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Supporting Information for

A novel approach to 5*H*-pyrazino[2,3-*b*]indoles via annulation of 3-diazoindolin-2-imines with 2*H*-azirines or 5-alkoxyisoxazoles under Rh(II) catalysis

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General Information

Melting points were determined on a Stuart Melting Point Apparatus SMP30 and are uncorrected. ^{1}H (400 MHz) and ^{13}C (100 MHz) NMR spectra were recorded on a Bruker AVANCE 400 spectrometer in solvents indicated below. Chemical shifts (δ) are reported in parts per million downfield from tetramethylsilane. High-resolution mass spectra were recorded on a Bruker MaXis mass spectrometer, electrospray ionization, positive mode. IR spectrum was recorded on a FTIR-8400S Shimadzu spectrometer using KBr disc method. Thin-layer chromatography (TLC) was conducted on aluminum sheets precoated with SiO_2 ALUGRAM SIL G/UV254. Column chromatography was performed on silica gel 60 M (0.04−0.063 mm). All solvents were distilled and dried prior to use. Toluene was distilled and stored over sodium metal. 1,2-Dichloroethane was washed with concentrated H_2SO_4 and water, distilled from P_2O_5, and stored over anhydrous K_2CO_3. Acetonitrile was distilled from P_2O_5 and redistilled from K_2CO_3. DMSO was refluxed over CaH_2 and distilled in vacuo. The catalysts $Rh_2(Oct)_4$[1], $Rh_2(Piv)_4$[2], and $Rh_2(esp)_2$[3] were prepared by the reported procedures and gave satisfactory elemental analyses. Isoxazoles **1a**,**b**,**d**−**f**,[4] **1c**,**g**,[5] 3-diazoindolin-2-imines **2a**−**g**,**k**−**m**[6] and azirines **3e**,[7] **3f**,**g**,[8] **3h**,[9] **3i**,**j**,[10] **3k**[5] were prepared by the reported procedures.

Synthesis of 3-diazoindolin-2-imines 2

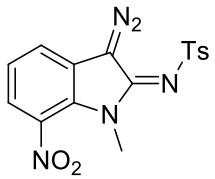
General procedure for the synthesis of 3-diazoindolin-2-imines 2

3-Diazoindolin-2-imines **2** were prepared similarly to the reported procedure.[6] To an oven-dried round-bottom flask equipped with a magnetic stirring bar were added corresponding indole (10 mmol), sulfonyl azide (20 mmol), and anhydrous DMSO (20 mL). The reaction mixture was stirred at 50 °C for 18 h, then quenched with water (200 mL) and extracted with CH_2Cl_2 (3 × 200 mL). The combined organic layers were dried (Na_2SO_4) and concentrated in vacuo. The crude product was purified by column chromatography on silica gel (eluent petroleum ether−EtOAc, 3:1).

Note that low conversion of indoles with electron-withdrawing substituents was observed (about 5−20%).

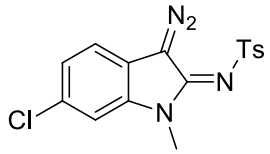
3-Diazoindolin-2-imines **2a**−**g**,**k**−**m** are known compounds and have full characterization data.[6]

***N*-(3-Diazo-1-methyl-7-nitroindolin-2-ylidene)-4-methylbenzenesulfonamide (2h)**



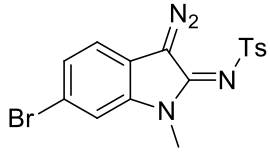
Orange solid (185 mg, yield 5%); mp 180−182 °C (dec.); R_f = 0.59 (hexane−EtOAc, 1:1); ^{1}H NMR ($CDCl_3$) δ 7.91 (d, *J* = 8.2 Hz, 2H), 7.70 (d, *J* = 8.2 Hz, 1H), 7.44 (d, *J* = 7.7 Hz, 1H), 7.34 (d, *J* = 8.2 Hz, 2H), 7.31−7.26 (m, 1H), 3.46 (s, 3H), 2.46 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 156.0, 143.1, 139.2, 136.4, 129.5, 126.9, 126.5, 122.7, 122.3, 121.8, 120.2, 32.8, 21.5; HRMS−ESI $[M + H]^+$ calcd for $C_{16}H_{14}N_5O_4S^+$ 372.0761; found 372.0774.

***N*-(6-Chloro-3-diazo-1-methylindolin-2-ylidene)-4-methylbenzenesulfonamide (2i)**



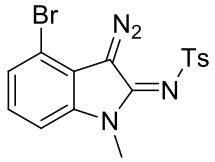
Orange solid (432 mg, yield 12%); mp 192−194 °C; R_f = 0.32 (hexane−EtOAc, 3:1); IR (KBr), ν/cm^{-1}: 2145 (C=N$^+$=N$^-$); ^{1}H NMR ($CDCl_3$) δ 7.90 (d, *J* = 8.2 Hz, 2H), 7.32 (d, *J* = 8.2 Hz, 2H), 7.22−7.14 (m, 2H), 7.10 (d, *J* = 1.4 Hz, 1H), 3.44 (s, 3H), 2.45 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 155.5, 142.6, 139.8, 135.0, 131.8, 129.4, 126.3, 123.0, 117.5, 117.2, 110.2, 64.3, 29.1, 21.5; HRMS−ESI [M + H]$^+$ calcd for $C_{16}H_{14}{}^{35}ClN_4O_2S^+$ 361.0521; found 361.0530.

***N*-(6-Bromo-3-diazo-1-methylindolin-2-ylidene)-4-methylbenzenesulfonamide (2j)**



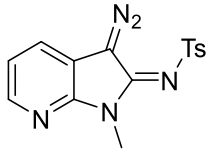
Orange solid (525 mg, yield 13%); mp 168−170 °C (dec.); R_f = 0.33 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 7.90 (d, *J* = 8.2 Hz, 2H), 7.35−7.29 (m, 3H), 7.23 (s, 1H), 7.10 (d, *J* = 8.1 Hz, 1H), 3.43 (s, 3H), 2.44 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 155.3, 142.7, 139.8, 135.3, 129.4, 126.4, 125.8, 119.1, 117.9, 117.8, 113.0, 64.3, 29.1, 21.5; HRMS−ESI [M + H]$^+$ calcd for $C_{16}H_{14}{}^{79}BrN_4O_2S^+$ 405.0015; found 405.0028.

***N*-(4-Bromo-3-diazo-1-methylindolin-2-ylidene)-4-methylbenzenesulfonamide (2n)**



Orange solid (242 mg, yield 6%); mp 197−198 °C (dec.); R_f = 0.41 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 7.92 (d, *J* = 8.2 Hz, 2H), 7.32 (d, *J* = 8.2 Hz, 2H), 7.29−7.26 (m, 1H), 7.13 (t, *J* = 8.0 Hz, 1H), 7.03 (d, *J* = 8.0 Hz, 1H), 3.44 (s, 3H), 2.45 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 155.9, 142.6, 140.1, 135.4, 129.3, 126.9, 126.7, 126.3, 116.7, 113.0, 108.6, 29.1, 21.5; HRMS−ESI [M + H]$^+$ calcd for $C_{16}H_{14}{}^{79}BrN_4O_2S^+$ 405.0015; found 405.0022.

***N*-(3-diazo-1-methyl-1,3-dihydro-2*H*-pyrrolo[2,3-*b*]pyridin-2-ylidene)-4-methylbenzenesulfonamide (2o)**



Orange solid (229 mg, yield 7%); mp 173−174 °C (dec.); R_f = 0.35 (hexane−EtOAc, 1:1); ^{1}H NMR ($CDCl_3$) δ 8.24 (dd, *J* = 5.1, 1.4 Hz, 1H), 7.95−7.88 (m, 2H), 7.53 (dd, *J* = 7.6, 1.4 Hz, 1H), 7.32 (d, *J* = 8.2 Hz, 2H), 7.12 (dd, *J* = 7.6, 5.1 Hz, 1H), 3.54 (s, 3H), 2.45 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 155.3, 146.6, 145.4, 142.8, 139.6, 129.4, 126.4, 124.0, 118.3, 113.5, 27.9, 21.5; HRMS−ESI [M + H]$^+$ calcd for $C_{15}H_{14}N_5O_2S^+$ 328.0863; found 328.0877.

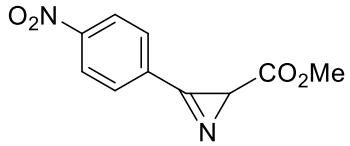
Synthesis of 2*H*-azirines 3

General procedure for the synthesis of azirine-2-carboxylates 3a−d and azirine-2-carboxamide 3l[11]

To a solution of isoxazole (0.6 mmol) in degassed acetonitrile (5 mL) was added iron(II) chloride tetrahydrate (12 mg, 0.06 mmol) under a stream of argon and the mixture was stirred at room temperature for 24 h. Then the reaction mixture was filtered through a pad of Celite and the solvent was removed in vacuo. The crude product was purified by flash chromatography on silica gel (eluent petroleum ether−EtOAc).

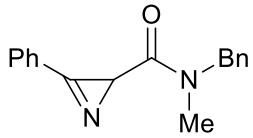
Azirine-2-carboxylates **3a**,[5] **3b**,[12] **3c**[13] are known compounds and have full characterization data.

Methyl 3-(4-nitrophenyl)-2*H*-azirine-2-carboxylate (3d)



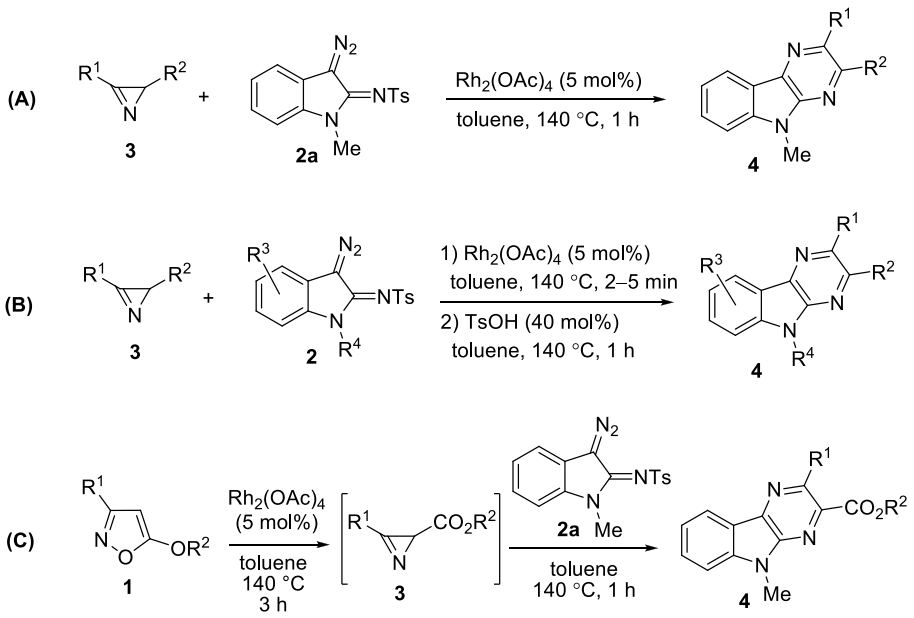
Obtained from 5-methoxy-3-(4-nitrophenyl)isoxazole.[14] Yellow solid (120 mg, yield 91%); mp 96−98 °C; R_f = 0.39 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.49−8.44 (m, 2H), 8.14−8.10 (m, 2H), 3.80 (s, 3H), 3.01 (s, 1H); ^{13}C NMR ($CDCl_3$) δ 171.2, 158.5, 150.8, 131.3, 127.9, 124.5, 52.6, 30.3; HRMS−ESI $[M + Na]^+$ calcd for $C_{10}H_8N_2NaO_4^+$ 243.0376; found 243.0382.

N-Benzyl-*N*-methyl-3-phenyl-2*H*-azirine-2-carboxamide (3l)



Obtained from *N*-benzyl-*N*-methyl-3-phenylisoxazol-5-amine.[5] Yellow oil (123 mg, yield 78%); R_f = 0.39 (hexane−EtOAc, 1:1); ^{1}H NMR ($CDCl_3$) δ (rotameric mixture ~ 1:1) 7.93 (d, J = 7.1 Hz, 1H), 7.81 (d, J = 7.1 Hz, 1H), 7.67−7.50 (m, 3H), 7.48−7.41 (m, 1H), 7.41−7.28 (m, 5H), 5.00 and 4.88 (AB-q, J = 16.8 Hz, 1H), 4.78 and 4.56 (AB-q, J = 14.6 Hz, 1H), 3.29 (s, 1.5H), 3.16 (s, 0.5H), 3.09 (s, 0.5H), 3.08 (s, 1.5H); ^{13}C NMR ($CDCl_3$) δ (rotameric mixture ~ 1:1) 170.8, 170.5, 159.3, 159.0, 137.0, 136.8, 133.43, 133.37, 130.29, 130.26, 129.14, 129.06, 129.0, 128.6, 128.2, 127.8, 127.4, 126.5, 123.1, 123.0, 53.3, 51.5, 34.9, 34.6, 29.1, 29.0; HRMS−ESI $[M + H]^+$ calcd for $C_{17}H_{17}N_2O^+$ 265.1335; found 265.1343.

Synthesis of 5*H*-pyrazino[2,3-*b*]indoles 4



General Procedure A (for 4a−d,i−m)

Azirine **3** (0.2 mmol), 3-diazoindolin-2-imine **2a** (0.4−0.8 mmol), $Rh_2(OAc)_4$ (4.4 mg, 0.01 mmol), and toluene (1 mL) were placed into a screw cap glass tube and heated at 140 °C (oil bath temperature) under stirring for 1 h. The solvent was removed in vacuo, and the residue was purified by column chromatography on silica gel (eluent hexane−EtOAc, 3:1) to give the desired products.

General Procedure B (for 4e−h,t−z,aa−af)

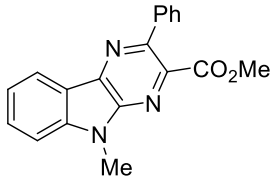
Azirine **3** (0.2 mmol), 3-diazoindolin-2-imine **2** (0.4−0.6 mmol), $Rh_2(OAc)_4$ (4.4 mg, 0.01 mmol), and toluene (1 mL) were placed into a screw cap glass tube and heated at 140 °C (oil bath temperature) under stirring until nitrogen evolution had ceased (about 2−5 min). Then, for elimination of *p*-toluenesulfinic acid, to the reaction mixture was added *p*-toluenesulfonic acid (14 mg, 0.08 mmol). The resulting mixture was stirred at 140 °C for 1 h and then concentrated in vacuo. The residue was purified by column chromatography on silica gel (eluent hexane−EtOAc, 3:1) to give the desired products.

General Procedure C (for 4a,n−s)

5-Alkoxyisoxazole **1** (0.2 mmol), $Rh_2(OAc)_4$ (4.4 mg, 0.01 mmol), and toluene (1 mL) were placed into a screw cap glass tube and heated at 140 °C (oil bath temperature) under stirring for 3 h until full consumption of isoxazole was detected (control by TLC, eluent hexane−Et_2O, 3:1). Then 3-diazoindolin-2-imine **2a** (0.6 mmol) was added to the reaction mixture. The resulting mixture was stirred at 140 °C for 1 h and then concentrated in vacuo. The residue was purified by column chromatography on silica gel (eluent hexane−EtOAc, 3:1) to give the desired products.

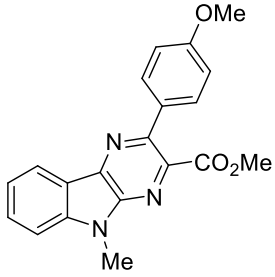
Characterization data for 5*H*-pyrazino[2,3-*b*]indoles 4

Methyl 5-methyl-2-phenyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4a)



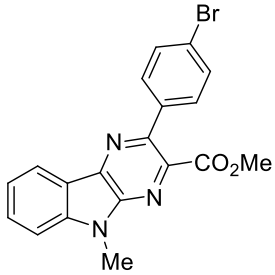
Obtained from azirine **3a** and 3-diazoindolin-2-imine **2a** (0.6 mmol) according to the general procedure A (55 mg, yield 87%). Also obtained from isoxazole **1a** and 3-diazoindolin-2-imine **2a** (0.6 mmol) according to the general procedure C (47 mg, yield 75%). White solid; mp 143−145 °C; R_f = 0.37 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.46 (d, *J* = 7.8 Hz, 1H), 7.76−7.69 (m, 3H), 7.58−7.40 (m, 5H), 4.04 (s, 3H), 3.84 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 168.1, 145.8, 143.3, 143.0, 139.2, 138.9, 136.8, 130.1, 128.8, 128.39, 128.38, 122.4, 121.2, 119.2, 109.6, 52.7, 27.8; HRMS−ESI $[M + Na]^+$ calcd for $C_{19}H_{15}N_3NaO_2^+$ 340.1056; found 340.1070.

Methyl 2-(4-methoxyphenyl)-5-methyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4b)



Obtained from azirine **3b** and 3-diazoindolin-2-imine **2a** (0.6 mmol) according to the general procedure A as a white solid (58 mg, yield 84%); mp 151−153 °C; R_f = 0.20 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.44 (d, *J* = 7.8 Hz, 1H), 7.73−7.65 (m, 3H), 7.53 (d, *J* = 8.3 Hz, 1H), 7.44−7.38 (m, 1H), 7.08−7.03 (m, 2H), 4.02 (s, 3H), 3.90 (s, 3H), 3.87 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 168.4, 160.0, 145.5, 143.3, 142.9, 138.9, 136.8, 131.4, 130.1 (2C), 122.4, 121.1, 119.3, 114.0, 109.6, 55.3, 52.8, 27.8; HRMS−ESI $[M + H]^+$ calcd for $C_{20}H_{18}N_3O_3^+$ 348.1343; found 348.1335.

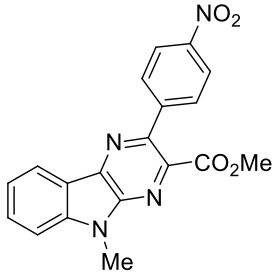
Methyl 2-(4-bromophenyl)-5-methyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4c)



Obtained from azirine **3c** and 3-diazoindolin-2-imine **2a** (0.4 mmol) according to the general procedure A as a white solid (51 mg, yield 65%); mp 167−169 °C; R_f = 0.48 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.44 (d, *J* = 7.8 Hz, 1H), 7.76−7.70 (m, 1H), 7.68−7.57 (m, 4H), 7.55 (d, *J* = 8.3 Hz, 1H), 7.43 (t, *J* = 7.5 Hz, 1H), 4.03 (s, 3H), 3.87 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 167.8, 144.7, 143.5, 143.2, 138.9, 138.0, 137.0, 131.6, 130.5, 130.4, 122.9, 122.5, 121.4, 119.1,

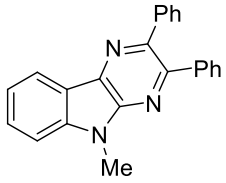
109.7, 52.9, 27.9; HRMS−ESI [M + Na]$^+$ calcd for $C_{19}H_{14}{}^{79}BrN_3NaO_2{}^+$ 418.0162; found 418.0169.

Methyl 5-methyl-2-(4-nitrophenyl)-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4d)



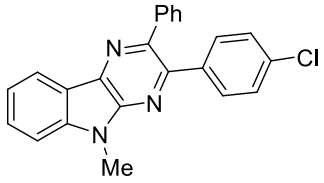
Obtained from azirine **3d** and 3-diazoindolin-2-imine **2a** (0.6 mmol) according to the general procedure A as a white solid (40 mg, yield 55%); mp 224−225 °C; R_f = 0.49 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.46 (d, J = 7.8 Hz, 1H), 8.41−8.35 (m, 2H), 7.92−7.85 (m, 2H), 7.81−7.75 (m, 1H), 7.60 (d, J = 8.3 Hz, 1H), 7.50−7.44 (m, 1H), 4.07 (s, 3H), 3.89 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 167.3, 147.7, 145.6, 143.7 (2C), 143.4, 138.9, 137.2, 130.8, 129.9, 123.5, 122.6, 121.7, 119.0, 109.9, 53.0, 28.0; HRMS−ESI [M + H]$^+$ calcd for $C_{19}H_{15}N_4O_4{}^+$ 363.1088; found 363.1090.

5-Methyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4e)



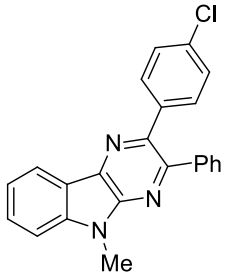
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2a** (0.4 mmol) according to the general procedure B (62 mg, yield 93%). Also obtained from azirine **3e** and 3-diazoindolin-2-imine **2b** (0.4 mmol) according to the general procedure B (40 mg, yield 60%). White solid; mp 202−203 °C; R_f = 0.47 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.47 (d, J = 7.8 Hz, 1H), 7.70−7.64 (m, 1H), 7.60−7.51 (m, 5H), 7.43−7.31 (m, 7H), 4.04 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 148.3, 145.5, 144.3, 142.4, 140.3, 140.0, 134.1, 130.27, 130.26, 128.8, 128.1, 128.0 (2C), 127.5, 121.9, 120.7, 119.8, 109.3, 27.6; HRMS−ESI [M + H]$^+$ calcd for $C_{23}H_{18}N_3{}^+$ 336.1495; found 336.1507.

3-(4-Chlorophenyl)-5-methyl-2-phenyl-5*H*-pyrazino[2,3-*b*]indole (4f)



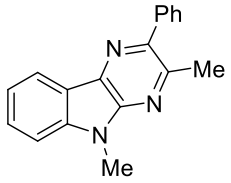
Obtained from azirine **3f** and 3-diazoindolin-2-imine **2a** (0.4 mmol) according to the general procedure B as a white solid (73 mg, yield 99%); mp 198−200 °C; R_f = 0.40 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.46 (d, J = 7.8 Hz, 1H), 7.71−7.64 (m, 1H), 7.55−7.49 (m, 5H), 7.43−7.35 (m, 4H), 7.34−7.29 (m, 2H), 4.02 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 146.9, 145.3, 144.3, 142.5, 140.1, 138.5, 134.4, 134.2, 131.6, 130.2, 129.0, 128.31, 128.28, 127.7, 122.0, 120.9, 119.7, 109.4, 27.6; HRMS−ESI [M + H]$^+$ calcd for $C_{23}H_{17}{}^{35}ClN_3{}^+$ 370.1106; found 370.1119.

2-(4-Chlorophenyl)-5-methyl-3-phenyl-5*H*-pyrazino[2,3-*b*]indole (4g)



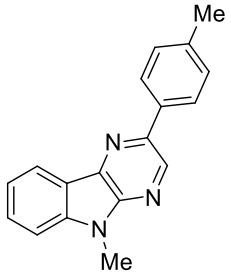
Obtained from azirine **3g** and 3-diazoindolin-2-imine **2a** (0.6 mmol) according to the general procedure B as a white solid (51 mg, yield 69%); mp 220−222 °C; R_f = 0.65 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.44 (d, *J* = 7.8 Hz, 1H), 7.70−7.64 (m, 1H), 7.57−7.51 (m, 3H), 7.50−7.45 (m, 2H), 7.43−7.35 (m, 4H), 7.34−7.29 (m, 2H), 4.02 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 148.3, 144.4, 144.1, 142.4, 139.8, 138.8, 134.2, 133.6, 131.6, 130.2, 129.0, 128.33, 128.25 (2C), 121.9, 120.9, 119.7, 109.4, 27.6; HRMS−ESI $[M + H]^+$ calcd for $C_{23}H_{17}{}^{35}ClN_3{}^+$ 370.1106; found 370.1119.

3,5-Dimethyl-2-phenyl-5*H*-pyrazino[2,3-*b*]indole (4h)



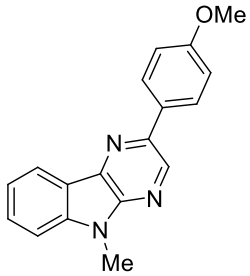
Obtained from azirine **3h** and 3-diazoindolin-2-imine **2a** (0.4 mmol) according to the general procedure B as a white solid (40 mg, yield 73%); mp 150−151 °C; R_f = 0.41 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.40 (d, *J* = 7.8 Hz, 1H), 7.69−7.66 (m, 2H), 7.65−7.60 (m, 1H), 7.56−7.48 (m, 3H), 7.48−7.43 (m, 1H), 7.40−7.34 (m, 1H), 3.99 (s, 3H), 2.77 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 147.1, 146.2, 144.4, 141.6, 140.3, 133.3, 129.5, 128.30, 128.29, 127.8, 121.5, 120.6, 119.9, 109.2, 27.4, 23.8; HRMS−ESI $[M + H]^+$ calcd for $C_{18}H_{16}N_3{}^+$ 274.1339; found 274.1352.

5-Methyl-2-(4-methylphenyl)-5*H*-pyrazino[2,3-*b*]indole (4i)



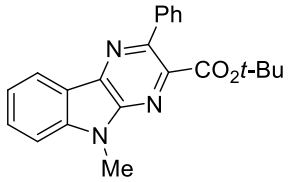
Azirine **3i** (0.2 mmol), 3-diazoindolin-2-imine **2a** (0.24 mmol), $Rh_2(OAc)_4$ (4.4 mg, 0.01 mmol), and 1,2-dichloroethane (1 mL) were placed into a screw cap glass tube and heated at 115 °C (oil bath temperature) under stirring for 1 h. The solvent was removed in vacuo, and the residue was purified by column chromatography on silica gel (eluent hexane−EtOAc, 3:1) to give **4i** as a white solid (20 mg, yield 37%): mp 140−142 °C; R_f = 0.40 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.85 (s, 1H), 8.46 (d, *J* = 7.8 Hz, 1H), 8.04 (d, *J* = 8.1 Hz, 2H), 7.68−7.63 (m, 1H), 7.50 (d, *J* = 8.2 Hz, 1H), 7.43−7.34 (m, 3H), 3.98 (s, 3H), 2.47 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 145.4, 144.5, 141.9, 138.3, 137.2, 135.4, 135.3, 129.6, 128.9, 126.7, 121.9, 120.7, 119.9, 109.3, 27.5, 21.2; HRMS−ESI $[M + H]^+$ calcd for $C_{18}H_{16}N_3{}^+$ 274.1339; found 274.1346.

2-(4-Methoxyphenyl)-5-methyl-5*H*-pyrazino[2,3-*b*]indole (4j)



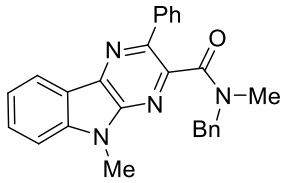
Obtained from azirine **3j** and 3-diazoindolin-2-imine **2a** as described above for the synthesis of **4i**. White solid (30 mg, yield 52%); mp 112−114 °C; R_f = 0.30 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.83 (s, 1H), 8.46 (d, *J* = 7.8 Hz, 1H), 8.12−8.06 (m, 2H), 7.69−7.63 (m, 1H), 7.52 (d, *J* = 8.2 Hz, 1H), 7.43−7.37 (m, 1H), 7.12−7.06 (m, 2H), 4.00 (s, 3H), 3.92 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 160.0, 145.2, 144.3, 141.9, 136.8, 135.3, 130.8, 128.8, 128.0, 121.8, 120.6, 119.8, 114.3, 109.3, 55.4, 27.5; HRMS−ESI $[M + H]^+$ calcd for $C_{18}H_{16}N_3O^+$ 290.1288; found 290.1299.

***tert*-Butyl 5-methyl-2-phenyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4k)**



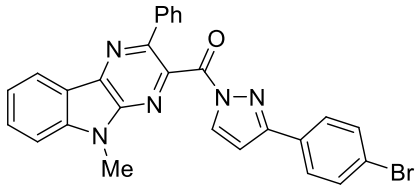
Obtained from azirine **3k** and 3-diazoindolin-2-imine **2a** (0.6 mmol) according to the general procedure A as a white solid (50 mg, yield 70%); mp 165−166 °C; R_f = 0.37 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.44 (d, *J* = 7.8 Hz, 1H), 7.73−7.67 (m, 3H), 7.56−7.45 (m, 4H), 7.43−7.37 (m, 1H), 4.04 (s, 3H), 1.38 (s, 9H); ^{13}C NMR ($CDCl_3$) δ 166.6, 145.7, 143.3, 143.1, 140.9, 139.6, 136.2, 129.8, 129.2, 128.3, 128.2, 122.4, 121.0, 119.3, 109.5, 82.8, 27.8, 27.6; HRMS−ESI $[M + H]^+$ calcd for $C_{22}H_{22}N_3O_2^+$ 360.1707; found 360.1723.

***N*-Benzyl-*N*,5-dimethyl-2-phenyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxamide (4l)**



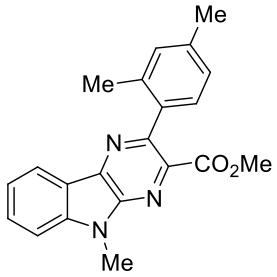
Obtained from azirine **3l** and 3-diazoindolin-2-imine **2a** (0.6 mmol) according to the general procedure A as a yellow oil (64 mg, yield 79%): R_f = 0.51 (hexane−EtOAc, 1:1); ^{1}H NMR ($CDCl_3$) δ (rotameric mixture ~ 1:1.5) 8.48−8.41 (m, 1H), 7.94 (d, *J* = 6.8 Hz, 0.8H), 7.89−7.82 (m, 1.2H), 7.74−7.65 (m, 1H), 7.58−7.46 (m, 4H), 7.45−7.38 (m, 1H), 7.33−7.25 (m, 2H), 7.25−7.21 (m, 1H), 7.13−7.09 (m, 1.2H), 7.07−7.03 (m, 0.8H), 4.73 (s, 1.2H), 4.08 (s, 0.8H), 4.03 (s, 1.8H), 3.97 (s, 1.2H), 2.95 (s, 1.2H), 2.52 (s, 1.8H); ^{13}C NMR ($CDCl_3$) δ (rotameric mixture ~ 1:1.3) 169.4, 169.0, 143.6, 143.5, 143.3, 143.09, 143.07, 142.70, 142.69, 137.97, 137.95, 136.06, 136.05, 135.9, 135.6, 129.63, 129.62, 129.2, 129.1, 128.65, 128.63, 128.61, 128.52, 128.50, 128.46, 128.3, 127.6, 127.43, 127.38, 122.1, 121.10, 121.09, 119.5, 109.6, 109.5, 54.1, 50.3, 35.1, 32.2, 27.8, 27.7; HRMS−ESI $[M + H]^+$ calcd for $C_{26}H_{23}N_4O^+$ 407.1866; found 407.1867.

[3-(4-Bromophenyl)-1*H*-pyrazol-1-yl](5-methyl-2-phenyl-5*H*-pyrazino[2,3-*b*]indol-3-yl)methanone (4m)



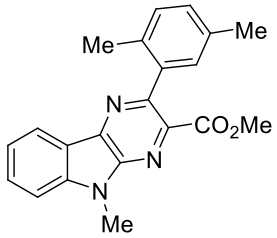
Obtained from azirine **3m** and 3-diazoindolin-2-imine **2a** (0.8 mmol) according to the general procedure A (reaction time: 5 min) as a white solid (82 mg, yield 81%); mp 171−172 °C; R_f = 0.47 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.53 (d, *J* = 7.8 Hz, 1H), 8.33 (d, *J* = 2.9 Hz, 1H), 7.78−7.70 (m, 3H), 7.58 (d, *J* = 8.3 Hz, 1H), 7.50−7.45 (m, 5H), 7.36−7.30 (m, 2H), 7.28−7.24 (m, 1H), 6.65 (d, *J* = 2.9 Hz, 1H), 4.03 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 166.4, 155.0, 145.8, 143.3, 143.2, 140.5, 138.3, 136.9, 131.7, 130.5, 130.3, 130.2, 128.7, 128.42, 128.40, 127.9, 123.4, 122.5, 121.3, 119.4, 109.7, 107.8, 27.9; HRMS−ESI $[M + H]^+$ calcd for $C_{27}H_{19}{}^{79}BrN_5O^+$ 508.0767; found 508.0791.

Methyl 2-(2,4-dimethylphenyl)-5-methyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4n)



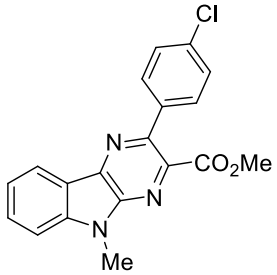
Obtained from isoxazole **1b** and 3-diazoindolin-2-imine **2a** according to the general procedure C as a white solid (65 mg, yield 94%); mp 181−182 °C; R_f = 0.29 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.44 (d, *J* = 7.8 Hz, 1H), 7.76−7.68 (m, 1H), 7.56 (d, *J* = 8.3 Hz, 1H), 7.41 (t, *J* = 7.5 Hz, 1H), 7.22−7.08 (m, 3H), 4.06 (s, 3H), 3.80 (s, 3H), 2.42 (s, 3H), 2.21 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 167.0, 147.3, 143.5, 143.1, 138.8, 138.0, 136.9, 136.1, 135.9, 131.0, 130.3, 129.1, 126.3, 122.6, 121.2, 119.1, 109.6, 52.6, 27.8, 21.3, 19.8; HRMS−ESI $[M + H]^+$ calcd for $C_{21}H_{20}N_3O_2^+$ 346.1550; found 346.1563.

Methyl 2-(2,5-dimethylphenyl)-5-methyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4o)



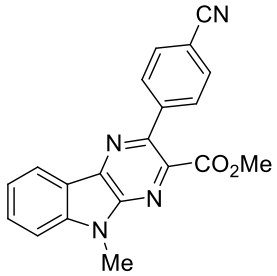
Obtained from isoxazole **1c** and 3-diazoindolin-2-imine **2a** according to the general procedure C as a white solid (53 mg, yield 77%); mp 124−126 °C; R_f = 0.29 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.46 (d, *J* = 7.8 Hz, 1H), 7.73 (t, *J* = 7.7 Hz, 1H), 7.57 (d, *J* = 8.3 Hz, 1H), 7.42 (t, *J* = 7.5 Hz, 1H), 7.25−7.17 (m, 2H), 7.13 (s, 1H), 4.07 (s, 3H), 3.79 (s, 3H), 2.39 (s, 3H), 2.17 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 166.9, 147.4, 143.5, 143.2, 138.7, 138.6, 136.9, 134.9, 133.2, 130.3, 130.0, 129.8, 129.2, 122.6, 121.2, 119.1, 109.6, 52.6, 27.8, 20.9, 19.3; HRMS−ESI $[M + H]^+$ calcd for $C_{21}H_{20}N_3O_2^+$ 346.1550; found 346.1558.

Methyl 2-(4-chlorophenyl)-5-methyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4p)



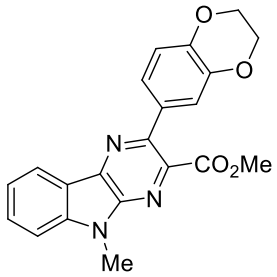
Obtained from isoxazole **1d** and 3-diazoindolin-2-imine **2a** according to the general procedure C as a white solid (52 mg, yield 74%); mp 153−155 °C; R_f = 0.45 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.45 (d, *J* = 7.8 Hz, 1H), 7.78−7.71 (m, 1H), 7.68−7.63 (m, 2H), 7.57 (d, *J* = 8.3 Hz, 1H), 7.52−7.47 (m, 2H), 7.44 (t, *J* = 7.5 Hz, 1H), 4.05 (s, 3H), 3.87 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 167.9, 144.7, 143.5, 143.1, 138.9, 137.5, 136.9, 134.7, 130.4, 130.2, 128.6, 122.5, 121.4, 119.1, 109.7, 52.9, 27.9; HRMS−ESI $[M + H]^+$ calcd for $C_{19}H_{15}{}^{35}ClN_3O_2{}^+$ 352.0847; found 352.0860.

Methyl 2-(4-cyanophenyl)-5-methyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4q)



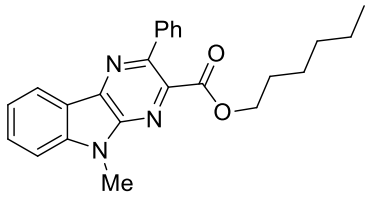
Obtained from isoxazole **1e** and 3-diazoindolin-2-imine **2a** according to the general procedure C as a white solid (36 mg, yield 53%); mp 205−206 °C; R_f = 0.30 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.43 (d, *J* = 7.8 Hz, 1H), 7.84−7.78 (m, 4H), 7.75 (t, *J* = 7.7 Hz, 1H), 7.57 (d, *J* = 8.3 Hz, 1H), 7.45 (t, *J* = 7.5 Hz, 1H), 4.04 (s, 3H), 3.88 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 167.4, 144.0, 143.6 (2C), 143.3, 138.8, 137.1, 132.1, 130.7, 129.6, 122.5, 121.7, 119.0, 118.7, 112.0, 109.9, 52.9, 27.9; HRMS−ESI $[M + H]^+$ calcd for $C_{20}H_{15}N_4O_2{}^+$ 343.1190; found 343.1193.

