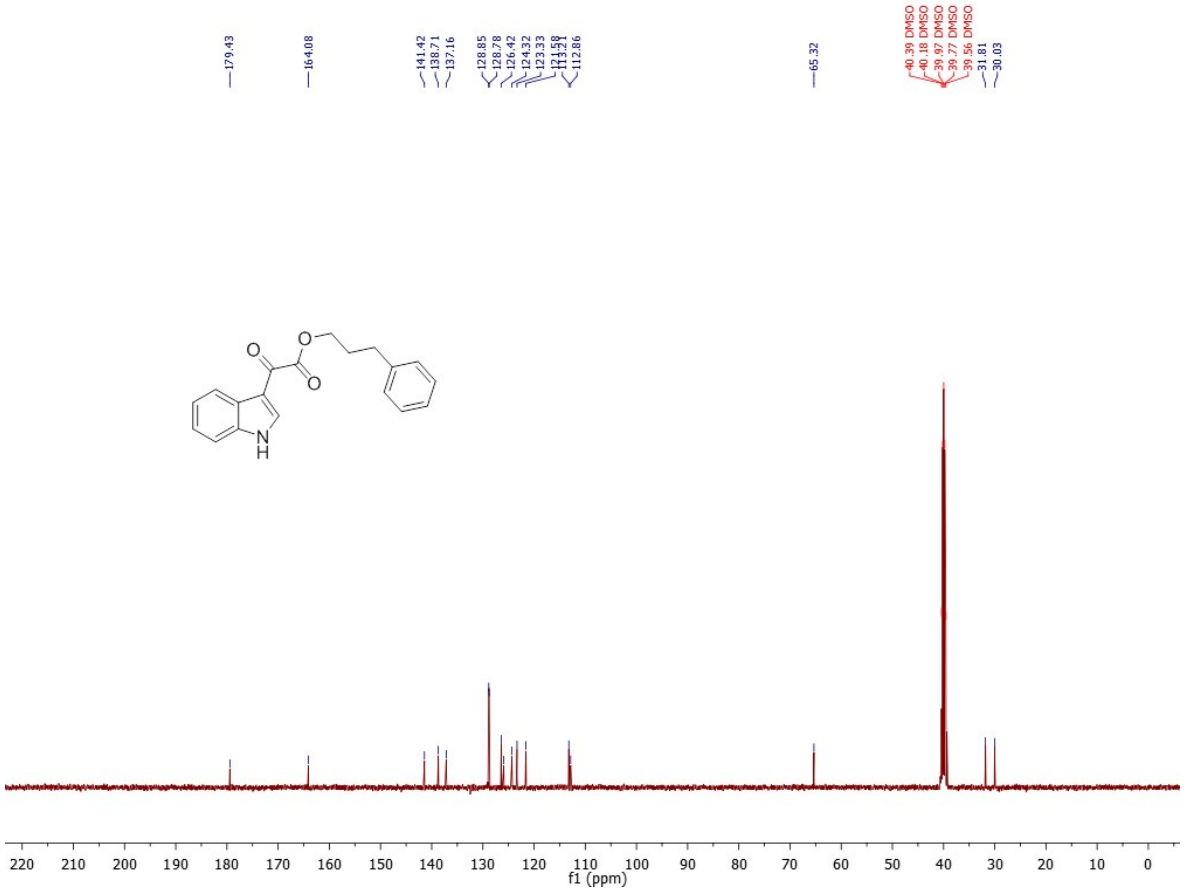

12.36
8.36
8.35
8.17
8.17
8.16
8.16
8.15
8.15
8.14
7.56
7.55
7.31
7.30
7.29
7.29
7.28
7.28
5.22
5.21
5.20
5.20
5.19
5.19
5.18
3.35 HDO
2.52 DMSO
2.51 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.85
1.83
1.82
1.80
1.64
1.63
1.61
1.60
1.42
1.41
1.41
1.39
1.35
1.33
1.30
1.23
O
O
O
N
H
1.00
1.08
1.09
1.05
2.09
1.03
2.06
2.05
18.13
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
f1 (ppm)

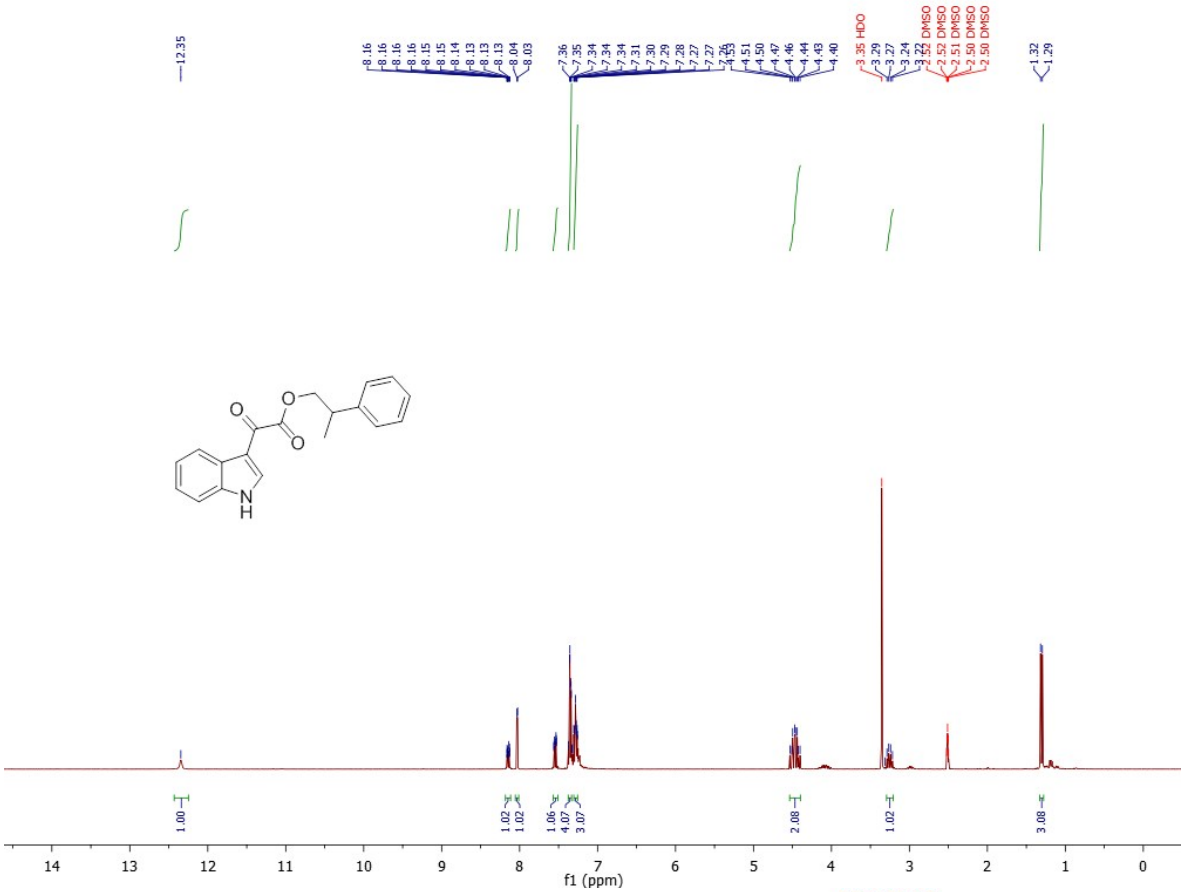

179.78
163.87
138.35
137.15
125.90
124.30
123.30
121.54
113.21
112.80
74.08
40.60 DMSO
40.39 DMSO
40.18 DMSO
39.97 DMSO
39.77 DMSO
39.56 DMSO
39.35 DMSO
29.03
24.04
23.40
23.19
20.93
O
O
O
N
H
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

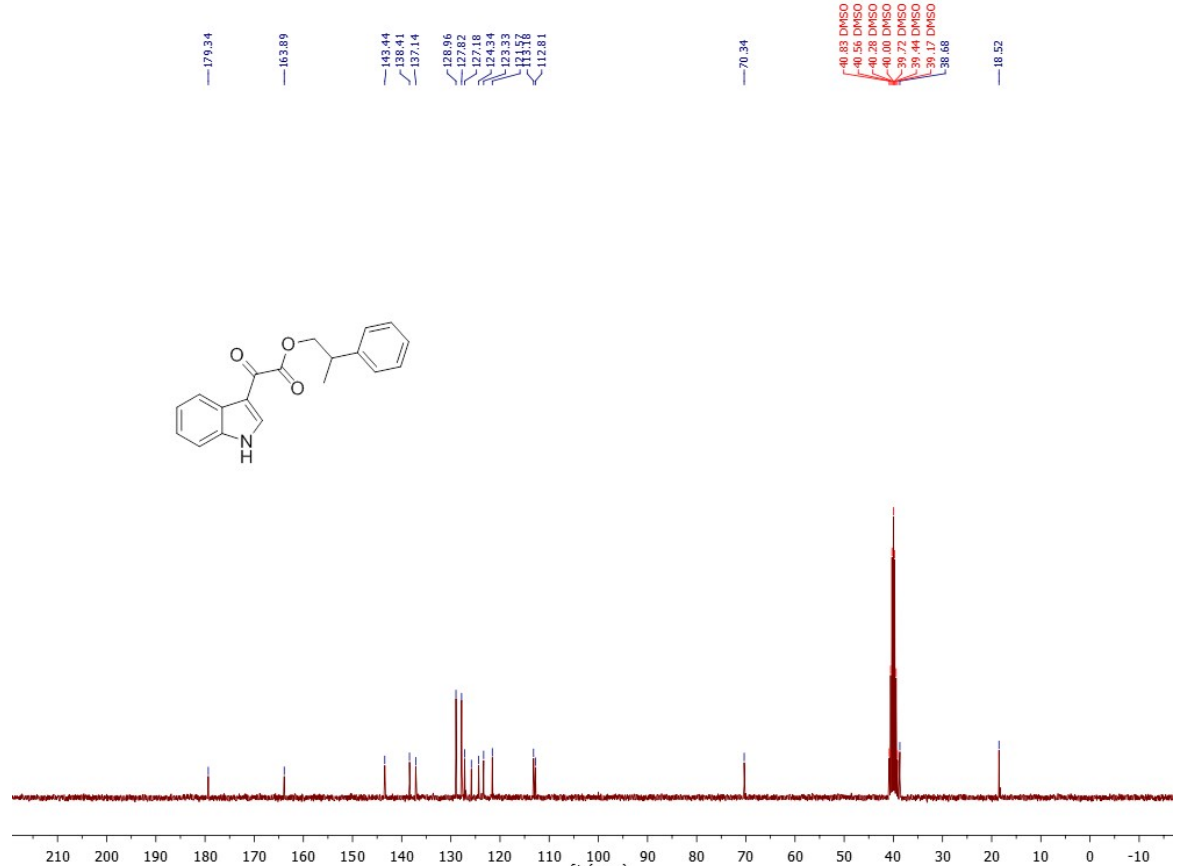

12.42
8.43
8.43
8.42
8.17
8.17
8.17
8.16
8.15
8.15
8.14
8.14
7.55
7.49
7.49
7.43
7.41
7.41
7.41
7.41
7.31
7.30
7.29
7.27
5.30
3.35 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
O
O
O
N
H
1.00
1.04
1.04
1.02
2.07
3.01
2.02
2.05
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

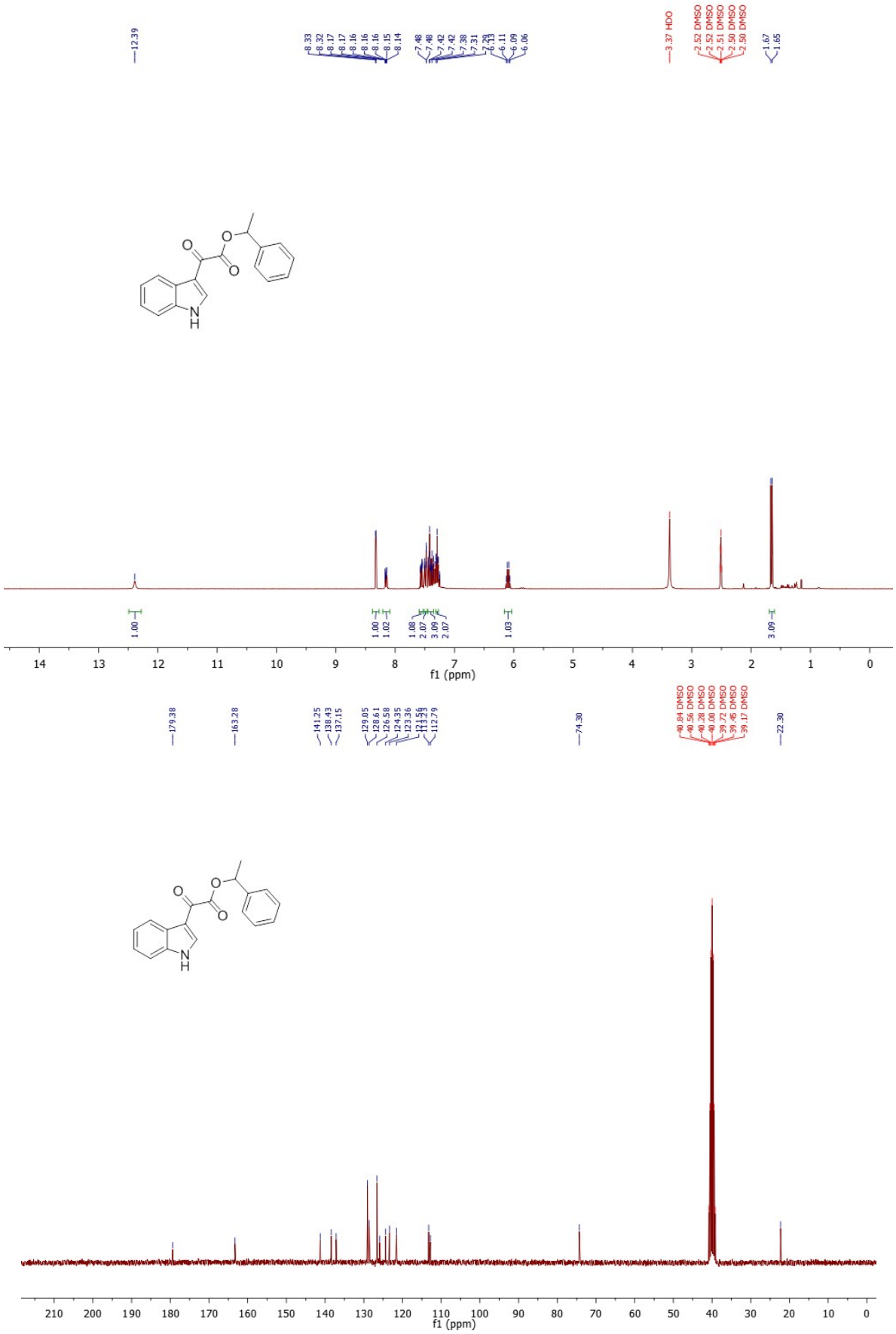

179.14
163.77
138.70
137.15
135.74
129.05
128.98
128.93
123.37
121.58
113.22
112.88
67.43
40.83 DMSO
40.56 DMSO
40.28 DMSO
40.00 DMSO
39.72 DMSO
39.44 DMSO
39.16 DMSO
O
O
O
N
H
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

