Electronic Supplementary Material (ESI) for ChemComm.

Supplementary Materials for

Decarboxylative Halogenation of Indoles by Vanadium Haloperoxidases

Lauren J. Harstad,[b] Clare E. Wells,[†b] Hyung Ji Lee,[†a,b] Lauren P.T. Ramos,[b] Manik Sharma,[a,b] Cameron A. Pascoe,[b] and Kyle F. Biegasiewicz*[a,b]

[a]*Department of Chemistry, Emory University, Atlanta, GA 30322, United States*

[b]*School of Molecular Sciences, Arizona State University, Tempe, AZ 85281, United States*

correspondence to: kbiegas@emory.edu

This PDF file includes:

Table of Contents

General Experimental Information

Unless indicated otherwise, all reagents and solvents used in this study were purchased from commercial suppliers and used as received (Sigma-Aldrich, Chem-Impex, Oakwood Chemicals, Fischer Scientific, VWR, Combi-Blocks). All nonaqueous reactions were perfomed using flame-dried glassware capped with a rubber septum under a blanket of nitrogen using an inlet and outlet needle connected to a mineral oil bubbler. All aqueous reactions were carried out using glassware that was not flame-dried prior to experimental set up and were not placed under nitrogen atmosphere. For experiments that required dried or degassed solvent, it was obtained from a solvent purification system from Pure Process Technology. Deionized water (H_2O) was used in any experiments where H_2O is included in the procedure unless specified otherwise.

Flash chromatography was performed on SiliaFlash® P60 (230-400 mesh, particle size 0.040-0.063 mm) using the indicated solvent systems in each procedure. Thin-layer chromatography (TLC) was performed using Unliplate HLF 250 micron F254 precoated glass plates and preperative TLC was performed on Uniplate GF 1000 micron F254 precoated glass plates. A short-wave UV lamp and/or plate staining were used for TLC analysis.

^{1}H- and ^{13}C-NMR were obtained on a Bruker Ascend™ (500 and 126 MHz, respectively). Chemical shifts are reported in ppm (δ) downfield from tetramethylsilane and are internally referenced to the internal deuterated solvent indicated. ^{1}H-NMR data is reported as follows: chemical shift [multiplicity, coupling constant (Hz), number of hydrogens]. Multiplicities are reported as follows: s (singlet), b (broad signal), d (doublet), dd (doublet of doublets), ddd (doublet of doublet of doublets), t (triplet), dt (doublet of triplets), tt (triplet of triplets), q (quartet), dq (doublet of quartets), p (pentet), m (multiplet). Infrared (IR) were acquired on a Thermo-Fisher Nicolet iS50 spectrometer taken neat and peaks are reported in frequency of absorption (cm^{-1}). High-resolution mass spectra were obtained using ionization techniques featuring electron impact (EI) on a mass analyzer (VG 70-VSE(A)).

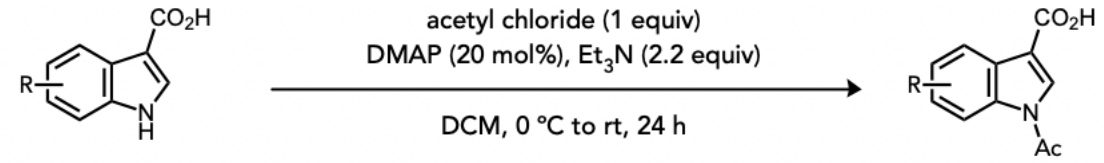
Analytical high-performance liquid chromatography (HPLC) was carried out using a Shimadzu LCMS-2020 System with a Kromasil EternityXT-2.5-C18 column (Dimensions: 4.6x50mm, Batch/Serial: 0000016627/A, Part No. XH2CLA05).

Protein Expression and Purification

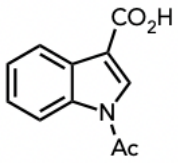
All protein expression and purification were perfomed using previously reported methods.[1]

Synthesis and Characterization of Substrates

General Procedure for Acylation of 3-Carboxyindoles (General Procedure A):



To a solution of 3-carboxyindole (1 equiv) in DCM (0.62 M) cooled to 0 ºC was added Et_3N (2.2 equiv) and DMAP (20 mol%). Acetyl chloride (1 equiv) was added dropwise while stirring and the mixture was allowed to warm to room temperature. After stirring for 24 h, the reaction mixture was poured over a 1 M aqueous HCl solution (0.1 M with respect to starting material). The precipitated solid was filtered over vacuum, rinsed repeatedly with water, dried under vacuum, and analyzed for purity. For substrates requiring additional purification, the crude product was next dissolved in EtOAc (0.05 M with respect to starting material). An equal quantity of saturated aqueous $NaHCO_3$ was added and the mixture stirred for 30 minutes, at which point the aqueous layer was isolated and acidified to pH 1 with concentrated HCl. This mixture was filtered over vacuum, rinsed with water, and again dried under vacuum to obtain the pure acylated indole.



1-acetyl-1*H*-indole-3-carboxylic acid (1)

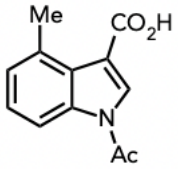
Synthesized from 1.00 g (6.21 mmol) of commercially available 1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.80 (s, 1H), 8.44 (s, 1H), 8.37 (d, *J* = 7.3 Hz, 1H), 8.10 (d, *J* = 6.3 Hz, 1H), 7.44 – 7.34 (m, 2H), 2.75 (s, 3H).

^{13}C NMR (126 MHz, DMSO): δ 170.75, 165.39, 135.82, 133.72, 127.90, 125.80, 124.80, 121.54, 116.48, 113.29, 24.29.

HRMS: calculated for $C_{11}H_9NO_3$ $[M\text{-}H^+]^-$: 202.0582. Found $[M\text{-}H^+]^-$: 202.0510.

IR (cm^{-1}): 2876.50, 1731.60, 1675.19, 1557.69, 1281.80, 1194.70, 753.98, 646.57.



1-acetyl-4-methyl-1*H*-indole-3-carboxylic acid (SM-3)

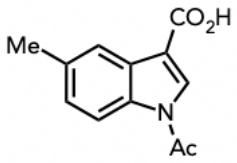
Synthesized from 0.392 g (2.24 mmol) of commercially available 4-methyl-1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.65 (s, 1H), 8.37 (s, 1H), 8.27 (d, J = 8.4 Hz, 1H), 7.28 (t, J = 7.4 Hz, 1H), 7.13 (d, J = 7.5 Hz, 1H), 2.71 (d, J = 12.0 Hz, 6H).

^{13}C NMR (126 MHz, DMSO): δ 170.49, 165.51, 136.43, 133.80, 131.88, 126.80, 126.20, 125.87, 115.02, 114.05, 24.42, 22.00.

HRMS: calculated for $C_{12}H_{11}NO_3$ $[M+H^+]^+$: 218.0739. Found $[M+H^+]^+$: 218.0817.

IR (cm^{-1}): 2935.16, 1725.35, 1697.69, 1543.56, 1434.76, 1338.53, 1213.21, 1162.25, 763.95, 655.43.



1-acetyl-5-methyl-1*H*-indole-3-carboxylic acid (SM-4)

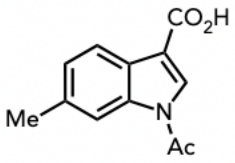
Synthesized from 0.950 g (5.42 mmol) of commercially available 5-methyl-1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.77 (s, 1H), 8.39 (s, 1H), 8.23 (d, *J* = 8.2 Hz, 1H), 7.90 (s, 1H), 7.22 (d, *J* = 8.9 Hz, 1H), 2.73 (s, 3H), 2.43 (s, 3H).

^{13}C NMR (126 MHz, DMSO): δ 170.55, 165.46, 134.07, 133.91, 133.67, 128.12, 126.99, 121.35, 116.12, 113.04, 24.16, 21.58.

HRMS: calculated for $C_{12}H_{11}NO_3$ $[M\text{-}H^+]^-$: 216.0739. Found $[M\text{-}H^+]^-$: 216.0670.

IR (cm^{-1}): 2920.44, 1711.72, 1675.16, 1560.28, 1382.42, 1279.43, 1200.01, 942.83, 638.90.



1-acetyl-6-methyl-1*H*-indole-3-carboxylic acid (SM-5)

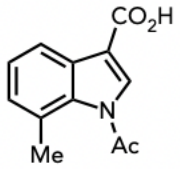
Synthesized from 1.00 g (6.21 mmol) of commercially available 6-methyl-1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.74 (s, 1H), 8.35 (s, 1H), 8.20 (s, 1H), 7.96 (d, *J* = 8.0 Hz, 1H), 7.21 (d, *J* = 8.2 Hz, 1H), 2.73 (s, 3H), 2.45 (s, 3H).

^{13}C NMR (126 MHz, DMSO): δ 170.71, 165.44, 136.21, 135.32, 133.08, 126.15, 125.67, 121.15, 116.52, 113.31, 24.30, 21.99.

HRMS: calculated for $C_{12}H_{11}NO_3$ $[M\text{-}H^+]^-$: 216.0739. Found $[M\text{-}H^+]^-$: 216.0669.

IR (cm^{-1}): 2926.97, 1729.80, 1686.51, 1554.95, 1366.19, 1281.30, 1189.76, 815.15, 644.09.



1-acetyl-7-methyl-1*H*-indole-3-carboxylic acid (SM-6)

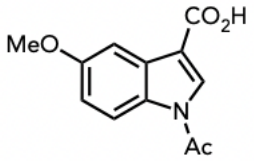
Synthesized from 0.392 g (2.24 mmol) of commercially available 7-methyl-1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.71 (s, 1H), 8.44 (s, 1H), 7.97 (d, *J* = 7.8 Hz, 1H), 7.29 (t, *J* = 7.6 Hz, 1H), 7.19 (d, *J* = 7.3 Hz, 1H), 2.79 (s, 3H), 2.45 (s, 3H).

^{13}C NMR (126 MHz, DMSO): δ 169.67, 165.39, 135.12, 134.70, 129.31, 128.48, 126.21, 124.95, 119.12, 112.67, 24.76, 22.45.

HRMS: calculated for $C_{12}H_{11}NO_3$ $[M\text{-}H^+]^-$: 216.0739. Found $[M\text{-}H^+]^-$: 216.0668.

IR (cm^{-1}): 2937.06, 1738.51, 1669.27, 1565.20, 1250.68, 1195.07, 948.37, 792.07, 652.43.



1-acetyl-5-methoxy-1*H*-indole-3-carboxylic acid (SM-7)

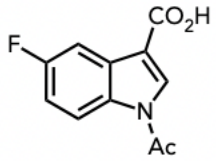
Synthesized from 0.952 g (4.98 mmol) of commercially available 5-methoxy-1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.78 (s, 1H), 8.39 (s, 1H), 8.24 (d, *J* = 9.0 Hz, 1H), 7.56 (s, 1H), 7.00 (d, *J* = 11.8 Hz, 1H), 3.82 (s, 3H), 2.72 (s, 3H).

^{13}C NMR (126 MHz, DMSO): δ 170.41, 165.45, 156.98, 134.04, 130.40, 129.05, 117.31, 114.40, 112.98, 103.79, 55.77, 24.00.

HRMS: calculated for $C_{12}H_{11}NO_4$ $[M\text{-}H^+]^-$: 232.0688. Found $[M\text{-}H^+]^-$: 232.0619.

IR (cm^{-1}): 2839.90, 1725.59, 1669.79, 1555.00, 1244.71, 1196.50, 1028.97, 939.72, 732.73, 637.14.



1-acetyl-5-fluoro-1*H*-indole-3-carboxylic acid (SM-8)

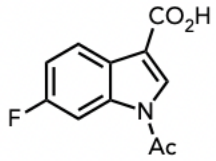
Synthesized from 0.230 g (1.28 mmol) of commercially available 5-fluoro-1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.94 (s, 1H), 8.52 (s, 1H), 8.36 (d, *J* = 4.4 Hz, 1H), 7.75 (d, *J* = 8.4 Hz, 1H), 7.26 (s, 1H), 2.75 (s, 3H).

^{13}C NMR (126 MHz, DMSO): δ 170.64, 165.11, 159.76 (d, *J* = 238.8 Hz), 135.22, 132.32, 129.16 (d, *J* = 10.5 Hz), 117.98 (d, *J* = 9.4 Hz), 113.50 (d, *J* = 25.1 Hz), 112.92 (d, *J* = 4.2 Hz), 106.91 (d, *J* = 25.1 Hz), 24.07.

HRMS: calculated for $C_{11}H_8FNO_3$ $[M\text{-}H^+]^-$: 220.0488. Found $[M\text{-}H^+]^-$: 220.0419.

IR (cm^{-1}): 2868.96, 1729.88, 1674.50, 1557.01, 1451.45, 1192.29, 946.63, 884.77, 633.23.



1-acetyl-6-fluoro-1*H*-indole-3-carboxylic acid (SM-9)

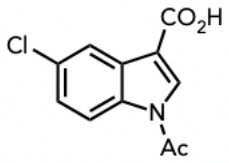
Synthesized from 0.400 g (2.24 mmol) of commercially available 6-fluoro-1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.86 (s, 1H), 8.46 (s, 1H), 8.11 – 8.07 (m, 2H), 7.29 – 7.25 (m, 1H), 2.75 (s, 3H).

^{13}C NMR (126 MHz, DMSO): δ 170.89, 165.18, 160.85 (d, J = 239.3 Hz), 135.76 (d, J = 13.5 Hz), 134.16 (d, J = 3.7 Hz), 124.47, 122.77 (d, J = 9.9 Hz), 113.09 (d, J = 14.6 Hz), 112.84, 103.41 (d, J = 28.7 Hz), 24.17.

HRMS: calculated for $C_{11}H_8FNO_3$ $[M\text{-}H^+]^-$: 220.0488. Found $[M\text{-}H^+]^-$: 220.0414.

IR (cm^{-1}): 2600.19, 1720.13, 1675.67, 1560.85, 1300.56, 1241.62, 1202.50, 884.47, 816.45, 644.92.



1-acetyl-5-chloro-1*H*-indole-3-carboxylic acid (SM-10)

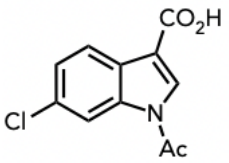
Synthesized from 0.950 g (4.86 mmol) of commercially available 5-chloro-1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.98 (s, 1H), 8.52 (s, 1H), 8.35 (d, *J* = 8.9 Hz, 1H), 8.05 (s, 1H), 7.45 (d, *J* = 8.9 Hz, 1H), 2.75 (s, 3H).

^{13}C NMR (126 MHz, DMSO): δ 170.76, 165.04, 135.10, 134.29, 129.33, 129.29, 125.74, 120.74, 118.06, 112.51, 24.16.

HRMS: calculated for $C_{11}H_8ClNO_3$ $[M\text{-}H^+]^-$: 236.0193. Found $[M\text{-}H^+]^-$: 236.0122.

IR (cm^{-1}): 2884.25, 1733.26, 1683.66, 1556.36, 1445.29, 1190.49, 937.84, 813.52, 658.14.



1-acetyl-6-chloro-1*H*-indole-3-carboxylic acid (SM-11)

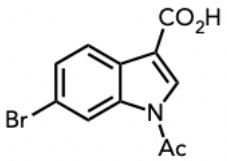
Synthesized from 0.400 g (2.05 mmol) of commercially available 6-chloro-1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.94 (s, 1H), 8.49 (s, 1H), 8.38 (d, *J* = 2.0 Hz, 1H), 8.08 (d, *J* = 8.5 Hz, 1H), 7.44 (dd, *J* = 8.5, 2.0 Hz, 1H), 2.75 (s, 3H).

^{13}C NMR (126 MHz, DMSO): δ 170.90, 165.07, 136.04, 134.48, 130.33, 126.72, 125.10, 122.85, 116.21, 113.10, 24.20.

HRMS: calculated for $C_{11}H_8ClNO_3$ $[M\text{-}H^+]^-$: 236.0193. Found $[M\text{-}H^+]^-$: 236.0121.

IR (cm^{-1}): 2861.92, 1720.54, 1671.03, 1543.33, 1418.08, 1193.03, 999.81, 818.08, 641.14.



1-acetyl-6-bromo-1*H*-indole-3-carboxylic acid (SM-12)

Synthesized from 0.400 g (1.67 mmol) of commercially available 6-bromo-1H-indole-3-carboxylic acid using General Procedure A.

^{1}H NMR (500 MHz, DMSO): δ 12.93 (s, 1H), 8.53 (d, *J* = 1.9 Hz, 1H), 8.47 (s, 1H), 8.02 (d, *J* = 8.5 Hz, 1H), 7.56 (dd, *J* = 8.5, 1.9 Hz, 1H), 2.75 (s, 3H).

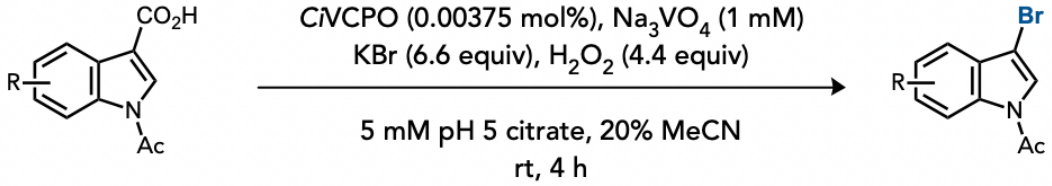
^{13}C NMR (126 MHz, DMSO): δ 170.91, 165.06, 136.39, 134.37, 127.77, 127.03, 123.22, 119.06, 118.49, 113.15, 24.20.

HRMS: calculated for $C_{11}H_8BrNO_3$ $[M\text{-}H^+]^-$: 279.9688. Found $[M\text{-}H^+]^-$: 279.9612.

IR (cm^{-1}): 2869.09, 1721.94, 1679.65, 1552.13, 1416.26, 1198.97, 996.18, 812.23, 638.91.

Analytical and Preparative Scale Decarboxylative Halogenation Procedures

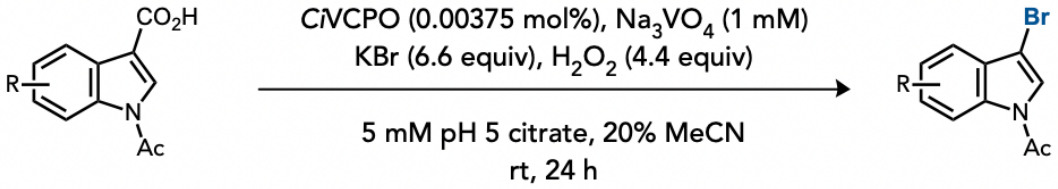
General Analytical Decarboxylative Bromination Procedure for N-Acetyl Substrates (General Procedure B):



An enzyme aliquot of the VHPO from *Curvularia inaequalis* (*Ci*VCPO, 10 μM, 50 μL) was removed from a -80 °C freezer and allowed to warm to room temperature over 5 min. After thawing, 15 μL was transferred to a fresh PCR tube and diluted with 25 mM pH 5 citrate buffer (2.5 μL). A 250 mM solution of aqueous Na_3VO_4 (4 μL) was added and the resulting mixture was centrifuged for 10 seconds using a Chemglass Life Sciences MLX-108-CLS mini centrifuge and then placed at room temperature until further use. To a 1-dram vial was then added H_2O purified by an Elga purification system (612.7 μL), 500 mM pH 5 citrate buffer (10 μL), and 176 mM aqueous KBr (150 μL, 6.6 equiv). A 20 mM solution of the N-acetyl carboxyindole substrate in MeCN (200 μL, 1 equiv, 0.004 mmol substrate) was then added. The aliquot containing the diluted *Ci*VCPO (0.00375 mol%, 150 nM in reaction) and Na_3VO_4 (1 mM in reaction) was then added to the reaction mixture followed by a 10% stock of H_2O_2 (5.8 μL, 4.4 equiv). The vial was then capped and placed on a shaker at room temperature for 4 hr. After this time, the reaction mixture was diluted with MeCN (650 μL), transferred to an Eppendorf tube, and centrifuged in a Benchmark MC-24™ Touch Centrifuge at 12,500 rpm for 5 min. After centrifugation, 650 μL of the top layer of the reaction mixture was transferred to an LCMS vial, which was then placed on an LCMS for analysis.*

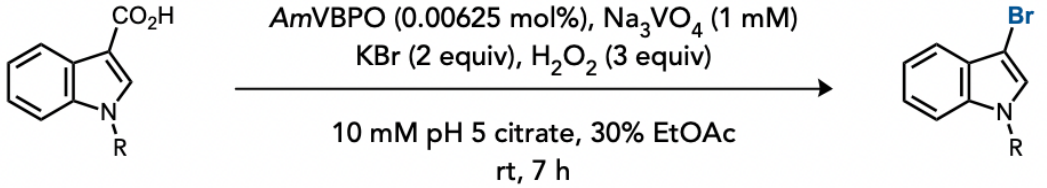
**100 μL of 1,3,5-tribromobenzene was added as an internal standard for yield confirmation, where applicable.*

General Preparative Decarboxylative Bromination Procedure for N-Acetyl Substrates (General Procedure C):



Two enzyme aliquots of the VHPO from *Curvularia inaequalis* (*Ci*VCPO, 10 µM, 750 µL each) were removed from a -80 °C freezer and allowed to warm to room temperature over 10 min. The first enzyme aliquot was diluted with 25 mM pH 5 citrate buffer (125 µL) and 250 mM aqueous Na_3VO_4 (200 µL). 375 µL from the second enzyme aliquot was transferred to a new Eppendorf tube and diluted with 25 mM pH 5 citrate buffer (62.5 µL) and 250 mM aqueous Na_3VO_4 (100 µL). The two aliquots were then stored at room temperature until further use. To a 100 mL round bottom flask containing a magnetic stir bar was added the substrate (1 equiv, 0.300 mmol) and MeCN (15 mL) while stirring. This was followed by addition of H_2O purified by an Elga purification system (46.2 mL), 500 mM pH 5 citrate buffer (0.750 mL) and 176 mM aqueous KBr (11.250 mL, 6.6 equiv). The contents of the two Eppendorf tubes containing the *Ci*VCPO (0.00375 mol%, 150 nM total) and Na_3VO_4 (1 mM in reaction) was added to the reaction mixture followed by a 30% stock of H_2O_2 (145 µL, 4.4 equiv). The reaction was then left to stir at room temperature at 800 rpm for 24 hr. After this time, the reaction mixture was concentrated to remove the MeCN and transferred to a separatory funnel. Additional H_2O (60 mL) was added and the mixture extracted with ethyl acetate (3 x 75 mL). The combined organic layers were then washed with brine (100 mL), dried over sodium sulfate, and concentrated under reduced pressure. The resulting crude sample was purified on a silica gel hand column to obtain the pure product.

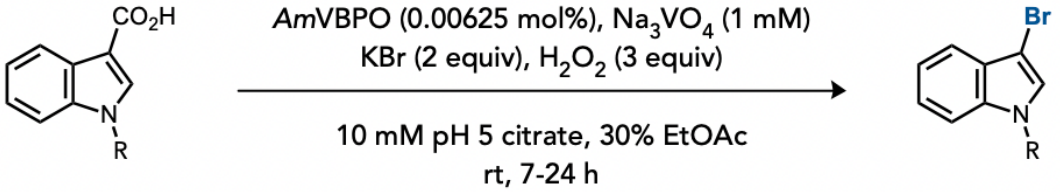
General Analytical Decarboxylative Bromination Procedure for N-Alkyl Substrates (General Procedure D):



An enzyme aliquot of the VHPO from *Acaryochloris marina* (*Am*VBPO, 10 μM, 50 μL) was removed from a -80 °C freezer and allowed to warm to room temperature over 5 min. After thawing, the aliquot was centrifuged for 10 seconds using a Chemglass Life Sciences MLX-108-CLS mini centrifuge and 25 μL was taken and combined with a 250 mM solution of aqueous Na_3VO_4 (4 μL) in a fresh PCR tube. The resulting solution was spun again in the mini centrifuge for 10 seconds and stored at room temperature until further use. To a 1-dram vial was then added H_2O purified by an Elga purification system (601.5 μL) and 500 mM pH 5 citrate buffer (20 μL). The vial was then physically shaken and, once the solution was homogenous, 176 mM aqueous KBr (45.5 μL, 2 equiv) was added and the vial physically shaken again. This was followed by addition of EtOAc (200 μL) and a 40 mM solution of the N-alkyl carboxyindole substrate in EtOAc (100 μL, 1 equiv, 0.004 mmol substrate), with the vial physically shaken after each addition. The aliquot containing the *Am*VBPO (0.00625 mol%, 250 nM in reaction) and Na_3VO_4 (1 mM in reaction) was then added to the reaction mixture followed by a 10% stock of H_2O_2 (4.0 μL, 3 equiv). The vial was then capped and placed on a shaker set to 880 rpm at room temperature for 7 hr. After this time, the reaction mixture was diluted with MeCN (650 μL), transferred to an Eppendorf tube, and spun down in a Benchmark MC-24™ Touch Centrifuge at 12,500 rpm for 5 min. After centrifugation, 600 μL of the top layer of the reaction mixture was transferred to an LCMS vial, which was then placed on an LCMS for analysis.*

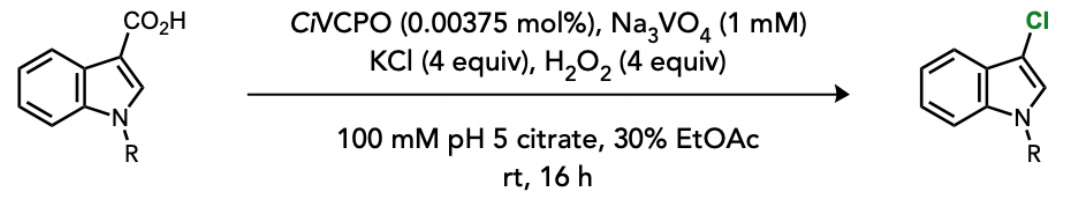
**100 μL of 1,3,5-tribromobenzene was added as an internal standard for yield confirmation, where applicable.*

General Preparative Decarboxylative Bromination Procedure for N-Alkyl Substrates (General Procedure E):



An enzyme aliquot of the VHPO from *Acaryochloris marina* (*Am*VBPO, 10 µM, 10 mL) was removed from a -80 °C freezer and allowed to warm to room temperature over 30 min. 1.875 mL from this aliquot was transferred to a 15 mL conical tube and combined with 250 mM aqueous Na_3VO_4 (300 µL). This solution was then allowed to sit at room temperature for 30 minutes. To a 100 mL round bottom flask containing a magnetic stir bar was added H_2O purified by an Elga purification system (45.1 mL), 500 mM pH 5 citrate buffer (1.5 mL) and 176 mM aqueous KBr (3.4 mL, 2 equiv). This was followed by addition of 10 mL of EtOAc, a 40 mM solution of the N-alkyl carboxyindole substrate (1 equiv, 0.300 mmol) in EtOAc (7.5 mL), and an additional 5 mL of EtOAc. The contents of the conical tube containing the *Am*VBPO (0.00625 mol%, 250 nM in reaction) and Na_3VO_4 (1 mM in reaction) was added to the reaction mixture followed by a 10% stock of H_2O_2 (297 µL, 3 equiv). The reaction was then left to stir at room temperature at 880 rpm for 7-24 hr. After this time, the reaction mixture was diluted with EtOAc (10 mL) and transferred to a separatory funnel. The mixture was extracted with EtOAc (3 x 40 mL) and the combined organic layers were dried over sodium sulfate and concentrated under reduced pressure. The resulting crude sample was purified on a silica gel hand column to obtain the pure product.

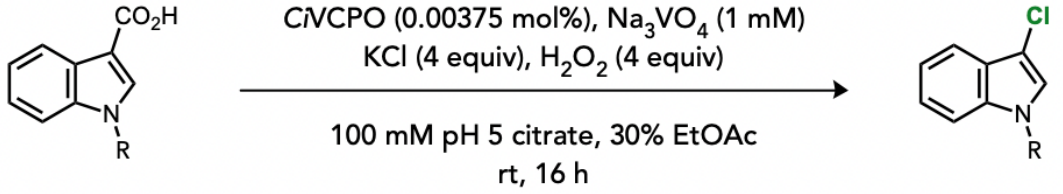
General Analytical Decarboxylative Chlorination Procedure for N-Alkyl Substrates (General Procedure F):



An enzyme aliquot of the VHPO from *Curvularia inaequalis* (*Ci*VCPO, 10 μM, 50 μL) was removed from a -80 °C freezer and allowed to warm to room temperature over 5 min. After thawing, the aliquot was centrifuged for 10 seconds using a Chemglass Life Sciences MLX-108-CLS mini centrifuge and 15 μL was taken and combined with a 250 mM solution of aqueous Na_3VO_4 (4 μL) in a fresh PCR tube. The resulting solution was spun again in the mini centrifuge for 10 seconds and placed in the refrigerator until further use. To a 1-dram vial was then added H_2O purified by an Elga purification system (385 μL) and 500 mM pH 5 citrate buffer (200 μL). The vial was then physically shaken and, once the solution was homogenous, 176 mM aqueous KCl (90.9 μL, 4 equiv) was added and the vial physically shaken again. This was followed by addition of EtOAc (200 μL) and a 40 mM solution of the N-alkyl carboxyindole substrate in EtOAc (100 μL, 1 equiv, 0.004 mmol substrate), with the vial physically shaken after each addition. The aliquot containing the *Ci*VCPO (0.00375 mol%, 150 nM in reaction) and Na_3VO_4 (1 mM in reaction) was then added to the reaction mixture, which was again physically shaken followed by addition of a 10% stock of H_2O_2 (5.3 μL, 4 equiv). The vial was then capped and placed on a shaker set to 1000 rpm at room temperature for 16 hr. After this time, the reaction mixture was diluted with MeCN (650 μL), transferred to an Eppendorf tube, and spun down in a Benchmark MC-24™ Touch Centrifuge at 12,500 rpm for 5 min. After centrifugation, 600 μL of the top layer of the reaction mixture was transferred to an LCMS vial, which was then placed on an LCMS for analysis.*

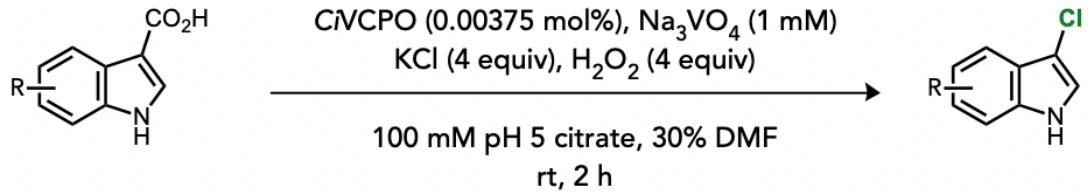
**100 μL of 1,3,5-tribromobenzene was added as an internal standard for yield confirmation, where applicable.*

General Preparative Decarboxylative Chlorination Procedure for N-Alkyl Substrates (General Procedure G):



Two enzyme aliquots of the VHPO from *Curvularia inaequalis* (*Ci*VCPO, 10 μM, 750 μL each) were removed from a -80 °C freezer and allowed to warm to room temperature over 10 min. A portion of the aliquots (1.125 μL) was then transferred to an Eppendorf tube and combined with 250 mM aqueous Na_3VO_4 (300 μL). This solution was stored in the refrigerator until further use. To a 100 mL round bottom flask containing a magnetic stir bar was added H_2O purified by an Elga purification system (28.9 mL), 500 mM pH 5 citrate buffer (15 mL) and 176 mM aqueous KCl (6.817 mL, 4 equiv) while stirring. This was followed by addition of the N-alkyl carboxyindole substrate (1 equiv, 0.300 mmol) in EtOAc (22.5 mL). The contents of the Eppendorf tube containing the *Ci*VCPO (0.00375 mol%, 150 nM in reaction) and Na_3VO_4 (1 mM in reaction) was added to the reaction mixture followed by a 10% stock of H_2O_2 (395 μL, 4 equiv). The reaction was then left to stir at room temperature for 16 hr. After this time, the reaction mixture was diluted with EtOAc (10 mL) and H_2O (10 mL) and transferred to a separatory funnel. The mixture was extracted with EtOAc (3 x 25 mL) and the combined organic layers were dried over sodium sulfate. The dried organic layer was then dry loaded onto silica gel and purified on a silica gel hand column.

