Chemoselective Cu-Catalyzed Synthesis of Diverse *N*-Arylindole carboxamides, β-Oxo amides and *N*-Arylindole-3-carbonitriles using Diaryliodonium Salts

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Supplementary Information

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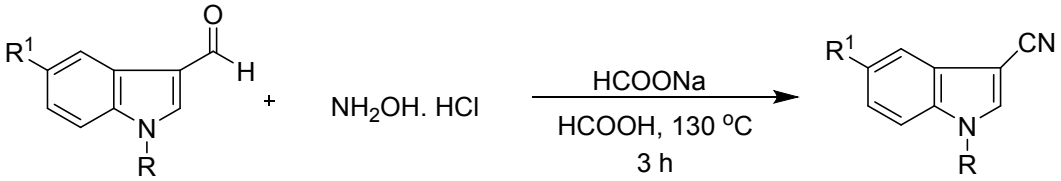
1. General Informations

All the laboratory reagents were purchased from Sigma-Aldich, Alfa Aesar and Spectrochem India Pvt. Ltd and used without further purification. The reactions were monitored by thin layer chromatography and performed on Merck pre-coated plates (silica gel 60 F_{254}, 0.2mm). Column chromatographic purification of products was carried out using silica gel (100-200 mesh) and ethyl acetate/hexane mixture was used for elution. ^{1}H NMR spectra and ^{13}C NMR spectra were recorded at 400 MHz and 100 MHz using $CDCl_3$ and DMSO-d_6 solutions. Chemical shifts are given in ppm relative to the residual solvent peak (^{1}H NMR: $CDCl_3$ δ 7.26; DMSO-d_6 δ 2.50; ^{13}C NMR: $CDCl_3$ δ 77.0; DMSO-d_6 δ 39.52) with multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constants (*J*, in Hz) and integration. Melting points were determined by using E-Z melting point apparatus and are uncorrected. High-resolution mass data were obtained on an Agilent 6545 Q-TOF LC/MS (ESI). Infrared spectra were recorded on Shimadzu IR Prestige-21 FT-IR spectrophotometer. Used α-cyano ketones and diaryliodonium salts were prepared according to literature reported methods.[1]

2. Experimental Procedures

A. General procedure for the synthesis of indole-3-carbonitriles (9a-e):[2] Indole-3-carboxaldehyde was synthesized from commercially available indole *via* Vilsmeier-Haack formylation as reported in the literature.[3]



9a-e

A round-bottom flask was successively charged with a mixture of indole-3-carboxaldehydes (13.78 mmol, 1.0 equiv), hydroxylamine hydrochloride (13.78 mmol, 1.0 equiv), and sodium formate (27.56 mmol, 2.0 equiv) dissolved in 15 mL of formic acid. The mixture was stirred for about 3 h at 130 °C until TLC revealed the complete consumption of the starting material. The reaction mixture was cooled to room temperature and poured into ice-cold water (150 mL) and

organic layer was extracted in dichloromethane (2 × 40 mL). The extracted organic layer was washed with saturated sodium bicarbonate (50 mL) and brine (50 mL) solution. Evaporated the organic phase under reduced pressure and the residue obtained was purified by silica gel column chromatography (ethyl acetate: hexane as eluent) to obtain pure indole-3-carbonitriles **9a-e** (65-70% yields).

B. General experimental procedure for *N*-arylindole-carboxamides (11a-k), *N*-phenyl-β-ketoamides (13a-d) and cephalandole A analogue (15): To the mixture indole-3-carbonitrile **9** or α-cyano ketones **12** (0.70 mmol, 1.0 equiv), copper(II)triflate (0.07 mmol) and diaryliodonium salts (**10**, 0.84 mmol, 1.2 equiv) were dissolved in DCE (2.5 mL, contains 0.1% v/v H_2O) under N_2 atmosphere. The resulting reaction mixture was stirred at 80 °C for 12 h in presence of inert (N_2) atmosphere. After completion of the reaction as indicated by TLC, the contents were cooled to room temperature and evaporated the solvent under reduced pressure. The obtained crude residue was purified by column chromatography using ethyl acetate and hexane as an eluent to obtain pure products **11a-k, 13a-d** and **15**.

C. General experimental procedure for the synthesis of *N*-arylindole-carbonitriles (14a-c): A 10 mL round bottom flask was charged with indole-3-carbonitrile (**9a,** (0.70 mmol, 1.0 equiv), $Cu(OTf)_2$ (0.07 mmol, 10 mol%), *N*,*N*-diisopropylethylamine (2.1 mmol, 3.0 equiv), and the corresponding diaryliodonium salt (**10**, 0.84 mmol, 1.2 equiv). 1,2-Dichloroethane (2.5 mL) was then added to the flask. The reaction mixture was stirred at 80 °C for 12 h under nitrogen atmosphere. After completion of the reaction as indicated by TLC analysis, the solvent was removed in vacuo and the residue was purified by column chromatography on silica gel (ethyl acetate: hexane as eluent) to obtain the desired product **14a**.

D. Experimental procedure for the reduction of indole-3-carboxamide 11a: To a mixture of indole-3-carboxamide **11a** (50 mg, 0.21 mmol) in anhydrous THF (5 mL), $LiAlH_4$ (0.53 mmol, 2.5 equiv) was added in one portion. The resulting reaction mixture was refluxed for 4 h (the reaction was closely monitored by TLC). Upon completion of the reaction, the contents were cooled to room temperature and carefully quenched with the addition of water (6.0 mL). The organic layer was then extracted with ethyl acetate (3.0 mL × 3) and the combined organic layer was dried over anhydrous Na_2SO_4. Organic layer was concentrated at reduced pressure, the

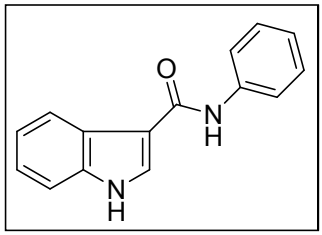
crude product was purified by column chromatography eluting with hexane and ethyl acetate (6 : 4) to obtain pure **16** in 42% yield.

E. Experimental procedure for indoloquinolone 17: A suspension of 1-methyl-*N*-phenyl-1*H*-indole-3-carboxamide **11j** (50 mg, 0.20 mmol), AgTFA (44.2 mg, 0.2 mmol), $Pd(OAc)_2$ (2.2 mg, 0.01 mmol) in AcOH (1.0 mL) was stirred at 120 °C for 12 h. After completion of the reaction, the contents were cooled to room temperature and basified with saturated aqueous solution of $NaHCO_3$, followed by organic layer was extracted with ethyl acetate (3 × 3 mL). The combined organic layers were dried over Na_2SO_4 and evaporated under reduced pressure to give the crude product which was purified by column chromatography on silica gel (*n*-hexane/EtOAc: 50/50) to yield the pure products **17** in 72% yield.

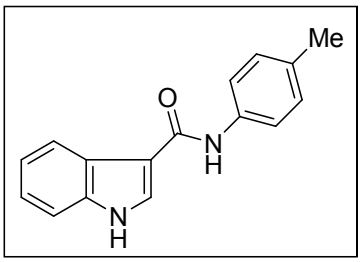
F. Experimental procedure for indoloquinolone 18: To a solution of **11k** (100 mg, 0.42 mmol) in dry THF (4.0 mL) were added NaH (20 mg, 0.84 mmol) and followed by methyliodide (0.08 mL, 1.26 mmol) at 0 ^{o}C. Resulting solution was refluxed for 4 h. After completion of the reaction, solvent was removed at rotavapor and then water (5.0 mL) was added carefully in the reaction mixture. The organic layer was separated in DCM (1.5 mL × 3) and then dried over Na_2SO_4. After evaporation of the solvent in vacuum, obtained *N*,1-dimethyl-*N*-phenyl-1*H*-indole-3-carboxamide was used for next step without any further purification.

Obtained *N*,1-dimethyl-*N*-phenyl-1*H*-indole-3-carboxamide (0.37 mmol) and $Pd(OAc)_2$ (0.037 mmol, 0.1 equiv), *t*-BuOK (0.074 mmol, 0.2 equiv), AgOAc (1.11 mmol, 3.0 equiv) were taken in 2.5 mL mixture of pivalic acid and acetic acid (3 : 1). The resulting solution was heated at 130 ^{o}C for 12 h. After completion of the reaction (as indicated by TLC), mixture was cooled down to room temperature and added a saturated solution of sodium carbonate. Organic layer was extracted with dichloromethane and removal of excess solvent gave crude product. Column chromatography of the crude product on silica gel using ethyl acetate and hexane (4 : 6) as eluant afforded **18** with overall 65% yield.

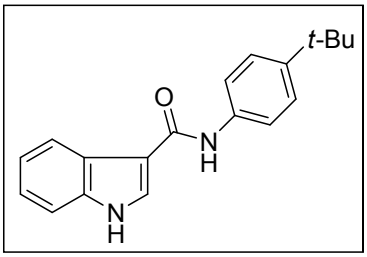
3. Characterization data



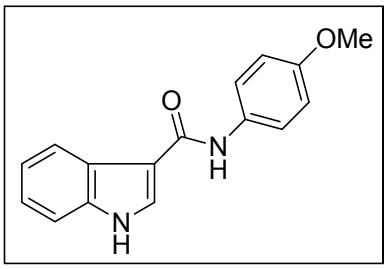
***N*-Phenyl-1*H*-indolyl-3-carboxamide (11a):** White solid, 91% yield, mp 172−173 °C (lit. mp 173-175 °C)[4]. ^{1}H NMR (400 MHz, DMSO-d_6) δ δ 11.75 (s, 1H), 9.72 (s, 1H), 8.31 (d, *J* = 2.4 Hz, 1H), 8.21 (d, *J* = 7.5 Hz, 1H), 7.78 (d, *J* = 7.8 Hz, 2H), 7.48 (d, *J* = 7.6 Hz, 1H), 7.34 (t, *J* = 7.6 Hz, 2H), 7.22 – 7.14 (m, 2H), 7.05 (t, *J* = 7.2 Hz, 1H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.7, 140.3, 136.7, 129.1, 129.0, 126.9, 123.1, 122.6, 121.5, 121.1, 120.2, 112.4, 111.0; IR (neat, cm^{-1}): 3375, 3248, 1643, 1602.



***N*-(*p*-Tolyl)-1*H*-indole-3-carboxamide (11b):** Off-white solid, 89% yield, mp 200−201 °C (lit. mp 200.9-201.1 °C)[5]. ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.71 (s, 1H), 9.64 (s, 1H), 8.27 (d, *J* = 3.0 Hz, 1H), 8.19 (d, *J* = 7.4 Hz, 1H), 7.65 (d, *J* = 8.4 Hz, 2H), 7.47 (d, *J* = 7.7 Hz, 1H), 7.21 – 7.12 (m, 4H), 2.28 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.6, 137.7, 136.6, 131.9, 129.4, 128.9, 126.9, 122.5, 121.5, 121.0, 120.2, 112.4, 111.0, 20.9; IR (neat, cm^{-1}): 3377, 3247, 1642, 1238.

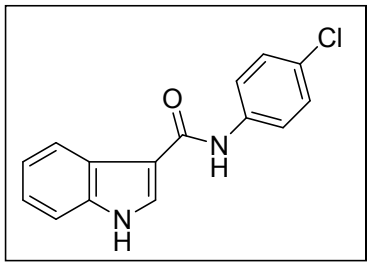


***N*-(4-(*tert*-Butyl)phenyl)-1*H*-indole-3-carboxamide(11c):** Off-white solid, 80% yield, mp 185−186 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.72 (s, 1H), 9.66 (s, 1H), 8.29 (d, *J* = 2.9 Hz, 1H), 8.21 (d, *J* = 7.4 Hz, 1H), 7.69 (d, *J* = 8.7 Hz, 2H), 7.47 (d, *J* = 7.7 Hz, 1H), 7.35 (d, *J* = 8.7 Hz, 2H), 7.22 – 7.12 (m, 2H), 1.29 (s, 9H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.6, 145.3, 137.7, 136.7, 128.9, 126.9, 125.6, 122.5, 121.6, 121.0, 120.0, 112.4, 111.0, 34.4, 31.7; IR (neat, cm^{-1}): 3213, 1636, 1234, 745; HRMS (ESI) *m/z* calcd for $C_{19}H_{21}N_2O$: 293.1648 $(M + H)^+$, found: 293.1642.

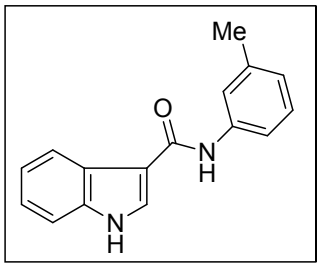


***N*-(4-Methoxyphenyl)-1*H*-indole-3-carboxamide (11d):** Off-white solid, 82% yield, mp 201−202 °C (lit. mp 200-202 °C)[6]. ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.71 (s, 1H), 9.63 (s, 1H), 8.26 (d, *J* = 3.0 Hz, 1H), 8.20 (d, *J* = 7.4 Hz, 1H), 7.69 – 7.66 (m, 2H), 7.47 (d, *J* = 7.7 Hz, 1H), 7.21 – 7.12 (m, 2H), 6.92 (d, *J* = 9.1 Hz, 2H), 3.75

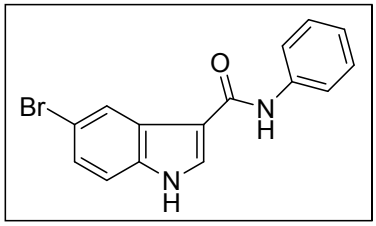
(s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.5, 155.3, 136.7, 133.3, 128.8, 126.9, 122.5, 121.8, 121.6, 121.0, 114.2, 112.4, 111.1, 55.6; IR (neat, cm^{-1}): 3398, 3217, 1631, 1236.



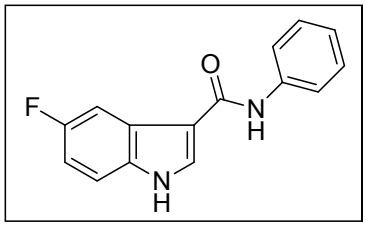
***N*-(4-Chlorophenyl)-1*H*-indole-3-carboxamide (11e):** Off-white solid, 75% yield, mp 224−225 °C (lit. mp 225-226 °C)[6]. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.25 (s, 1H), 8.16 (d, *J* = 7.5 Hz, 1H), 7.77 (d, *J* = 8.9 Hz, 2H), 7.48 (d, *J* = 7.8 Hz, 1H), 7.37 (d, *J* = 8.9 Hz, 2H), 7.22 – 7.14 (m, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.8, 138.9, 136.5, 129.3, 129.1, 128.9, 126.8 126.6, 122.9, 121.7, 121.4, 112.5, 110.5; IR (neat, cm^{-1}): 3410, 3118, 1641, 1233.



***N*-(*m*-Tolyl)-1*H*-indole-3-carboxamide (11f):** Off-white solid, 86% yield, mp 196−197 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.73 (s, 1H), 9.64 (s, 1H), 8.30 (d, *J* = 3.0 Hz, 1H), 8.21 (d, *J* = 7.4 Hz, 1H), 7.64 (s, 1H), 7.57 (d, *J* = 8.2 Hz, 1H), 7.48 (d, *J* = 7.6 Hz, 1H), 7.23 – 7.13 (m, 3H), 6.86 (d, *J* = 7.5 Hz, 1H), 2.32 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.7, 140.2, 138.1, 136.7, 129.0, 128.8, 126.90, 123.8, 122.6, 121.6, 121.1, 120.7, 117.3, 112.4, 111.0, 21.7; IR (neat, cm^{-1}): 3379, 3231, 1642, 1235; HRMS (ESI) *m/z* calcd for $C_{16}H_{15}N_2O$: 251.1179 $(M + H)^+$, found: 251.1175.

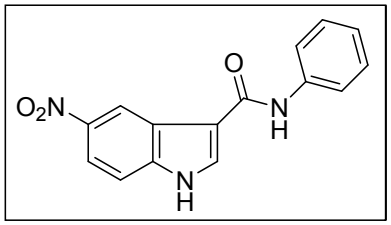


5-Bromo-*N*-phenyl-1*H*-indole-3-carboxamide (11g): Off-white solid, 75% yield, mp 220−221 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.95 (s, 1H), 9.80 (s, 1H), 8.37 – 8.35 (m, 2H), 7.76 (d, *J* = 7.6 Hz, 2H), 7.47 (d, *J* = 8.6 Hz, 1H), 7.36 – 7.30 (m, 3H), 7.06 (t, *J* = 7.4 Hz, 1H); ^{13}C NMR (100 MHz, DMSO) δ 163.3, 140.0, 135.4, 130.4, 129.0, 128.7, 125.2, 123.7, 123.3, 120.3, 114.5, 114.0, 110.5; IR (neat, cm^{-1}): 3402, 3290, 1641; HRMS (ESI) *m/z* calcd for $C_{15}H_{12}BrN_2O$: 315.0128 $(M + H)^+$, found: 315.0118.



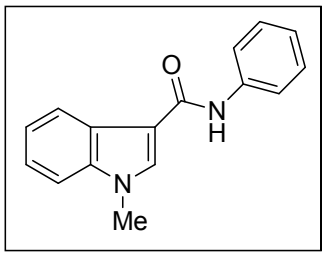
5-Fluoro-*N*-phenyl-1*H*-indole-3-carboxamide (11h): Off-white solid, 70% yield, mp 211−213 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.81 (s, 1H), 8.33 (s, 1H), 7.85 (dd, *J* = 10.2, 2.6 Hz, 1H), 7.71 (d, *J* = 7.6 Hz, 2H), 7.49 (dd, *J* = 8.9, 4.6 Hz, 1H), 7.33 (t, *J* = 7.9 Hz, 2H),

7.08 – 7.03 (m, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.6, 158.39 (d, J_F = 231.8 Hz), 139.7, 133.1, 130.5, 129.1, 127.26 (d, J_F = 11.0 Hz), 123.5, 120.3, 113.64 (d, J_F = 9.9 Hz), 111.05 (d, J_F = 26.1 Hz), 110.8 (d, J_F = 4.6 Hz), 106.14 (d, J_F = 24.5 Hz); IR (neat, cm^{-1}): 3411, 3296, 1642; HRMS (ESI) *m/z* calcd for $C_{15}H_{12}FN_2O$: 255.0928 (M + H)$^+$, found: 255.0920.

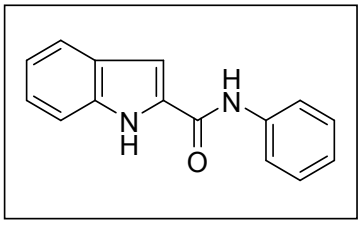


5-Nitro-*N*-phenyl-1*H*-indole-3-carboxamide(11i): Off-white solid, 78% yield, mp 272−273 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.40 (s, 1H), 9.97 (s, 1H), 9.13 (d, *J* = 2.3 Hz, 1H), 8.56 (d, *J* = 2.9 Hz, 1H), 8.10 (dd, *J* = 9.0, 2.4 Hz, 1H), 7.78 (d, *J* = 7.6 Hz, 2H), 7.69 (d, *J* = 9.0 Hz, 1H), 7.38 – 7.34 (m, 2H), 7.08 (t, *J* = 6.9 Hz, 1H);

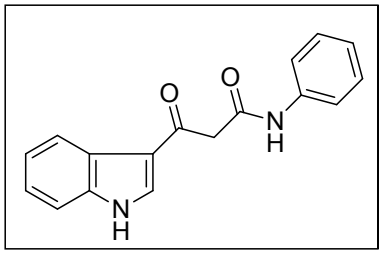
^{13}C NMR (100 MHz, DMSO-d_6) δ 162.8, 142.4, 139.8, 132.6, 129.1, 127.1, 126.3, 123.6, 120.4, 118.3, 118.0, 113.2, 112.9; IR (neat, cm^{-1}): 3428, 3290, 1645, 1523, 1485; HRMS (ESI) *m/z* calcd for $C_{15}H_{12}N_3O_3$: 282.0873 (M + H)$^+$, found: 282.0869.



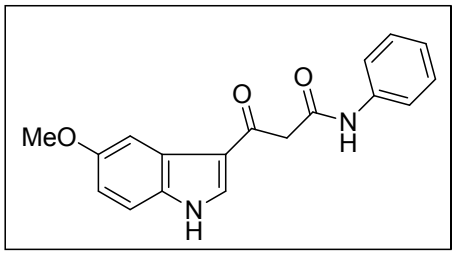
1-Methyl-*N*-phenyl-1*H*-indole-3-carboxamide (11j): Off-white solid, 85% yield, mp 172−173 °C (lit. mp 172-173 °C);[7] ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.74 (s, 1H), 8.27 (s, 1H), 8.21 (d, *J* = 7.6 Hz, 1H), 7.77 (d, *J* = 7.6 Hz, 2H), 7.54 (d, *J* = 8.1 Hz, 1H), 7.33 (t, *J* = 7.6 Hz, 2H), 7.27 – 7.25 (m, 1H), 7.22 – 7.18 (m, 1H), 7.04 (t, *J* = 7.4 Hz, 1H), 3.89 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.3, 140.3, 137.3, 132.9, 129.0, 127.2, 123.1, 122.7, 121.7, 121.4, 120.1, 110.8, 110.0, 33.6; IR (neat, cm^{-1}): 3290, 1638.



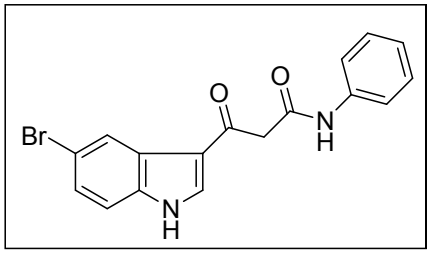
***N*-Phenyl-1*H*-indole-2-carboxamide (11k):** Pale yellow solid, 81% yield, mp 194-195 °C (lit. mp 192-193 °C)[8]. ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.75 (s, 1H), 10.22 (s, 1H), 7.82 (d, *J* = 8.8, 1.2 Hz, 2H), 7.69 (d, *J* = 8.0 Hz, 1H), 7.49 – 7.44 (m, 2H), 7.40 – 7.36 (m, 2H), 7.25 – 7.21 (m, 1H), 7.14 – 7.06 (m, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 160.2, 139.4, 137.3, 131.9, 129.2, 127.5, 124.2, 124.0, 122.2, 120.6, 120.4, 112.9, 104.3; IR (neat, cm^{-1}): 3428, 3341, 1648.



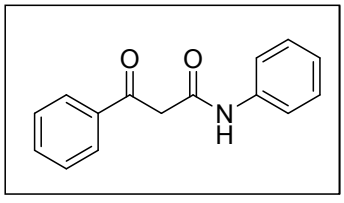
3-(1*H*-Indol-3-yl)-3-oxo-*N*-phenylpropanamide(13a): Light brown solid, 75% yield, mp 214−215 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.06 (s, 1H), 10.20 (s, 1H), 8.43 (d, *J* = 3.1 Hz, 1H), 8.19 (d, *J* = 7.0 Hz, 1H), 7.62 (d, *J* = 7.7 Hz, 2H), 7.50 (d, *J* = 8.1 Hz, 1H), 7.32 (t, *J* = 7.9 Hz, 2H), 7.26 – 7.19 (m, 2H), 7.06 (t, *J* = 7.4 Hz, 1H), 3.99 (s, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 189.2, 166.3, 139.6, 137.1, 135.7, 129.2, 125.8, 123.7, 123.5, 122.4, 121.7, 119.5, 116.8, 112.7, 49.3; IR (neat, cm^{-1}): 3310, 1667, 1601, 1420, 1339, 1173; HRMS (ESI) *m/z* calcd for $C_{17}H_{15}N_2O_2$: 279.1128 (M + H)$^+$, found: 279.1126.