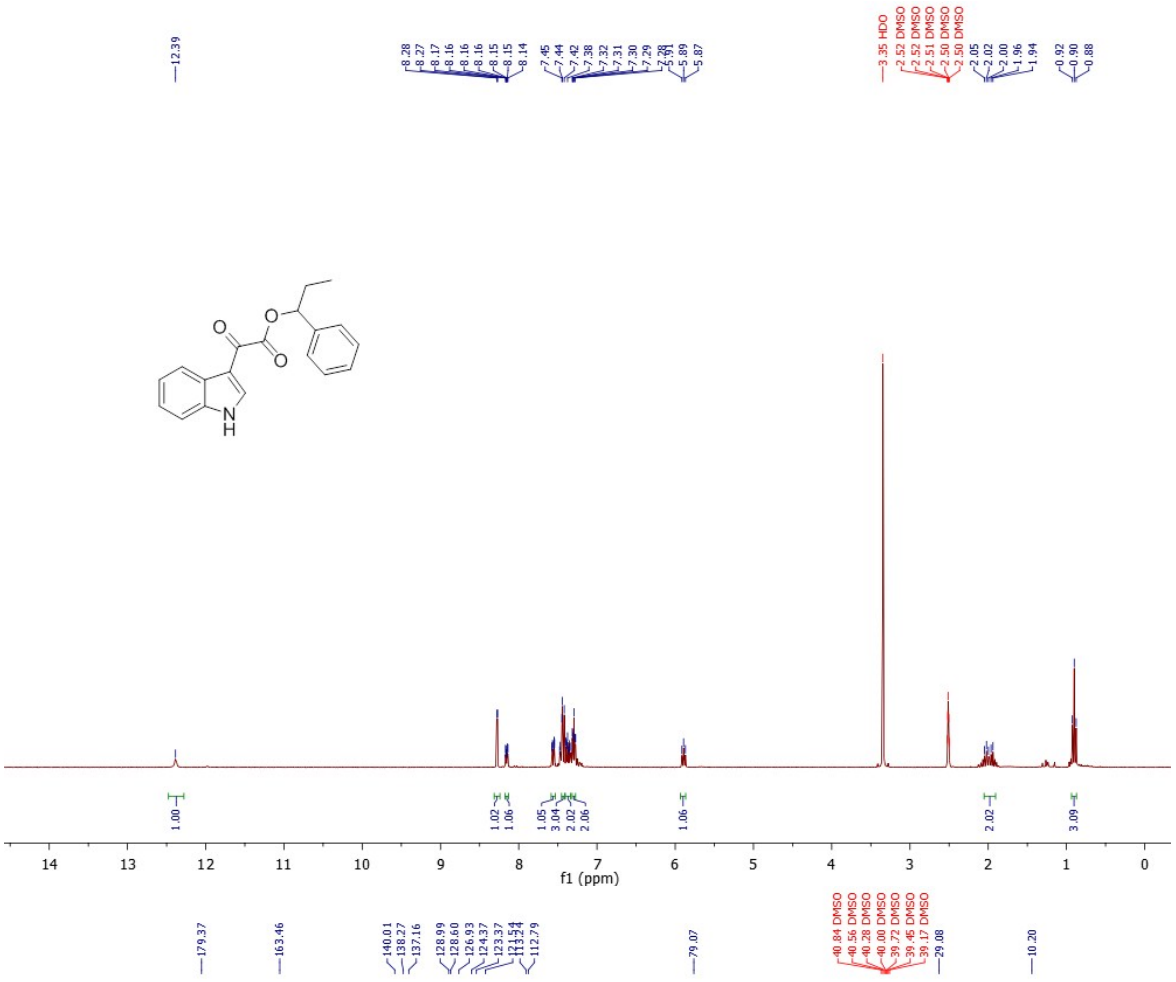

12.41
8.43
8.42
8.19
8.19
8.19
8.18
8.18
8.17
8.17
7.57
7.57
7.56
7.56
7.55
7.55
7.32
7.32
7.31
7.30
7.30
7.28
7.28
7.25
7.24
7.23
4.32
4.30
3.36 HDO
2.71
2.69
2.51 DMSO
2.51 DMSO
2.08 DMSO
2.06
2.04
2.02
2.01
1.99
1.00
1.03
1.01
1.01
7.12
2.00
2.09
2.10
f1 (ppm)

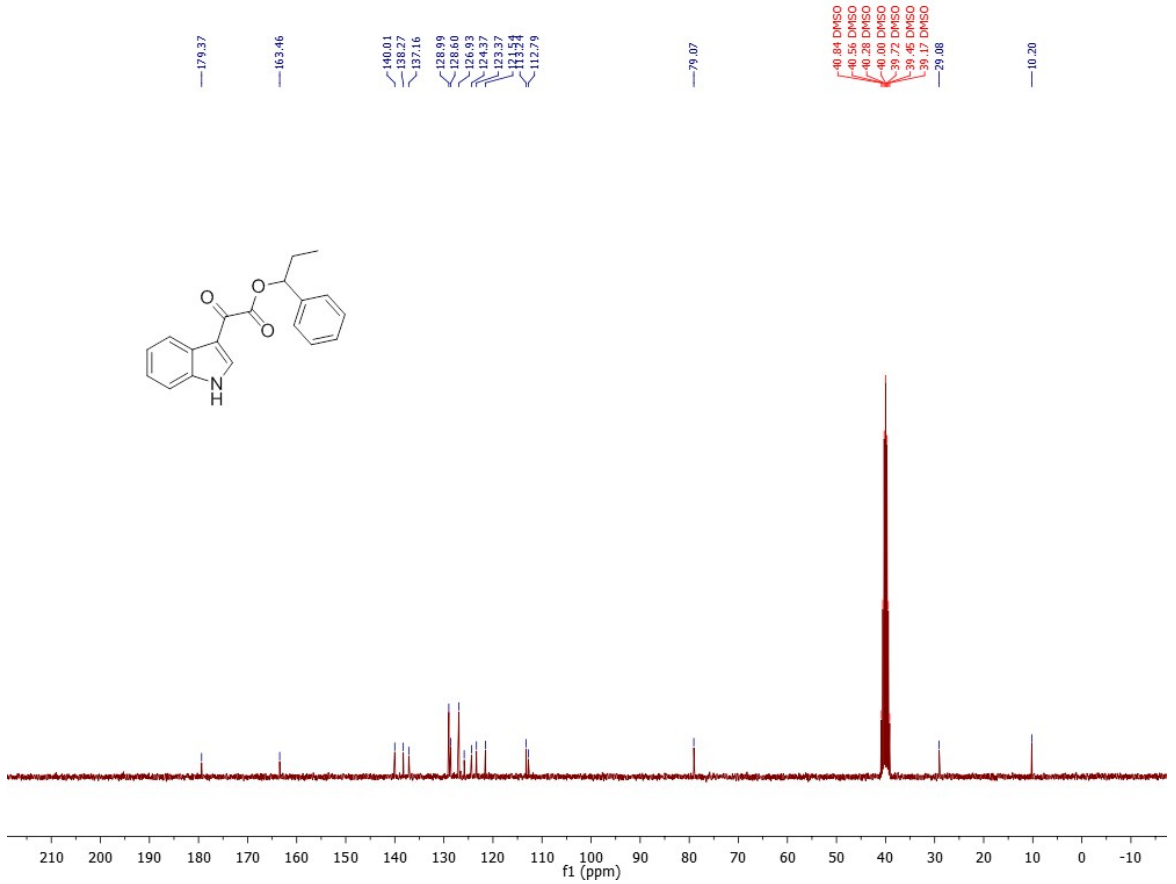

179.43
164.08
141.42
138.71
137.16
128.85
128.78
126.42
124.32
123.33
112.86
65.32
40.39 DMSO
40.18 DMSO
39.97 DMSO
39.77 DMSO
39.56 DMSO
31.81
30.03
f1 (ppm)

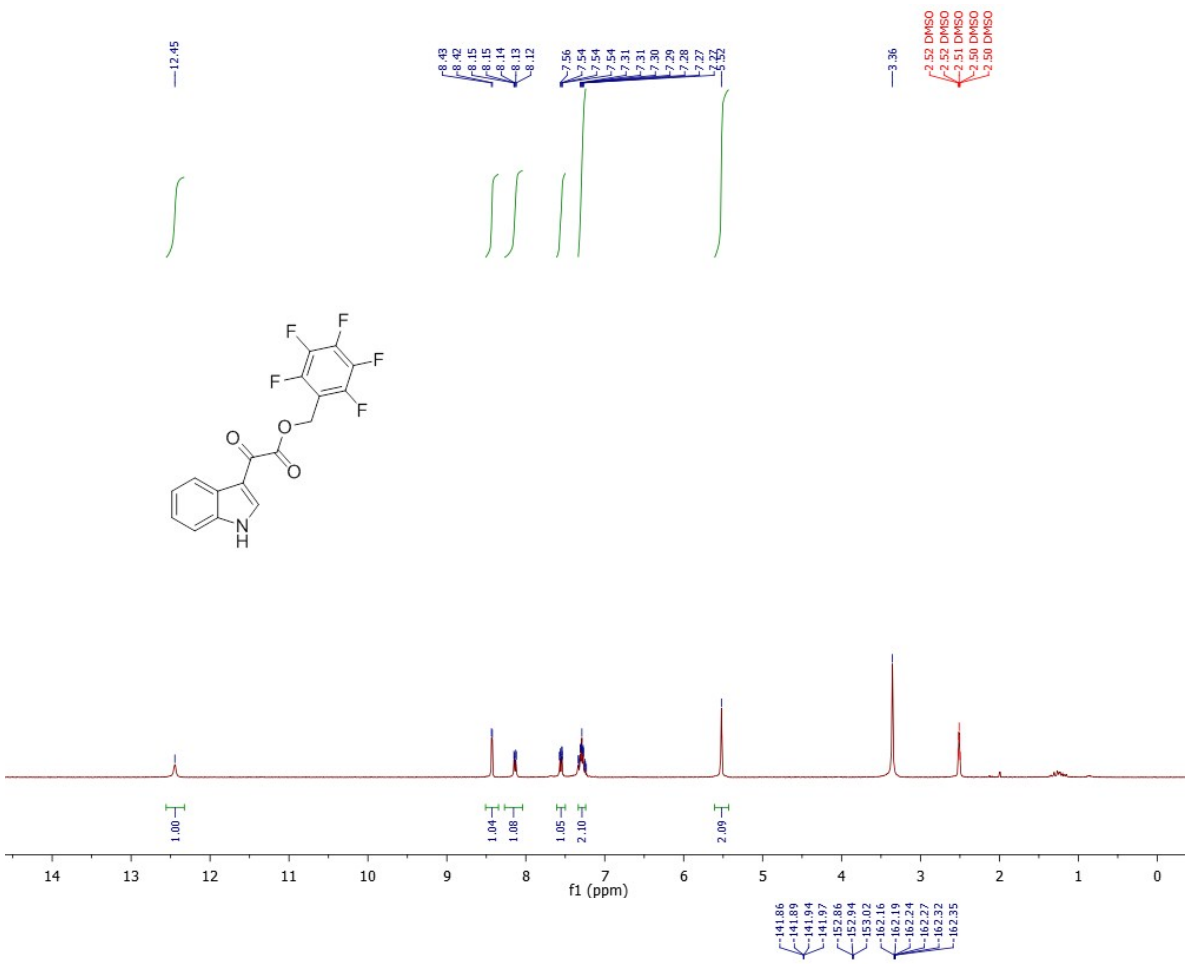

12.35
8.16
8.16
8.16
8.16
8.15
8.15
8.14
8.13
8.13
8.13
8.04
8.03
7.36
7.35
7.34
7.34
7.34
7.31
7.30
7.29
7.28
7.27
7.27
4.53
4.51
4.50
4.47
4.46
4.44
4.43
4.40
3.35 HDO
3.29
3.27
3.24
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.32
1.29
O
O
O
N
H
1.00
1.02
1.02
1.06
4.07
3.07
2.08
1.02
3.08
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


179.34
163.89
143.44
138.41
137.14
128.96
127.82
127.18
124.34
123.33
121.57
113.18
112.81
70.34
40.83 DMSO
40.56 DMSO
40.28 DMSO
40.00 DMSO
39.72 DMSO
39.44 DMSO
39.17 DMSO
38.68
18.52
O
O
O
N
H
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

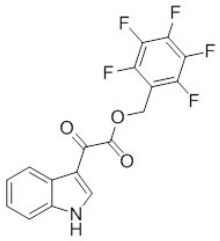

12.39
8.33
8.32
8.17
8.17
8.16
8.16
8.16
8.15
8.14
7.48
7.48
7.42
7.42
7.38
7.31
7.23
7.11
6.11
6.09
6.06
3.37 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.67
1.65
O
O
O
N
H
1.00
1.00
1.02
1.08
2.07
3.09
2.07
1.03
3.09
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)
179.38
163.28
141.25
138.43
137.15
129.05
128.61
126.58
124.35
123.36
121.56
113.55
112.79
74.30
40.84 DMSO
40.56 DMSO
40.28 DMSO
40.00 DMSO
39.72 DMSO
39.45 DMSO
39.17 DMSO
22.30
O
O
O
N
H
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

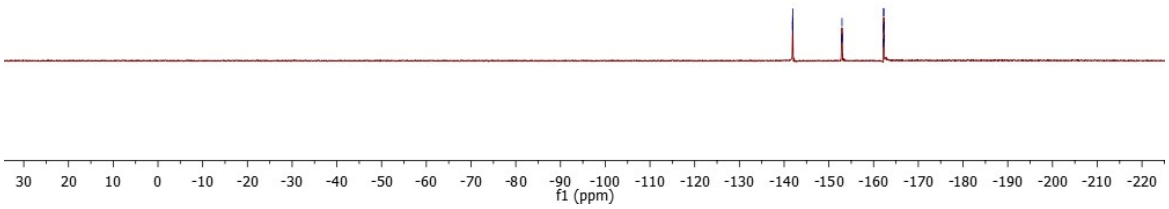

12.39
8.28
8.27
8.17
8.16
8.16
8.16
8.15
8.15
8.14
7.45
7.44
7.42
7.38
7.32
7.31
7.30
7.29
5.89
5.87
3.35 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
2.05
2.02
2.00
1.96
1.94
0.92
0.90
0.88
1.00
1.02
1.06
1.05
3.04
2.02
2.06
1.06
2.02
3.09
f1 (ppm)