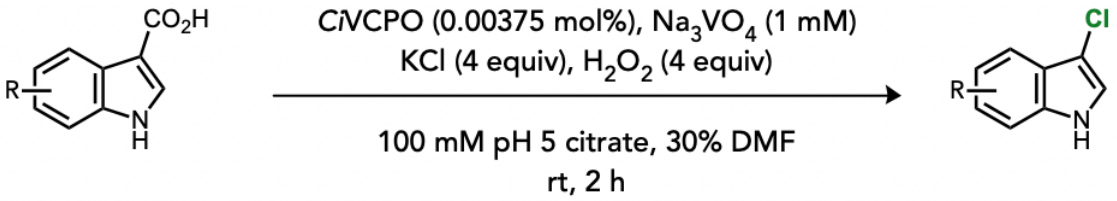
General Analytical Decarboxylative Chlorination Procedure for N-H Substrates (General Procedure H):



An enzyme aliquot of the VHPO from *Curvularia inaequalis* (*Ci*VCPO, 10 μM, 50 μL) was removed from a -80 °C freezer and allowed to warm to room temperature over 5 min. After thawing, the aliquot was centrifuged for 10 seconds using a Chemglass Life Sciences MLX-108-CLS mini centrifuge and 15 μL was taken and combined with a 250 mM solution of aqueous Na_3VO_4 (4 μL) in a fresh PCR tube. The resulting solution was spun again in the mini centrifuge for 10 seconds and placed in the refrigerator until further use. To a 1-dram vial was then added H_2O purified by an Elga purification system (385 μL) and 500 mM pH 5 citrate buffer (200 μL). The vial was then physically shaken and, once the solution was homogenous, 176 mM aqueous KCl (90.9 μL, 4 equiv) was added and the vial physically shaken again. This was followed by addition of DMF (200 μL) and a 40 mM solution of the N-H carboxyindole substrate in DMF (100 μL, 1 equiv, 0.004 mmol substrate), with the vial physically shaken after each addition. The aliquot containing the *Ci*VCPO (0.00375 mol%, 150 nM in reaction) and Na_3VO_4 (1 mM in reaction) was then added to the reaction mixture, which was again physically shaken followed by addition of a 10% stock of H_2O_2 (5.3 μL, 4 equiv). The vial was then capped and placed on a shaker set to 1000 rpm at room temperature for 2 hr. After this time, the reaction mixture was diluted with MeCN (650 μL), transferred to an Eppendorf tube, and spun down in a Benchmark MC-24™ Touch Centrifuge at 12,500 rpm for 5 min. After centrifugation, 600 μL of the top layer of the reaction mixture was transferred to an LCMS vial, which was then placed on an LCMS for analysis.*

**100 μL of 1,3,5-tribromobenzene was added as an internal standard for yield confirmation, where applicable.*

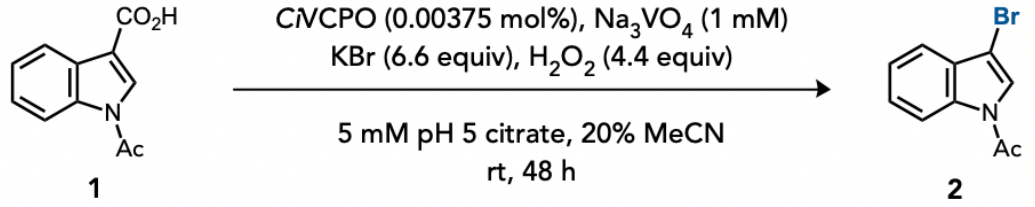
General Preparative Decarboxylative Chlorination Procedure for N-H Substrates (General Procedure I):



Two enzyme aliquots of the VHPO from *Curvularia inaequalis* (*Ci*VCPO, 10 μM, 750 μL each) were removed from a -80 °C freezer and allowed to warm to room temperature over 10 min. A portion of the aliquots (1.125 μL) was then transferred to an Eppendorf tube and combined with 250 mM aqueous Na_3VO_4 (300 μL). This solution was stored in the refrigerator until further use. To a 100 mL round bottom flask containing a magnetic stir bar was added H_2O purified by an Elga purification system (28.9 mL), 500 mM pH 5 citrate buffer (15 mL) and 176 mM aqueous KCl (6.817 mL, 4 equiv) while stirring. This was followed by addition of the N-H carboxyindole substrate (1 equiv, 0.300 mmol) in DMF (22.5 mL). The contents of the Eppendorf tube containing the *Ci*VCPO (0.00375 mol%, 150 nM in reaction) and Na_3VO_4 (1 mM in reaction) was added to the reaction mixture followed by a 10% stock of H_2O_2 (395 μL, 4 equiv). The reaction was then left to stir at room temperature for 2 hr. After this time, the reaction mixture was diluted with EtOAc (10 mL) and H_2O (10 mL) and transferred to a separatory funnel. The mixture was extracted with EtOAc (3 x 25 mL) and then the combined organic layers washed with H_2O (3 x 15 mL) and dried over sodium sulfate. The dried organic layer was then dry loaded onto silica gel and purified on a silica gel hand column.

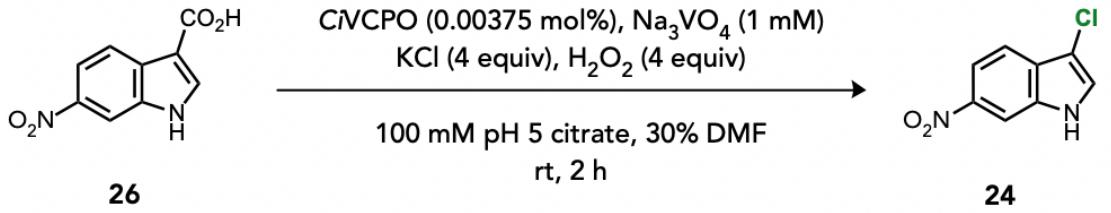
Gram Scale Decarboxylative Halogenation Procedures

Gram Scale Decarboxylative Bromination of 1-acetyl-1*H*-indole-3-carboxylic acid 1:



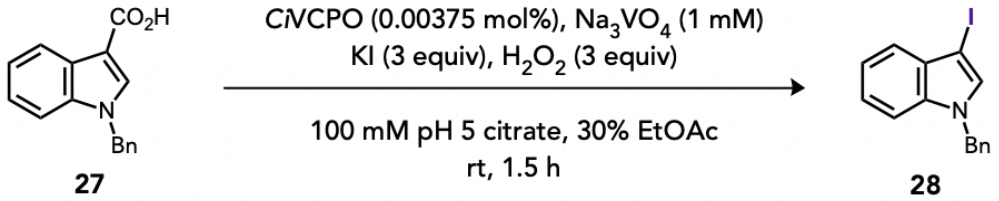
Enzyme aliquots (33) of the VHPO from *Curvularia inaequalis* (*Ci*VCPO, 10 µM, 563 µL each) were removed from a -80 °C freezer and allowed to warm to room temperature over 10 min. 18.450 mL of the enzyme solution was transferred from the aliquots to a 50 mL conical tube and diluted with 25 mM pH 5 citrate buffer (3.075 mL) and 250 mM aqueous Na_3VO_4 (4.92 mL). The solution was then stored at room temperature until further use. To a 2 L round bottom flask containing a magnetic stir bar was added the substrate (1.000 g, 1 equiv, 4.92 mmol) and MeCN (246 mL) while stirring. This was followed by addition of H_2O purified by an Elga purification system (758.4 mL), 500 mM pH 5 citrate buffer (12.3 mL) and 176 mM aqueous KBr (184.5 mL, 6.6 equiv). The contents of the conical tube containing the *Ci*VCPO (0.00375 mol%, 150 nM in reaction) and Na_3VO_4 (1 mM in reaction) was added to the reaction mixture followed by a 30% stock of H_2O_2 (2.378 mL, 4.4 equiv). The reaction was then left to stir at room temperature at 800 rpm for 48 hr. After this time, the reaction mixture was divided into three parts. Each part was concentrated to remove the MeCN and transferred to a separatory funnel, where it was extracted with ethyl acetate (3 x 250 mL) and the combined organic layers washed with brine (250 mL), dried over sodium sulfate, and concentrated under reduced pressure. The resulting crude samples were combined and purified via silica gel hand column to obtain the pure 3-bromoindole **2** (936.2 mg, 3.93 mmol) in 80% yield.

Gram Scale Decarboxylative Chlorination of 6-nitro-1*H*-indole-3-carboxylic acid (26):



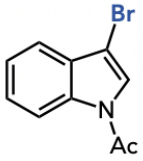
An enzyme aliquot of *Curvularia inaequalis* (*Ci*VCPO, 10 μM, 18.56 mL), was removed from a -80 °C freezer and allowed to warm to room temperature over 10 min. After thawing, the enzyme (18.56 mL) was then combined with an aqueous solution of 250 mM Na_3VO_4 (4.95 mL) in a new conical tube and stored in the refrigerator. To a 2000 mL round bottom flask containing a magnetic stir bar, H_2O purified by an Elga purification system (693 mL), 1 M pH 5 citrate buffer (123.8 mL) and 1 M KCl (19.8 mL, 4 equiv) was added while stirring. Then, 6-nitro-1*H*-indole-3-carboxylic acid (**26**) (4.95 mmol, 1 equiv, 1.02 g) was dissolved in DMF (371 mL) and added to the reaction mixture. The conical tube containing the *Ci*VCPO (0.00375 mol%, 150 nM) and Na_3VO_4 (1 mM in reaction) was removed from the refrigerator and added to the reaction mixture. A 10% stock of H_2O_2 (6.534 mL, 4 equiv) is then added to the reaction mixture and the reaction was allowed to stir at room temperature for 2 hours. After this time, the reaction mixture was diluted with ethyl acetate (100 mL) and H_2O (100 mL) and transferred to a separatory funnel. The aqueous layer was extracted with ethyl acetate (3 x 250 mL) and the combined organic layers were then washed with H_2O (3 x 150 mL) and dried over sodium sulfate. The dried organic layer was dry loaded onto silica gel and purified on a silica gel hand column to give 3-chloro-7-nitro-1*H*-indole (**24**) in 71% yield (0.690 g, 3.51 mmol).

Decarboxylative Iodination of 1-benzyl-1*H*-indole-3-carboxylic acid:



Two enzyme aliquots of *Curvularia inaequalis* (*Ci*VCPO, 10 μM, 750 μL) each, were removed from a -80 °C freezer and allowed to warm to room temperature over 10 min. After thawing, the enzyme (1.125 mL) was then combined with an aqueous solution of 250 mM Na_3VO_4 (300 μL) in a new Eppendorf tube and stored in the refrigerator. To a 100 mL round bottom flask containing a magnetic stir bar, H_2O purified by an Elga purification system (34.3 mL), 1 M pH 5 citrate buffer (7.5 mL) and 100 mM KI (9 mL, 3 equiv) was added while stirring. Then, the corresponding N-H carboxyindole (0.3 mmol, 1 equiv) was dissolved in EtOAc (22.5 mL) and added to the reaction mixture. The Eppendorf tube containing the *Ci*VCPO (0.00375 mol%, 150 nM) and Na_3VO_4 (0.25 equiv) is removed from the refrigerator and added to the reaction mixture. A 10% stock of H_2O_2 (297 μL, 3 equiv) was then added to the reaction mixture and the reaction is allowed to stir at room temperature for 1.5 hours. After this time, the reaction mixture was diluted with ethyl acetate (10 mL) and H_2O (10 mL) (additional ethyl acetate and H_2O used to rinse flask as needed) and transferred to a separatory funnel. The aqueous layer was extracted with ethyl acetate (3 x 25 mL) and the combined organic layers were then washed with H_2O (1 x 15 mL) and dried over sodium sulfate. The dried organic layer was dry loaded onto silica gel for preparation of purification via flash chromatography to give the corresponding N-Bn 3-iodoindole in 76% yield (75.9 mg).

Product Characterization



1-(3-bromo-1*H*-indol-1-yl)ethan-1-one (2)

Synthesized from 1-acetyl-1H-indole-3-carboxylic acid (1) following General Procedure C.

Yield: 85% (60.8 mg, 0.255 mmol)

Purification: Eluted with 10% EtOAc in hexanes (R_f =0.30)

^{1}H-NMR (500 MHz; DMSO): δ 8.37 (d, *J* = 8.0 Hz, 1H), 8.19 (s, 1H), 7.51 (d, *J* = 7.7 Hz, 1H), 7.48 – 7.37 (m, 2H), 2.66 (s, 3H).

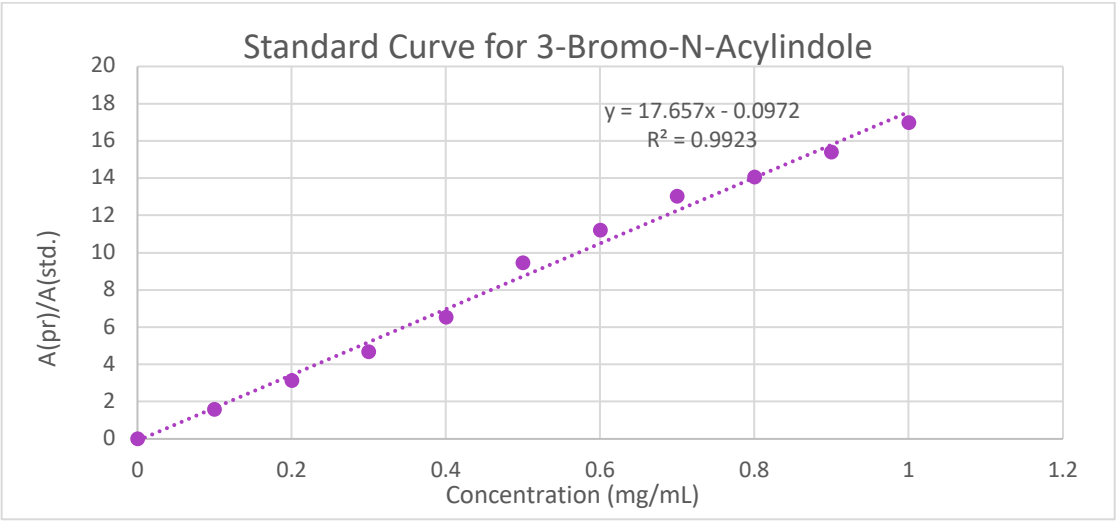
^{13}C-NMR (126 MHz; DMSO): δ 169.67, 134.67, 129.23, 127.01, 126.44, 124.62, 119.33, 116.53, 98.15, 24.23.

HRMS: calculated for $C_{10}H_8BrNO$ $[M+H^+]^+$: 237.9789. Found $[M+H^+]^+$: 237.9866.

IR (cm^{-1}): 3135.76, 1676.51, 1445.45, 1385.71, 1320.25, 1203.00, 732.17, 633.68.

Standard Curve for Analytical Runs:

Procedure for using standard curve is as follows: 1,3,5-tribromobenzene (2mg/mL solution, 100 µL) is added to 900 µL of the reaction mixture and yield is determined by LCMS analysis based on the below standard curve. LCMS conditions: 10 µL injection volume, 1.5 mL/min mobile phase rate, 10-100% solvent B over 5.5 min. Mobile Phase: Solvent A – H_2O w/ 0.1% formic acid, Solvent B – MeCN w/ 0.1% formic acid.



1-(3-bromo-4-methyl-1*H*-indol-1-yl)ethan-1-one (3)

Synthesized from 1-acetyl-4-methyl-1H-indole-3-carboxylic acid (SM-3) following General Procedure C.

Yield: 89% (67.6 mg, 0.268 mmol)

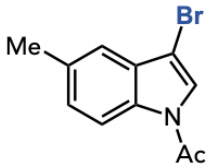
Purification: Eluted with 10% EtOAc in hexanes (R_f = 0.33)

^{1}H-NMR (500 MHz; DMSO): δ 8.29 (d, *J* = 8.4 Hz, 1H), 8.11 (s, 1H), 7.27 (t, *J* = 7.8 Hz, 1H), 7.10 (d, *J* = 7.3 Hz, 1H), 2.75 (s, 3H), 2.64 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 169.53, 135.15, 130.68, 127.45, 126.37, 126.20, 126.03, 114.53, 96.86, 24.36, 19.23.

HRMS: calculated for $C_{11}H_{10}BrNO$ $[M+H^+]^+$: 251.9946. Found $[M+H^+]^+$: 252.0024.

IR (cm^{-1}): 3132.95, 1680.47, 1413.58, 1305.05, 1250.41, 1154.23, 955.55, 768.83, 741.80, 684.43.



1-(3-bromo-5-methyl-1*H*-indol-1-yl)ethan-1-one (4)

Synthesized from 1-acetyl-5-methyl-1H-indole-3-carboxylic acid (SM-4) following General Procedure C.

Yield: 93% (70.1 mg, 0.278 mmol)

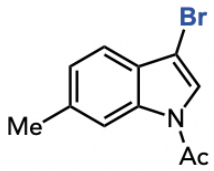
Purification: Eluted with 10% EtOAc in hexanes (R_f =0.31)

^{1}H-NMR (500 MHz; DMSO): δ 8.23 (d, *J* = 8.4 Hz, 1H), 8.13 (s, 1H), 7.29 (s, 1H), 7.25 (d, *J* = 8.4 Hz, 1H), 2.64 (s, 3H), 2.44 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 169.45, 133.92, 132.92, 129.40, 127.67, 126.95, 119.05, 116.26, 97.96, 24.10, 21.38.

HRMS: calculated for $C_{11}H_{10}BrNO$ $[M+H^+]^+$: 251.9946. Found $[M+H^+]^+$: 252.0022.

IR (cm^{-1}): 3132.60, 1678.36, 1386.89, 1313.59, 1206.32, 937.41, 795.33, 637.51.



1-(3-bromo-6-methyl-1*H*-indol-1-yl)ethan-1-one (5)

Synthesized from 1-acetyl-6-methyl-1H-indole-3-carboxylic acid (SM-5) following General Procedure C.

Yield: 84% (63.5 mg, 0.252 mmol)

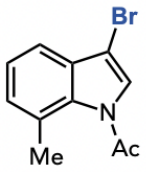
Purification: Eluted with 10% EtOAc in hexanes (R_f =0.31)

^{1}H-NMR (500 MHz; DMSO): δ 8.21 (s, 1H), 8.09 (s, 1H), 7.38 (d, *J* = 8.0 Hz, 1H), 7.23 (d, *J* = 8.0 Hz, 1H), 2.64 (s, 3H), 2.46 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 169.62, 136.12, 135.03, 127.11, 126.30, 125.94, 118.96, 116.60, 98.18, 24.25, 22.00.

HRMS: calculated for $C_{11}H_{10}BrNO$ $[M+H^+]^+$: 251.9946. Found $[M+H^+]^+$: 252.0025.

IR (cm^{-1}): 3127.06, 1687.97, 1384.59, 1314.48, 1203.89, 797.50, 625.89.



1-(3-bromo-7-methyl-1*H*-indol-1-yl)ethan-1-one (6)

Synthesized from 1-acetyl-7-methyl-1H-indole-3-carboxylic acid (SM-6) following General Procedure C.

Yield: 71% (53.5 mg, 0.212 mmol)

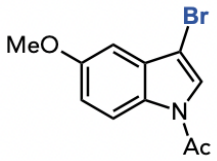
Purification: Eluted with DCM (R_f =0.88)

^{1}H-NMR (500 MHz; DMSO): δ 8.16 (s, 1H), 7.35 – 7.20 (m, 2H), 7.23 (d, *J* = 6.5 Hz, 1H), 2.69 (s, 3H), 2.48 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 168.60, 134.19, 130.72, 129.21, 127.92, 126.70, 124.89, 117.00, 97.72, 24.71, 22.53.

HRMS: calculated for $C_{11}H_{10}BrNO$ $[M+H^+]^+$: 251.9946. Found $[M+H^+]^+$: 252.0025.

IR (cm^{-1}): 2924.52, 1708.51, 1370.25, 1306.42, 1206.35, 942.28, 776.23, 742.32, 626.83.



1-(3-bromo-5-methoxy-1*H*-indol-1-yl)ethan-1-one (7)

Synthesized from 1-acetyl-5-methoxy-1H-indole-3-carboxylic acid (SM-7) following General Procedure C.

Yield: 24% (19.5 mg, 0.073 mmol)

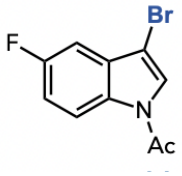
Purification: Eluted with 5% EtOAc in hexanes (R_f = 0.16)

^{1}H-NMR (500 MHz; $CDCl_3$): δ 8.34 (d, *J* = 9.1 Hz, 1H), 7.49 (s, 1H), 7.03 (dd, *J* = 9.0, 2.6 Hz, 1H), 6.98 (d, *J* = 2.6 Hz, 1H), 3.92 (s, 3H), 2.63 (s, 3H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 167.48, 157.06, 130.35, 129.52, 124.62, 117.57, 115.27, 101.67, 99.81, 55.72, 23.59.

HRMS: calculated for $C_{11}H_{10}BrNO_2$ $[M+H^+]^+$: 267.9895. Found $[M+H^+]^+$: 267.9973.

IR (cm^{-1}): 3142.16, 1701.13, 1477.58, 1383.49, 1249.61, 1207.80, 837.11.



1-(3-bromo-5-fluoro-1*H*-indol-1-yl)ethan-1-one (8)

Synthesized from 1-acetyl-5-fluoro-1H-indole-3-carboxylic acid (SM-8) following General Procedure C.

Yield: 48% (36.9 mg, 0.144 mmol)

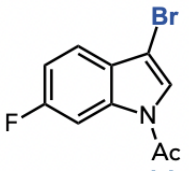
Purification: Eluted with 10% EtOAc in hexanes (R_f =0.24)

^{1}H-NMR (500 MHz; DMSO): δ 8.39 – 8.36 (m, 1H), 8.28 (s, 1H), 7.31 – 7.27 (m, 2H), 2.66 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 169.55, 159.65 (d, J = 239.9 Hz), 131.23, 130.55 (d, J = 10.5 Hz), 128.90, 118.16, 114.12 (d, J = 25.1 Hz), 105.04 (d, J = 24.6 Hz), 97.37 (d, J = 4.2 Hz), 24.02.

HRMS: calculated for $C_{10}H_7BrFNO$ $[M+H^+]^+$: 255.9695. Found $[M+H^+]^+$: 255.9776.

IR (cm^{-1}): 3132.86, 1677.03, 1388.00, 1251.36, 1198.20, 845.14, 800.38, 638.90.



1-(3-bromo-6-fluoro-1*H*-indol-1-yl)ethan-1-one (9)

Synthesized from 1-acetyl-6-fluoro-1H-indole-3-carboxylic acid (SM-9) following General Procedure C.

Yield: 52% (39.7 mg, 0.155 mmol)

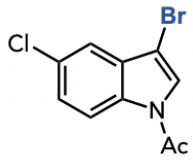
Purification: Eluted with 10% EtOAc in hexanes (R_f =0.28)

^{1}H-NMR (500 MHz; DMSO): δ 8.21 (s, 1H), 8.11 (dd, *J* = 10.4, 2.4 Hz, 1H), 7.52 (dd, *J* = 8.7, 5.4 Hz, 1H), 7.30 – 7.26 (m, 1H), 2.65 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 169.83, 161.38 (d, *J* = 240.4 Hz), 134.55 (d, *J* = 13.6 Hz), 127.62 (d, *J* = 4.2 Hz), 125.91, 120.74 (d, *J* = 10.5 Hz), 112.79 (d, *J* = 24.6 Hz), 103.48 (d, *J* = 28.7 Hz), 97.73, 24.12.

HRMS: calculated for $C_{10}H_7BrFNO$ $[M+H^+]^+$: 255.9695. Found $[M+H^+]^+$: 255.9768.

IR (cm^{-1}): 3142.46, 1679.46, 1428.84, 1330.46, 1206.92, 954.97, 848.34, 805.89, 625.38.



1-(3-bromo-5-chloro-1*H*-indol-1-yl)ethan-1-one (10)

Synthesized from 1-acetyl-5-chloro-1H-indole-3-carboxylic acid (SM-10) following General Procedure C.

Yield: 44% (35.9 mg, 0.132 mmol)

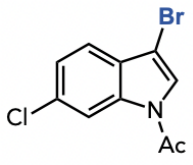
Purification: Eluted with 10% EtOAc in hexanes (R_f =0.26)

^{1}H-NMR (500 MHz; DMSO): δ 8.35 (d, *J* = 8.8 Hz, 1H), 8.28 (s, 1H), 7.51 (d, *J* = 2.1 Hz, 1H), 7.47 (dd, *J* = 8.8, 2.2 Hz, 1H), 2.66 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 169.70, 133.21, 130.72, 129.09, 128.75, 126.36, 118.71, 118.13, 96.90, 24.11.

HRMS: calculated for $C_{10}H_7BrClNO$ $[M+H^+]^+$: 271.9400. Found $[M+H^+]^+$: 271.9481.

IR (cm^{-1}): 3133.22, 1702.28, 1440.83, 1371.45, 1302.28, 1200.73, 927.47, 782.43, 643.03.



1-(3-bromo-6-chloro-1*H*-indol-1-yl)ethan-1-one (11)

Synthesized from 1-acetyl-6-chloro-1H-indole-3-carboxylic acid (SM-11) following General Procedure C.

Yield: 39% (31.9 mg, 0.117 mmol)

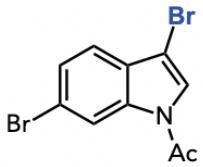
Purification: Eluted with 10% EtOAc in hexanes (R_f =0.30)

^{1}H-NMR (500 MHz; DMSO): δ 8.38 (s, 1H), 8.24 (s, 1H), 7.52 (d, *J* = 8.4 Hz, 1H), 7.45 (d, *J* = 8.4 Hz, 1H), 2.66 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 169.88, 134.84, 130.99, 128.14, 128.05, 124.88, 120.81, 116.22, 97.67, 24.15.

HRMS: calculated for $C_{10}H_7BrClNO$ $[M+H^+]^+$: 271.9400. Found $[M+H^+]^+$: 271.9474.

IR (cm^{-1}): 3129.29, 1689.14, 1420.63, 1312.05, 1200.77, 932.89, 807.83, 643.85.



1-(3,6-dibromo-1*H*-indol-1-yl)ethan-1-one (12)

Synthesized from 1-acetyl-6-bromo-1H-indole-3-carboxylic acid (SM-10) following General Procedure C.

Yield: 35% (32.9 mg, 0.104 mmol)

Purification: Eluted with 10% EtOAc in hexanes (R_f =0.28)

^{1}H-NMR (500 MHz; DMSO): δ 8.54 (d, *J* = 1.8 Hz, 1H), 8.24 (s, 1H), 7.57 (dd, *J* = 8.4, 1.8 Hz, 1H), 7.48 (d, *J* = 8.4 Hz, 1H), 2.66 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 169.90, 135.20, 128.44, 127.95, 127.55, 121.17, 119.15, 119.06, 97.74, 24.15.

HRMS: calculated for $C_{10}H_7Br_2NO$ $[M+H^+]^+$: 315.8894. Found $[M+H^+]^+$: 315.8965.

IR (cm^{-1}): 3127.16, 1700.89, 1418.78, 1319.72, 1198.78, 924.70, 806.94, 640.37.

3-bromo-1-methyl-1*H*-indole (13)

Synthesized from commercially available 1-methyl-1H-indole-3-carboxylic acid following General Procedure E with the reaction run for 7 hours.

Yield: 73% (45.9 mg, 0.218 mmol)

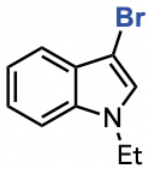
Purification: Eluted with 5% EtOAc in hexanes (R_f =0.53)

^{1}H-NMR (500 MHz; DMSO): δ 7.56 (s, 1H), 7.51 (d, *J* = 8.1 Hz, 1H), 7.42 (d, *J* = 8.0 Hz, 1H), 7.25 (t, *J* = 7.7 Hz, 1H), 7.16 (t, *J* = 7.5 Hz, 1H), 3.80 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 136.45, 129.14, 126.89, 122.75, 120.44, 118.63, 110.83, 87.86, 33.23.

IR (cm^{-1}): 2930.40, 1404.73, 1322.82, 1238.91, 965.92, 733.40.

Note: rapid degradation of the purified product was observed if stored for longer than 12 h at 0 °C.



3-bromo-1-ethyl-1*H*-indole (14)

Synthesized from commercially available 1-ethyl-1H-indole-3-carboxylic acid following General Procedure E with the reaction run for 7 hours.

Yield: 59% (40.0 mg, 0.178 mmol)

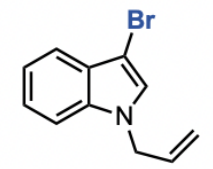
Purification: Eluted with DCM (R_f =0.95)

^{1}H-NMR (500 MHz; DMSO): δ 7.63 (s, 1H), 7.55 (d, *J* = 8.3 Hz, 1H), 7.42 (d, *J* = 8.0 Hz, 1H), 7.24 (ddd, *J* = 8.3, 7.0, 1.2 Hz, 1H), 7.16 – 7.13 (m, 1H), 4.22 (q, *J* = 7.2 Hz, 2H), 1.36 (t, *J* = 7.2 Hz, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 135.45, 127.62, 126.98, 122.70, 120.42, 118.77, 110.80, 88.18, 41.14, 15.88.

HRMS: calculated for $C_{10}H_{10}BrN$ $[M]^+$: 222.9997. Found $[M]^+$: 222.9995.

IR (cm^{-1}): 2976.76, 1456.46, 1349.18, 1319.17, 1219.64, 1154.82, 735.06.



1-allyl-3-bromo-1*H*-indole (15)

Synthesized from commercially available 1-allyl-1H-indole-3-carboxylic acid following General Procedure E with the reaction run for 24 hours.

Yield: 42% (29.6 mg, 0.125 mmol)

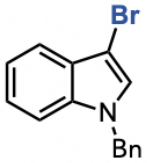
Purification: Eluted with DCM (R_f =0.95)

^{1}H-NMR (500 MHz; DMSO): δ 7.58 (s, 1H), 7.51 (d, *J* = 8.3 Hz, 1H), 7.44 (d, *J* = 8.0 Hz, 1H), 7.24 (ddd, *J* = 8.3, 7.0, 1.3 Hz, 1H), 7.16 (ddd, *J* = 8.0, 7.0, 1.0 Hz, 1H), 6.00 (ddt, *J* = 17.1, 10.3, 5.5 Hz, 1H), 5.17 (dd, *J* = 10.2, 1.5 Hz, 1H), 5.05 (dd, *J* = 17.1, 1.6 Hz, 1H), 4.84 (dt, *J* = 5.6, 1.6 Hz, 2H).

^{13}C-NMR (126 MHz; DMSO): δ 135.81, 134.50, 128.28, 127.05, 122.85, 120.60, 118.80, 117.55, 111.17, 88.57, 48.77.

HRMS: calculated for $C_{11}H_{10}BrN$ $[M+H^+]^+$: 235.9997. Found $[M+H^+]^+$: 236.0075.

IR: (cm^{-1}) 2916.81, 1458.06, 1319.60, 1252.64, 1197.61, 988.83, 924.24, 734.55.



1-benzyl-3-bromo-1*H*-indole (16)

Synthesized from commercially available 1-benzyl-1H-indole-3-carboxylic acid (27) following General Procedure E with the reaction run for 24 hours.

Yield: 87% (74.3 mg, 0.260 mmol)

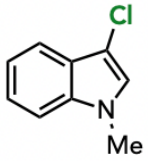
Purification: Eluted with DCM (R_f =0.95)

^{1}H-NMR (500 MHz; DMSO): δ 7.76 (s, 1H), 7.55 (d, *J* = 8.5 Hz, 1H), 7.44 (d, *J* = 7.9 Hz, 1H), 7.33 – 7.13 (m, 7H), 5.44 (s, 2H).

^{13}C-NMR (126 MHz; DMSO): δ 138.20, 135.79, 129.08, 128.61, 128.60, 127.99, 127.62, 127.17, 122.98, 120.67, 118.84, 111.29, 88.86, 49.82.

HRMS: calculated for $C_{15}H_{12}BrN$ $[M]^+$: 285.0153. Found $[M]^+$: 285.0164.

IR (cm^{-1}): 3053.07, 1453.78, 1322.69, 1251.20, 1193.15, 1161.23, 943.25, 726.40, 693.37, 636.13.



3-chloro-1-methyl-1*H*-indole (17)

Synthesized from commercially available 1-methyl-1H-indole-3-carboxylic acid following General Procedure G.

Yield: 80% (39.8 mg, 0.240 mmol)

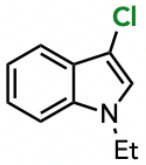
Purification: Eluted with 10% EtOAc in hexanes (R_f =0.59)

^{1}H-NMR (500 MHz; DMSO): δ 7.53 (s, 1H), 7.51 – 7.49 (m, 2H), 7.27 – 7.24 (m, 1H), 7.15 (t, *J* = 7.4 Hz, 1H), 3.78 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 135.96, 126.80, 125.28, 122.77, 120.30, 117.75, 110.87, 102.49, 33.15.

HRMS: calculated for C_9H_8ClN $[M+H^+]^+$: 166.0345. Found $[M+H^+]^+$: 166.0423.

IR (cm^{-1}): 2928.42, 1463.87, 1323.23, 1239.15, 1108.96, 966.15, 735.20.



3-chloro-1-ethyl-1*H*-indole (18)

Synthesized from commercially available 1-ethyl-1H-indole-3-carboxylic acid following General Procedure G.

Yield: 85% (45.8 mg, 0.255 mmol)

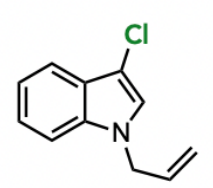
Purification: Eluted with 10% EtOAc in hexanes (R_f =0.62)

^{1}H-NMR (500 MHz; DMSO): δ 7.60 (s, 1H), 7.54 (d, *J* = 8.3 Hz, 1H), 7.50 (d, *J* = 8.0 Hz, 1H), 7.24 (ddd, *J* = 8.3, 7.0, 1.3 Hz, 1H), 7.14 (ddd, *J* = 7.9, 7.0, 0.9 Hz, 1H), 4.20 (q, *J* = 7.2 Hz, 2H), 1.35 (t, *J* = 7.2 Hz, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 134.98, 125.39, 125.28, 122.73, 120.27, 117.87, 110.85, 102.76, 41.05, 15.84.

HRMS: calculated for $C_{10}H_{10}ClN$ $[M+H^+]^+$: 180.0502. Found $[M+H^+]^+$: 180.0579.

IR (cm^{-1}): 2929.69, 1458.46, 1351.34, 1324.25, 1222.19, 1155.68, 735.79.



1-allyl-3-chloro-1*H*-indole (19)

Synthesized from commercially available 1-allyl-1H-indole-3-carboxylic acid following General Procedure G.

Yield: 80% (46.0 mg, 0.240 mmol)

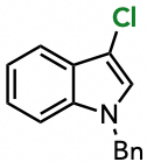
Purification: Eluted with 10% EtOAc in hexanes (R_f =0.62)

^{1}H-NMR (500 MHz; DMSO): δ 7.55 (s, 1H), 7.51 (t, *J* = 7.4 Hz, 2H), 7.23 (t, *J* = 7.7 Hz, 1H), 7.15 (t, *J* = 7.6 Hz, 1H), 6.03 – 5.96 (m, 1H), 5.16 (dd, *J* = 10.2, 1.5 Hz, 1H), 5.05 (dd, *J* = 17.1, 1.6 Hz, 1H), 4.82 (dt, *J* = 5.5, 1.6 Hz, 2H).

^{13}C-NMR (126 MHz; DMSO): δ 135.35, 134.48, 125.94, 125.46, 122.88, 120.45, 117.90, 117.49, 111.20, 103.13, 48.69.

HRMS: calculated for $C_{11}H_{10}ClN$ $[M+H^+]^+$: 192.0502. Found $[M+H^+]^+$: 192.0582.

IR (cm^{-1}): 2922.65, 1460.33, 1324.10, 1253.05, 1199.82, 925.22, 735.69.