Methyl 2-(2,3-dihydrobenzo[*b*][1,4]dioxin-6-yl)-5-methyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4r)



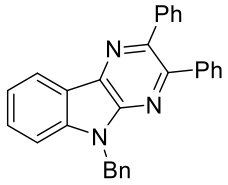
Obtained from isoxazole **1f** and 3-diazoindolin-2-imine **2a** according to the general procedure C as a white solid (62 mg, yield 83%); mp 180−182 °C; R_f = 0.30 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.43 (d, *J* = 7.8 Hz, 1H), 7.70 (t, *J* = 7.6 Hz, 1H), 7.52 (d, *J* = 8.2 Hz, 1H), 7.40 (t, *J* = 7.5 Hz, 1H), 7.32 (d, *J* = 2.0 Hz, 1H), 7.16 (dd, *J* = 8.3, 2.0 Hz, 1H), 6.98 (d, *J* = 8.3 Hz, 1H), 4.34 (s, 4H), 4.01 (s, 3H), 3.90 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 168.2, 145.1, 144.1, 143.6, 143.3, 142.9, 139.0, 136.7, 132.2, 130.1, 122.4, 122.0, 121.2, 119.2, 117.9, 117.2, 109.6, 64.5, 64.3, 52.8, 27.8; HRMS−ESI $[M + H]^+$ calcd for $C_{21}H_{18}N_3O_4{}^+$ 376.1292 found 376.1298.

Hexyl 5-methyl-2-phenyl-5*H*-pyrazino[2,3-*b*]indole-3-carboxylate (4s)



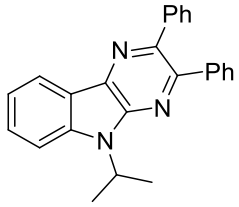
Obtained from isoxazole **1g** and 3-diazoindolin-2-imine **2a** according to the general procedure C as a white solid (61 mg, yield 79%); R_f = 0.57 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.45 (d, *J* = 7.9 Hz, 1H), 7.75−7.68 (m, 3H), 7.56−7.39 (m, 5H), 4.22 (t, *J* = 6.6 Hz, 2H), 4.03 (s, 3H), 1.51−1.42 (m, 2H), 1.34−1.07 (m, 6H), 0.89 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$) δ 168.0, 145.7, 143.25, 143.15, 139.8, 139.1, 136.6, 130.0, 128.9, 128.40, 128.35, 122.4, 121.2, 119.3, 109.6, 66.2, 31.3, 28.1, 27.8, 25.3, 22.4, 13.9; HRMS−ESI $[M + H]^+$ calcd for $C_{24}H_{26}N_3O_2^+$ 388.2020; found 388.2027.

5-Benzyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4t)



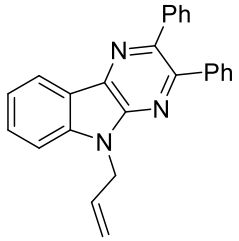
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2c** (0.4 mmol) according to the general procedure B as a white solid (59 mg, yield 72%); mp 205−206 °C; R_f = 0.49 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.48 (d, *J* = 7.8 Hz, 1H), 7.60−7.54 (m, 5H), 7.45 (d, *J* = 8.2 Hz, 1H), 7.41−7.27 (m, 12H), 5.77 (s, 2H); ^{13}C NMR ($CDCl_3$) δ 148.4, 145.9, 144.3, 141.6, 140.4, 139.9, 136.8, 134.0, 130.34, 130.25, 128.8, 128.7, 128.2, 128.05, 127.98, 127.61, 127.60, 127.3, 122.0, 120.9, 120.1, 110.3, 45.1; HRMS−ESI $[M + H]^+$ calcd for $C_{29}H_{22}N_3^+$ 412.1808; found 412.1825.

5-Isopropyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4u)



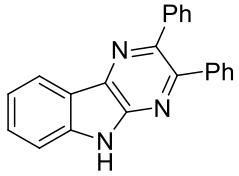
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2d** (0.4 mmol) according to the general procedure B as a white solid (52 mg, yield 72%); mp 141−143 °C; R_f = 0.63 (hexane−EtOAc, 9:1); ^{1}H NMR ($CDCl_3$) δ 8.48 (d, *J* = 7.8 Hz, 1H), 7.69−7.61 (m, 2H), 7.58−7.50 (m, 4H), 7.40−7.30 (m, 7H), 5.43 (sept, *J* = 7.0 Hz, 1H), 1.82 (d, *J* = 7.0 Hz, 6H); ^{13}C NMR ($CDCl_3$) δ 147.9, 145.2, 143.9, 140.9, 140.5, 140.2, 134.0, 130.35, 130.25, 128.5, 128.1, 128.0, 127.9, 127.5, 122.1, 120.25, 120.21, 110.8, 46.0, 20.9; HRMS−ESI $[M + H]^+$ calcd for $C_{25}H_{22}N_3^+$ 364.1808; found 364.1817.

5-Allyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4v)



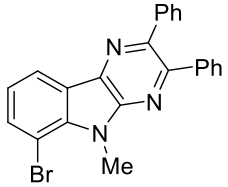
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2e** (0.4 mmol) according to the general procedure B as a white solid (71 mg, yield 98%); mp 164−165 °C; R_f = 0.57 (hexane−EtOAc, 9:1); ^{1}H NMR ($CDCl_3$) δ 8.46 (d, *J* = 7.8 Hz, 1H), 7.63 (t, *J* = 7.7 Hz, 1H), 7.57−7.50 (m, 5H), 7.40 (t, *J* = 7.5 Hz, 1H), 7.37−7.31 (m, 6H), 6.15−6.04 (m, 1H), 5.30−5.16 (m, 4H); ^{13}C NMR ($CDCl_3$) δ 148.3, 145.8, 143.9, 141.7, 140.3, 140.0, 134.0, 132.4, 130.3, 130.2, 128.7, 128.1, 128.02, 127.99, 127.6, 122.0, 120.8, 119.9, 117.4, 110.2, 43.7; HRMS−ESI $[M + H]^+$ calcd for $C_{25}H_{20}N_3^+$ 362.1652; found 362.1660.

2,3-Diphenyl-5*H*-pyrazino[2,3-*b*]indole (4w)



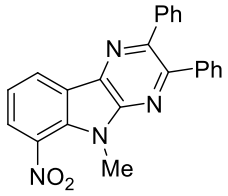
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2f** (0.4 mmol) according to the general procedure B as a white solid (29 mg, yield 45%); mp 279−281 °C; R_f = 0.49 (hexane−EtOAc, 3:1); ^{1}H NMR (DMSO-d_6) δ 12.21 (s, 1H), 8.25 (d, *J* = 7.8 Hz, 1H), 7.65−7.58 (m, 2H), 7.46−7.39 (m, 4H), 7.37−7.28 (m, 7H); ^{13}C NMR (DMSO-d_6) δ 147.9, 144.8, 144.1, 141.1, 140.1, 139.7, 133.3, 130.0, 129.9, 129.0, 127.94, 127.93, 127.91, 127.4, 121.1, 120.6, 119.3, 112.2; HRMS−ESI $[M + H]^+$ calcd for $C_{22}H_{16}N_3^+$ 322.1339; found 322.1351.

6-Bromo-5-methyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4x)



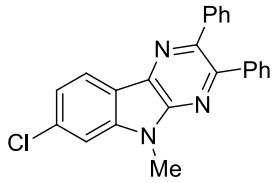
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2g** (0.4 mmol) according to the general procedure B as a white solid (72 mg, yield 87%); mp 239−241 °C; R_f = 0.64 (hexane−EtOAc, 9:1); ^{1}H NMR ($CDCl_3$) δ 8.40 (d, *J* = 7.7 Hz, 1H), 7.67 (d, *J* = 7.7 Hz, 1H), 7.59−7.51 (m, 4H), 7.39−7.32 (m, 6H), 7.20 (t, *J* = 7.8 Hz, 1H), 4.43 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 149.3, 146.5, 144.8, 140.0, 139.7, 138.9, 133.8, 133.2, 130.3, 130.2, 128.25, 128.16, 128.1, 127.7, 123.0, 121.7, 120.9, 103.9, 30.7; HRMS−ESI $[M + H]^+$ calcd for $C_{23}H_{17}{}^{79}BrN_3^+$ 414.0600; found 414.0619.

5-Methyl-6-nitro-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4y)



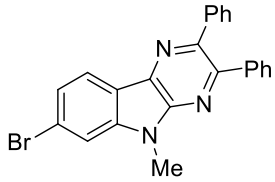
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2h** (0.4 mmol) according to the general procedure B as a white solid (50 mg, yield 66%); mp 244−245 °C; R_f = 0.49 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.71 (dd, *J* = 7.7, 2.0 Hz, 1H), 8.17 (dd, *J* = 8.0, 2.0 Hz, 1H), 7.59−7.51 (m, 4H), 7.44 (t, *J* = 7.9 Hz, 1H), 7.40−7.33 (m, 6H), 4.11 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 150.4, 147.8, 145.6, 139.6, 139.3, 136.5, 133.7, 132.5, 130.2, 130.1, 128.6, 128.3, 128.2, 128.1, 126.8, 125.3, 124.3, 119.9, 31.4; HRMS−ESI $[M + H]^+$ calcd for $C_{23}H_{17}N_4O_2^+$ 381.1346; found 381.1352.

7-Chloro-5-methyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4z)



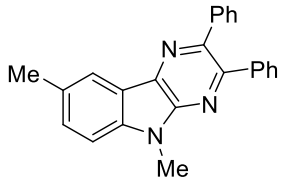
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2i** (0.4 mmol) according to the general procedure B as a white solid (50 mg, yield 68%); mp 232−234 °C; R_f = 0.57 (hexane−EtOAc, 9:1); ^{1}H NMR ($CDCl_3$) δ 8.35 (d, *J* = 8.3 Hz, 1H), 7.58−7.49 (m, 5H), 7.38−7.31 (m, 7H), 4.00 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 148.7, 146.1, 144.6, 142.8, 140.1, 139.8, 134.7, 133.5, 130.23, 130.18, 128.19, 128.16, 128.1, 127.7, 122.8, 121.4, 118.3, 109.7, 27.7; HRMS−ESI $[M + H]^+$ calcd for $C_{23}H_{17}{}^{35}ClN_3^+$ 370.1106; found 370.1105.

7-Bromo-5-methyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4aa)



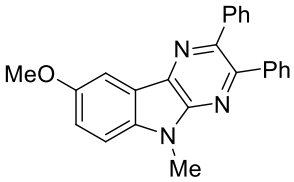
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2j** (0.4 mmol) according to the general procedure B as a white solid (53 mg, yield 64%); mp 250−252 °C; R_f = 0.59 (hexane−EtOAc, 9:1); ^{1}H NMR ($CDCl_3$) δ 8.29 (d, *J* = 8.3 Hz, 1H), 7.69 (s, 1H), 7.58−7.48 (m, 5H), 7.38−7.31 (m, 6H), 4.00 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 148.8, 146.2, 144.4, 142.9, 140.1, 139.8, 133.5, 130.23, 130.19, 128.21, 128.17, 128.1, 127.7, 124.1, 123.0, 122.7, 118.7, 112.7, 27.7; HRMS−ESI $[M + H]^+$ calcd for $C_{23}H_{17}{}^{79}BrN_3^+$ 414.0600; found 414.0594.

5,8-Dimethyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4ab)



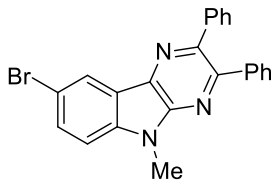
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2k** (0.4 mmol) according to the general procedure B as a white solid (67 mg, yield 96%); mp 231−232 °C; R_f = 0.52 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.27 (s, 1H), 7.59−7.51 (m, 4H), 7.48 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.42 (d, *J* = 8.4 Hz, 1H), 7.38−7.31 (m, 6H), 4.01 (s, 3H), 2.59 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 148.1, 145.2, 144.5, 140.7, 140.4, 140.1, 134.0, 130.3, 130.24, 130.23, 130.17, 128.1, 128.02, 127.97, 127.4, 121.7, 119.8, 109.0, 27.6, 21.3; HRMS−ESI $[M + H]^+$ calcd for $C_{24}H_{20}N_3^+$ 350.1652; found 315.1660.

8-Methoxy-5-methyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4ac)



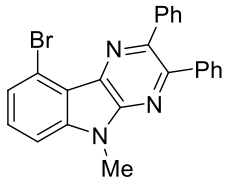
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2l** (0.4 mmol) according to the general procedure B as a white solid (62 mg, yield 85%); mp 199−200 °C; R_f = 0.43 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 7.94 (d, *J* = 2.4 Hz, 1H), 7.59−7.50 (m, 4H), 7.44 (d, *J* = 7.9 Hz, 1H), 7.38−7.28 (m, 7H), 4.01 (s, 3H), 3.97 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 154.8, 148.3, 145.1, 144.6, 140.4, 140.0, 137.2, 133.9, 130.3, 130.2, 128.1, 128.02, 128.01, 127.5, 119.9, 118.9, 110.3, 103.5, 56.0, 27.6; HRMS−ESI $[M + H]^+$ calcd for $C_{24}H_{20}N_3O^+$ 366.1601; found 366.1613.

8-Bromo-5-methyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4ad)



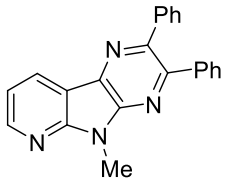
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2m** (0.4 mmol) according to the general procedure B as a white solid (82 mg, yield 99%); mp 228−229 °C; R_f = 0.63 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.58 (d, *J* = 1.9 Hz, 1H), 7.73 (dd, *J* = 8.7, 1.9 Hz, 1H), 7.58−7.49 (m, 4H), 7.40 (d, *J* = 8.7 Hz, 1H), 7.37−7.34 (m, 6H), 4.01 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 149.2, 146.1, 144.4, 140.8, 140.0, 139.7, 132.8, 131.4, 130.24, 130.16, 128.3, 128.2, 128.1, 127.7, 124.6, 121.3, 113.7, 110.9, 27.7; HRMS−ESI $[M + H]^+$ calcd for $C_{23}H_{17}{}^{79}BrN_3^+$ 414.0600; found 414.0614.

9-Bromo-5-methyl-2,3-diphenyl-5*H*-pyrazino[2,3-*b*]indole (4ae)



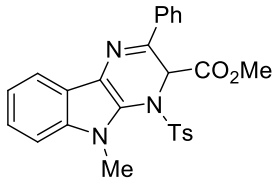
Obtained from azirine **3e** and 3-diazoindolin-2-imine **2n** (0.6 mmol) according to the general procedure B as a white solid (69 mg, yield 84%); mp 235−236 °C; R_f = 0.59 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 7.66−7.54 (m, 5H), 7.52−7.46 (m, 2H), 7.41−7.30 (m, 6H), 4.04 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 148.7, 145.6, 144.0, 143.2, 140.06, 140.05, 133.5, 130.4, 130.2, 128.9, 128.3, 128.2, 128.0, 127.6, 124.9, 118.7, 117.1, 108.2, 27.7; HRMS−ESI $[M + H]^+$ calcd for $C_{23}H_{17}{}^{79}BrN_3{}^+$ 414.0600; found 414.0617.

5-Methyl-2,3-diphenyl-5*H*-pyrido[3',2':4,5]pyrrolo[2,3-*b*]pyrazine (4af)



Obtained from azirine **3e** and 3-diazoindolin-2-imine **2o** (0.5 mmol) according to the general procedure B as a white solid (59 mg, yield 88%); mp 203−204 °C; R_f = 0.20 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 8.72−8.66 (m, 2H), 7.60−7.48 (m, 4H), 7.39−7.31 (m, 7H), 4.13 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 152.9, 149.5, 148.8, 146.7, 144.2, 140.0, 139.6, 132.0, 130.3, 130.12, 130.07, 128.3, 128.2, 128.1, 127.8, 116.8, 113.5, 26.5; HRMS−ESI $[M + H]^+$ calcd for $C_{22}H_{17}N_4{}^+$ 337.1448; found 337.1463.

Methyl 5-methyl-4-(4-methylphenylsulfonyl)-2-phenyl-4,5-dihydro-3*H*-pyrazino[2,3-*b*]indole-3-carboxylate (5a)



Obtained from azirine **3a** and 3-diazoindolin-2-imine **2a** (0.6 mmol) according to the general procedure A (temperature: 110 °C, reaction time: 2 min) as a white solid (53 mg, yield 56%); mp 100−103 °C; R_f = 0.47 (hexane−EtOAc, 3:1); ^{1}H NMR ($CDCl_3$) δ 7.82 (d, J = 7.8 Hz, 1H), 7.74−7.69 (m, 2H), 7.45 (d, J = 8.2 Hz, 1H), 7.43−7.34 (m, 4H), 7.28−7.23 (m, 1H), 7.11 (d, J = 8.2 Hz, 2H), 6.77 (d, J = 8.2 Hz, 2H), 6.03 (s, 1H), 4.04 (s, 3H), 3.60 (s, 3H), 2.22 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 166.8, 147.5, 145.0, 136.6, 135.7, 132.8, 129.7, 129.2, 128.1, 127.0, 126.8, 124.6, 123.0, 122.1, 120.9, 120.0, 118.4, 110.1, 58.1, 53.2, 31.2, 21.5; HRMS−ESI $[M + H]^+$ calcd for $C_{26}H_{24}N_3O_4S^+$ 474.1482; found 474.1499.

References

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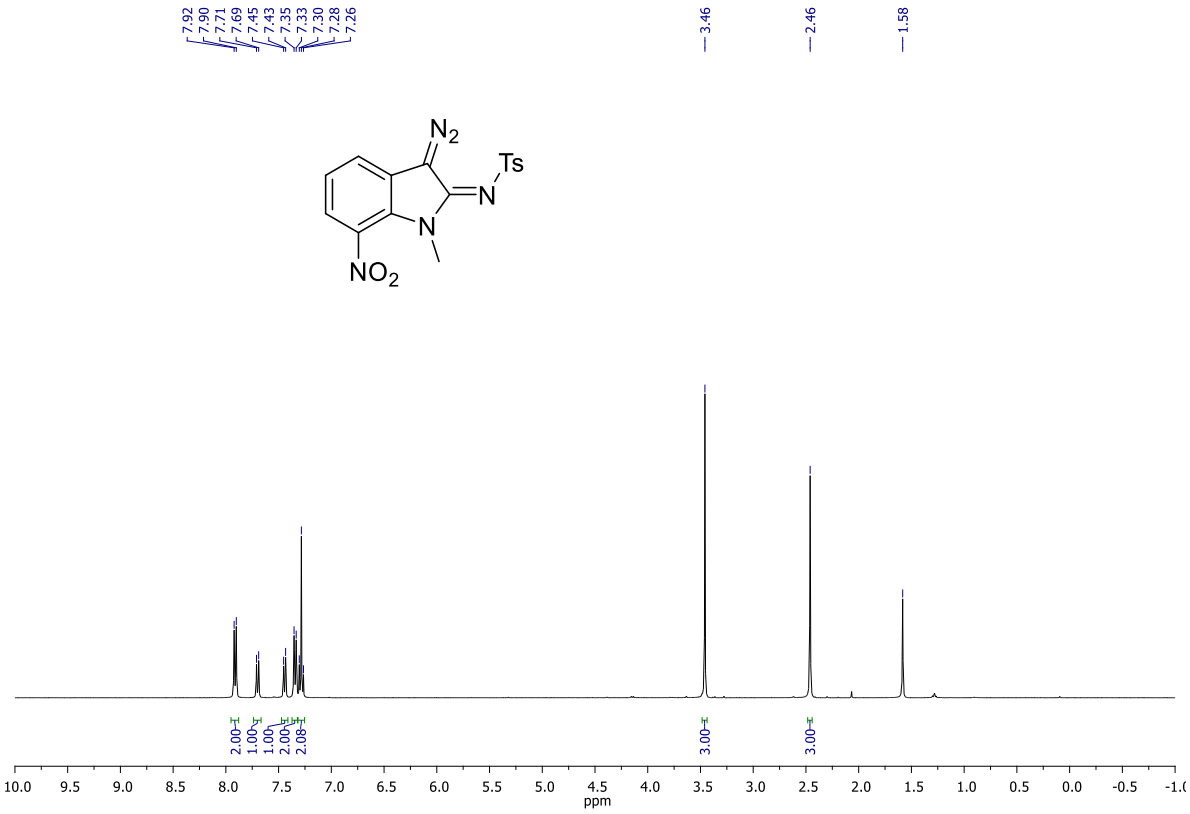
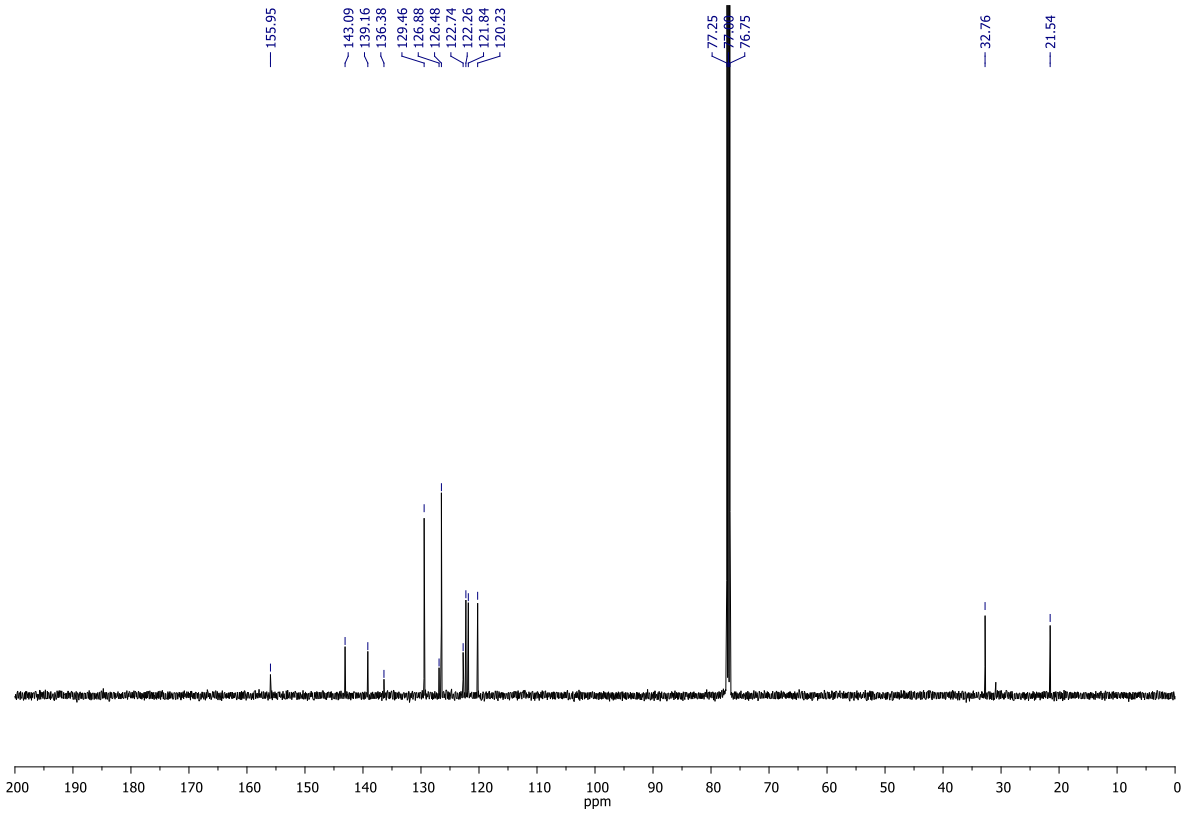
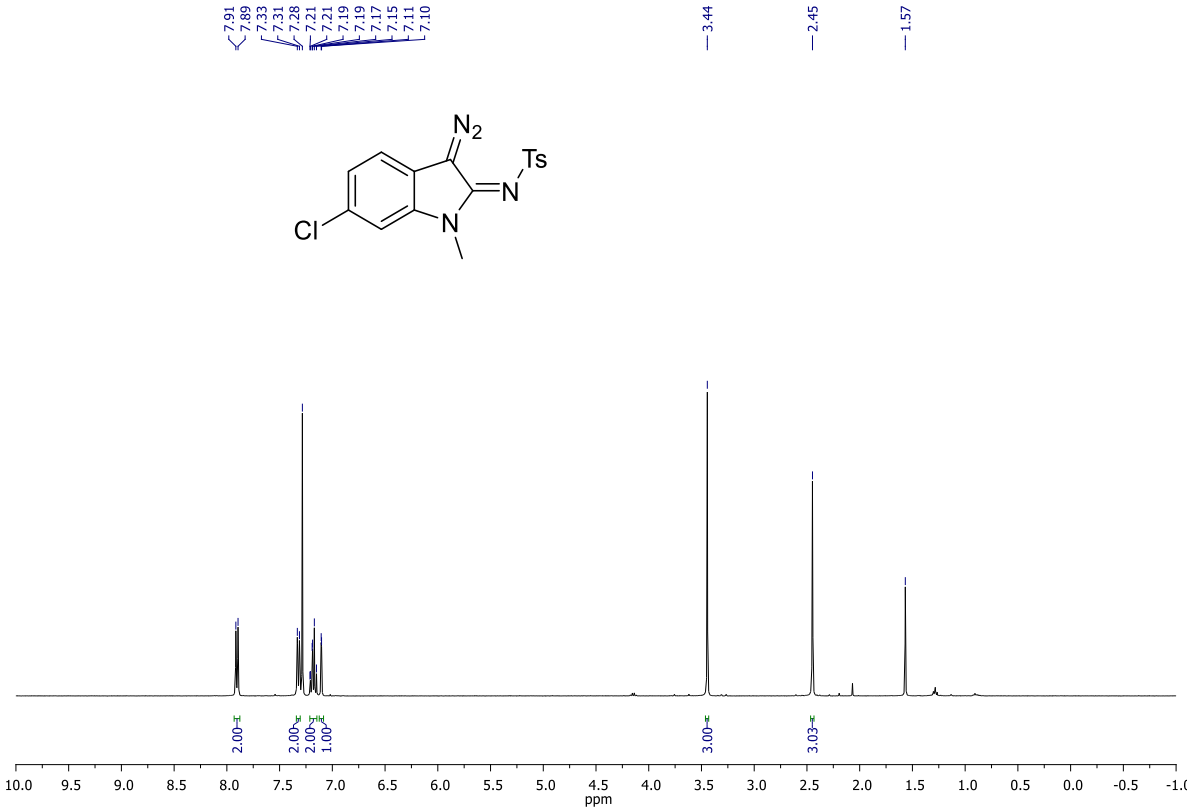
^{1}H and ^{13}C NMR spectra of 3-diazoindolin-2-imines 2h–j,n,o

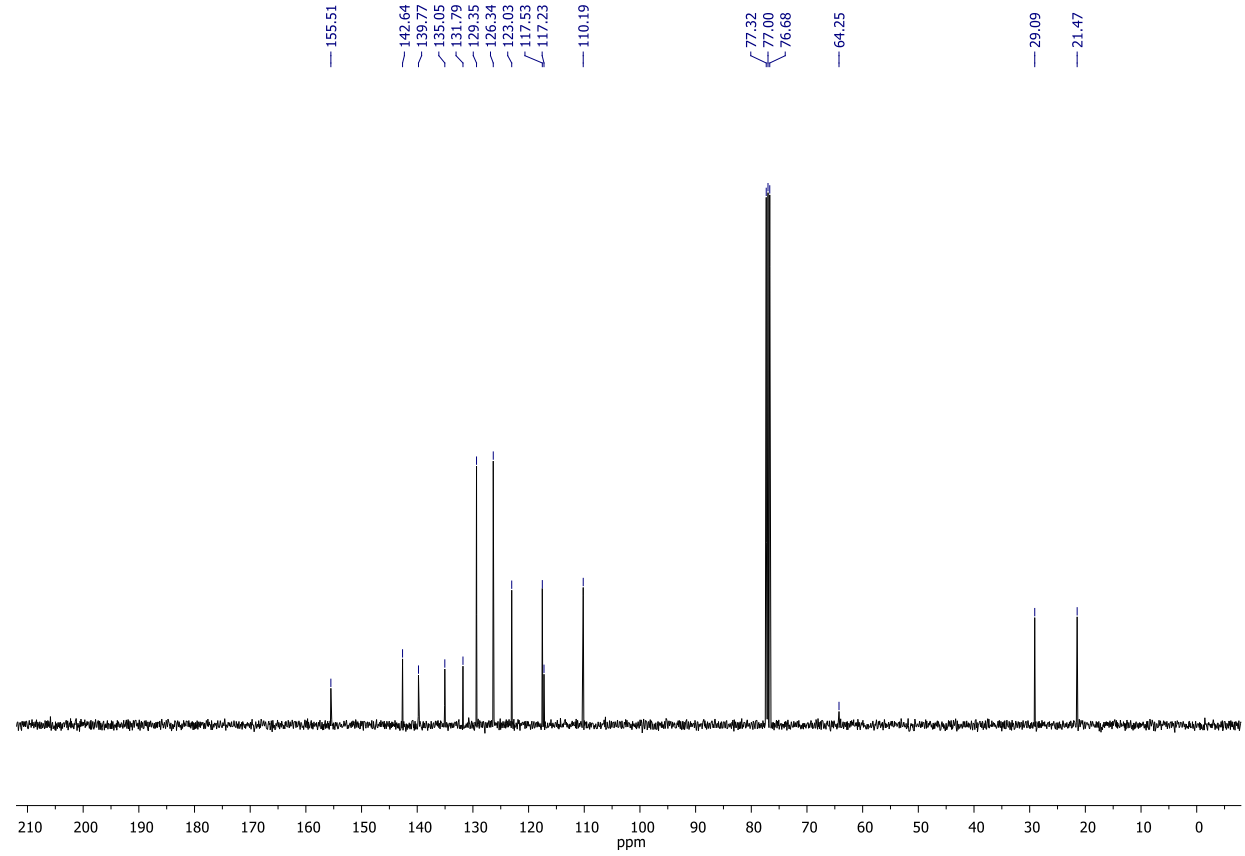
^{1}H and ^{13}C NMR spectra of compound **2h**



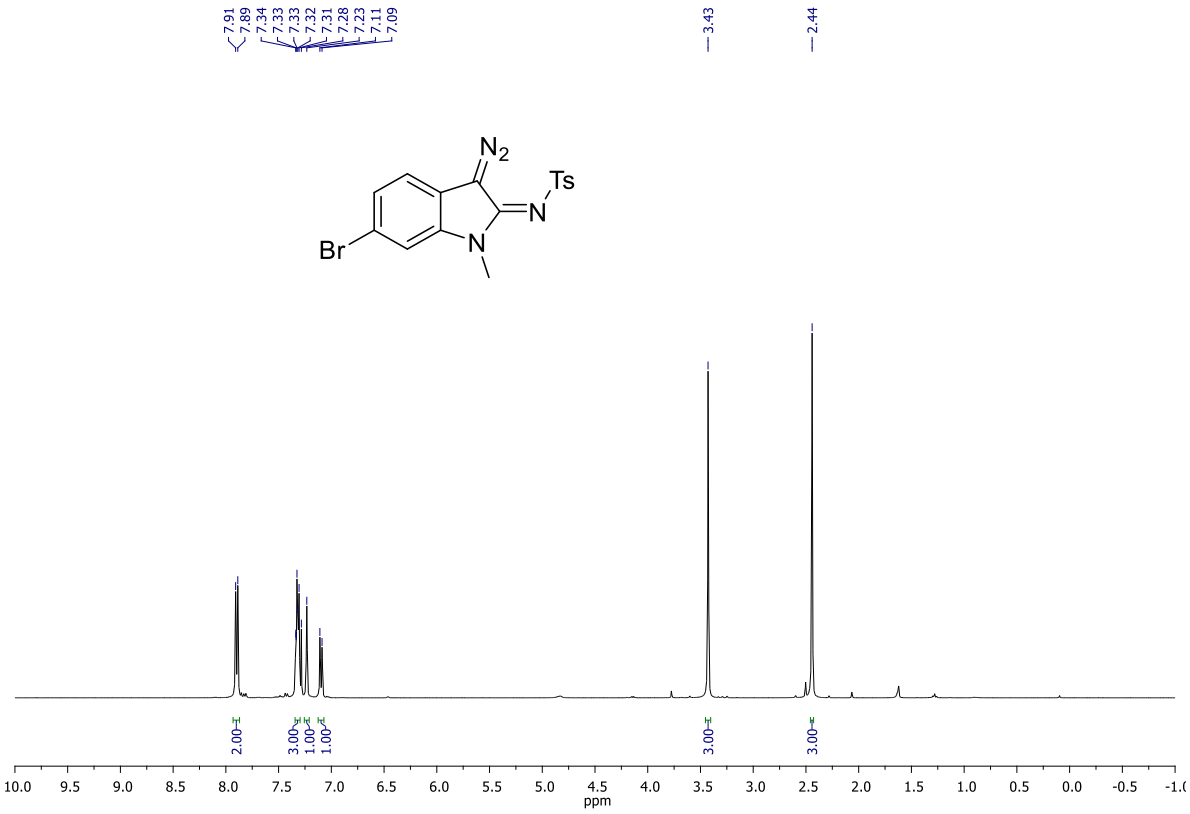


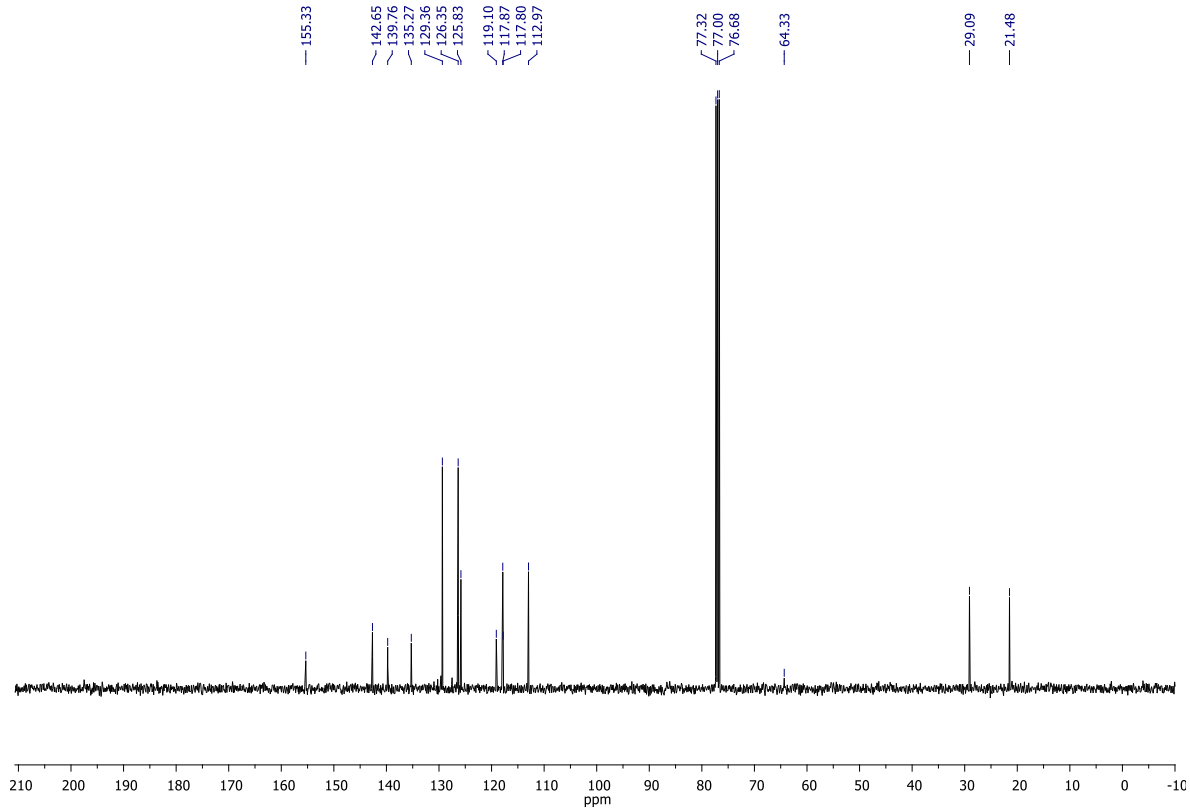
^{1}H and ^{13}C NMR spectra of compound **2i**