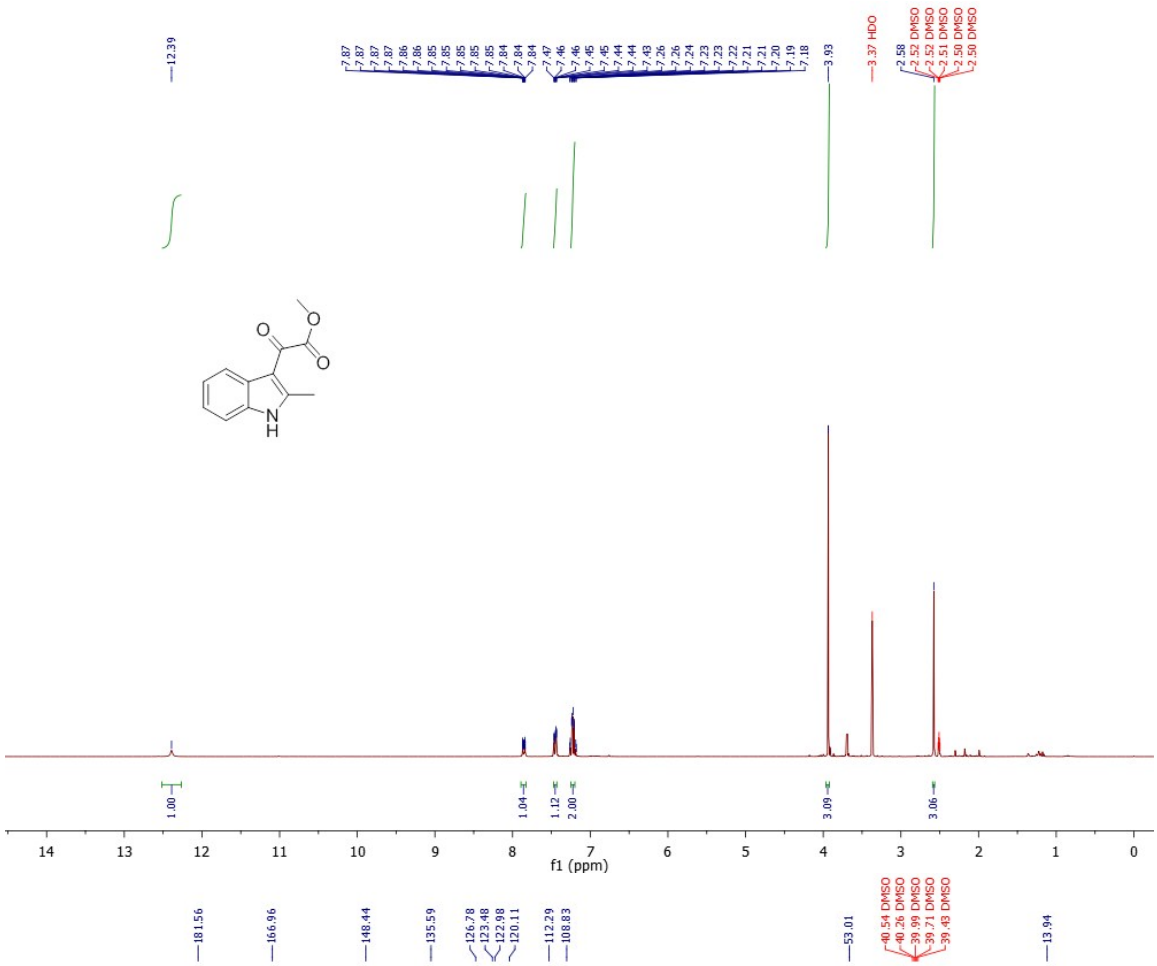

179.37
163.46
140.01
138.27
137.16
128.99
128.60
126.93
124.37
123.37
112.79
79.07
40.84 DMSO
40.56 DMSO
40.28 DMSO
40.00 DMSO
39.72 DMSO
39.45 DMSO
39.17 DMSO
29.08
10.20
f1 (ppm)

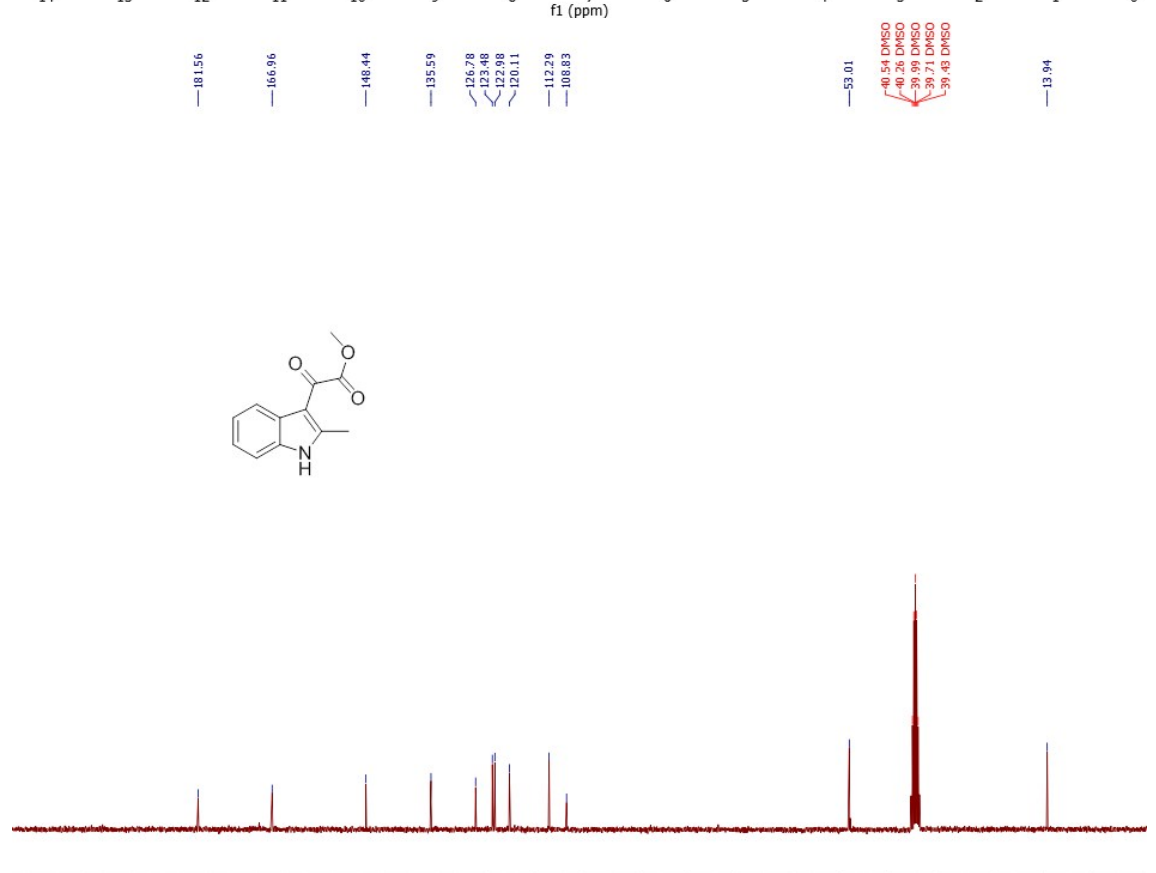

12.45
8.43
8.42
8.15
8.15
8.14
8.13
8.12
7.56
7.54
7.54
7.54
7.31
7.31
7.30
7.29
7.28
7.27
5.52
3.36
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
F
F
F
F
F
O
O
O
N
H
1.00
1.04
1.08
1.05
2.10
2.09
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

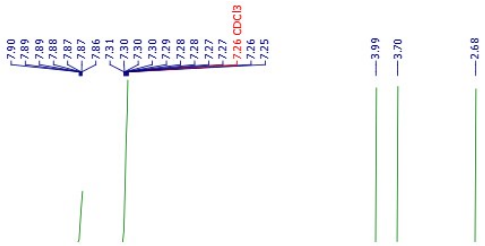
141.86
141.89
141.94
141.97
152.86
152.94
153.02
162.16
162.19
162.24
162.27
162.32
162.35

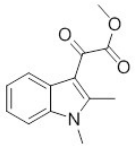

F
F
F
F
F
O
O
O
N
H

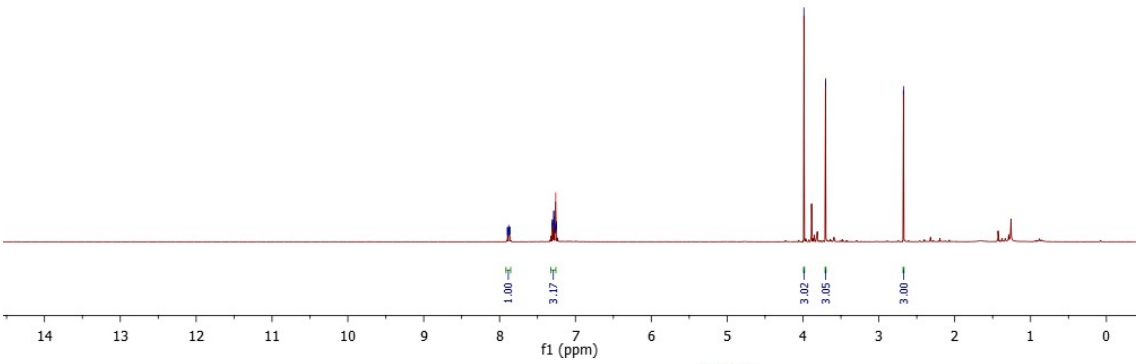

30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
-220
f1 (ppm)


12.39
7.87
7.87
7.87
7.87
7.86
7.86
7.85
7.85
7.85
7.85
7.84
7.84
7.84
7.84
7.47
7.46
7.46
7.45
7.45
7.44
7.44
7.43
7.26
7.26
7.24
7.23
7.23
7.22
7.21
7.21
7.20
7.19
7.18
3.93
3.37 HDO
2.58
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.00
1.04
1.12
2.00
3.09
3.06
f1 (ppm)

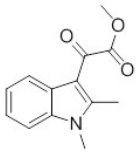

181.56
166.96
148.44
135.59
126.78
123.48
122.98
120.11
112.29
108.83
53.01
40.54 DMSO
40.26 DMSO
39.99 DMSO
39.71 DMSO
39.43 DMSO
13.94
f1 (ppm)

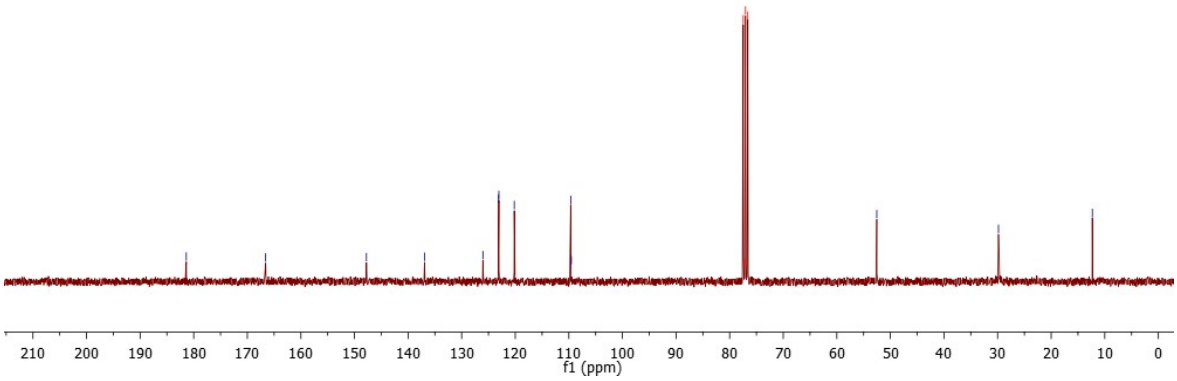

7.90
7.89
7.89
7.88
7.87
7.87
7.86
7.31
7.30
7.30
7.30
7.29
7.28
7.28
7.27
7.27
7.26 CDCl3
7.26
7.25
3.99
3.70
2.68