1-benzyl-3-chloro-1*H*-indole (20)

Synthesized from commercially available 1-benzyl-1H-indole-3-carboxylic acid (27) following General Procedure G.

Yield: 28% (20.3 mg, 0.084 mmol)

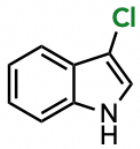
Purification: Eluted with 10% EtOAc in hexanes (R_f =0.60)

^{1}H-NMR (500 MHz; DMSO): δ 7.73 (s, 1H), 7.53 (dd, *J* = 15.9, 8.1 Hz, 2H), 7.32 (t, *J* = 7.1 Hz, 2H), 7.28 – 7.19 (m, 4H), 7.17 – 7.12 (m, 1H), 5.42 (s, 2H).

^{13}C-NMR (126 MHz; DMSO): δ 138.21, 135.35, 129.07, 127.98, 127.59, 126.31, 126.29, 125.58, 123.01, 120.54, 117.95, 111.34, 103.40, 49.75.

HRMS: calculated for $C_{15}H_{12}ClN$ $[M+H^+]^+$: 242.0658. Found $[M+H^+]^+$: 242.0738.

IR (cm^{-1}): 2923.59, 1458.70, 1324.59, 1248.35, 1163.98, 732.36, 695.61.



3-chloro-1*H*-indole (21)

Synthesized from commercially available 1H-indole-3-carboxylic acid following General Procedure I.

Yield: 82% (37.3 mg, 0.246 mmol)

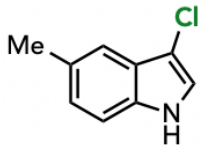
Purification: Eluted with 30% EtOAc in hexanes (R_f =0.60)

^{1}H-NMR (500 MHz; DMSO): δ 11.38 (s, 1H), 7.55 – 7.49 (m, 2H), 7.46 (d, *J* = 8.2 Hz, 1H), 7.22 – 7.18 (m, 1H), 7.14 – 7.11 (m, 1H).

^{13}C-NMR (126 MHz; DMSO): δ 135.44, 125.06, 122.83, 122.68, 120.18, 117.54, 112.66, 103.67.

HRMS: calculated for C_8H_6ClN $[M\text{-}H^+]^-$: 150.0189. Found $[M\text{-}H^+]^-$: 150.0109.

IR: (cm^{-1}) 3404.01, 2928.66, 1721.25, 1452.72, 1238.27, 1202.88, 997.50, 737.22.



3-chloro-5-methyl-1*H*-indole (22)

Synthesized from commercially available 5-methyl-1H-indole-3-carboxylic acid following General Procedure I.

Yield: 82% (40.7 mg, 0.246 mmol)

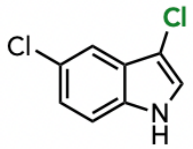
Purification: Eluted with DCM (R_f = 0.90)

^{1}H-NMR (500 MHz; DMSO): δ 11.21 (s, 1H), 7.44 (d, *J* = 2.7 Hz, 1H), 7.31 (d, *J* = 8.4 Hz, 1H), 7.26 (s, 1H), 7.01 (dd, *J* = 8.4, 1.7 Hz, 1H), 2.40 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 133.78, 128.93, 125.19, 124.35, 122.78, 116.95, 112.38, 103.01, 21.58.

HRMS: calculated for C_9H_8ClN $[M\text{-}H^+]^-$: 164.0345. Found $[M\text{-}H^+]^-$: 164.0268.

IR (cm^{-1}): 3394.76, 2916.31, 1454.17, 1240.06, 1163.17, 980.94, 875.12, 789.16.



3,5-dichloro-1*H*-indole (23)

Synthesized from commercially available 5-chloro-1H-indole-3-carboxylic acid following General Procedure I.

Yield: 71% (39.9 mg, 0.214 mmol)

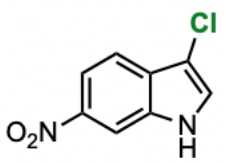
Purification: Eluted with 10% acetone in DCM (R_f =0.93)

^{1}H-NMR (500 MHz; DMSO): δ 11.58 (s, 1H), 7.62 (d, *J* = 2.7 Hz, 1H), 7.49 – 7.45 (m, 2H), 7.19 (dd, *J* = 8.7, 2.1 Hz, 1H).

^{13}C-NMR (126 MHz; DMSO): δ 133.90, 126.08, 124.99, 124.82, 122.81, 116.68, 114.41, 103.15.

HRMS: calculated for $C_8H_5Cl_2N$ $[M+H^+]^+$: 185.9799. Found $[M+H^+]^+$: 185.9877.

IR (cm^{-1}): 3410.37, 3123.67, 1458.87, 1442.80, 1200.44, 865.90, 797.43, 783.94, 604.22.



3-chloro-6-nitro-1*H*-indole (24)

Synthesized from commercially available 6-nitro-1H-indole-3-carboxylic acid (26) following General Procedure I.

Yield: 73% (43.0 mg, 0.219 mmol)

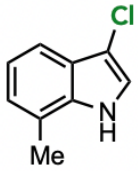
Purification: Eluted with 1:1 hexanes to EtOAc with 5% MeOH (R_f =0.83)

^{1}H-NMR (500 MHz; DMSO): δ 12.15 (s, 1H), 8.38 (d, *J* = 2.1 Hz, 1H), 7.98 – 8.01 (m, 2H), 7.69 (d, *J* = 8.8 Hz, 1H).

^{13}C-NMR (126 MHz; DMSO): δ 143.31, 133.76, 129.84, 129.38, 118.16, 115.35, 109.60, 104.70.

HRMS: calculated for $C_8H_5ClN_2O_2$ $[M\text{-}H^+]^-$: 195.0040. Found $[M\text{-}H^+]^-$: 194.9964.

IR (cm^{-1}): 3315.63, 3120.87, 1502.74, 1334.99, 1206.99, 1062.05, 998.92, 827.15, 747.91, 730.52.



3-chloro-7-methyl-1*H*-indole (25)

Synthesized from commercially available 7-methyl-1H-indole-3-carboxylic acid following General Procedure I.

Yield: 85% (42.4 mg, 0.256 mmol)

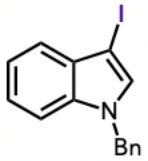
Purification: Eluted with DCM (R_f =0.88)

^{1}H-NMR (500 MHz; DMSO): δ 11.35 (s, 1H), 7.51 (d, *J* = 2.7 Hz, 1H), 7.33 (d, *J* = 7.8 Hz, 1H), 7.04 – 6.98 (m, 2H), 2.48 (s, 3H).

^{13}C-NMR (126 MHz; DMSO): δ 134.91, 124.77, 123.11, 122.54, 121.89, 120.38, 115.13, 104.04, 16.89.

HRMS: calculated for C_9H_8ClN $[M+H^+]^+$: 166.0345. Found $[M+H^+]^+$: 166.0425.

IR (cm^{-1}): 3388.66, 2920.50, 1325.58, 1159.71, 1103.96, 777.27, 745.71.



1-benzyl-3-iodo-1*H*-indole (28)

Synthesized from commercially available 1-benzyl-1H-indole-3-carboxylic acid (27).

Yield: 76% (75.9 mg, 0.228 mmol)

Purification: Eluted with 20% EtOAc in hexanes (R_f =0.77)

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.51 – 7.48 (m, 1H), 7.39 – 7.23 (m, 7H), 7.19 – 7.13 (m, 2H), 5.34 (s, 2H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 136.80, 136.41, 132.11, 130.66, 128.91, 127.94, 126.98, 122.88, 121.33, 120.55, 109.90, 56.02, 50.43.

IR (cm^{-1}): 3027.78, 1452.35, 1351.97, 1314.82, 1190.76, 1168.28, 727.72, 694.75.

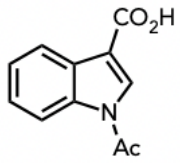
Note: rapid degradation of the purified product was observed if stored for longer than 12 h at 0 °C.

References

(1) C.E. Wells, L.P.T. Ramos, L.J. Harstad, L.Z. Hessefort, H.J. Lee, M. Sharma, K.F. Biegasiewicz, *ACS Catal.*, 2023, **13**, 4622.

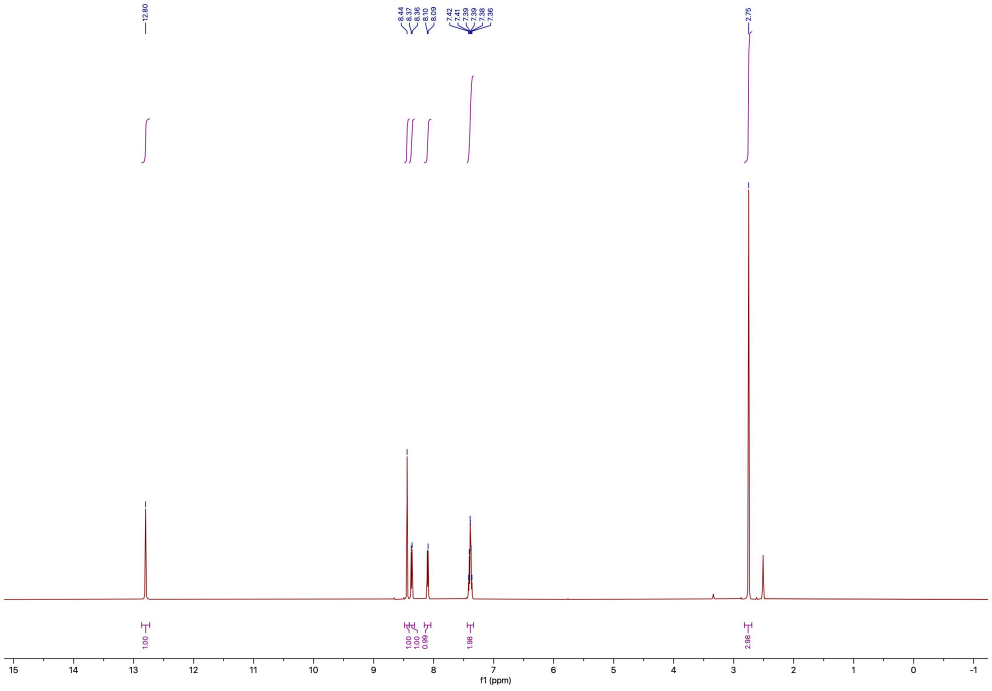
(2) P.L. Kotian, Y.S. Babu, W. Zhang, L. Vogeti, M. Wu, V.R. Chintareddy, and K. Raman, WIPO, 2017136395, 2017.

Physical Data

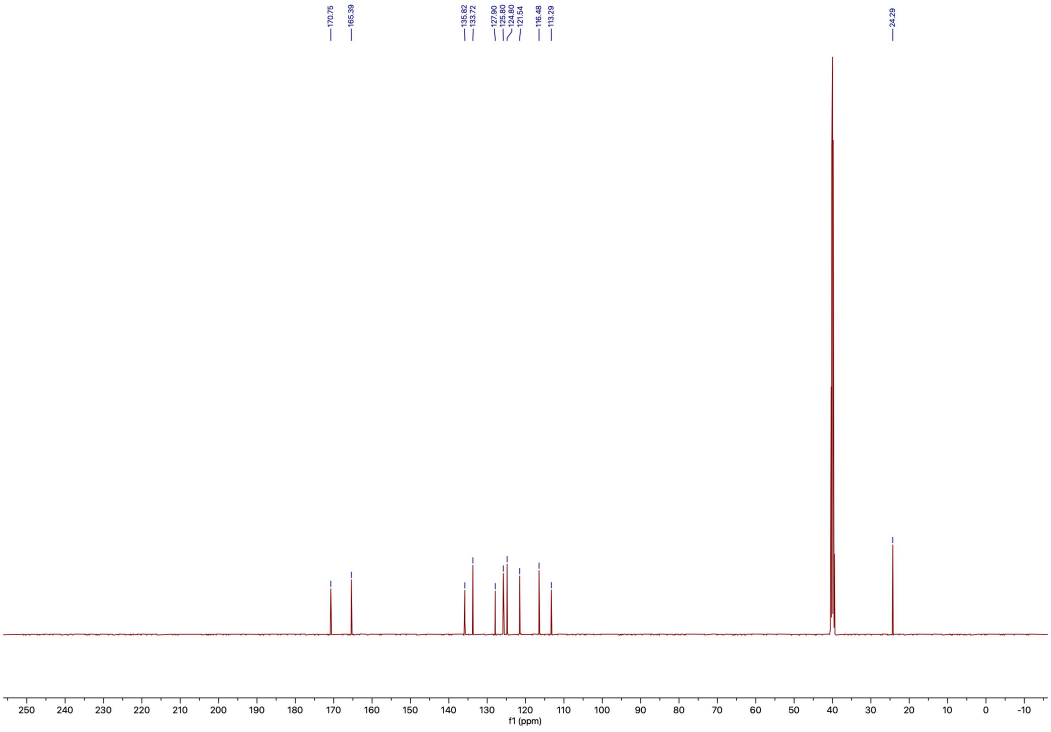


1-acetyl-1H-indole-3-carboxylic acid (1):

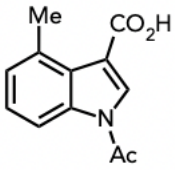
^{1}H-NMR
DMSO-d_6



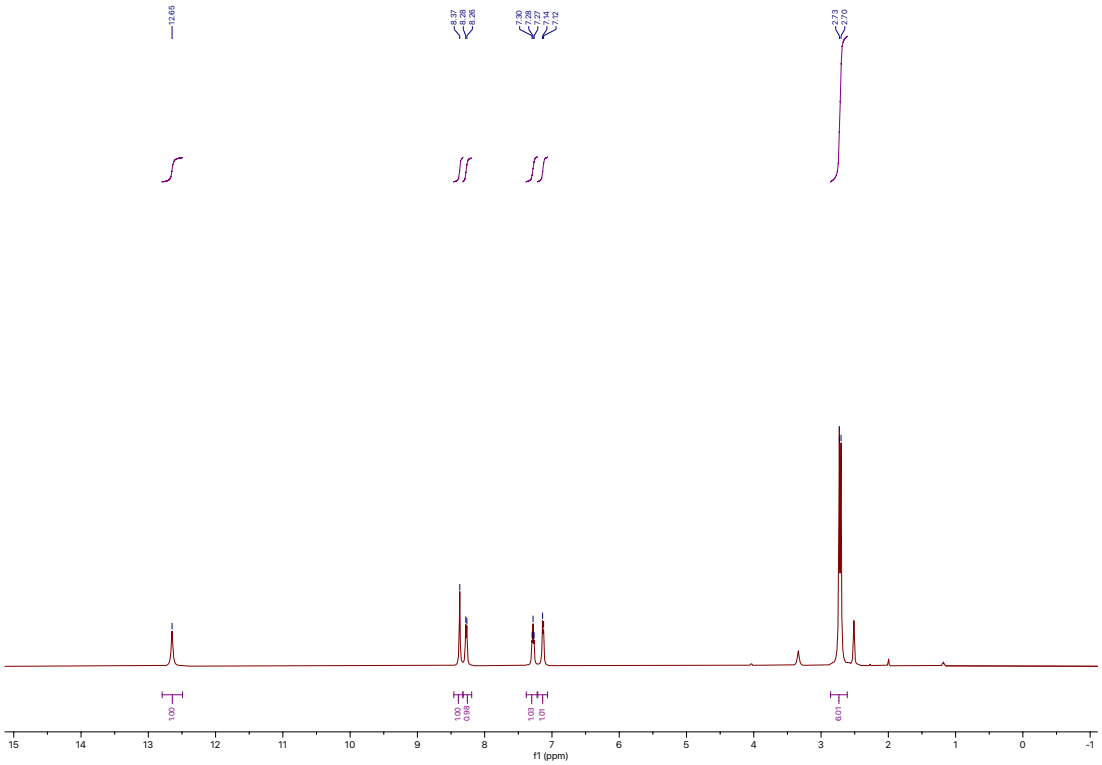
^{13}C-NMR
DMSO-d_6



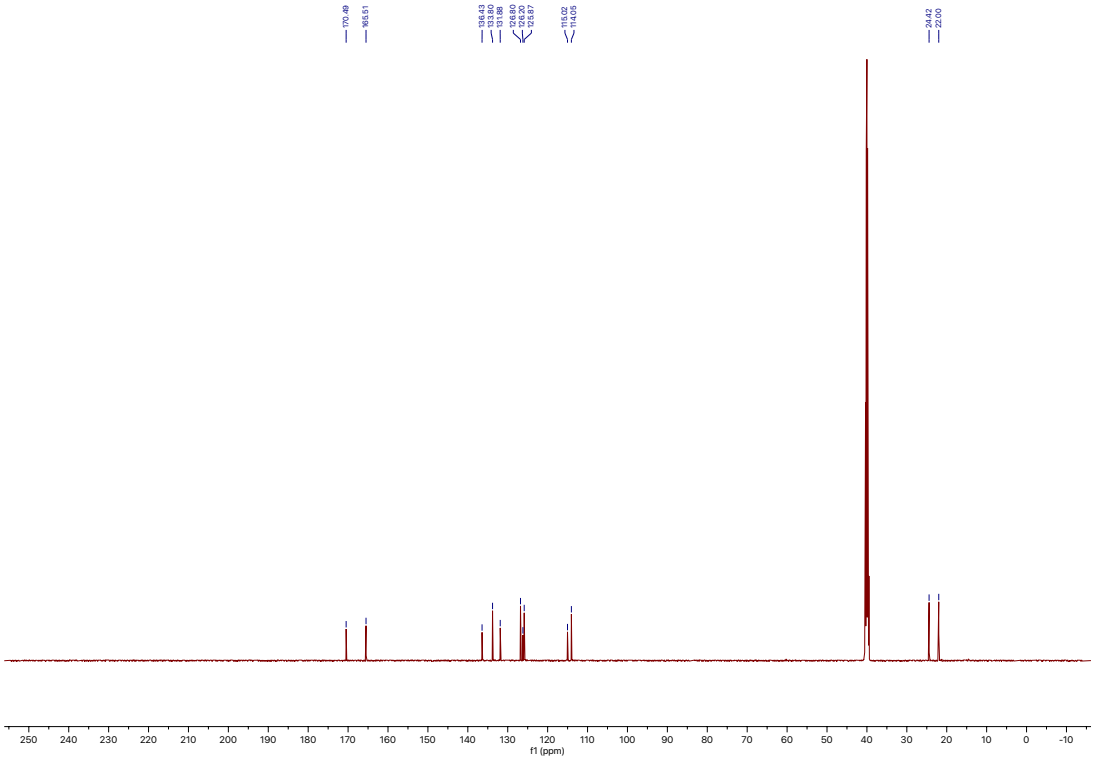
1-acetyl-4-methyl-1H-indole-3-carboxylic acid (SM-3):



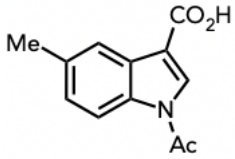
^{1}H-NMR
DMSO-d_6



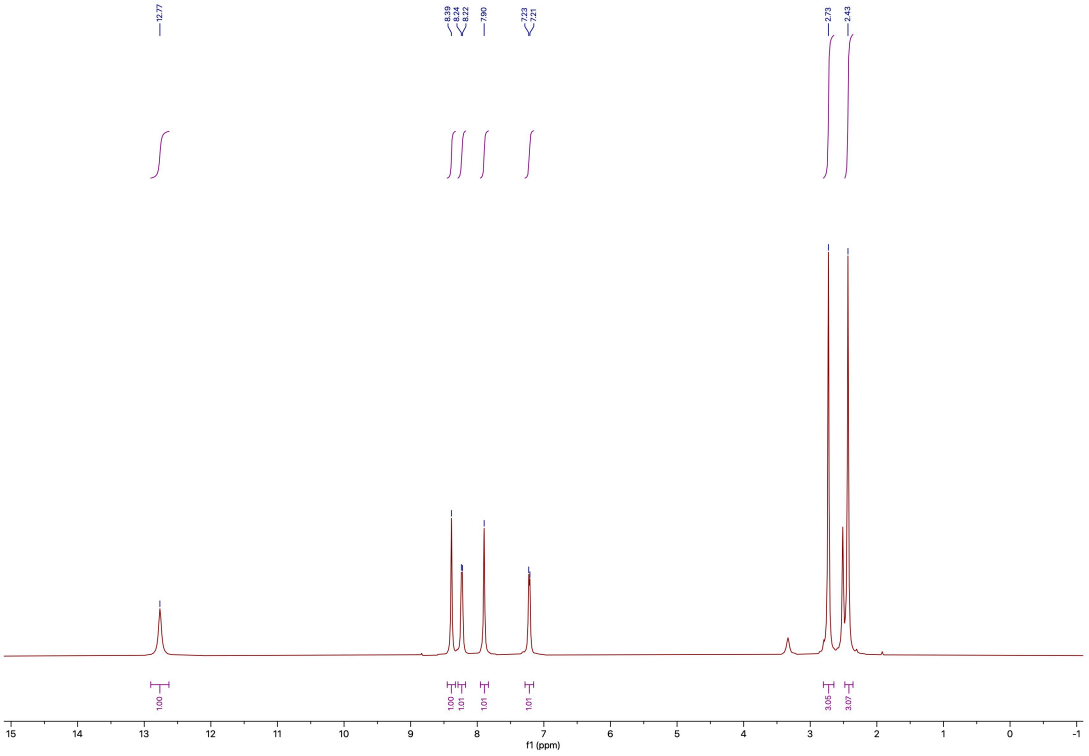
^{13}C-NMR
DMSO-d_6



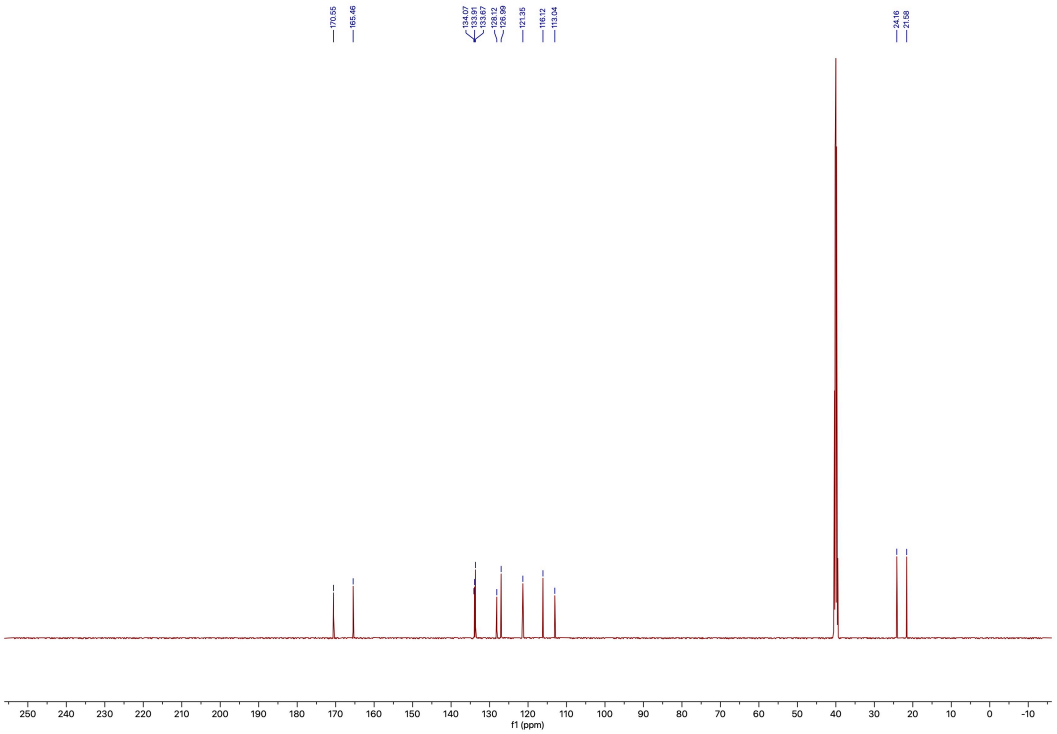
1-acetyl-5-methyl-1H-indole-3-carboxylic acid (SM-4):



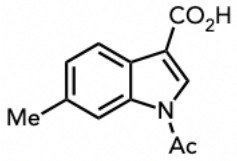
^{1}H-NMR
DMSO-d_6



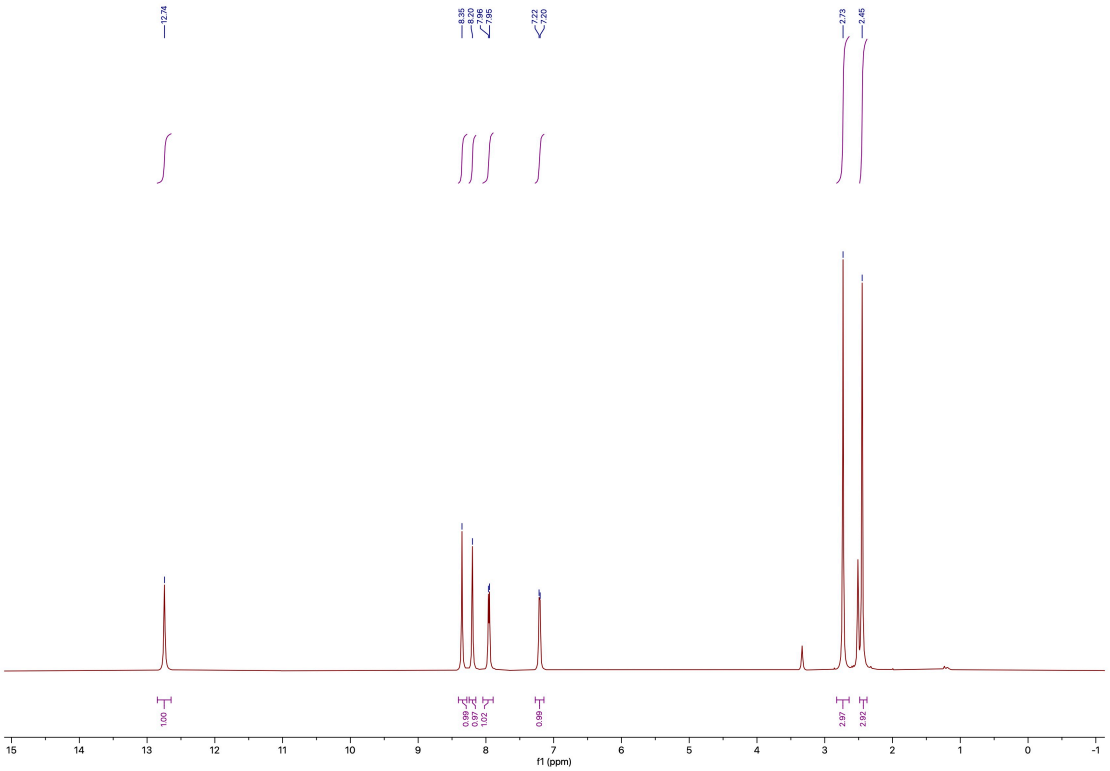
^{13}C-NMR
DMSO-d_6



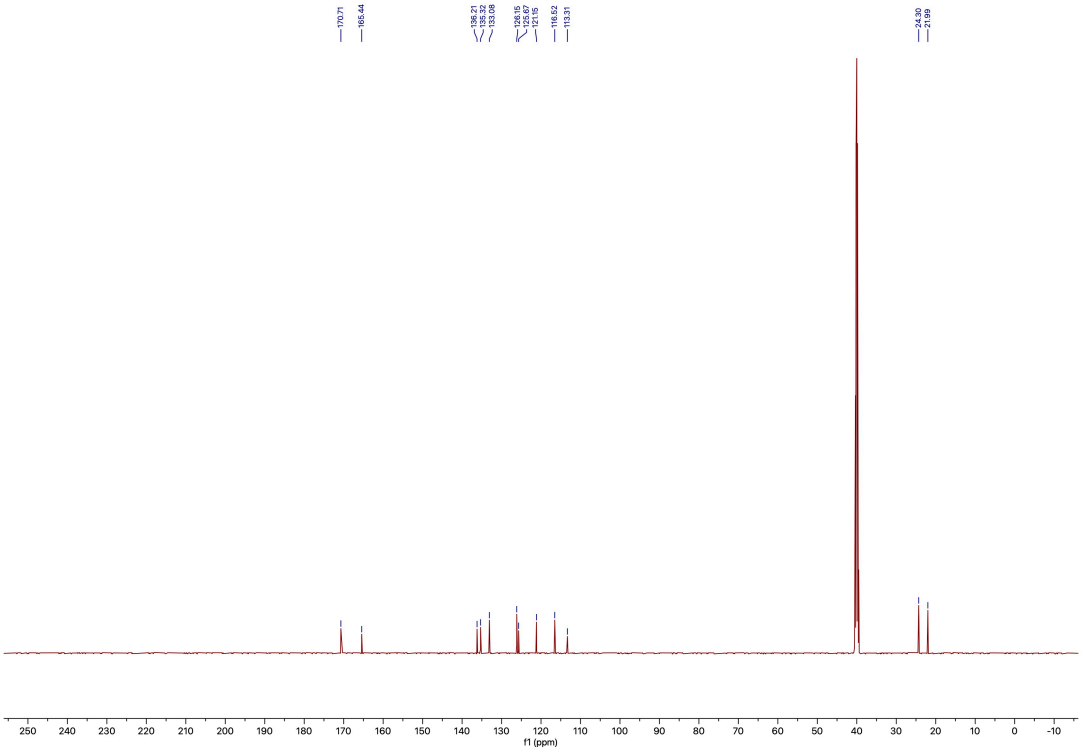
1-acetyl-6-methyl-1H-indole-3-carboxylic acid (SM-5):



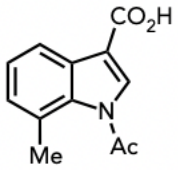
^{1}H-NMR
DMSO-d_6



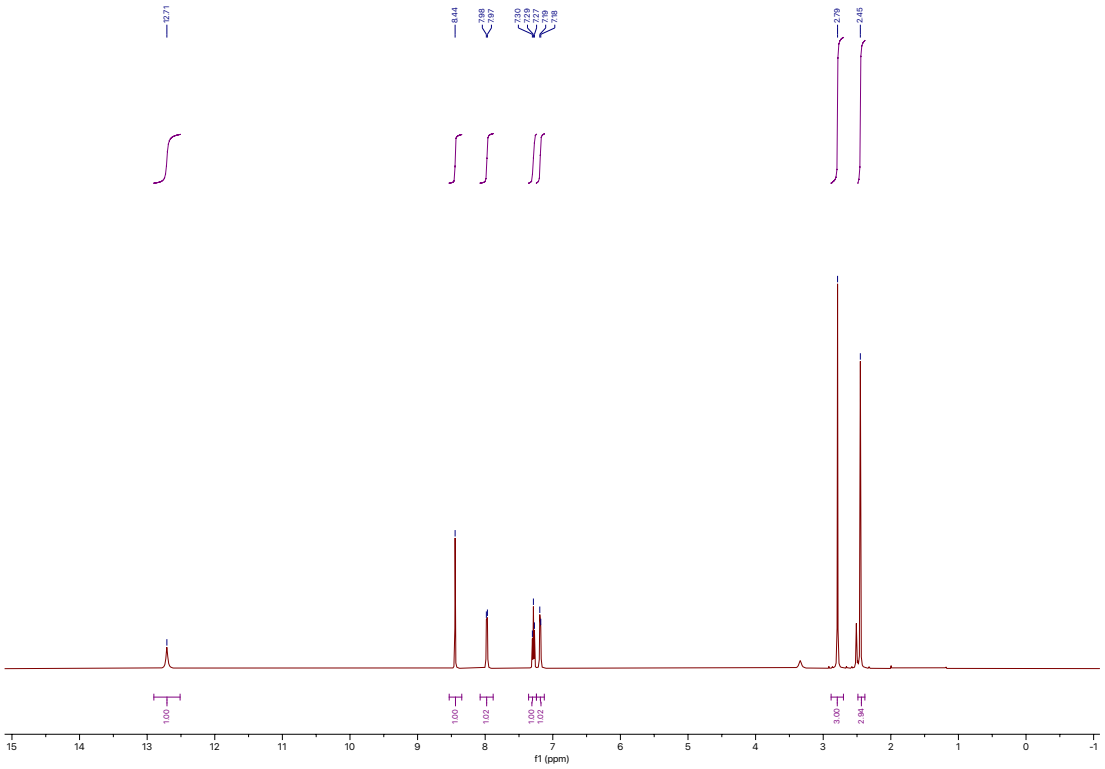
^{13}C-NMR
DMSO-d_6



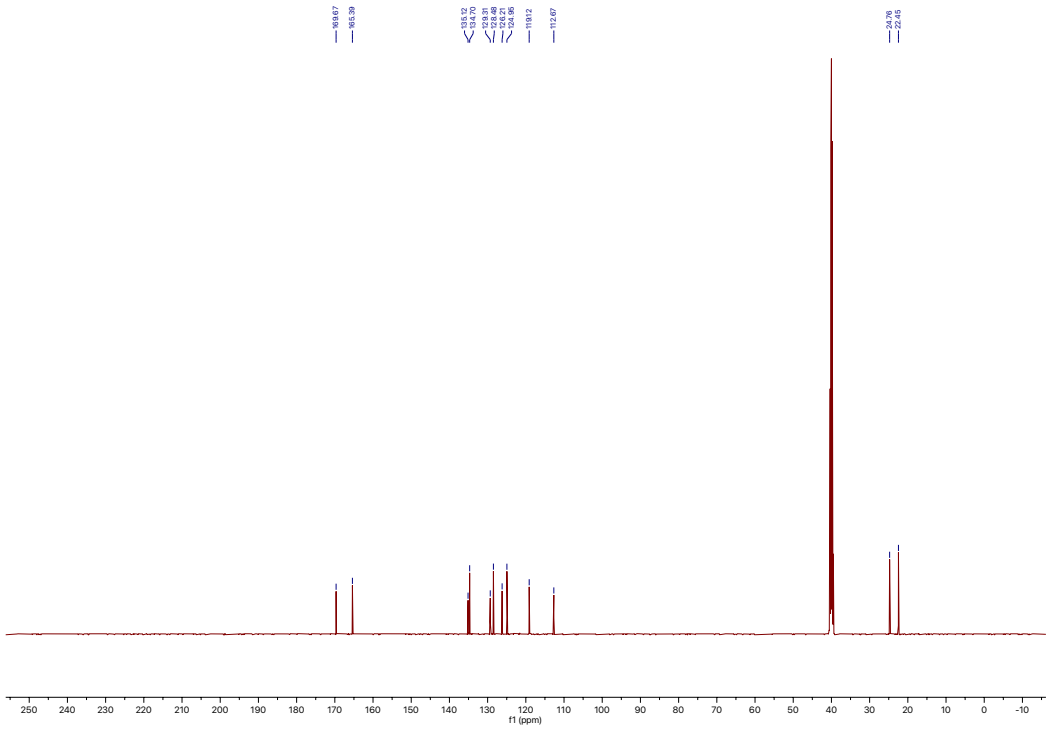
1-acetyl-7-methyl-1H-indole-3-carboxylic acid (SM-6):



