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Supporting Information

Ambient access to a new family of pyrrole-fused pyrazine nitrones *via* 2-carbonyl-*N*-allenylpyrroles

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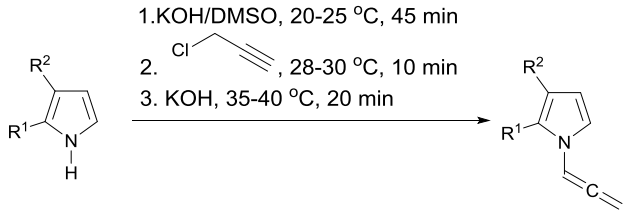
1. General Remarks

^{1}H (400.13 MHz), ^{13}C (100.61 MHz) and ^{15}N (40.55 MHz) NMR spectra were recorded on a "Bruker Avance 400" instrument in $CDCl_3$ and $DMSO_{d6}$ at rt. Chemical shifts δ are quoted in parts per million (ppm). The residual solvent peak δ_H 7.26, δ_C 77.16 and δ_H 2.5, δ_C 39.52, corresponding, was used as a reference.

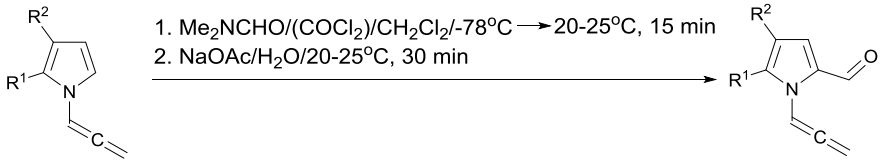
The assignment of signals in the ^{1}H NMR spectra was made using COSY and NOESY experiments. Resonance signals of carbon atoms were assigned based on ^{1}H-^{13}C HSQC and ^{1}H-^{13}C HMBC experiments. The values of the δ ^{15}N were measured through the 2D ^{1}H-^{15}N HMBC experiment and were referenced to CH_3NO_2 (0.0 ppm). Coupling constant (*J*) are reported in Herts (Hz). The multiplicity abbreviations used are: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet. Elemental analysis (C, H, N) was performed on an EA FLASH 1112 Series (CHN Analyzer). IR spectra were measured on a Bruker Vertex-70 as a film. All chemical and solvent were purchased from commercial sources.

2. General Procedure for Synthesis of *N*-allenylpyrroles



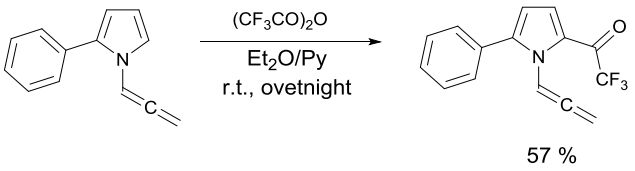
N-allenylpyrroles were prepared according to the literature method. A mixture of the pyrrole (0.025 mol), KOH pellets (15% water content, 0.10 mol) and DMSO (water content < 0.2%) (50 mL) was stirred at r.t. for 45 min. Subsequently, freshly distilled propargyl chloride (0.05 mol) was added over 10 min, while keeping the internal temperature between 28 and 30°C (exothermic reaction). A further amount of KOH (0.30 mol) was added, while heating between 35 and 40°C for 20 min and then the reaction mixture was poured into H_2O (100 mL) under efficient stirring. The mixture was extracted with Et_2O (3 x 50 mL). The Et_2O extract was washed with H_2O until the aqueous layer had become neutral, and subsequently dried ($MgSO_2$). The liquid remaining after evaporation of the solvent in vacuo was chromatographed over alumina, using a mixture of Et_2O and hexane (1:3) as eluent. Evaporation of the solvent in vacuo gave the *N*-allenylpyrroles.