3-(5-Methoxy-1*H*-indol-3-yl)-3-oxo-*N*-phenylpropanamide (13b): Light brown solid, 70% yield, mp 208−210 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.95 (s, 1H), 10.17 (s, 1H), 8.36 (d, *J* = 3.1 Hz, 1H), 7.70 (d, *J* = 2.5 Hz, 1H), 7.63 – 7.61 (m, 2H), 7.39 (d, *J* = 8.8 Hz, 1H), 7.31 (t, *J* = 7.9 Hz, 2H), 7.06 (t, *J* = 7.4 Hz, 1H), 6.86 (dd, *J* = 8.8, 2.6 Hz, 1H), 3.96 (s, 2H), 3.78 (s, 3H).); ^{13}C NMR (100 MHz, DMSO-d_6) δ 189.1, 166.3, 156.0 , 139.6, 135.7 , 131.9, 129.2, 126.7, 123.7, 119.5, 116.7, 113.4, 113.3, 103.4, 55.7, 49.3; IR (neat, cm^{-1}): 3309, 3140, 1697, 1664, 1560; HRMS (ESI) *m/z* calcd for $C_{18}H_{17}N_2O_3$: 309.1234 (M + H)$^+$, found: 309.1228.

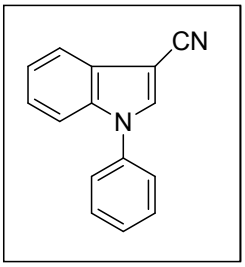


3-(5-Bromo-1*H*-indol-3-yl)-3-oxo-*N*-phenylpropanamide (13c): Light brown solid, 64% yield, mp 227−228 °C; ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.27 (s, 1H), 10.22 (s, 1H), 8.49 (d, *J* = 3.1 Hz, 1H), 8.32 (d, *J* = 1.9 Hz, 1H), 7.61 (d, *J* = 7.6 Hz, 2H), 7.49 (d, *J* = 8.6 Hz, 1H), 7.38 (dd, *J* = 8.6, 2.0 Hz, 1H), 7.32 (t, *J* = 7.9 Hz, 2H), 7.06 (t, *J* = 7.4 Hz, 1H), 3.99 (s, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 189.4, 166.1, 139.5, 136.8, 135.9, 129.2, 127.6, 126.1, 123.8, 123.8, 119.5, 116.3, 115.2, 114.9, 49.3; IR (neat, cm^{-1}): 3395, 3294, 1670, 995; HRMS (ESI) *m/z* calcd for $C_{17}H_{14}BrN_2O_2$: 357.0233 (M + H)$^+$, found: 357.0196.

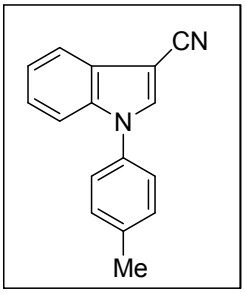


3-Oxo-*N*, 3-diphenylpropanamide (13d): Off-white solid, 82% yield, mp 102−103 °C (lit. mp 102−104 °C);[9] ^{1}H NMR (400 MHz, $CDCl_3$) δ

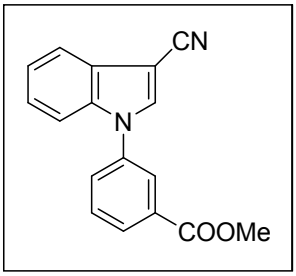
9.32 (s, 1H), 8.06 (d, *J* = 7.5 Hz, 2H), 7.66 (t, *J* = 7.4 Hz, 1H), 7.61 (d, *J* = 7.9 Hz, 2H), 7.54 (t, *J* = 7.7 Hz, 2H), 7.36 (t, *J* = 7.8 Hz, 2H), 7.15 (t, *J* = 7.4 Hz, 1H), 4.14 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 196.5, 163.8, 137.6, 136.1, 134.4, 129.0, 129.0, 128.6, 124.6, 120.2, 45.6; IR (neat, cm^{-1}): 3310, 1693, 1658, 1595, 1543, 1442.



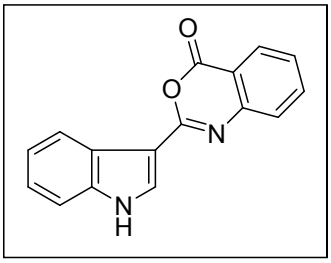
1-Phenyl-1*H*-indole-3-carbonitrile (14a): Yellowish solid, 93% yield, mp 115−116 °C (lit. mp 116 °C)[10]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 – 7.84 (m, 1H), 7.81 (s, 1H), 7.63 – 7.59 (m, 2H), 7.55 – 7.49 (m, 4H), 7.39 – 7.36 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 137.8, 135.6, 134.7, 130.1, 128.4, 128.0, 124.9, 124.6, 122.8, 120.0, 115.5, 111.6, 88.1; IR (neat, cm^{-1}): 3119, 2221, 1541; HRMS (ESI) *m/z* calcd for $C_{15}H_{11}N_2$: 219.0917 $(M + H)^+$, found: 219.0911.



1-(*p*-Tolyl)-1*H*-indole-3-carbonitrile (14b): White solid, 85% yield, mp 101−102 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 – 7.83 (m, 1H), 7.79 (s, 1H), 7.53 – 7.49 (m, 1H), 7.38 – 7.35 (m, 6H), 2.49 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.5, 135.8, 135.3, 134.7, 130.5, 127.9, 124.8, 124.4, 122.7, 120.0, 115.6, 111.6, 87.8, 21.1; IR (neat, cm^{-1}): 3113, 2920, 2222, 1535; HRMS (ESI) *m/z* calcd for $C_{16}H_{13}N_2$: 233.1073 $(M + H)^+$, found: 233.1066.

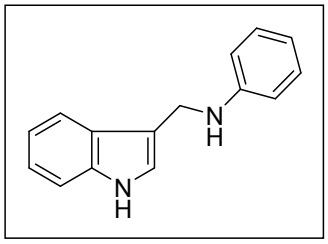


Methyl 3-(3-cyano-1*H*-indol-1-yl)benzoate (14c): Off-white solid, 79% yield, mp 170−171 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 (dd, *J* = 6.8, 1.8 Hz, 2H), 7.87 (d, *J* = 2.6 Hz, 1H), 7.85 (s, 1H), 7.74 – 7.66 (m, 2H), 7.54 – 7.52 (m, 1H), 7.41 – 7.37 (m, 2H), 3.99 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 138.1, 135.5, 134.4, 132.4, 130.2, 129.3, 129.0, 128.0, 125.8, 124.9, 123.1, 120.2, 115.2, 111.3, 88.9, 52.6; IR (neat, cm^{-1}): 3120, 2958, 2222, 1539; HRMS (ESI) *m/z* calcd for $C_{17}H_{13}N_2O_2$: 277.0972 $(M + H)^+$, found: 277.0966.

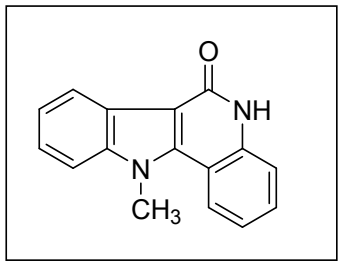


2-(1*H*-Indol-3-yl)-4*H*-benzo[*d*][1,3]oxazin-4-one (15): Pale yellow solid, 63% yield, mp 236−237 °C (lit. mp 235-236 °C)[11]. ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.14 (s, 1H), 8.44 (dd, *J* = 6.1, 3.1 Hz, 1H), 8.31 (d, *J* = 3.0 Hz, 1H), 8.13 (d, *J* = 1.2 Hz, 1H), 7.93 – 7.89 (m, 1H), 7.69 (d, *J*

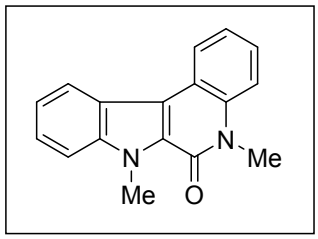
= 7.7 Hz, 1H), 7.56 – 7.50 (m, 2H), 7.31 – 7.27 (m, 2H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 159.8, 156.1, 148.1, 137.4, 137.2, 132.1, 128.5, 127.4, 126.7, 125.4, 123.4, 122.0, 121.7, 116.7, 113.0, 106.9; IR (neat, cm^{-1}) 3414, 1746, 1539; HRMS (ESI) *m/z* calcd for $C_{16}H_{11}N_2O_2$: 263.0815 (M + H)$^+$, found: 263.0806.



***N*-((1*H*-Indol-3-yl)methyl)aniline**[12] **(16):** Brown liquid, 42% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.71 (d, *J* = 7.9 Hz, 1H), 7.42 (d, *J* = 8.2 Hz, 1H), 7.27 – 7.16 (m, 5H), 6.79 – 6.73 (m, 3H), 4.52 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.6, 136.4, 129.3, 126.7, 122.7, 122.4, 119.8, 119.0, 117.4, 114.0, 112.9, 111.3, 40.1; IR (neat, cm^{-1}) 2943, 1519, 1022.



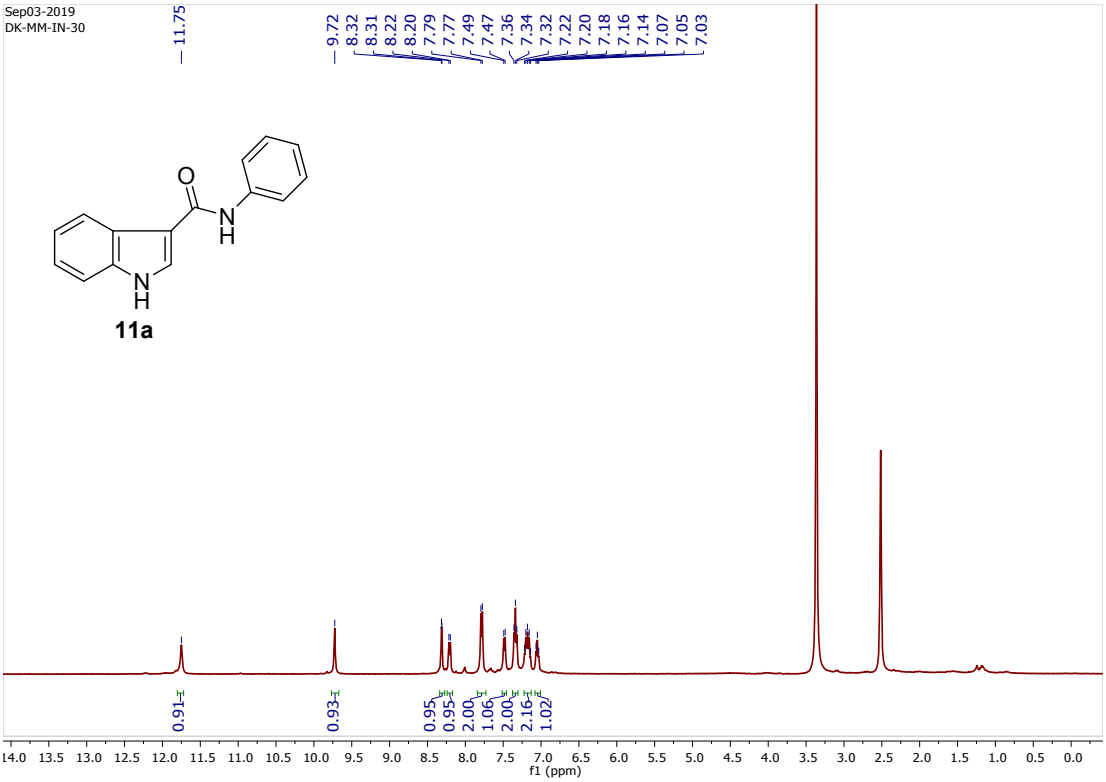
11-Methyl-5,11-dihydro-6*H*-indolo[3,2-*c*]quinolin-6-one (17): Pale yellow solid, 72% yield, mp 312−313 °C (lit. mp 310-315 °C)[13]. ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.54 (s, 1H), 8.49 (d, *J* = 8.2 Hz, 1H), 8.32 (d, *J* = 7.7 Hz, 1H), 7.81 (d, *J* = 8.4 Hz, 1H), 7.55 – 7.54 (m, 2H), 7.47 – 7.43 (m, 1H), 7.34 – 7.30 (m, 2H), 4.34 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 159.9, 140.4, 139.8, 138.9, 129.3, 124.5, 123.8, 123.6, 121.9, 121.8, 121.3, 116.9, 113.0, 110.7, 107.4, 33.8; IR (neat, cm^{-1}): 3394, 1655, 1022, 825, 763.



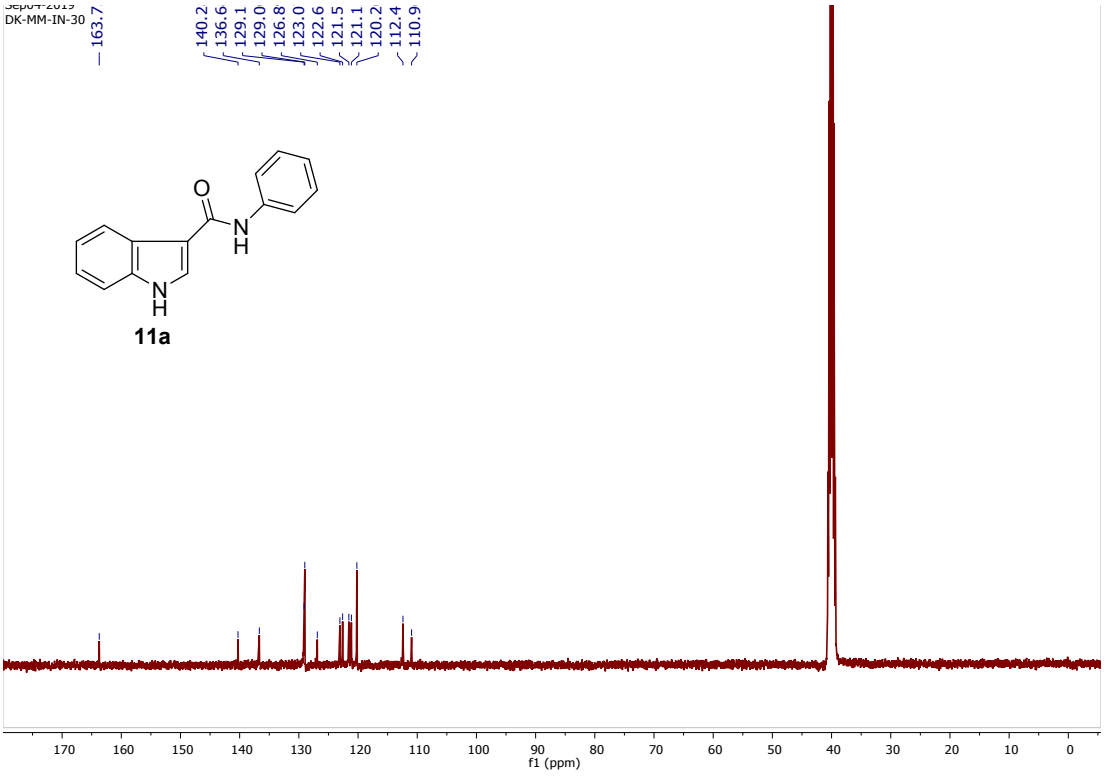
5,7-Dimethyl-5,7-dihydro-6*H*-indolo[2,3-*c*]quinolin-6-one (18): Off-white solid, 65% yield, mp 231−232 °C (lit. mp 234 °C)[14]. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.56 (d, *J* = 7.3 Hz, 2H), 7.77 (d, *J* = 8.4 Hz, 1H), 7.66 (d, *J* = 8.5 Hz, 1H), 7.60 − 7.52 (m, 2H), 7.45 − 7.37 (m, 2H), 4.34 (s, 3H), 3.80 (s, 3H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 156.4, 140.7, 136.3, 127.0, 126.5, 126.1, 123.9, 123.1, 123.1, 121.7, 121.4, 119.1, 118.0, 116.0, 111.7, 31.9, 29.6; IR (neat, cm^{-1}): 3051, 1640, 1273, 728.