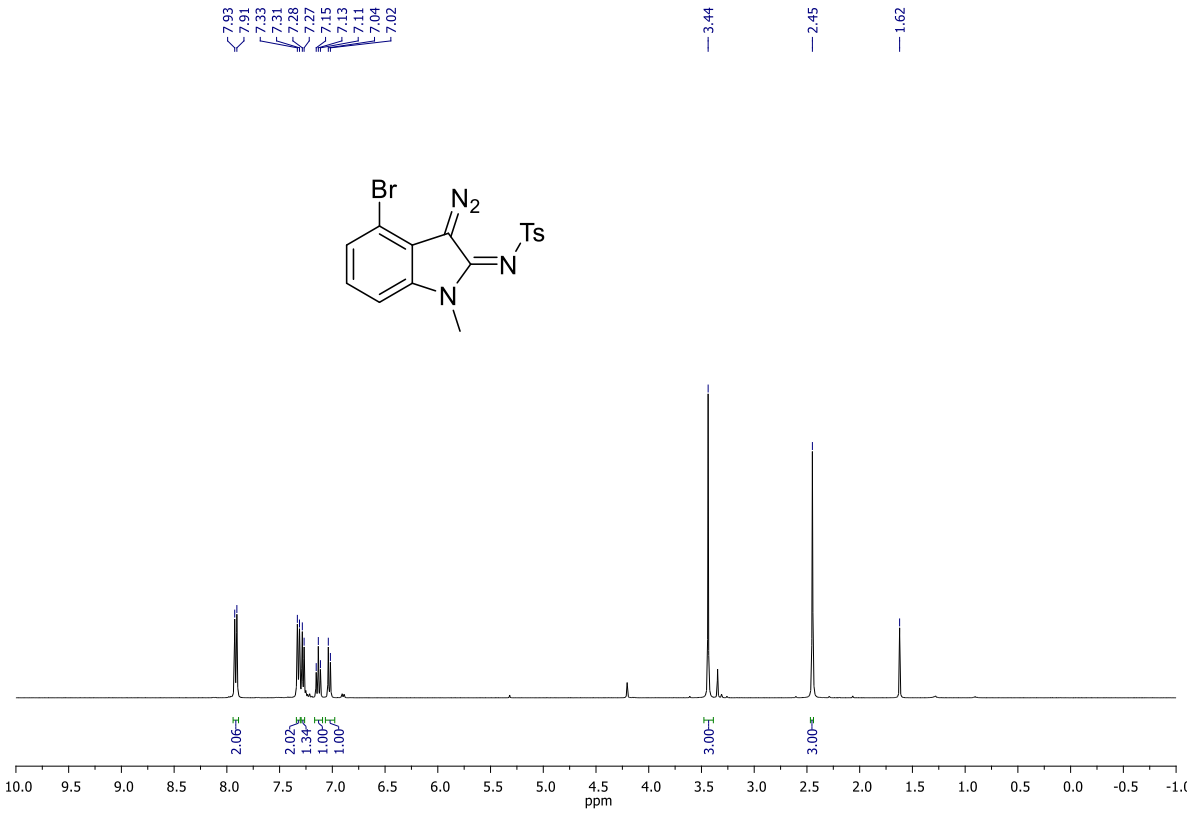


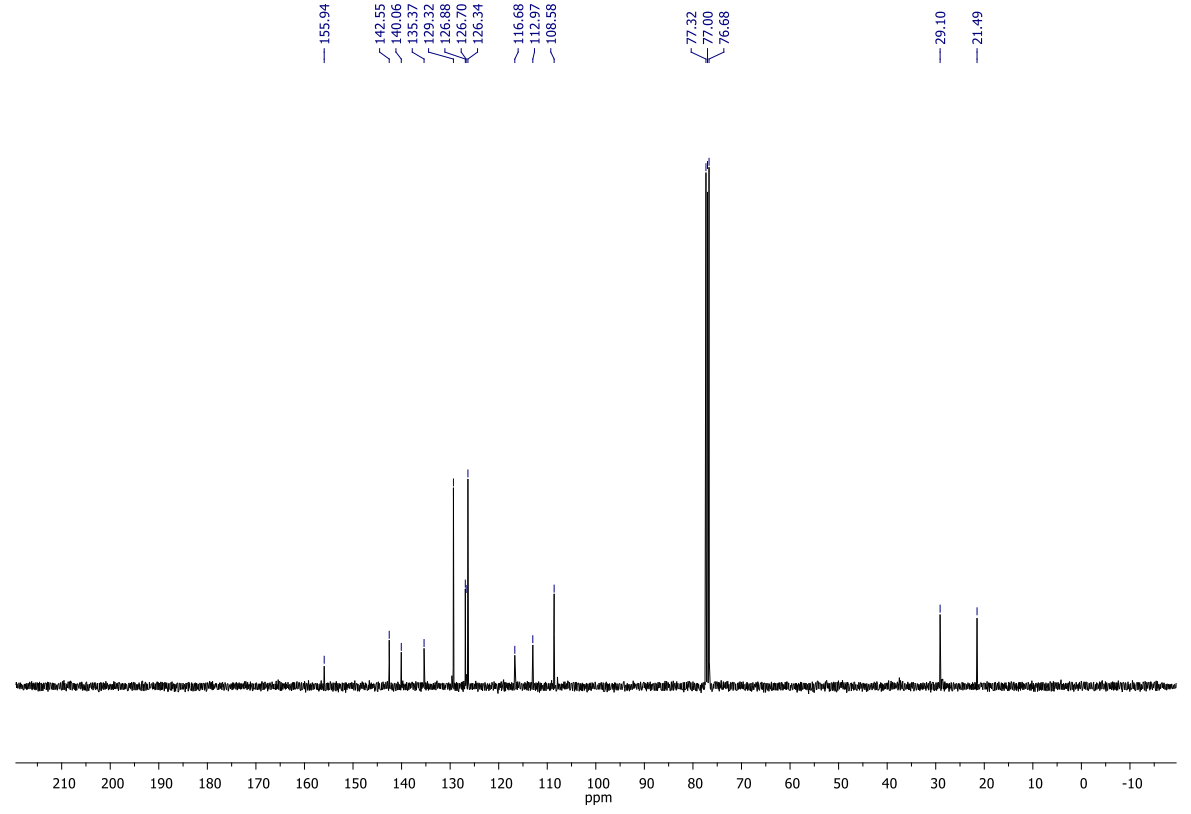
^{1}H and ^{13}C NMR spectra of compound **2j**



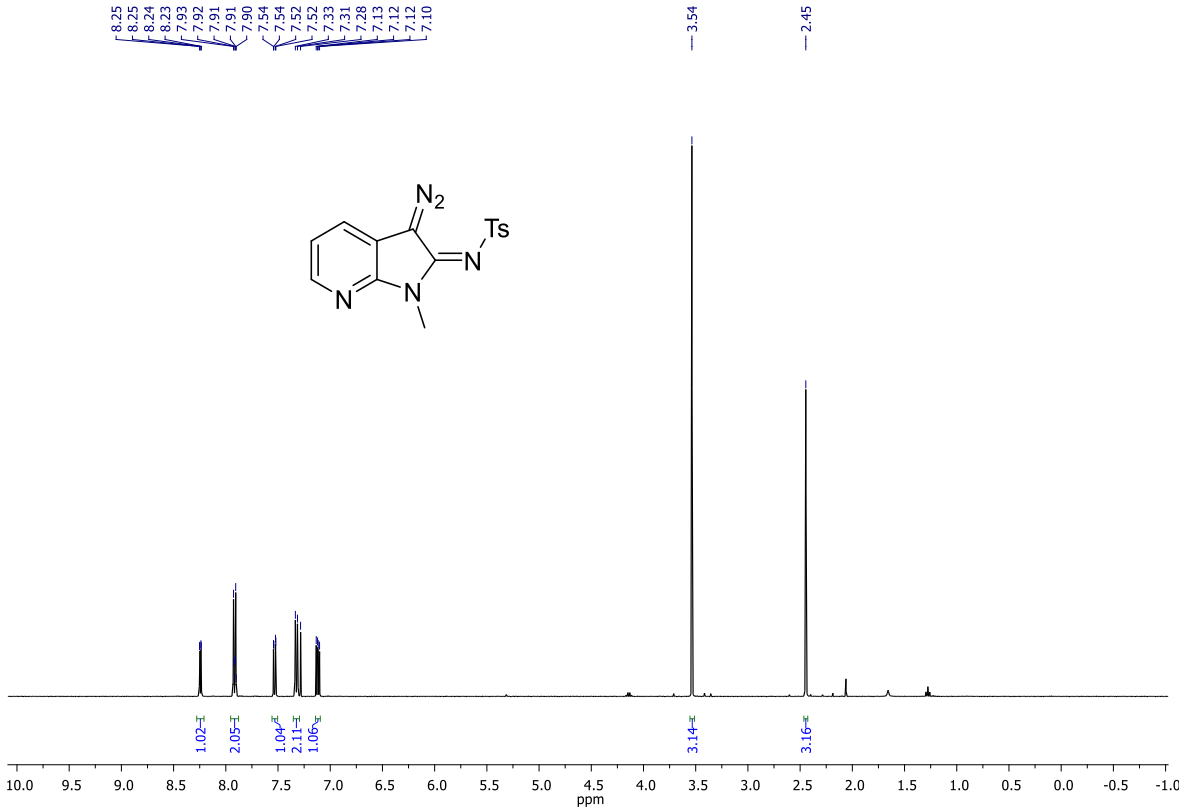


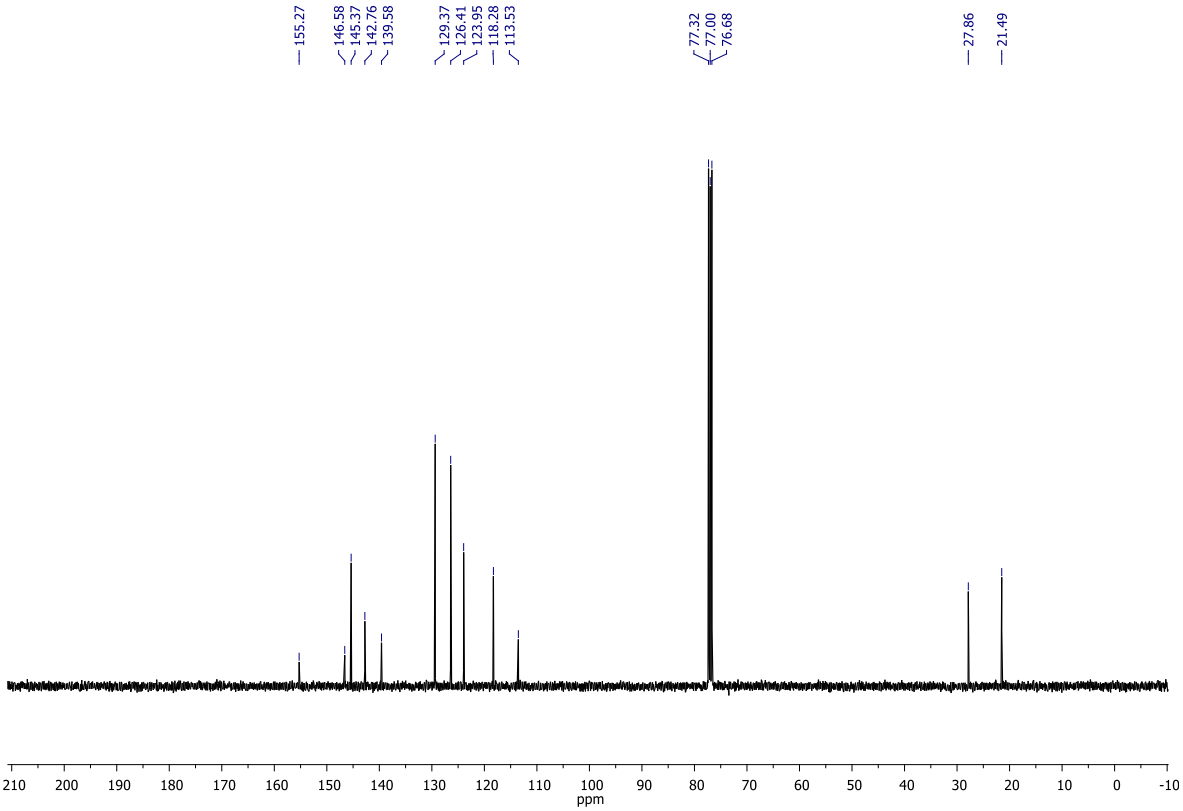
^{1}H and ^{13}C NMR spectra of compound **2n**





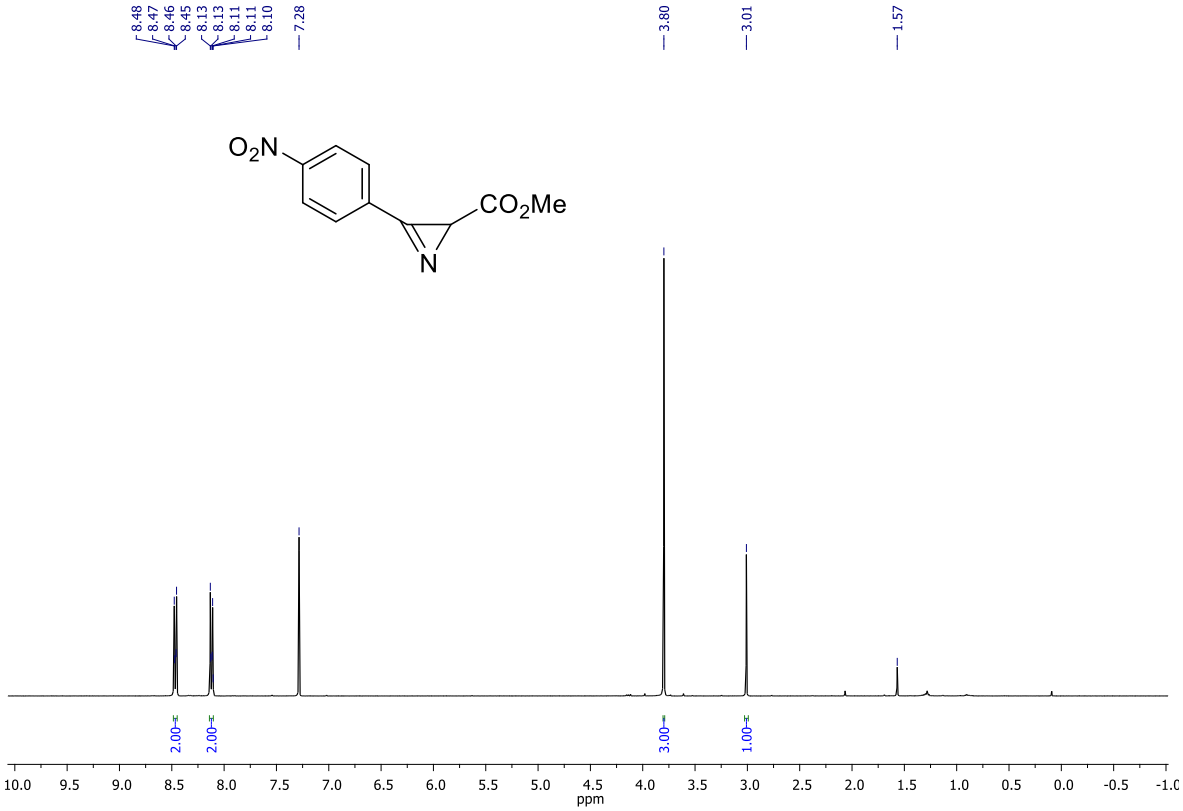
^{1}H and ^{13}C NMR spectra of compound **2o**

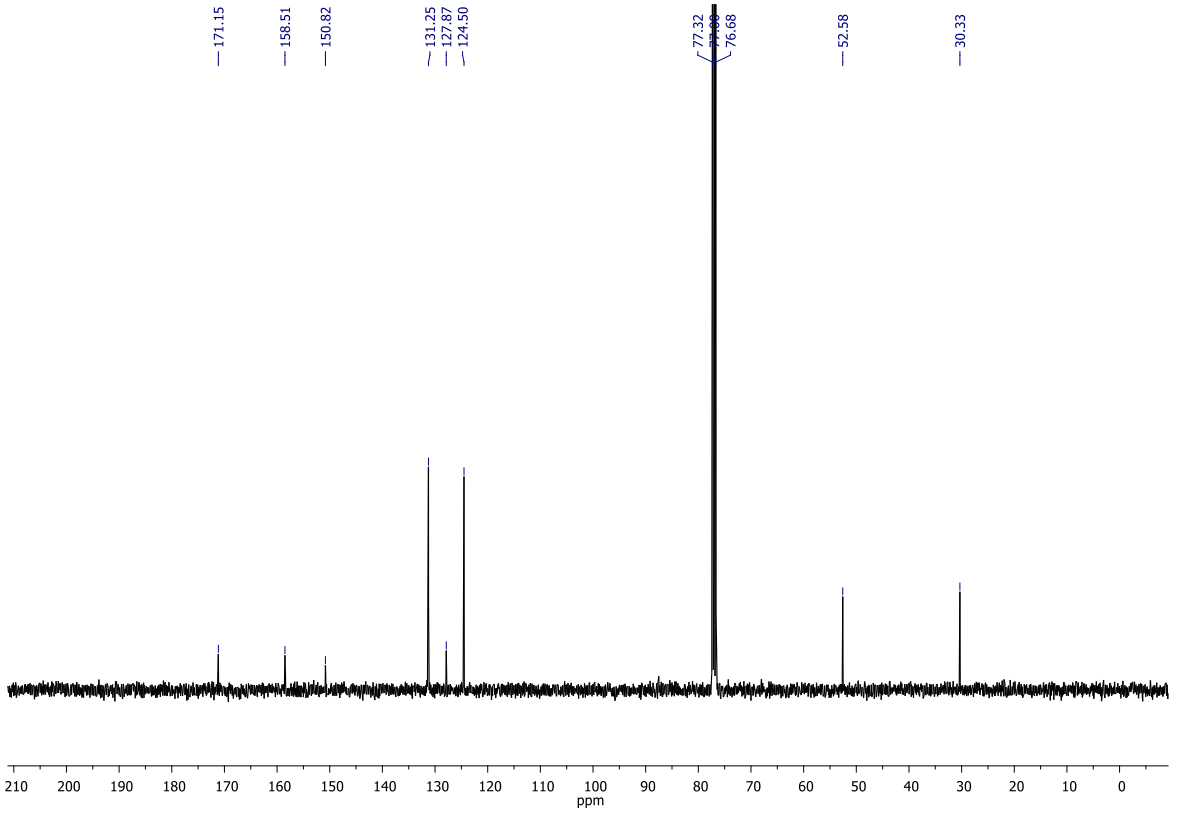




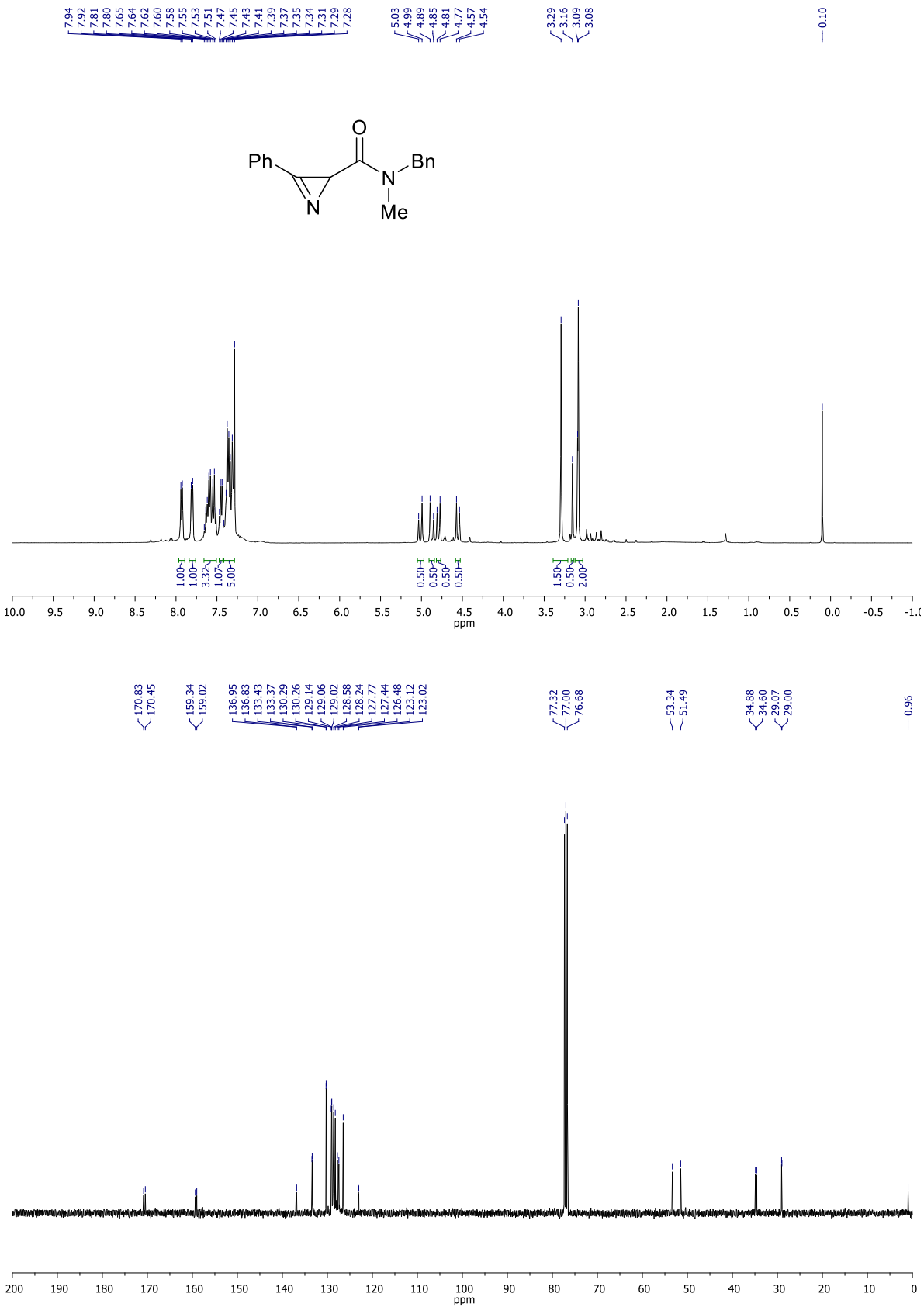
^{1}H and ^{13}C NMR spectra of azirines 3d,l

^{1}H and ^{13}C NMR spectra of compound **3d**



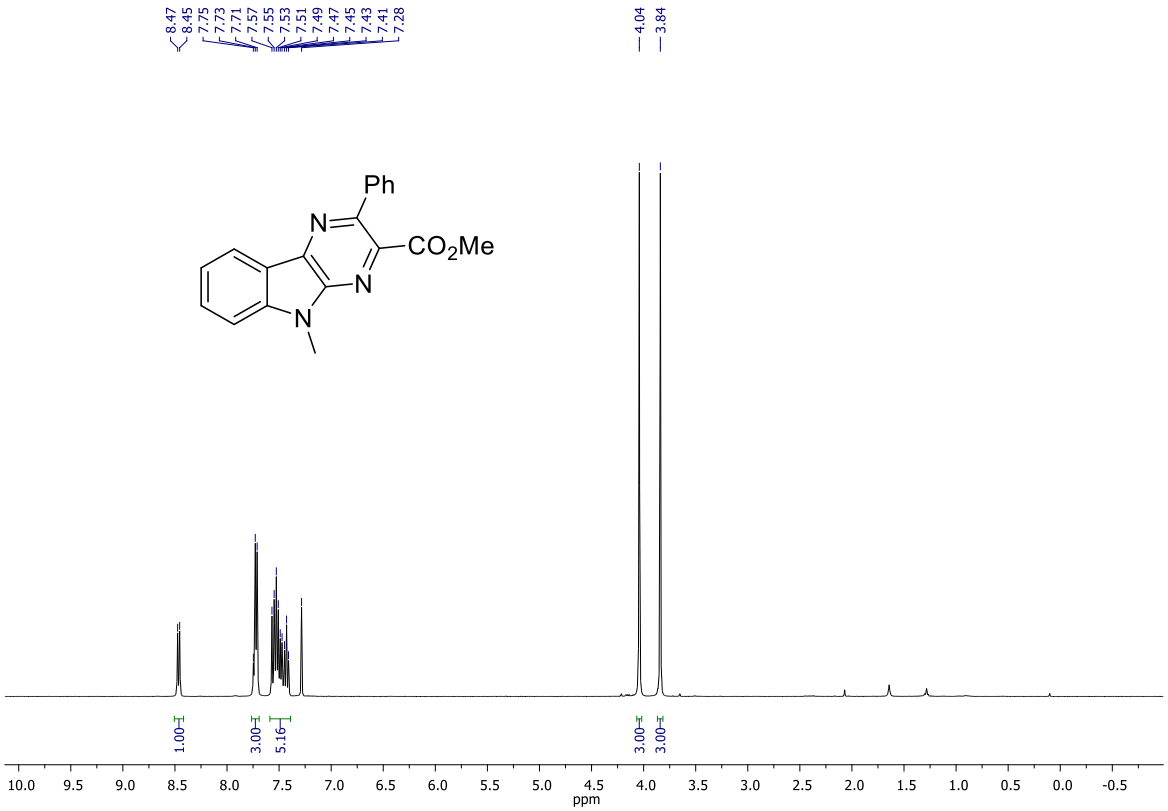


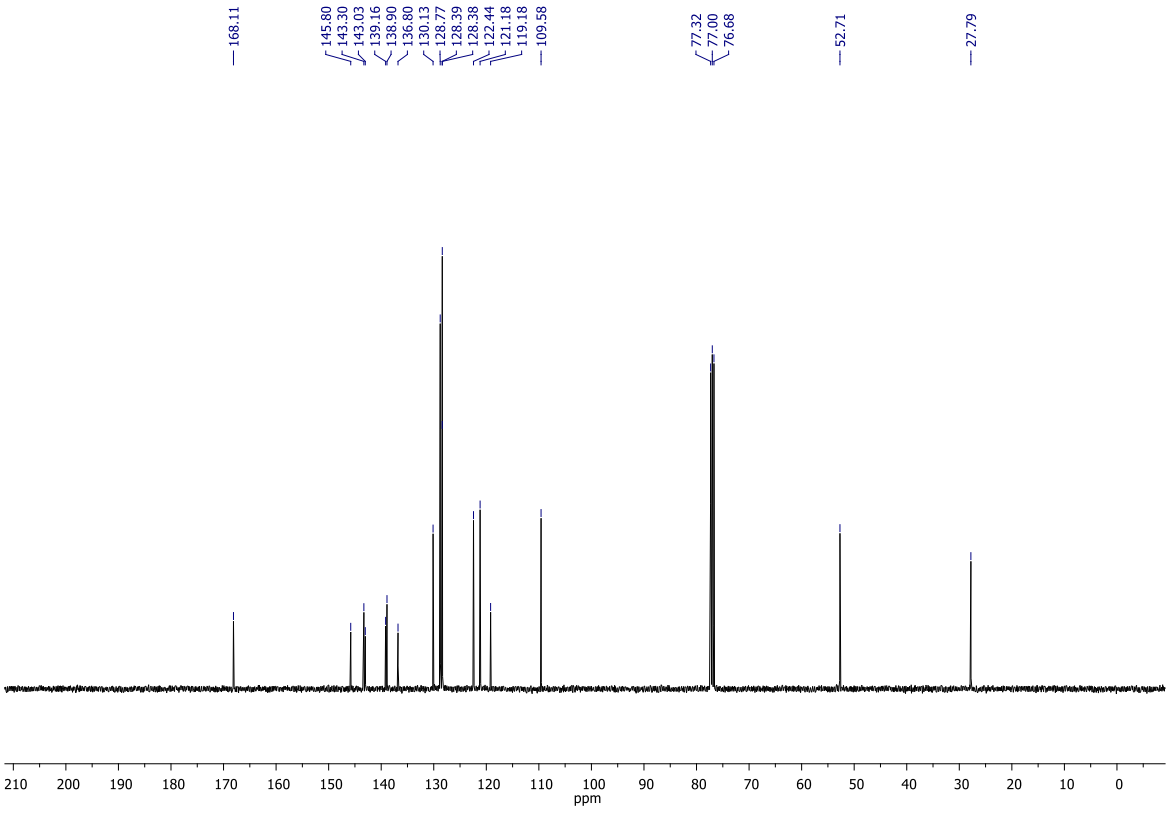
^{1}H and ^{13}C NMR spectra of compound **3l** (rotameric mixture ~ 1:1)



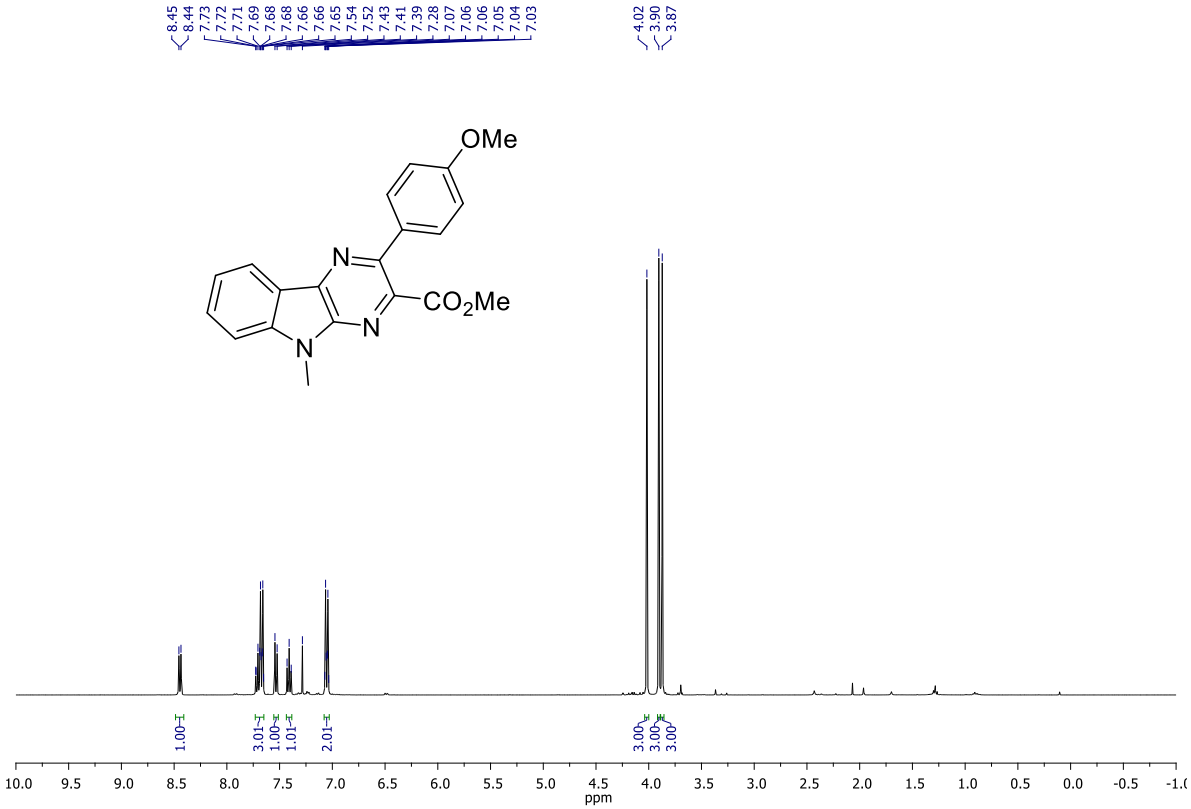
^{1}H and ^{13}C NMR spectra of 5*H*-pyrazino[2,3-*b*]indoles 4

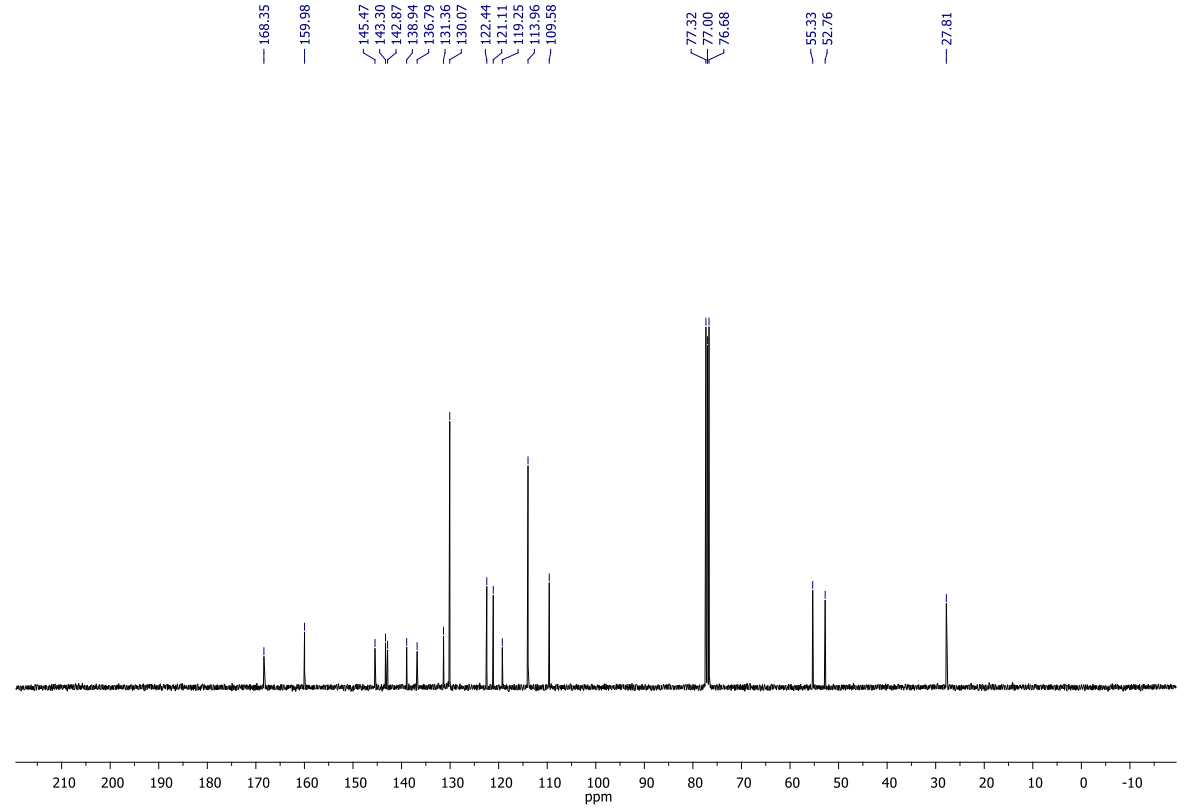
^{1}H and ^{13}C NMR spectra of compound **4a**