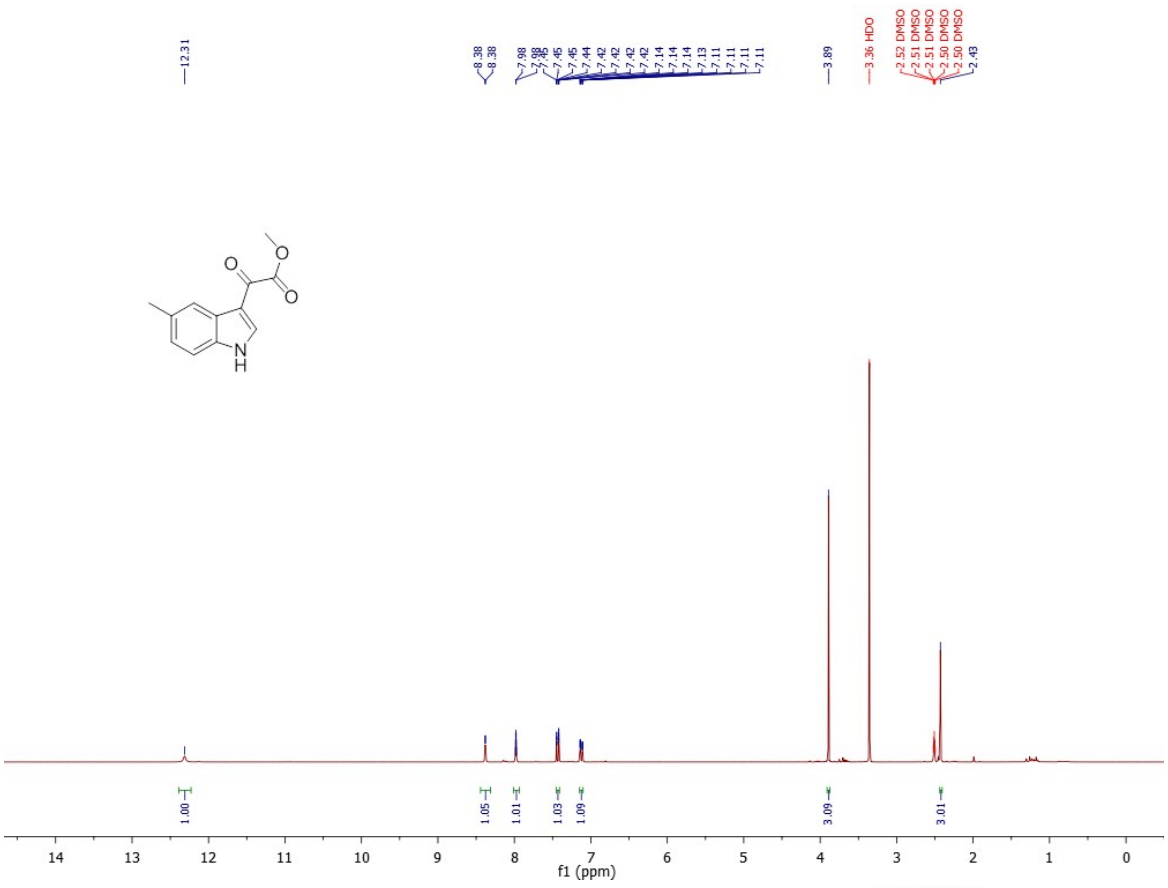


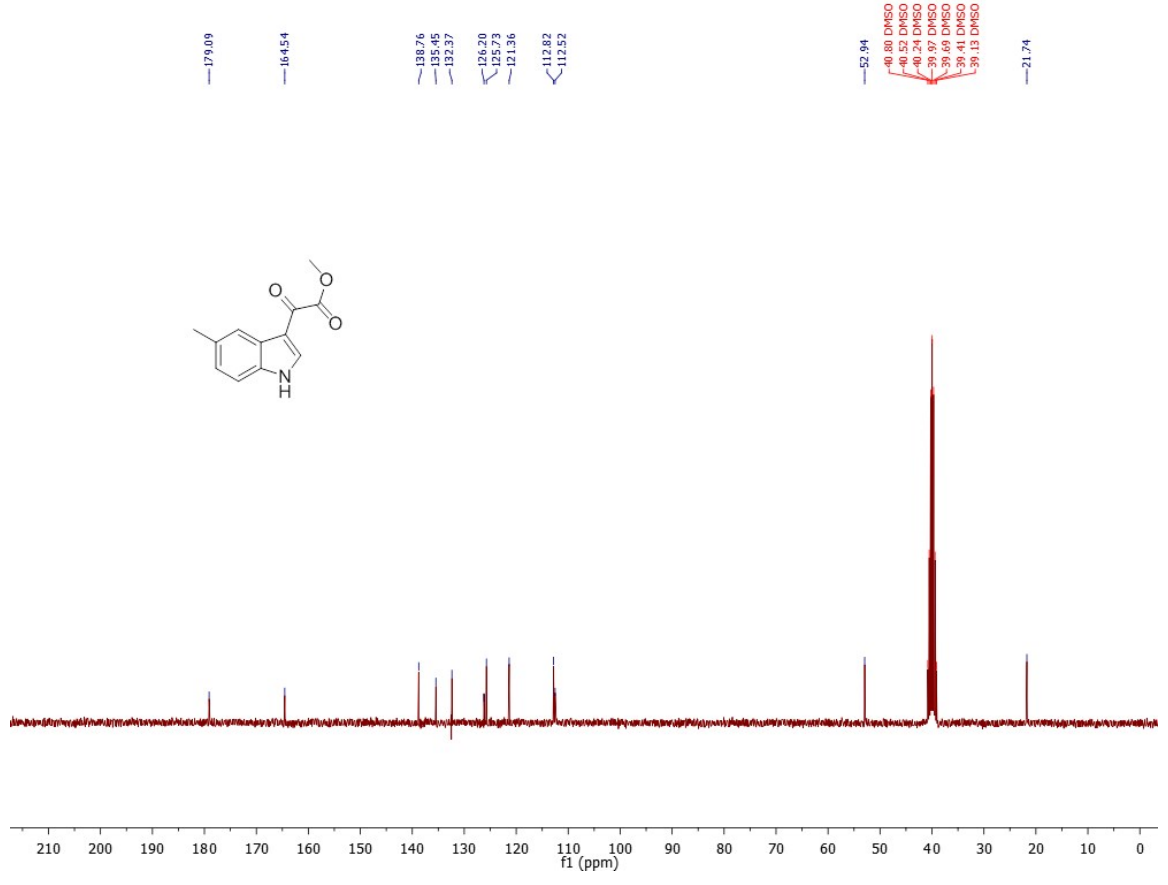

1.00
3.17
3.02
3.05
3.00
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

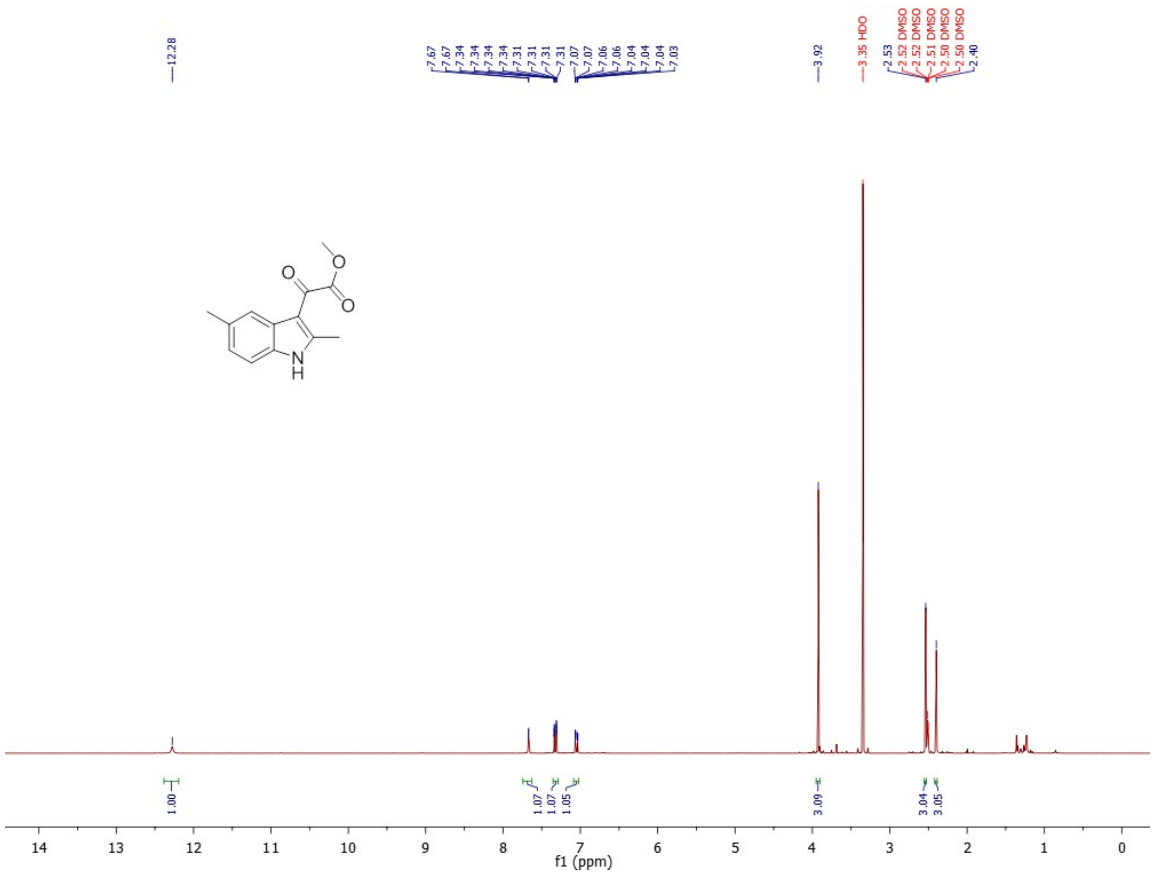

181.39
166.58
147.77
136.92
126.04
123.11
123.06
120.18
109.66
109.54
77.46 CDCl3
77.24 CDCl3
77.04 CDCl3
76.61 CDCl3
52.55
29.83
12.32

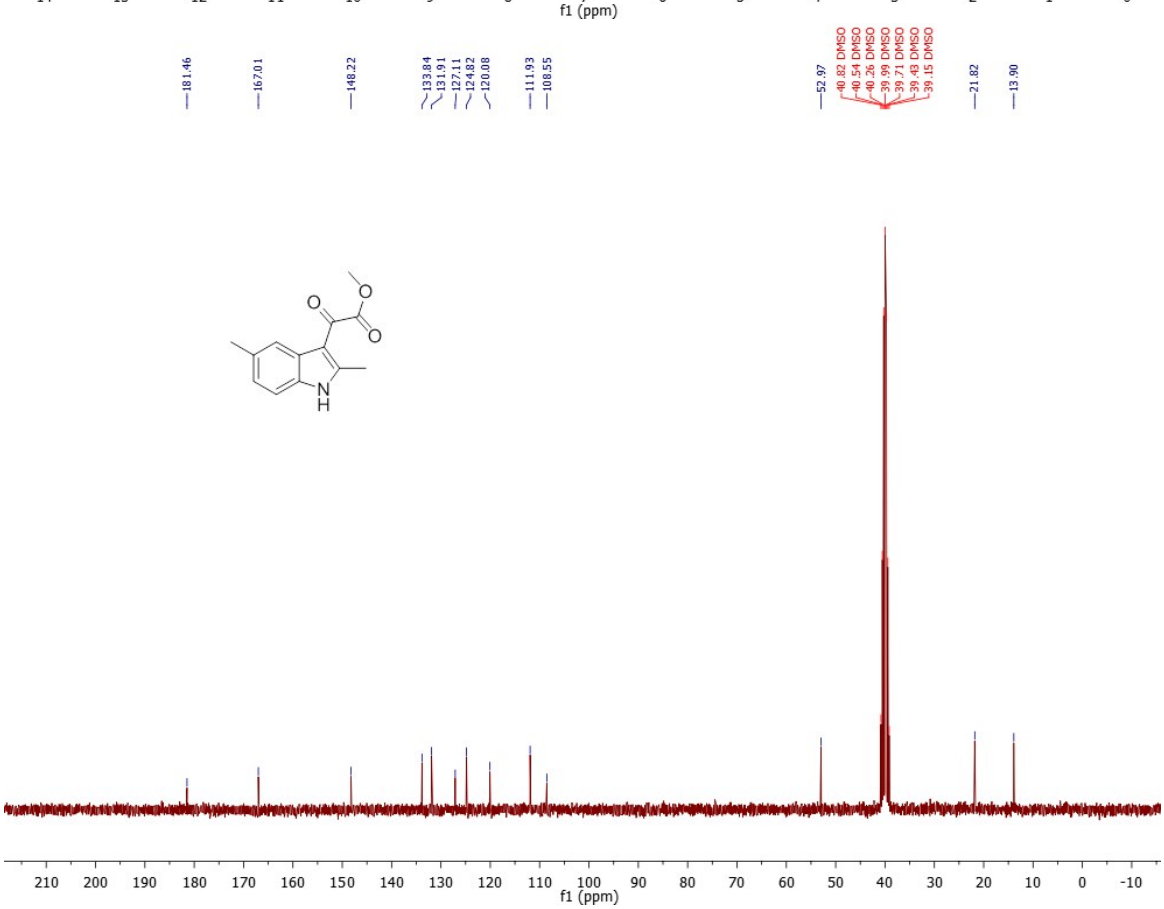


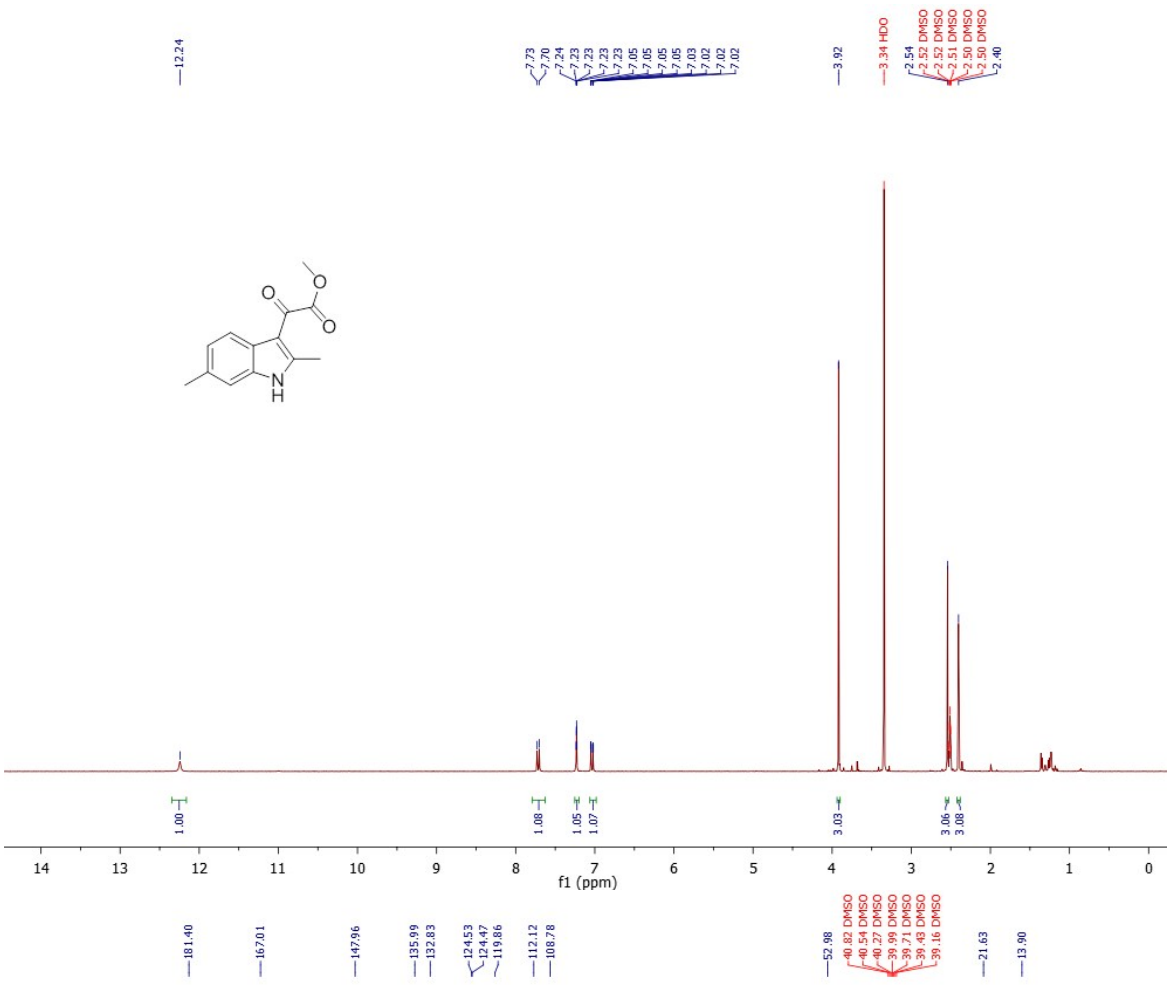

210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

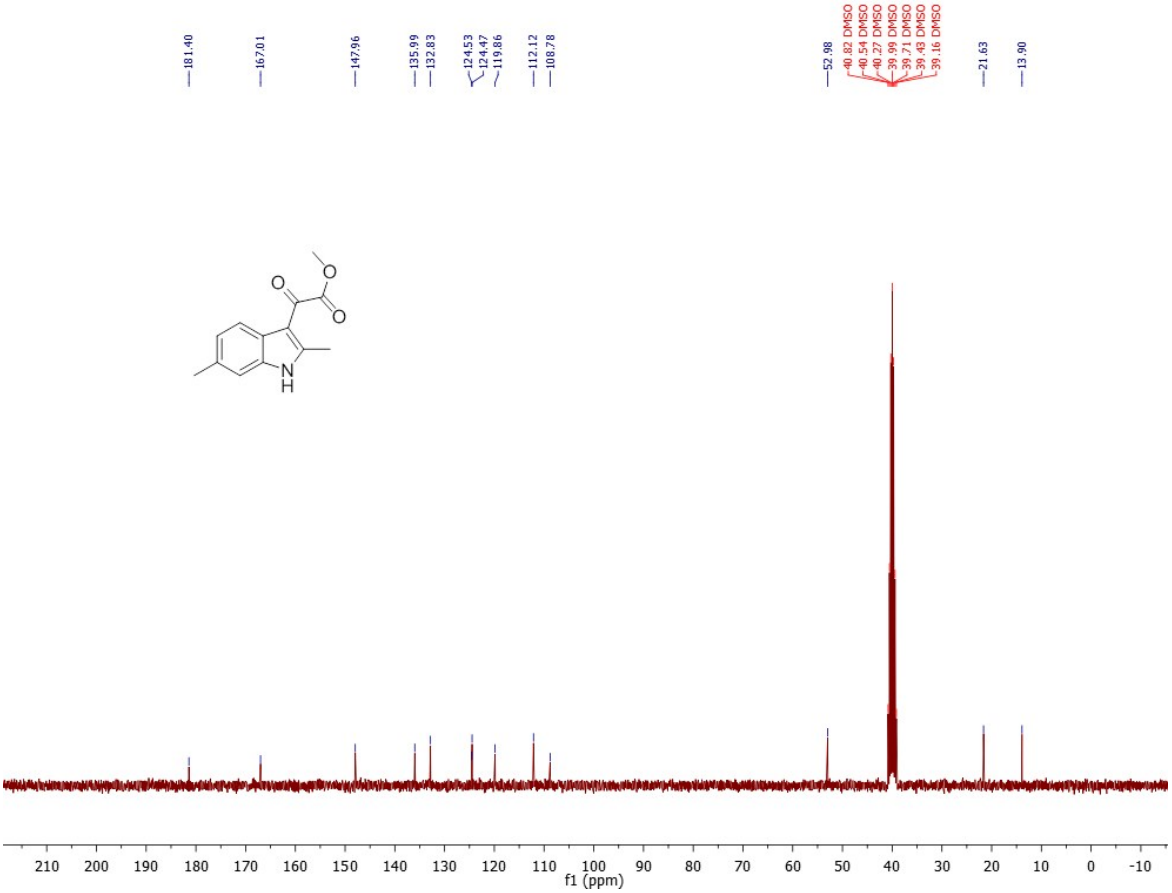

12.31
8.38
8.38
7.98
7.98
7.46
7.45
7.45
7.44
7.42
7.42
7.42
7.42
7.14
7.14
7.14
7.13
7.11
7.11
7.11
7.11
3.89
3.36 HDO
2.52 DMSO
2.51 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
2.43
O
O
O
N
H
1.00
1.05
1.01
1.03
1.09
3.09
3.01
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