4. Copies of ^{1}H &^{13}C NMR spectra

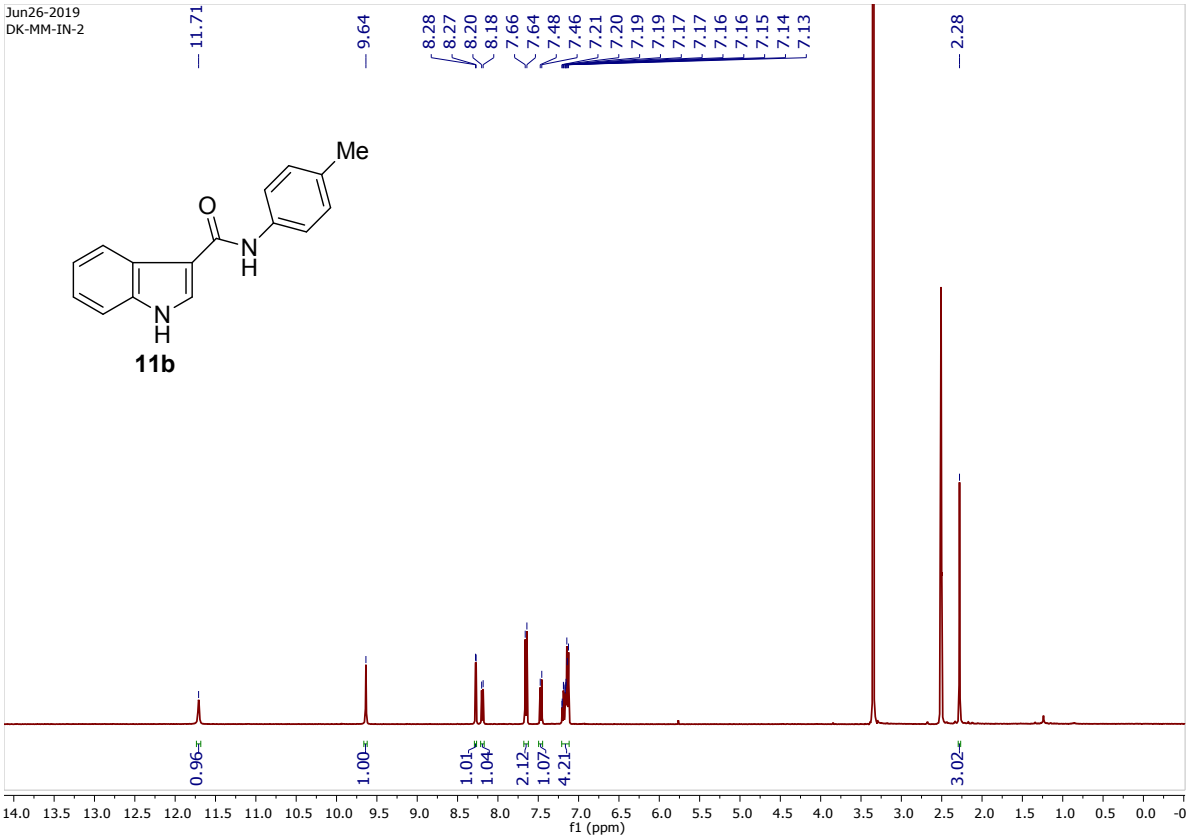
^{1}H NMR spectrum of 11a



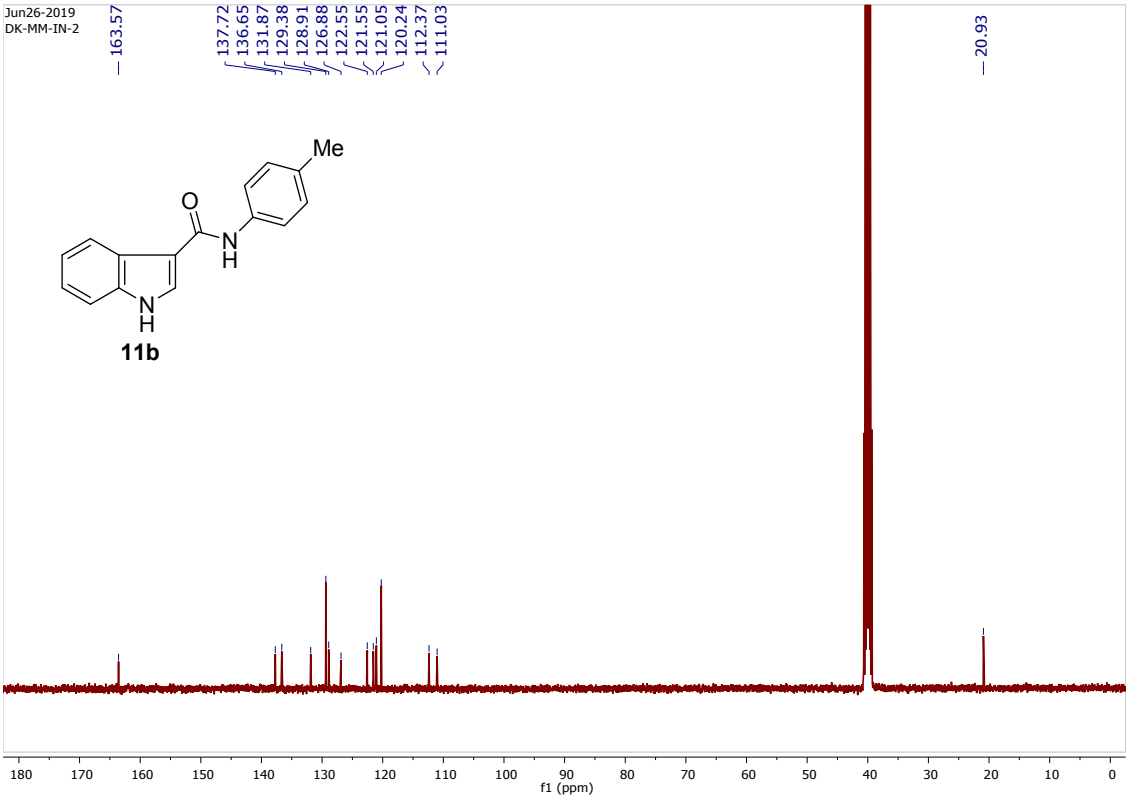
^{13}C NMR spectrum of 11a



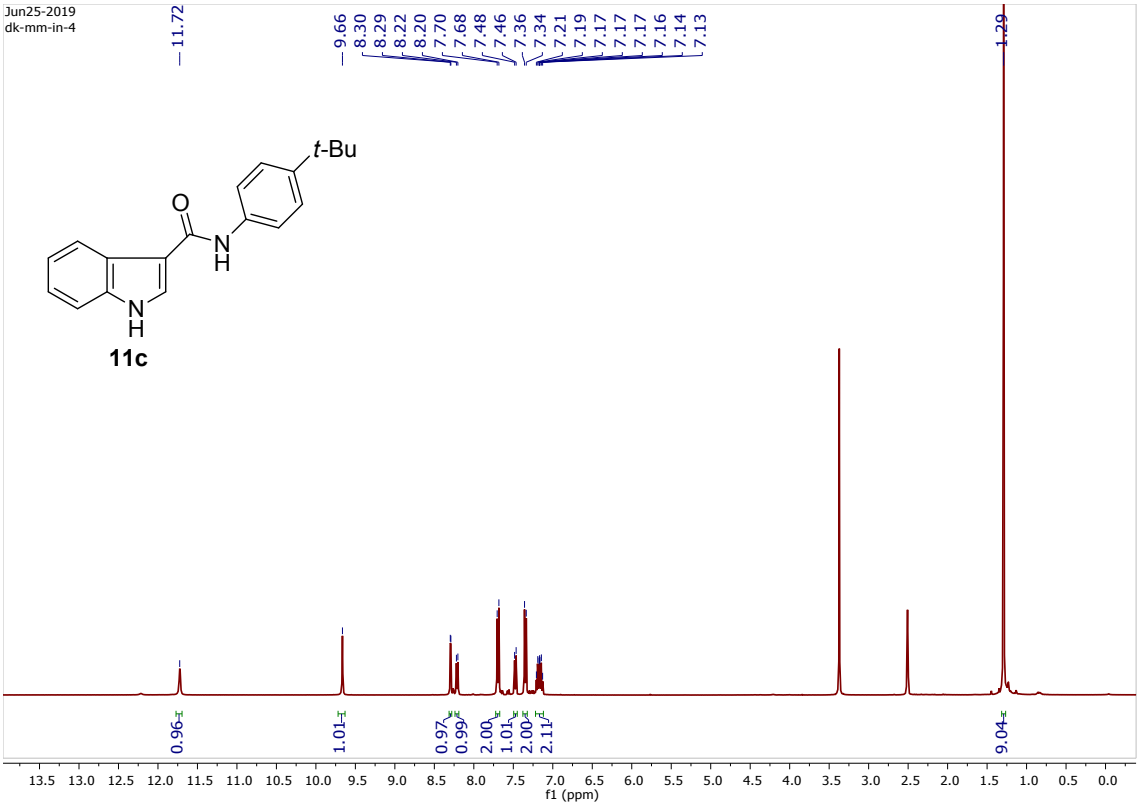
^{1}H NMR spectrum of 11b



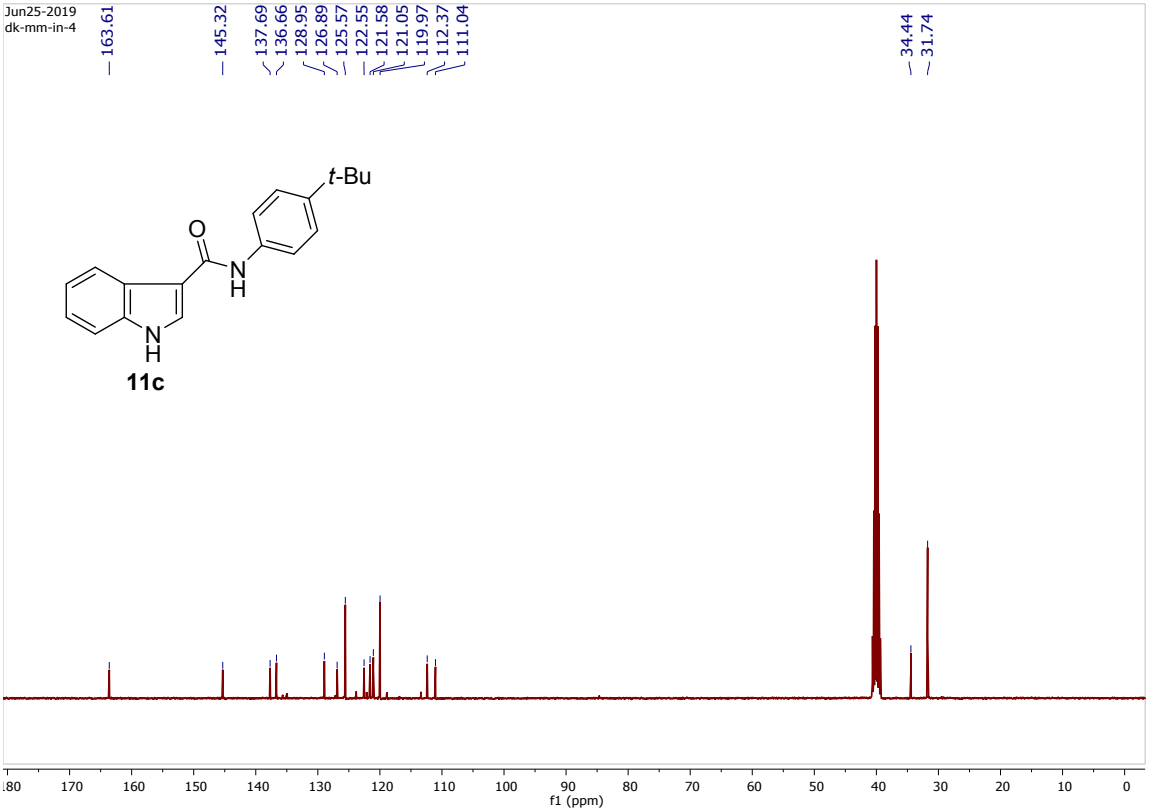
^{13}C NMR spectrum of 11b



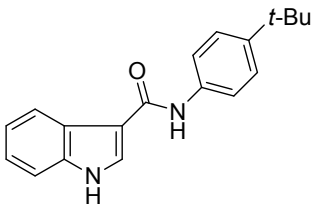
^{1}H NMR spectrum of 11c



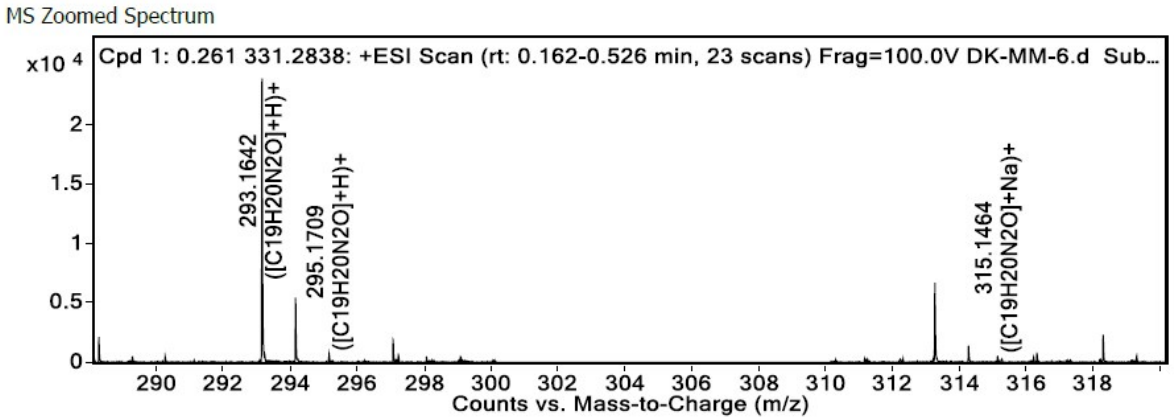
^{13}C NMR spectrum of 11c



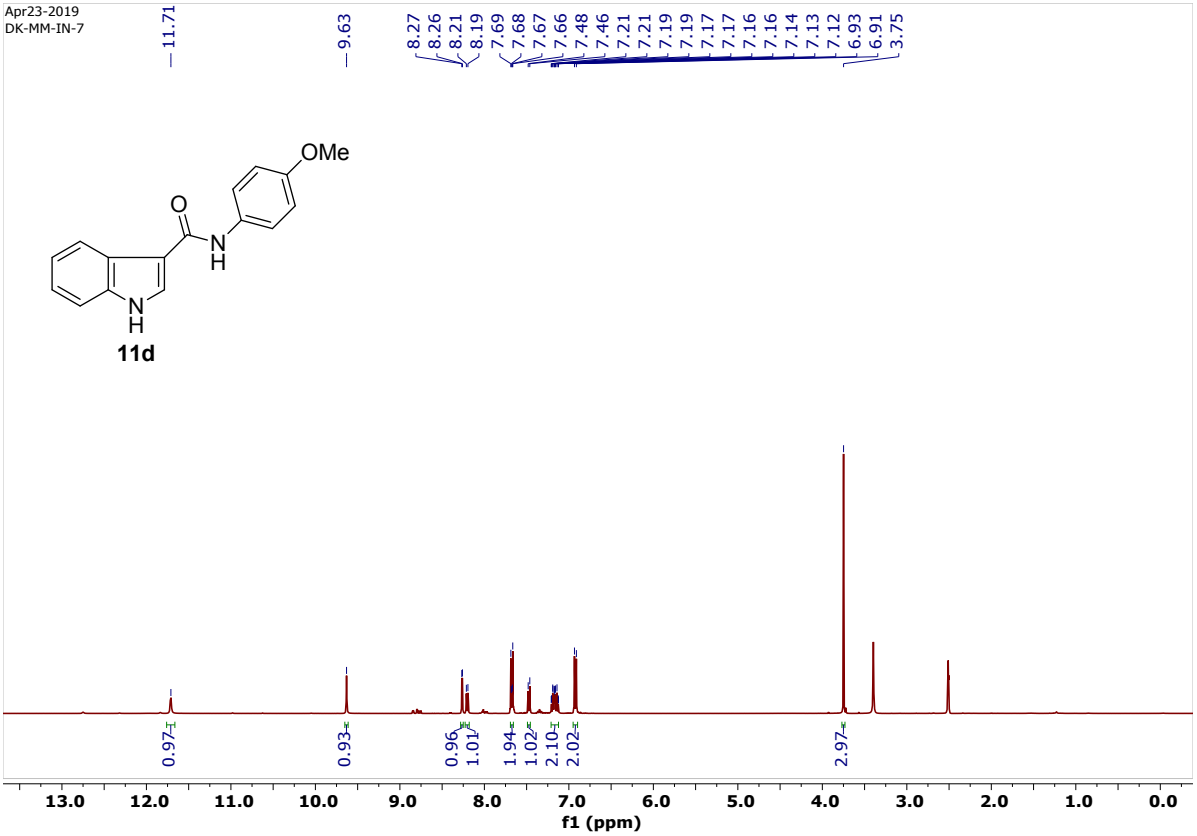
HRMS Spectrum of 11c



11c

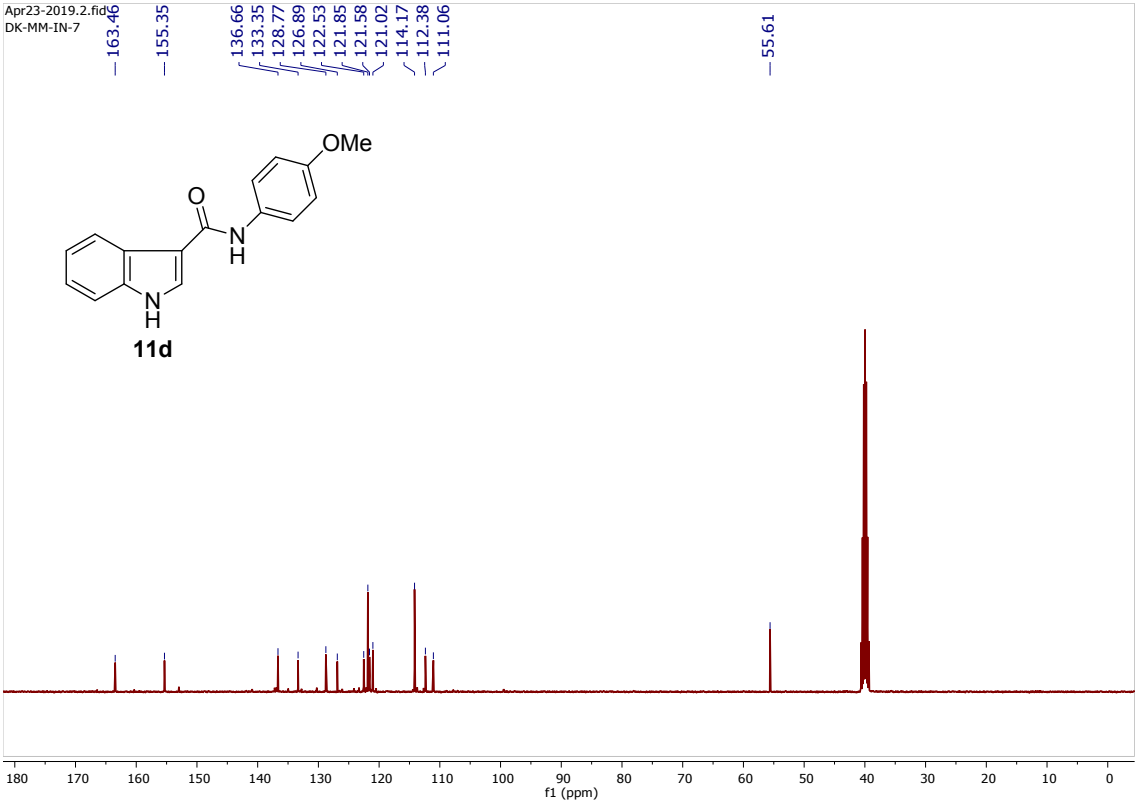


^{1}H NMR spectrum of 11d

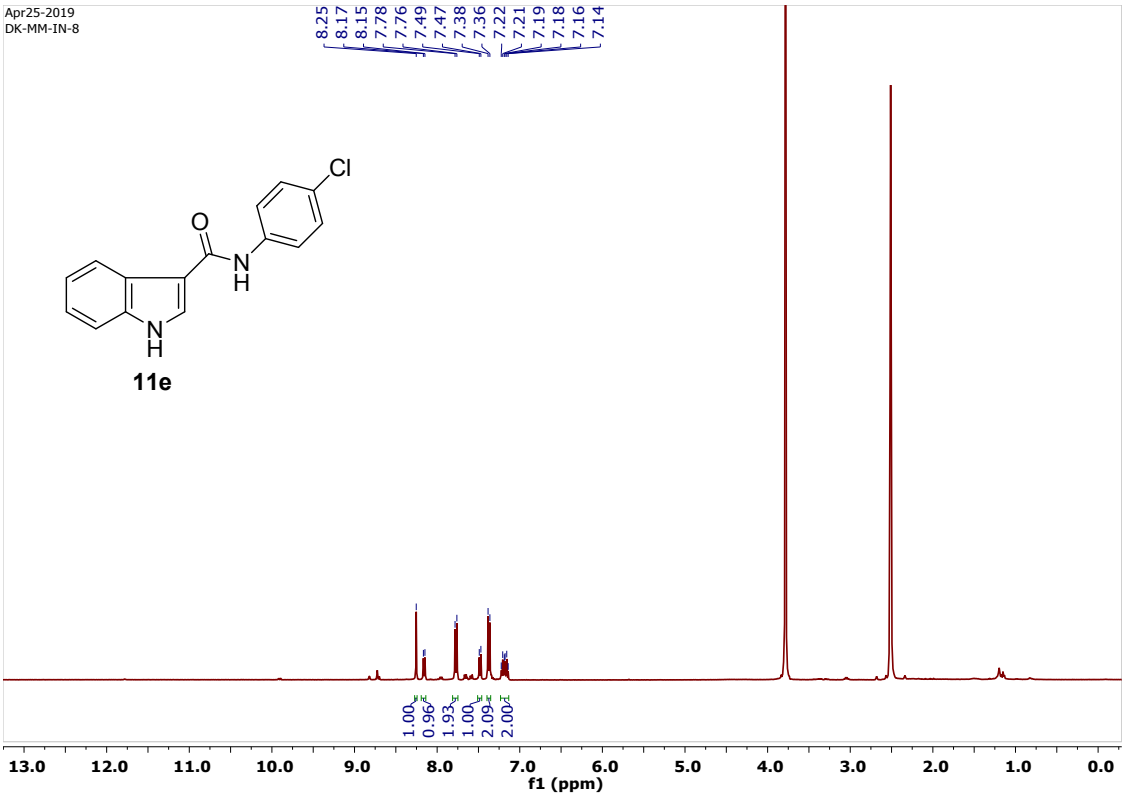


11d

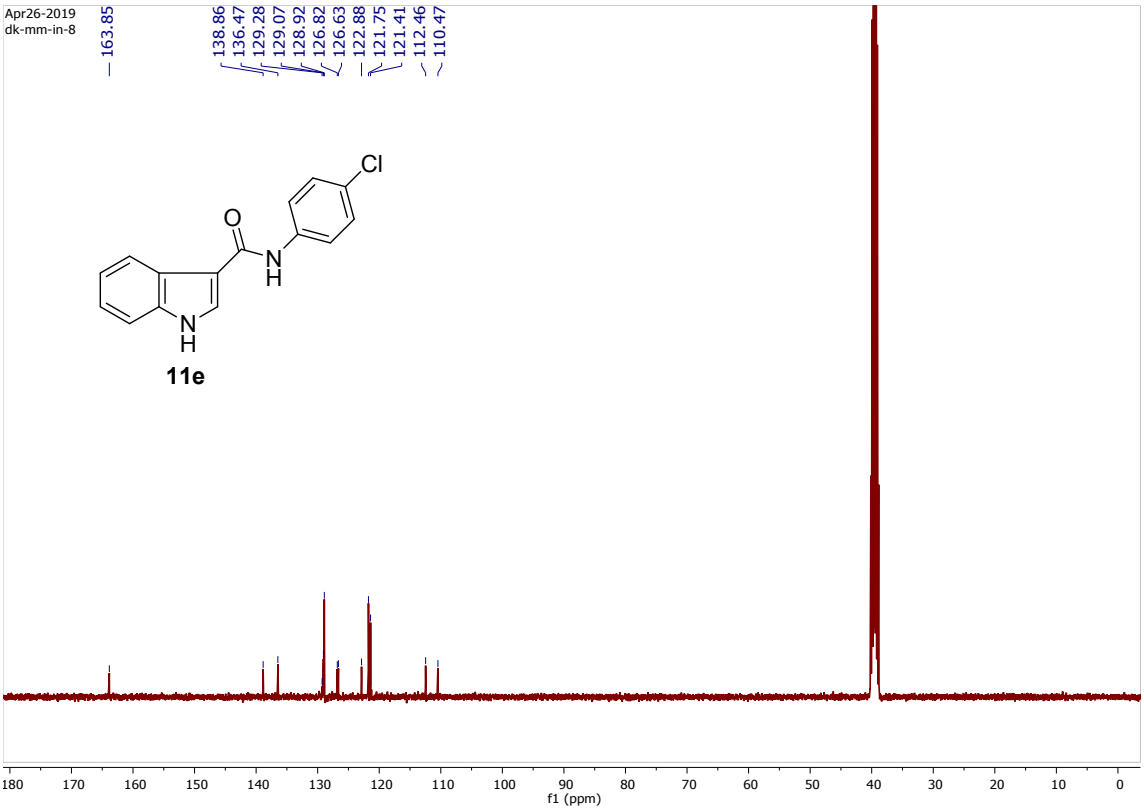
^{13}C NMR spectrum of 11d



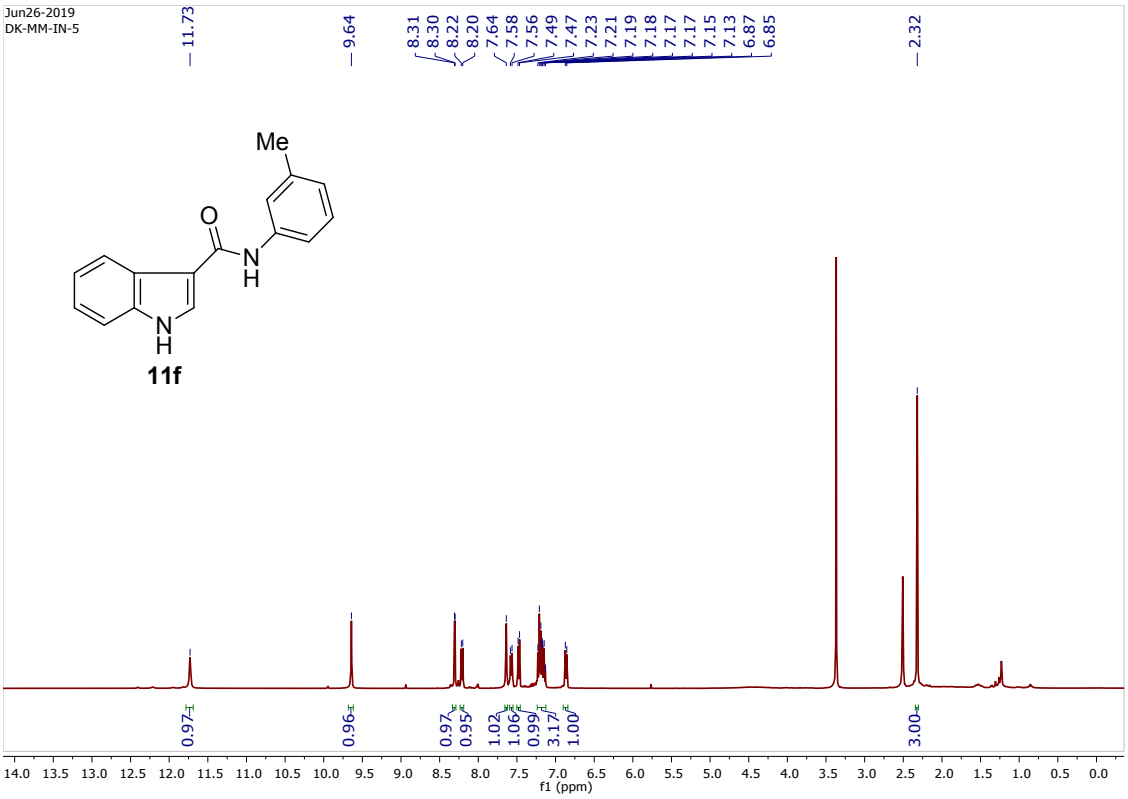