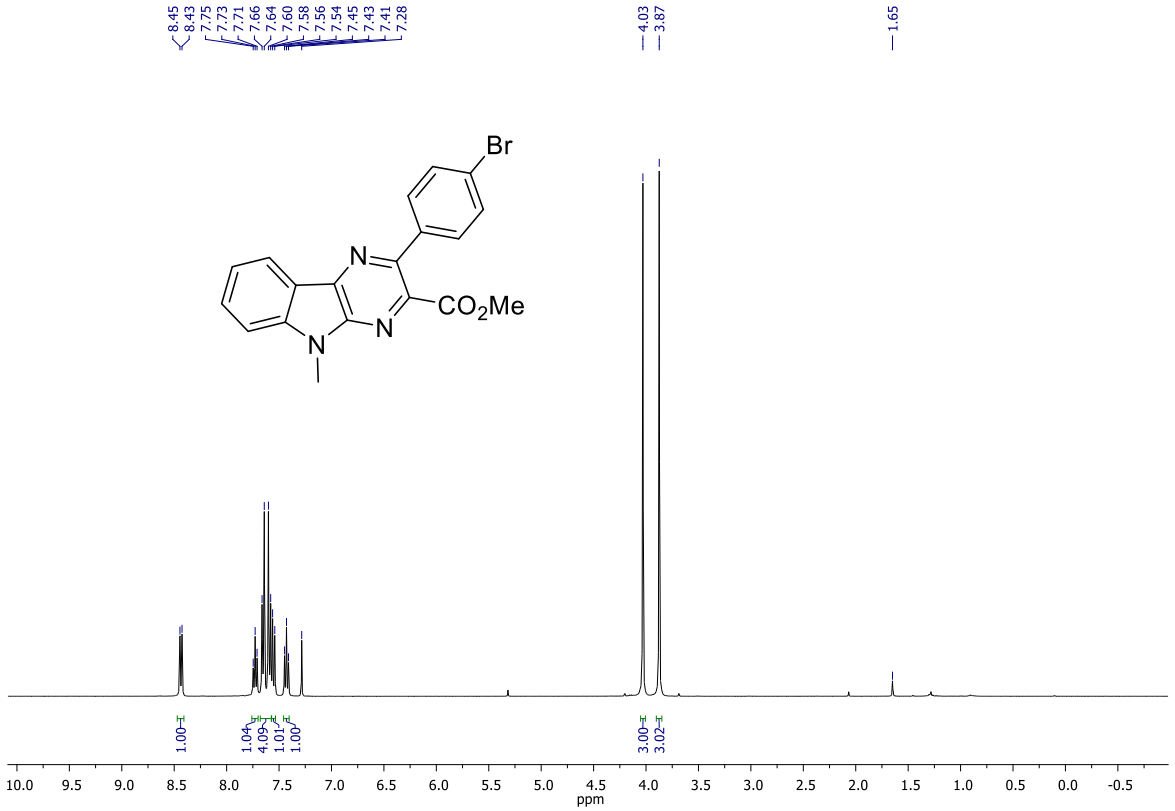


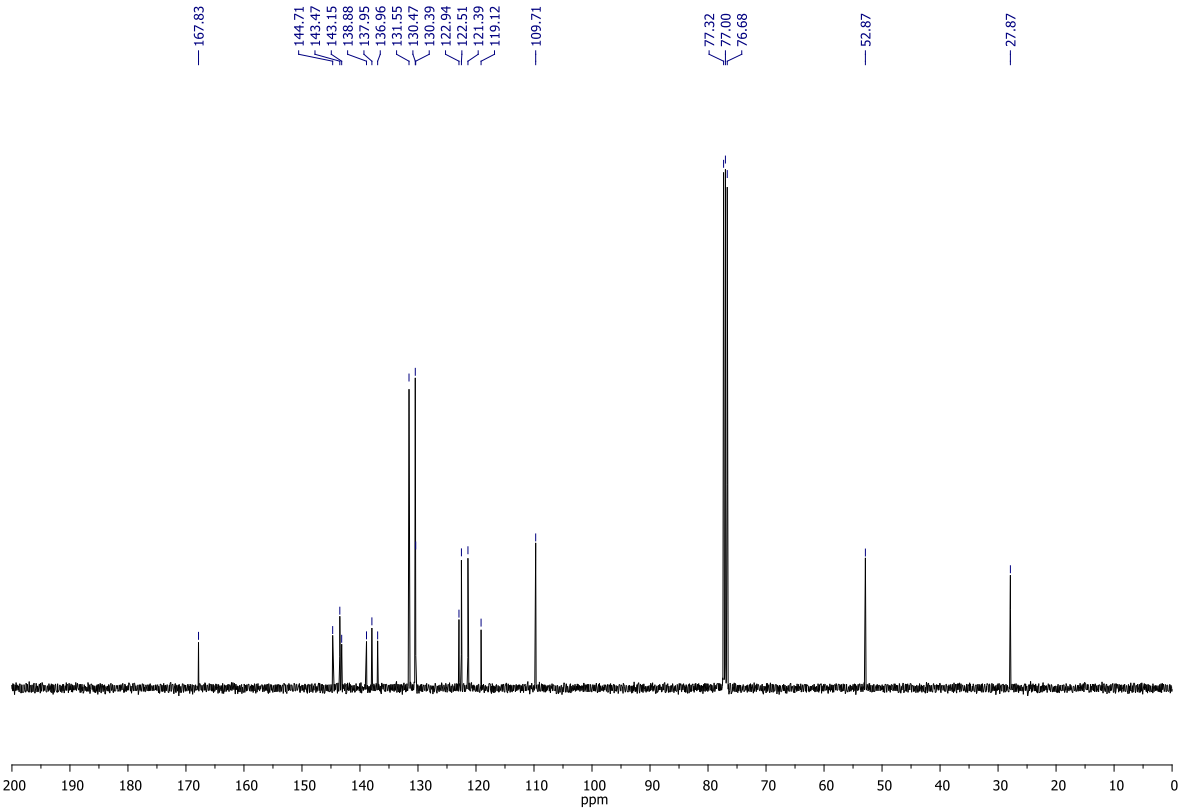
^{1}H and ^{13}C NMR spectra of compound **4b**



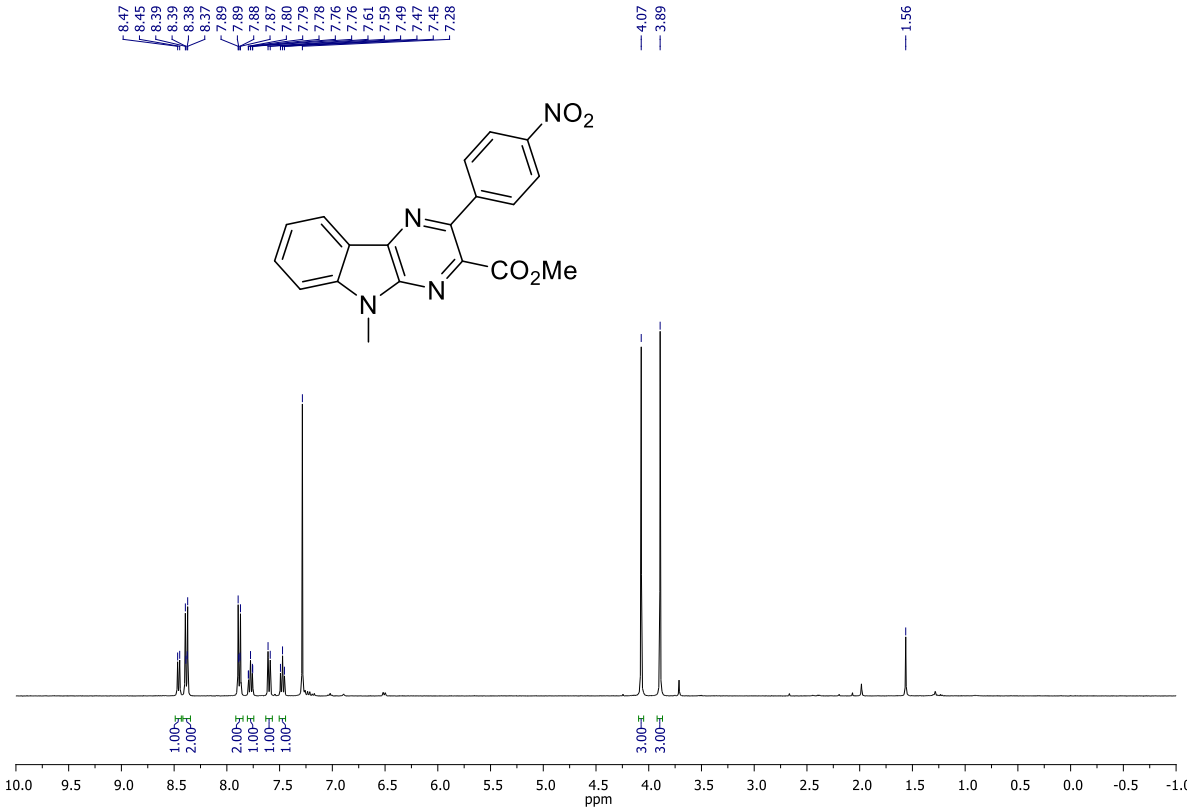


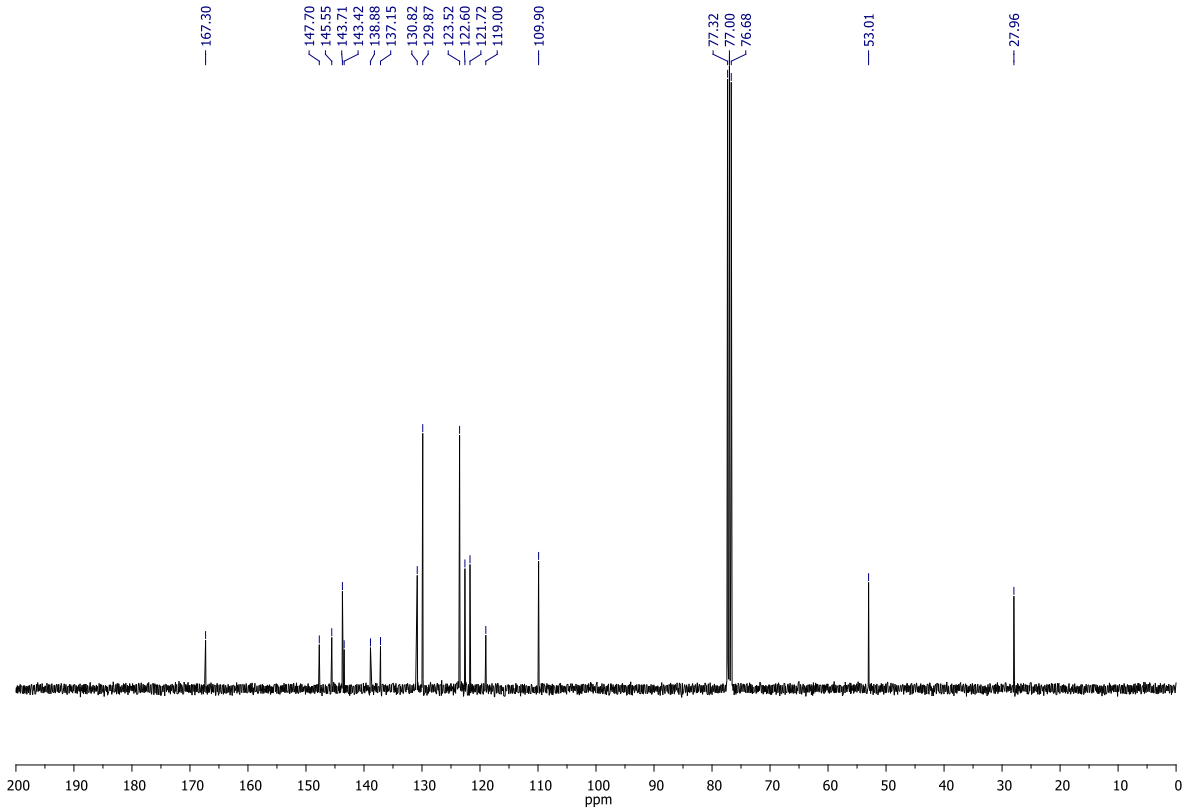
^{1}H and ^{13}C NMR spectra of compound **4c**



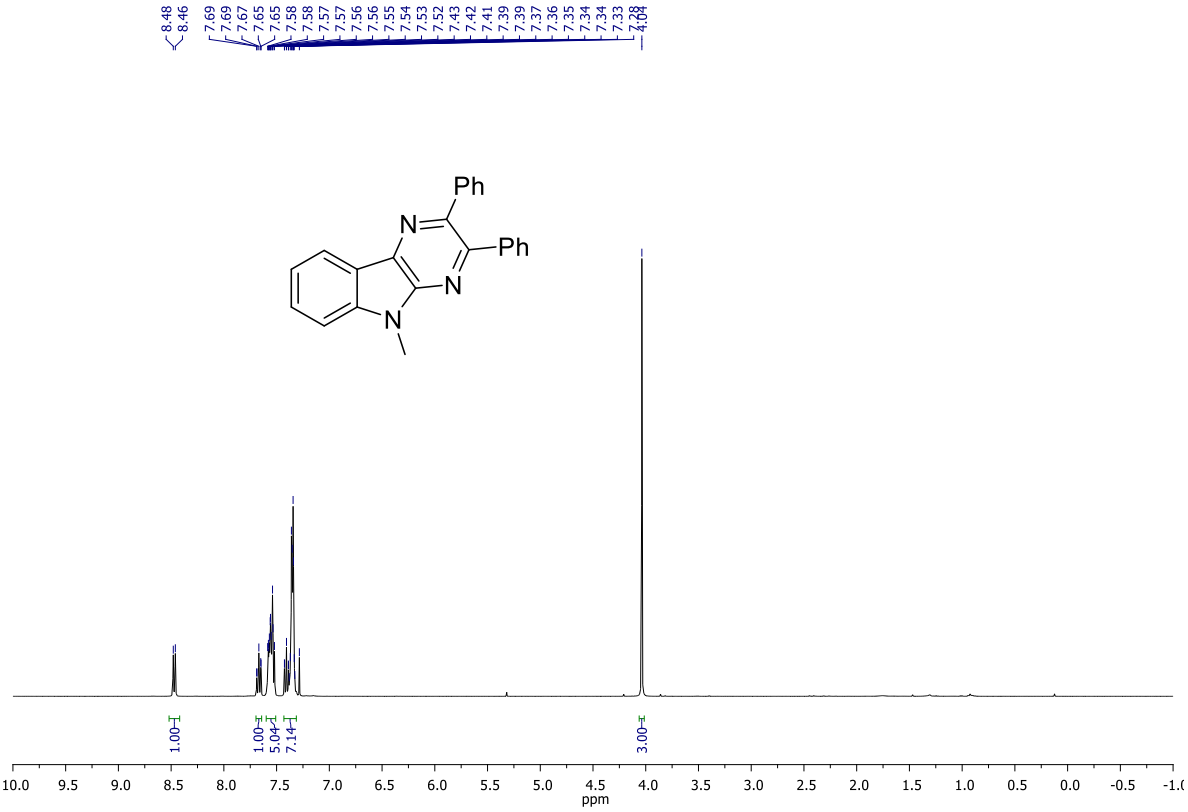


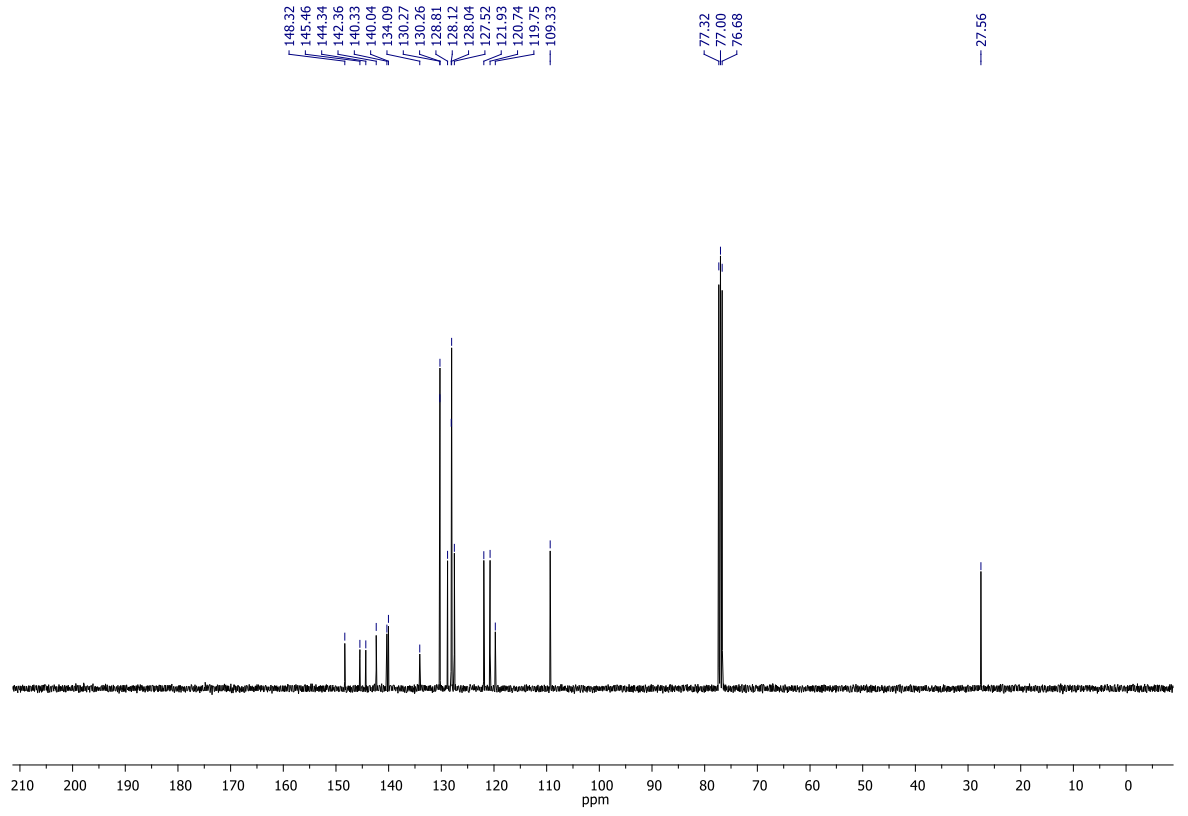
^{1}H and ^{13}C NMR spectra of compound **4d**



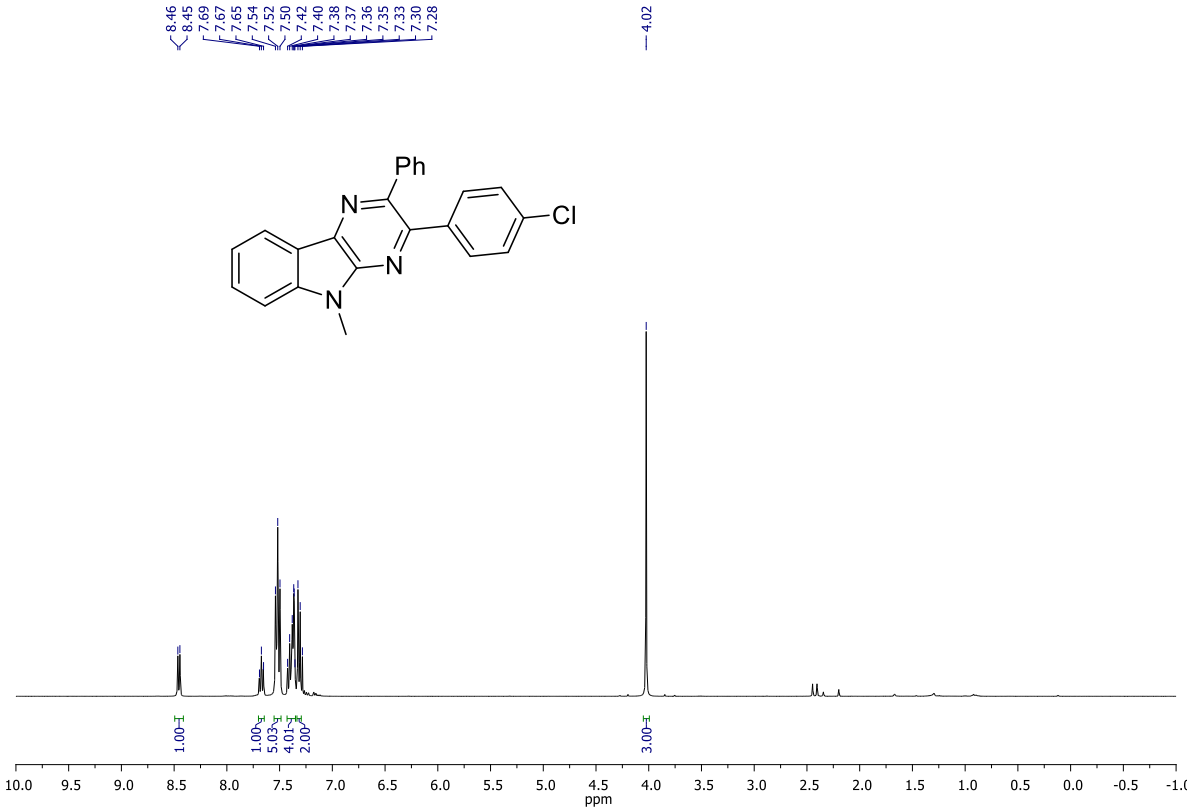


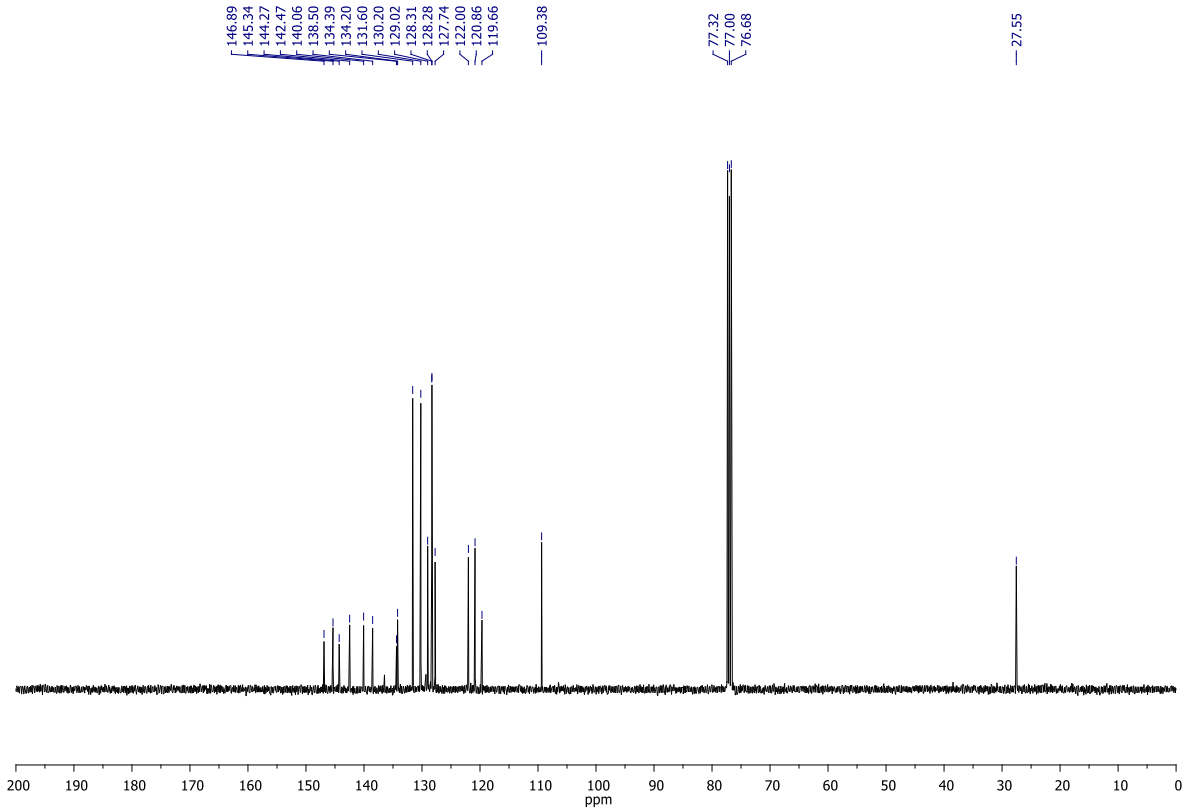
^{1}H and ^{13}C NMR spectra of compound **4e**



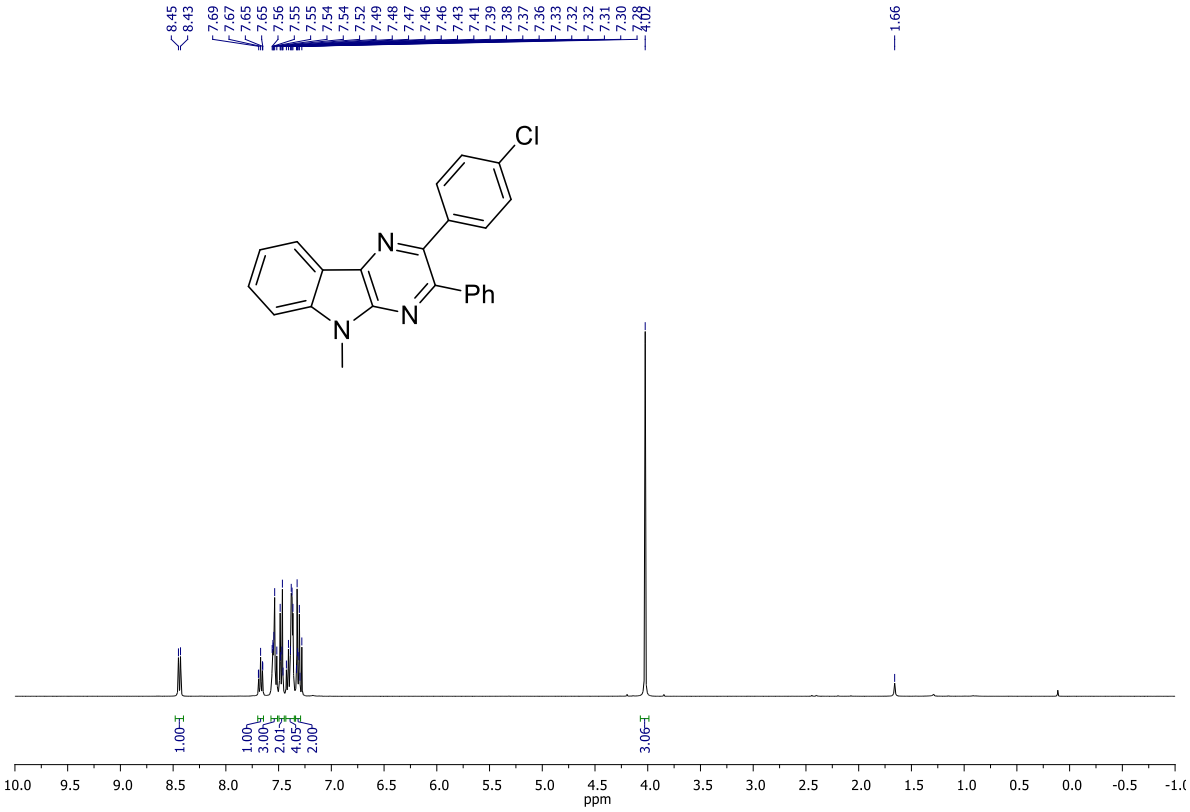


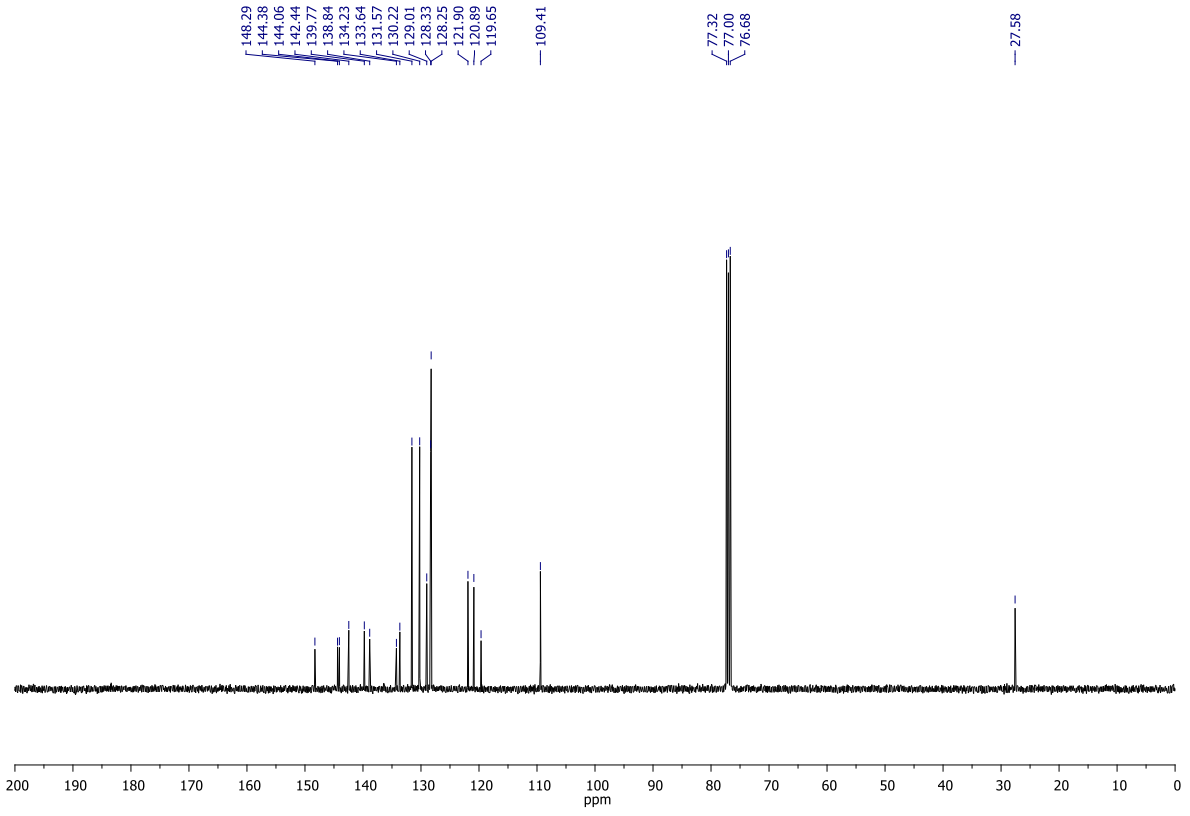
^{1}H and ^{13}C NMR spectra of compound **4f**



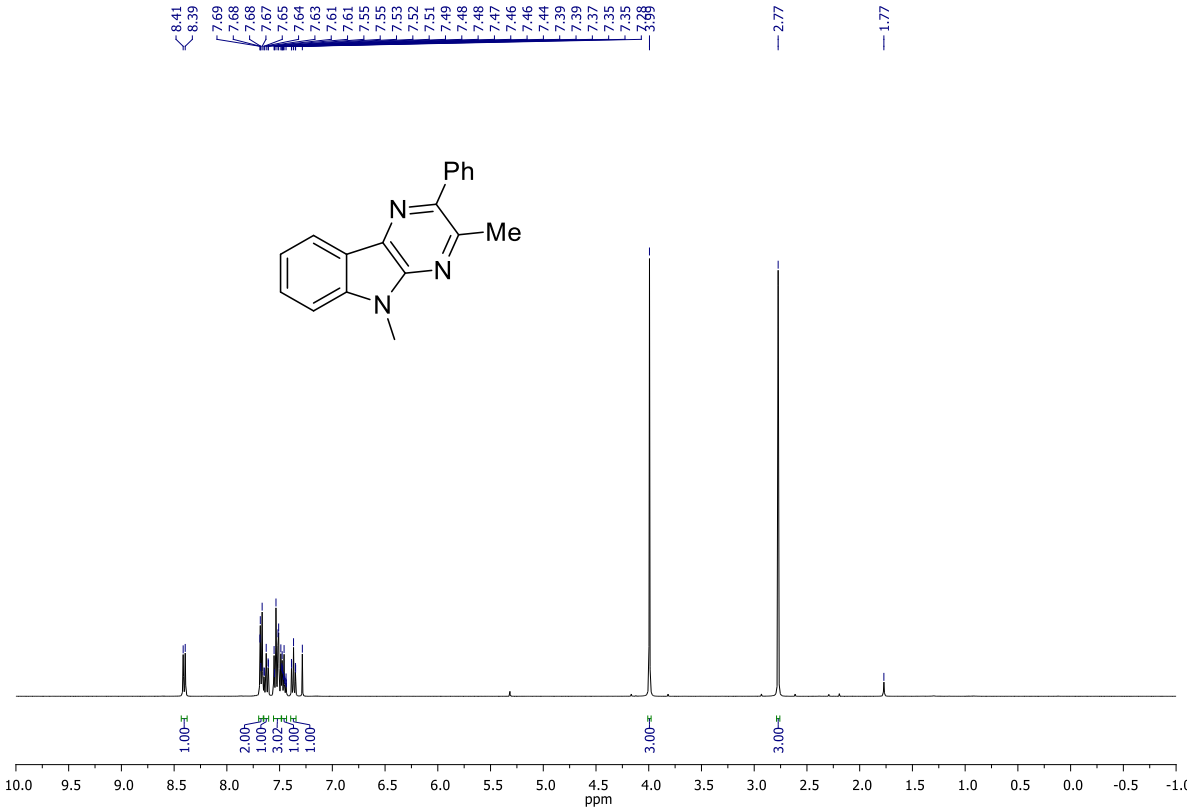


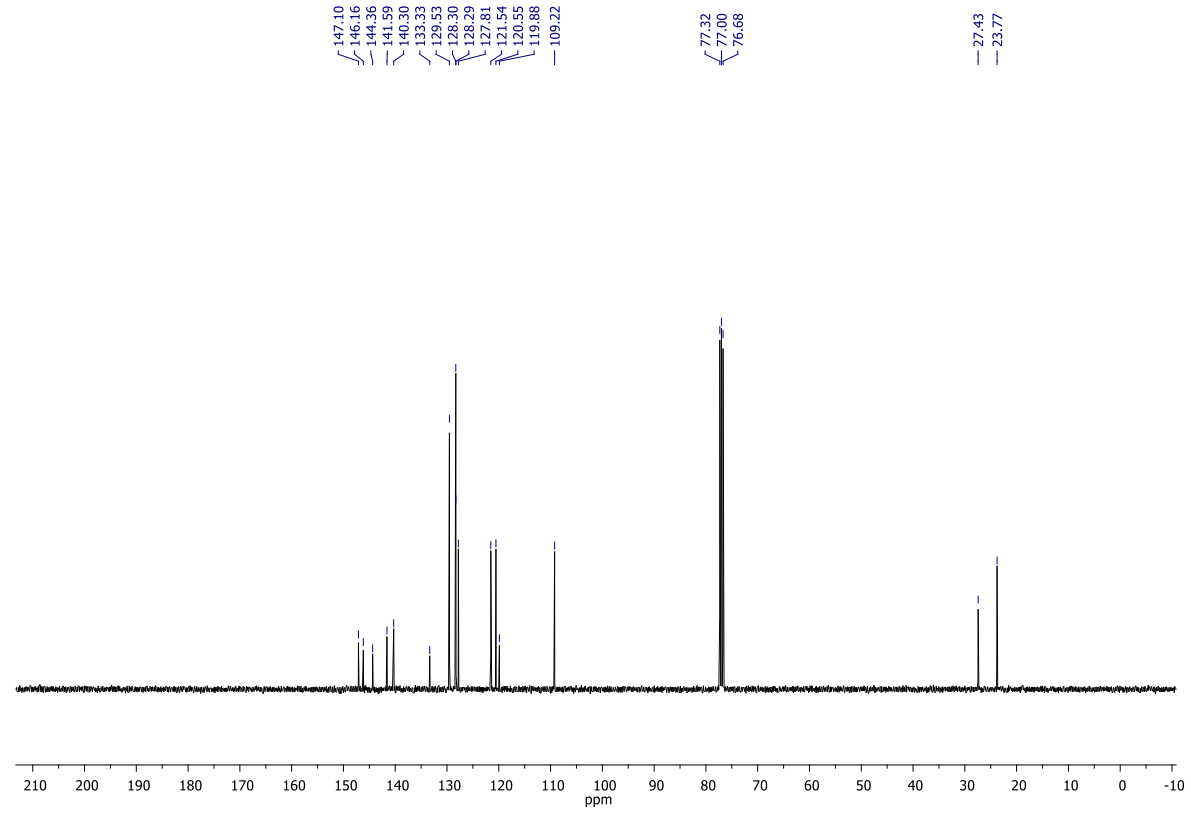
^{1}H and ^{13}C NMR spectra of compound **4g**