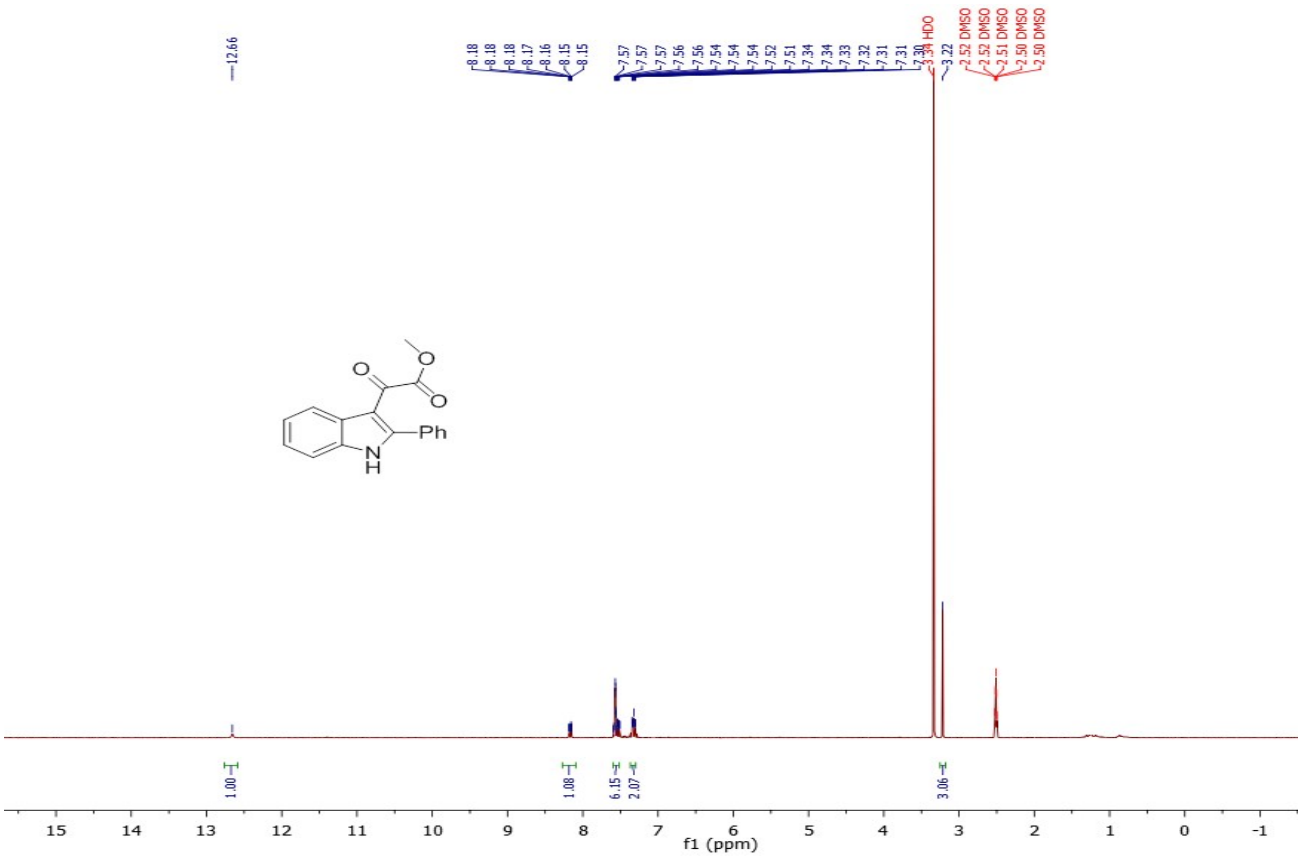

179.09
164.54
138.76
135.45
132.37
126.20
125.73
121.36
112.82
112.52
52.94
40.80 DMSO
40.52 DMSO
40.24 DMSO
39.97 DMSO
39.69 DMSO
39.41 DMSO
39.13 DMSO
21.74
O
O
O
N
H
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

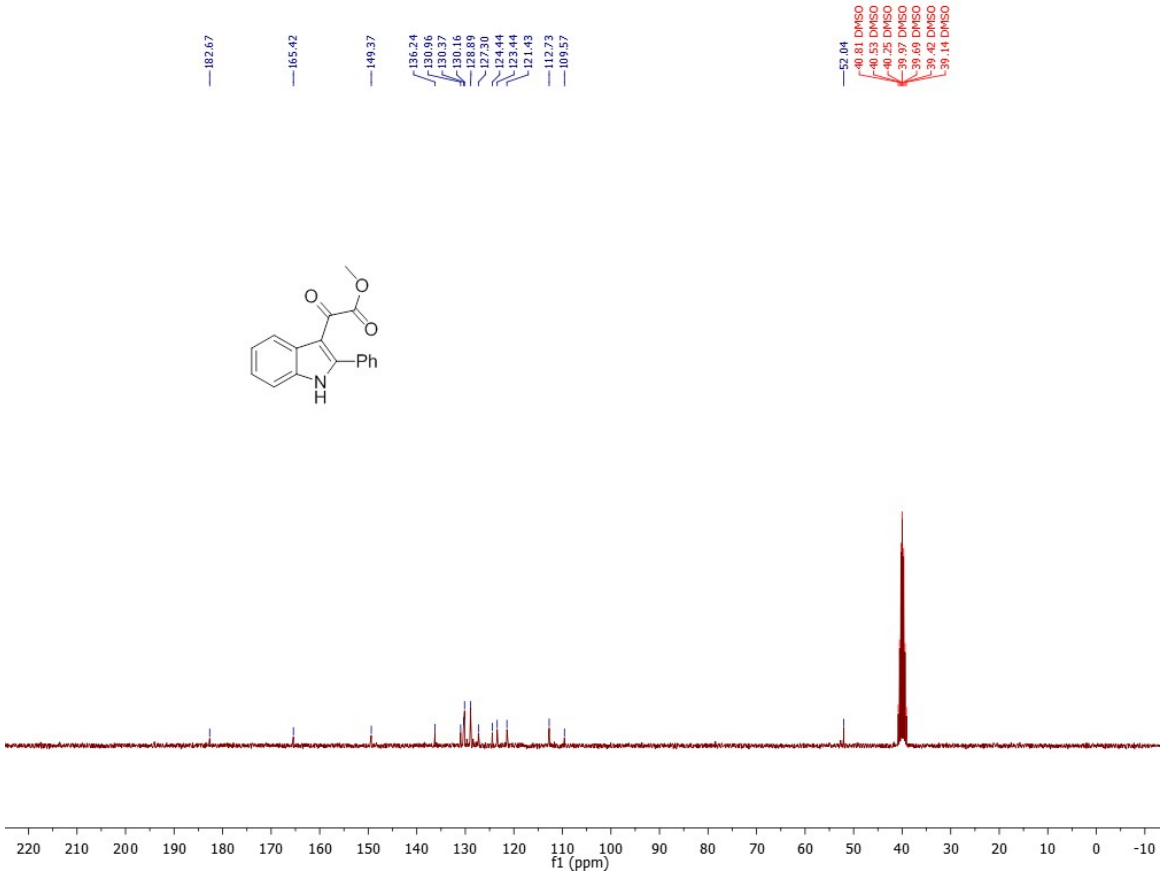

12.28
7.67
7.67
7.34
7.34
7.34
7.34
7.31
7.31
7.31
7.31
7.07
7.07
7.06
7.06
7.04
7.04
7.04
7.03
3.92
3.35 HDO
2.53
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
2.40
O
O
O
N
H
1.00
1.07
1.07
1.05
3.09
3.04
3.05
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
f1 (ppm)

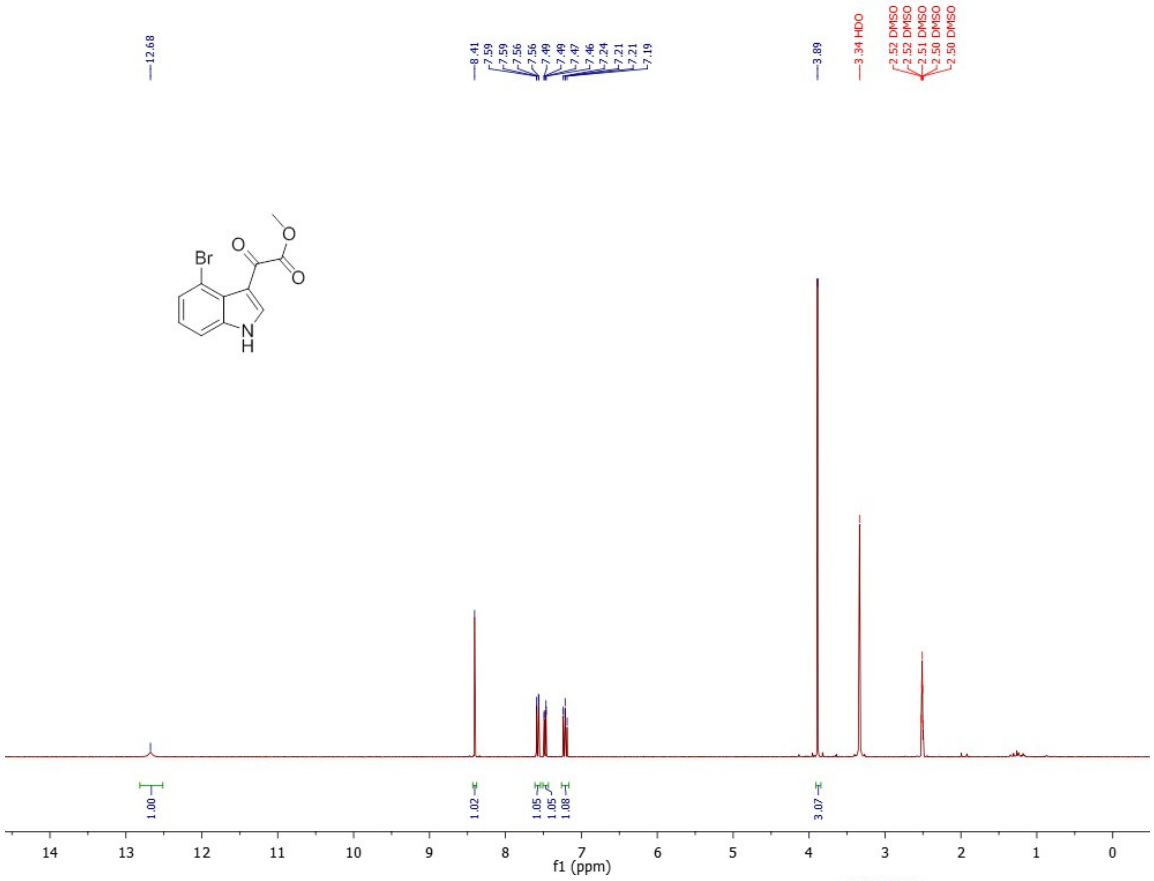

181.46
167.01
148.22
133.84
131.91
127.11
124.82
120.08
111.93
108.55
52.97
40.82 DMSO
40.54 DMSO
40.26 DMSO
39.99 DMSO
39.71 DMSO
39.43 DMSO
39.15 DMSO
21.82
13.90
O
O
O
N
H
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

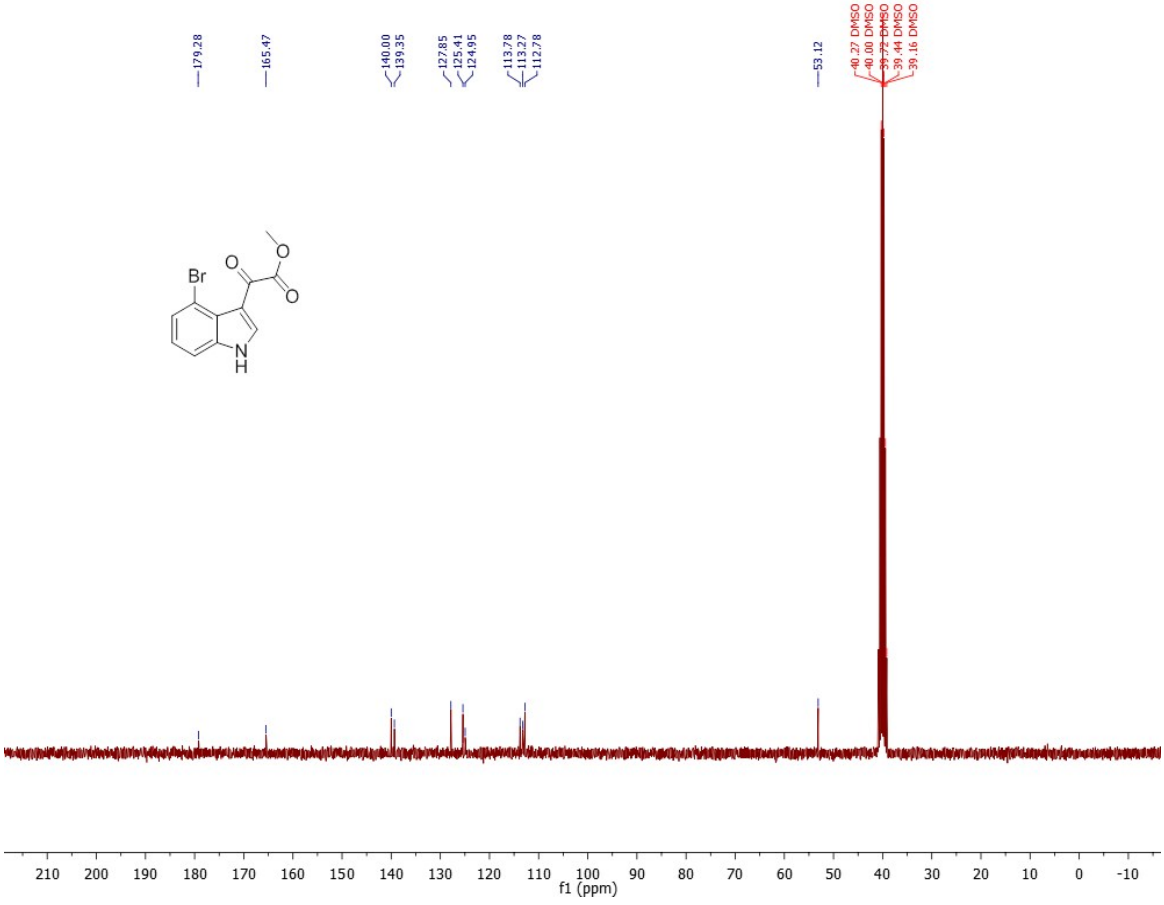

12.24
7.73
7.70
7.24
7.23
7.23
7.23
7.23
7.05
7.05
7.05
7.05
7.03
7.02
7.02
7.02
3.92
3.34 HDO
2.54
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
2.40
O
O
O
N
H
1.00
1.08
1.05
1.07
3.03
3.06
3.08
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
f1 (ppm)