^{1}H NMR spectrum of 11e



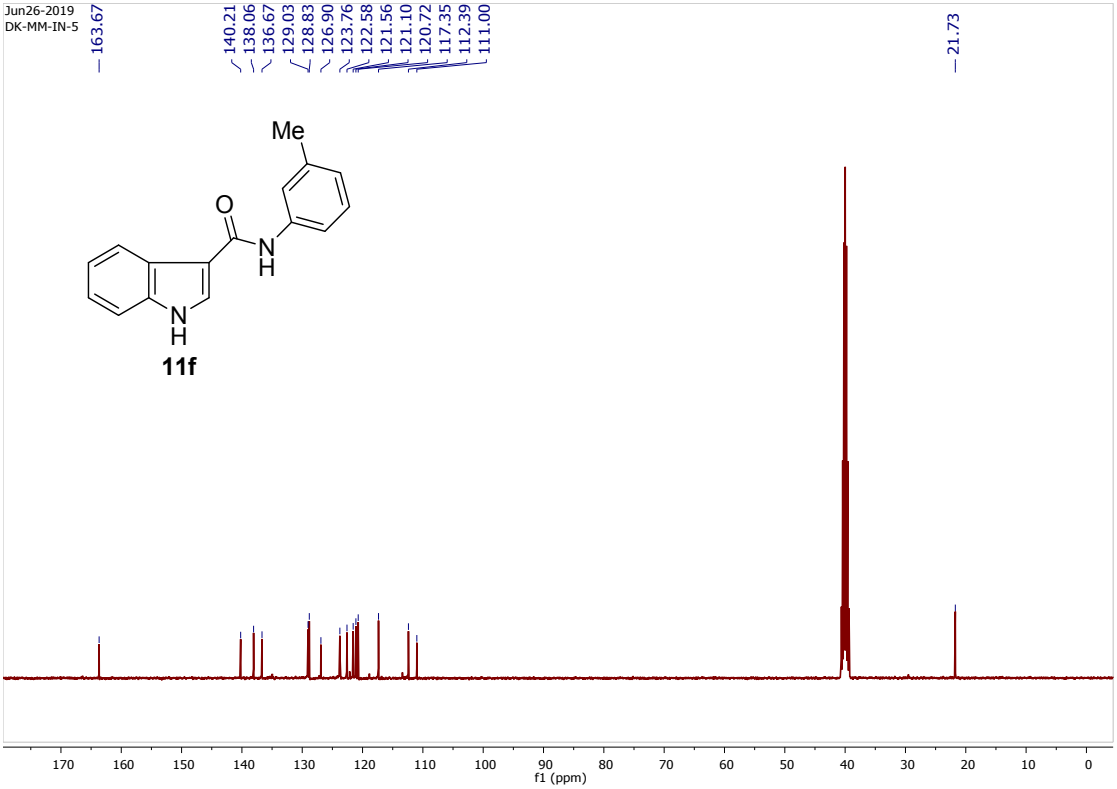
^{13}C NMR spectrum of 11e



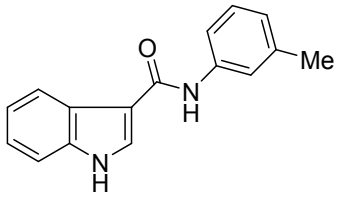
^{1}H NMR spectrum of 11f

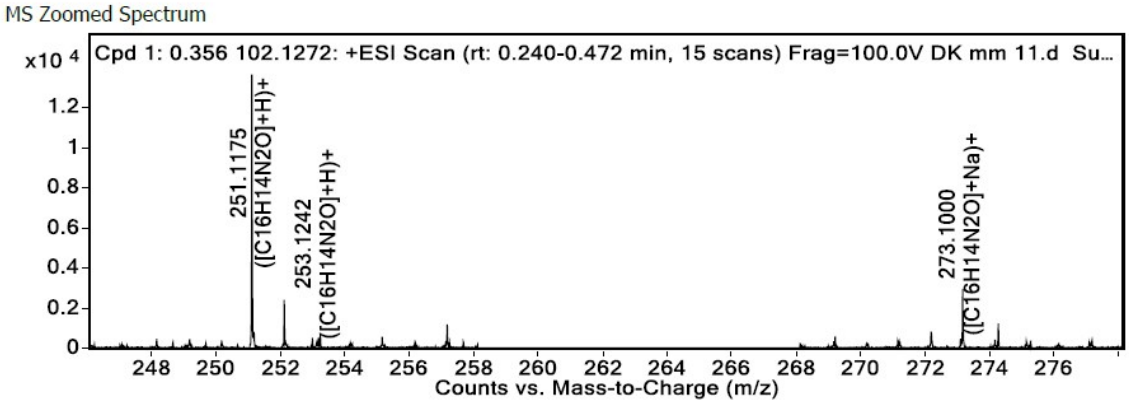


^{13}C NMR spectrum of 11f

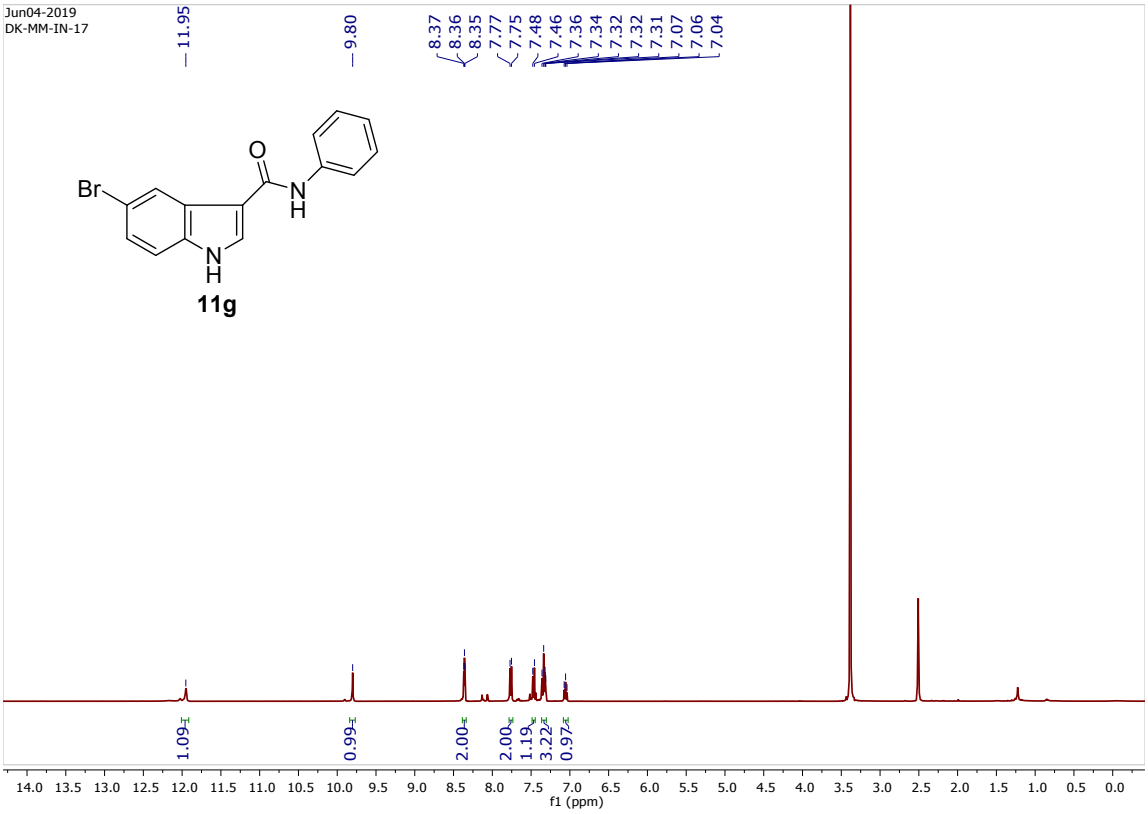


HRMS Spectrum of 11f

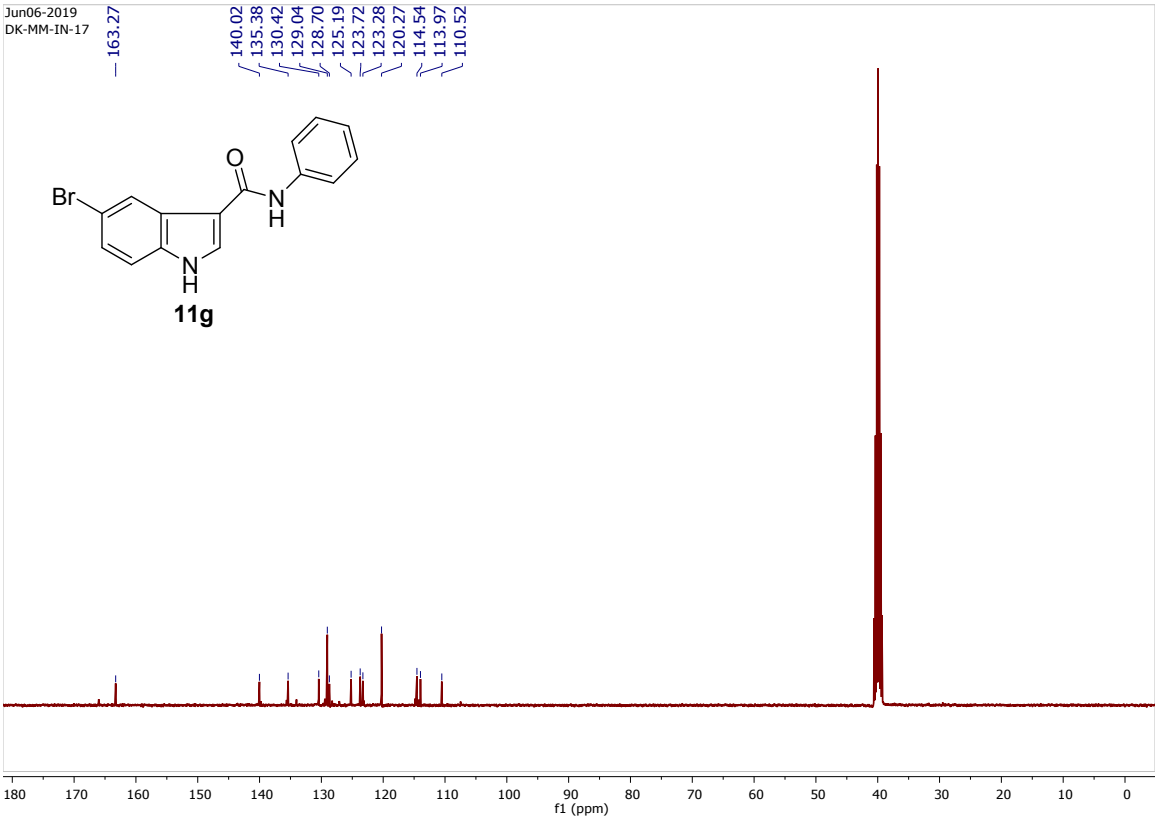




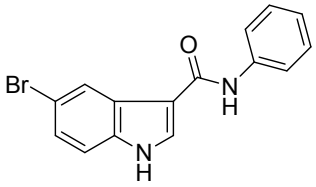
^{1}H NMR spectrum of 11g



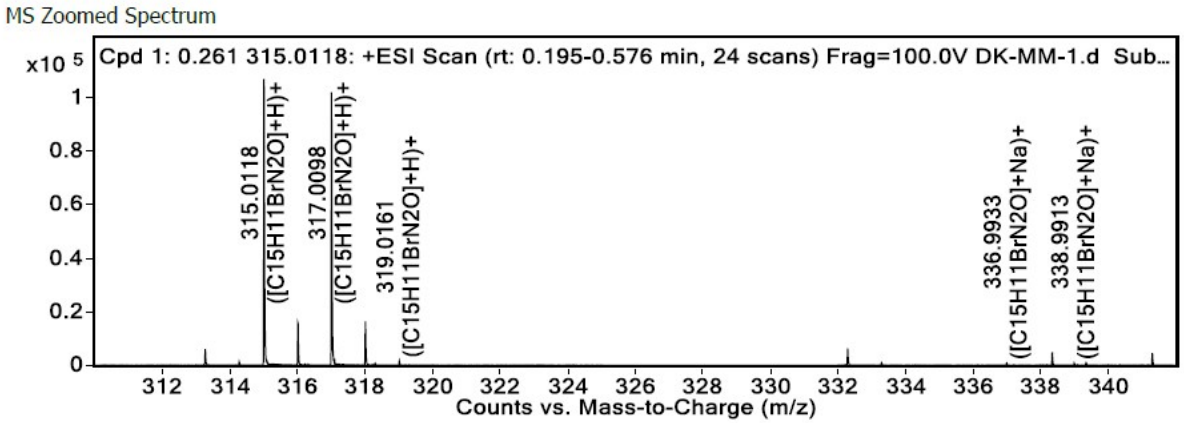
^{13}C NMR spectrum of 11g



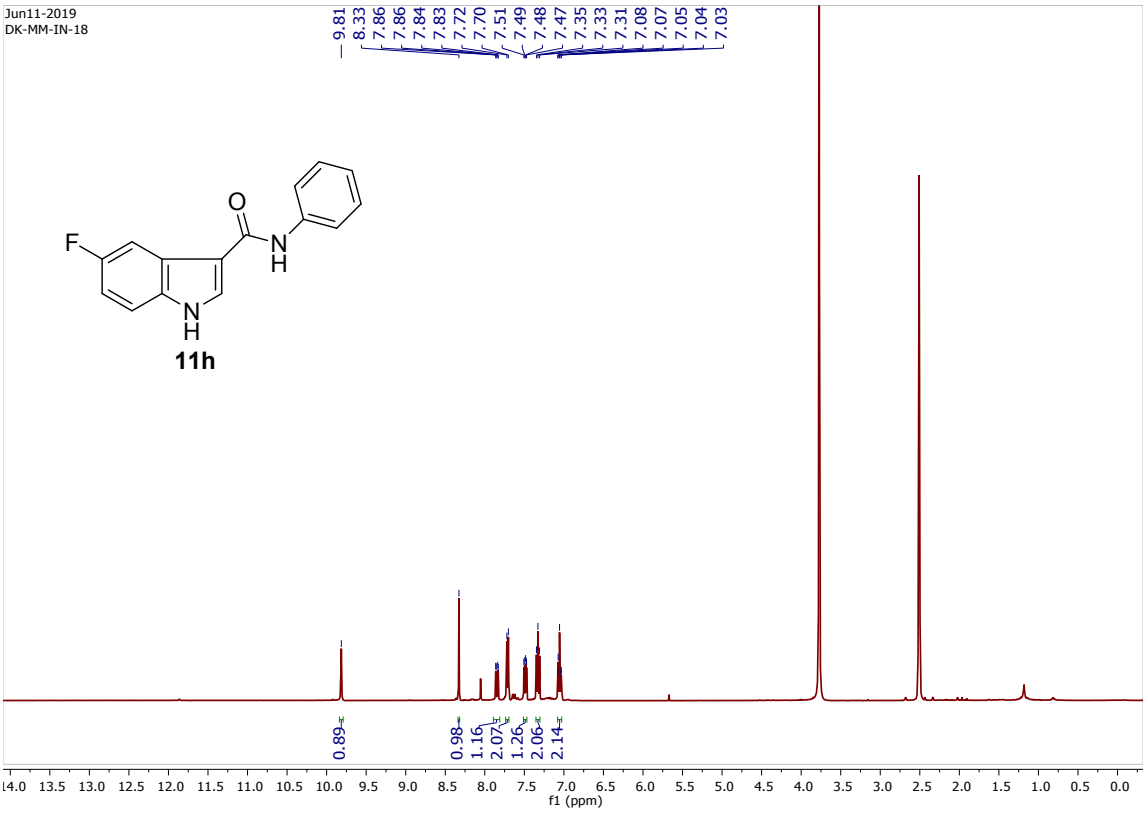
HRMS Spectrum of 11g



11g

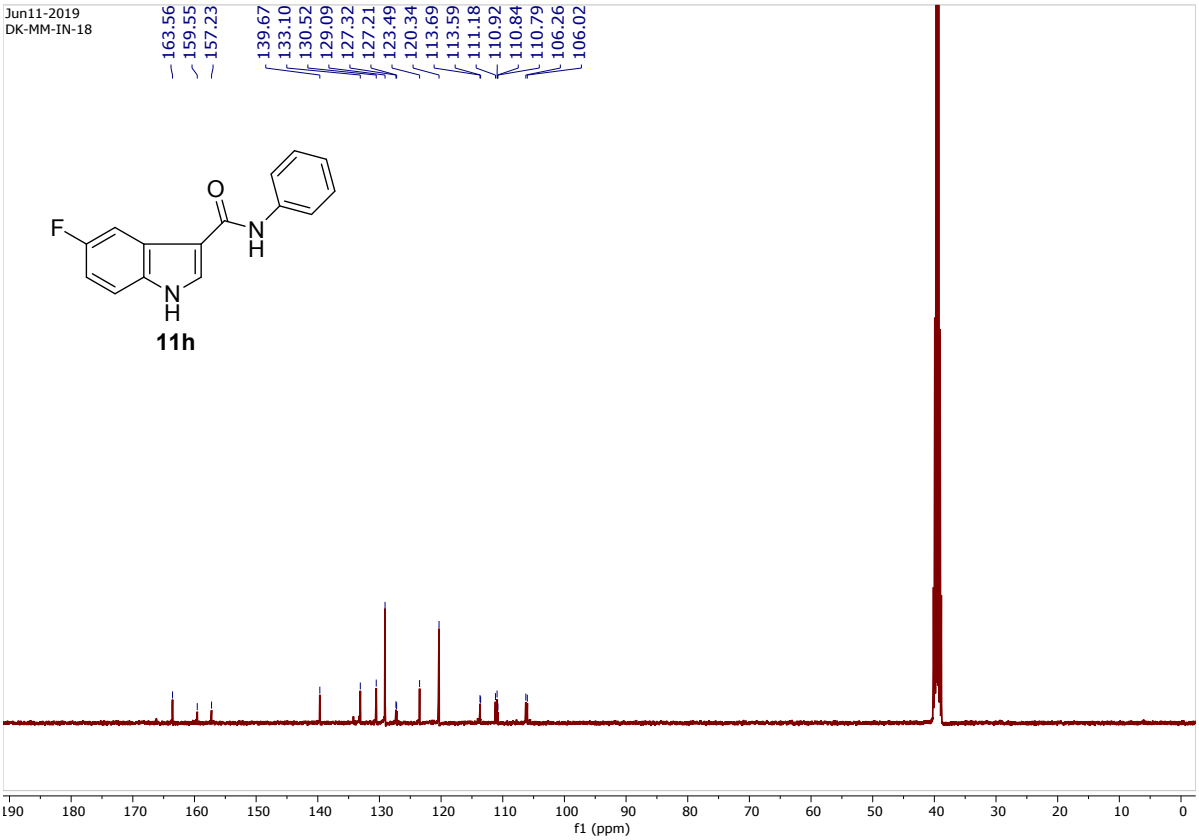


^{1}H NMR spectrum of 11h

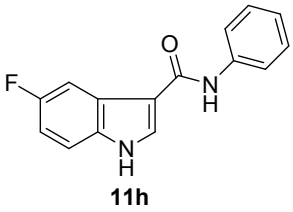


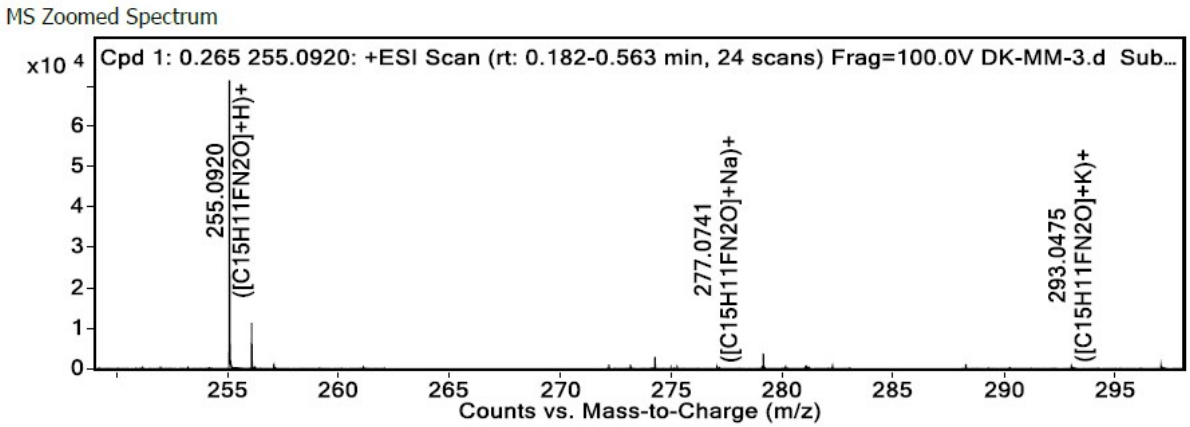
11h

^{13}C NMR spectrum of 11h

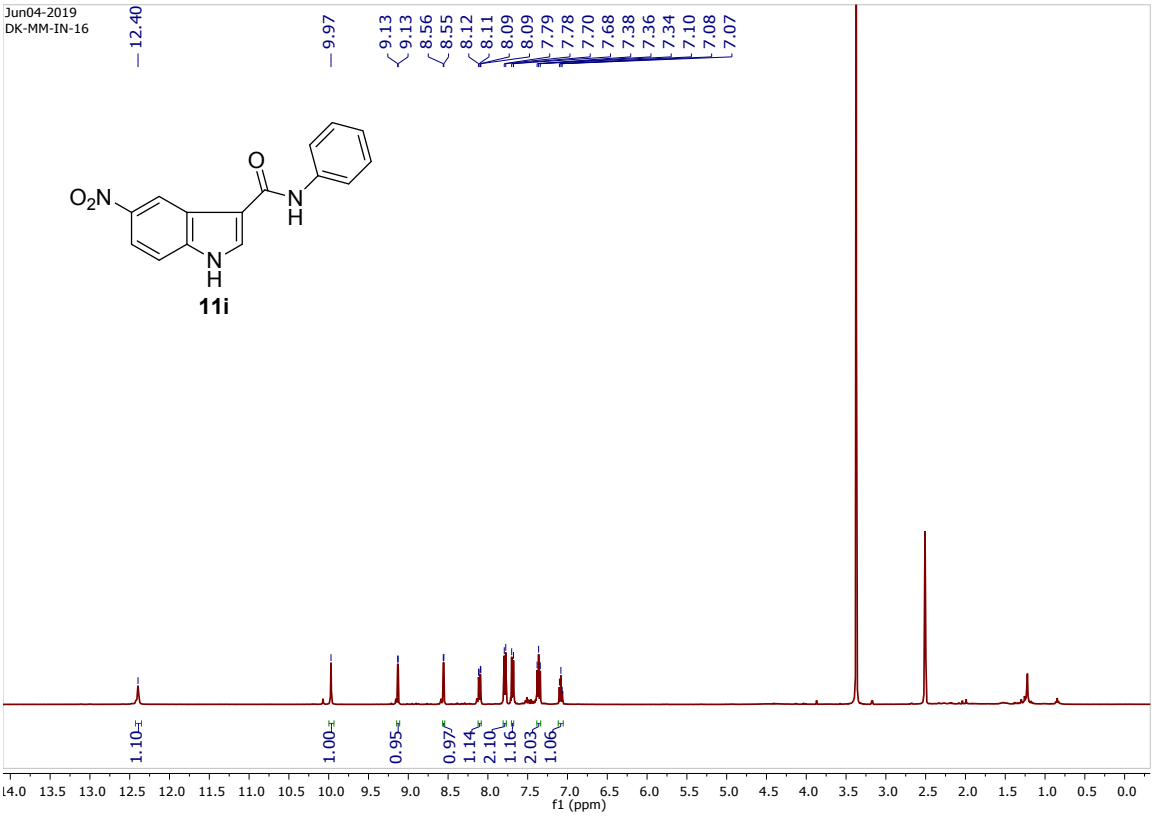