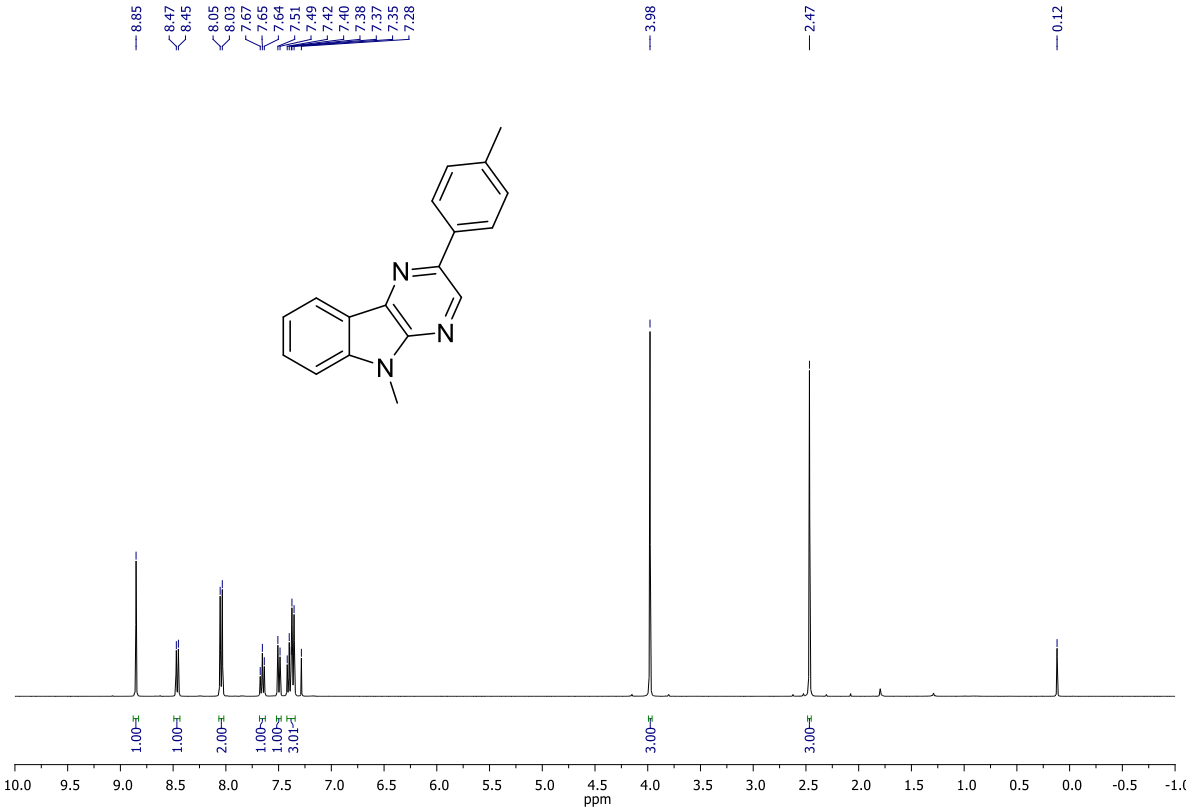


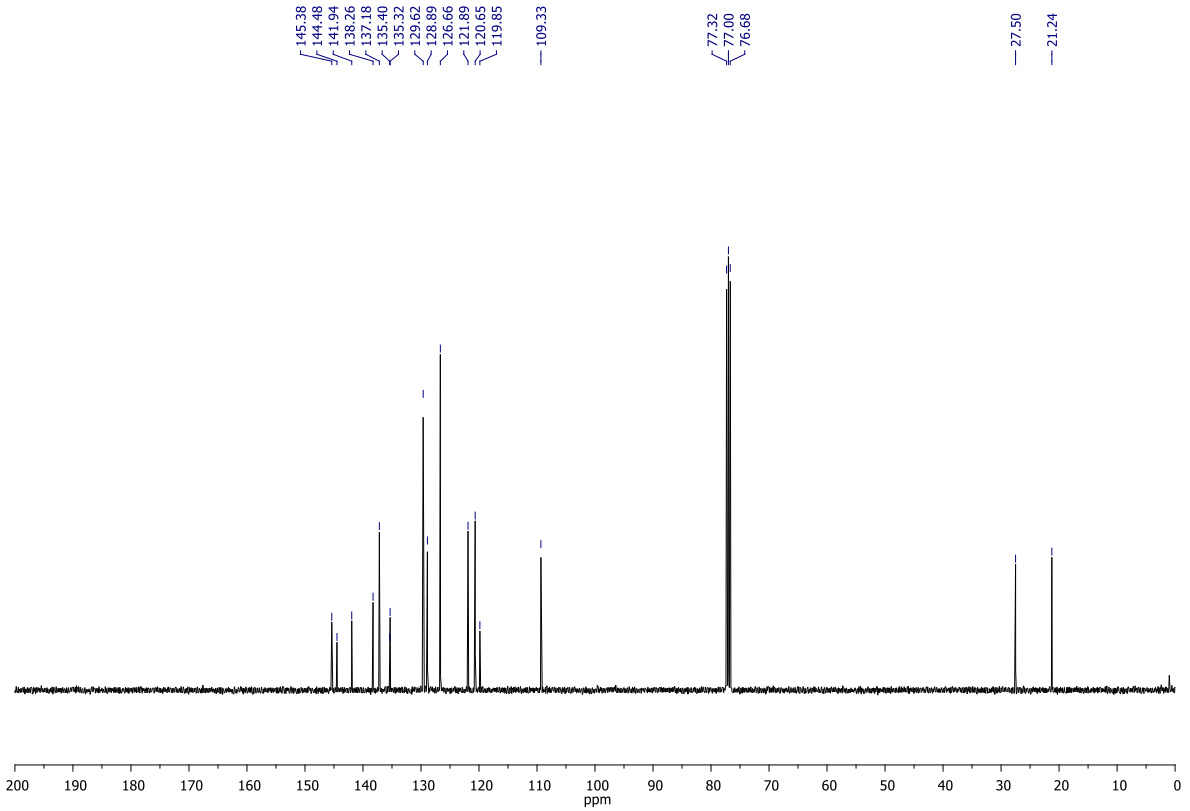
^{1}H and ^{13}C NMR spectra of compound **4h**



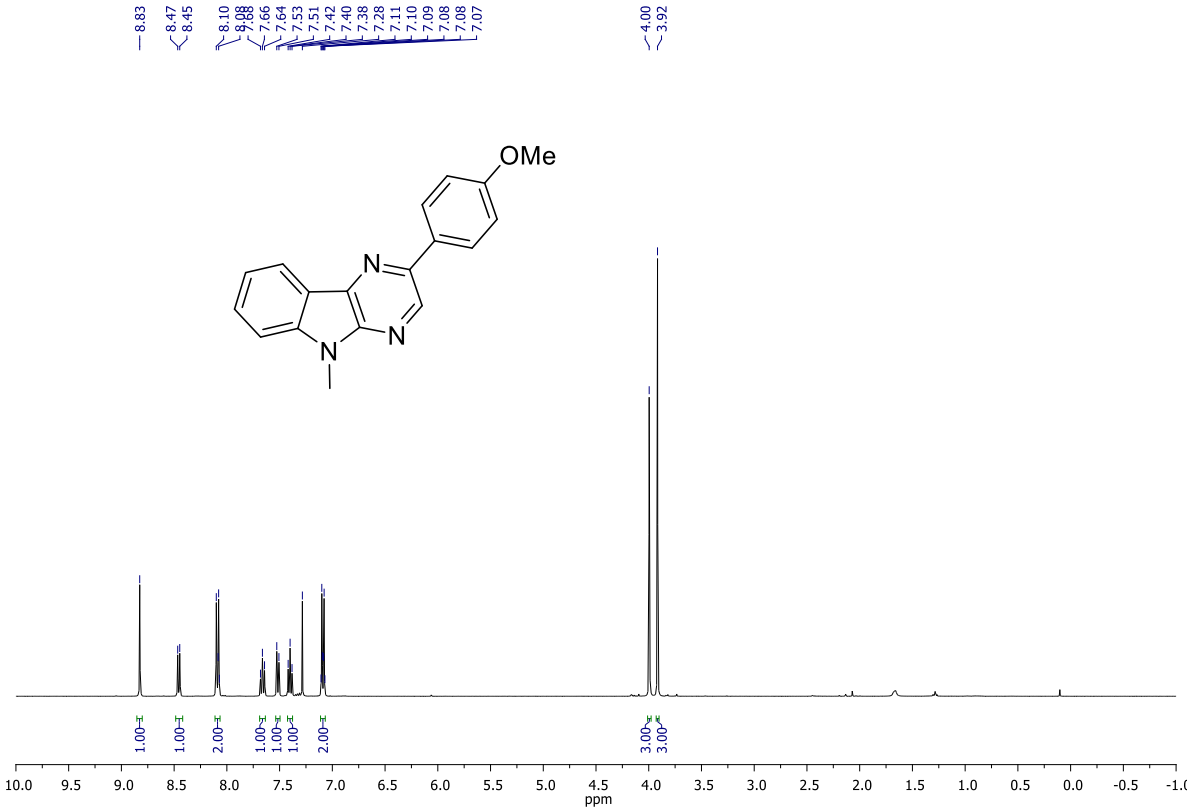


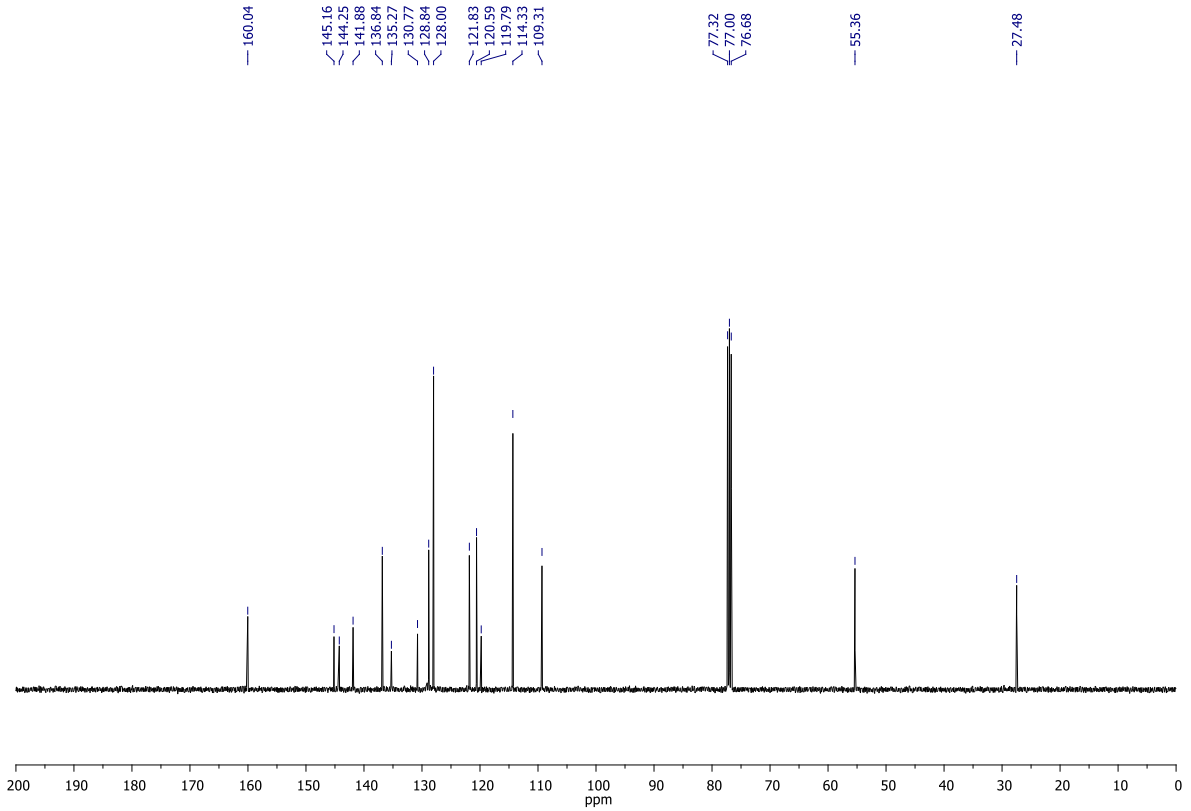
^{1}H and ^{13}C NMR spectra of compound **4i**



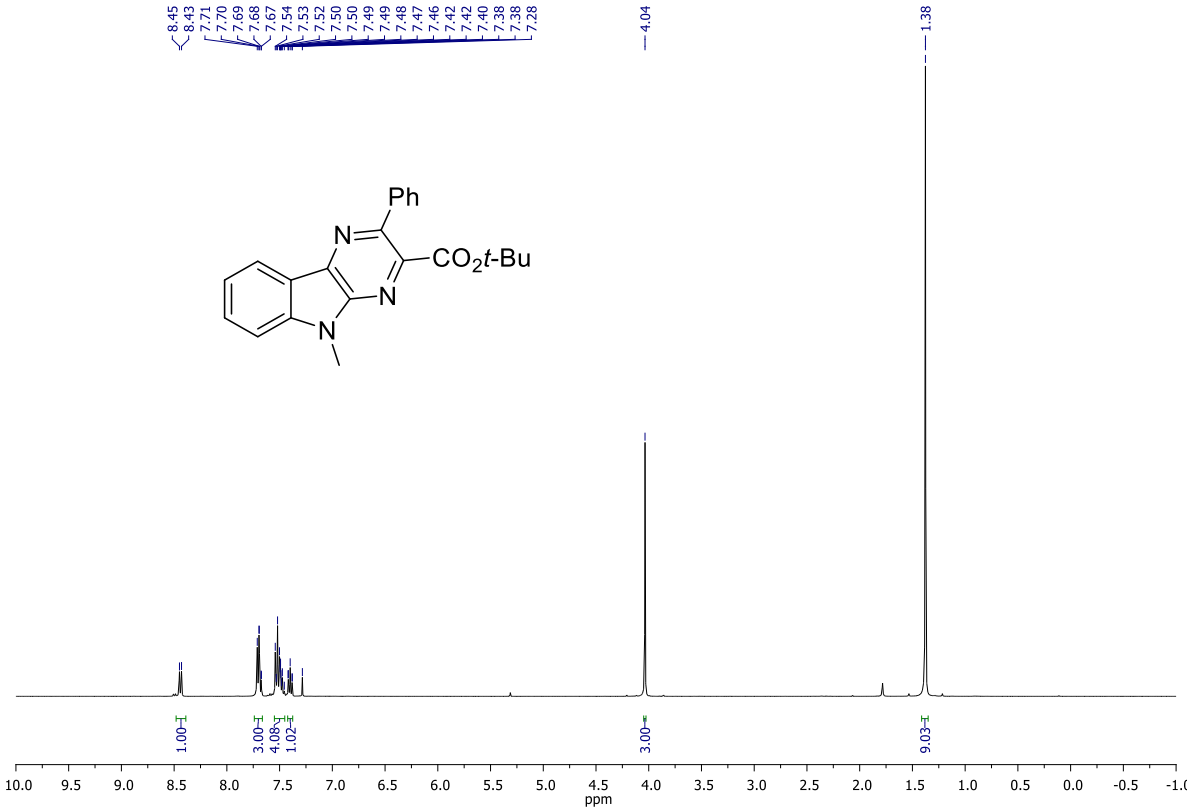


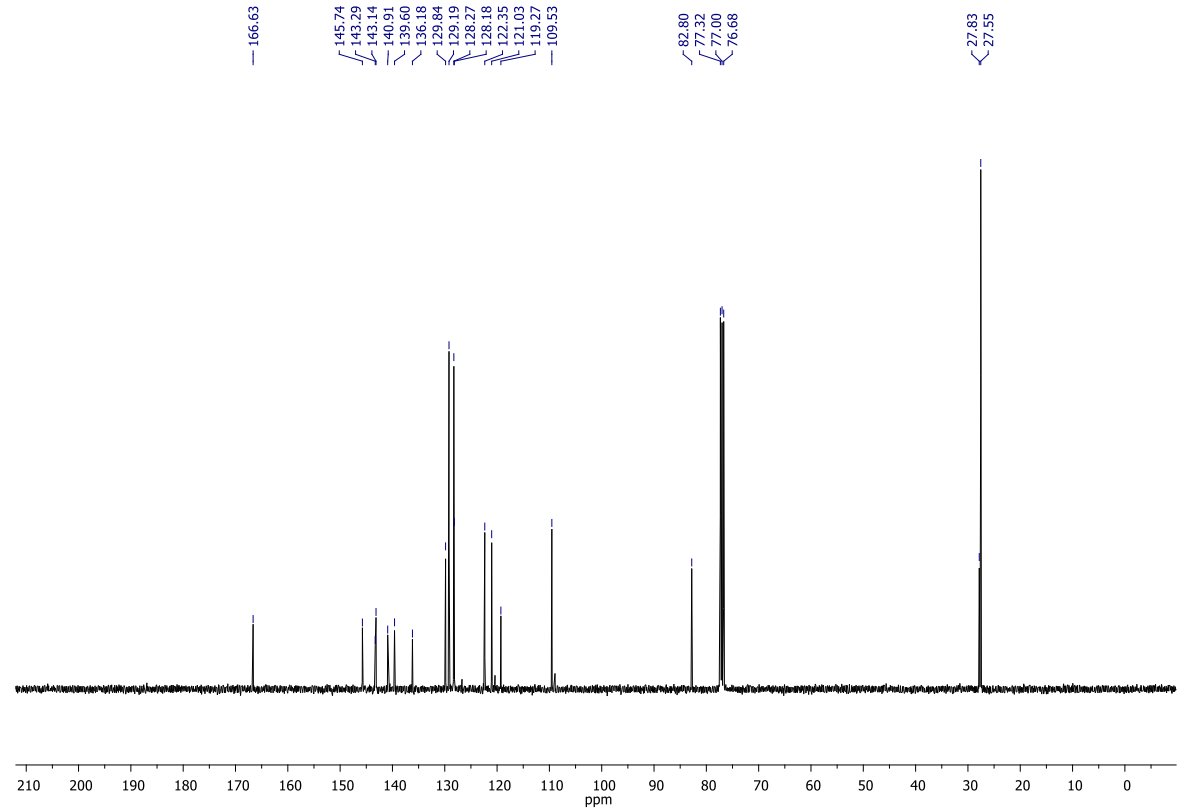
^{1}H and ^{13}C NMR spectra of compound **4j**



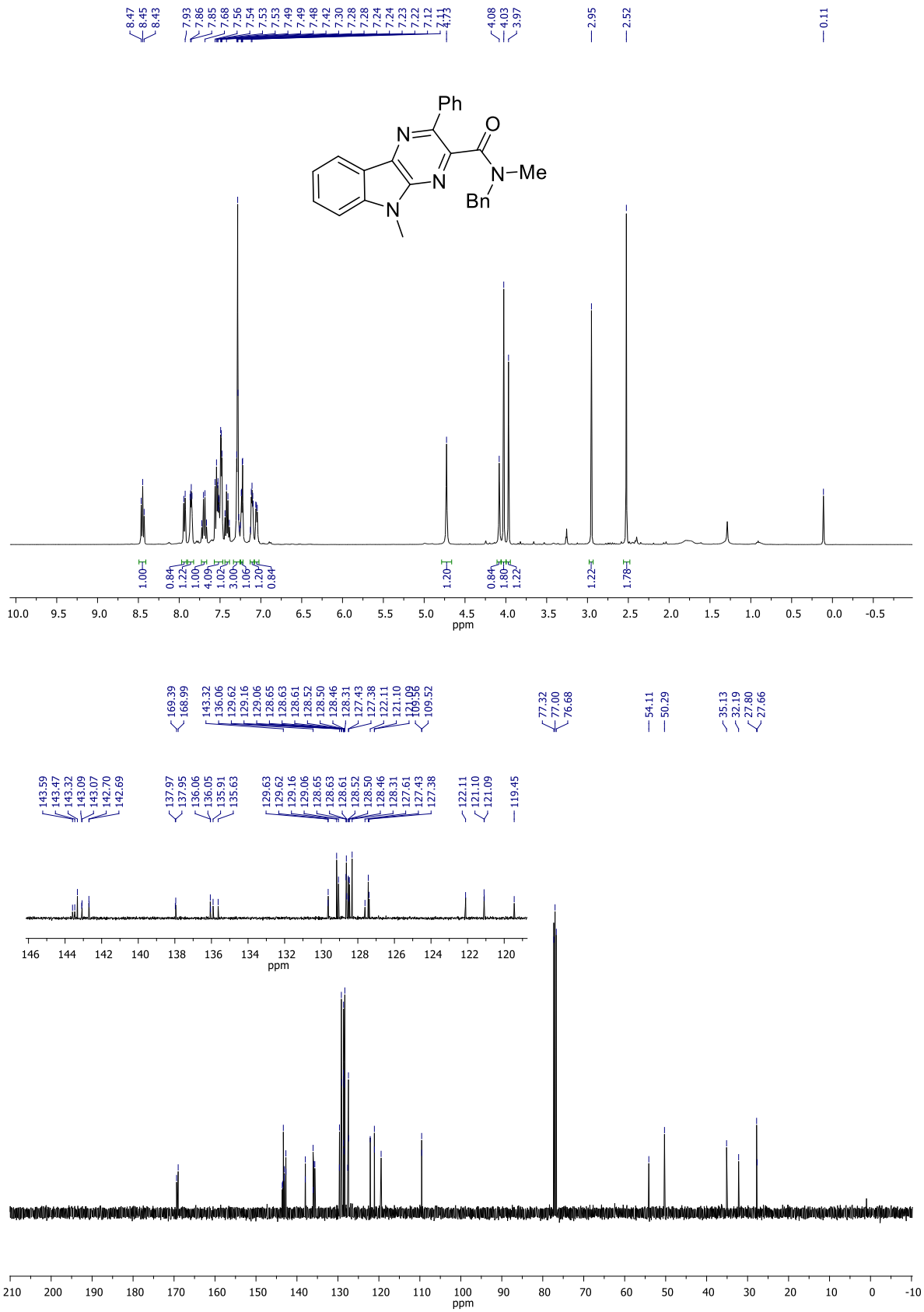


^{1}H and ^{13}C NMR spectra of compound **4k**

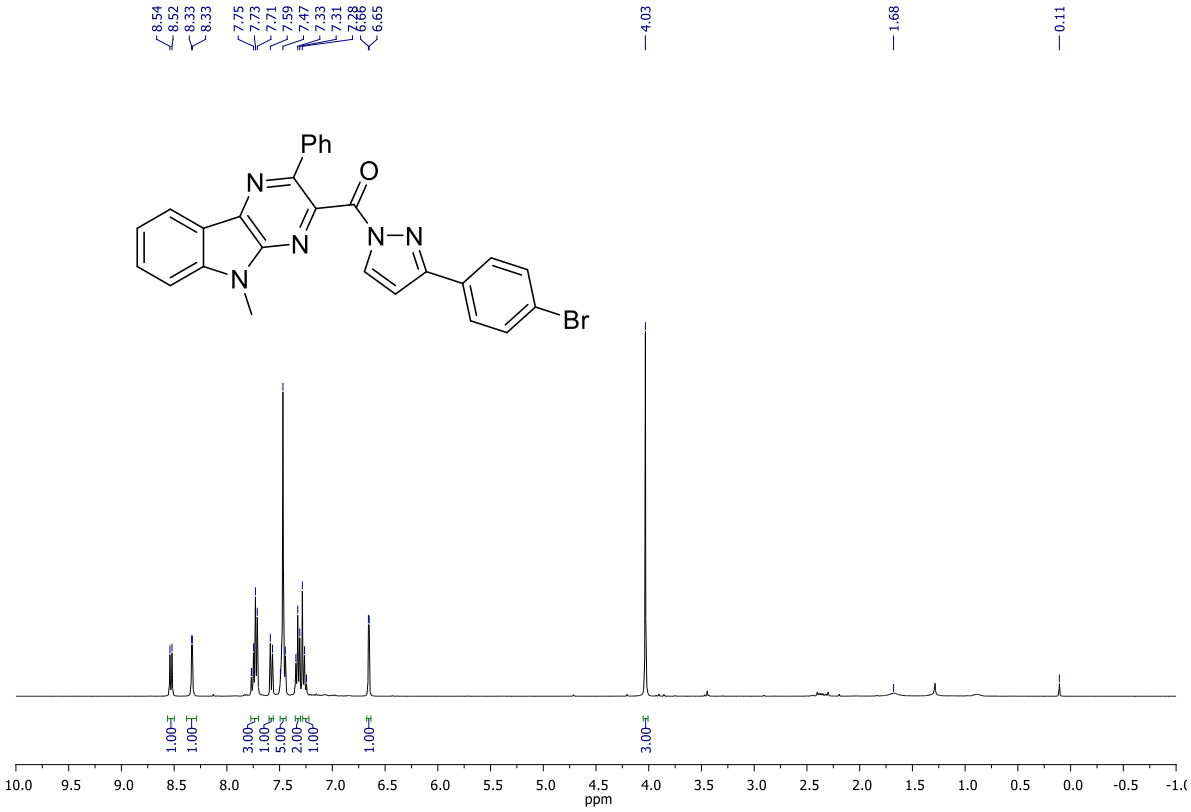


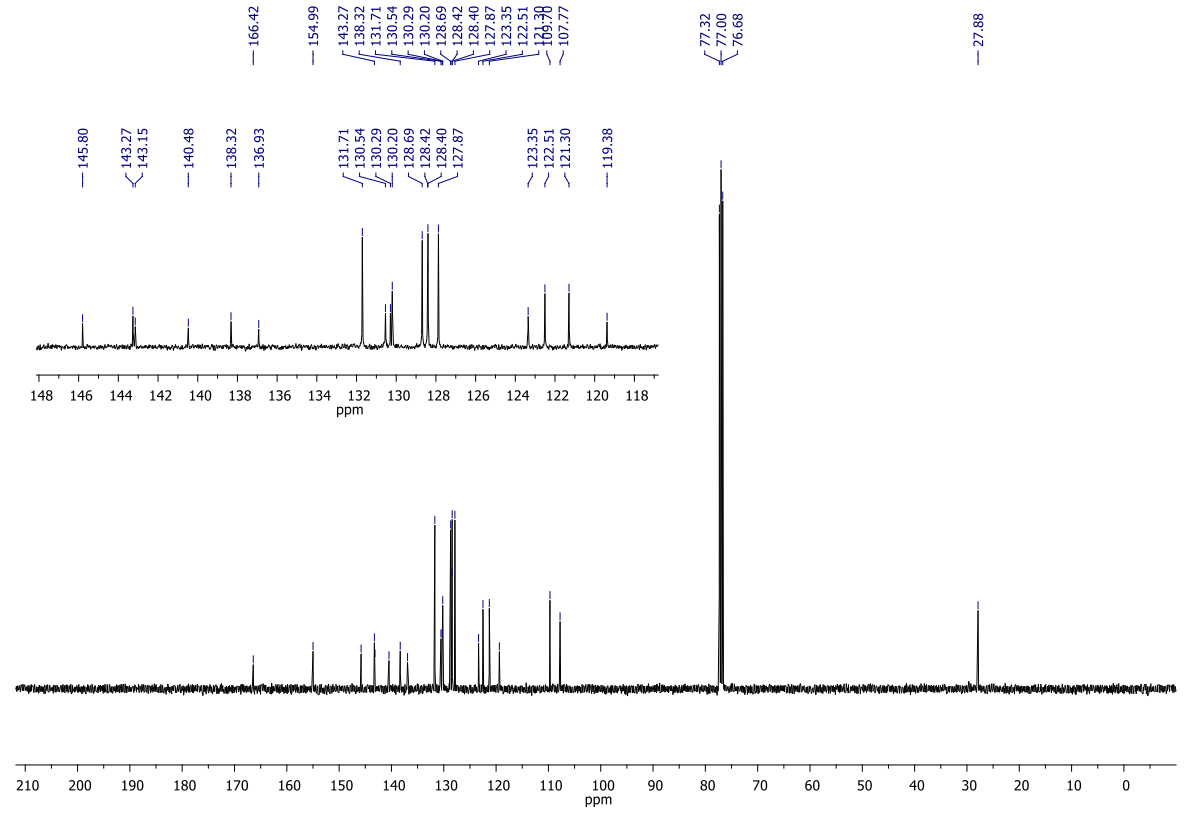


^{1}H and ^{13}C NMR spectra of compound **4l** (rotameric mixture ~ 1:1.5)

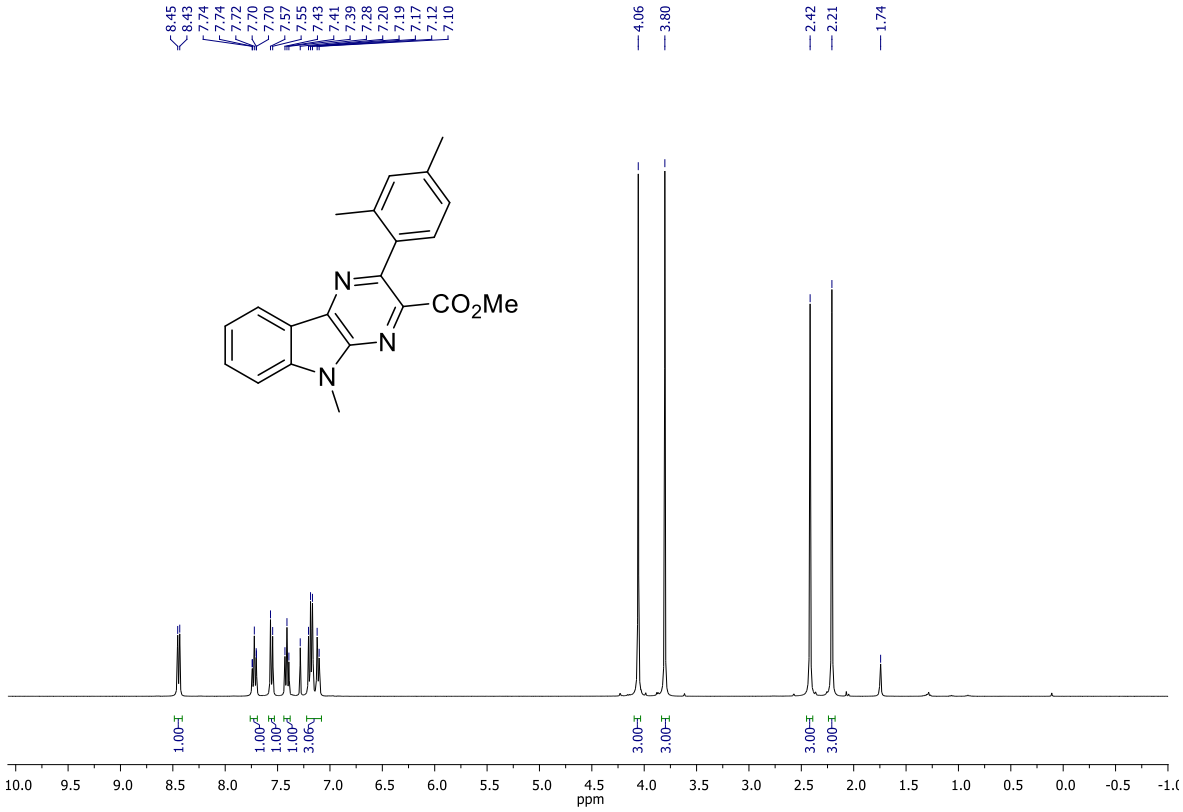


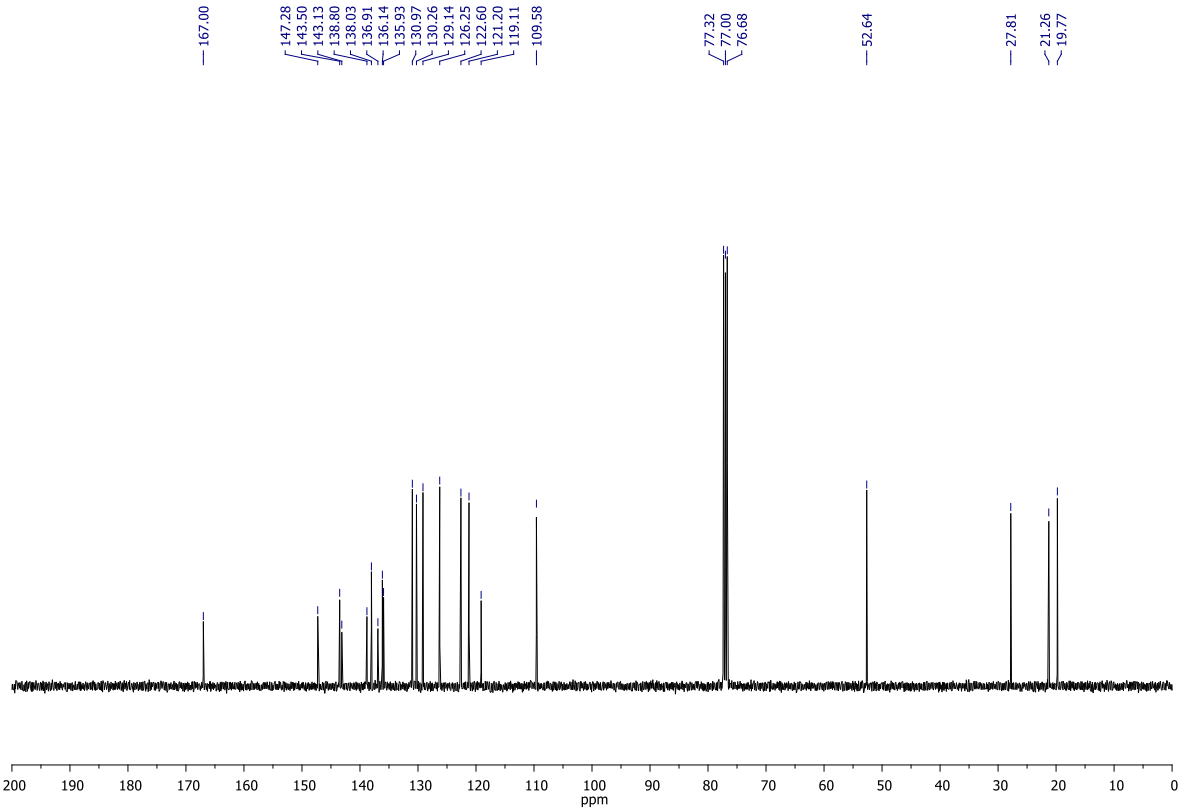
^{1}H and ^{13}C NMR spectra of compound **4m**



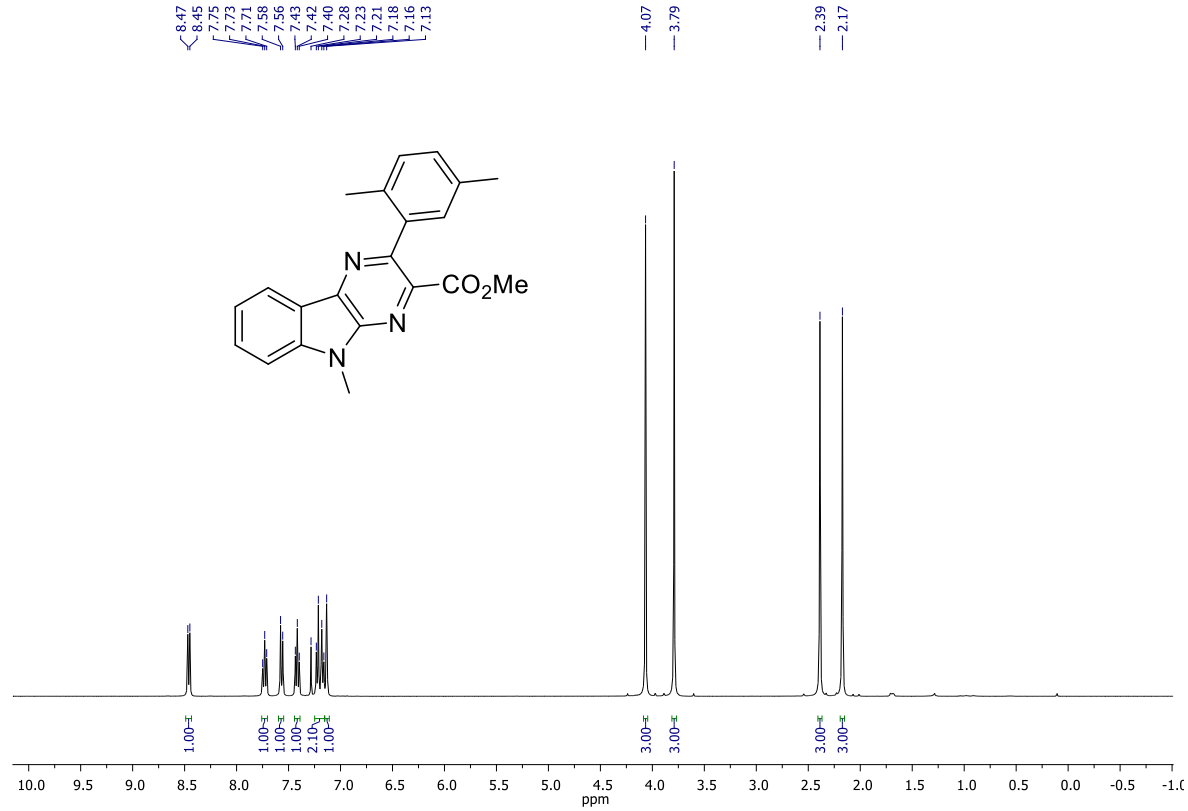


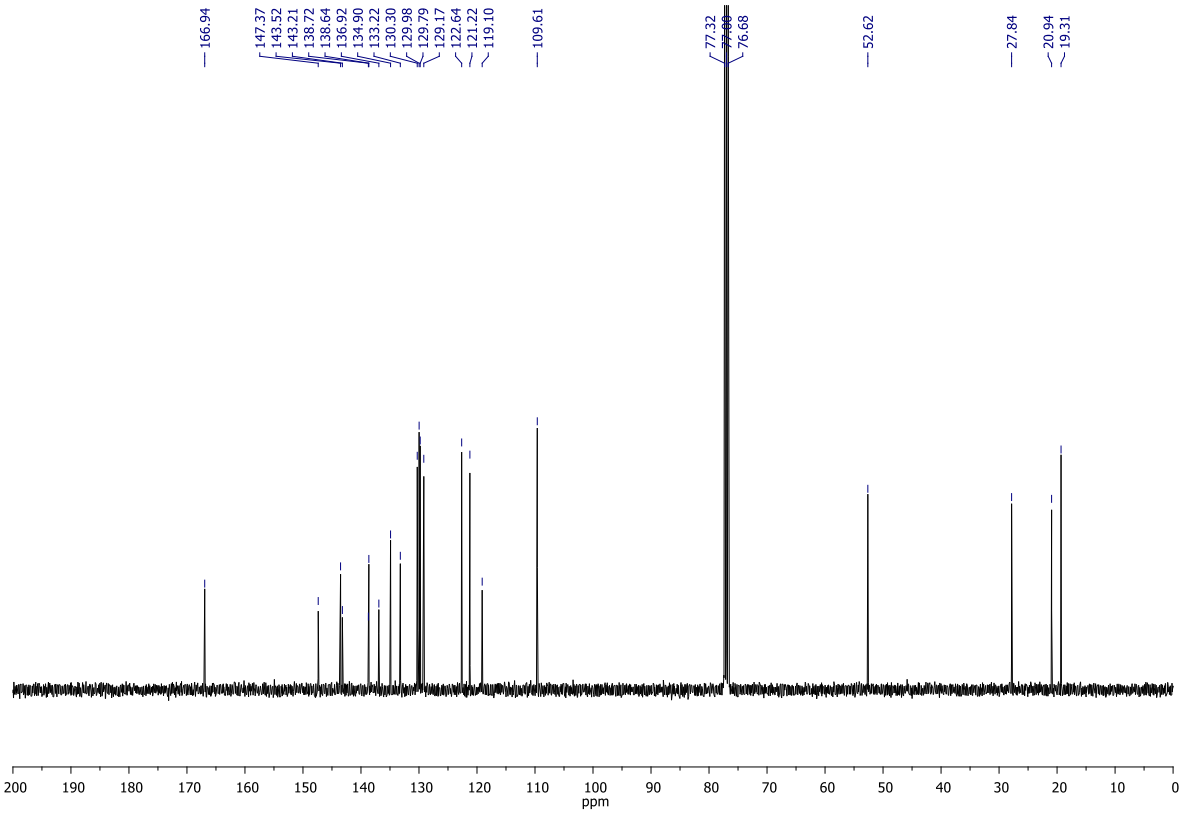
^{1}H and ^{13}C NMR spectra of compound **4n**