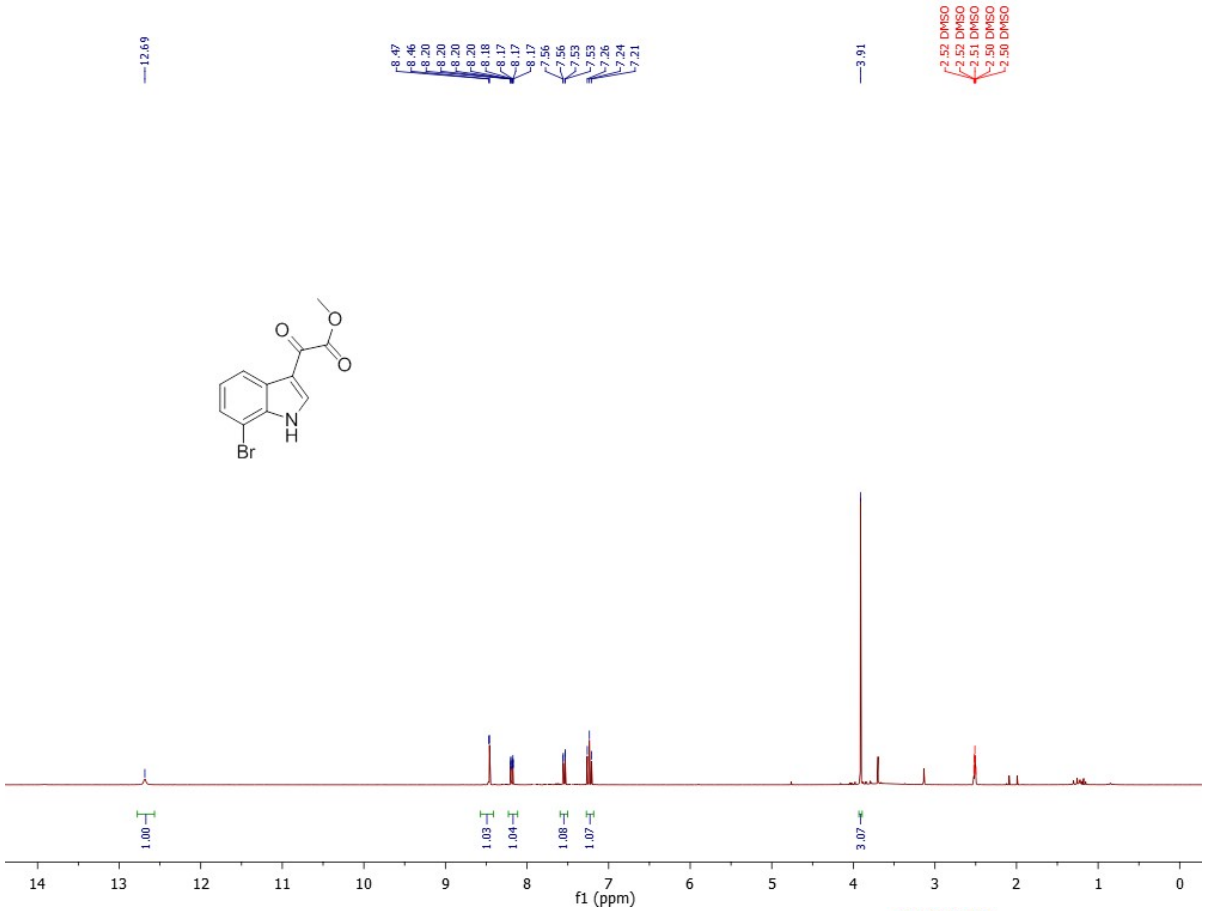

181.40
167.01
147.96
135.99
132.83
124.53
124.47
119.86
112.12
108.78
52.98
40.82 DMSO
40.54 DMSO
40.27 DMSO
39.99 DMSO
39.71 DMSO
39.43 DMSO
39.16 DMSO
21.63
13.90
O
O
O
N
H
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

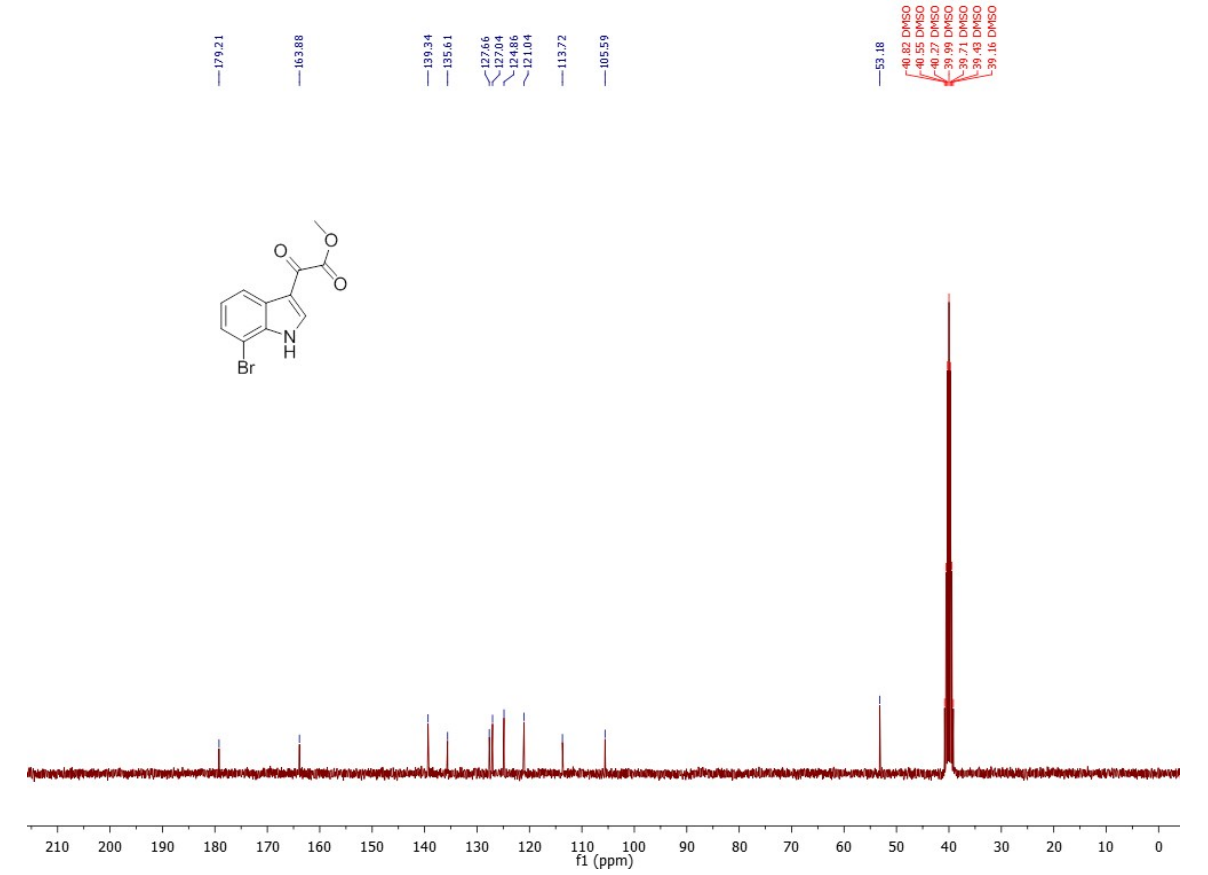

12.66
8.18
8.18
8.18
8.17
8.16
8.15
8.15
7.57
7.57
7.57
7.56
7.56
7.54
7.54
7.54
7.52
7.51
7.34
7.33
7.32
7.31
7.31
7.30
3.34 HDO
3.22
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
O
O
O
Ph
N
H
1.00
1.08
6.15
2.07
3.06
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1
f1 (ppm)

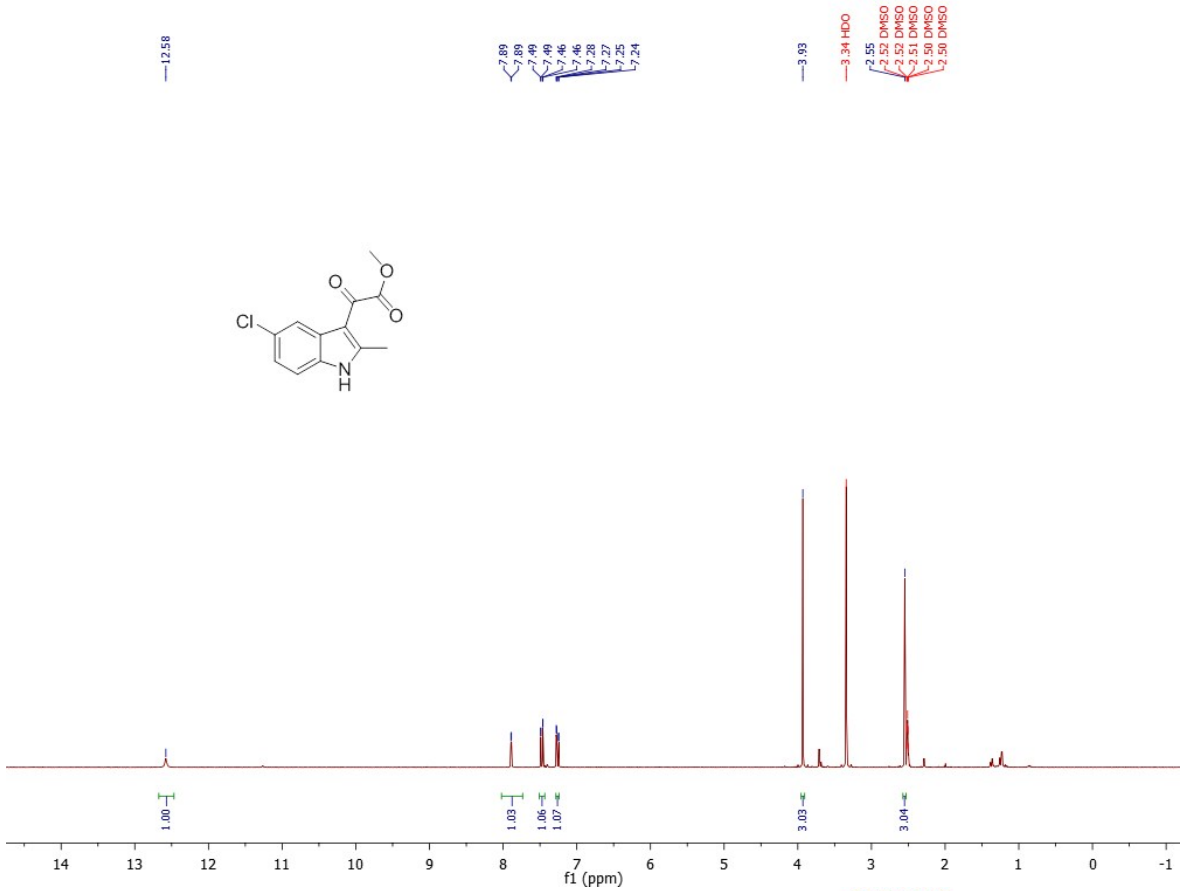

182.67
165.42
149.37
136.24
130.96
130.37
130.16
128.89
127.30
124.44
123.44
121.43
112.73
109.57
52.04
40.81 DMSO
40.53 DMSO
40.25 DMSO
39.97 DMSO
39.69 DMSO
39.42 DMSO
39.14 DMSO
O
O
O
Ph
N
H
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

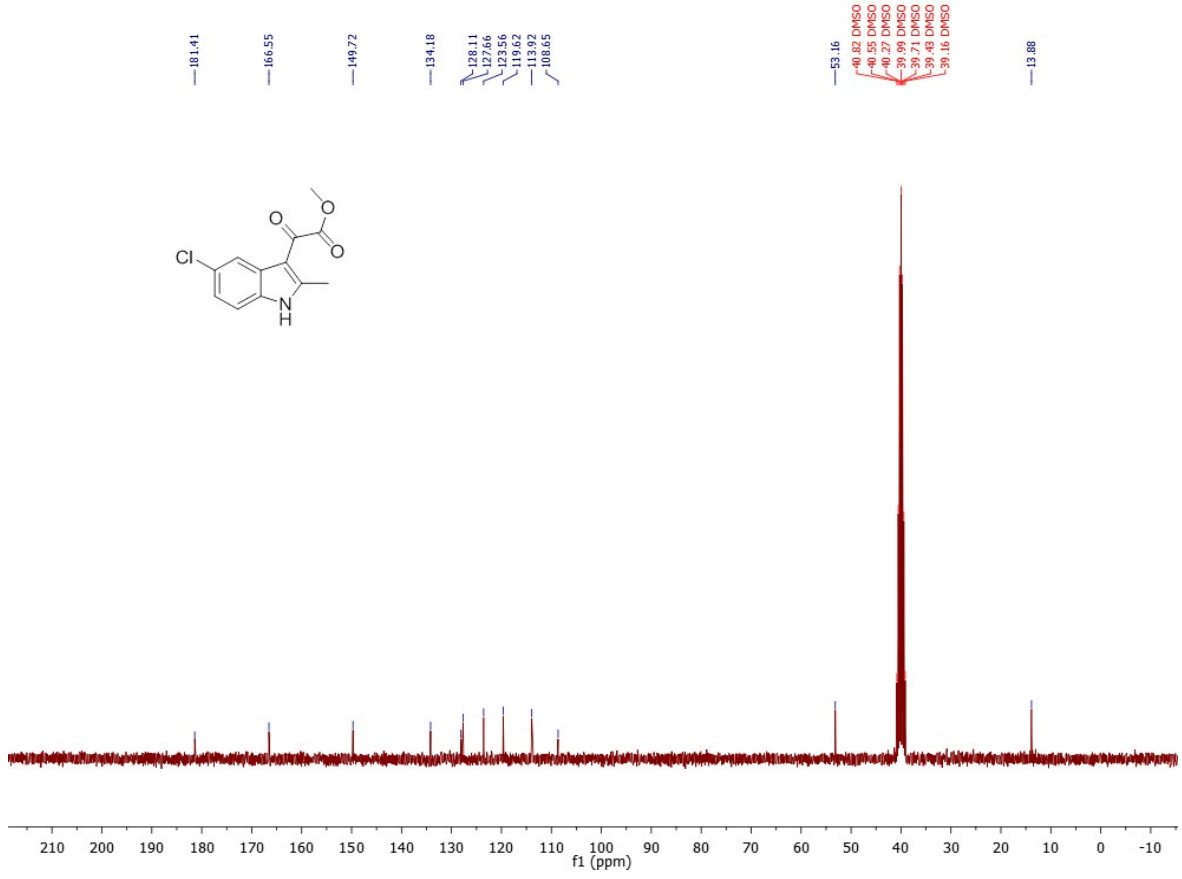

12.68
8.41
7.59
7.59
7.56
7.56
7.49
7.49
7.47
7.46
7.24
7.21
7.21
7.19
3.89
3.34 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
Br
O
O
O
N
H
1.00
1.02
1.05
1.05
1.08
3.07
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