HRMS Spectrum of 11h

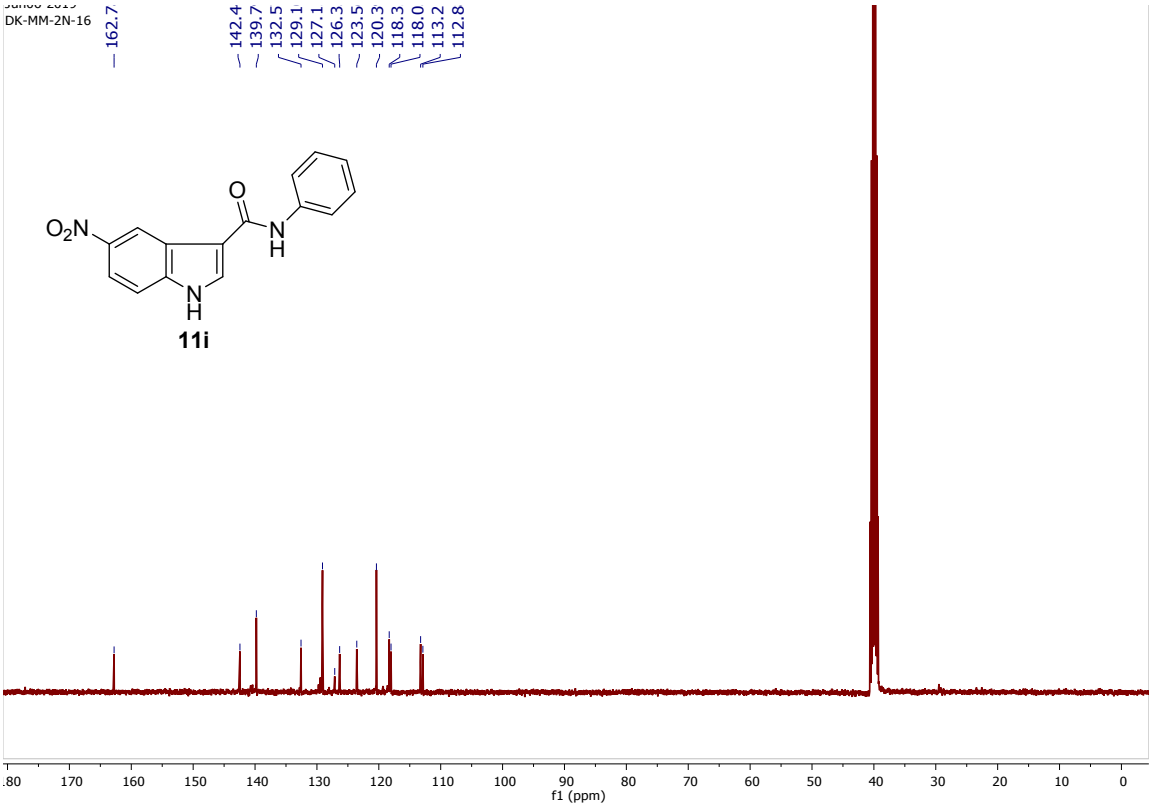




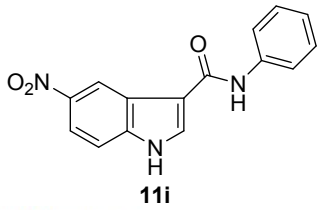
^{1}H NMR spectrum of 11i



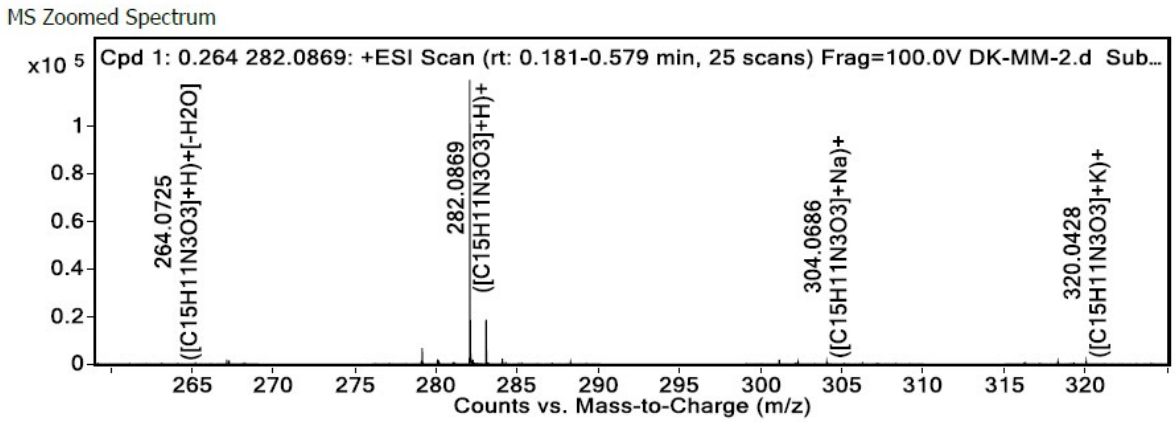
^{13}C NMR spectrum of 11i



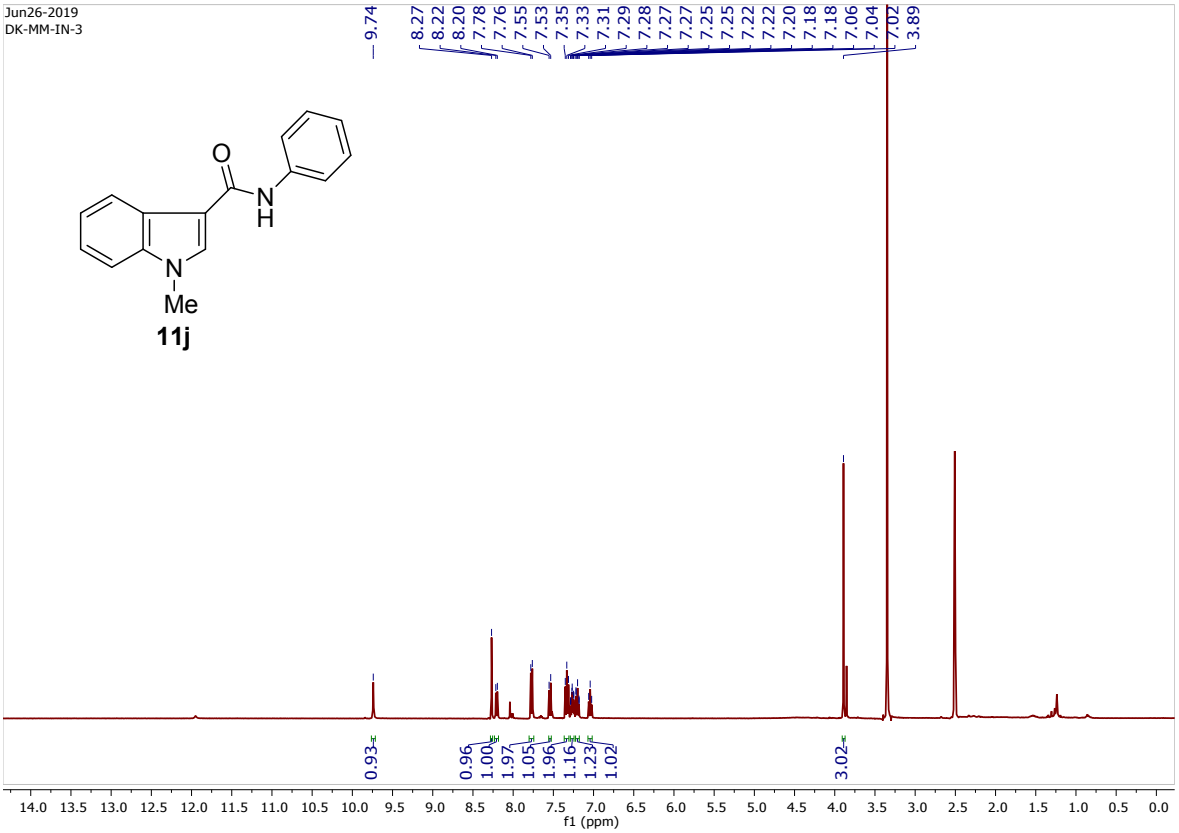
HRMS Spectrum of 11i



11i

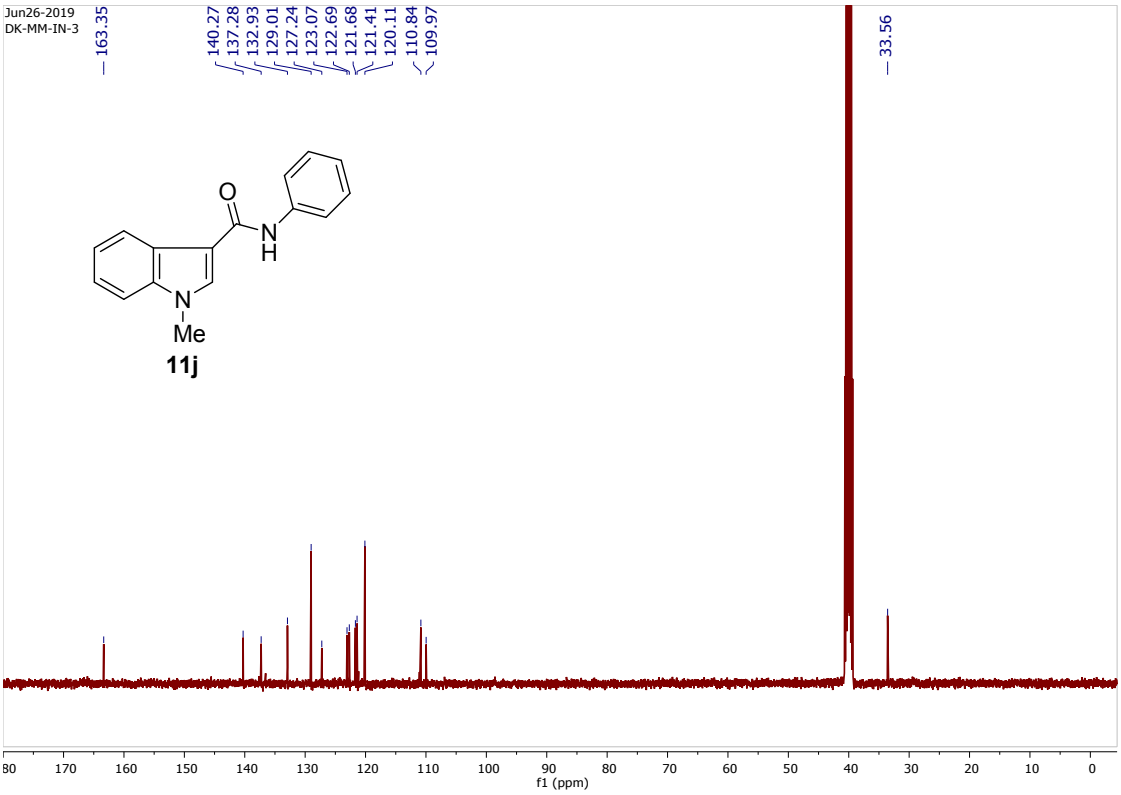


^{1}H NMR spectrum of 11j

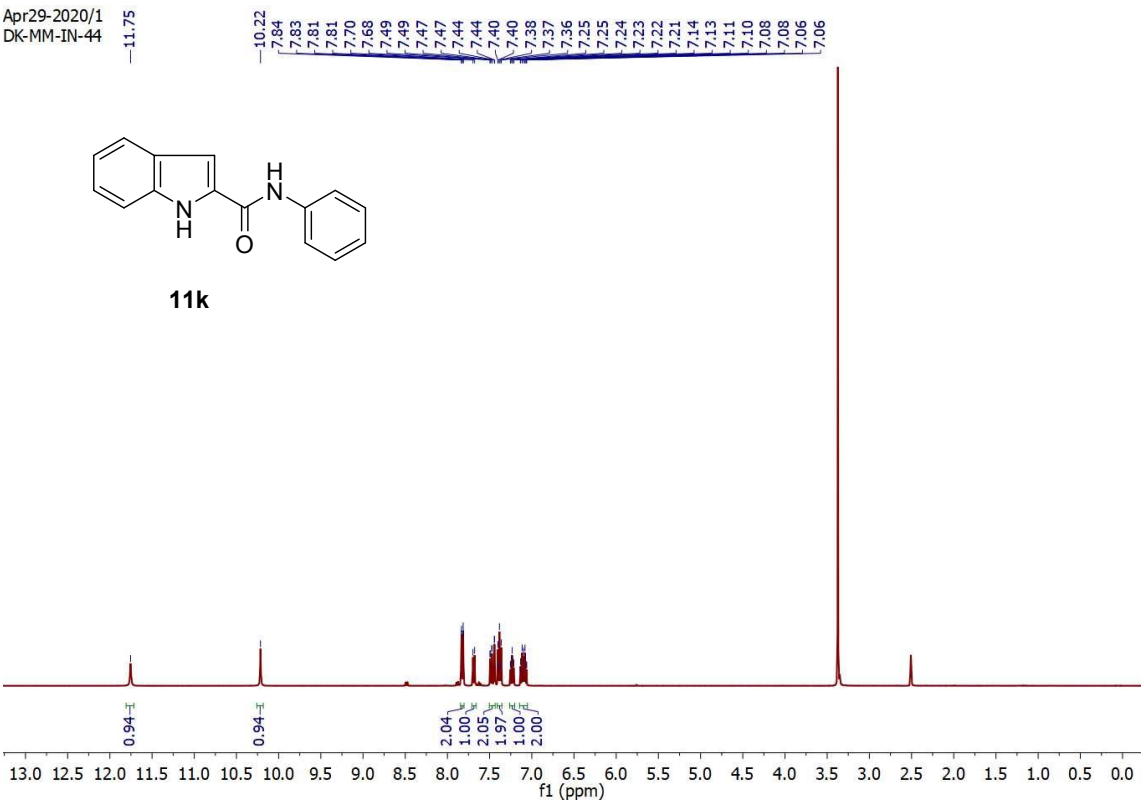


11j

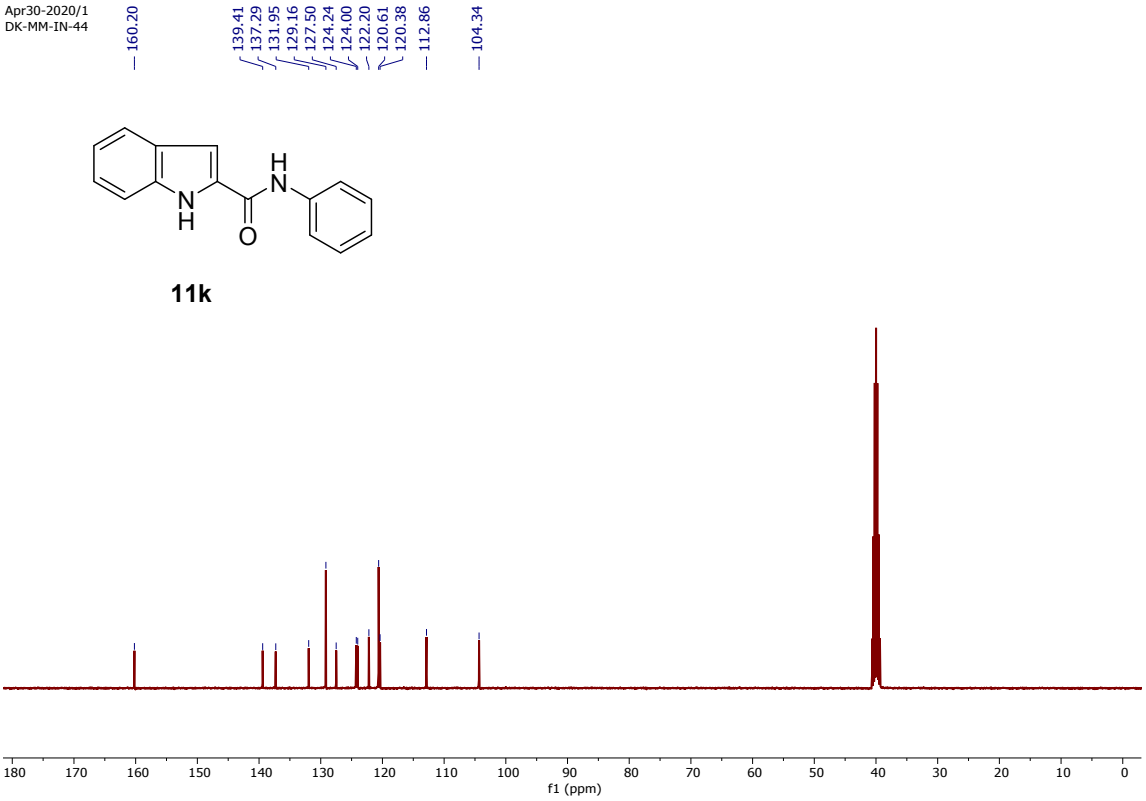
^{13}C NMR spectrum of 11j



^{1}H NMR spectrum of 11k

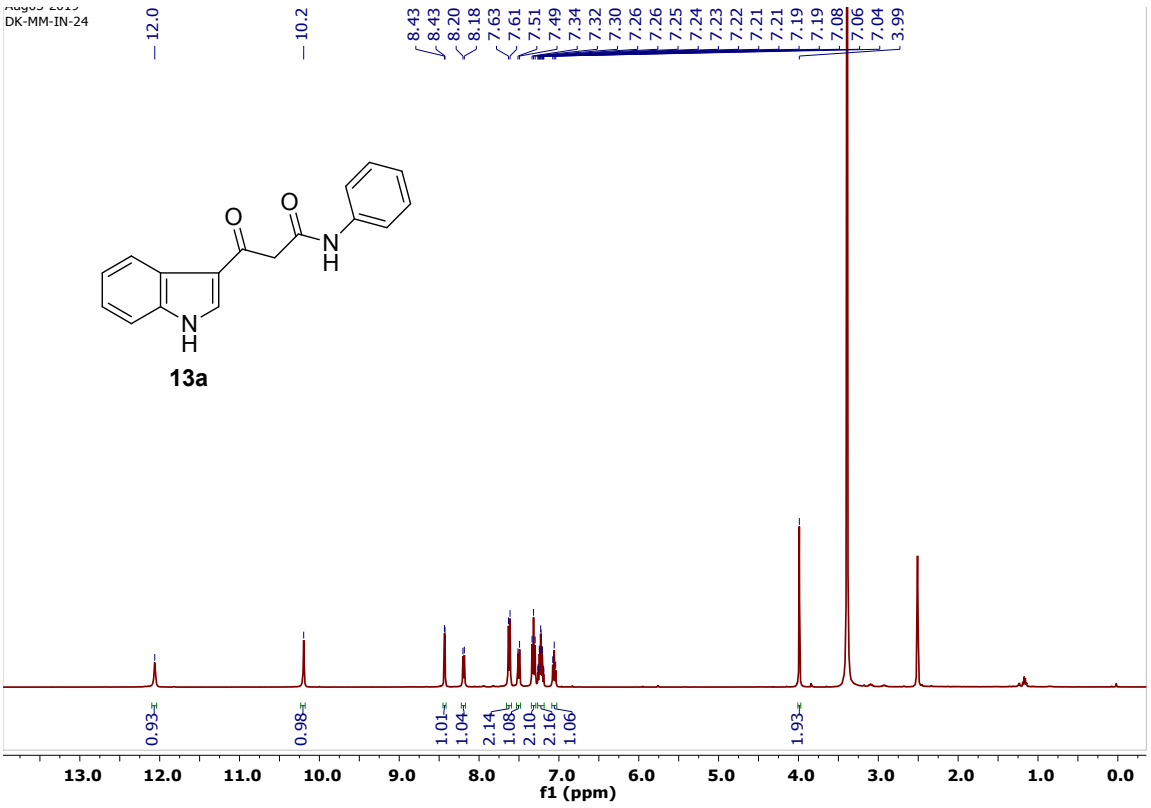


^{13}C NMR spectrum of 11k

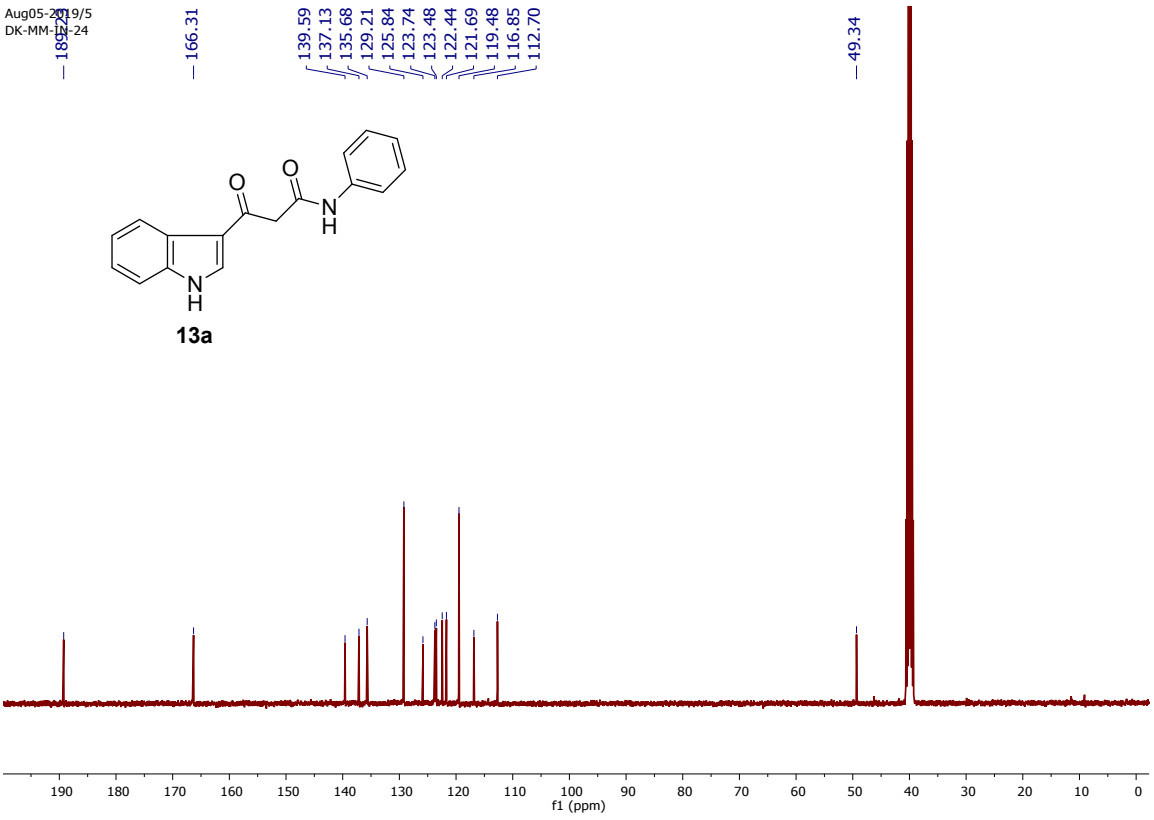


11k

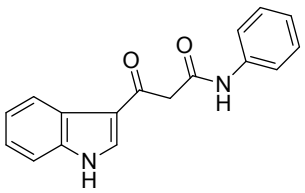
^{1}H NMR spectrum of 13a



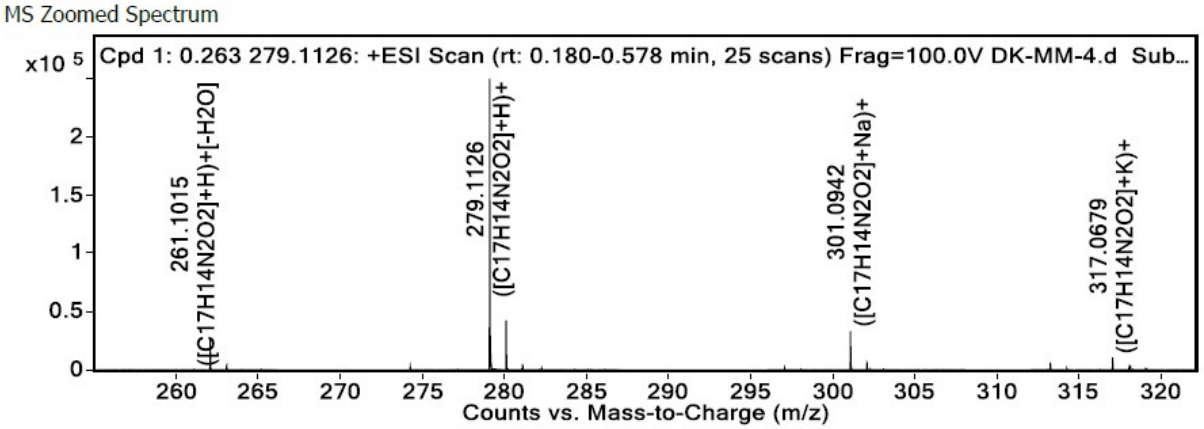
^{13}C NMR spectrum of 13a