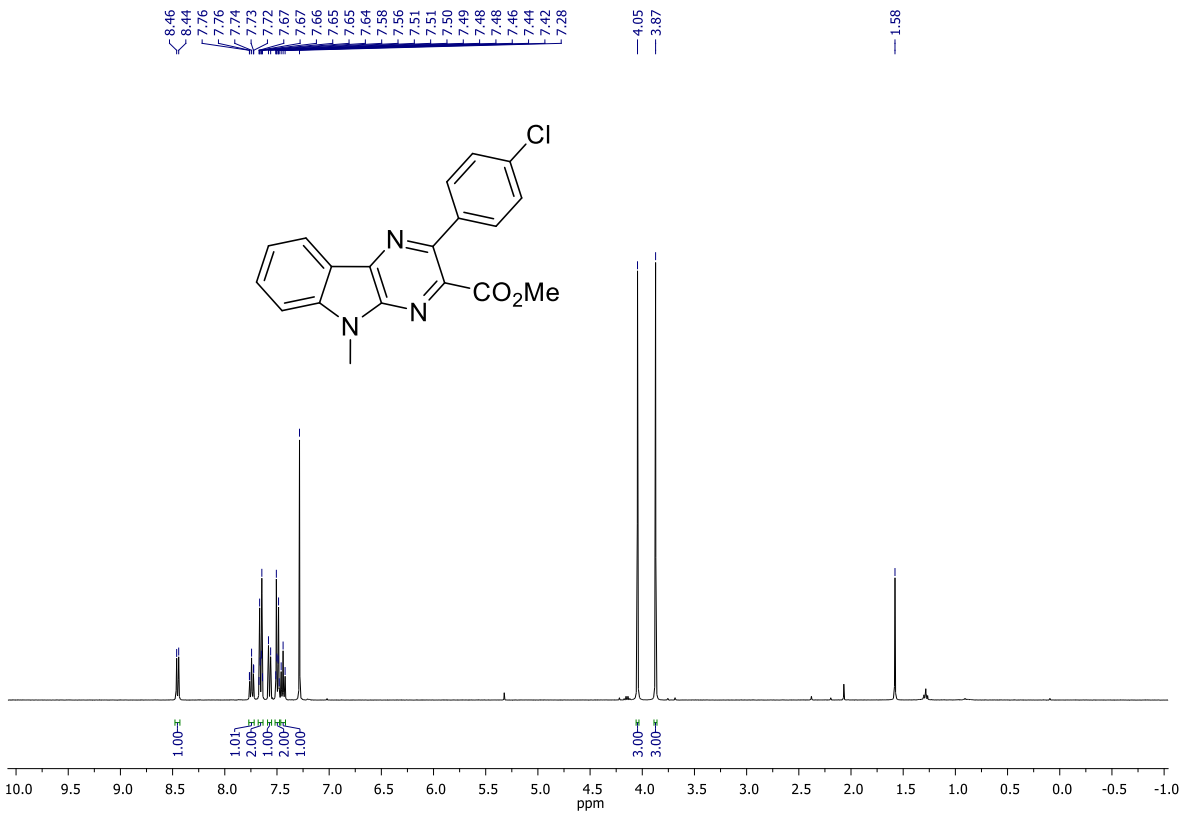


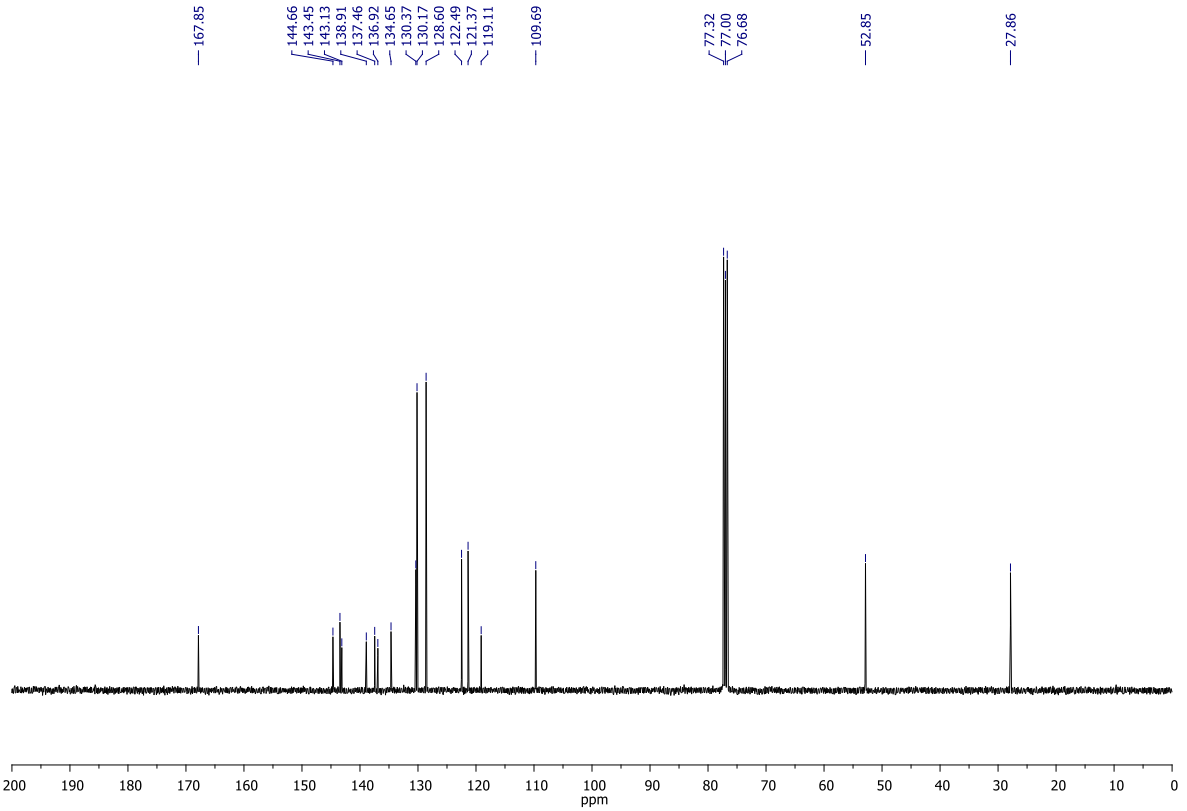
^{1}H and ^{13}C NMR spectra of compound **4o**



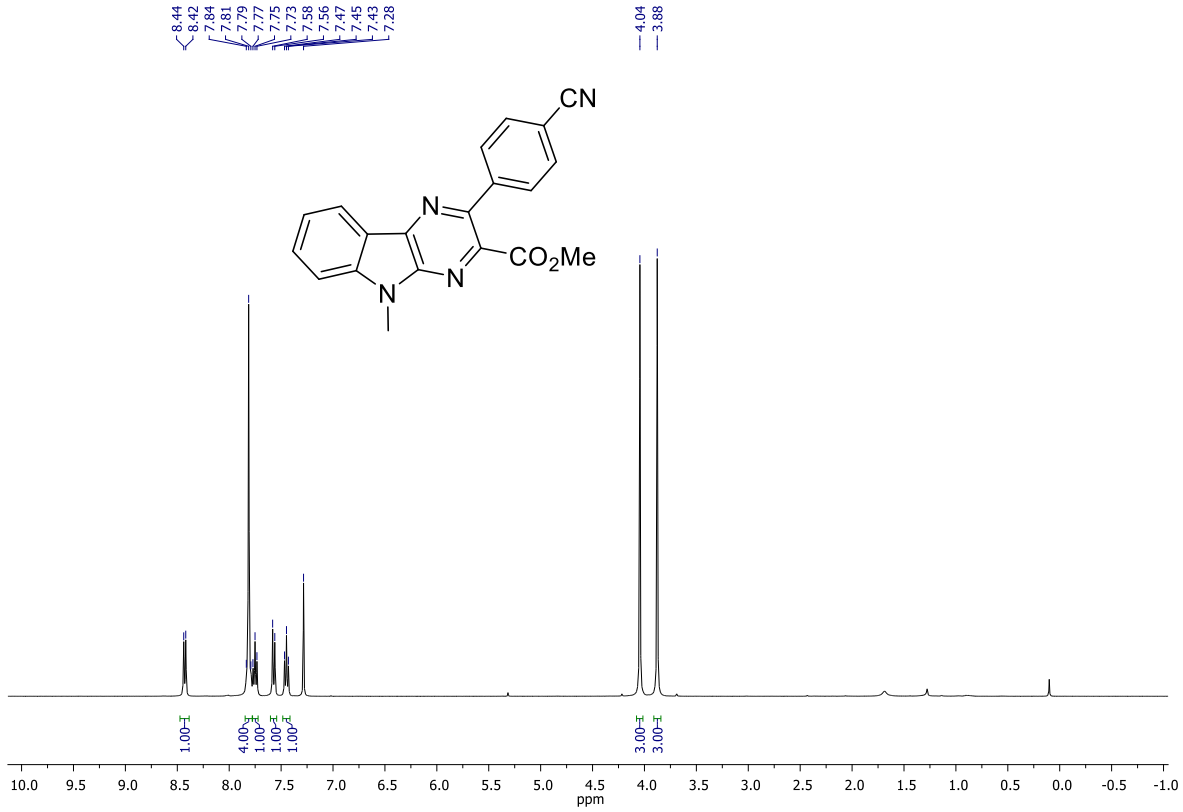


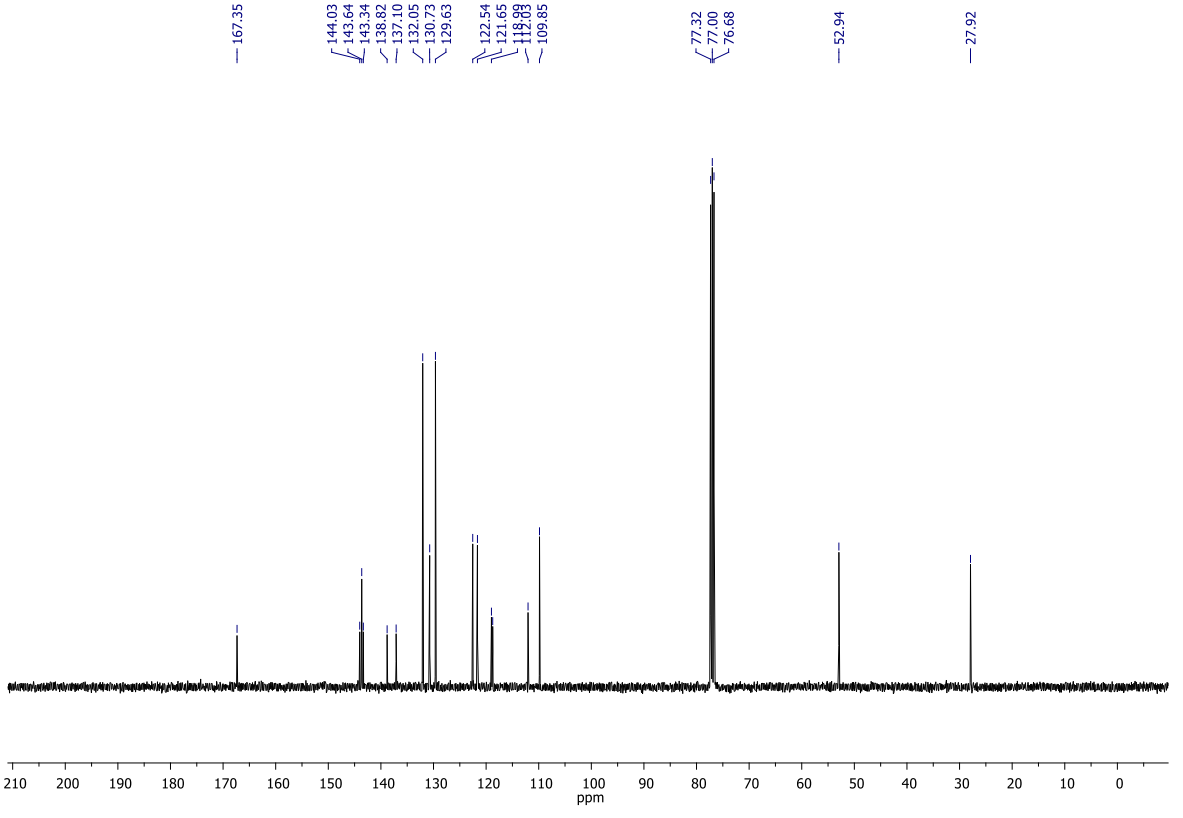
^{1}H and ^{13}C NMR spectra of compound **4p**



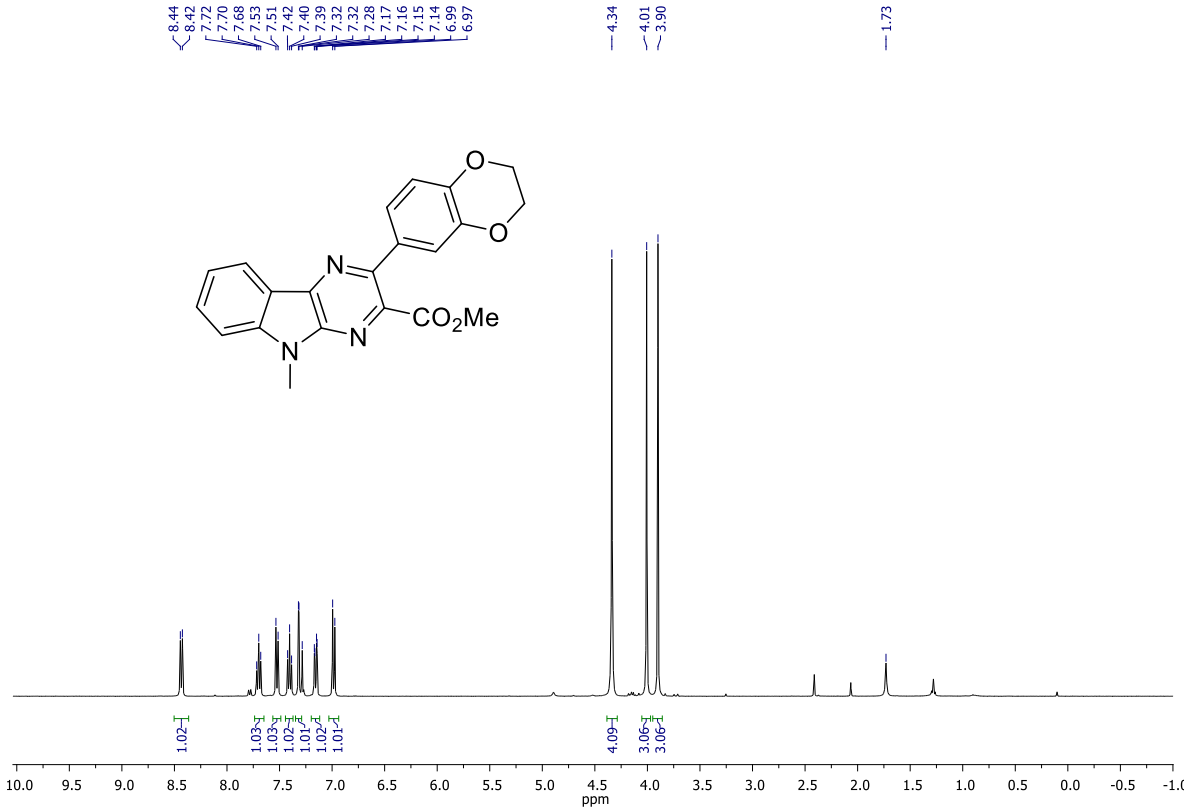


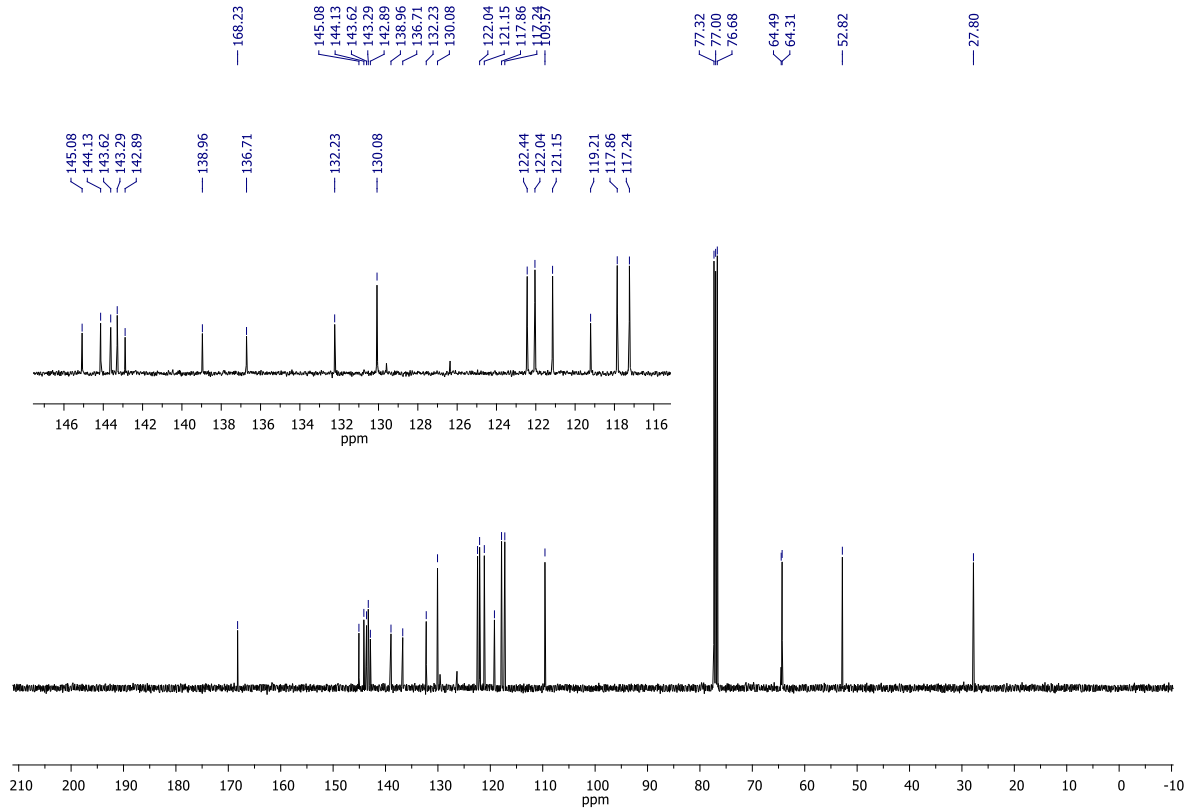
^{1}H and ^{13}C NMR spectra of compound **4q**



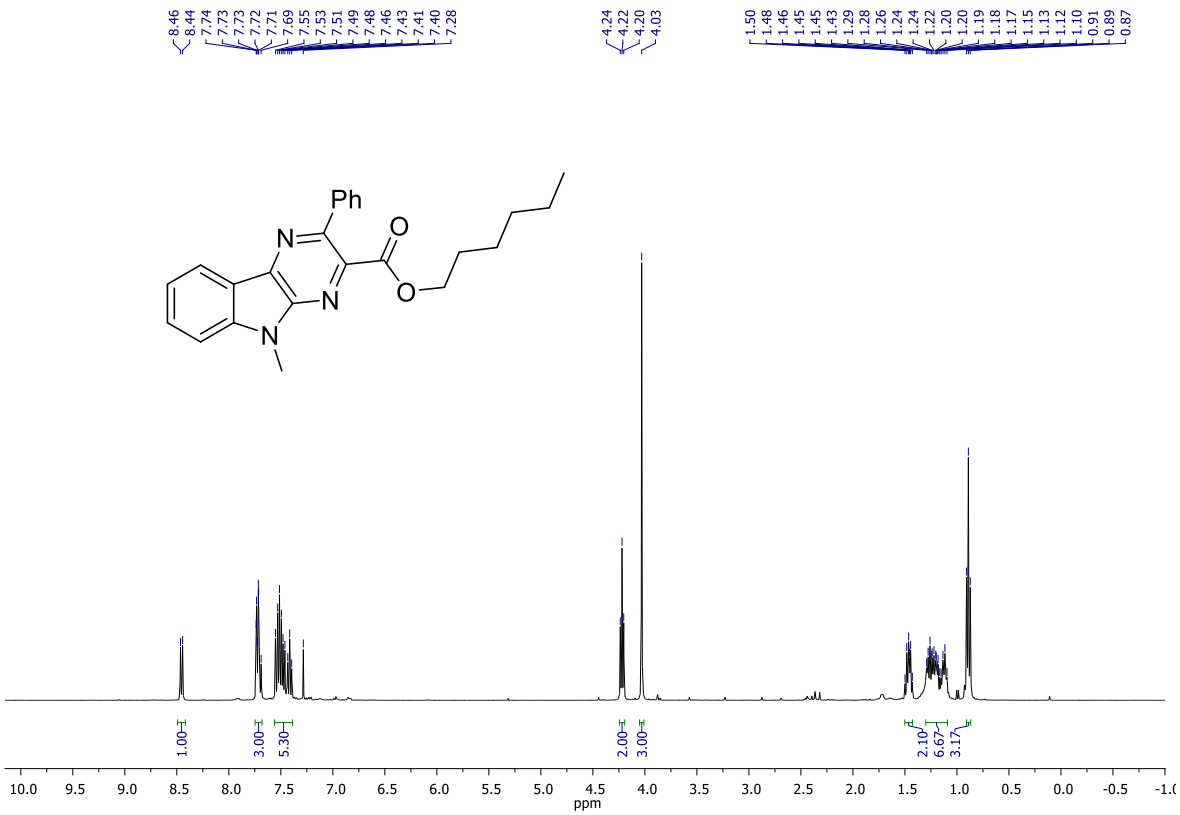


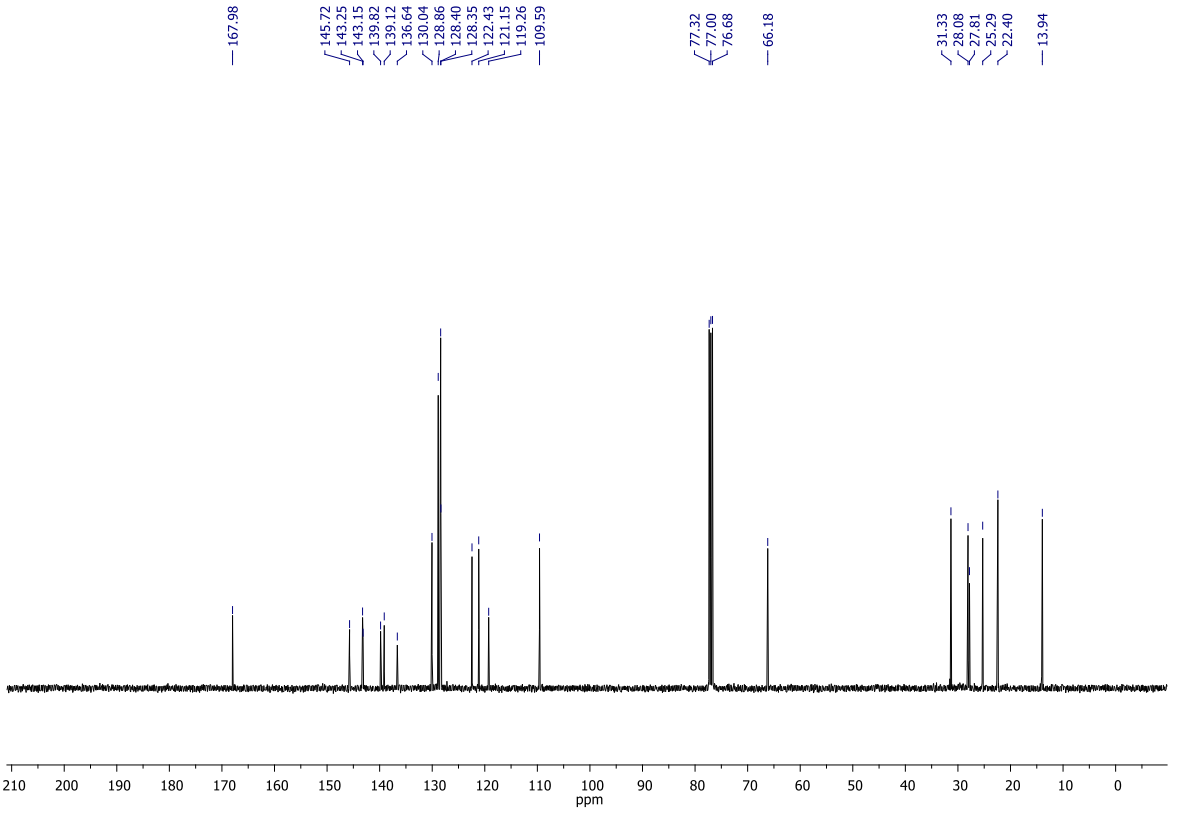
^{1}H and ^{13}C NMR spectra of compound **4r**



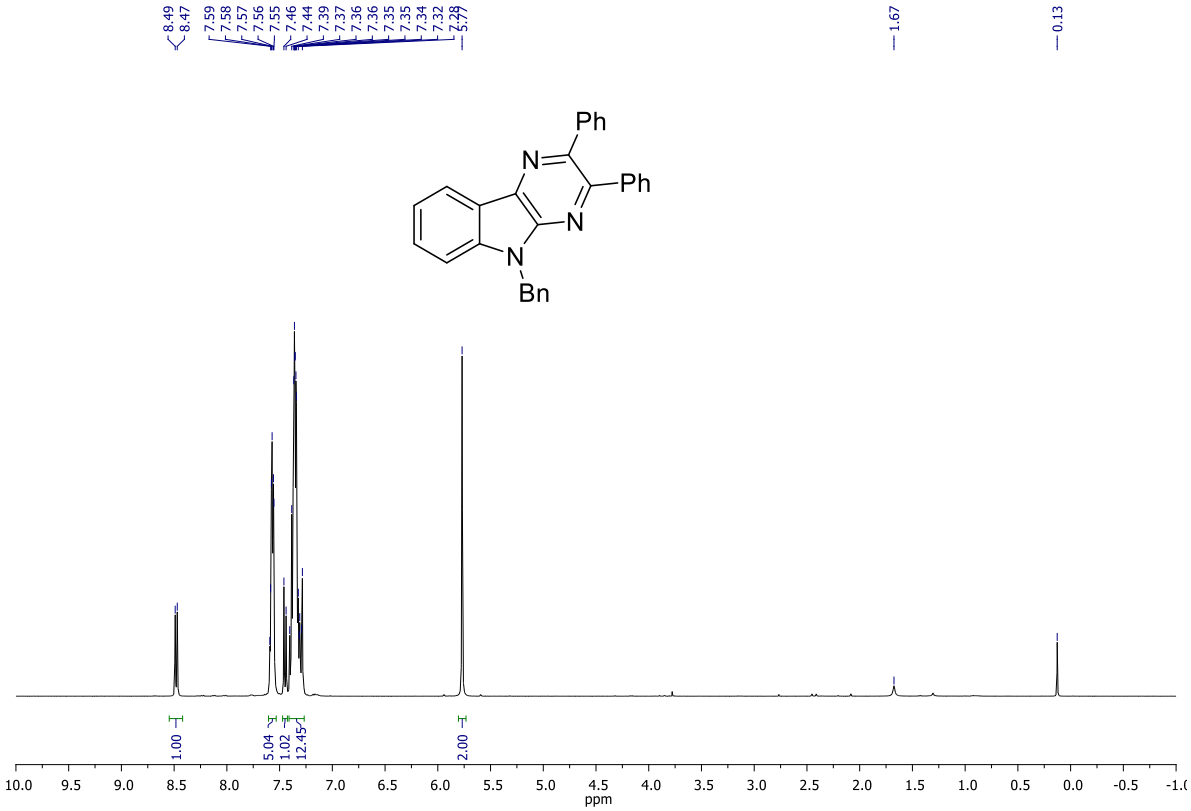


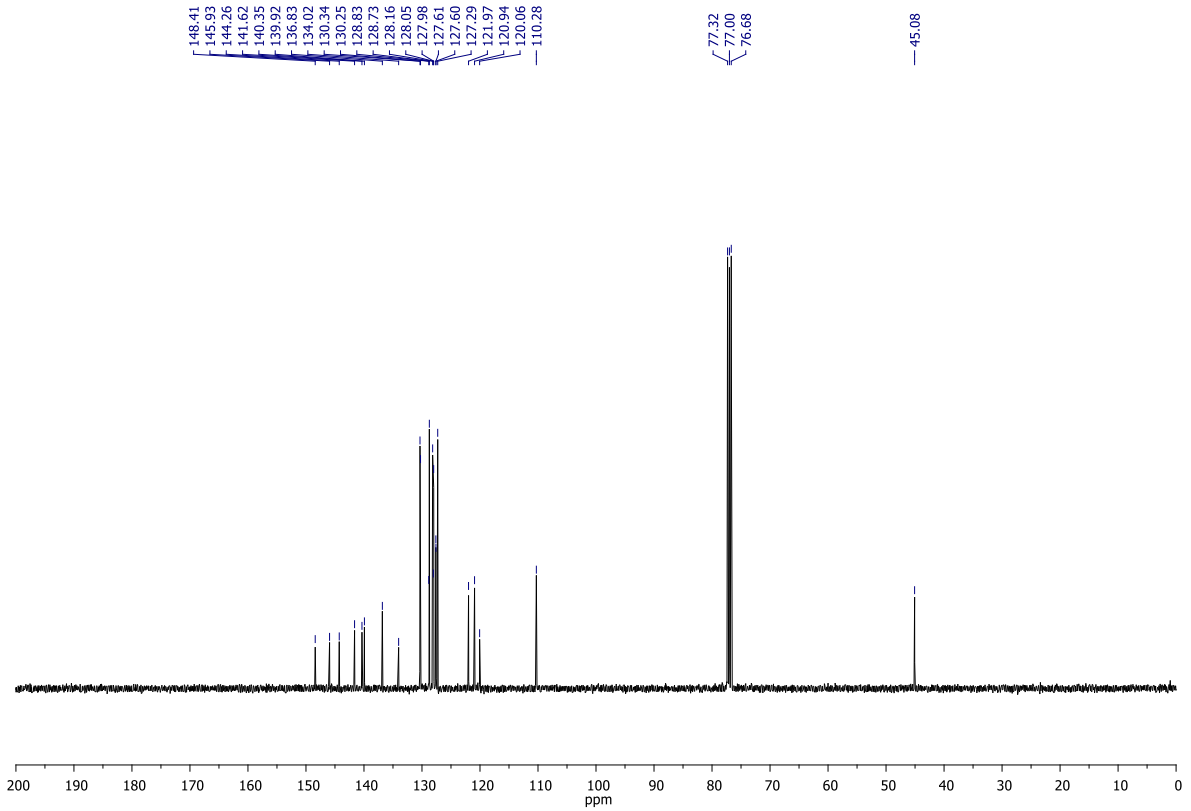
^{1}H and ^{13}C NMR spectra of compound **4s**



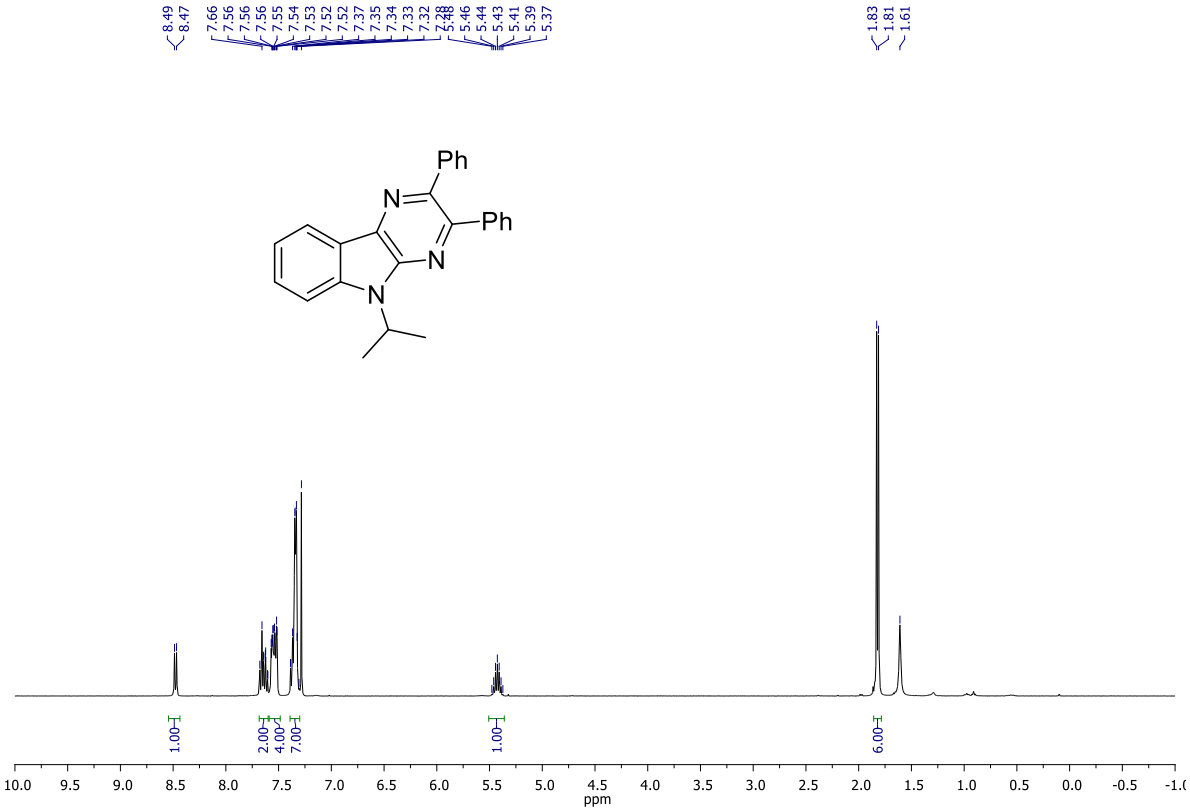


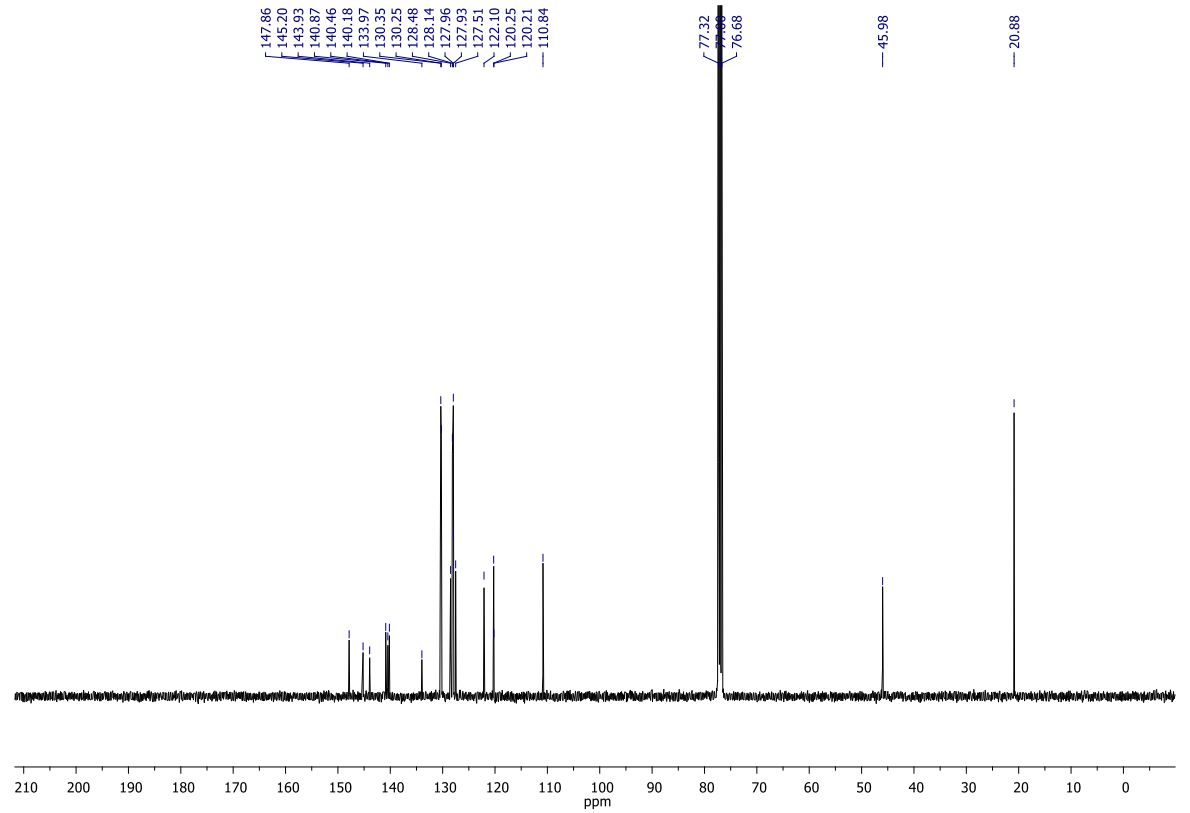
^{1}H and ^{13}C NMR spectra of compound **4t**