3. General Procedure for Synthesis of *N*-allenylpyrrole-2-carbaldehydes



N-allenylpyrrole-2-carbaldehydes were prepared according to the literature method. $(COCl)_2$ (11.0 mmol) was added dropwise to DMF (11.0 mmol) in CH_2Cl_2 (3.0 ml) at ~78 °C (acetone and nitrogen), and the white crystals obtained were stirred for 15 min without cooling. Then a solution of 1-allenylpyrrole (10 mmol) in CH_2Cl_2 (10.0 ml) was added dropwise over 10 min at 25 °C. The resulting mixture was stirred for 15 min at r.t. Then a solution of NaOAc (50 mmol) in H_2O (45 ml) was added and the stirring was continued for 0.5 h at r.t. The lower (organic) layer was separated. The aqueous layer was extracted with CH_2Cl_2 (5 × 30 ml). The combined organic phases were washed with sat. aq $NaHCO_3$ (3 × 30 mL) and H_2O (3 × 30 mL), and dried (K_2CO_3). The residue obtained after evaporation of the CH_2Cl_2 was purified on basic alumina (hexane); this gave *N*-allenylpyrrole-2-carbaldehydes.

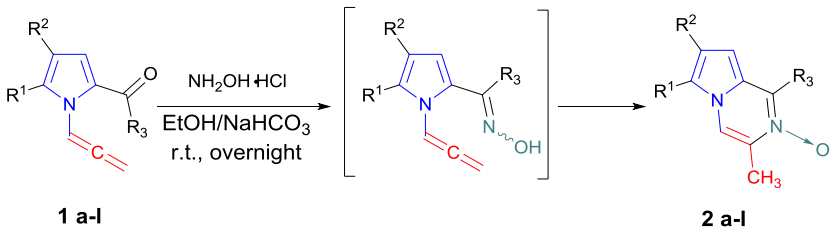
4. General Procedure for Synthesis of 2,2,2-trifluoro-1-(5-phenyl-1-(propa-1,2-dien-1-yl)-1H-pyrrol-2-yl)ethan-1-one.



57 %

The solution of thifluoroacetic anhydride (3.03 g, 14.43 mmol) in dry Et_2O (12 mL) was added dropwise to the mixture of *N*-allenylpyrrole (1.453 g, 8.017 mmol) and pyridine (1.141 g, 14.43 mmol) in dry Et_2O (40 mL) under stirring for 30 min. Then the reaction mixture was stirred at room temperature overnight and diluted with a saturated solution of $NaHCO_3$. The organic layer was separated, water layer was extracted with Et_2O (1 x 30 mL). The combined ether layers were washed with water (3 x 10 mL) and dried over K_2CO_3. The residue obtained after evaporation of the Et_2O to give 2,2,2-trifluoro-1-(5-phenyl-1-(propa-1,2-dien-1-yl)-1H-pyrrol-2-yl)ethan-1-one.

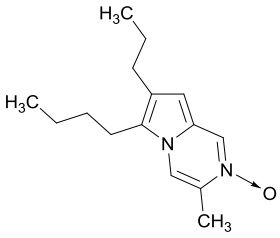
5. General Procedure for Synthesis of *N*-oxides *2a – 2l*



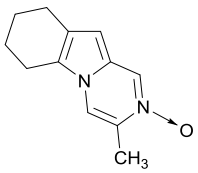
1 a-l **2 a-l**

A mixture of the *N*-allenylpyrrole-2-carbaldehyde (0.49 mmol), $NH_2OH•HCl$ (0.49 mmol), $NaHCO_3$ (0.49 mmol) and EtOH (not absolute) (2 ml) stirred at room temperature overnight. Then the reaction mixture was filtered from an inorganic precipitate. and the solvent was evaporated. Products received were purified over Al_2O_3 column by flash chromatography (eluent hexane, then ethanol).

6. Characterization Data of Products *2a – 2l*

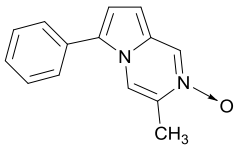


7-butyl-3-methyl-6-propylpyrrolo[1,2-a]pyrazine 2-oxide (2a). Glassy brown mass (57 mg, 48% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (s, 1H, CH=N), 7.48 (s, 1H, CH=C), 6.43 (s, 1H, pyrr), 2.80 – 2.76 (m, 2H, CH_2), 2.55 – 2.51 (m, 2H, CH_2), 2.43 (s, 3H, CH_3), 1.65 – 1.59 (m, 2H, CH_2), 1.54 – 1.49 (m, 2H, CH_2), 1.39 – 1.33 (m, 2H, CH_2), 0.96 – 0.94 (t, *J* = 7.3 Hz, 3H, CH_3), 0.93 – 0.91 (t, *J* = 7.3 Hz, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 130.7 (pyrr), 129.9 (C–N), 128.3 (CH=N), 125.6 (pyrr), 124.9 (pyrr), 114.8 (CH=C), 102.3 (pyrr), 29.7 (CH_2), 28.3 (CH_2), 23.8 (CH_2), 23.4 (CH_2), 22.5 (CH_2), 14.9 (CH_3), 13.9 (CH_3), 13.8 (CH_3). ^{15}N NMR (41 MHz, $CDCl_3$) δ -204.4 (N pyrr), -120.6 (NO). IR (film) 3429, 2956, 2866, 2211, 1655, 1446, 1325, 1175, 1013, 912, 815, 730, 638, 531, 419 cm^{-1}. Anal. Calcd for $C_{15}H_{22}N_2O$: C 73.13, H 9.00, N 11.37 %. Found: C 73.20, H 8.87, N 11.40 %.