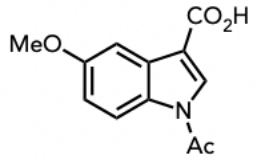
^{1}H-NMR
DMSO-d_6



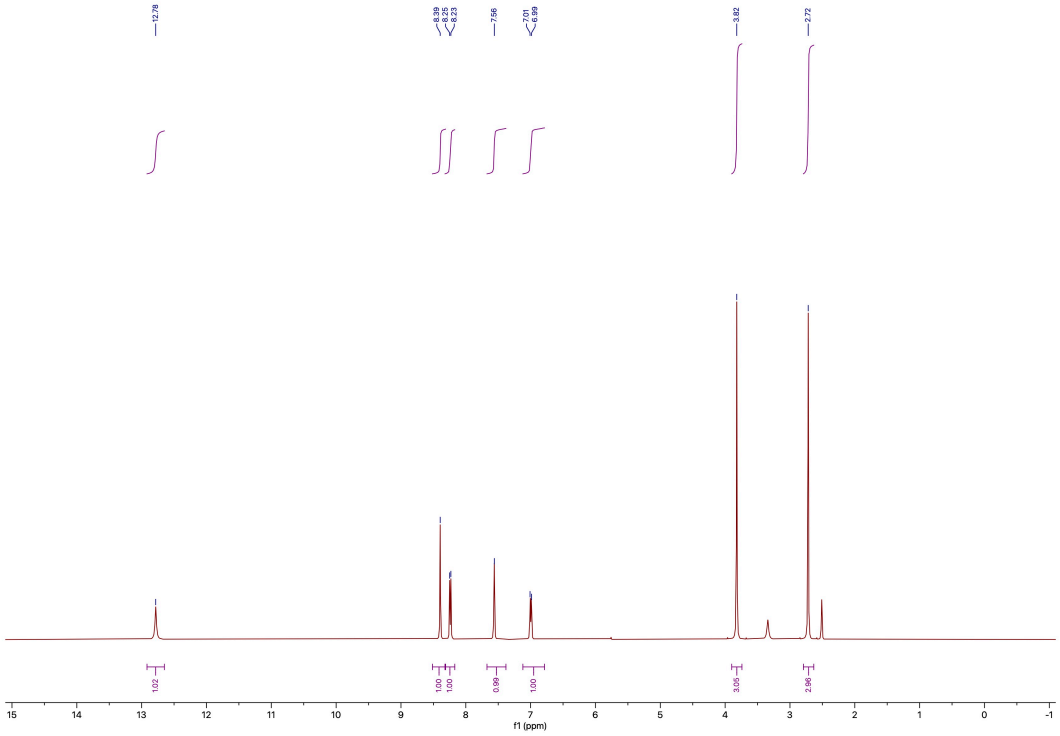
^{13}C-NMR
DMSO-d_6



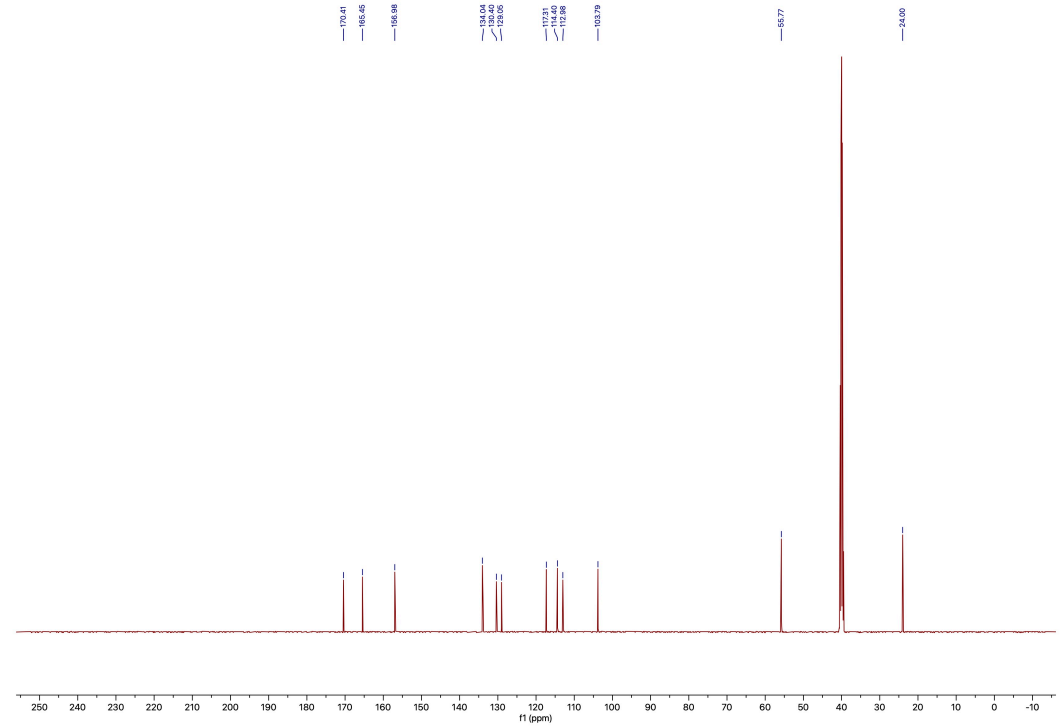
1-acetyl-5-methoxy-1H-indole-3-carboxylic acid (SM-7):



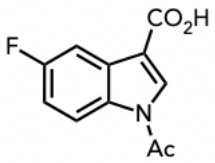
^{1}H-NMR
DMSO-d_6



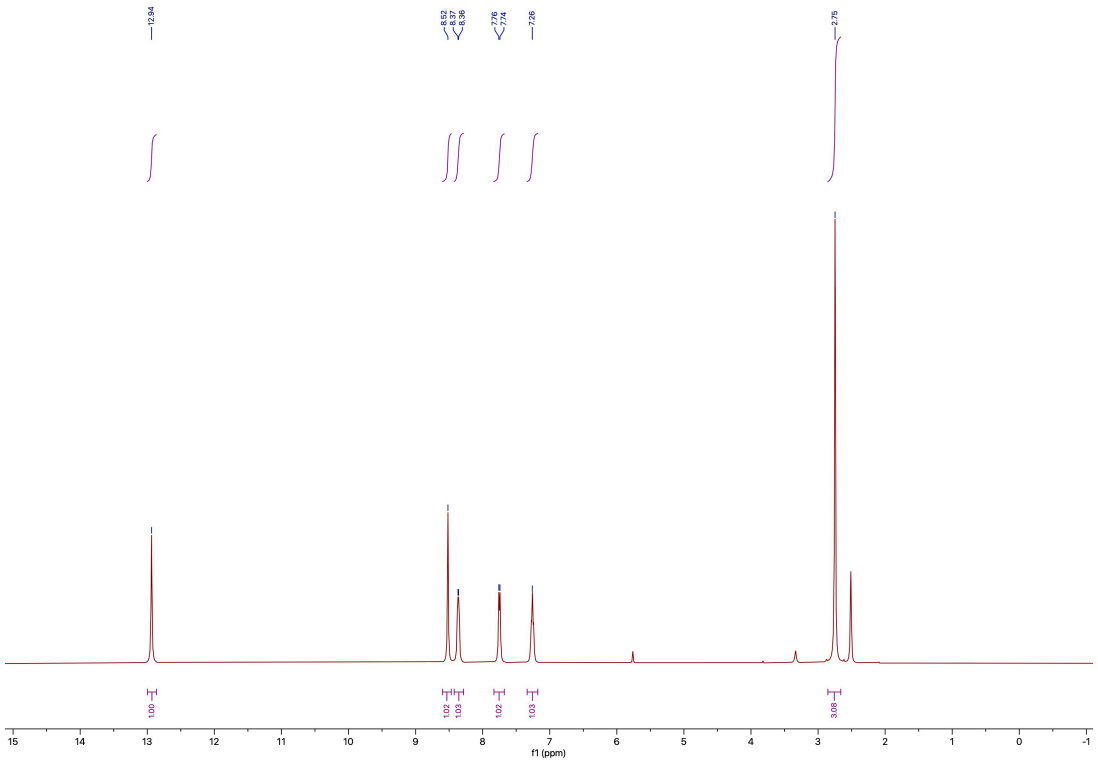
^{13}C-NMR
DMSO-d_6



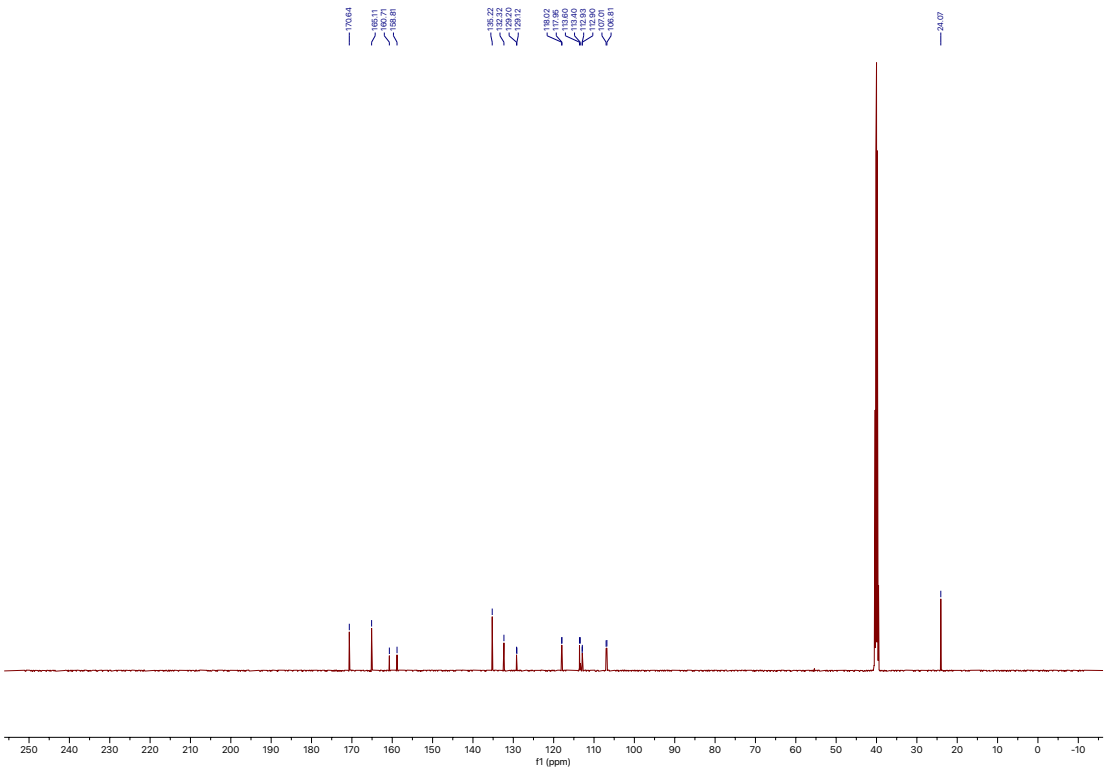
1-acetyl-5-fluoro-1H-indole-3-carboxylic acid (SM-8):



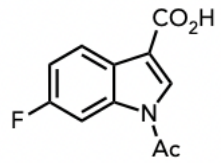
^{1}H-NMR
DMSO-d_6



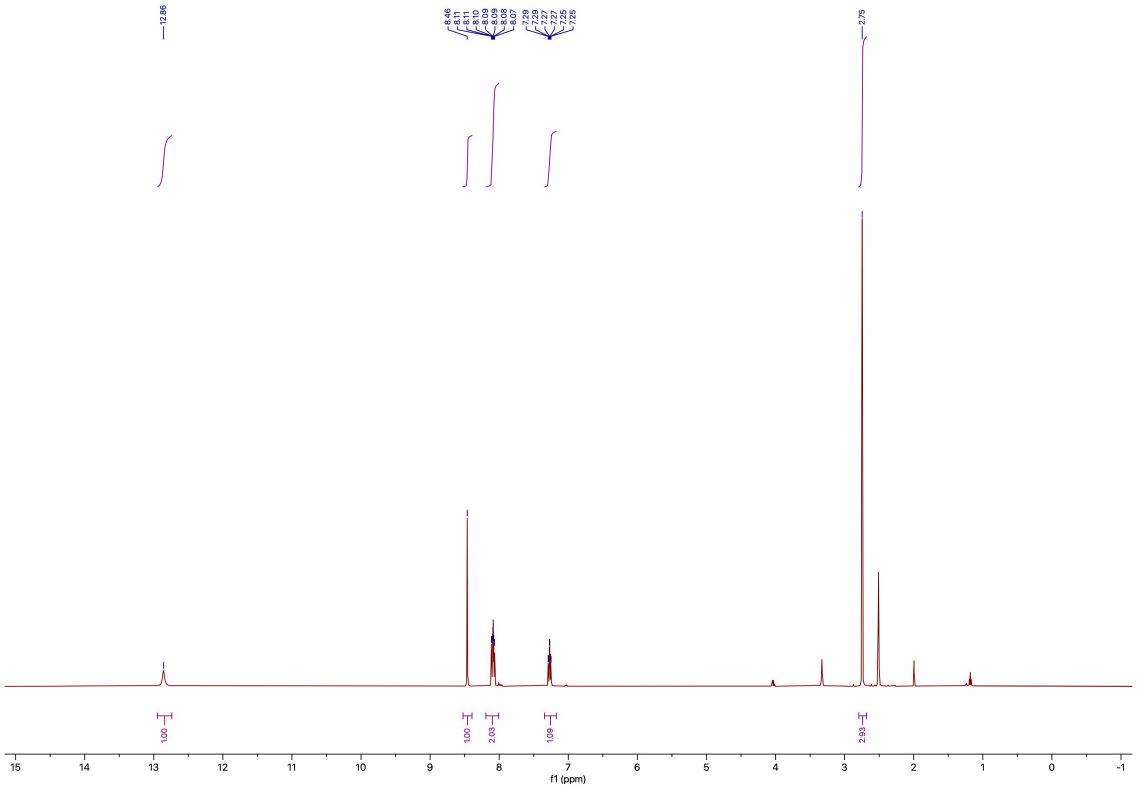
^{13}C-NMR
DMSO-d_6



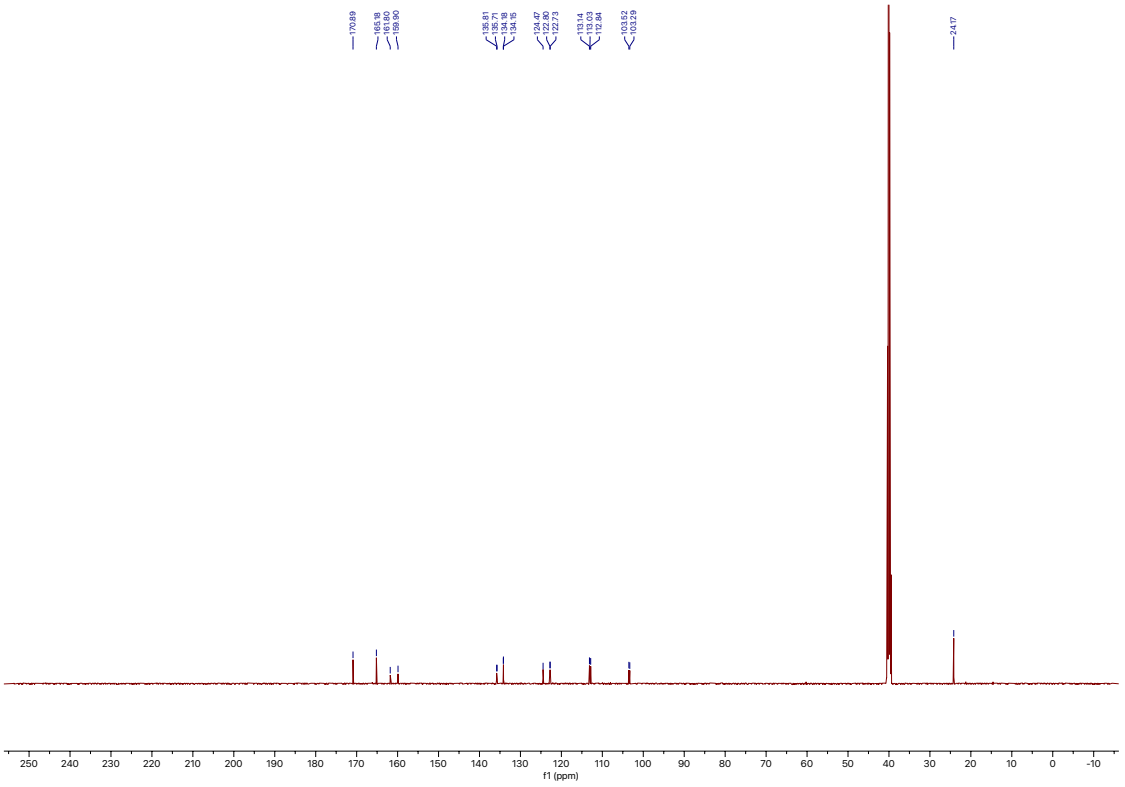
1-acetyl-6-fluoro-1H-indole-3-carboxylic acid (SM-9):



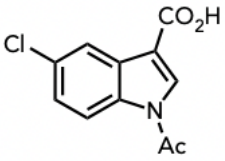
^{1}H-NMR
DMSO-d_6



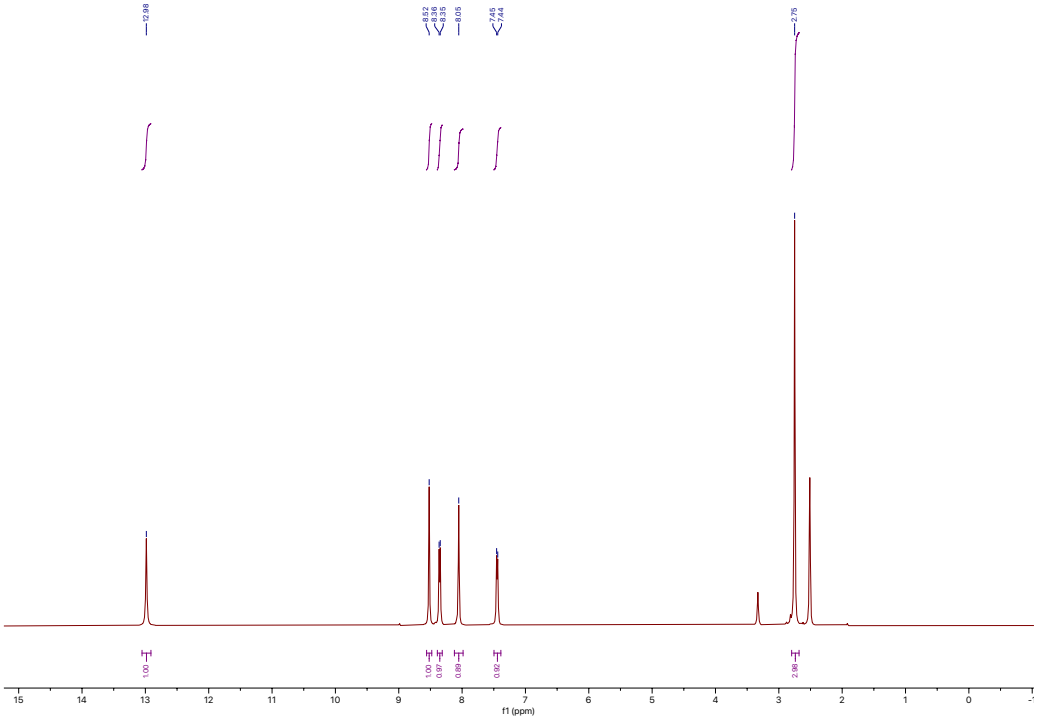
^{13}C-NMR
DMSO-d_6



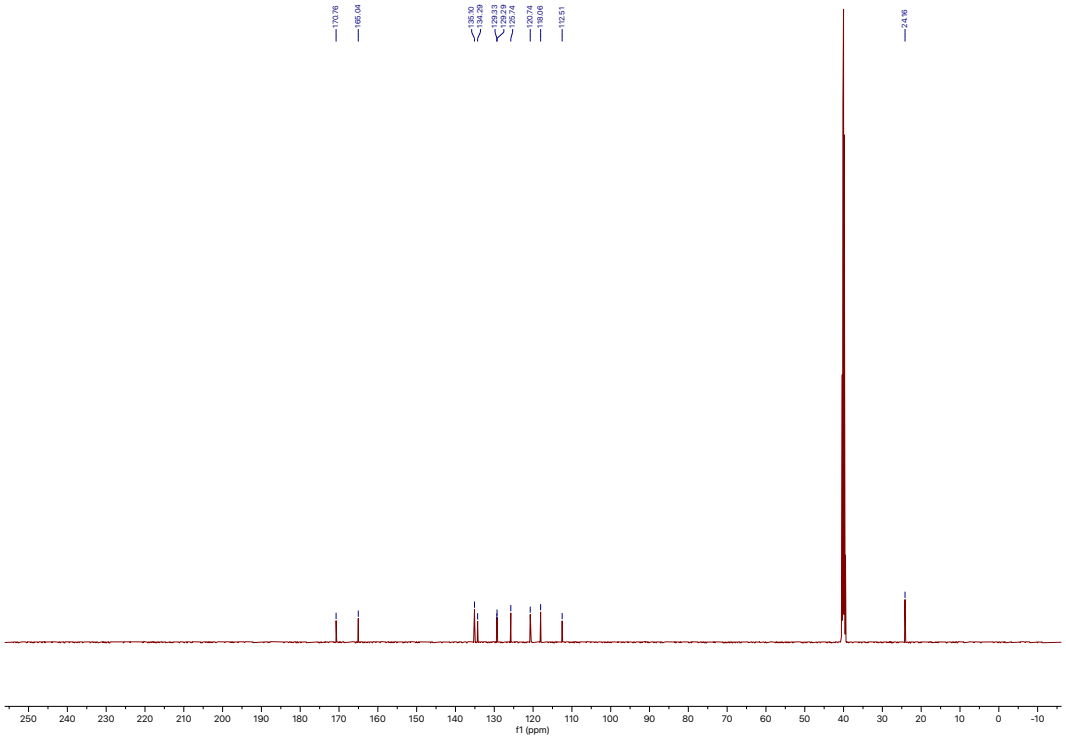
1-acetyl-5-chloro-1H-indole-3-carboxylic acid (SM-10):



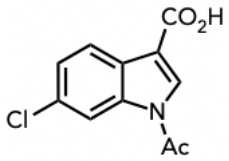
^{1}H-NMR
DMSO-d_6



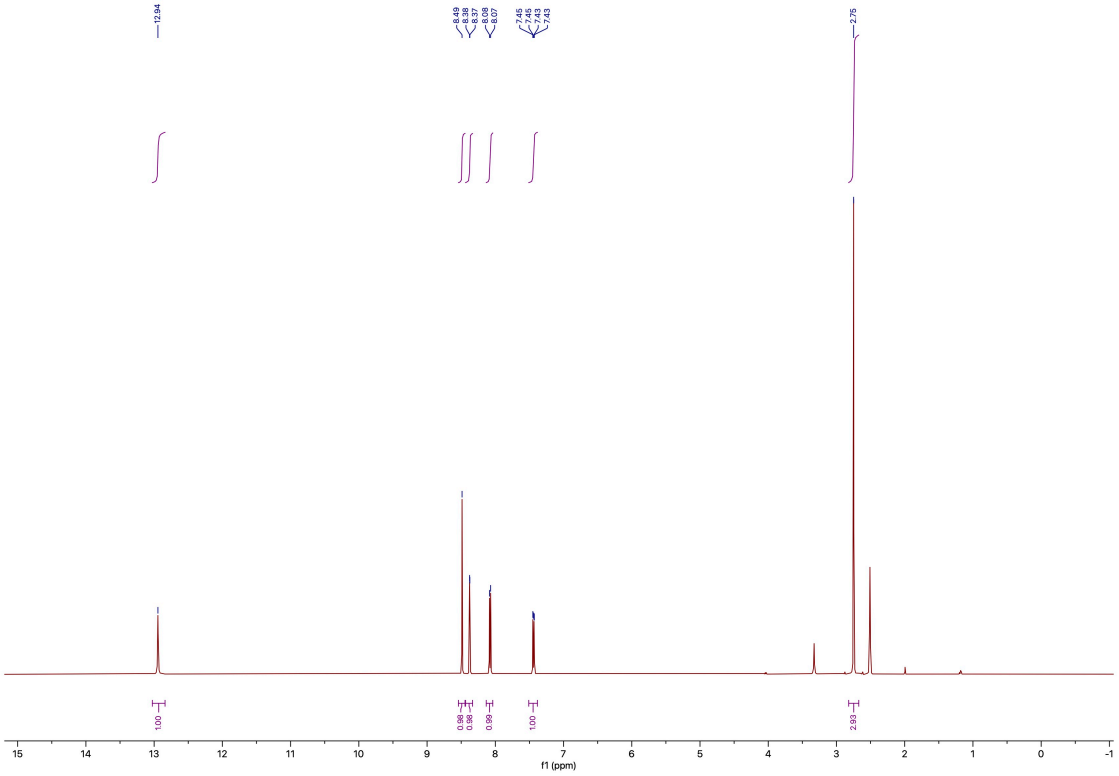
^{13}C-NMR
DMSO-d_6



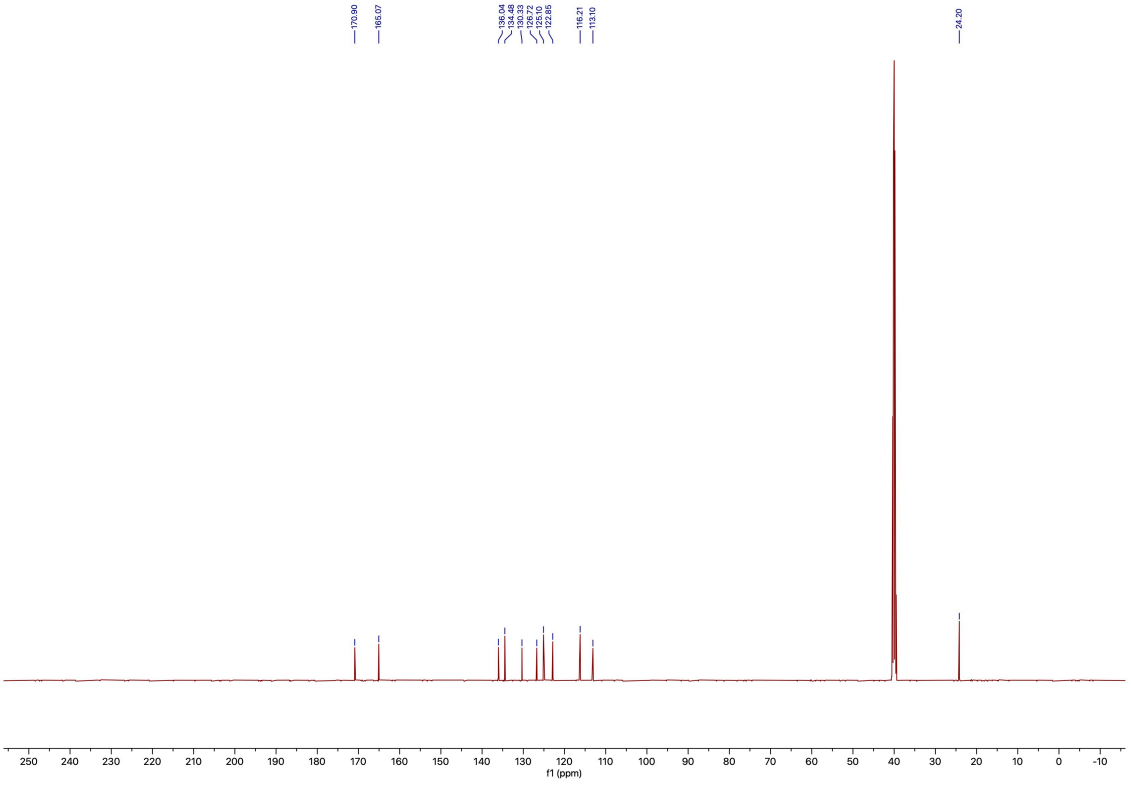
1-acetyl-6-chloro-1H-indole-3-carboxylic acid (SM-11):



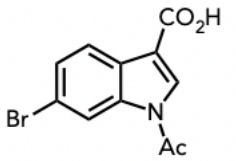
^{1}H-NMR
DMSO-d_6



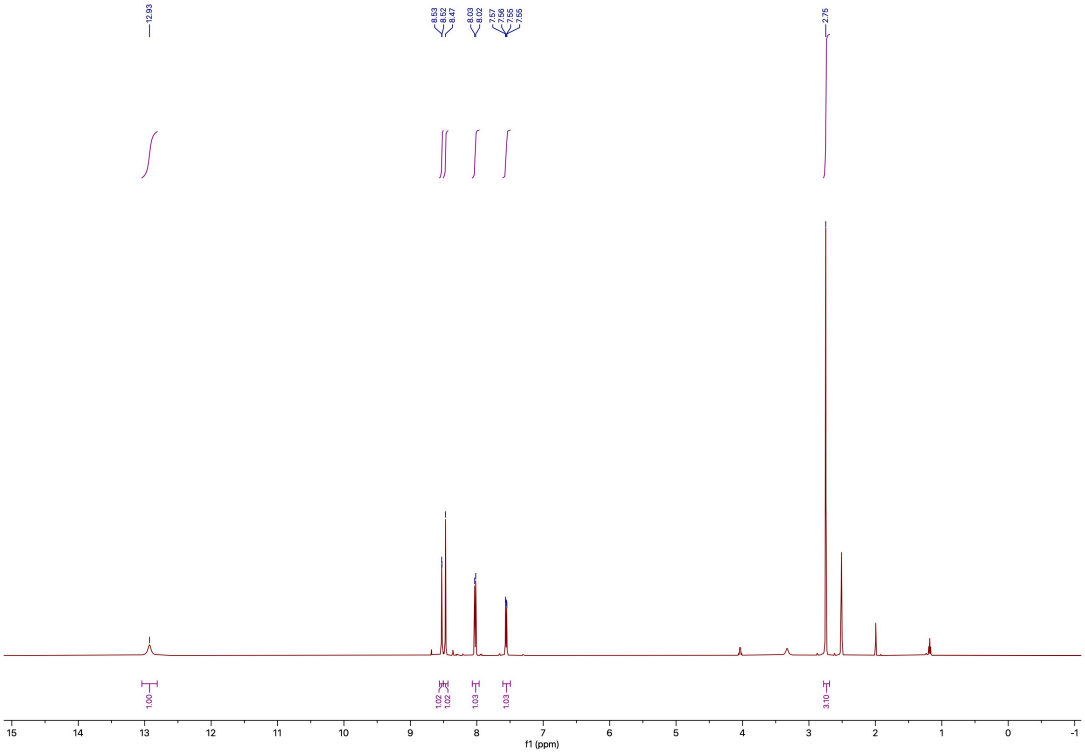
^{13}C-NMR
DMSO-d_6



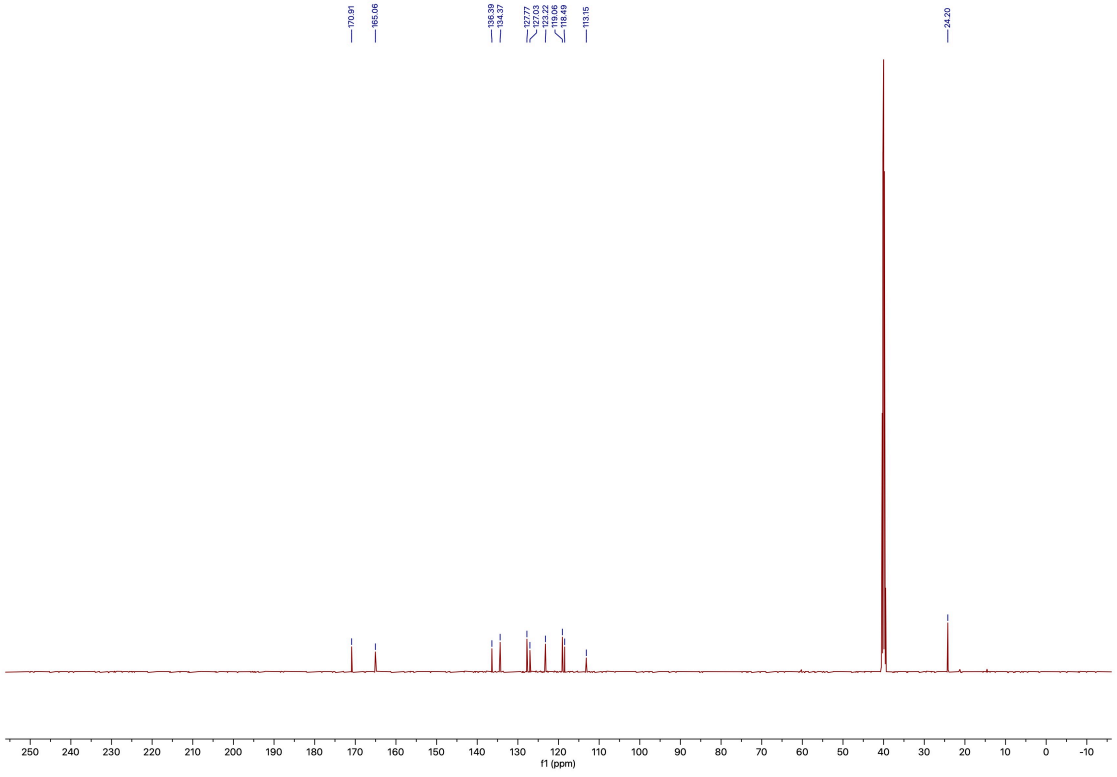
1-acetyl-6-bromo-1H-indole-3-carboxylic acid (SM-12):