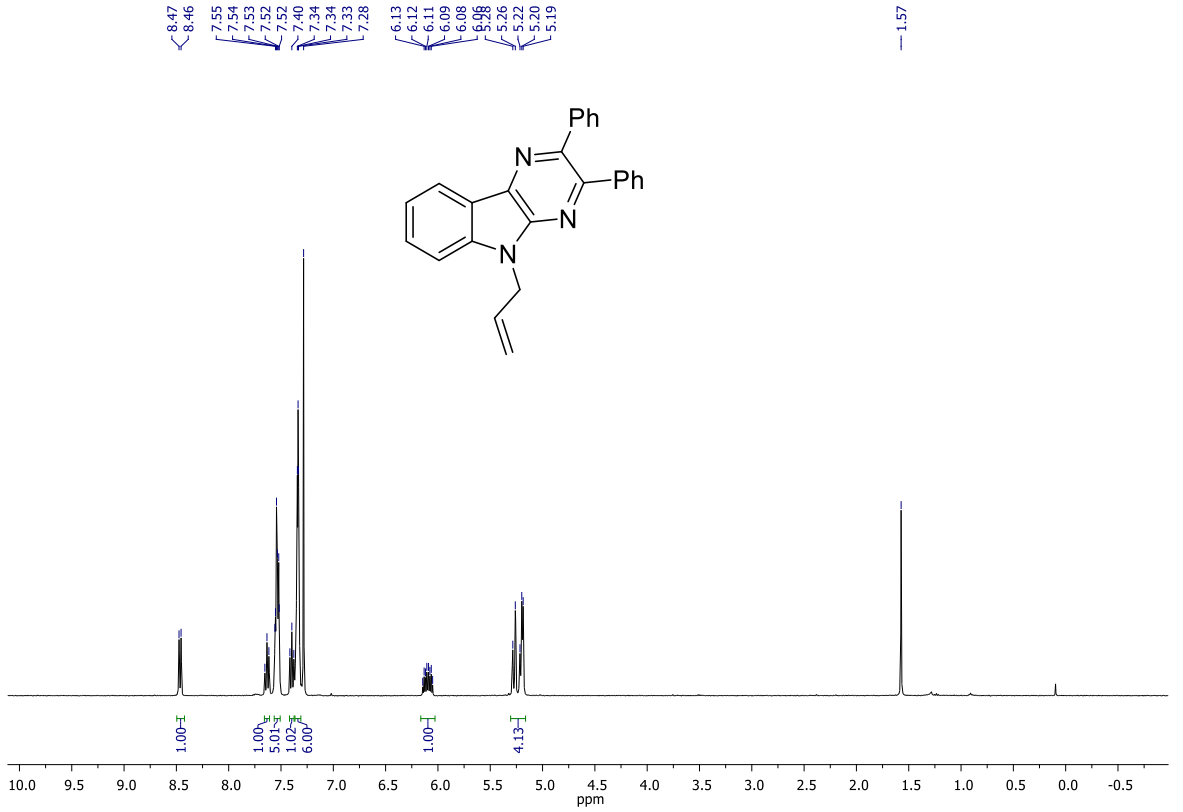


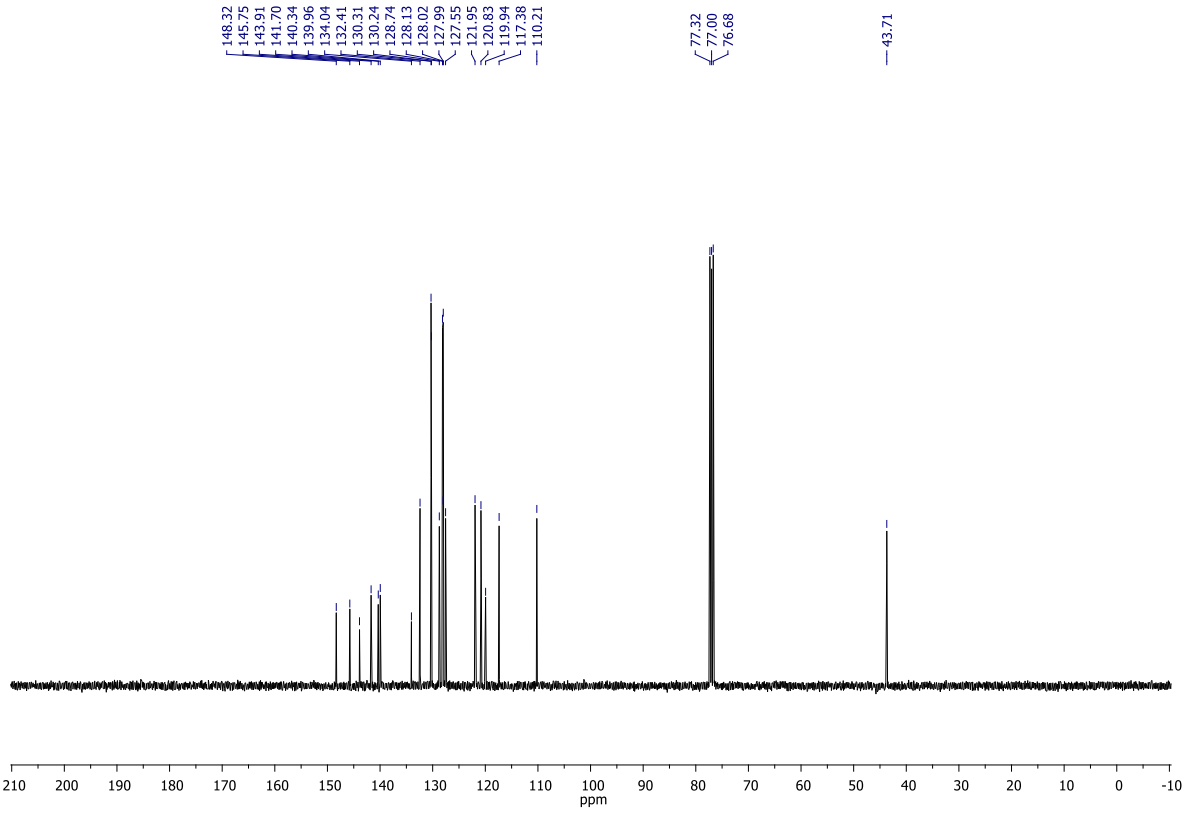
^{1}H and ^{13}C NMR spectra of compound **4u**



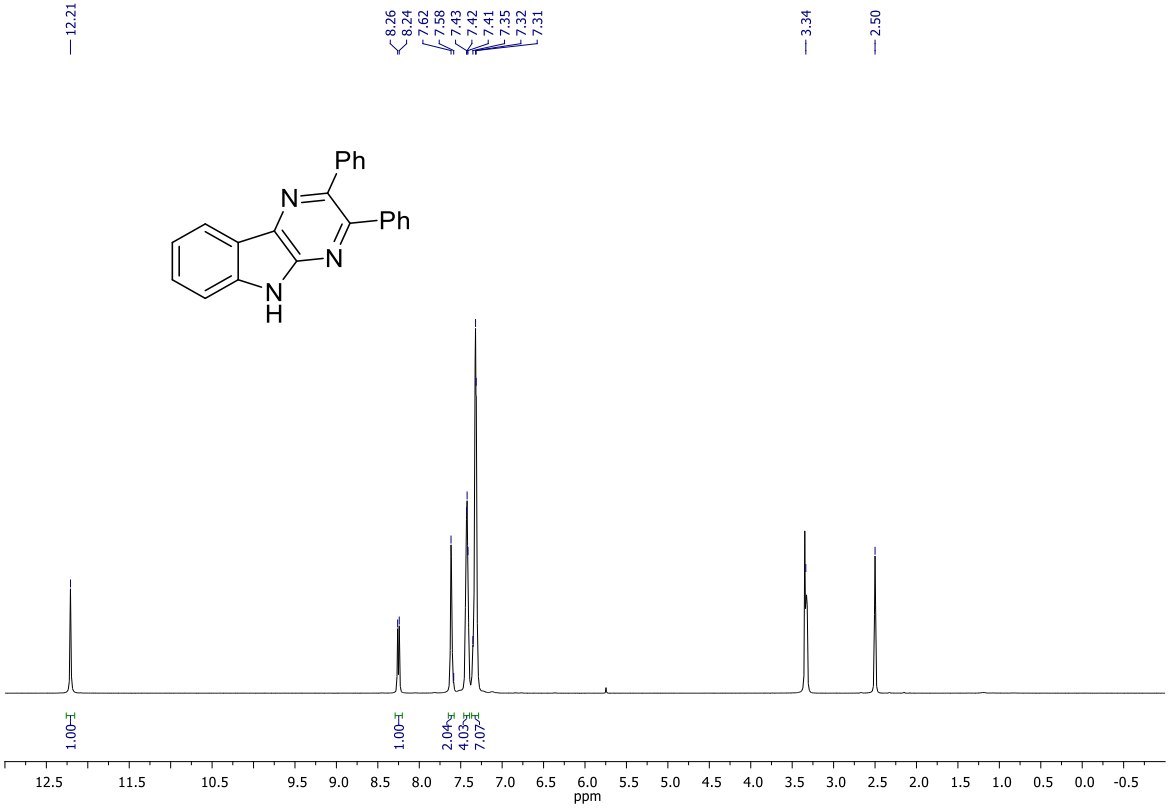


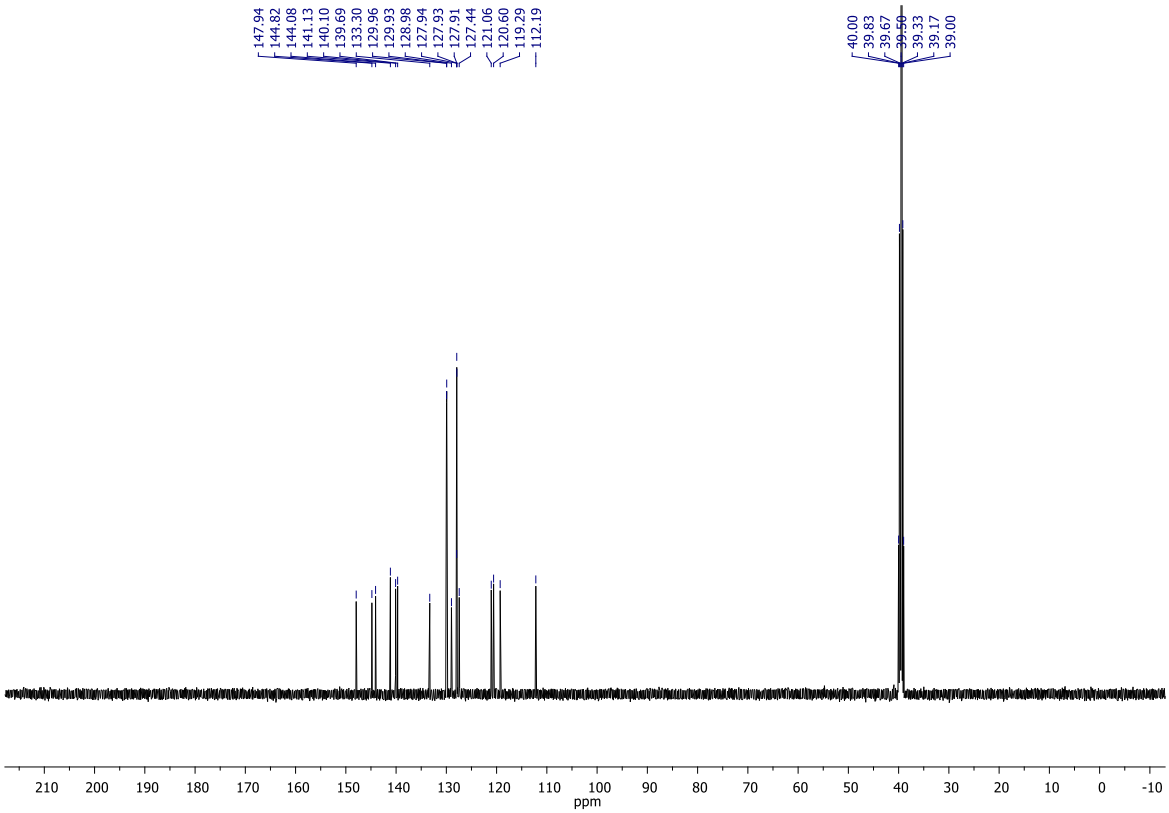
^{1}H and ^{13}C NMR spectra of compound **4v**



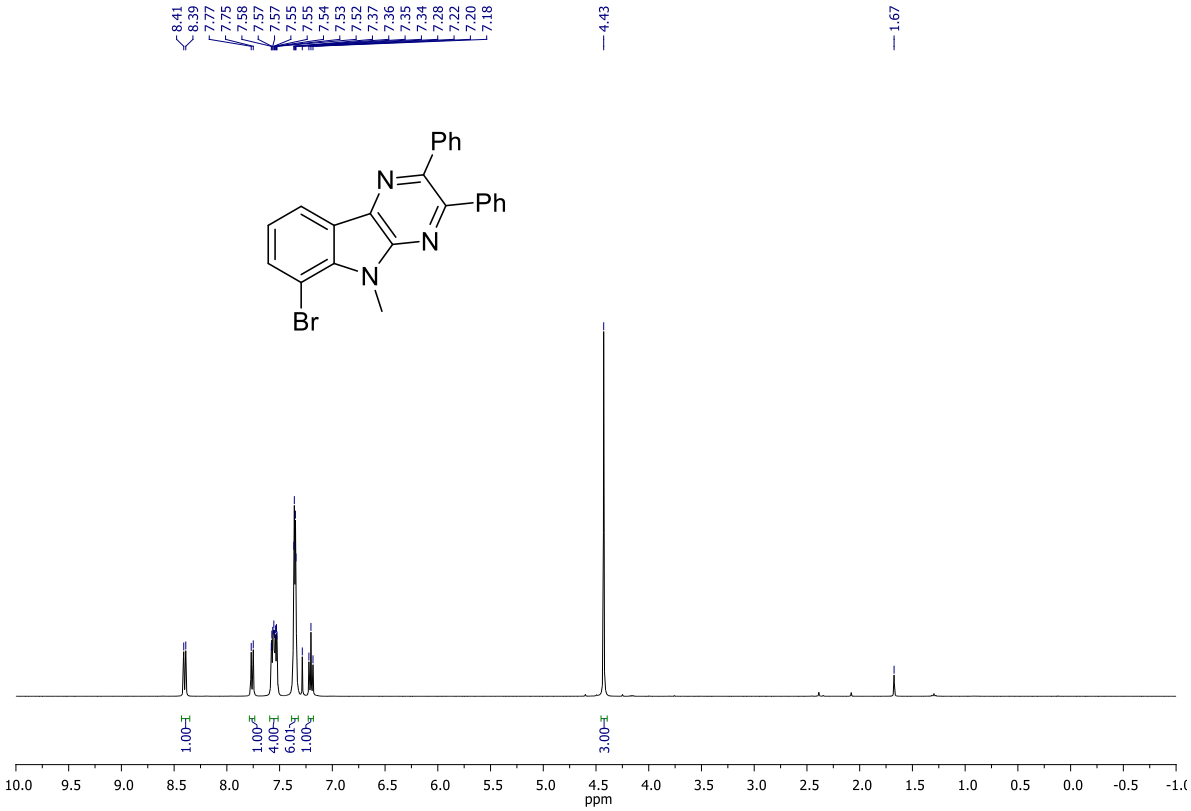


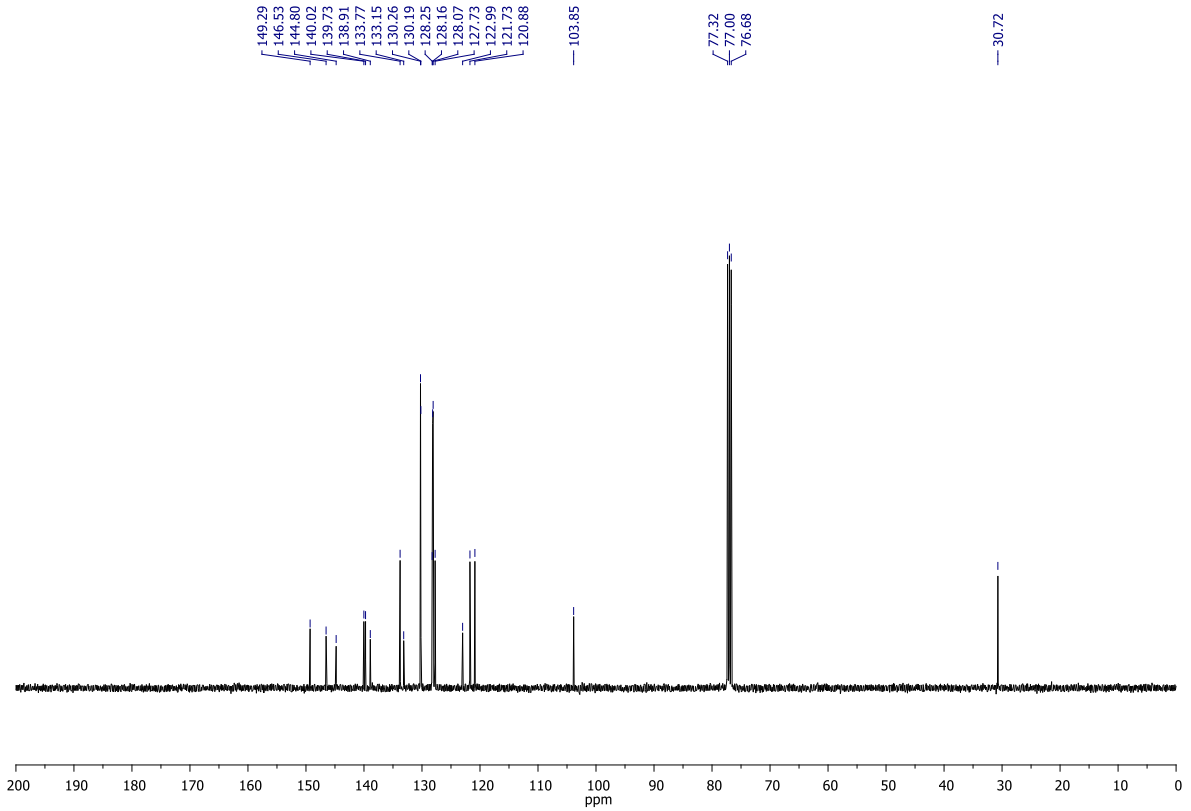
^{1}H and ^{13}C NMR spectra of compound **4w**



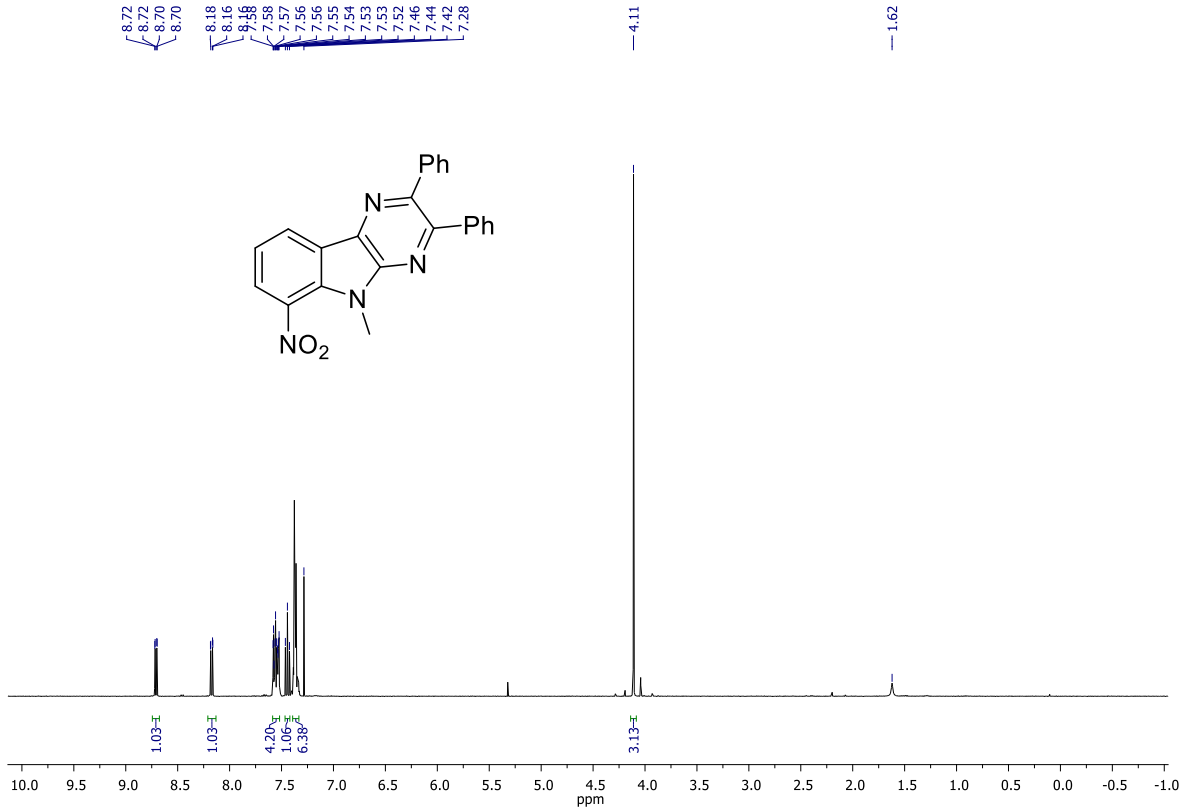


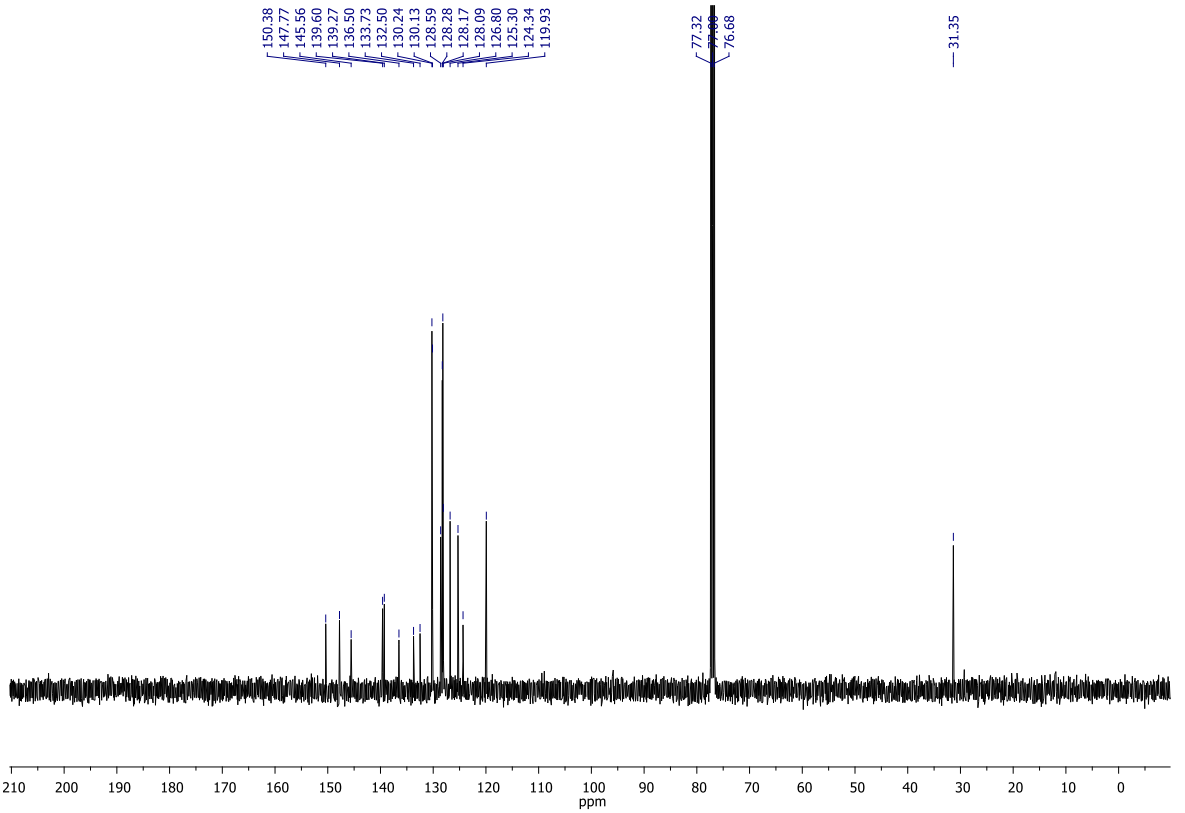
^{1}H and ^{13}C NMR spectra of compound **4x**



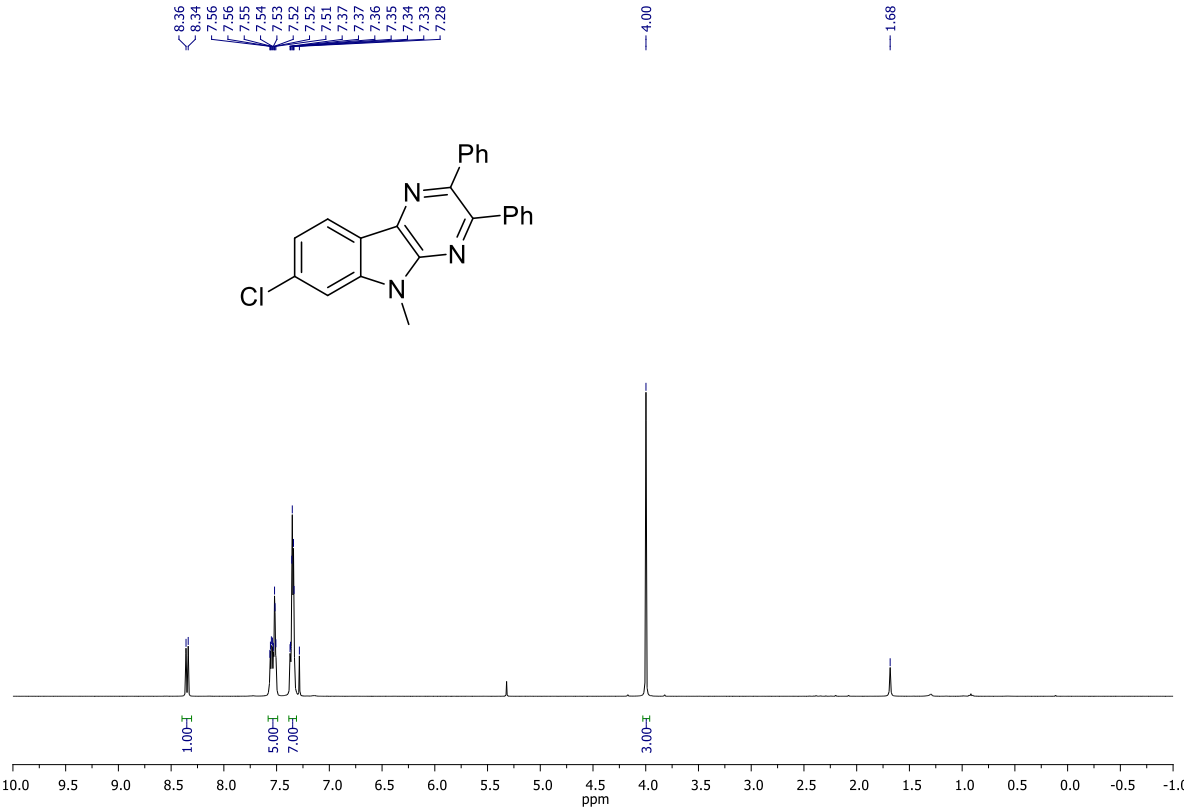


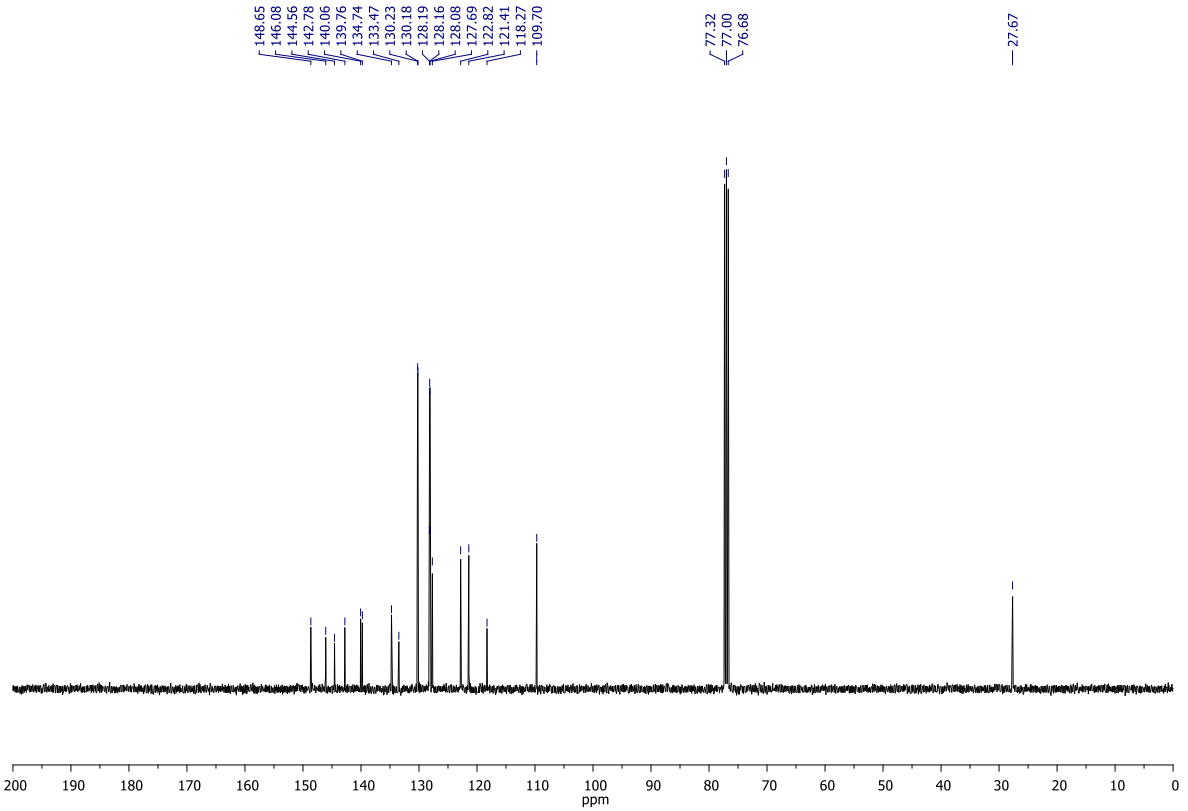
^{1}H and ^{13}C NMR spectra of compound **4y**



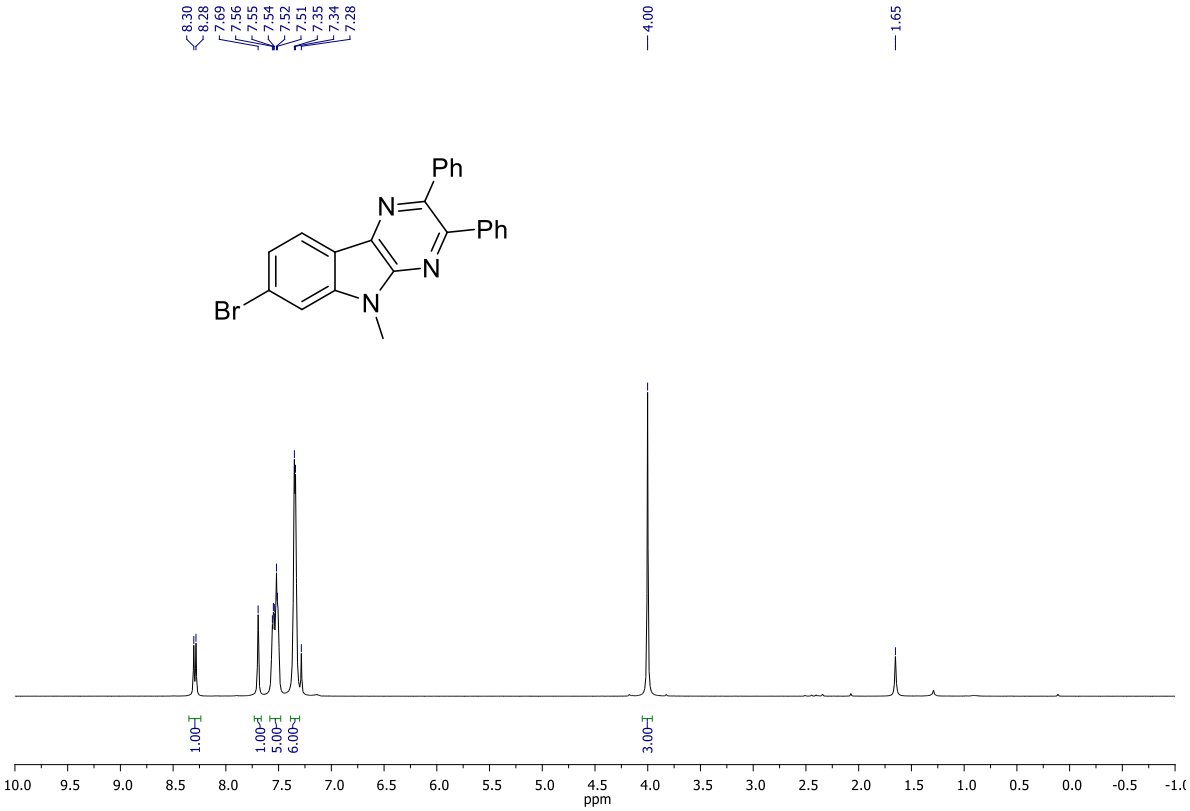


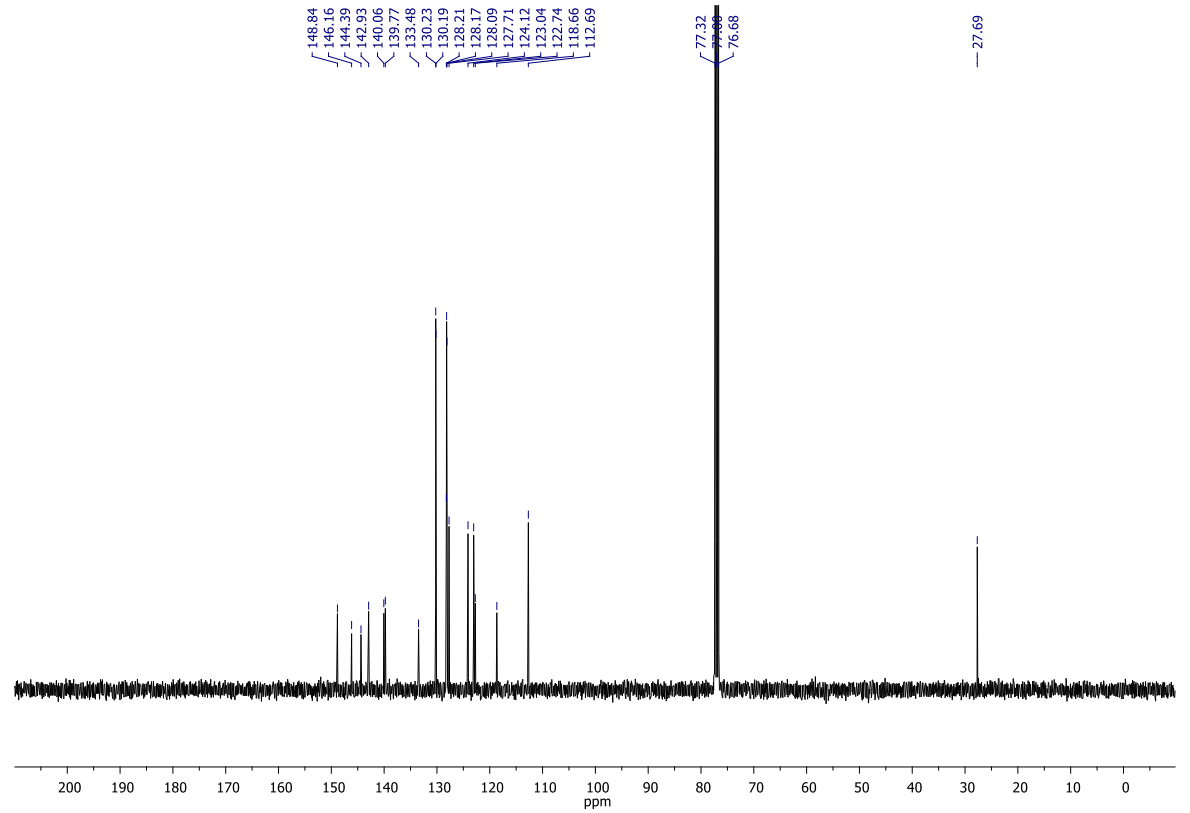
^{1}H and ^{13}C NMR spectra of compound **4z**