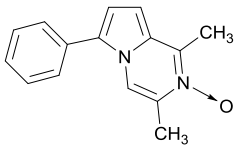


3-methyl-6,7,8,9-tetrahydropyrazino[1,2-a]indole-2-oxide (2b). Glassy brown mass (53 mg, 53% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (s, 1H, CH=N), 7.43 (s, 1H, CH=C), 6.38 (s, 1H, pyrr), 2.76 – 2.69 (m, 4H, indole), 2.45 (s, 3H, CH_3), 1.98 – 1.96 (m, 2H, indole), 1.86 –

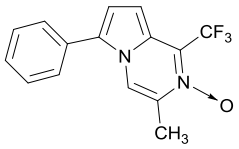
1.83 (m, 2H, indole). ^{13}C NMR (100 MHz, $CDCl_3$) δ 130.2 (C=N), 128.3 (CH=N), 127.9 (pyrr), 126.0 (pyrr), 123.2 (pyrr), 114.6 (CH=C), 100.7 (pyrr), 23.6 (CH_2), 23.2 (CH_2), 22.5 (CH_2), 21.2 (CH_2), 15.0 (CH_3). IR (film) 3352, 2923, 2853, 1652, 1437, 1319, 1261, 1134, 798, 732, 604, 509 cm^{-1}. Anal. Calcd for $C_{12}H_{14}N_2O$: C 71.26, H 6.98, N 13.85 %. Found: C 71.41, H 7.09, N 13.98 %.



3-methyl-6-phenylpyrrolo[1,2-a]pyrazine-2-oxide (2c). Glassy brown mass (83 mg, 76% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.46 (s, 1H, CH=N), 7.98 (s, 1H, CH=C), 7.49 – 7.48 (m, 4H, Ph), 7.39 (m, 1H, Ph), 6.88 (d, *J* = 4.3 Hz, 1H, pyrr), 6.64 (d, *J* = 4.3 Hz, 1H, pyrr), 2.38 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 131.5 (C–N), 130.4 (Ph), 129.3 (Ph), 128.7 (CH=N), 128.3 (Ph), 128.1 (pyrr), 128.0 (pyrr), 127.9 (Ph), 116.7 (pyrr), 115.7 (CH=C), 103.0 (pyrr), 14.8 (CH_3). ^{15}N NMR (41 MHz, $CDCl_3$) δ -205.9 (N pyrr), -112.8 (NO). IR (film) 3364, 3154, 2865, 2843, 1672, 1500, 1474, 1289, 1325, 1297, 1154, 1012, 1013, 925, 815, 689, 611, 502, 447, 410 cm^{-1}. Anal. Calcd for $C_{14}H_{12}N_2O$: C 74.98, H 5.39, N 12.49 %. Found: C 74.89, H 5.41, N 12.65 %.