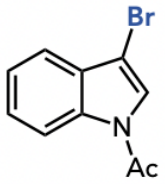
^{1}H-NMR
DMSO-d_6



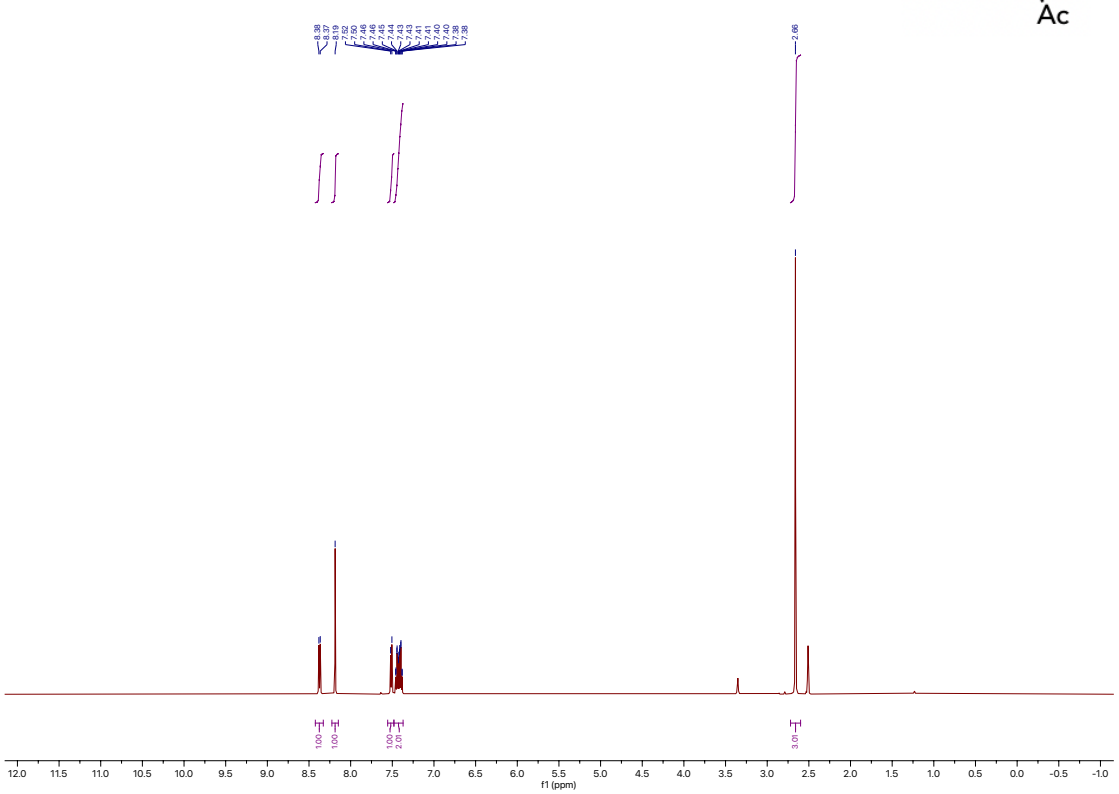
^{13}C-NMR
DMSO-d_6



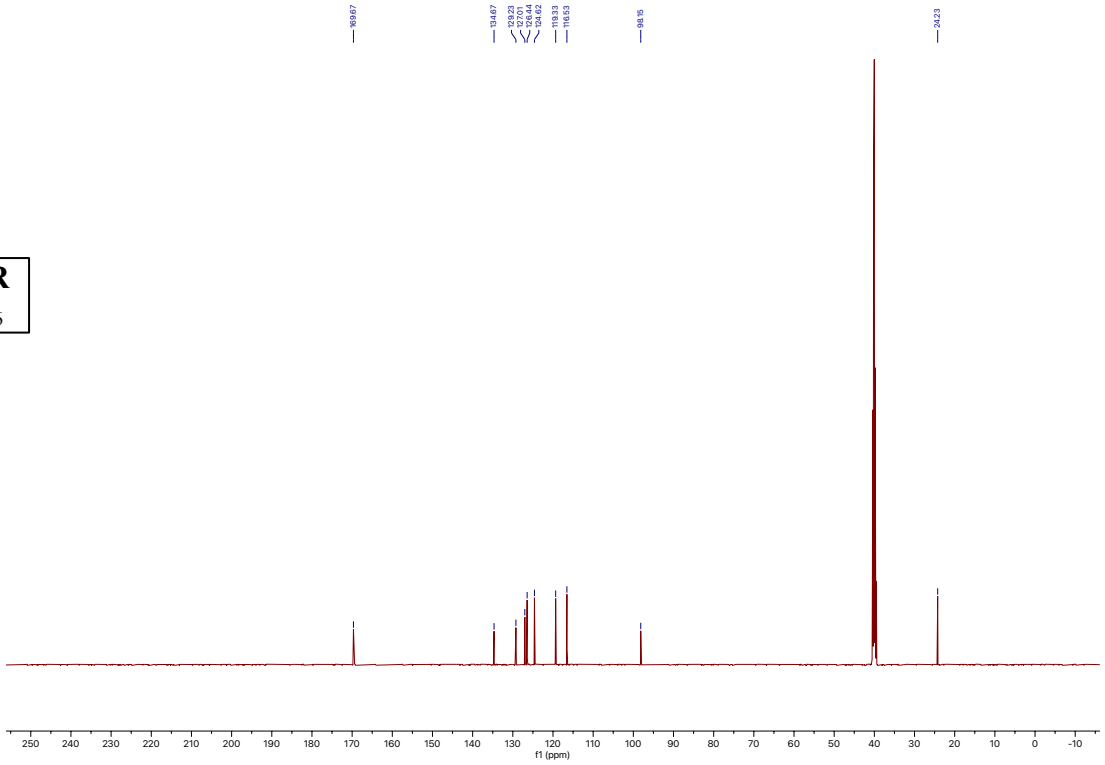
1-(3-bromo-1H-indol-1-yl)ethan-1-one (2):



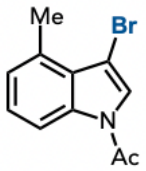
^{1}H-NMR
DMSO-d_6



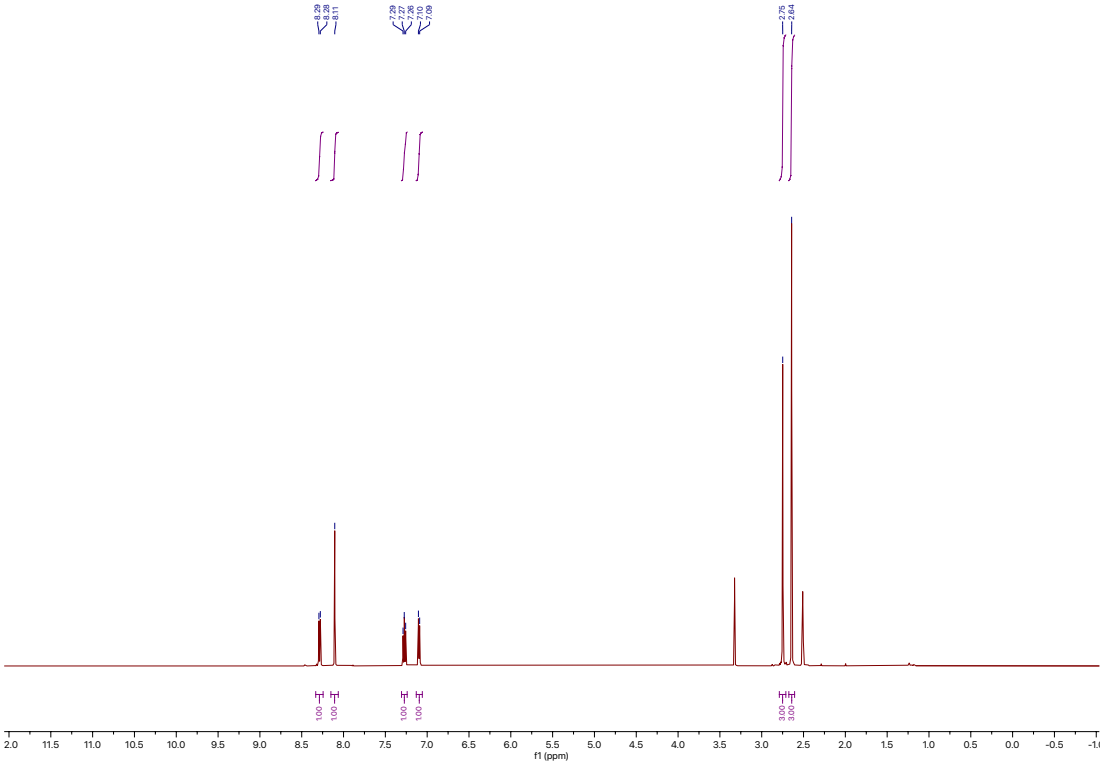
^{13}C-NMR
DMSO-d_6



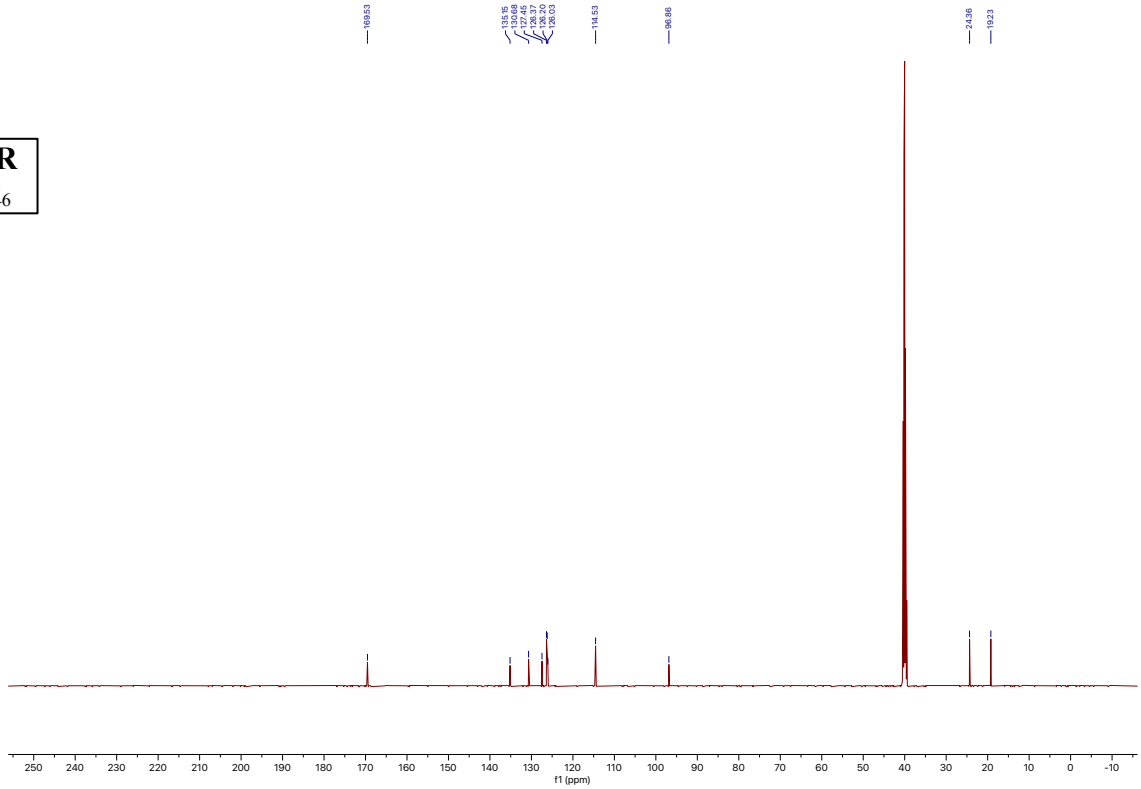
1-(3-bromo-4-methyl-1H-indol-1-yl)ethan-1-one (3):



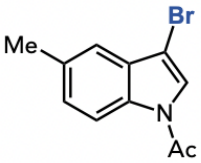
^{1}H-NMR
DMSO-d_6



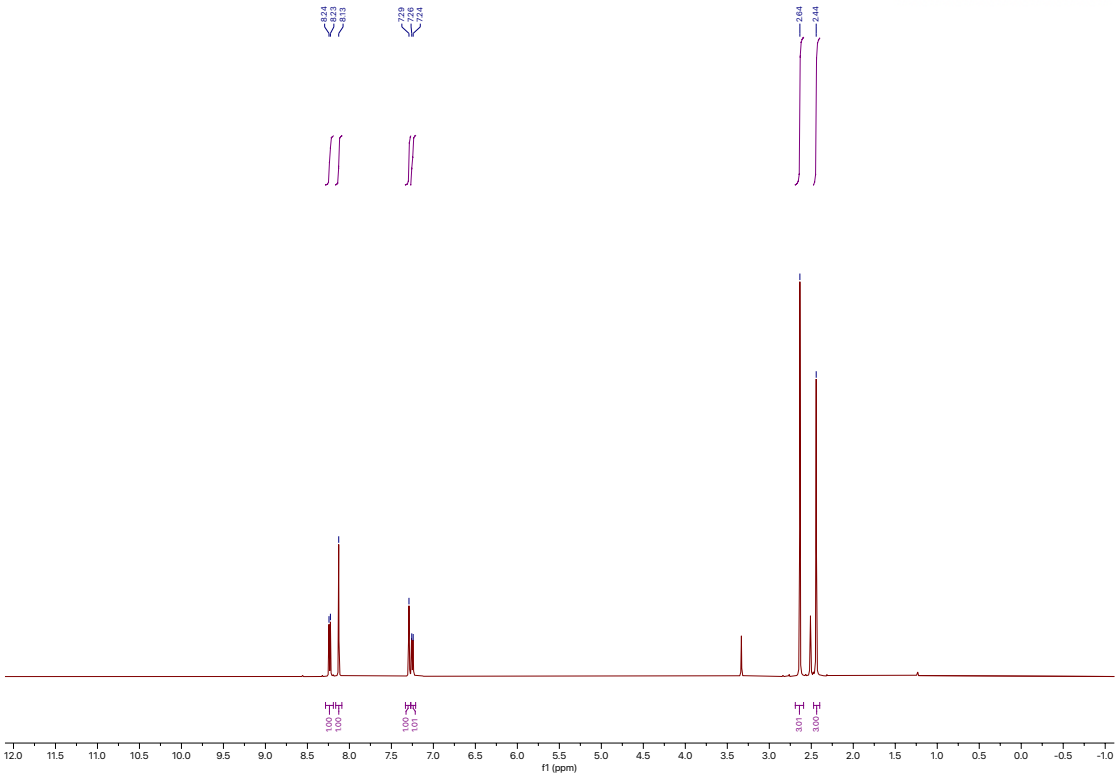
^{13}C-NMR
DMSO-d_6



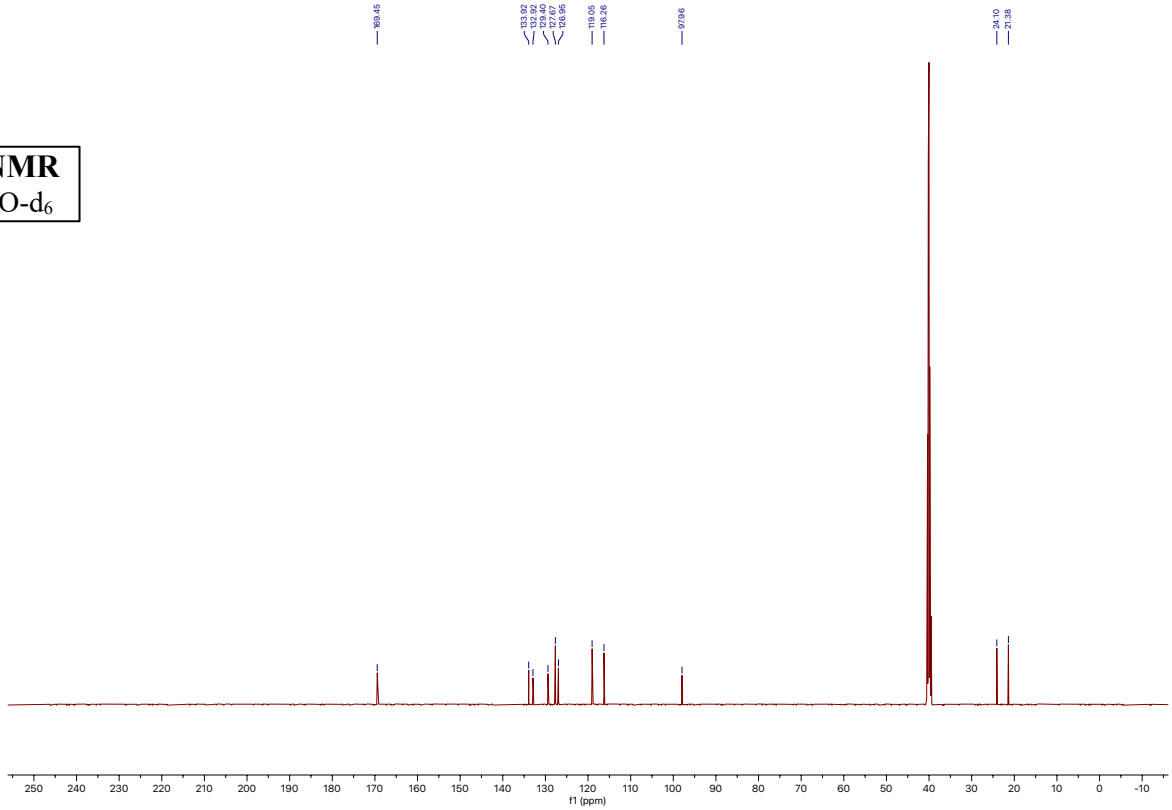
1-(3-bromo-5-methyl-1H-indol-1-yl)ethan-1-one (4):



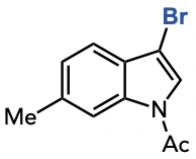
^{1}H-NMR
DMSO-d_6



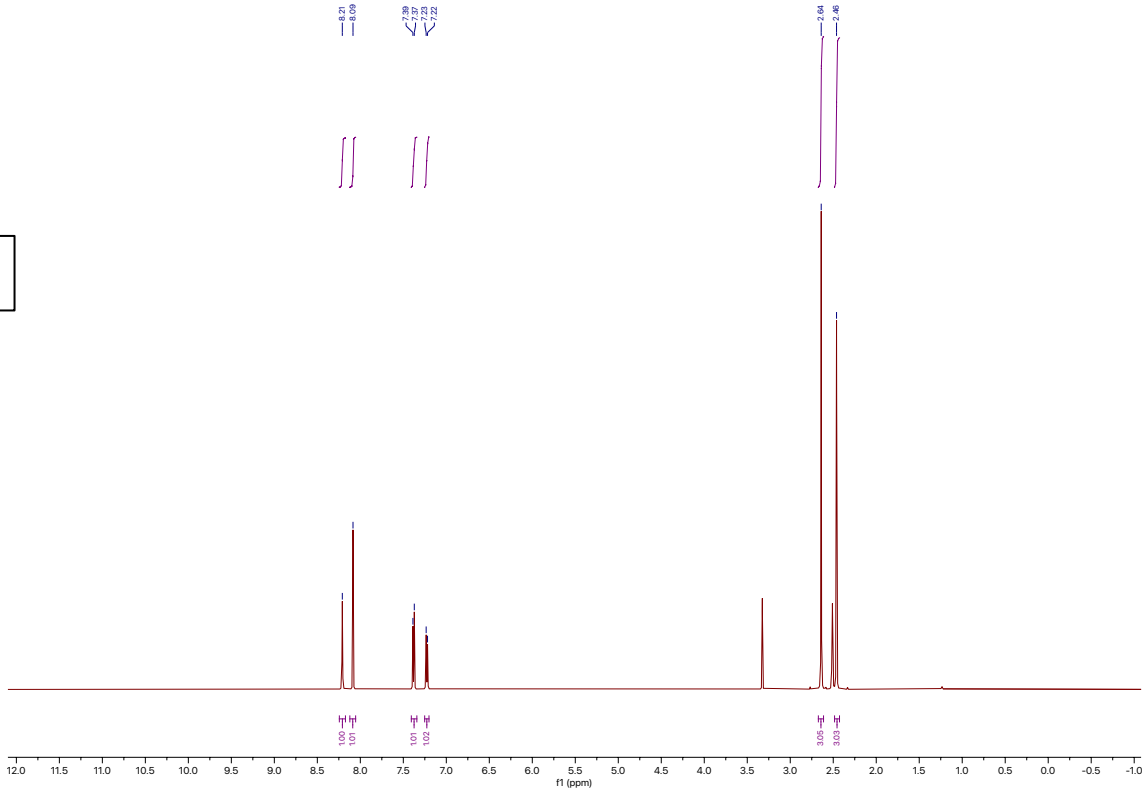
^{13}C-NMR
DMSO-d_6



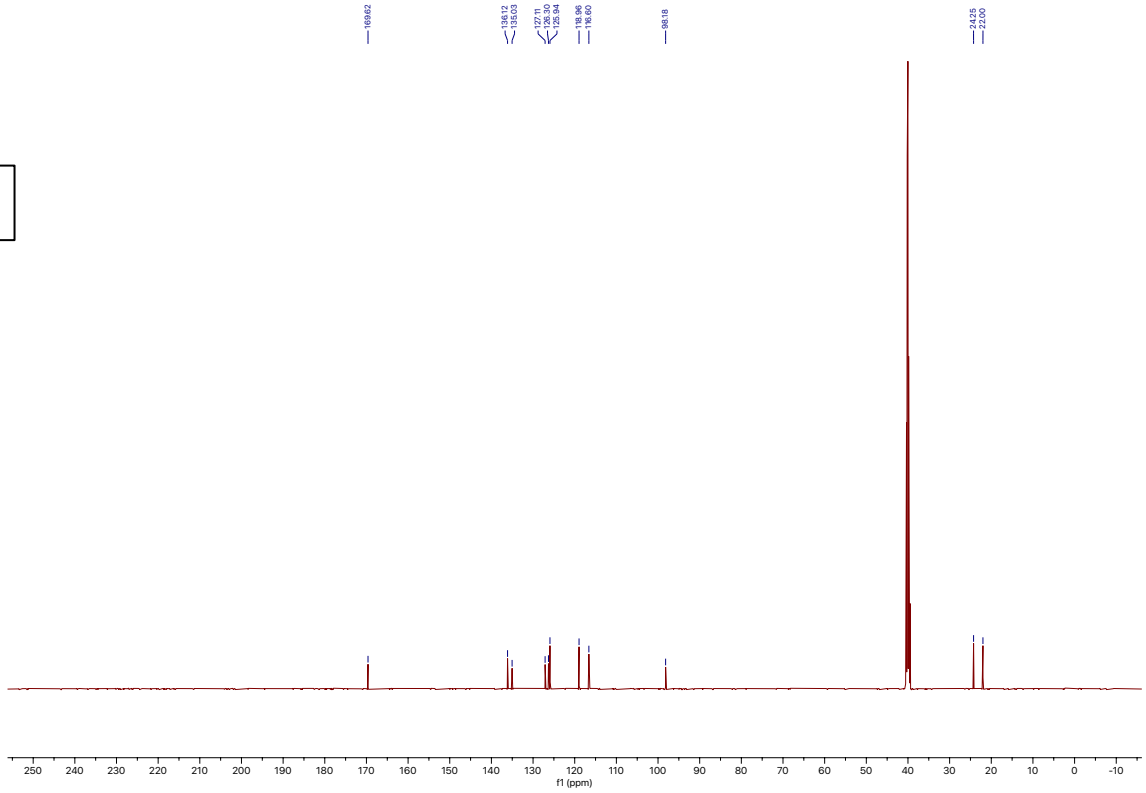
1-(3-bromo-6-methyl-1H-indol-1-yl)ethan-1-one (5):



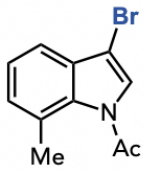
^{1}H-NMR
DMSO-d_6



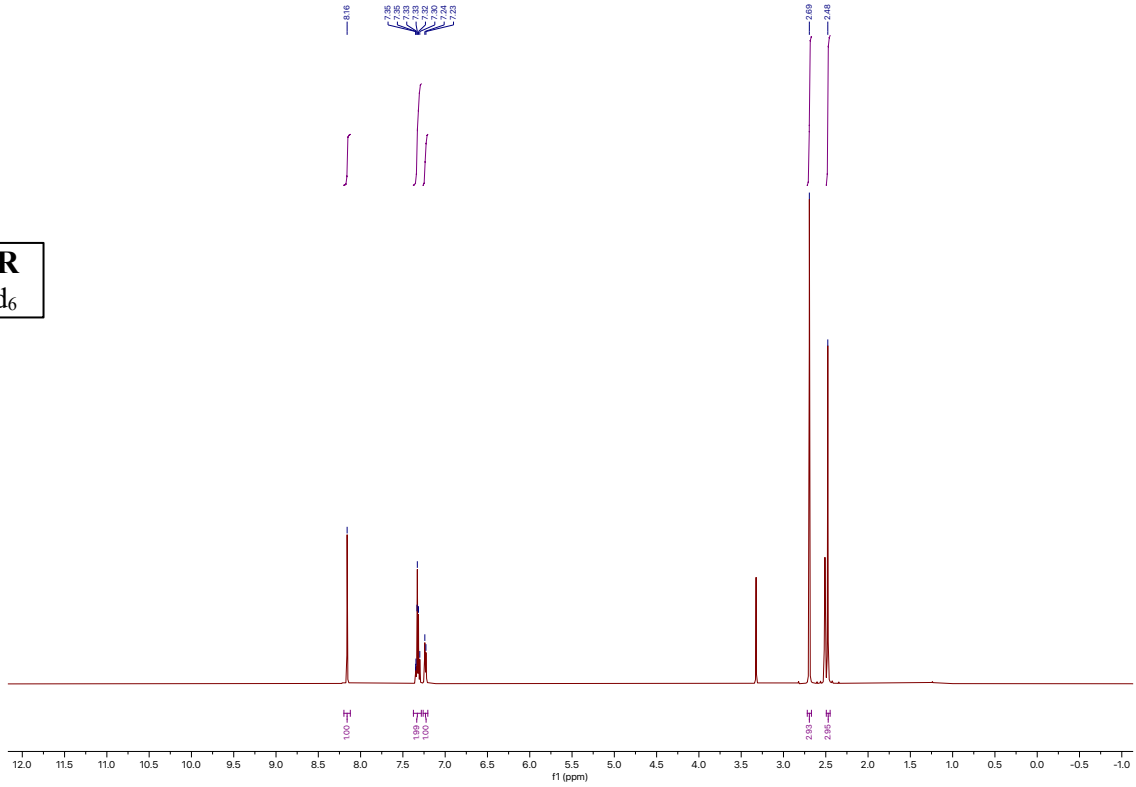
^{13}C-NMR
DMSO-d_6



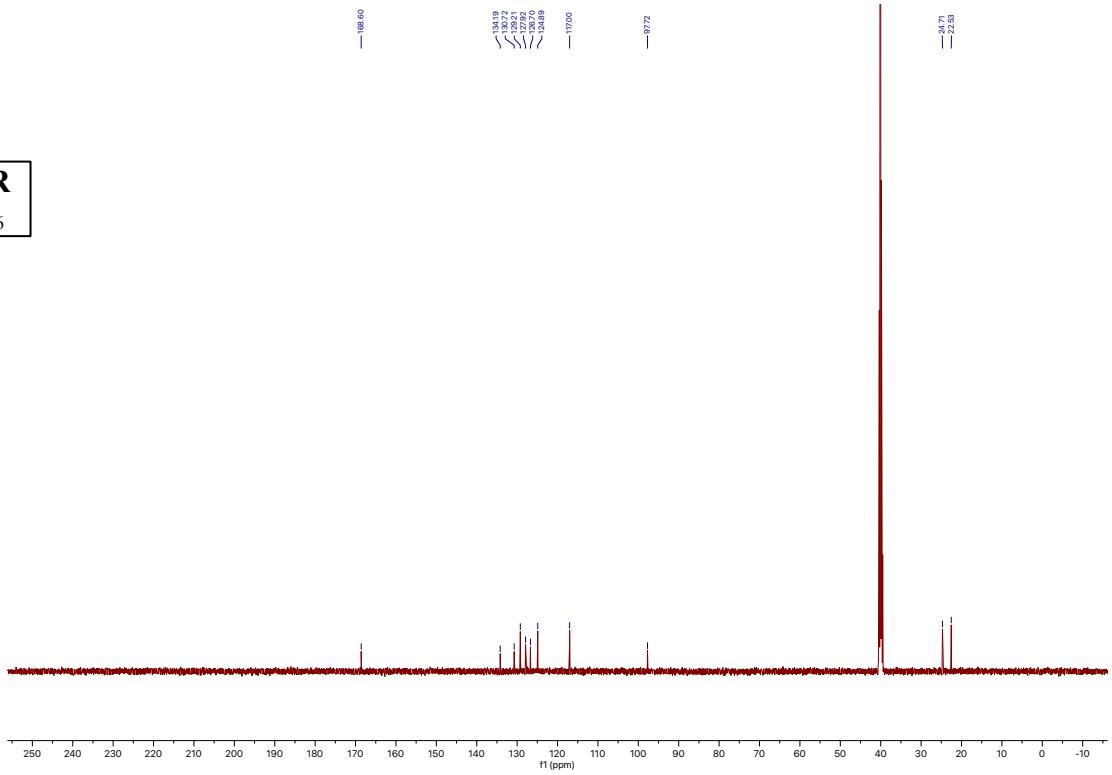
1-(3-bromo-7-methyl-1H-indol-1-yl)ethan-1-one (6):



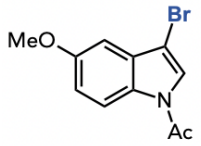
^{1}H-NMR
DMSO-d_6



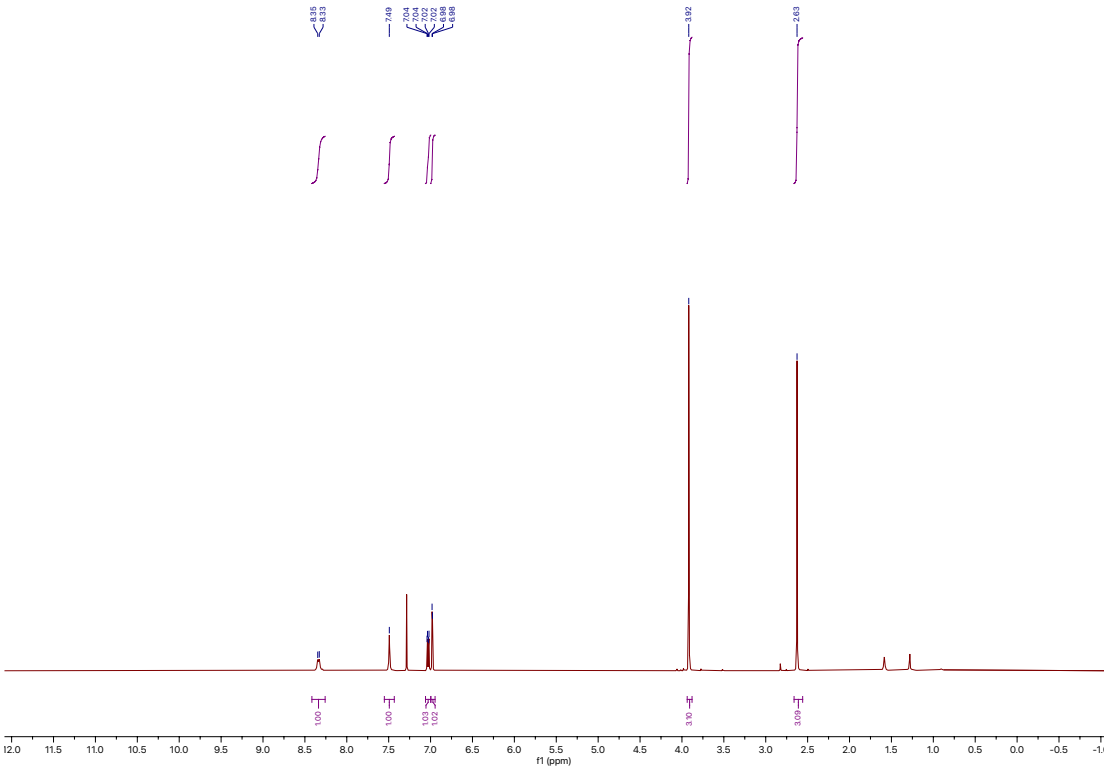
^{13}C-NMR
DMSO-d_6



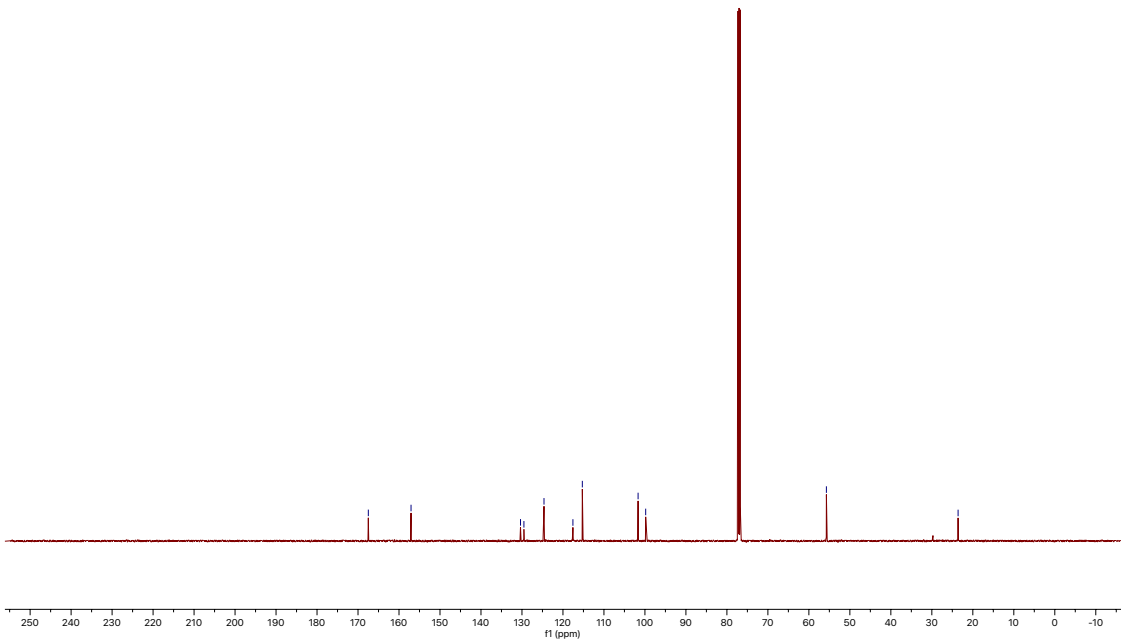
1-(3-bromo-5-methoxy-1H-indol-1-yl)ethan-1-one (7):