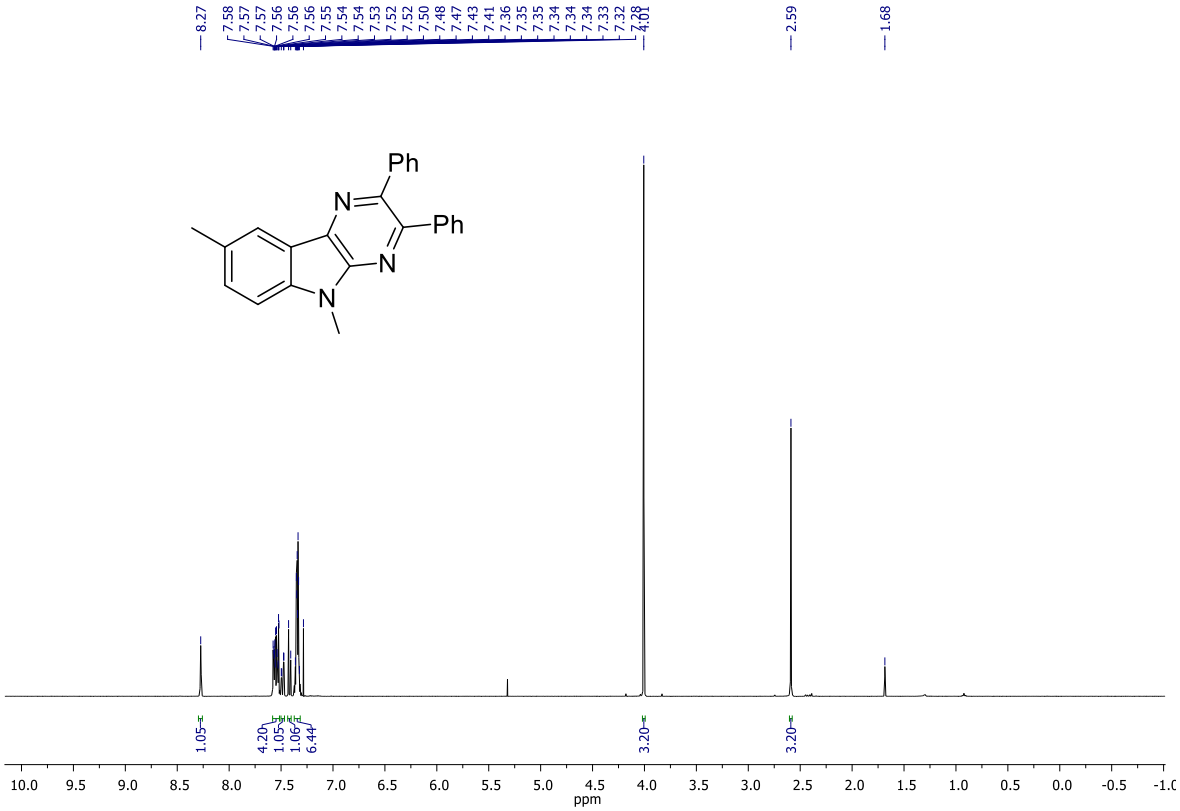


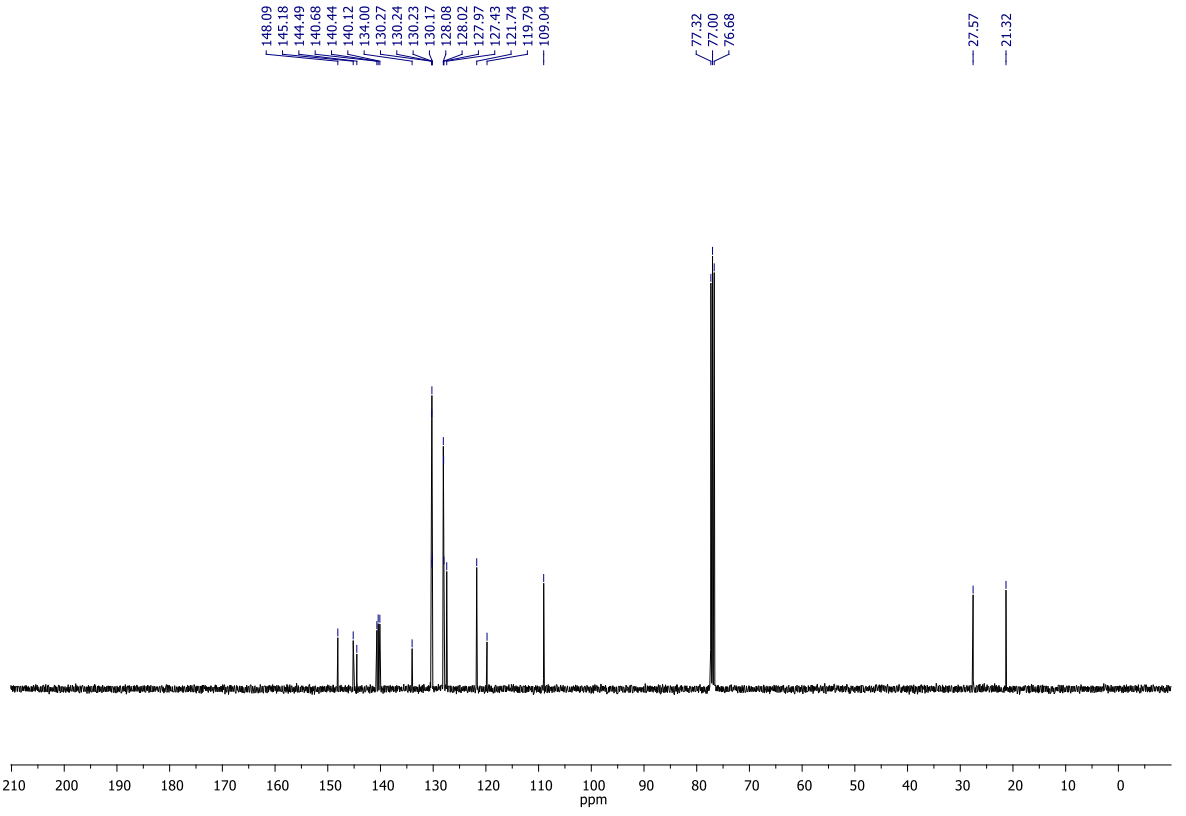
^{1}H and ^{13}C NMR spectra of compound **4aa**



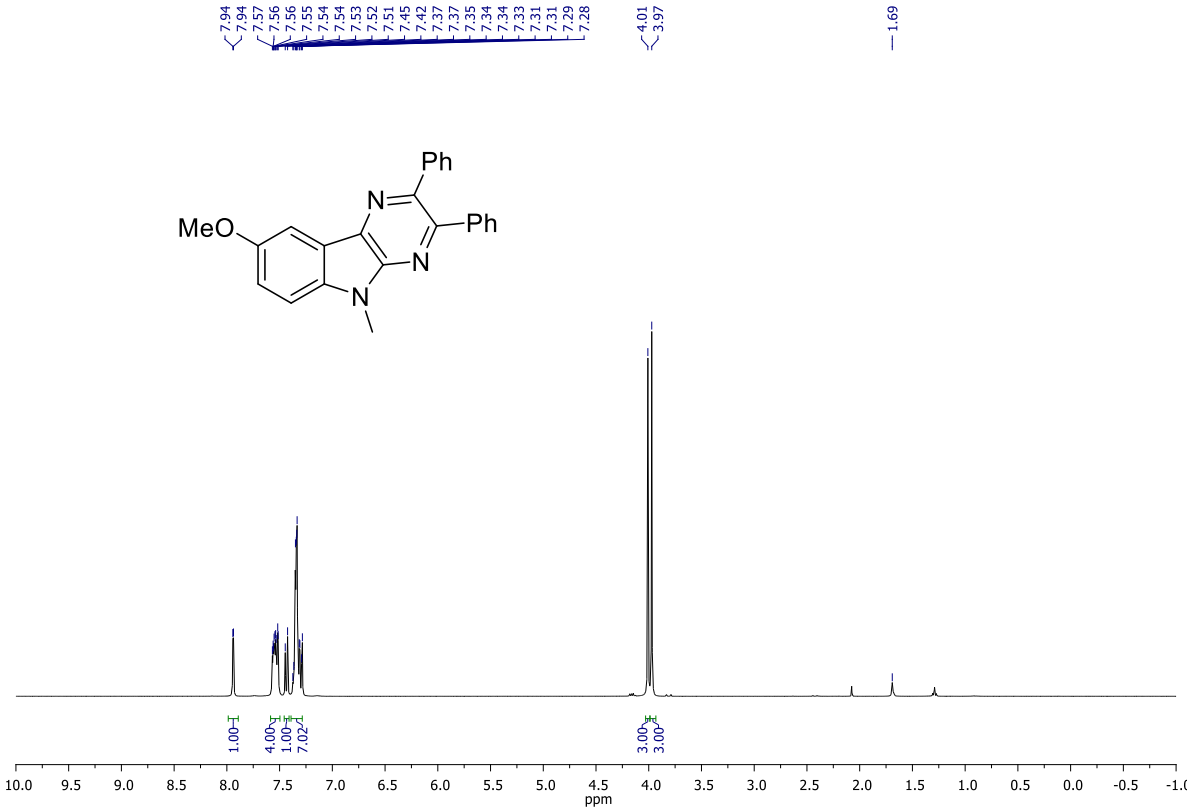


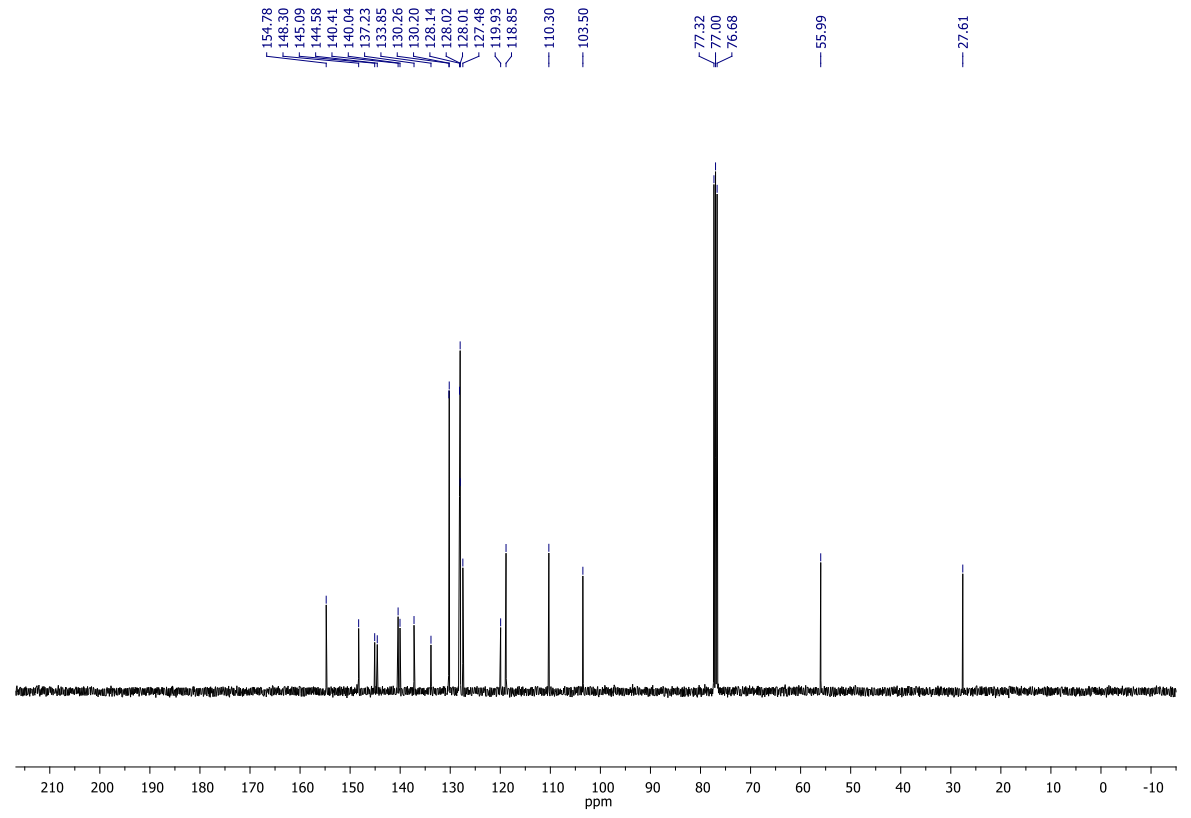
^{1}H and ^{13}C NMR spectra of compound **4ab**



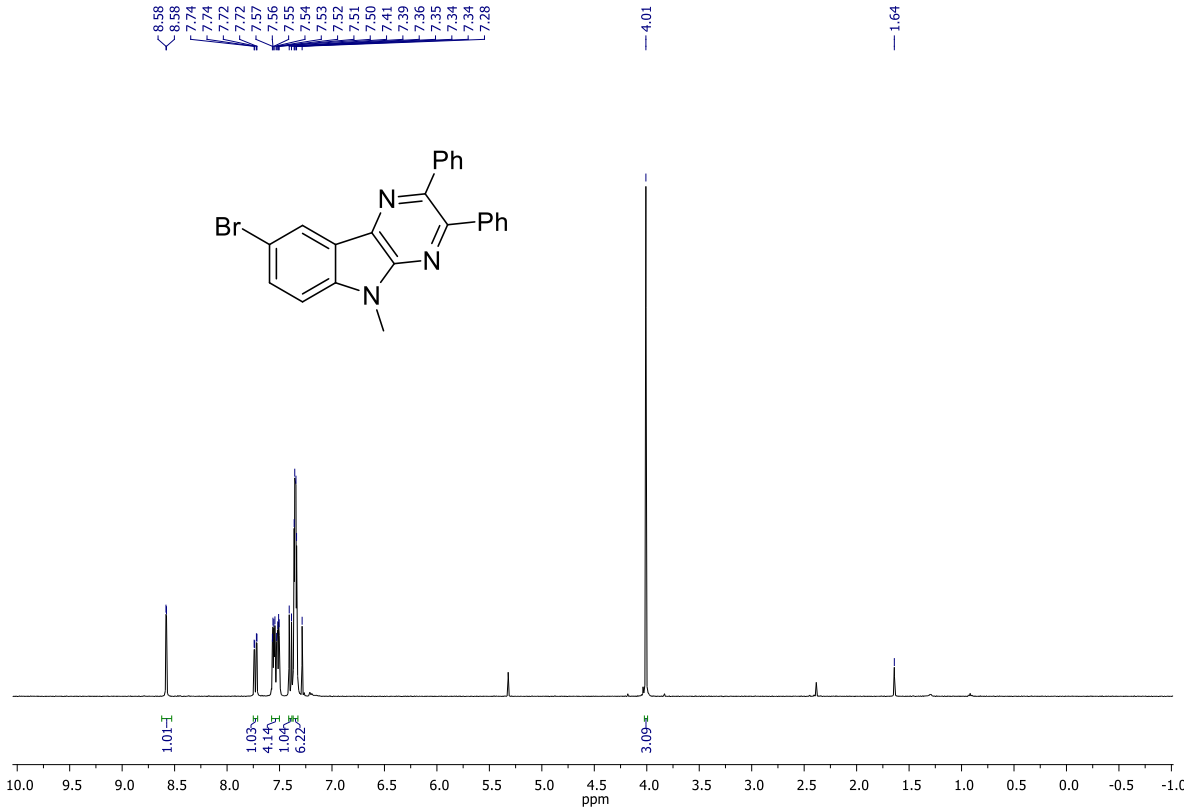


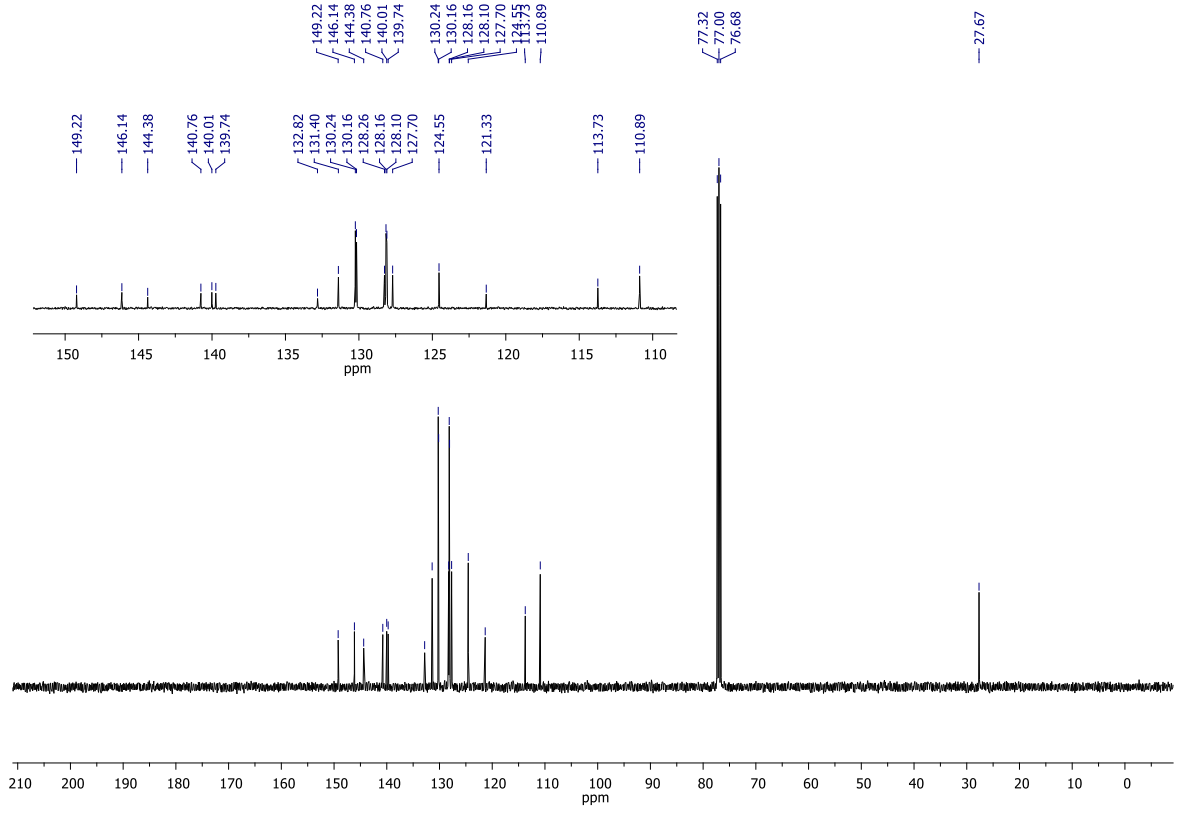
^{1}H and ^{13}C NMR spectra of compound **4ac**



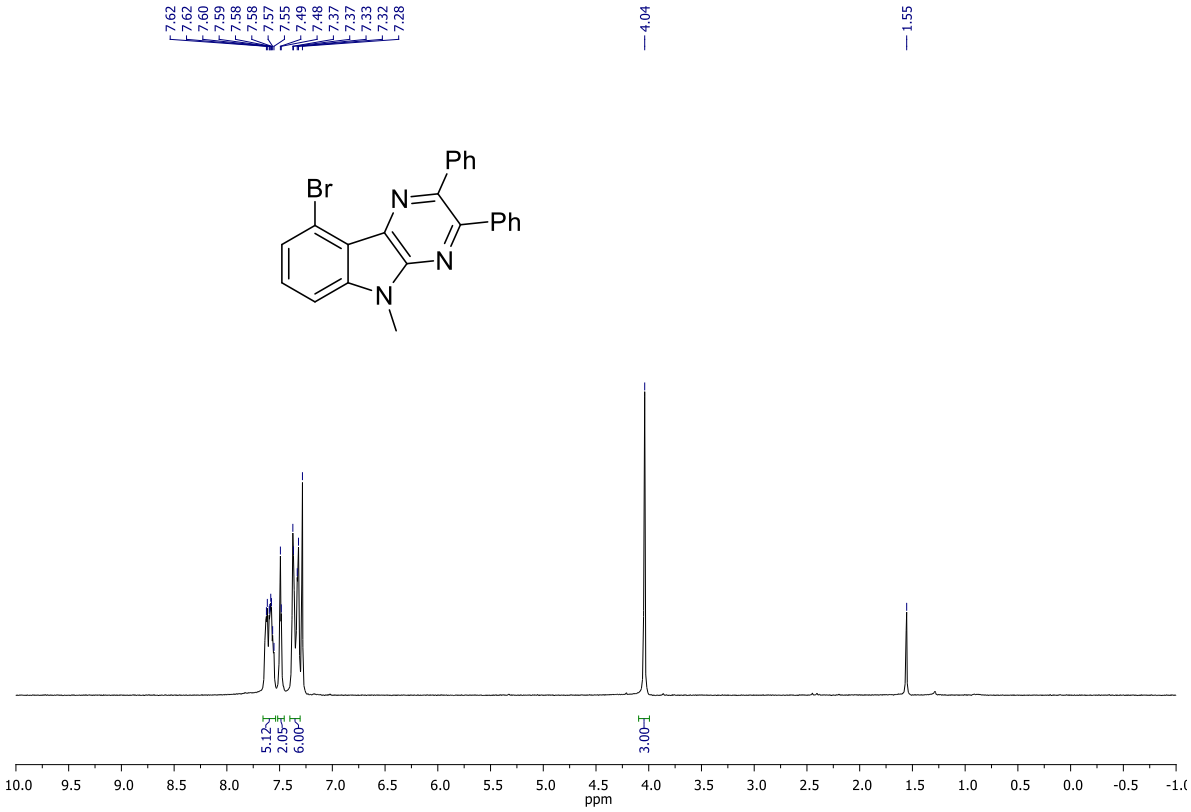


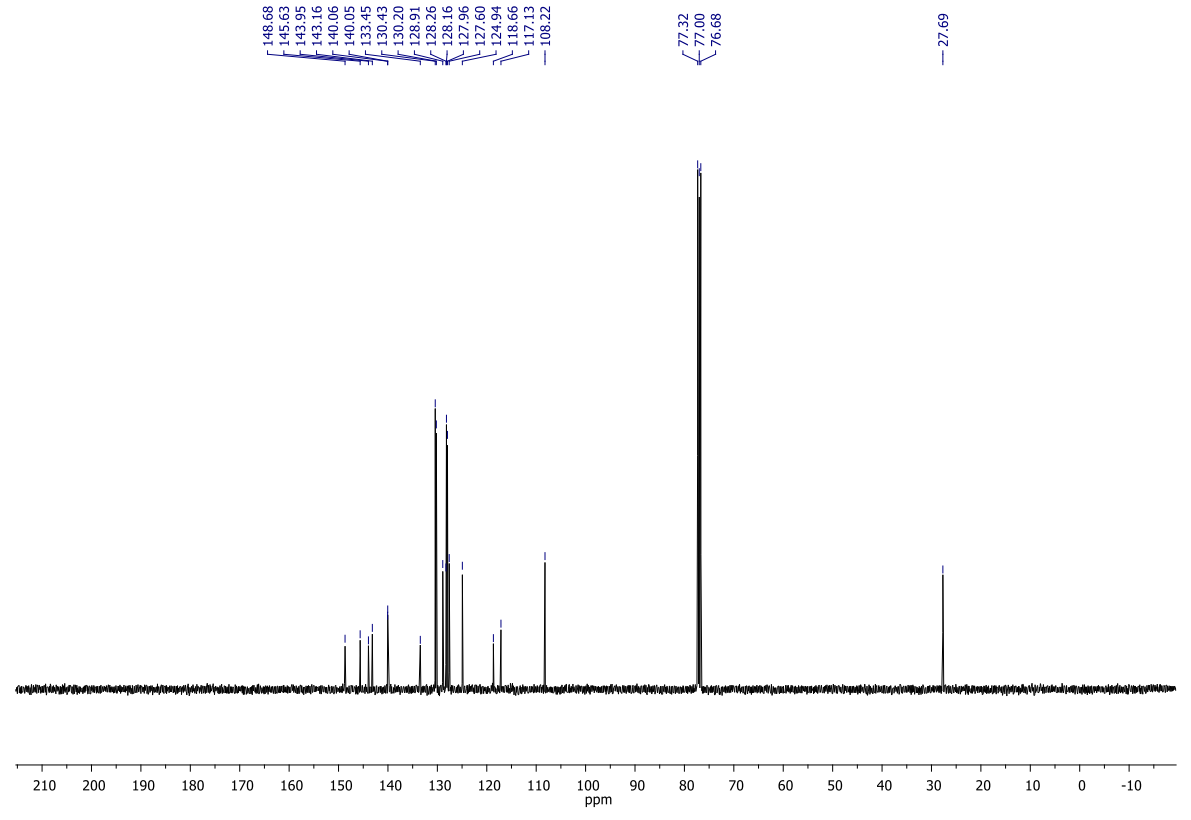
^{1}H and ^{13}C NMR spectra of compound **4ad**



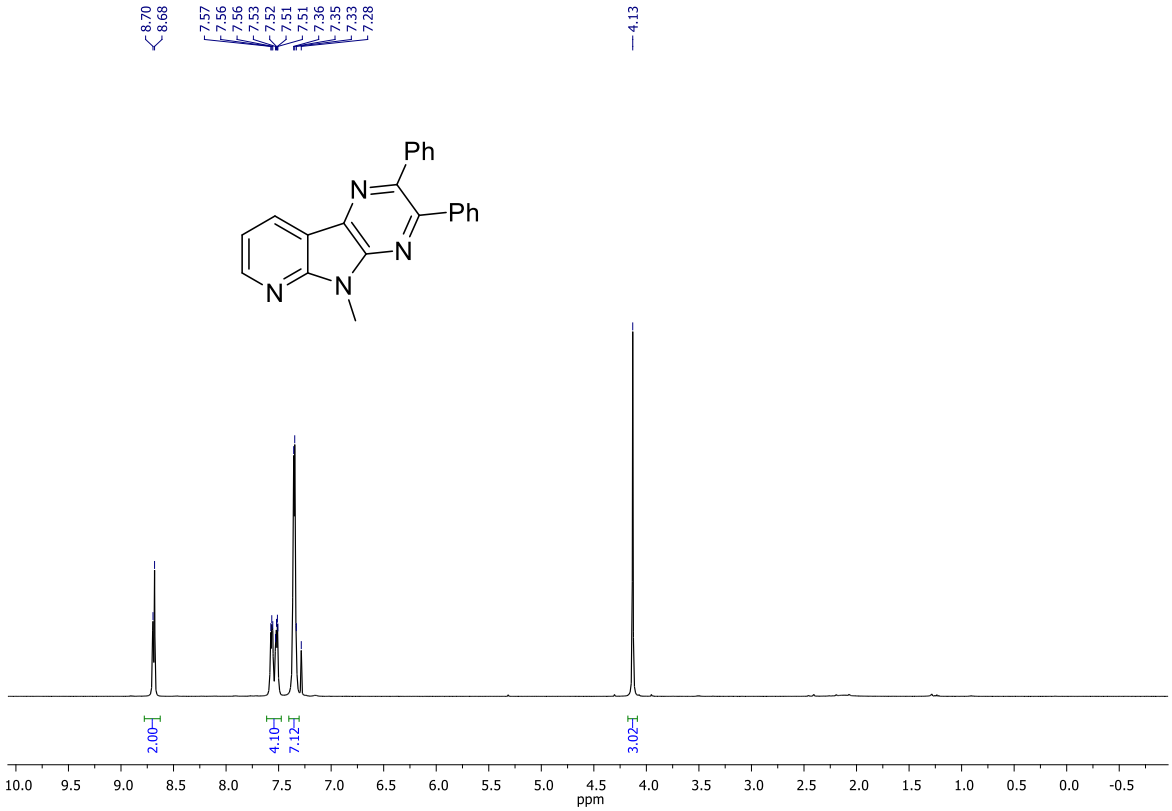


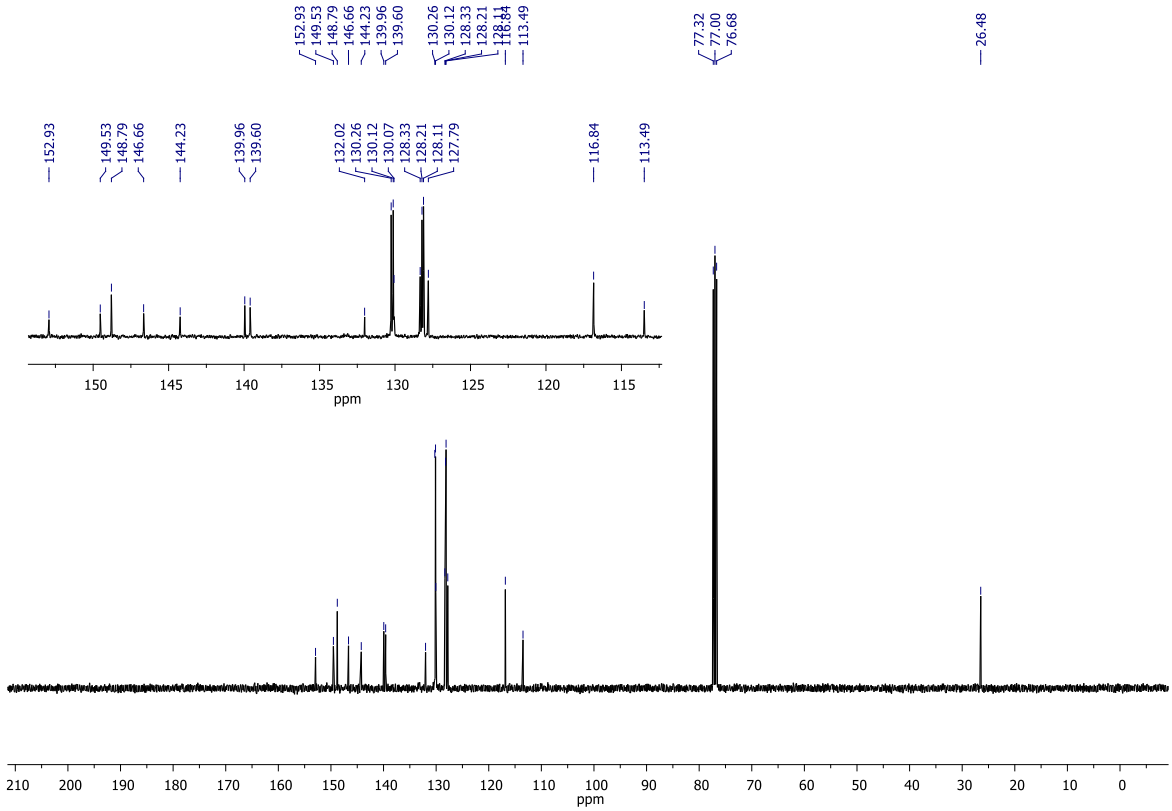
^{1}H and ^{13}C NMR spectra of compound **4ae**



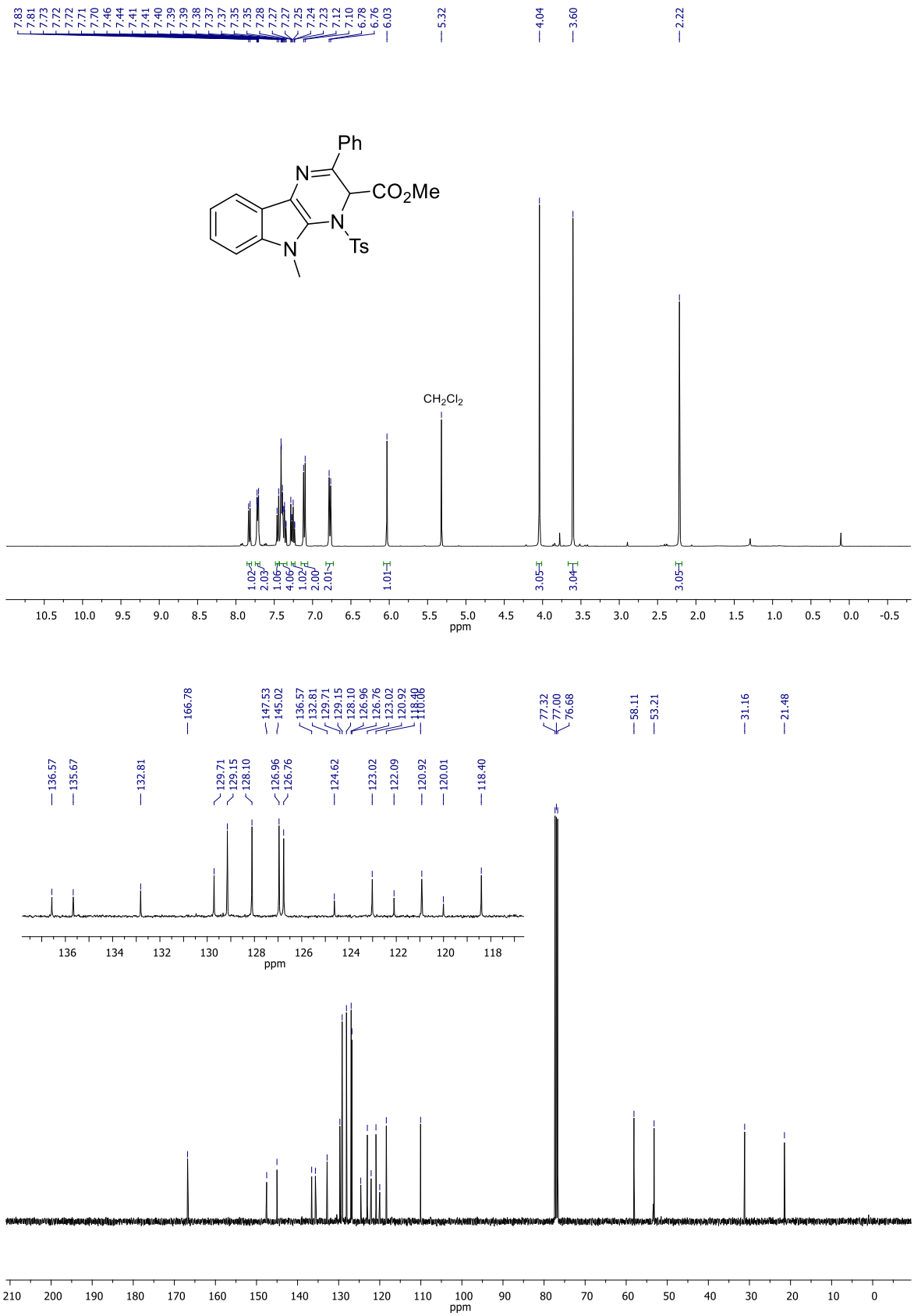


^{1}H and ^{13}C NMR spectra of compound **4af**





^{1}H and ^{13}C NMR spectra of compound **5a**



X-Ray crystal structure of compound 4j