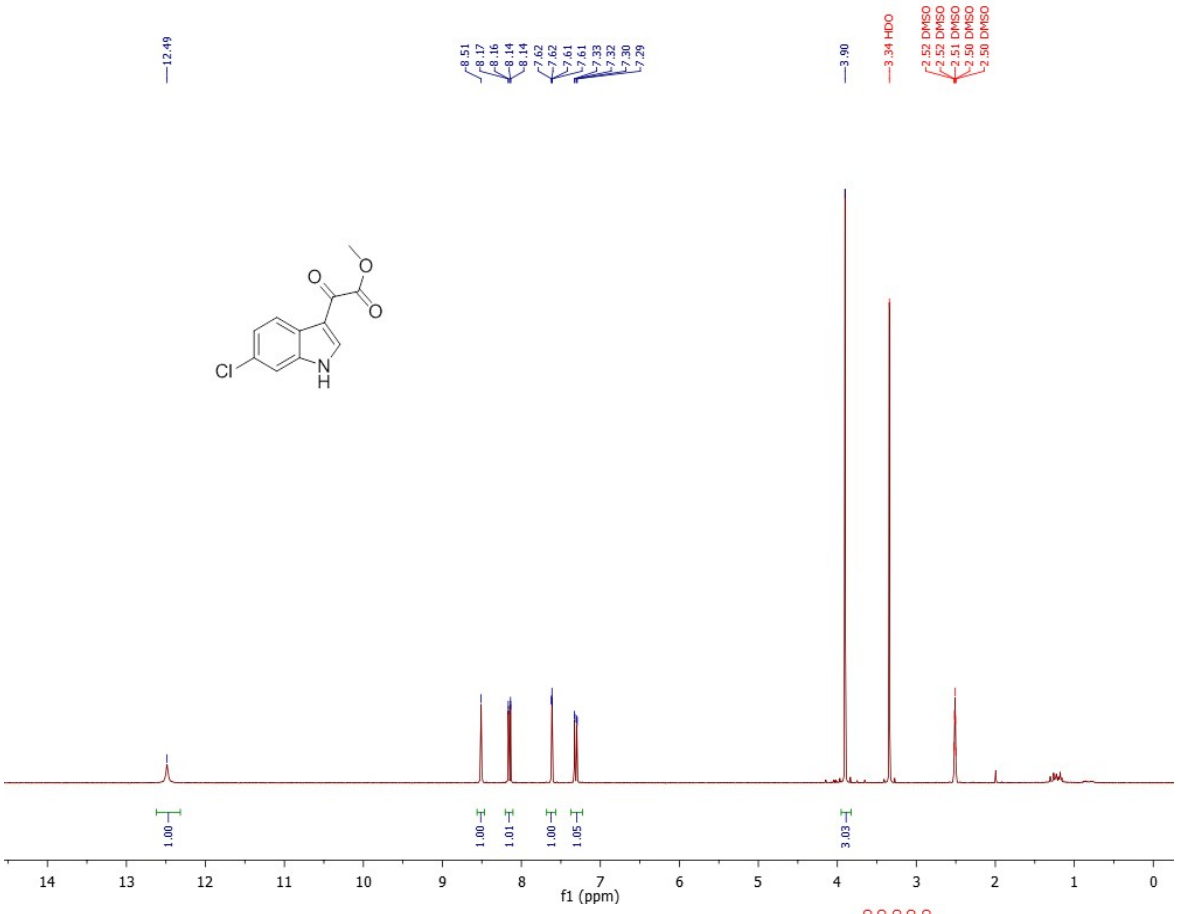

179.28
165.47
140.00
139.35
127.85
125.41
124.95
113.78
113.27
112.78
53.12
40.27 DMSO
40.00 DMSO
39.72 DMSO
39.44 DMSO
39.16 DMSO
Br
O
O
O
N
H
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

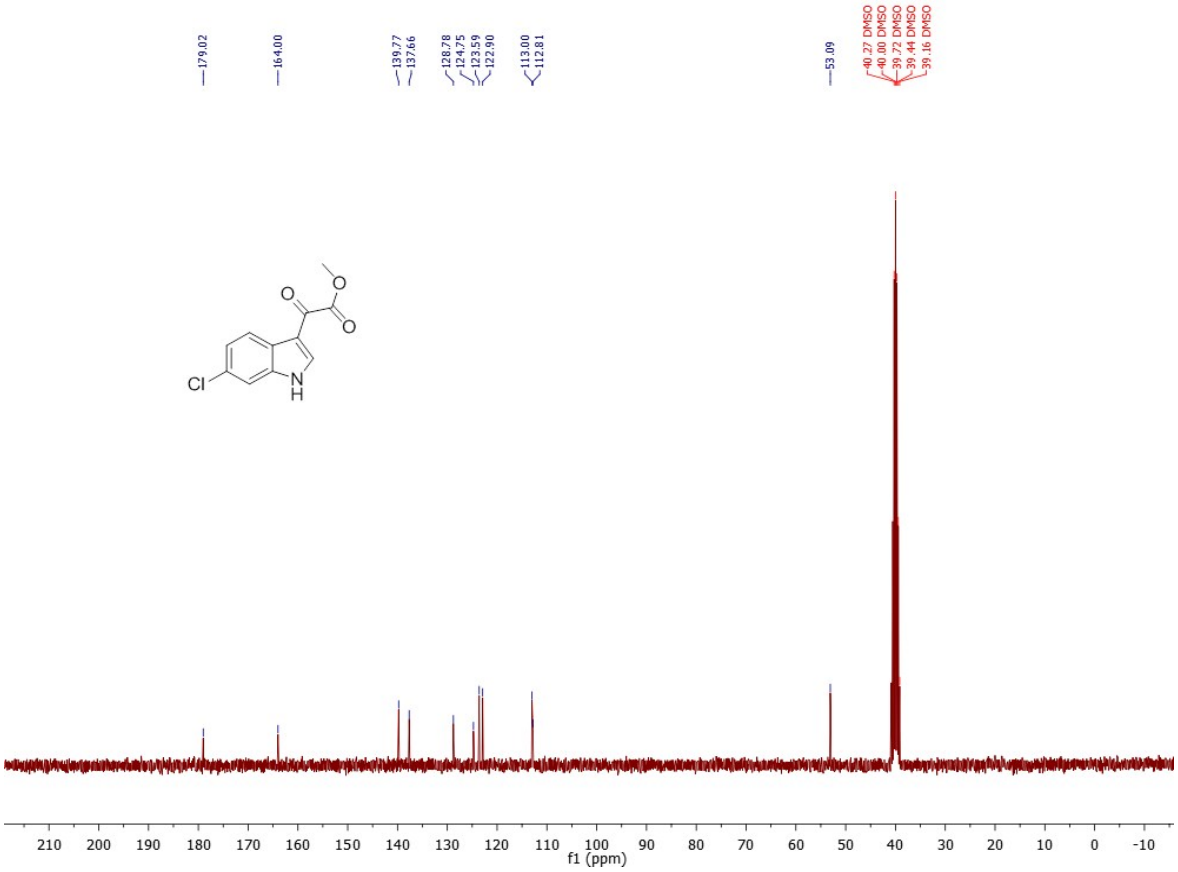

12.69
8.47
8.46
8.20
8.20
8.20
8.20
8.18
8.17
8.17
8.17
7.56
7.56
7.53
7.53
7.26
7.24
7.21
3.91
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
O
O
O
N
H
Br
1.00
1.03
1.04
1.08
1.07
3.07
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

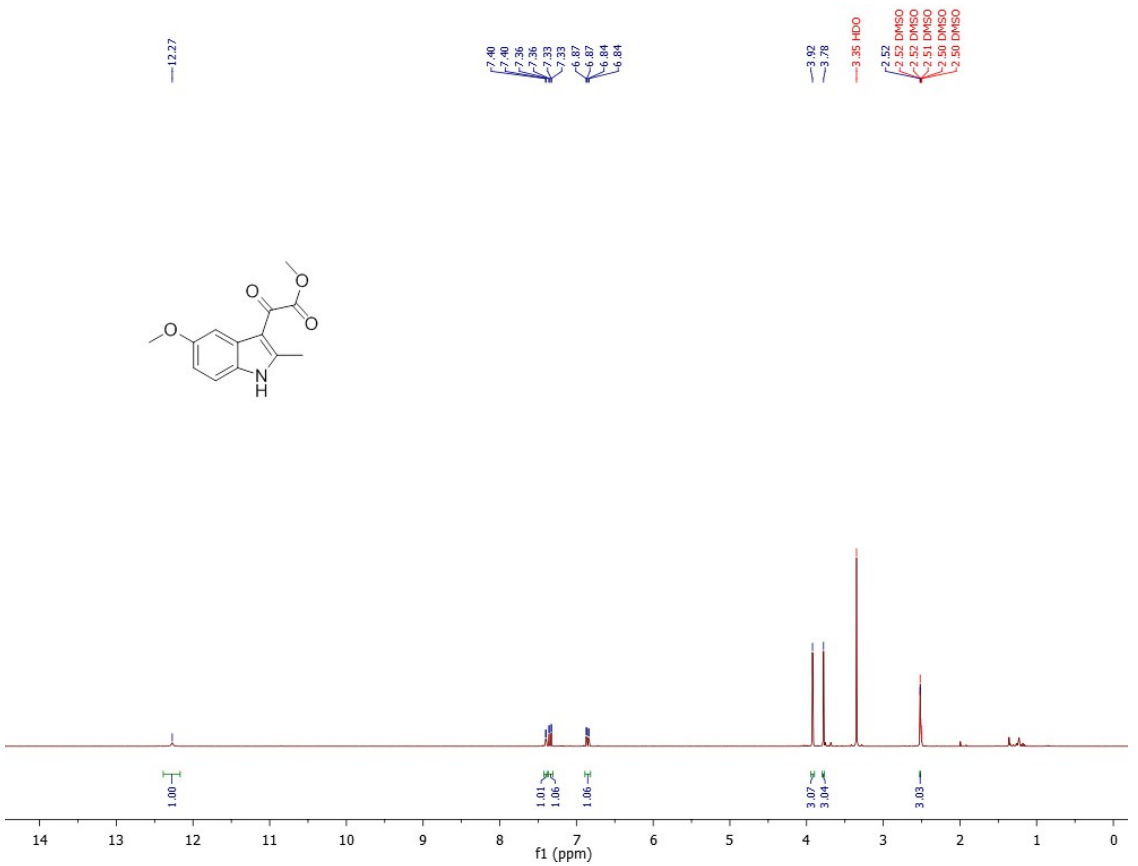

179.21
163.88
139.34
135.61
127.66
127.04
124.86
121.04
113.72
105.59
53.18
40.82 DMSO
40.55 DMSO
40.27 DMSO
39.99 DMSO
39.71 DMSO
39.43 DMSO
39.16 DMSO
O
O
O
N
H
Br
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

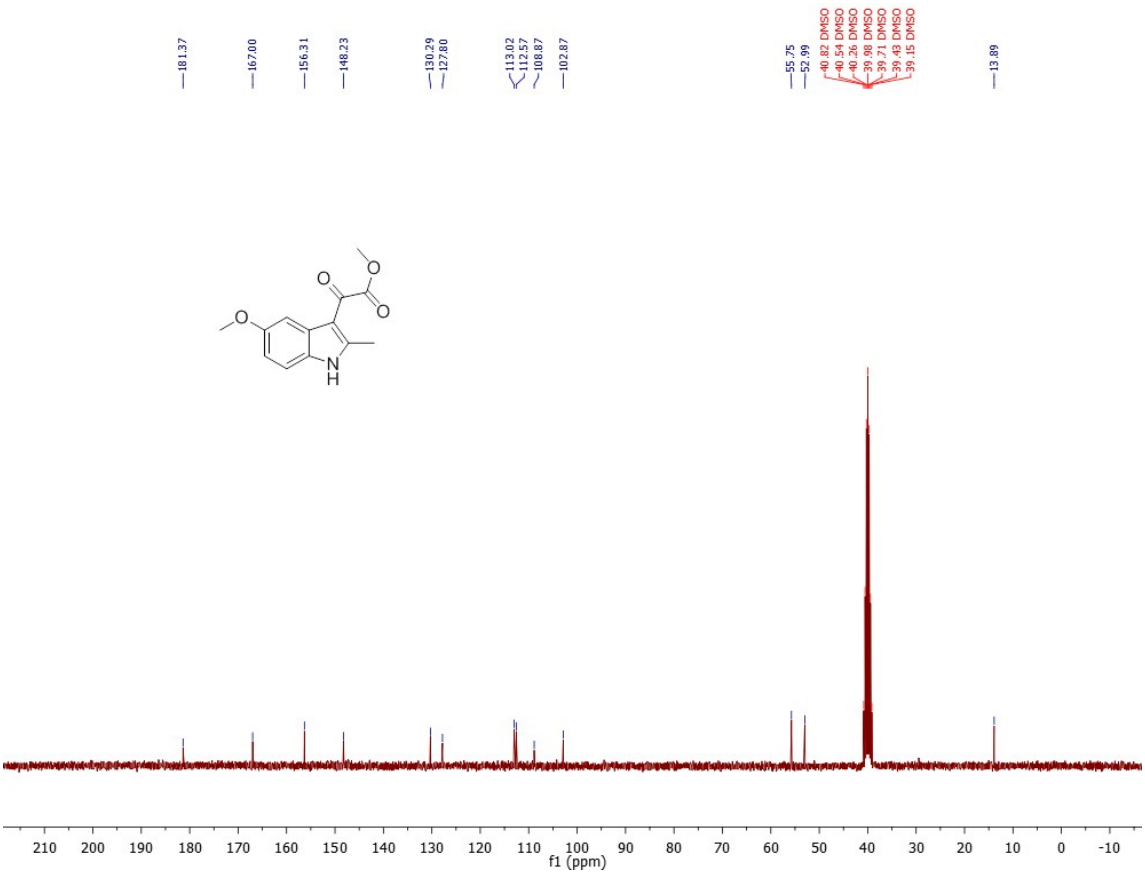

12.58
7.89
7.89
7.49
7.49
7.46
7.46
7.28
7.27
7.25
7.24
3.93
3.34 HDO
2.55
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
Cl
O
O
O
N
H
1.00
1.03
1.06
1.07
3.03
3.04
f1 (ppm)