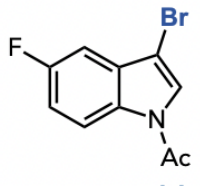
^{1}H-NMR
$CDCl_3$



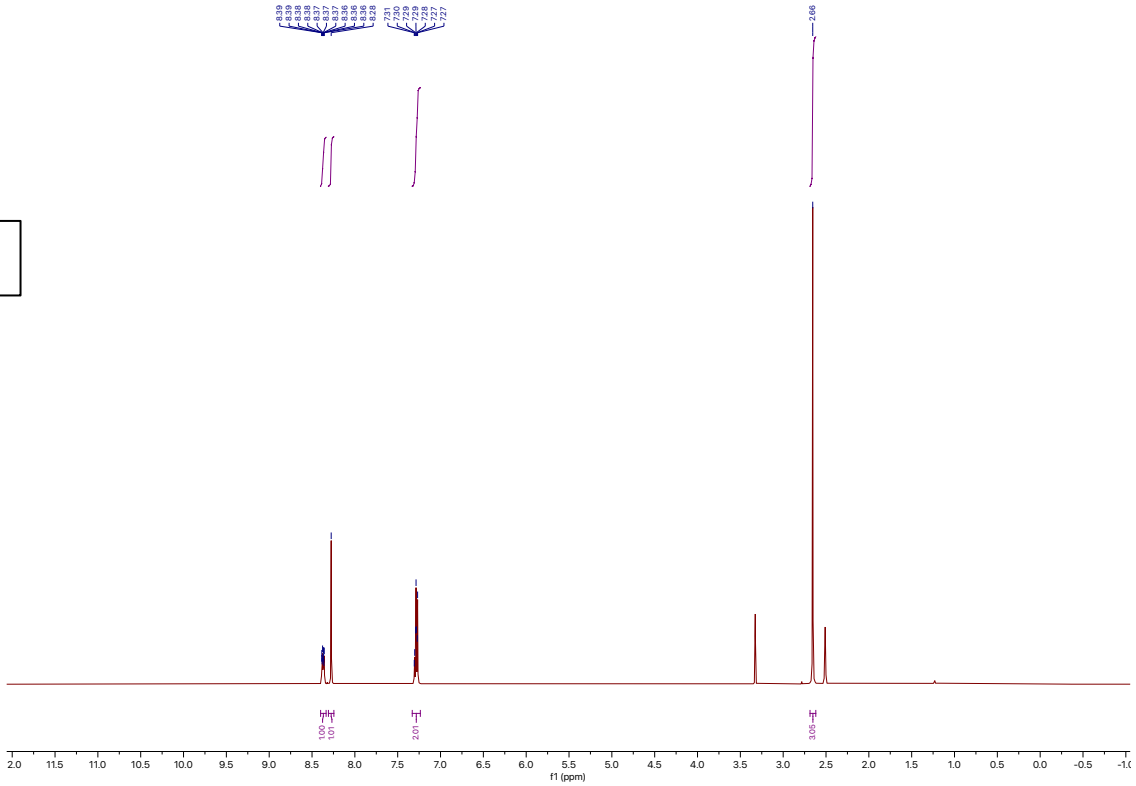
^{13}C-NMR
$CDCl_3$



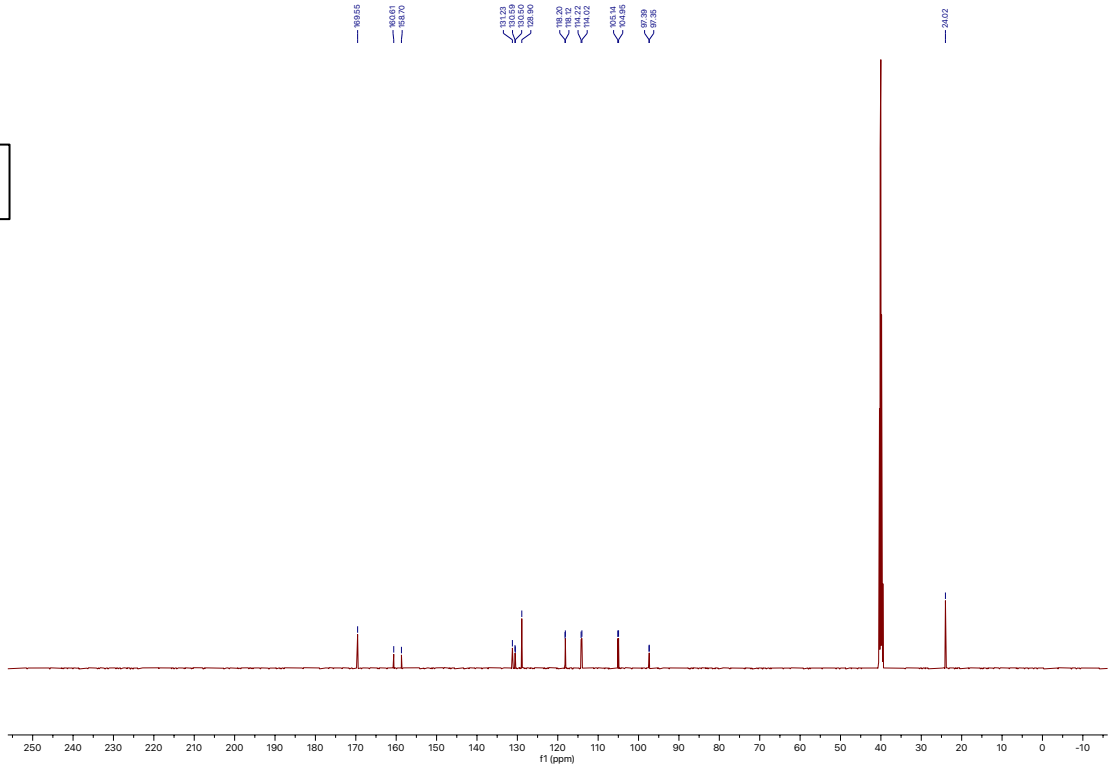
1-(3-bromo-5-fluoro-1H-indol-1-yl)ethan-1-one (8):



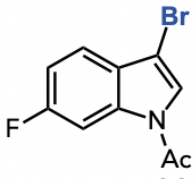
^{1}H-NMR
DMSO-d_6



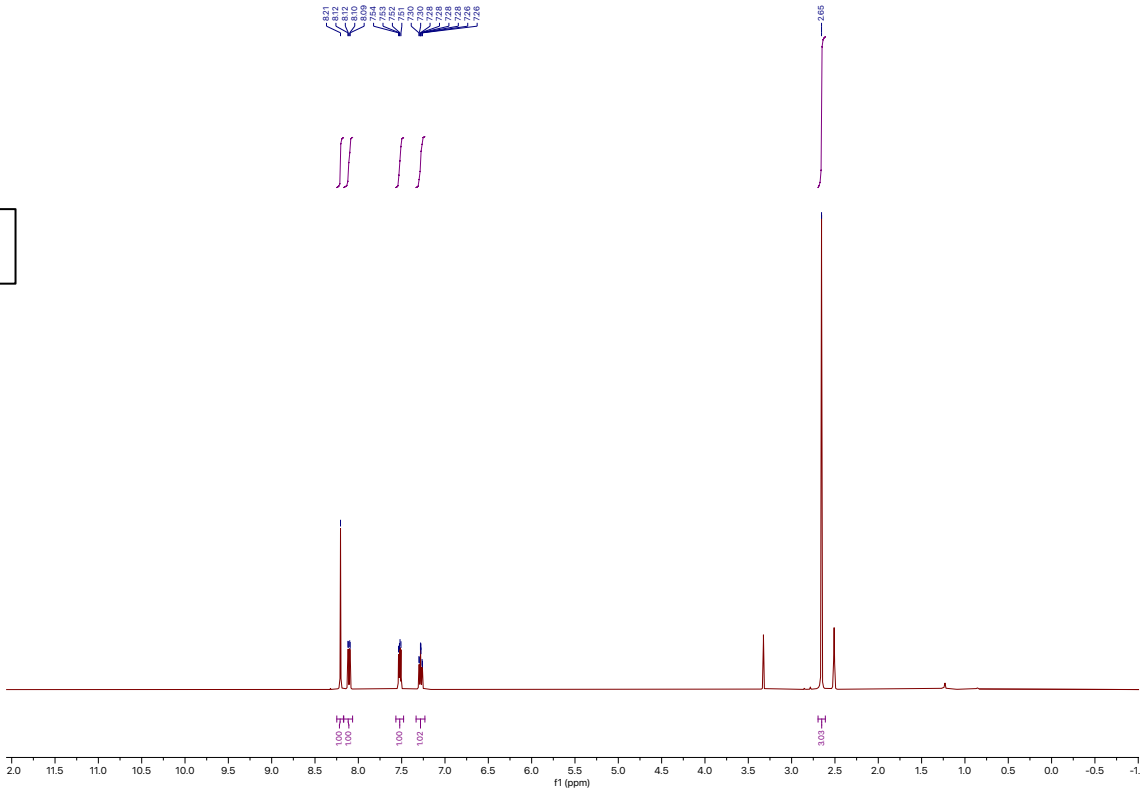
^{13}C-NMR
DMSO-d_6



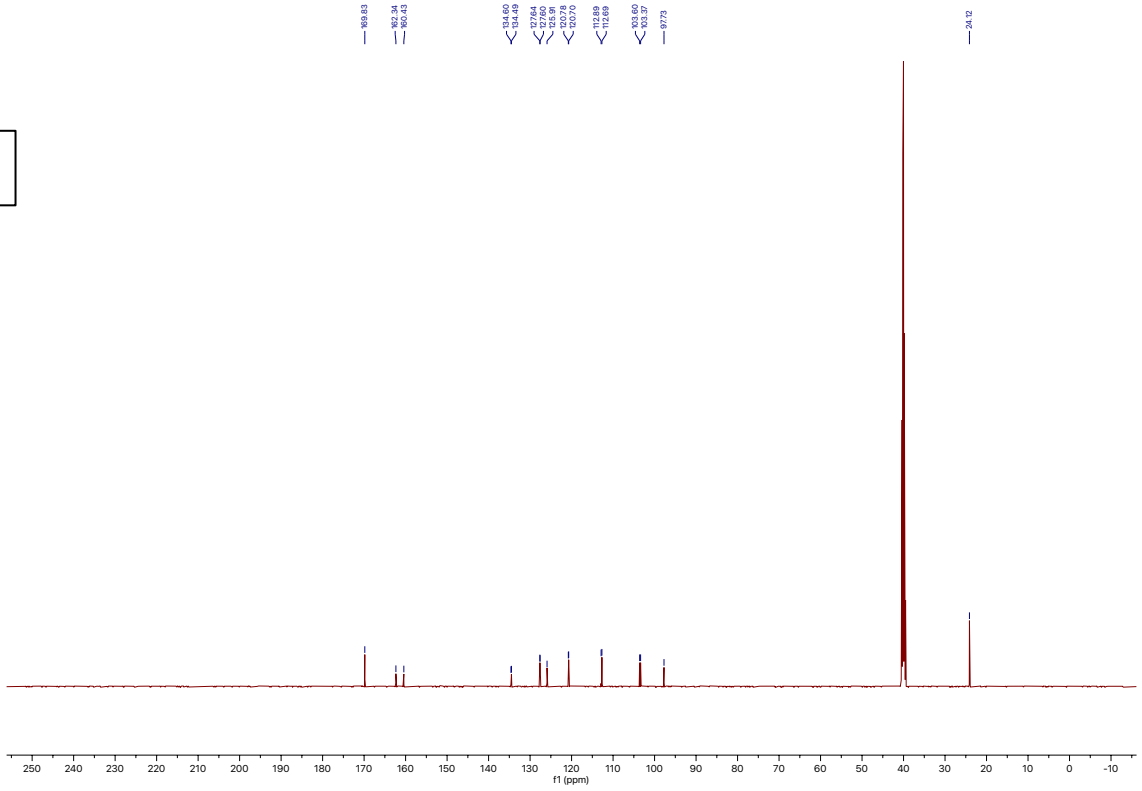
1-(3-bromo-6-fluoro-1H-indol-1-yl)ethan-1-one (9):



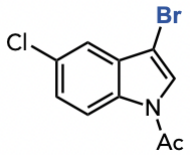
^{1}H-NMR
DMSO-d_6



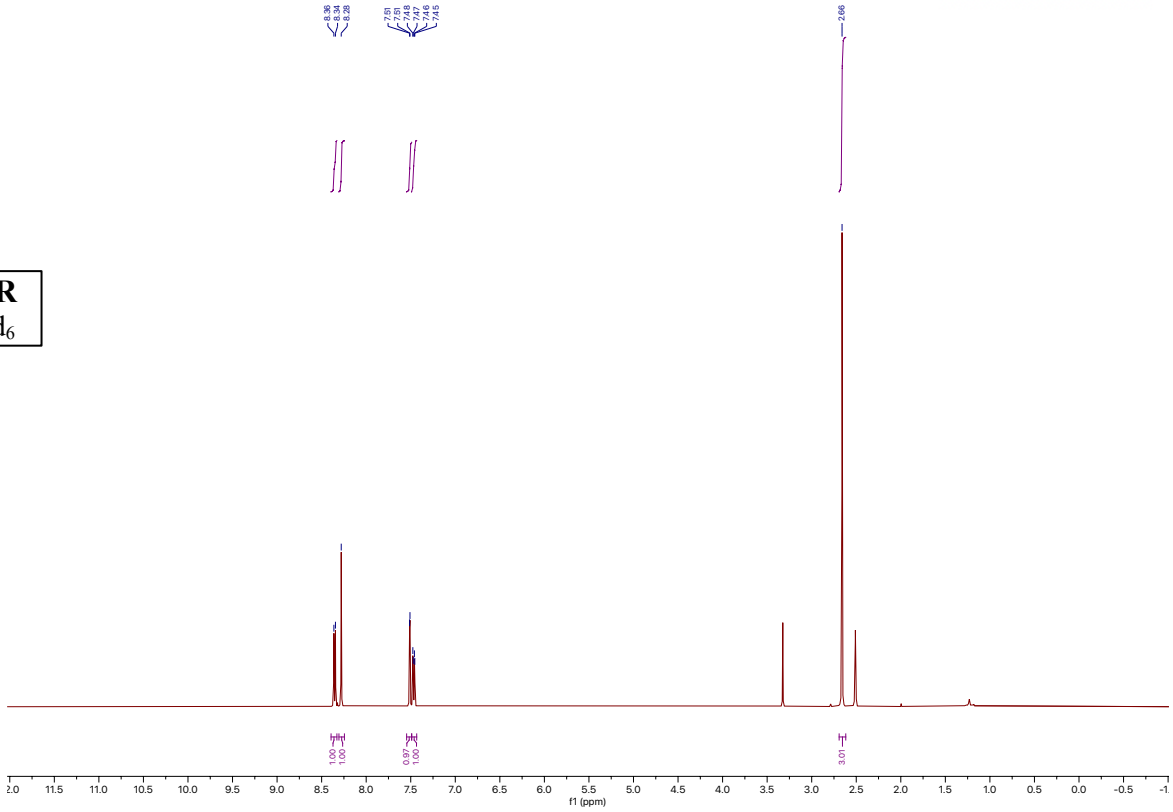
^{13}C-NMR
DMSO-d_6



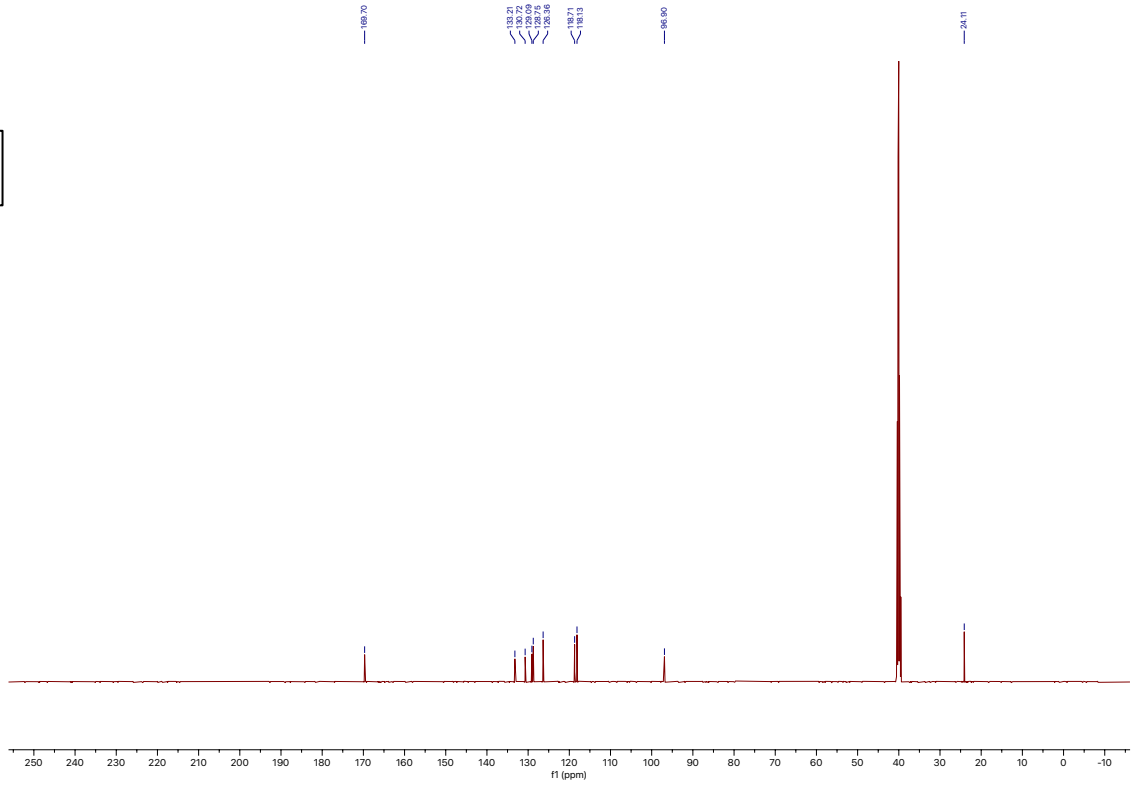
1-(3-bromo-5-chloro-1H-indol-1-yl)ethan-1-one (10):



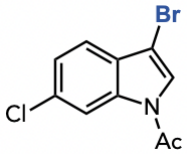
^{1}H-NMR
DMSO-d_6



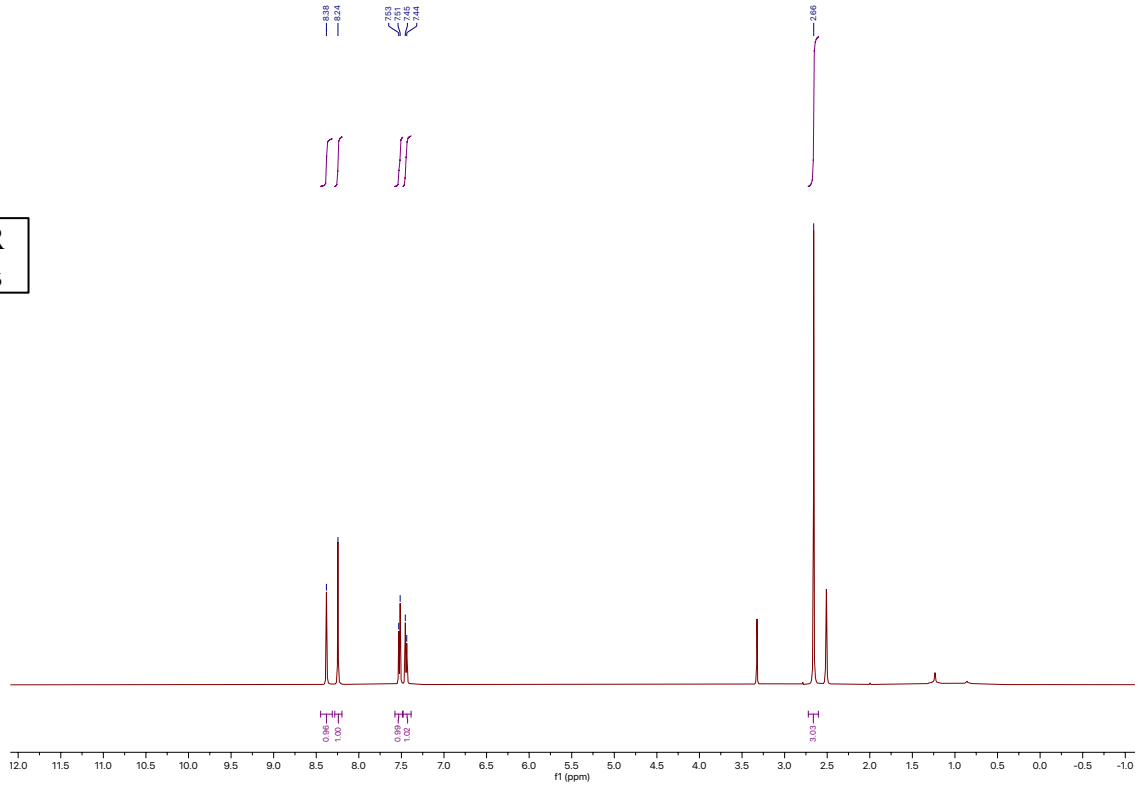
^{13}C-NMR
DMSO-d_6



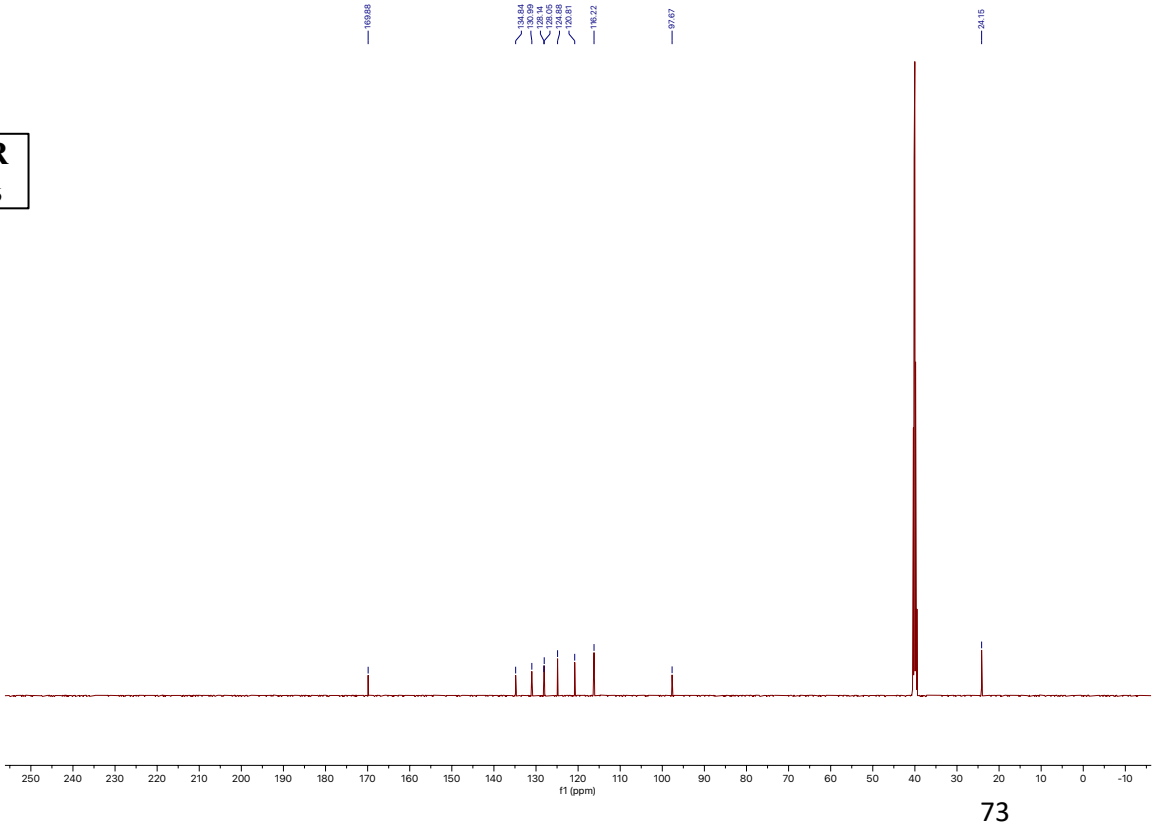
1-(3-bromo-6-chloro-1H-indol-1-yl)ethan-1-one (11):



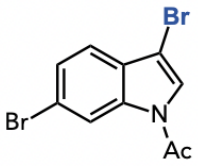
^{1}H-NMR
DMSO-d_6



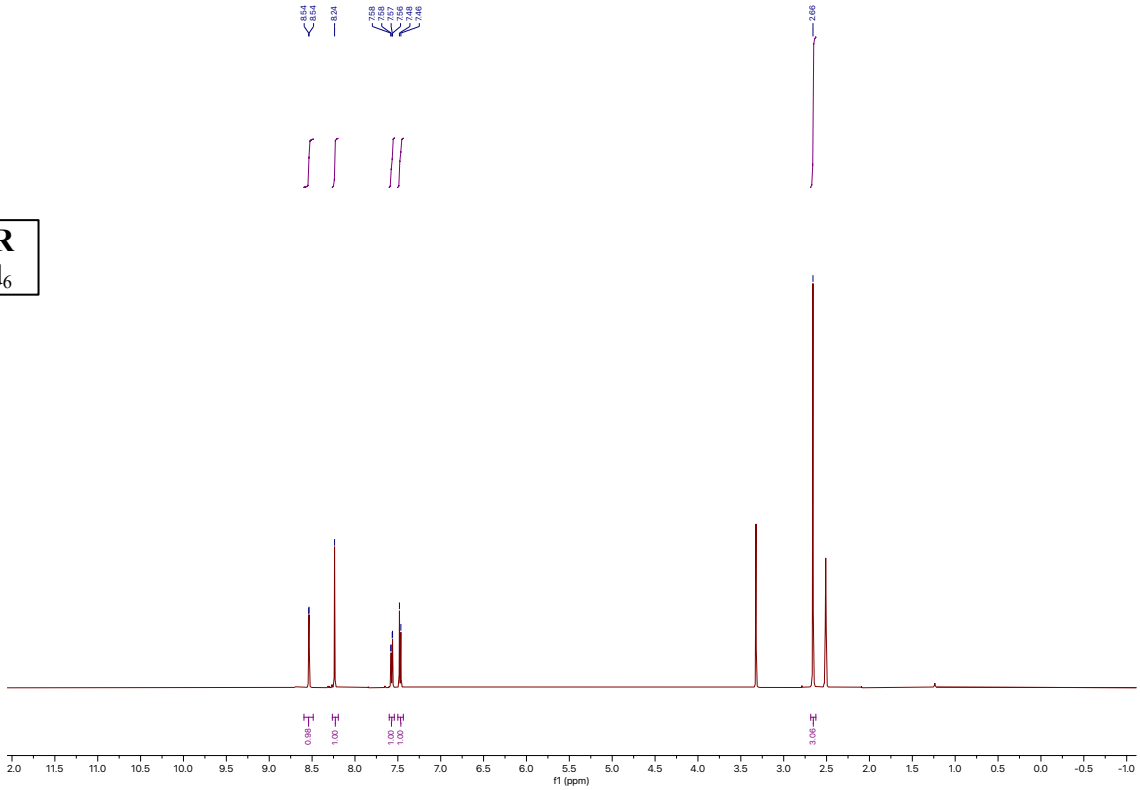
^{13}C-NMR
DMSO-d_6



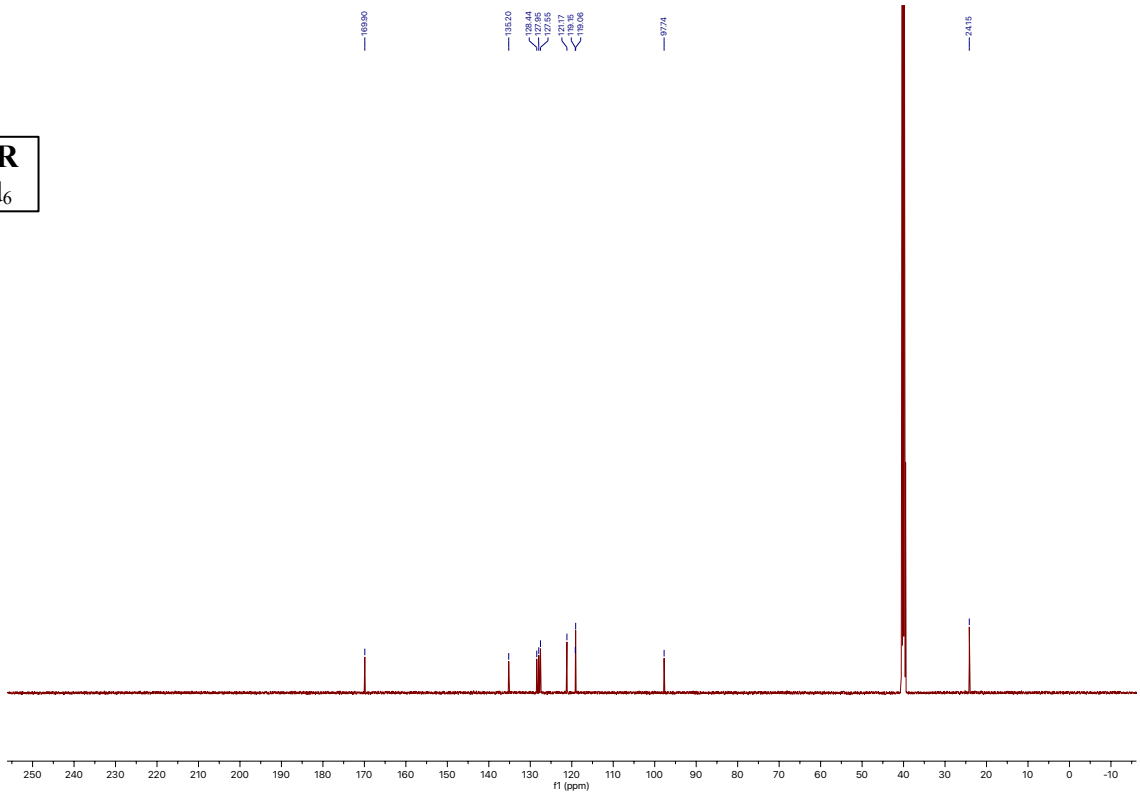
1-(3,6-dibromo-1H-indol-1-yl)ethan-1-one (12):