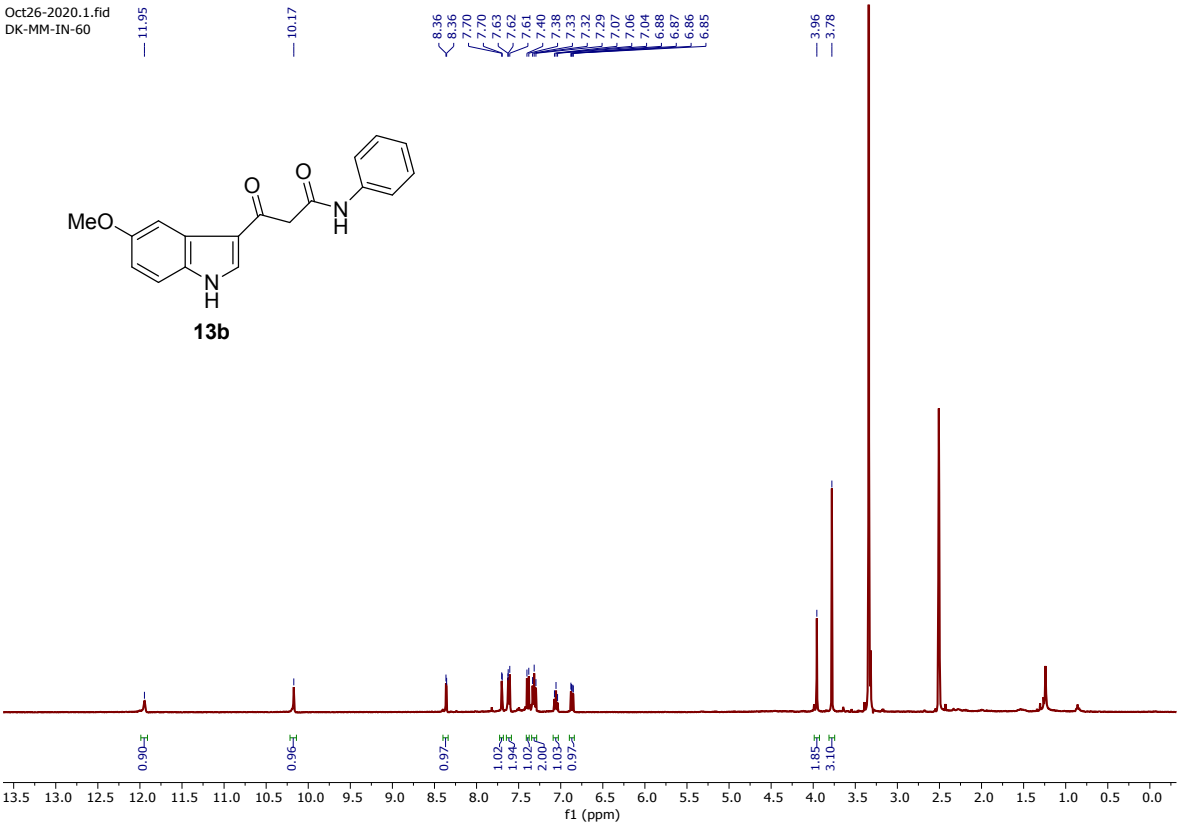
HRMS Spectrum of 13a



13a

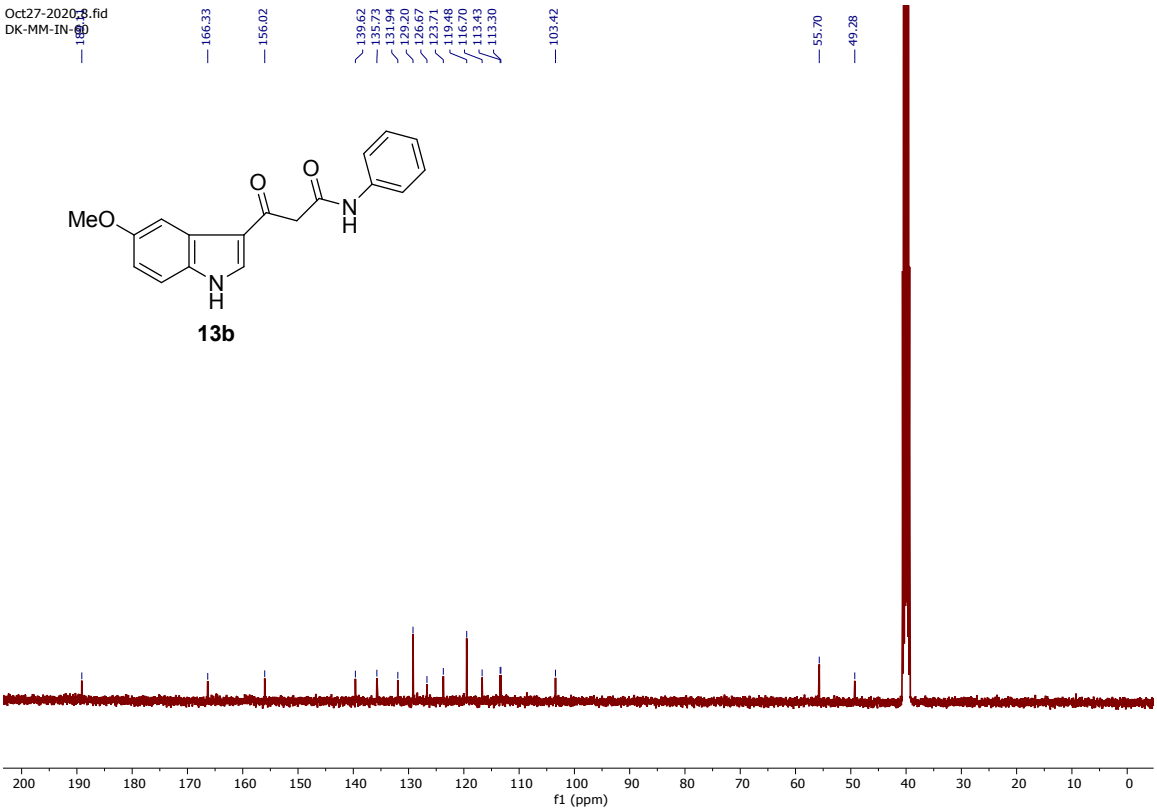


^{1}H NMR spectrum of 13b

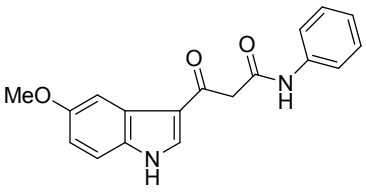


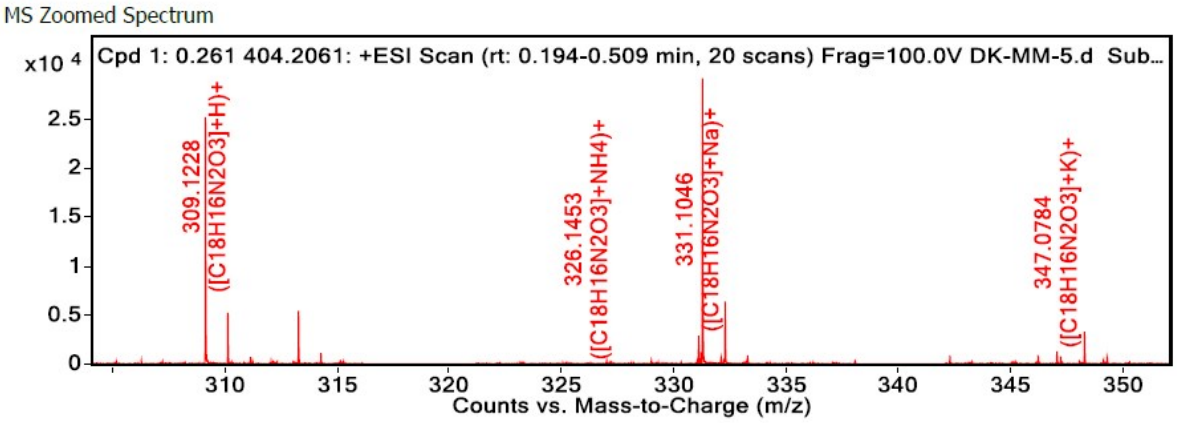
13b

^{13}C NMR spectrum of 13b

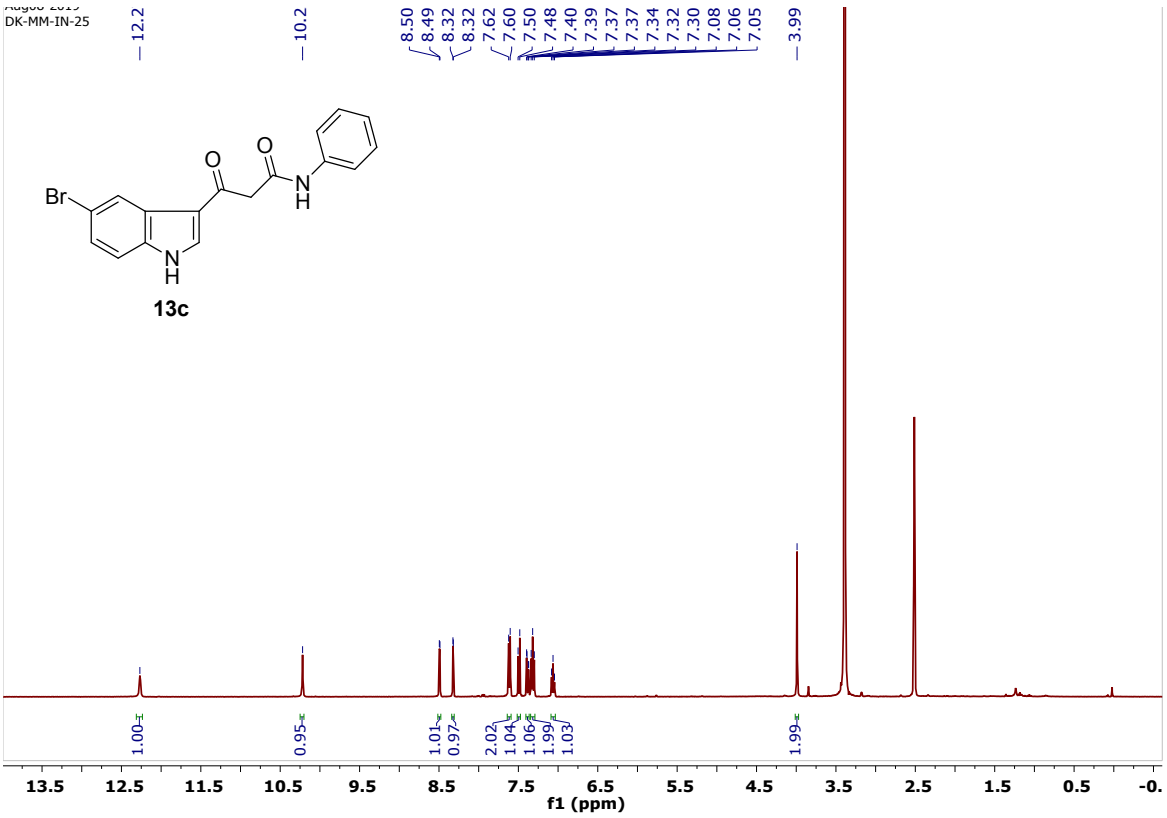


HRMS Spectrum of 13b

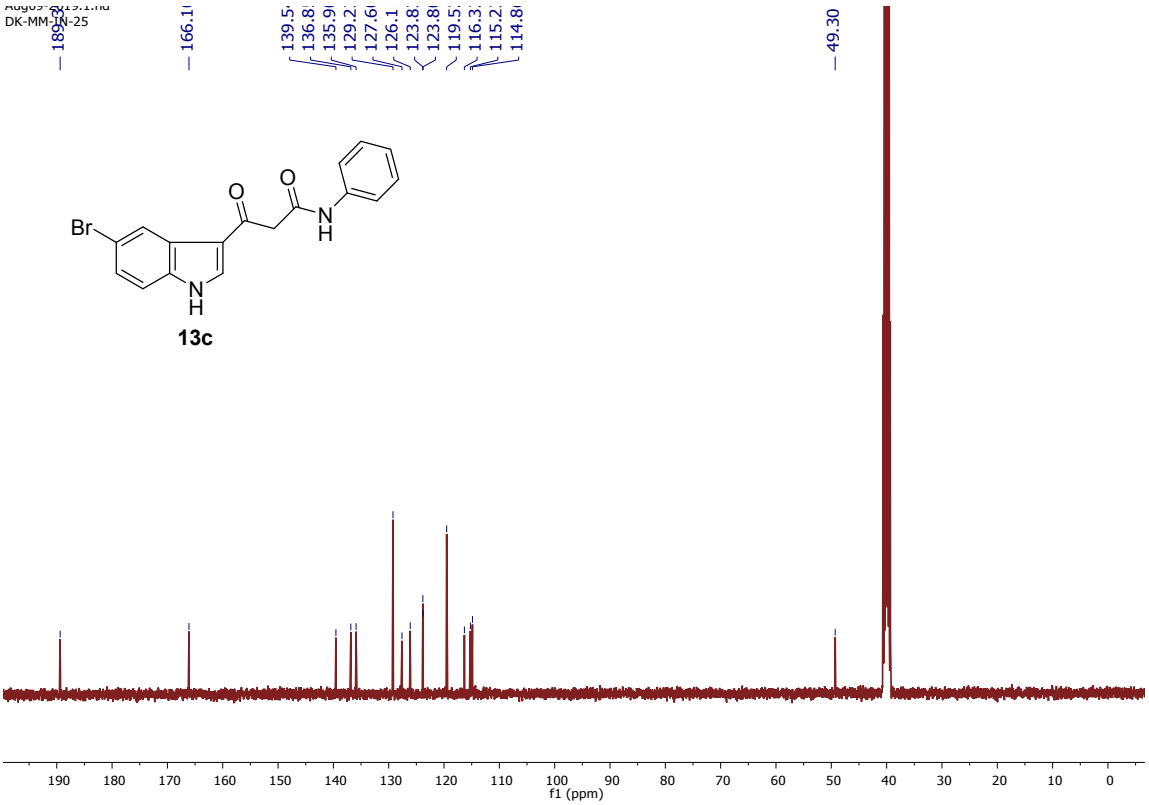




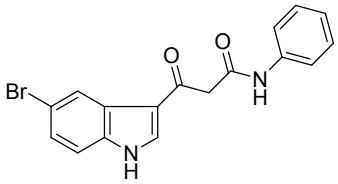
^{1}H NMR spectrum of 13c



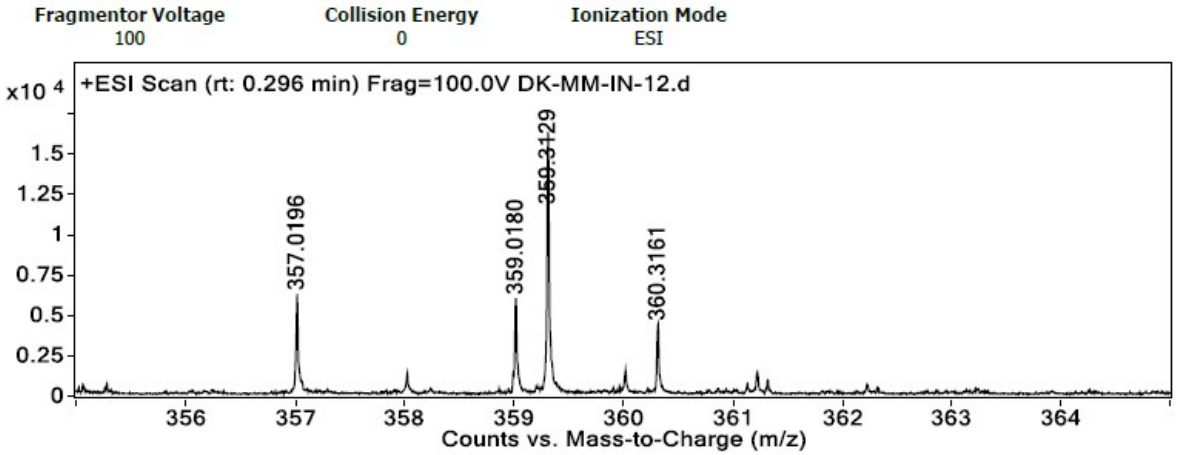
^{13}C NMR spectrum of 13c



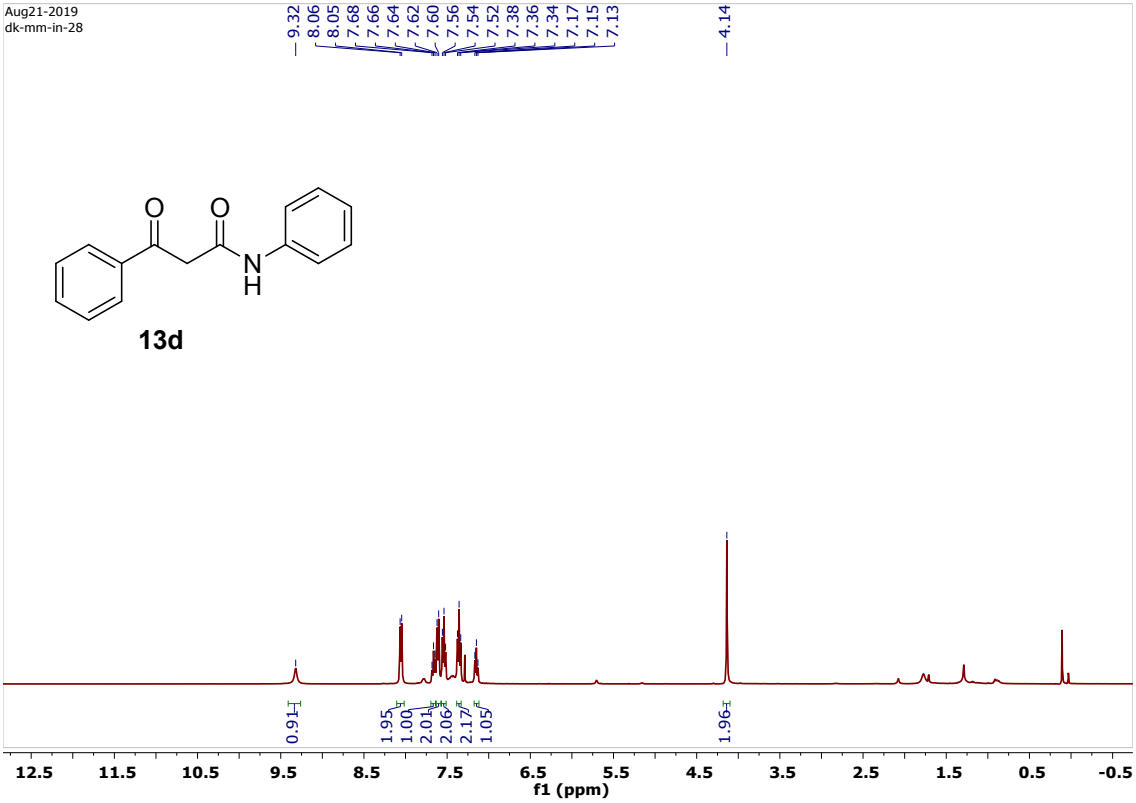
HRMS Spectrum of 13c



13c

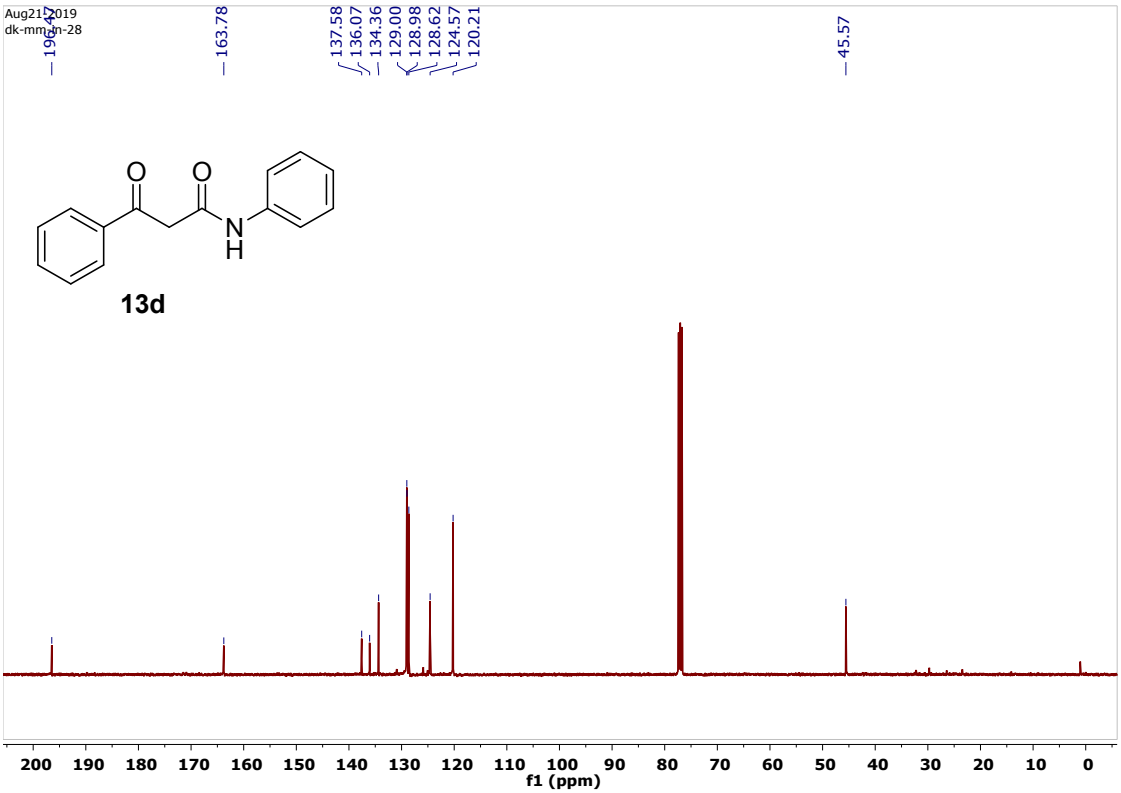


^{1}H NMR spectrum of 13d

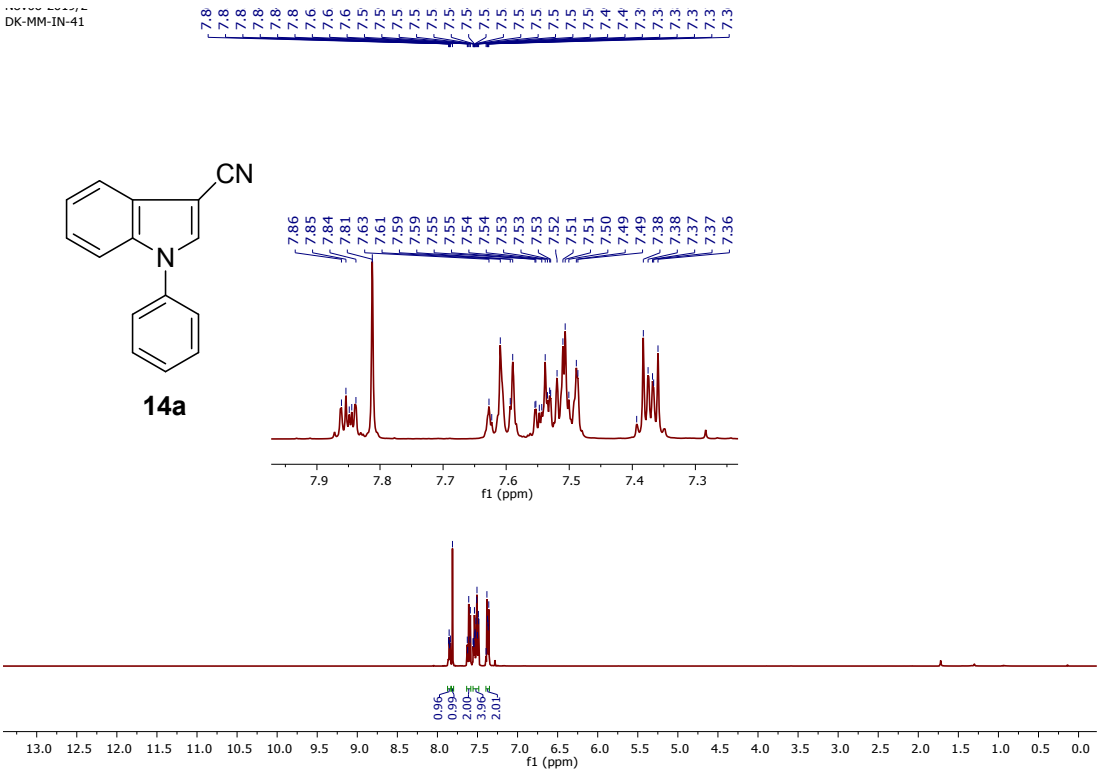


13d

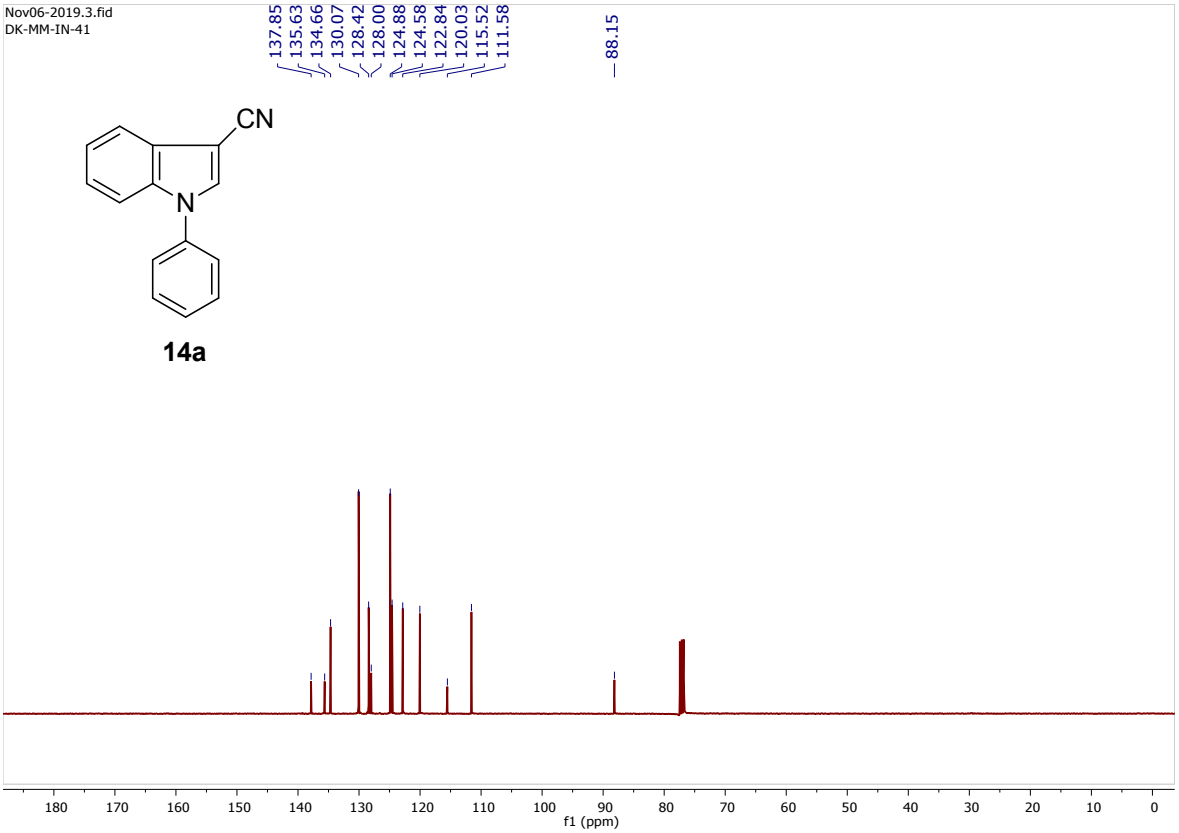
^{13}C NMR spectrum of 13d