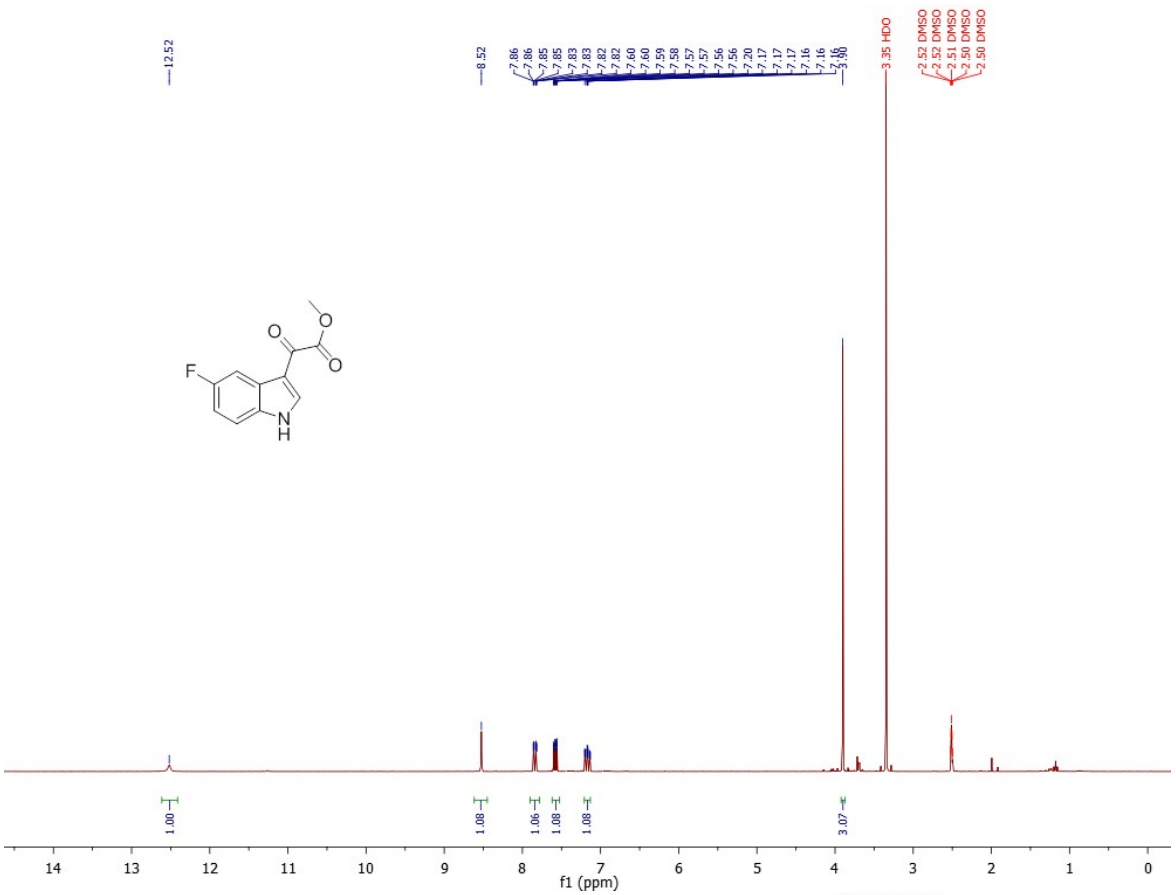

181.41
166.55
149.72
134.18
128.11
127.66
123.56
119.62
113.92
108.65
53.16
40.82 DMSO
40.55 DMSO
40.27 DMSO
39.99 DMSO
39.71 DMSO
39.43 DMSO
39.16 DMSO
13.88
Cl
O
O
O
N
H
f1 (ppm)

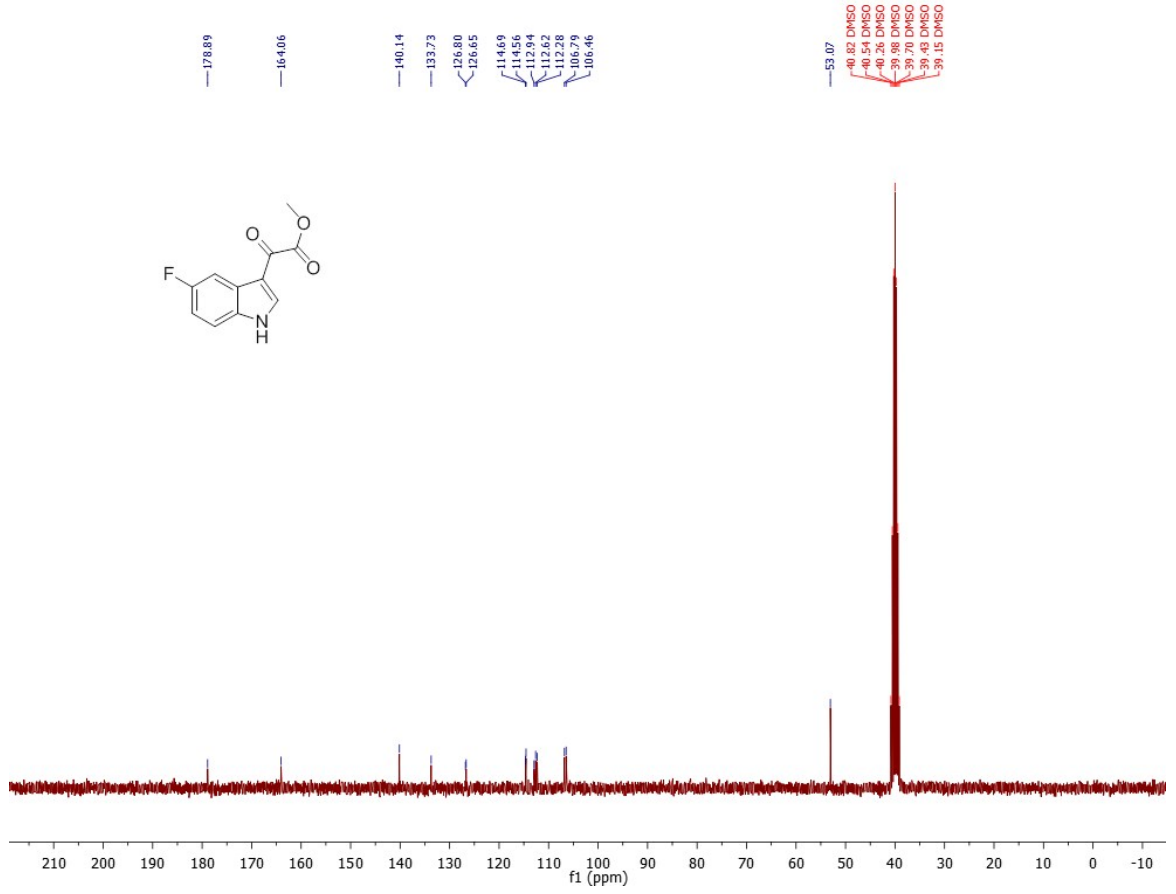

12.49
8.51
8.17
8.16
8.14
8.14
7.62
7.62
7.61
7.61
7.33
7.32
7.30
7.29
3.90
3.34 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
O
O
O
Cl
N
H
1.00
1.00
1.01
1.00
1.05
3.03
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

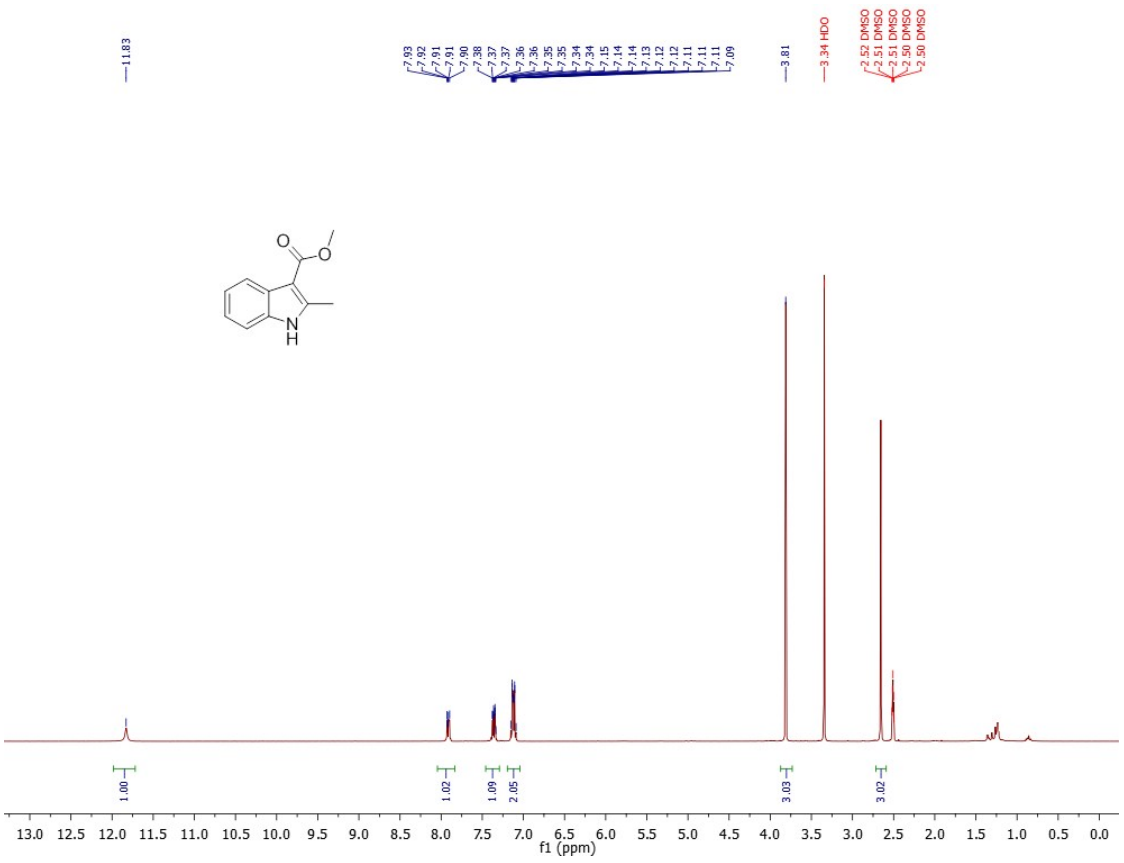

179.02
164.00
139.77
137.66
128.78
124.75
123.59
122.90
113.00
112.81
53.09
40.27 DMSO
40.00 DMSO
39.72 DMSO
39.44 DMSO
39.16 DMSO
O
O
O
Cl
N
H
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

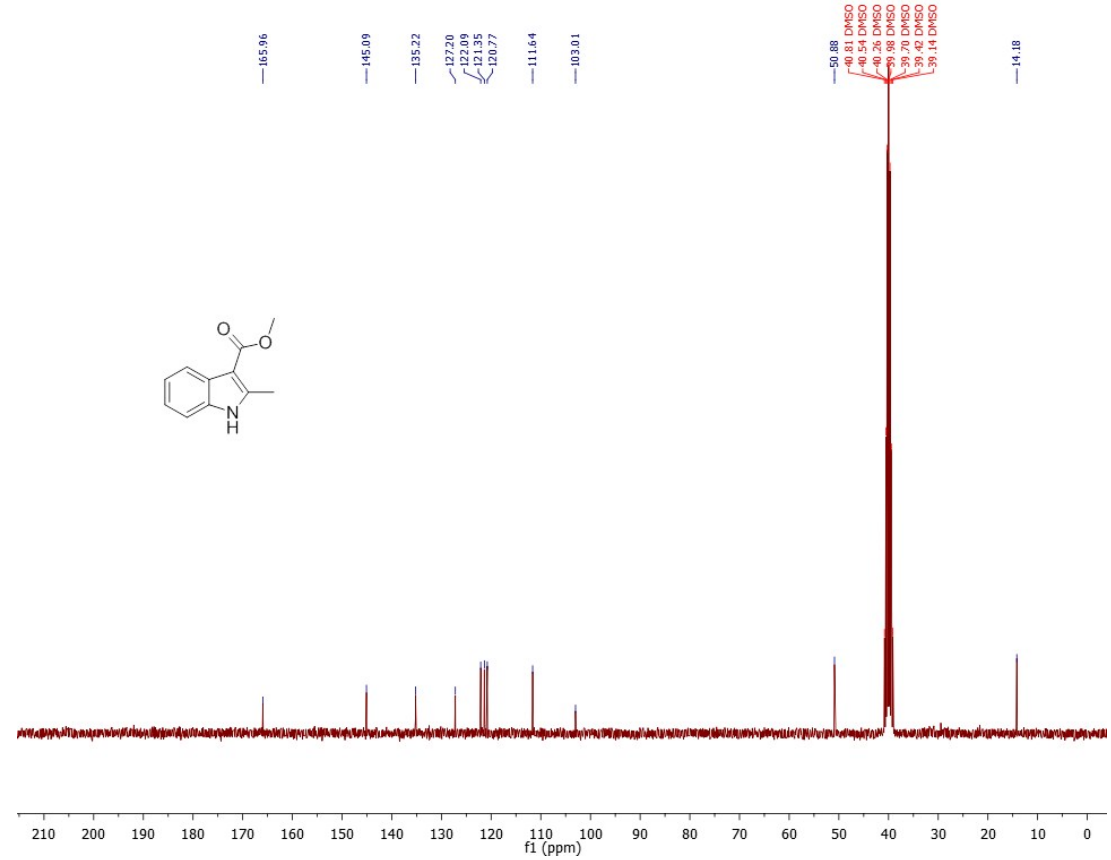

12.27
7.40
7.40
7.36
7.36
7.33
7.33
6.87
6.87
6.84
6.84
3.92
3.78
3.35 HDO
2.52
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
1.00
1.01
1.06
1.06
3.07
3.04
3.03
f1 (ppm)


181.37
167.00
156.31
148.23
130.29
127.80
113.02
112.57
108.87
102.87
55.75
52.99
40.82 DMSO
40.54 DMSO
40.26 DMSO
39.98 DMSO
39.71 DMSO
39.43 DMSO
39.15 DMSO
13.89
f1 (ppm)


12.52
8.52
7.86
7.86
7.85
7.85
7.83
7.83
7.82
7.82
7.60
7.60
7.59
7.58
7.57
7.57
7.56
7.56
7.20
7.17
7.17
7.16
7.16
3.90
3.35 HDO
2.52 DMSO
2.52 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
F
O
O
O
N
H
1.00
1.08
1.06
1.08
1.08
3.07
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


178.89
164.06
140.14
133.73
126.80
126.65
114.69
114.56
112.94
112.62
112.28
106.79
106.46
53.07
40.82 DMSO
40.54 DMSO
40.26 DMSO
39.98 DMSO
39.70 DMSO
39.43 DMSO
39.15 DMSO
F
O
O
O
N
H
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


11.83
7.93
7.92
7.91
7.91
7.90
7.38
7.37
7.37
7.36
7.36
7.35
7.35
7.34
7.34
7.15
7.14
7.14
7.13
7.12
7.12
7.11
7.11
7.11
7.09
3.81
3.34 HDO
2.52 DMSO
2.51 DMSO
2.51 DMSO
2.50 DMSO
2.50 DMSO
O
O
N
H
1.00
1.02
1.09
2.05
3.03
3.02
13.0 12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


165.96
145.09
135.22
127.20
122.09
121.35
120.77
111.64
103.01
50.88
40.81 DMSO
40.54 DMSO
40.26 DMSO
39.98 DMSO
39.70 DMSO
39.42 DMSO
39.14 DMSO
14.18
O
O
N
H
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)