^{1}H-NMR
DMSO-d_6

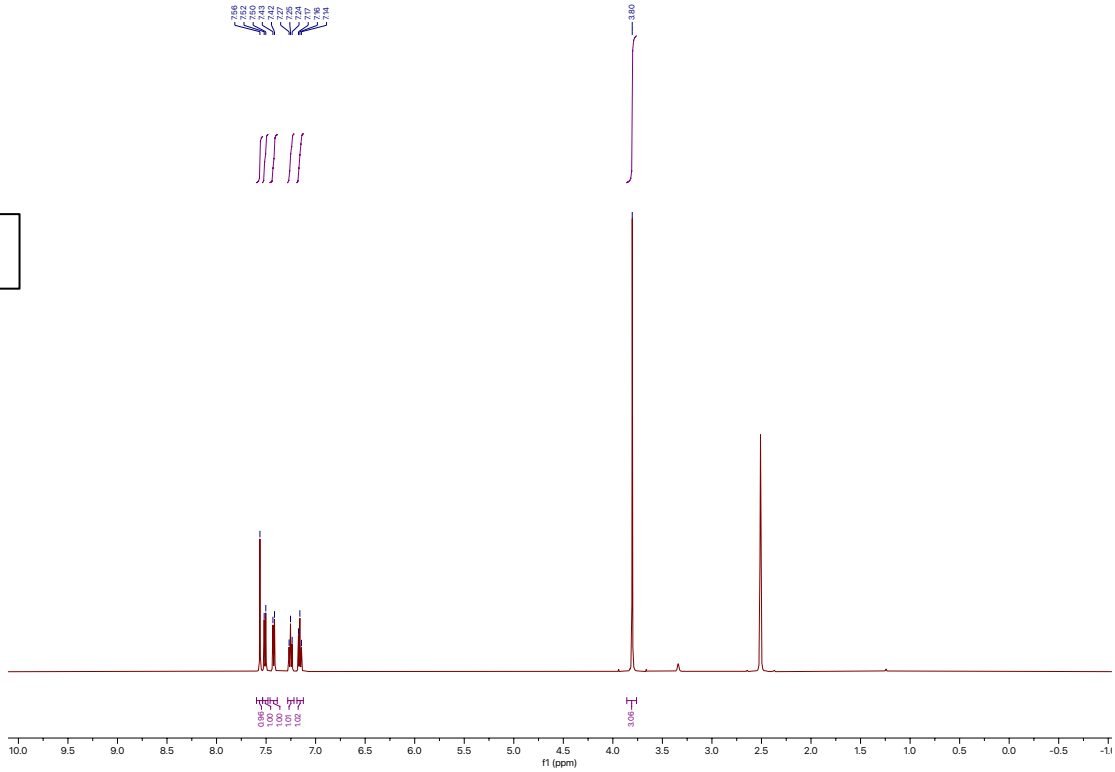


^{13}C-NMR
DMSO-d_6

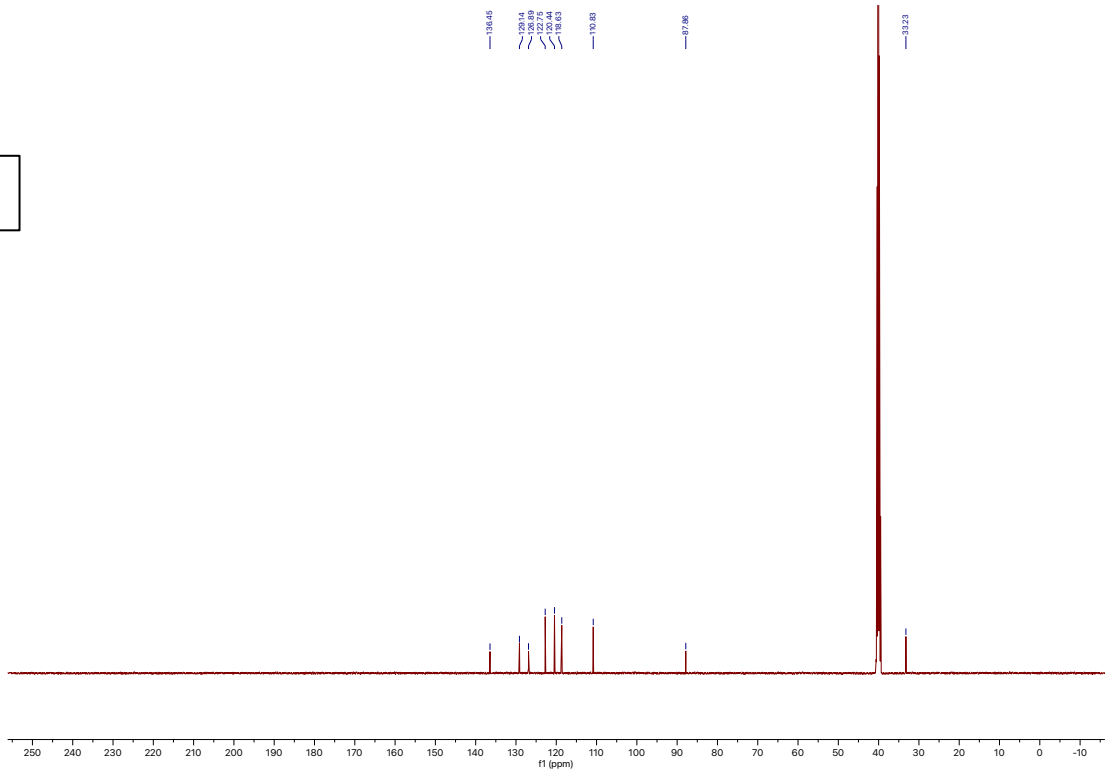


3-bromo-1-methyl-1H-indole (13):

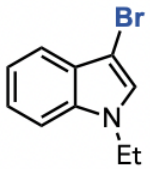
^{1}H-NMR
DMSO-d_6



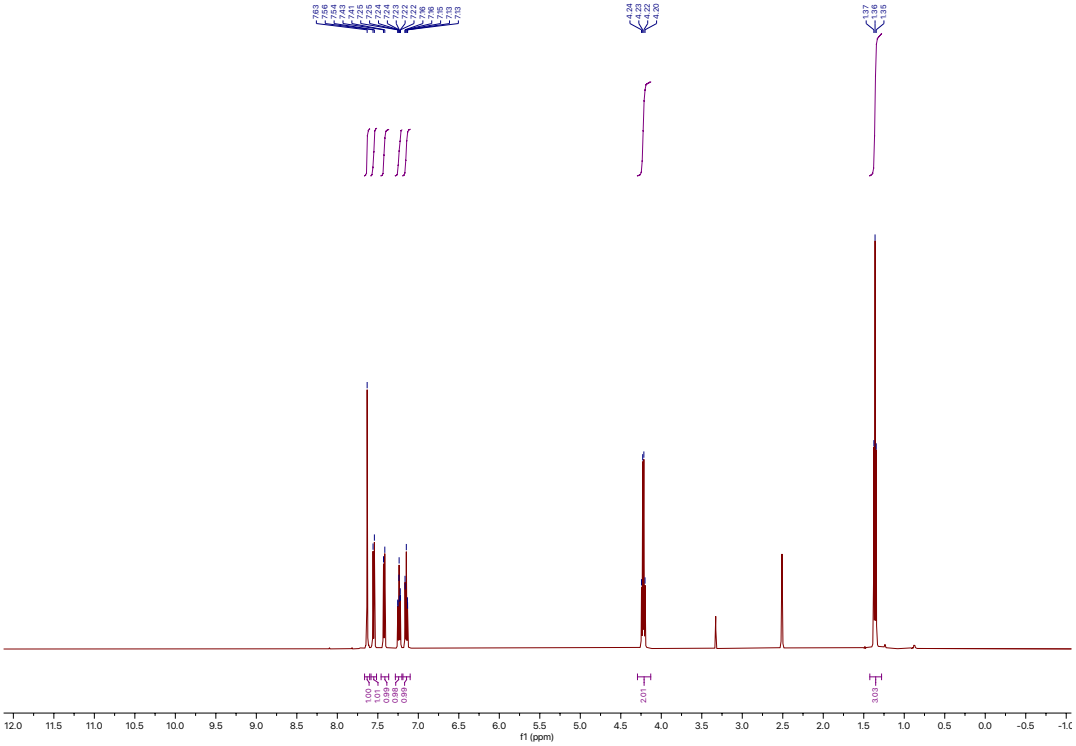
^{13}C-NMR
DMSO-d_6



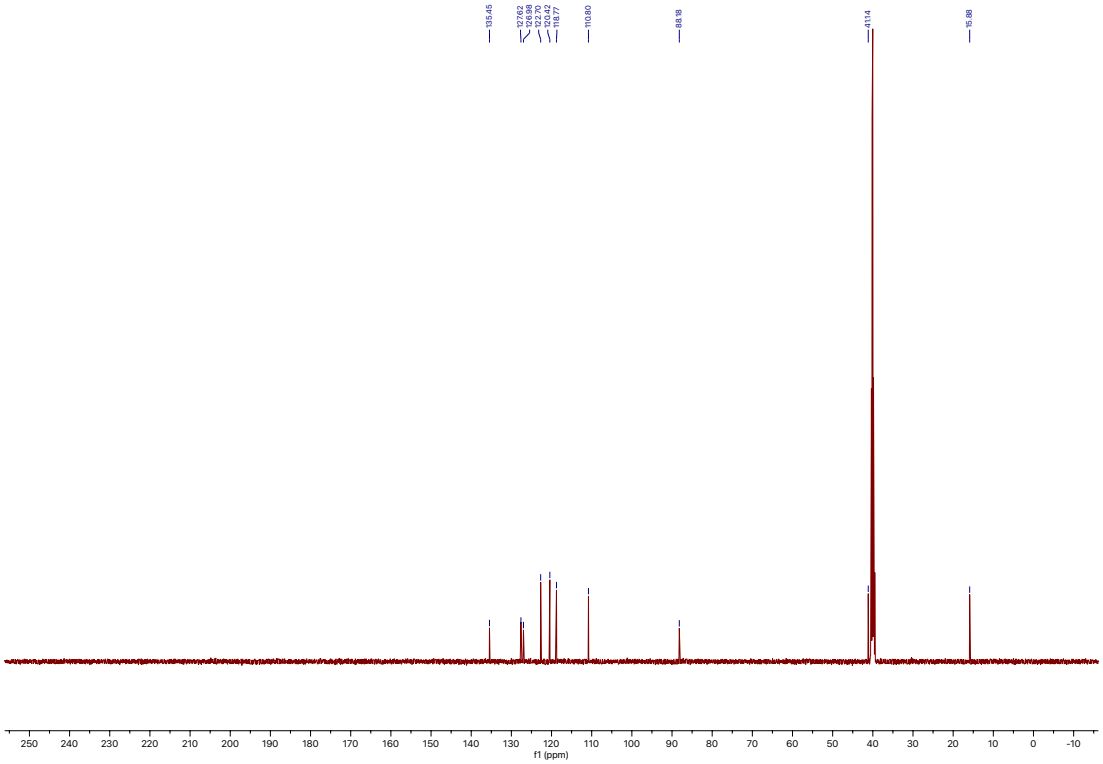
3-bromo-1-ethyl-1H-indole (14):



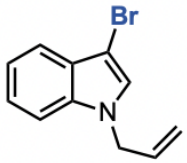
^{1}H-NMR
DMSO-d_6



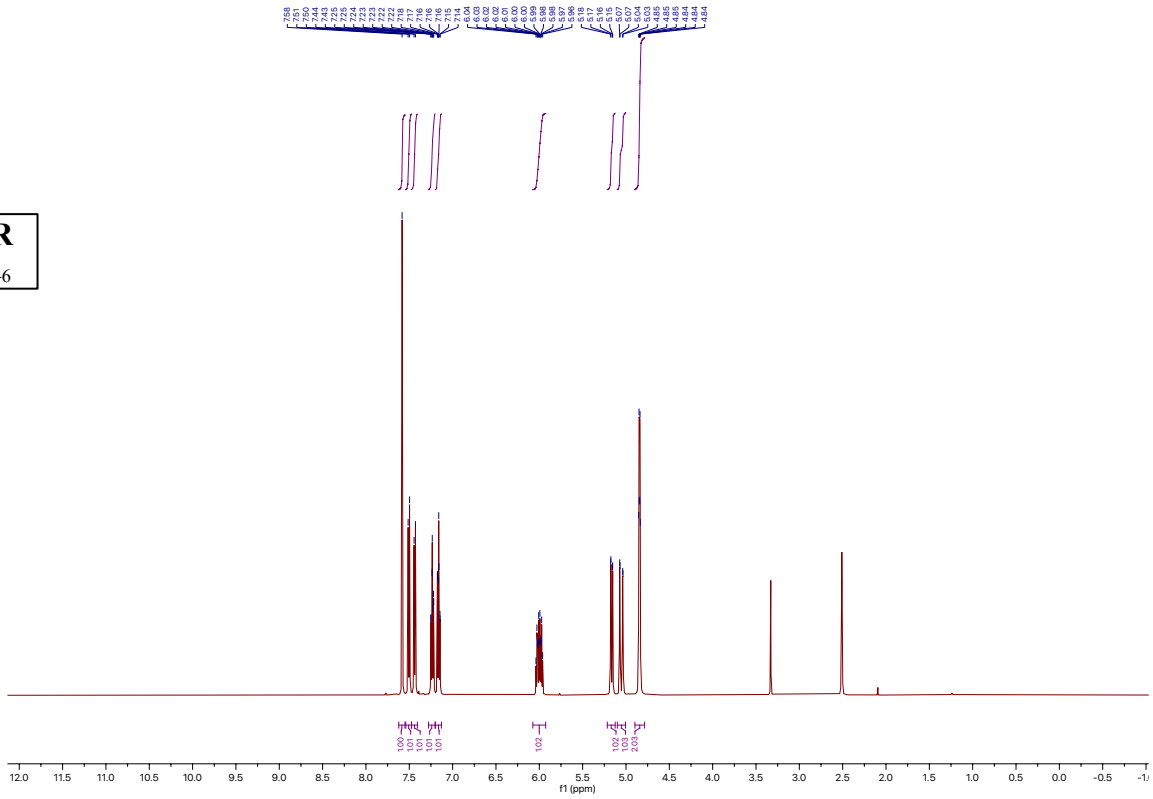
^{13}C-NMR
DMSO-d_6



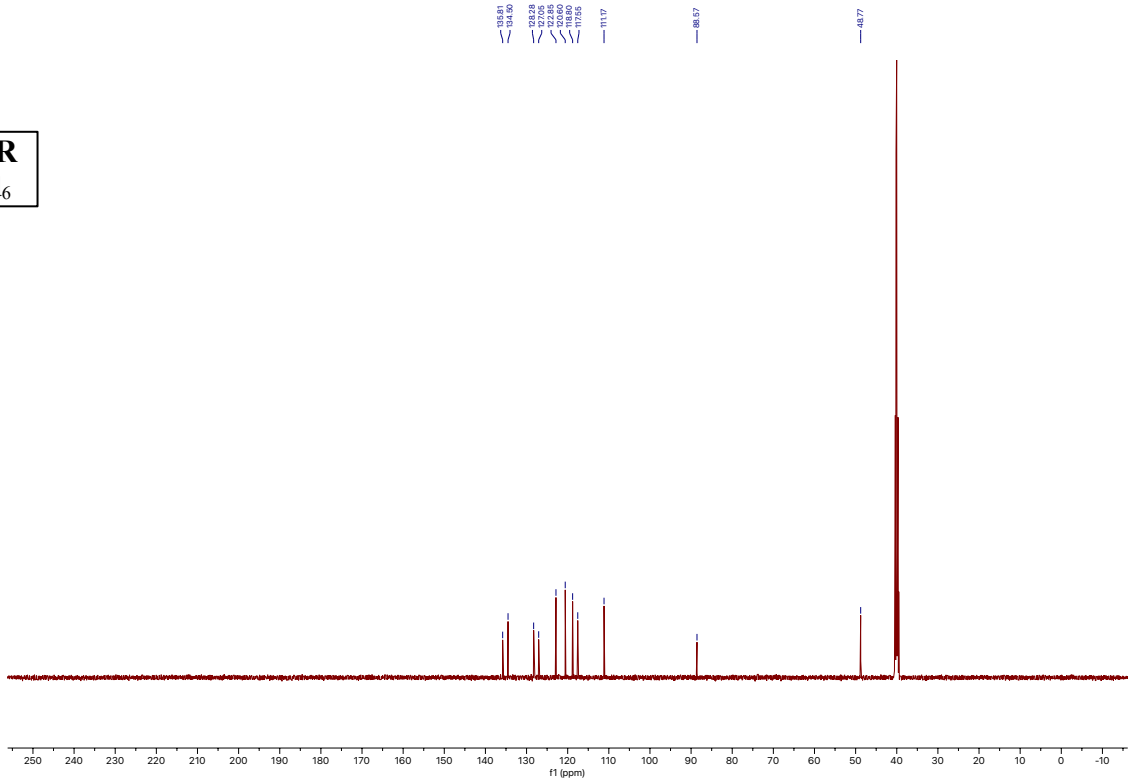
1-allyl-3-bromo-1H-indole (15):



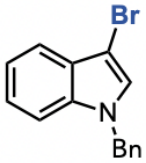
^{1}H-NMR
DMSO-d_6



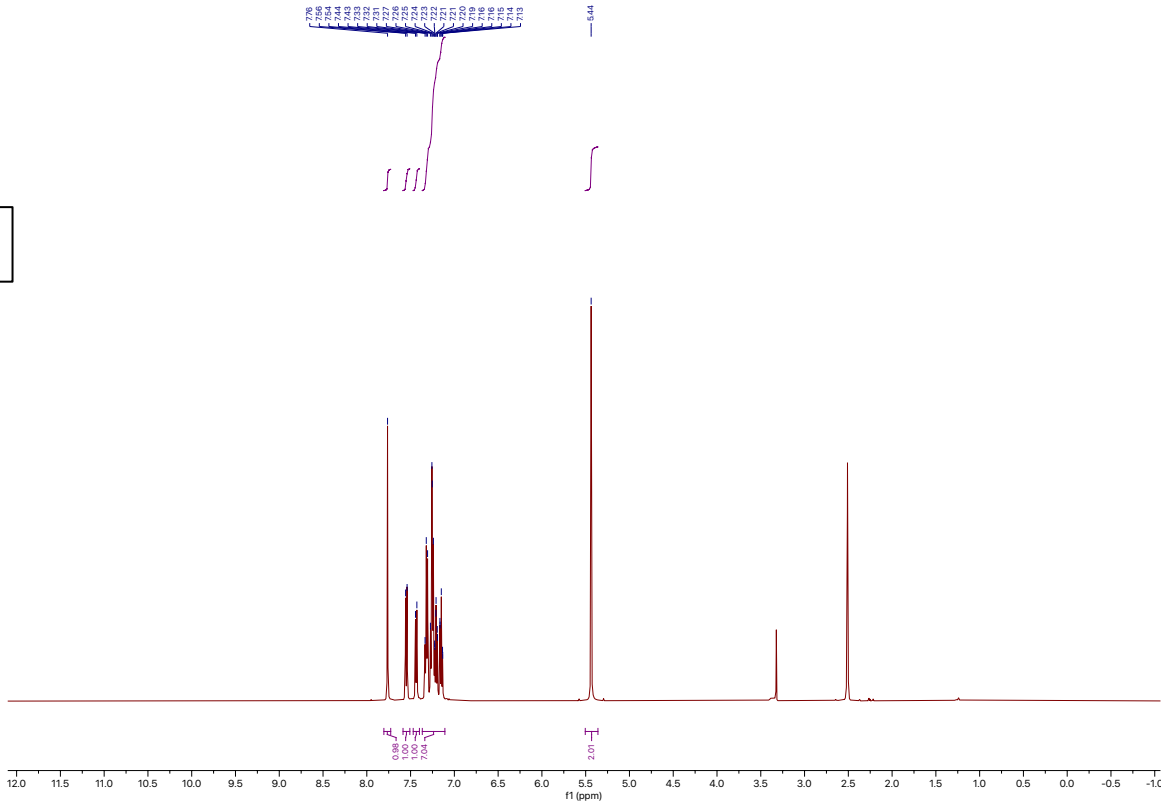
^{13}C-NMR
DMSO-d_6



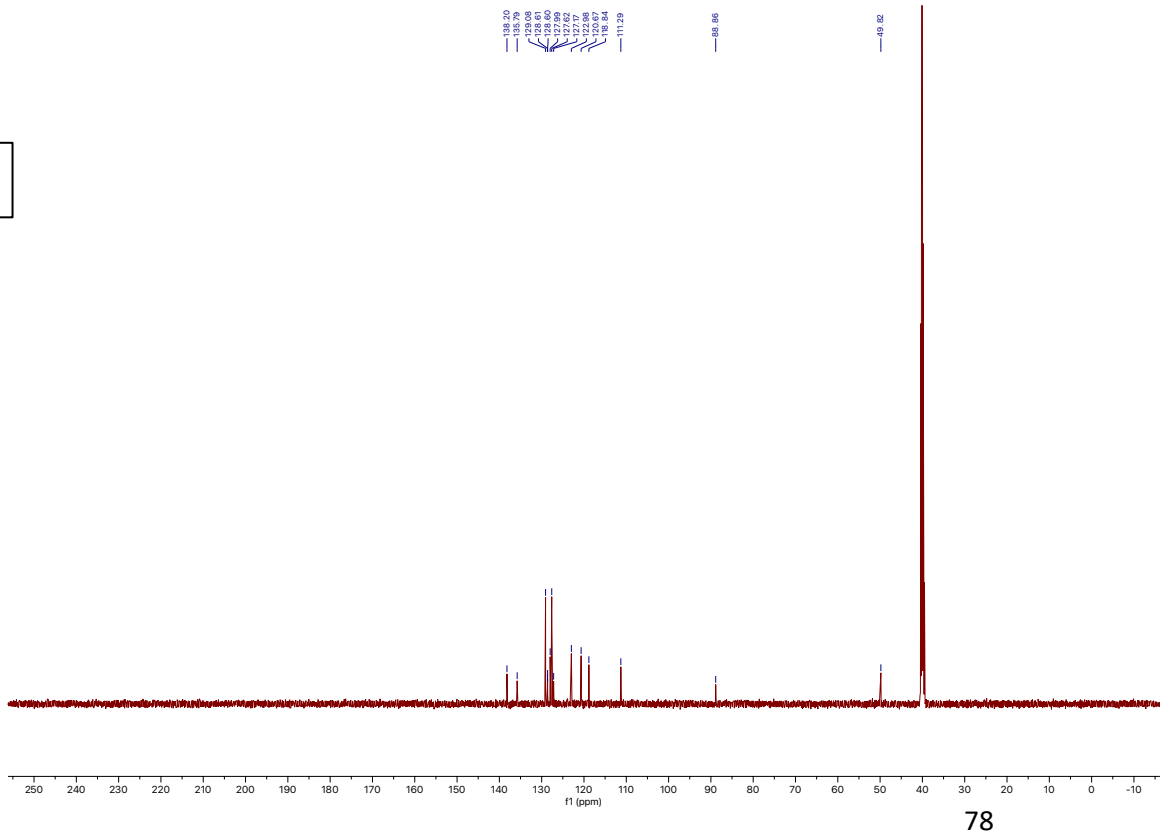
1-benzyl-3-bromo-1H-indole (16):



^{1}H-NMR
DMSO-d_6

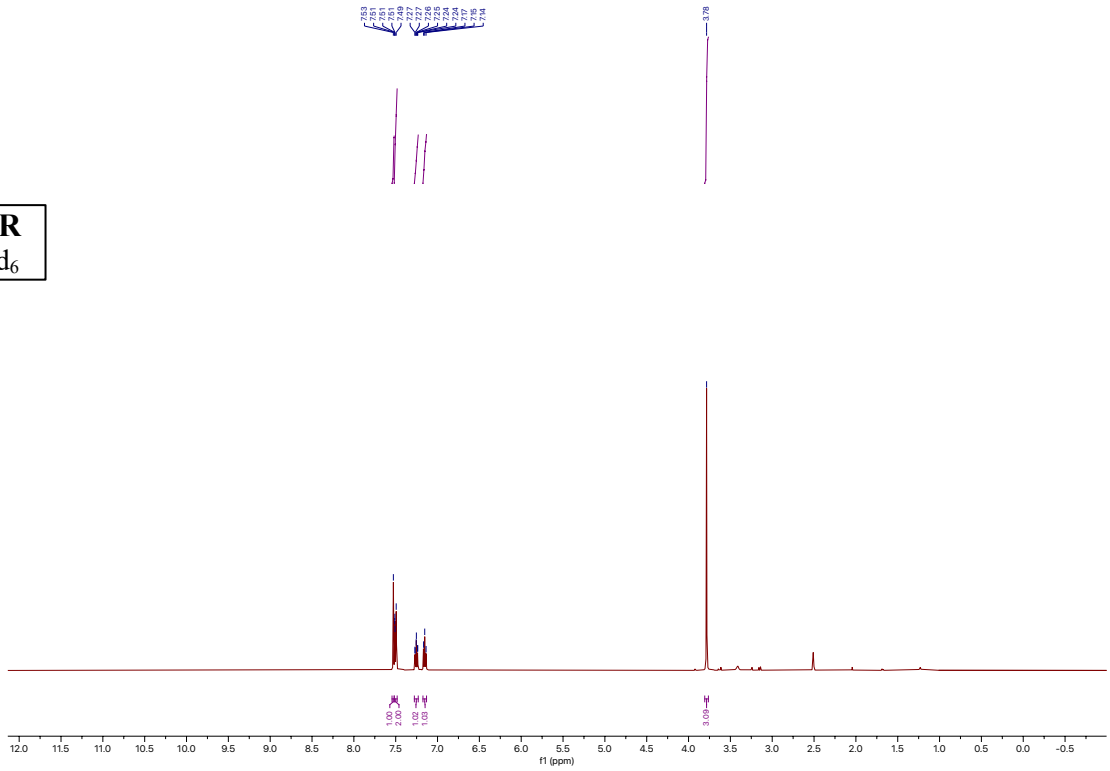


^{13}C-NMR
DMSO-d_6

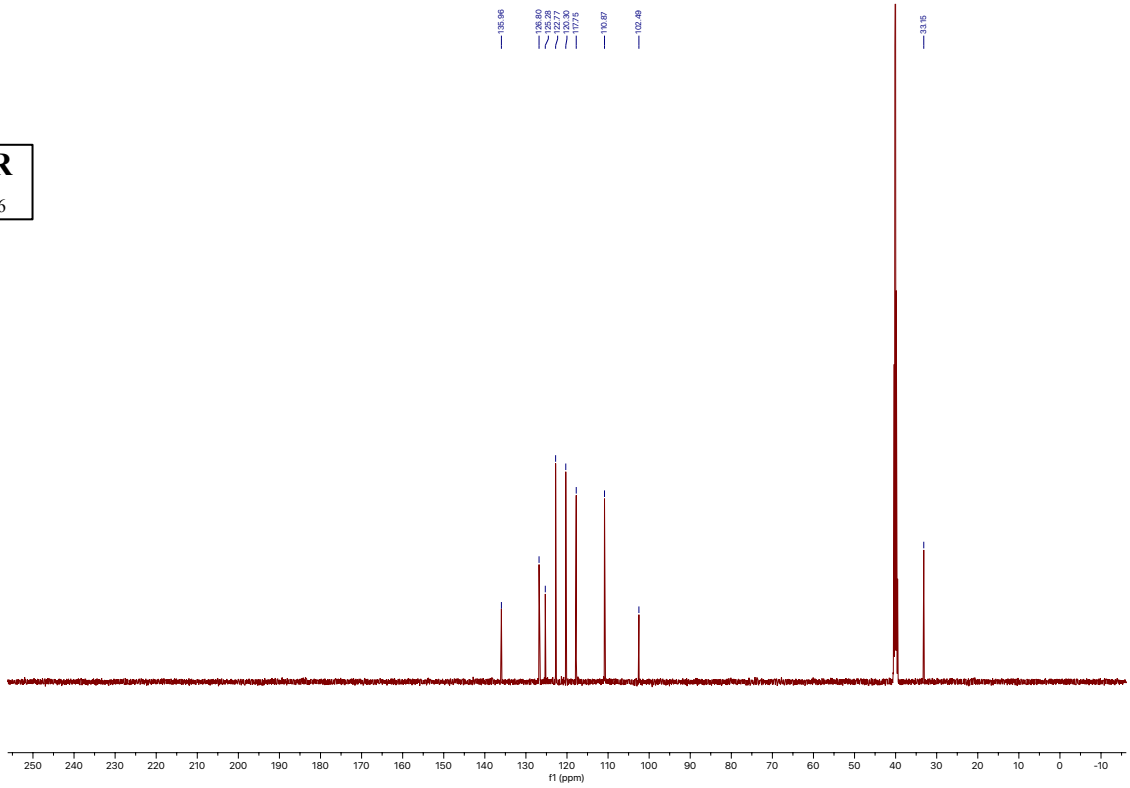


3-chloro-1-methyl-1H-indole (17):

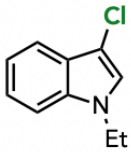
^{1}H-NMR
DMSO-d_6



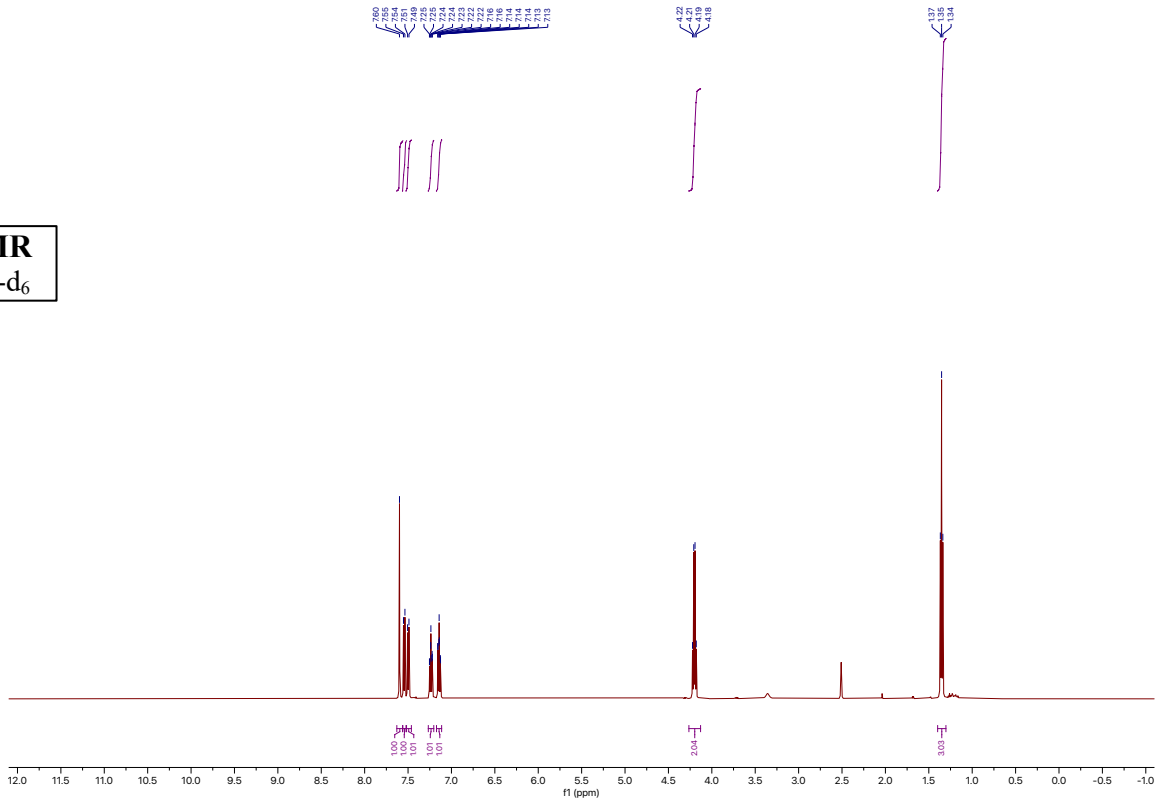
^{13}C-NMR
DMSO-d_6



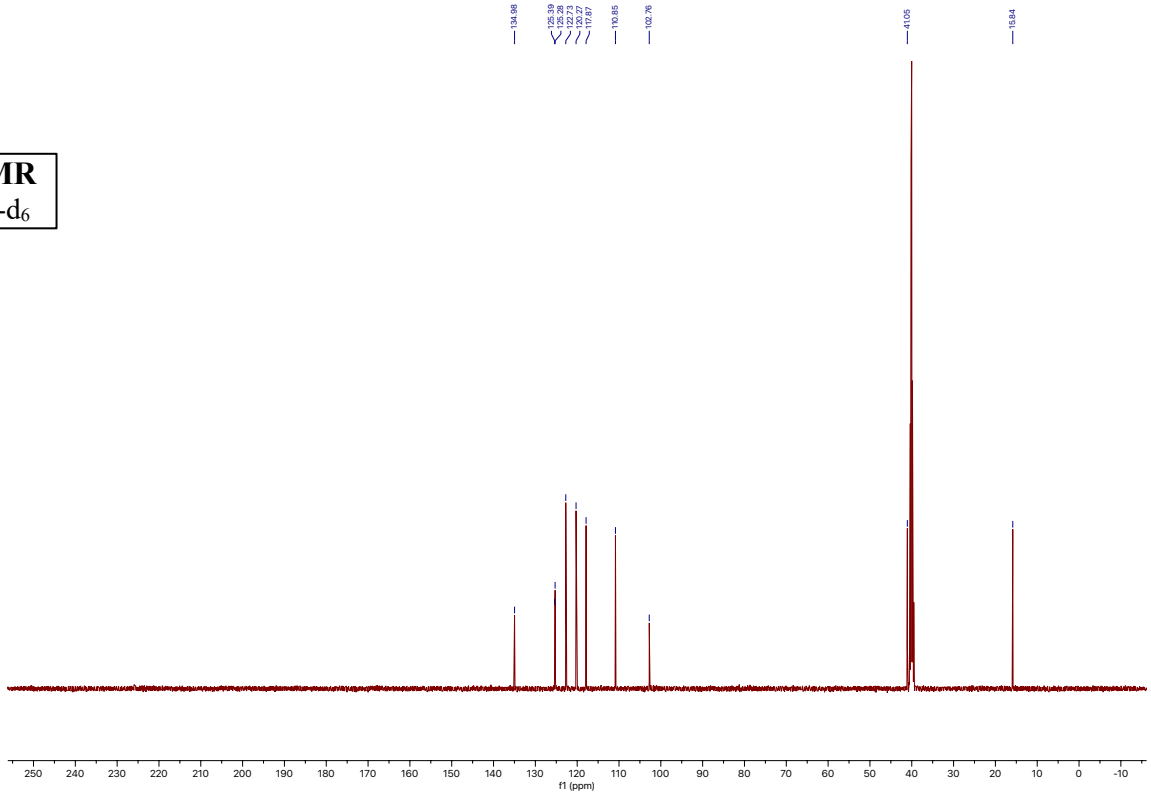
3-chloro-1-ethyl-1H-indole (18):



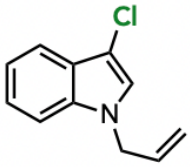
^{1}H-NMR
DMSO-d_6

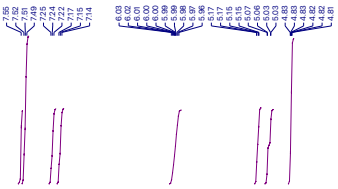


^{13}C-NMR
DMSO-d_6

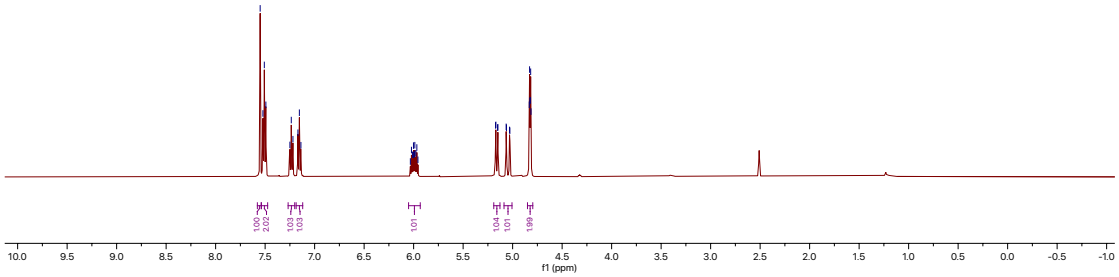


1-allyl-3-chloro-1H-indole (19):