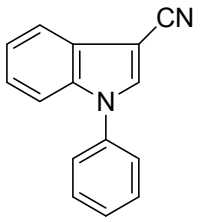
^{1}H NMR spectrum of 14a



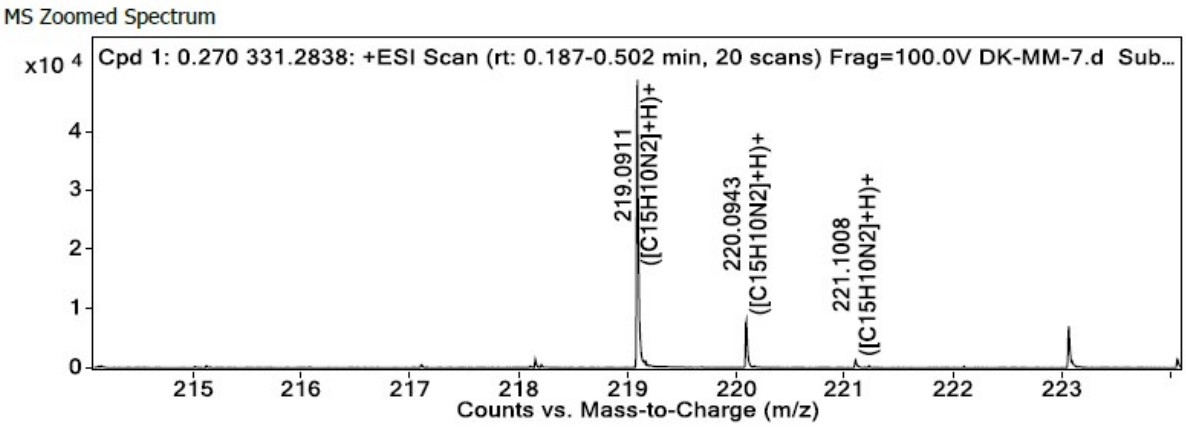
^{13}C NMR spectrum of 14a



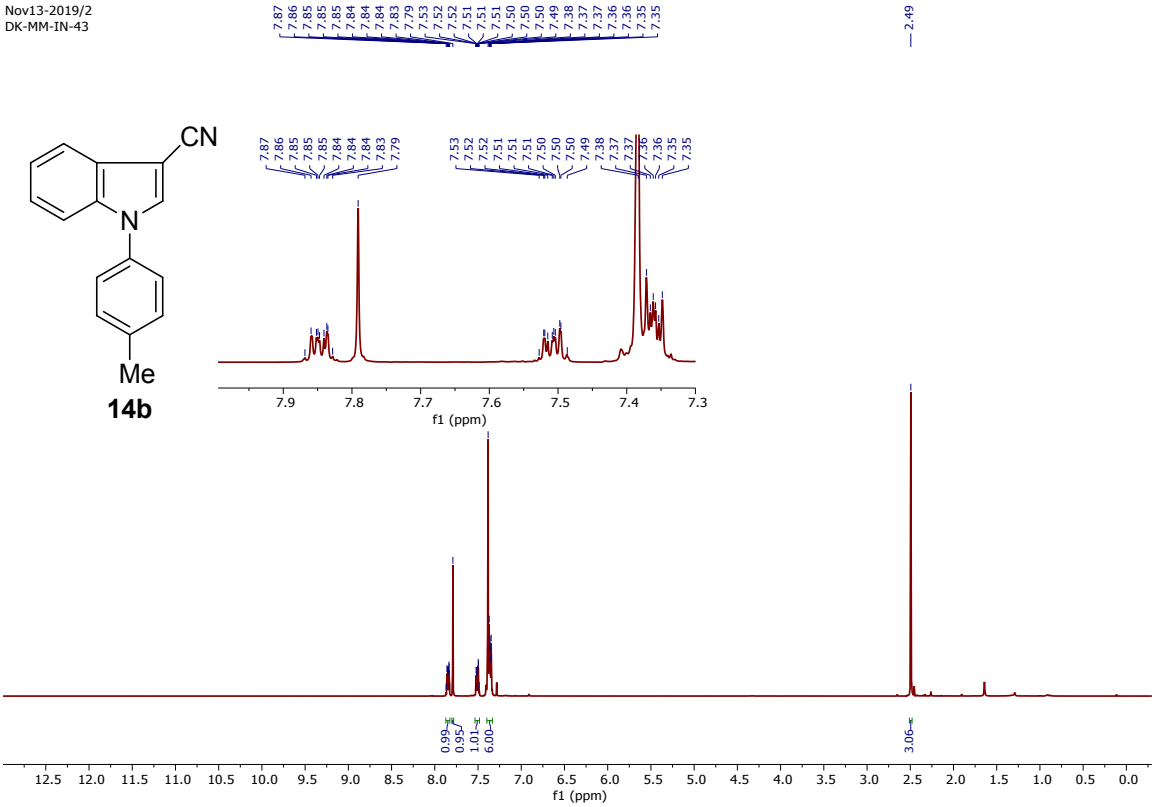
HRMS Spectrum of 14a



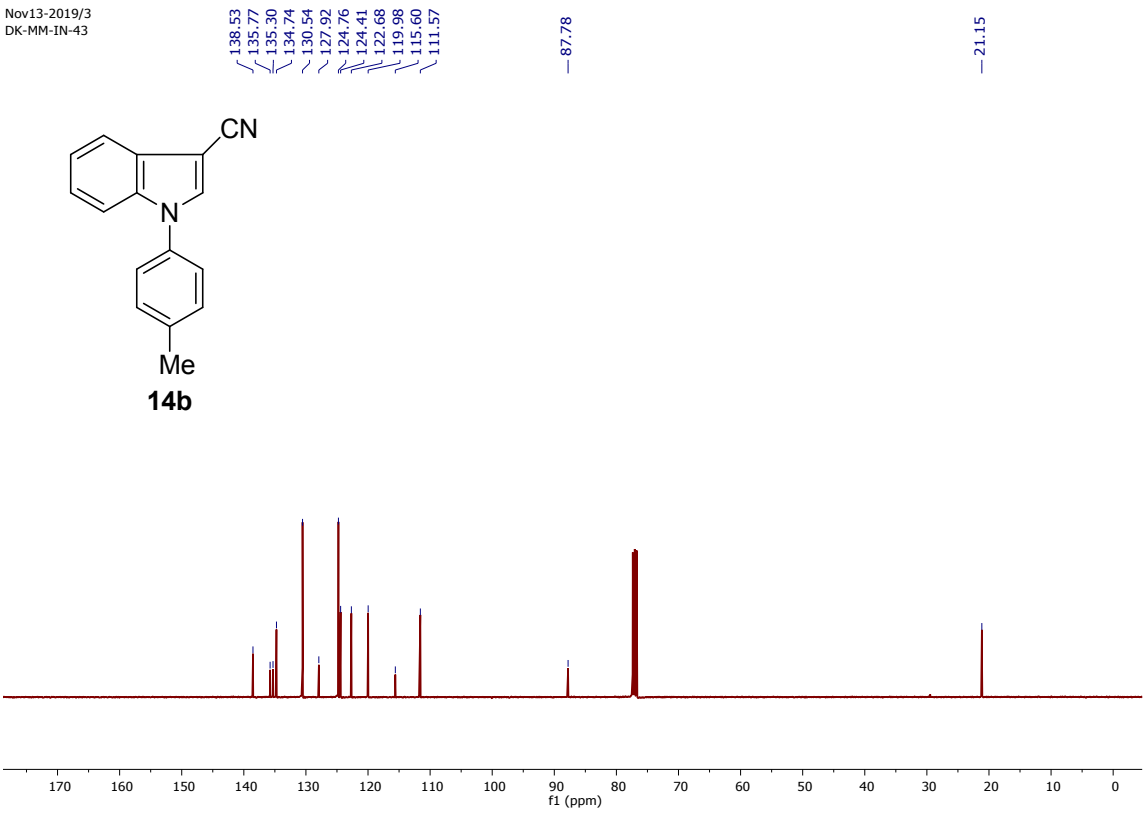
14a



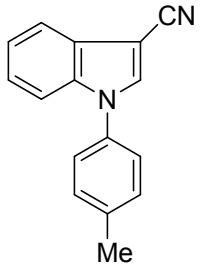
^{1}H NMR spectrum of 14b



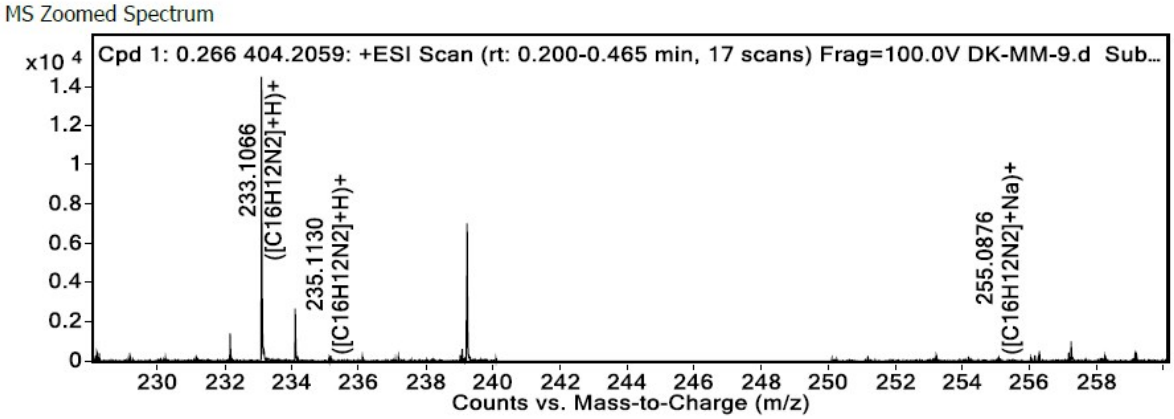
^{13}C NMR spectrum of 14b



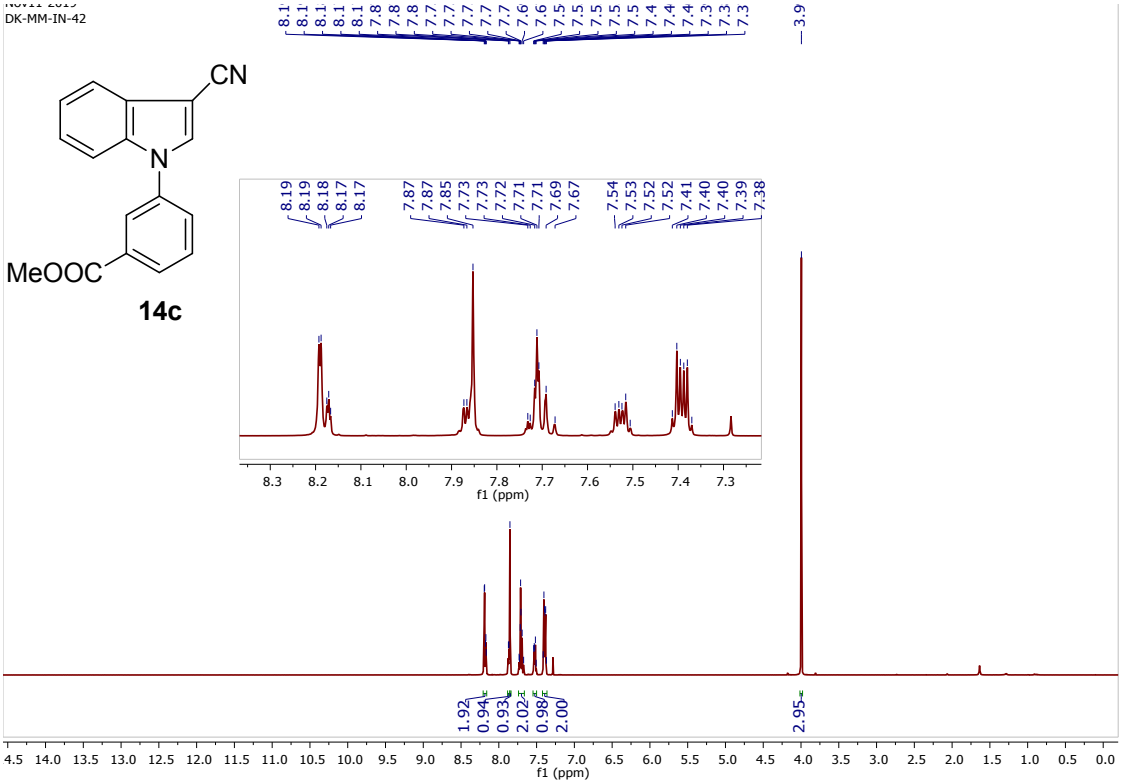
HRMS Spectrum of 14b



14b

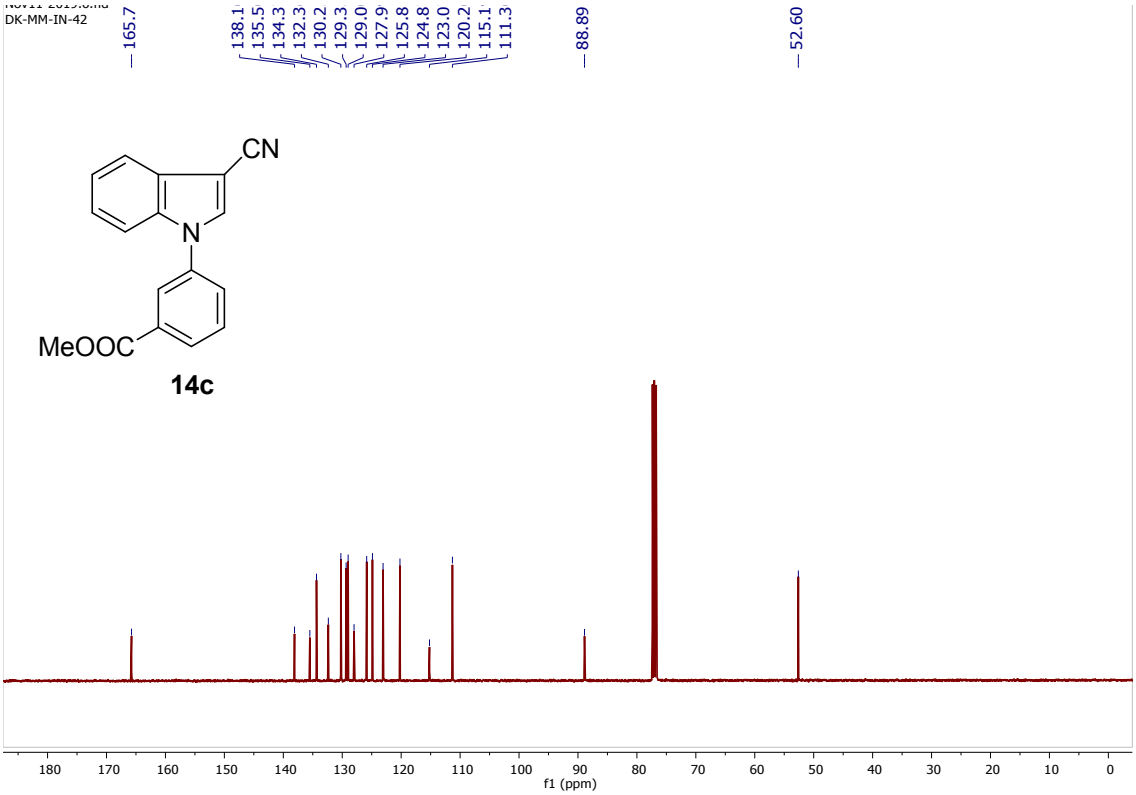


^{1}H NMR spectrum of 14c

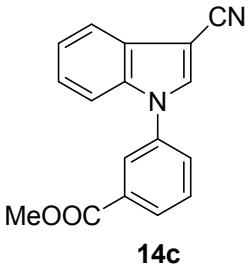


14c

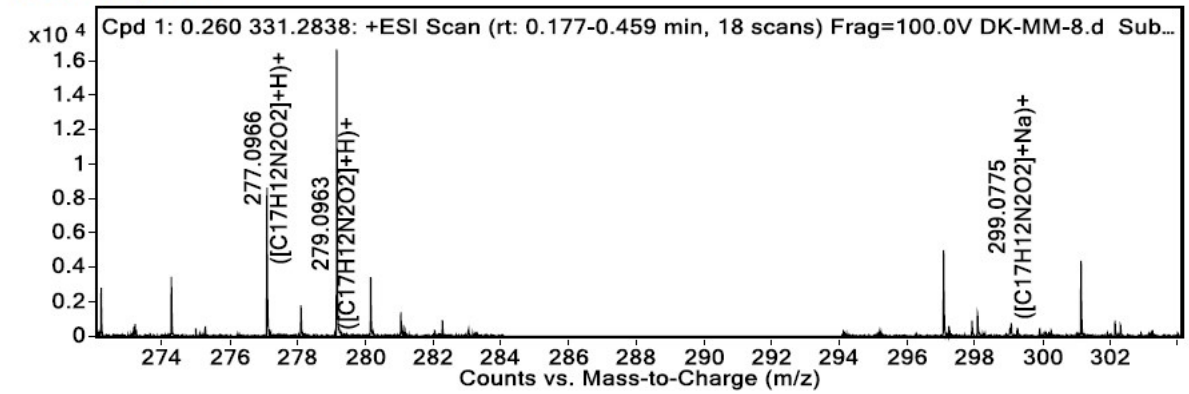
^{13}C NMR spectrum of 14c



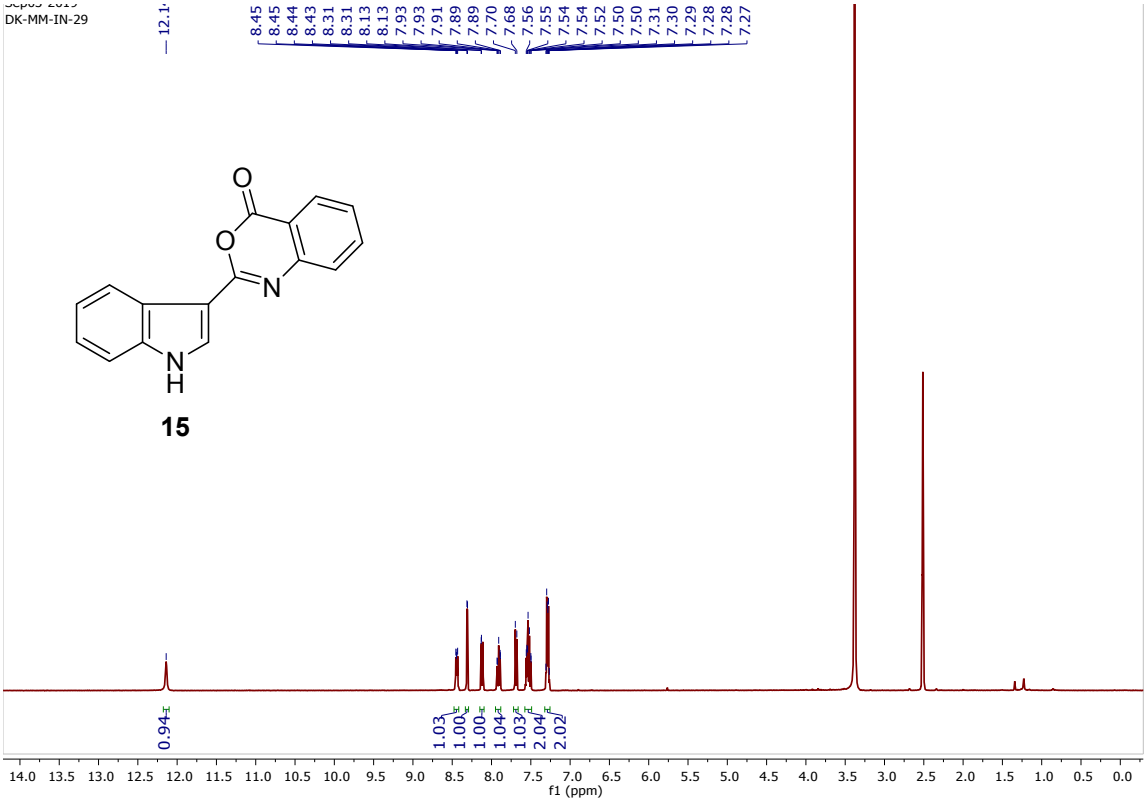
HRMS Spectrum of 14c



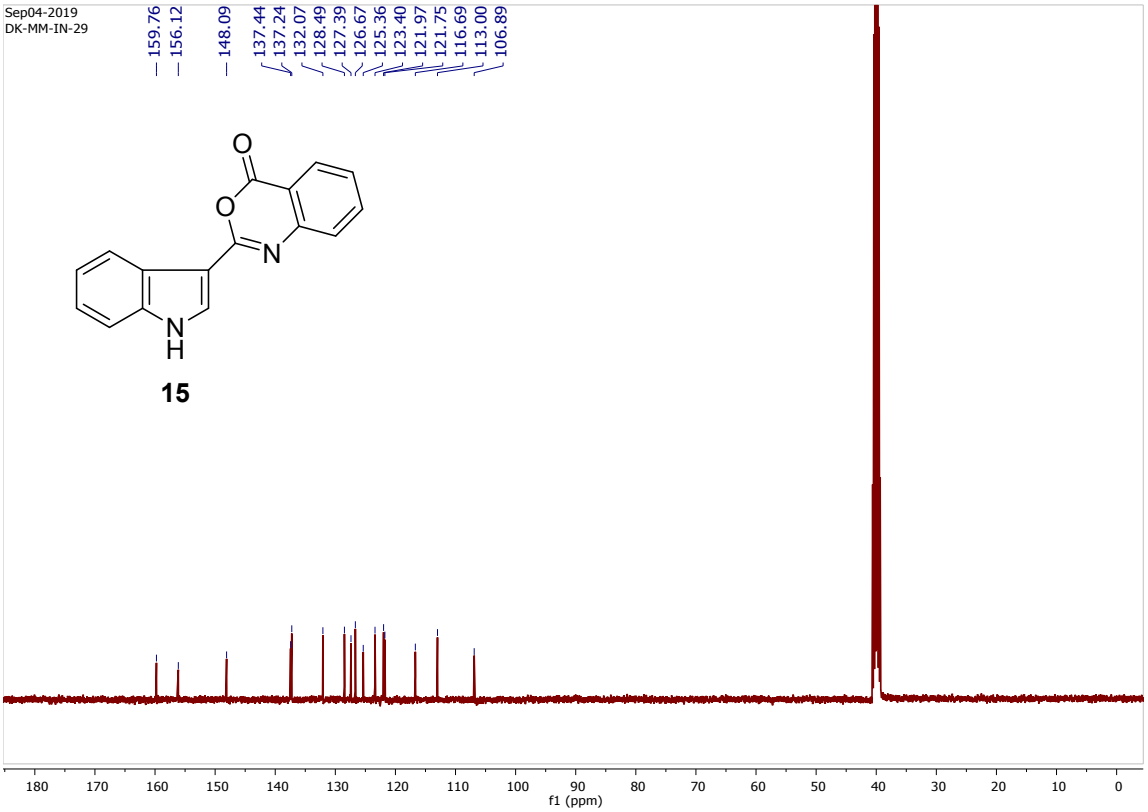
MS Zoomed Spectrum



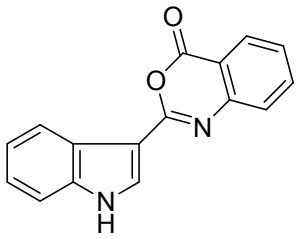
^{1}H NMR spectrum of 15



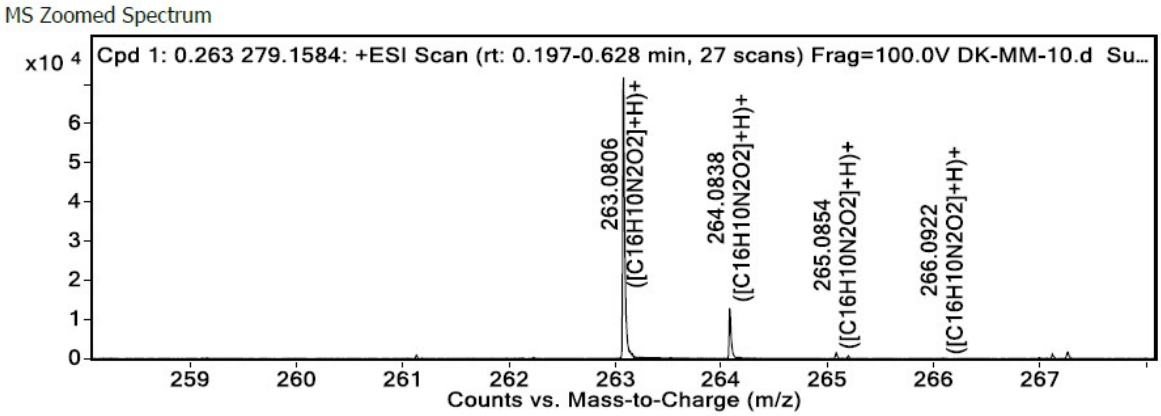
^{13}C NMR spectrum of 15



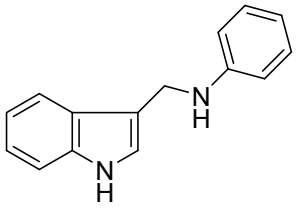
HRMS Spectrum of 15



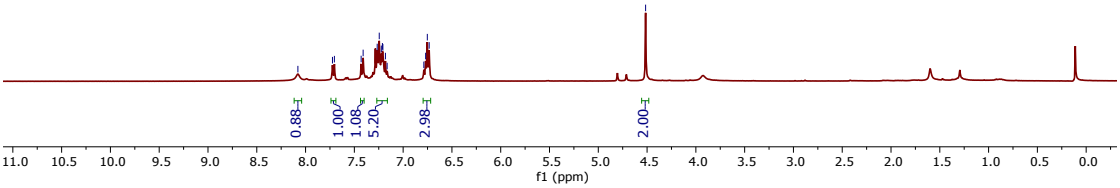
15



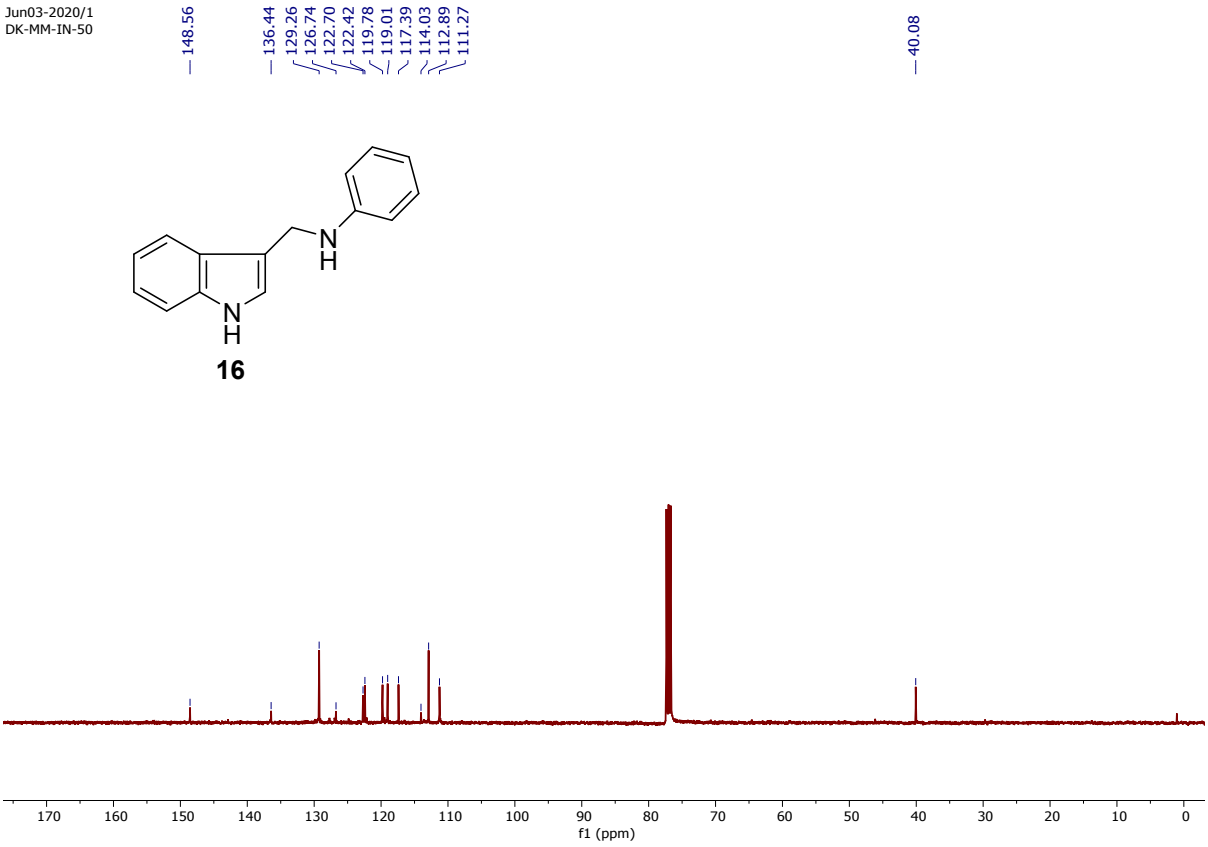
^{1}H NMR spectrum of 16



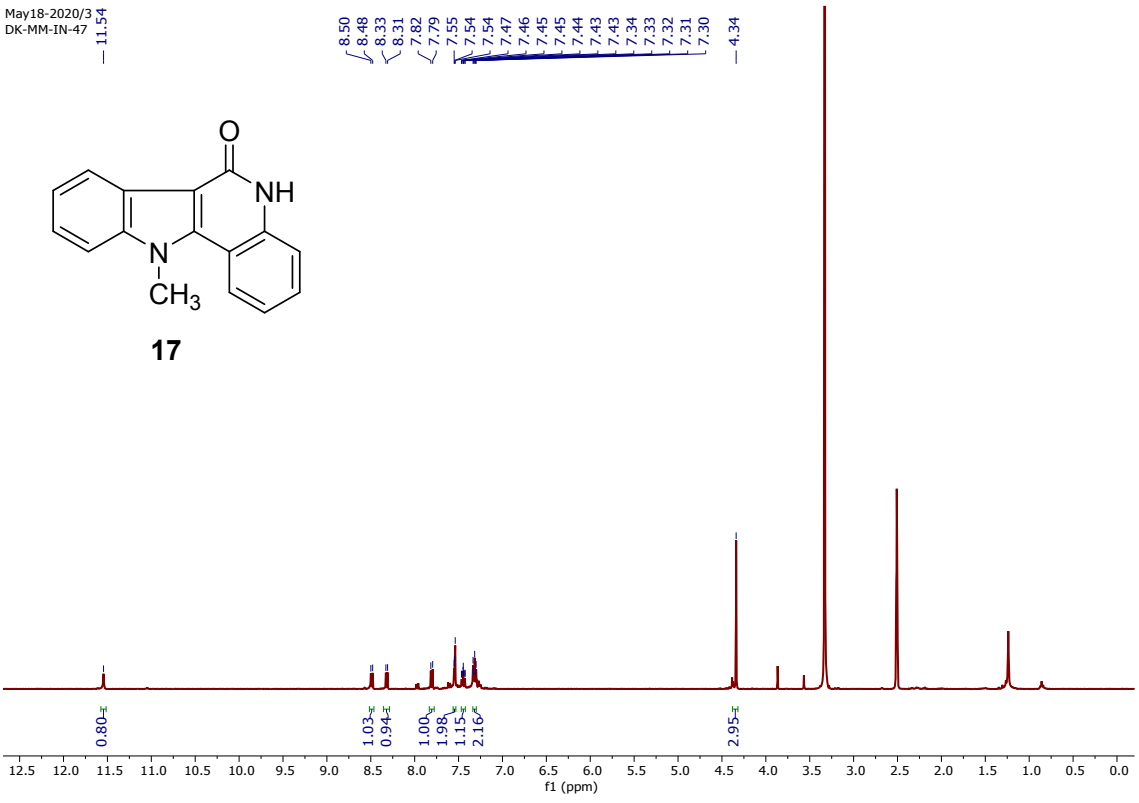
16



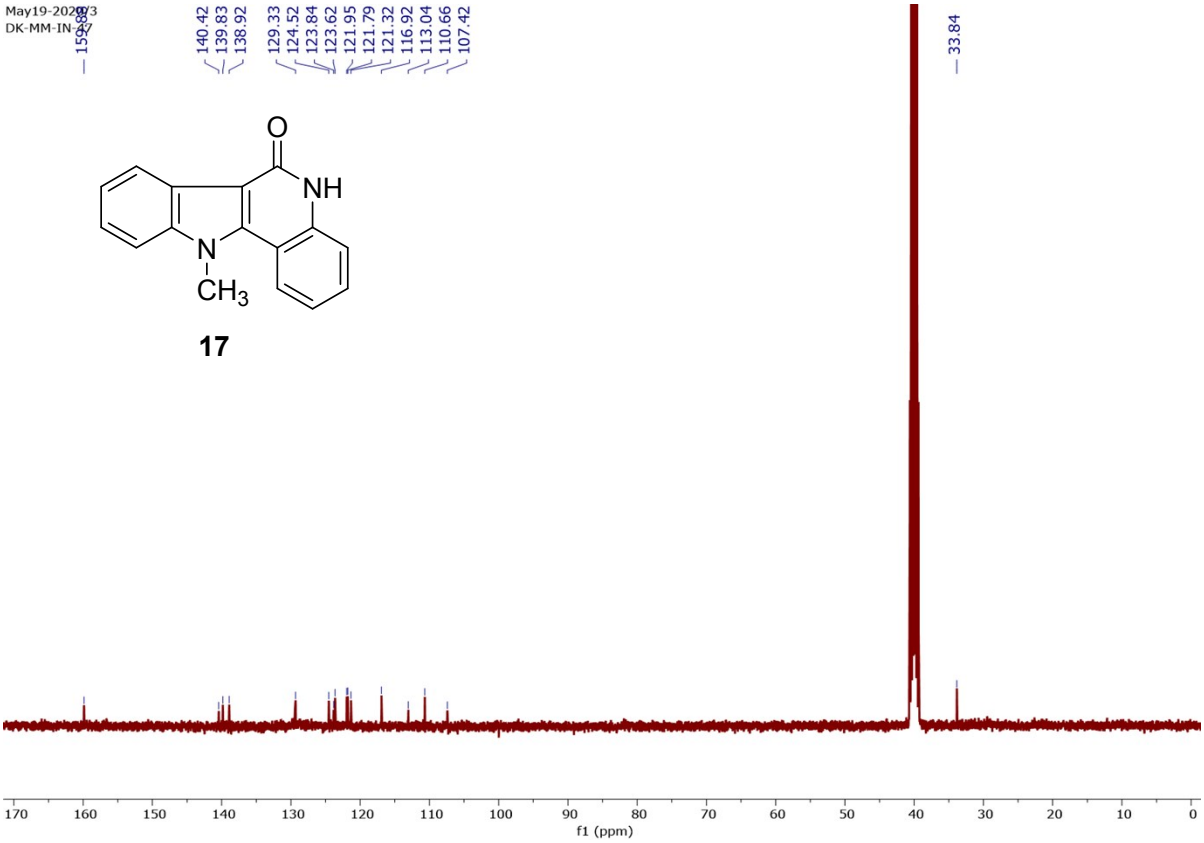
^{13}C NMR spectrum of 16



^{1}H NMR spectrum of 17

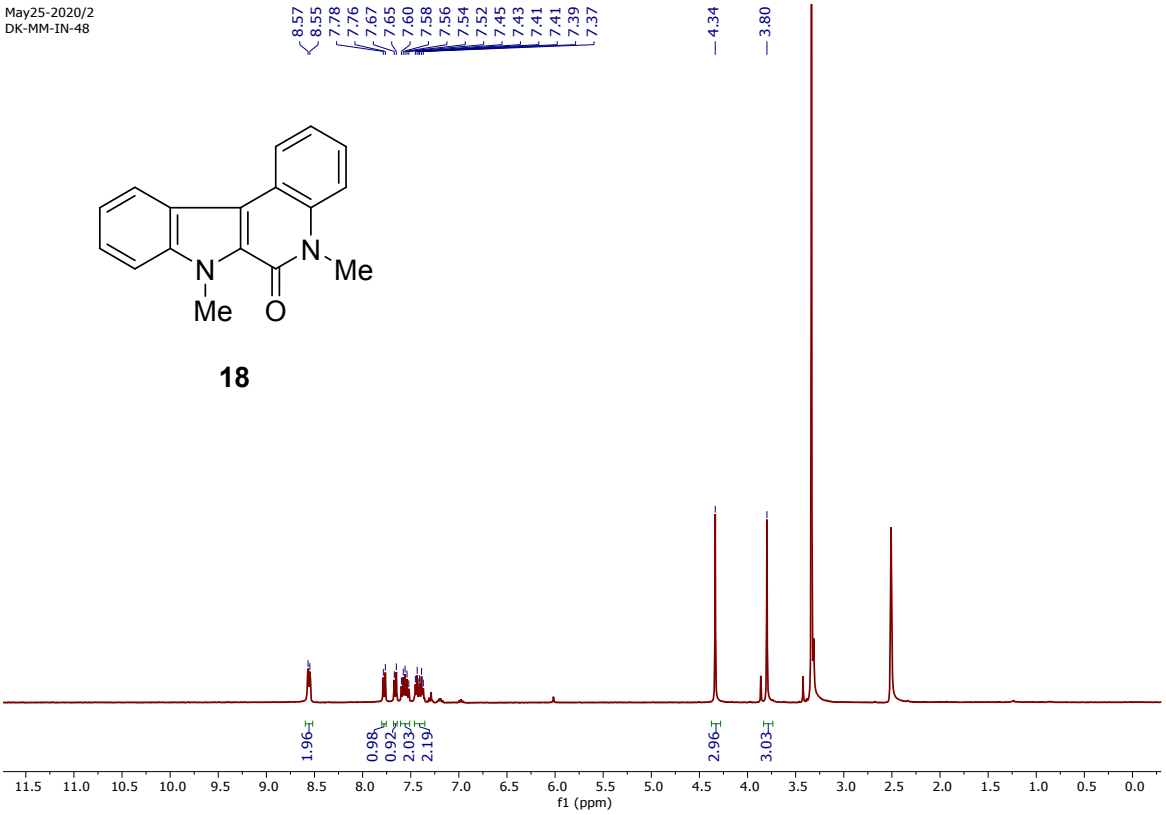


^{13}C NMR spectrum of 17



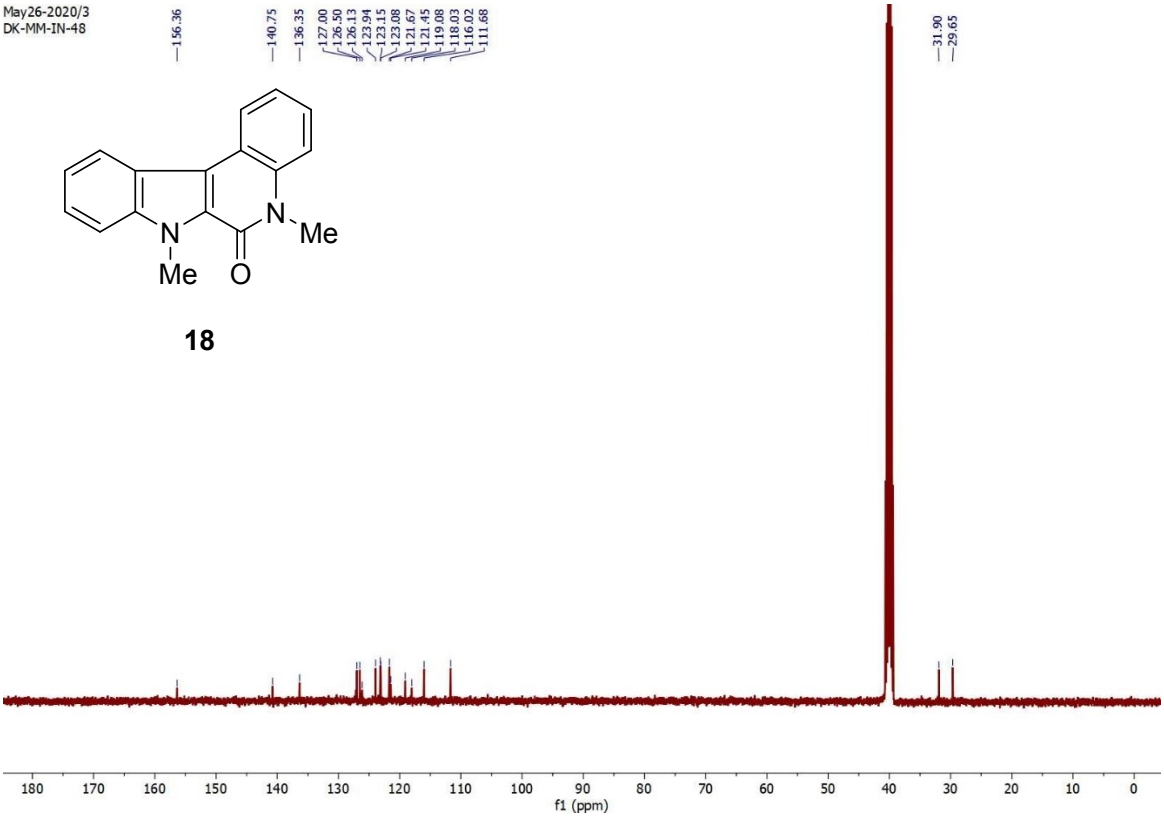
17

^{1}H NMR spectrum of 18



18

^{13}C NMR spectrum of 18



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5. References

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