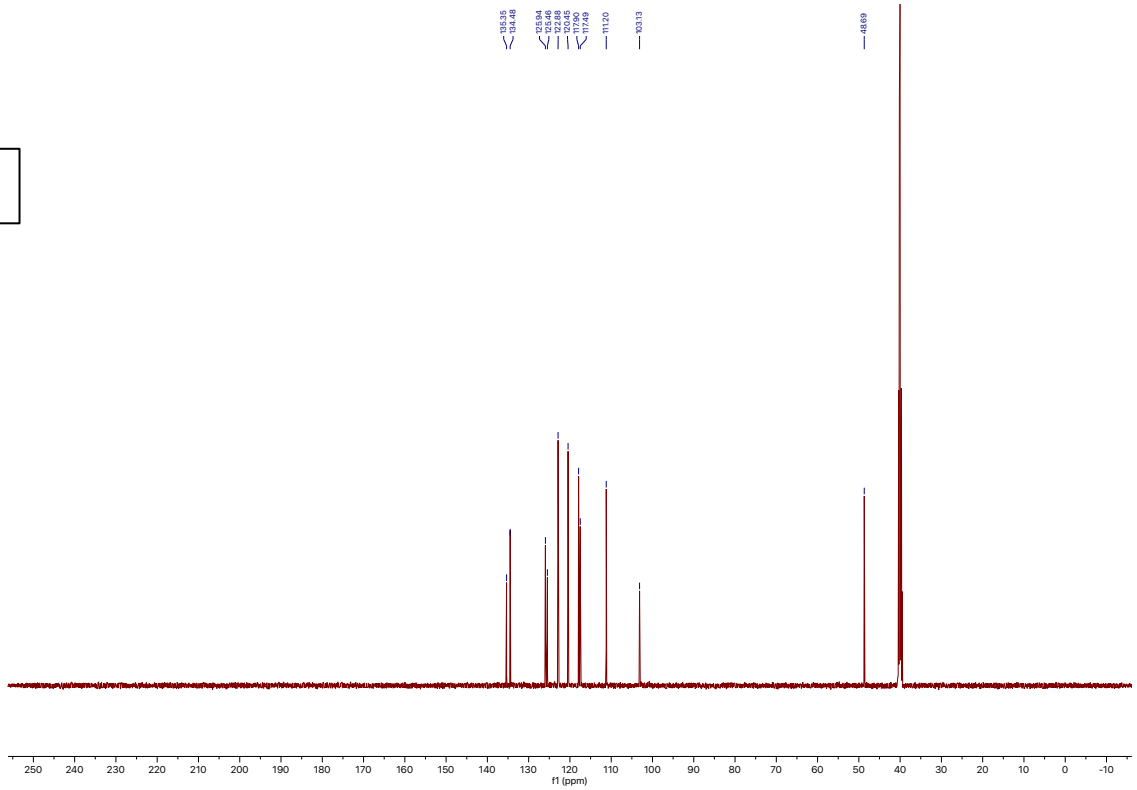




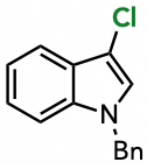
^{1}H-NMR
DMSO-d_6



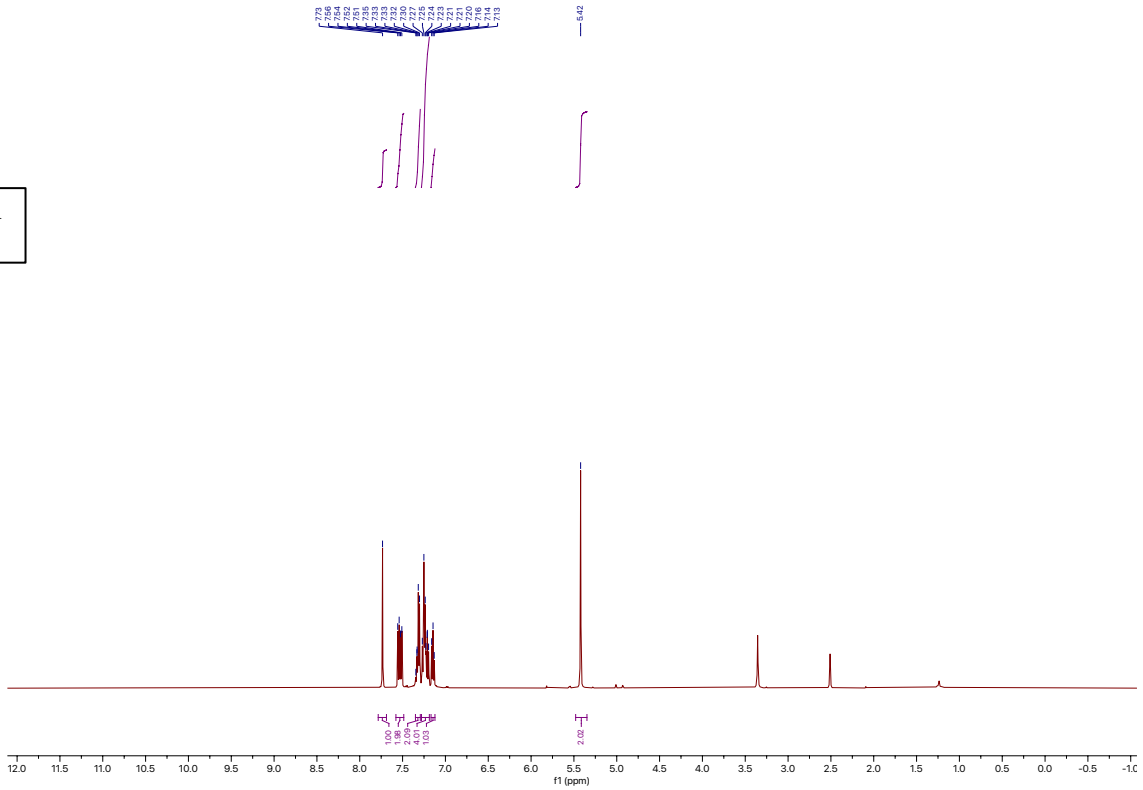
^{13}C-NMR
DMSO-d_6



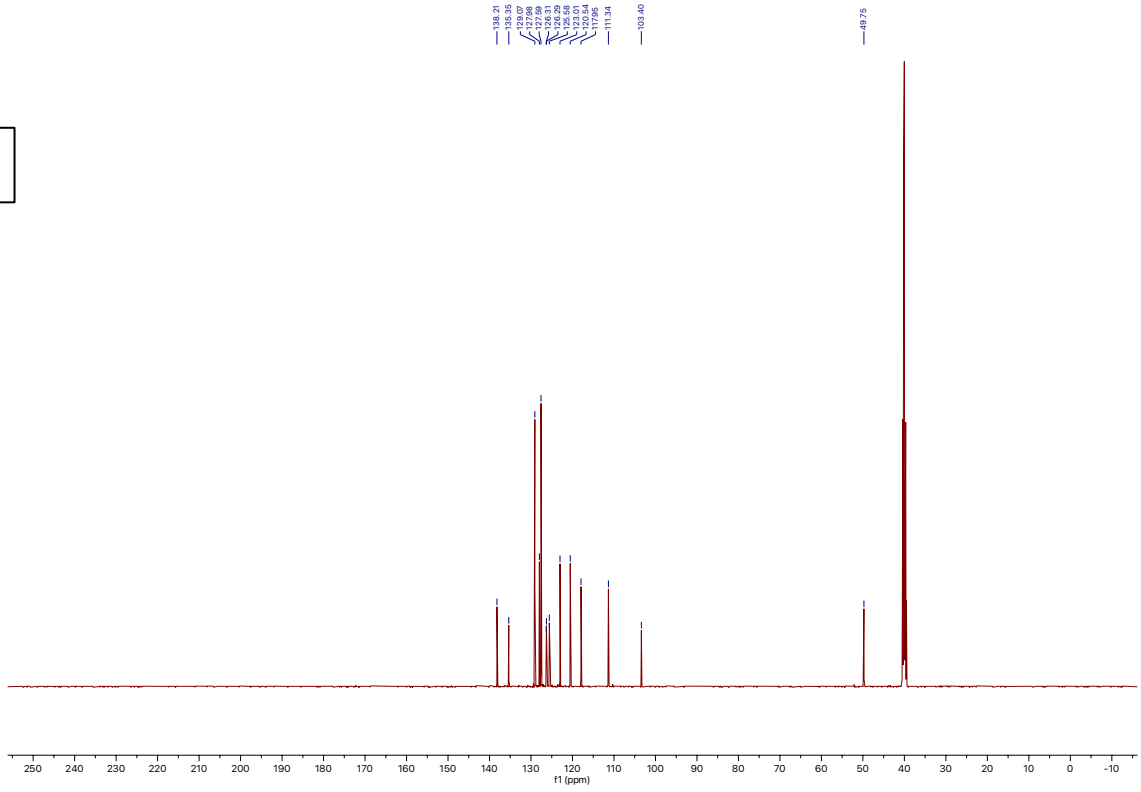
1-benzyl-3-chloro-1H-indole (20):



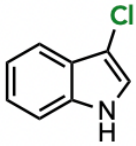
^{1}H-NMR
DMSO-d_6

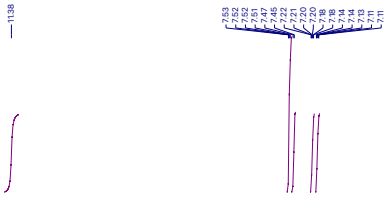


^{13}C-NMR
DMSO-d_6

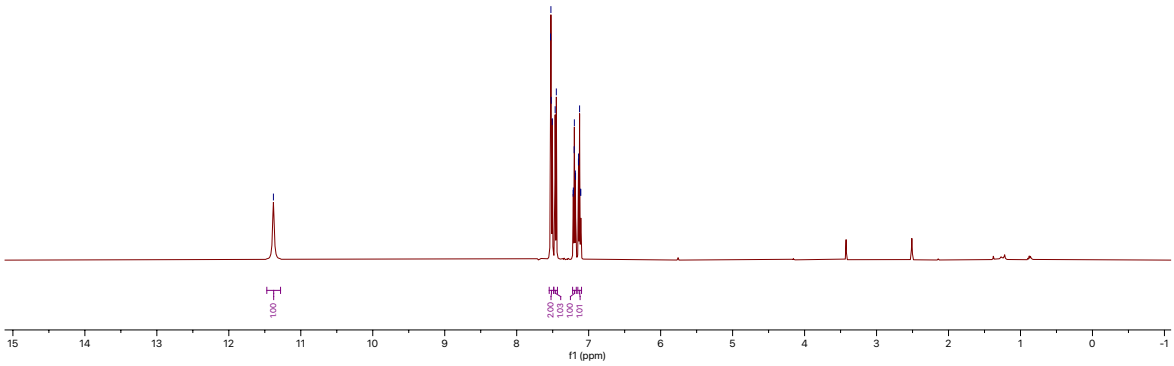


3-chloro-1H-indole (21):

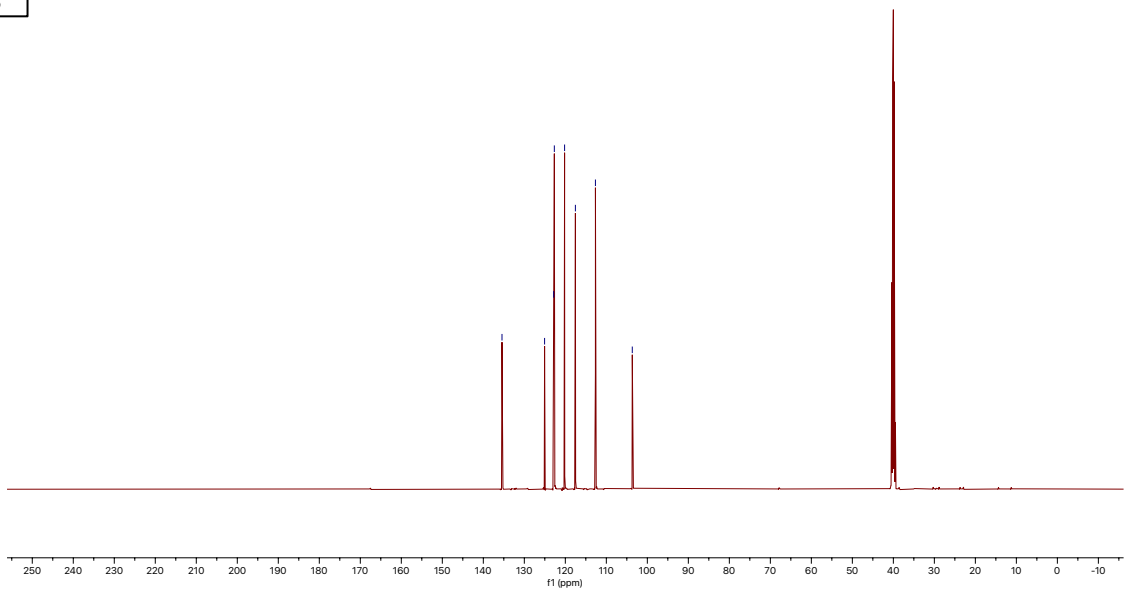




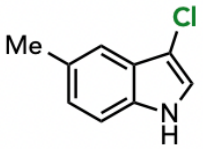
^{1}H-NMR
DMSO-d_6



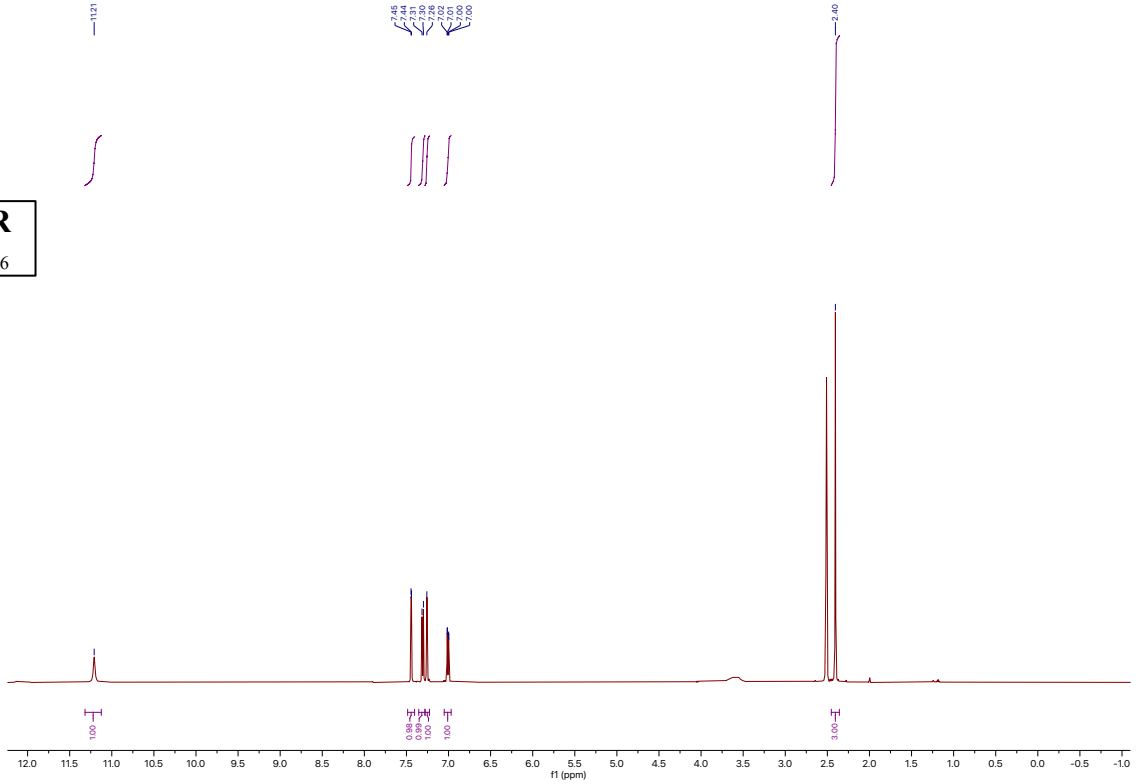
^{13}C-NMR
DMSO-d_6



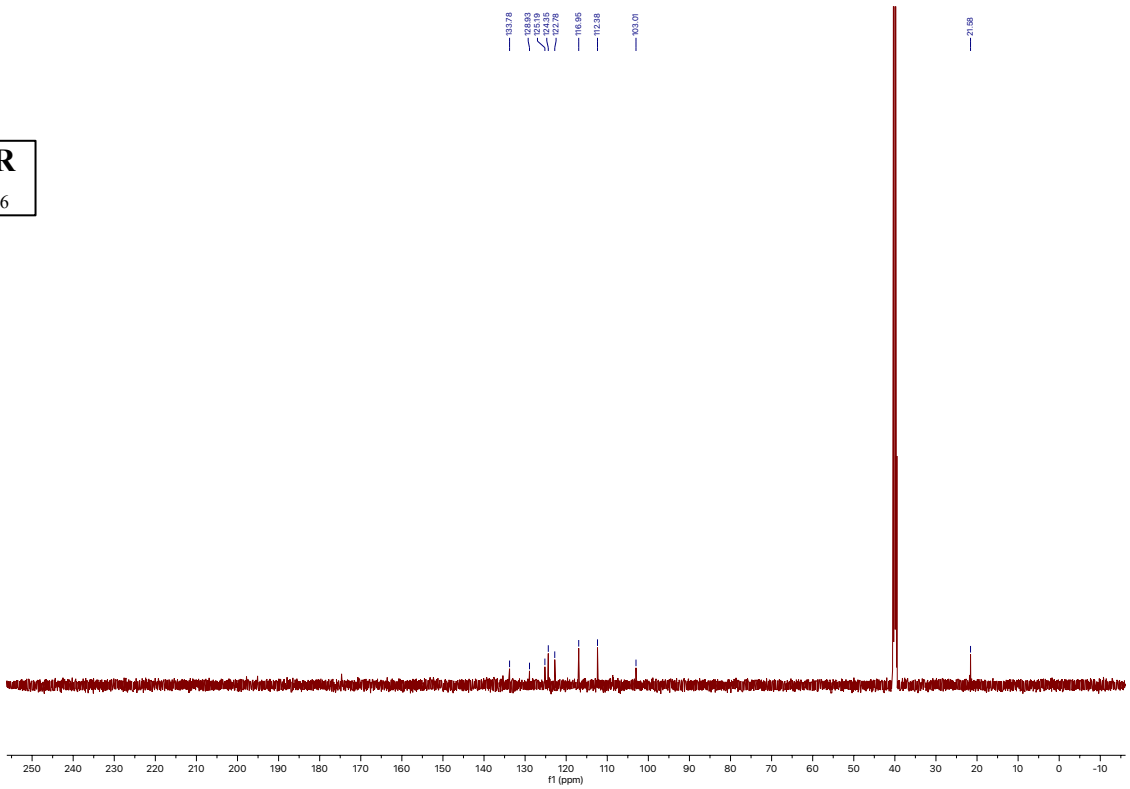
3-chloro-5-methyl-1H-indole (22):



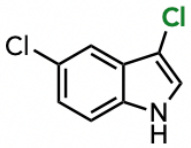
^{1}H-NMR
DMSO-d_6



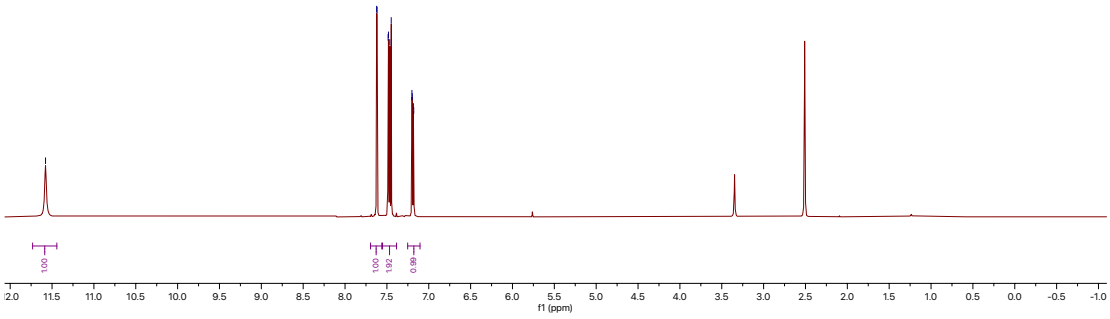
^{13}C-NMR
DMSO-d_6



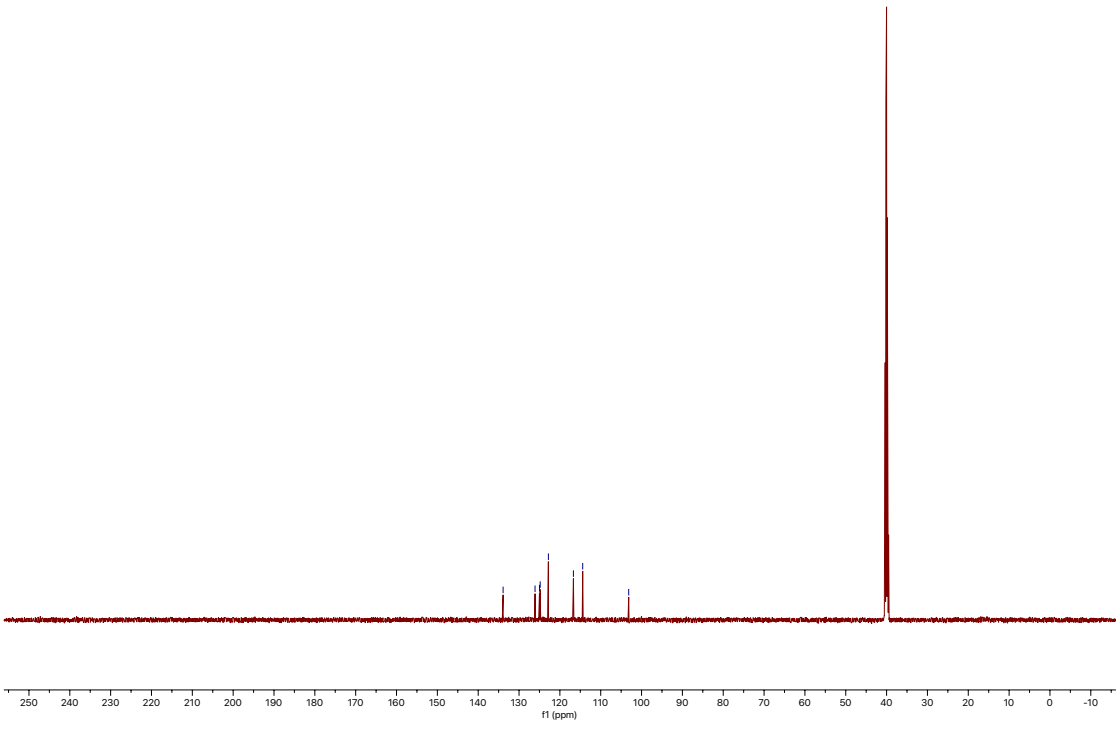
3,5-dichloro-1H-indole (23):



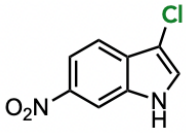
^{1}H-NMR
DMSO-d_6



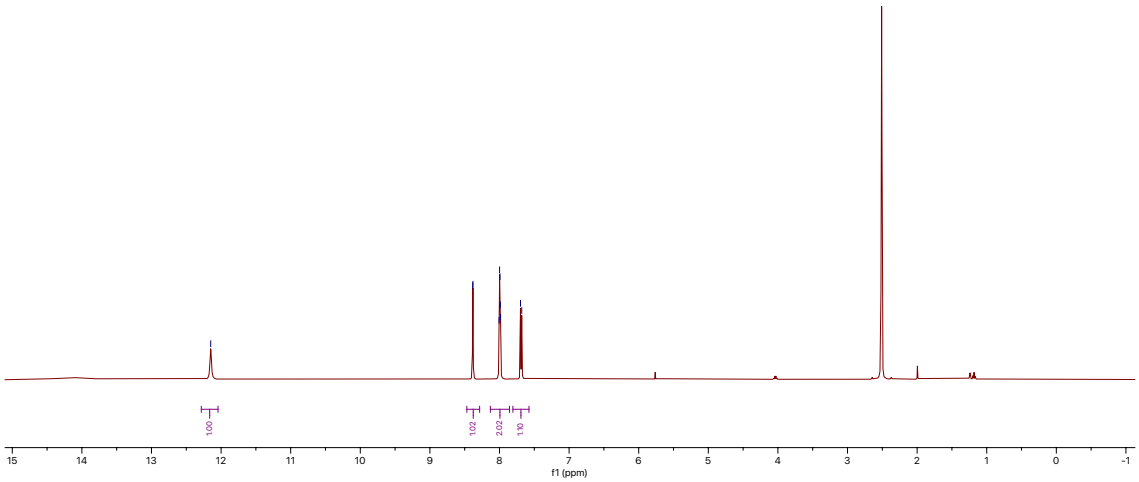
^{13}C-NMR
DMSO-d_6



3-chloro-6-nitro-1H-indole (24):

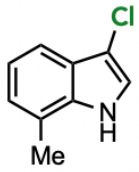


^{1}H-NMR
DMSO-d_6

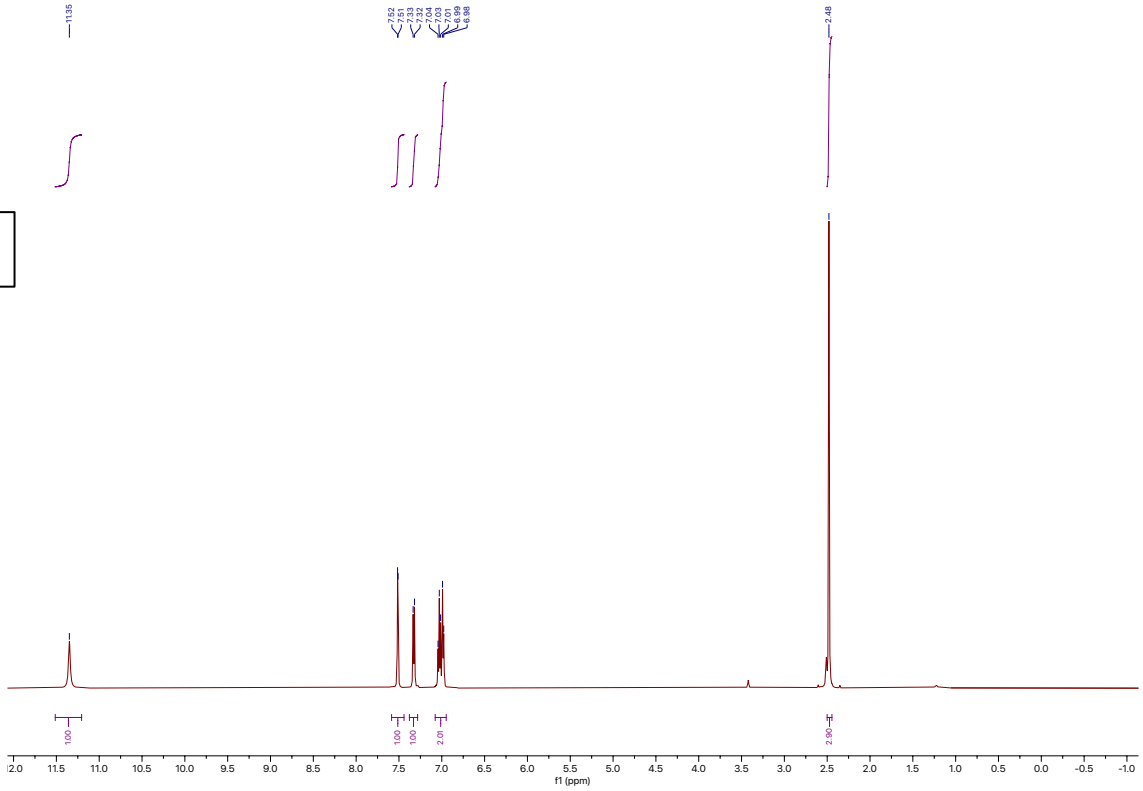


^{13}C-NMR
DMSO-d_6

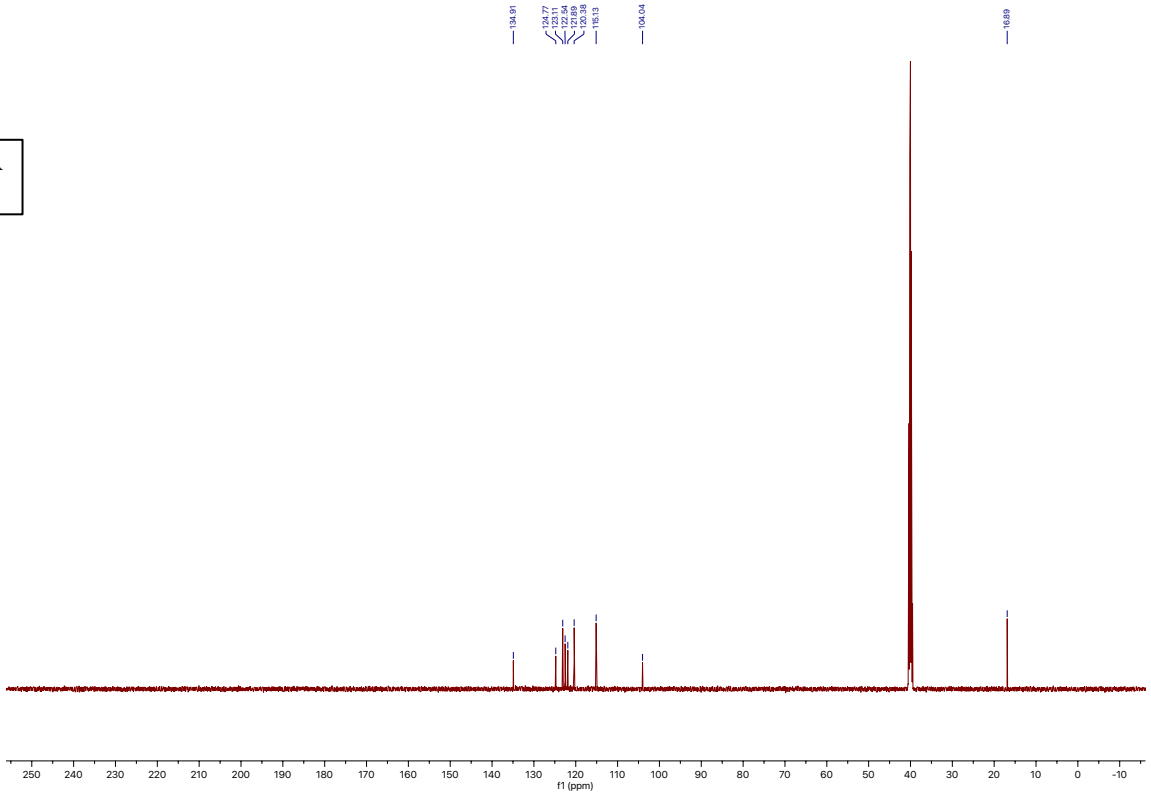
3-chloro-7-methyl-1H-indole (25):



^{1}H-NMR
DMSO-d_6

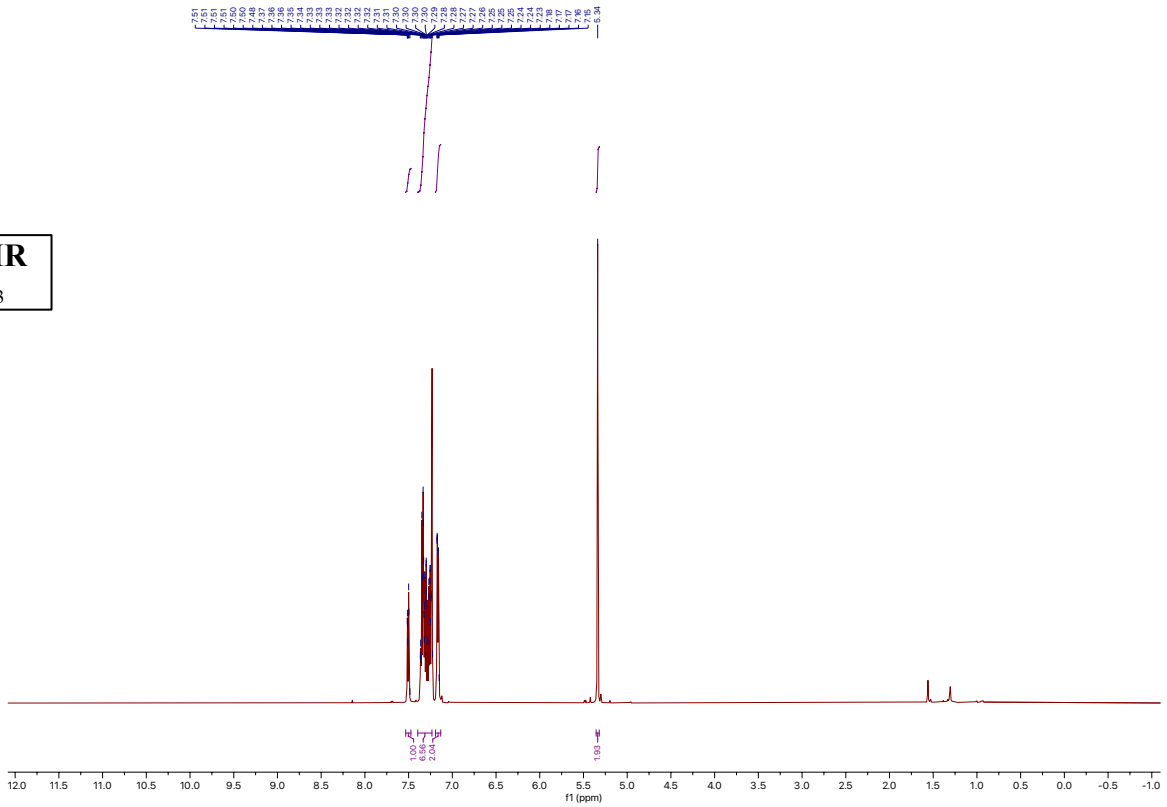


^{13}C-NMR
DMSO-d_6



1-benzyl-3-iodo-1H-indole (28):

^{1}H-NMR
$CDCl_3$



^{13}C-NMR
$CDCl_3$