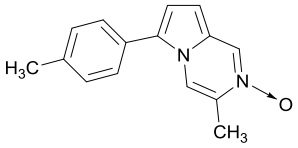


1,3-dimethyl-6-phenylpyrrolo[1,2-a]pyrazine-2-oxide (2d). Glassy brown mass (92 mg, 79% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (s, 1H, CH=C), 7.52 – 7.50 (m, 4H, Ph), 7.41 (m, 1H, Ph), 6.86 (d, *J* = 4.1 Hz, 1H, pyrr), 6.67 (d, *J* = 4.1 Hz, 1H, pyrr), 2.69 (s, 3H, CH_3), 2.42 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 139.3 (C–N), 131.5 (Ph), 130.8 (Ph), 129.3 (C=N), 128.9 (Ph), 128.3 (pyrr), 128.1 (pyrr), 115.9 (pyrr), 114.2 (CH=C), 103.2 (pyrr), 15.4 (CH_3), 14.0 (CH_3). ^{15}N NMR (41 MHz, $CDCl_3$) δ -208.5 (N pyrr), -117.6 (NO). IR (film) 3356, 3074, 2736, 2710, 1602, 1436, 1412, 1225, 1198, 1297, 1151, 1055, 1026, 903, 840, 638, 612, 499, 419, 415 cm^{-1}. Anal. Calcd for $C_{14}H_{12}N_{2O}$: C 75.61, H 5.92, N 11.76 %. Found: C 75.73, H 5.99, N 11.81 %.

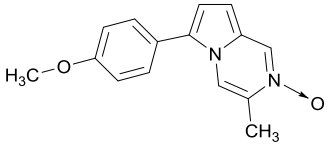


3-methyl-6-phenyl-1-(trifluoromethyl)pyrrolo[1,2-a]pyrazine-2-oxide (2e). Glassy brown mass (127 mg, 89% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (s, 1H, CH=N), 7.56 – 7.51 (m, 4H, Ph), 7.46 (m, 1H, Ph), 6.98 (d, *J* = 4.4 Hz, 1H, pyrr), 6.93 (m, 1H, pyrr), 2.39 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 132.4 (C–N), 129.9 (Ph), 129.5 (Ph), 129.3 (CH=N), 128.9 (Ph), 128.8 (pyrr), 128.4 (Ph), 124.7 (Ph), 122.3 (pyrr), 119.6 (q, *J* = 273.3 Hz, CF_3), 117.8 (pyrr), 117.6 (CH=C), 104.1 (pyrr), 14.5 (CH_3). ^{15}N NMR (41 MHz, $CDCl_3$) δ -207.0 (N pyrr), -106.6 (NO). IR (film) 3446, 3098, 2923, 1802, 1654, 1514, 1466, 1419, 1362, 1261, 1235, 1206, 1185, 1143,

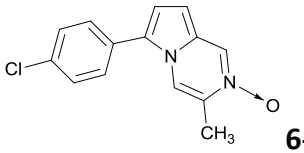
1021, 902, 878, 806, 781, 757, 701, 678, 560, 480, 447 cm^{-1}. Anal. Calcd for $C_{14}H_{12}N_{2O}$: C 65.22, H 4.01, N 10.14 %. Found: C 65.37, H 4.11, N 10.19 %.



3-methyl-6-(p-tolyl)pyrrolo[1,2-a]pyrazine-2-oxide (2f). Glassy brown mass (94 mg, 81% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (s, 1H, CH=N), 7.98 (s, 1H, CH=C), 7.43 – 7.41 (m, 2H, Ph), 7.34 – 7.32 (m, 2H, Ph), 6.88 (d, *J* = 4.3 Hz, 1H, pyrr), 6.66 (d, *J* = 4.3 Hz, 1H, pyrr), 2.44 (s, 3H, CH_3-Ph), 2.41 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.5 (C–N), 131.5 (Ph), 130.1 (Ph), 128.8 (CH=N), 128.2 (Ph), 128.03 (pyrr), 128.01 (Ph), 127.6 (pyrr), 116.6 (CH=C), 115.8 (pyrr), 103.0 (pyrr), 21.4 (CH_3), 15.0 (CH_3). IR (film) 3440; 3034; 2962; 2919; 2859; 1900; 1649; 1530; 1453; 1372; 1324; 1243; 1158; 1093; 1038; 941; 813; 752; 687; 631; 543; 496; 463; 423 cm^{-1}. Anal. Calcd for $C_{15}H_{14}N_2O$: C 75.61, H 5.92, N 11.76 %. Found: C 75.70, H 5.85, N 11.93 %.

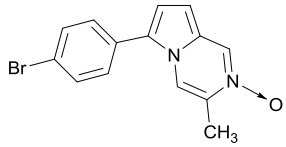


6-(4-methoxyphenyl)-3-methylpyrrolo[1,2-a]pyrazine-2-oxide (2g). Glassy brown mass (108 mg, 87 % yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (s, 1H, CH=N), 7.93 (s, 1H, CH=C), 7.45 – 7.43 (m, 2H, Ph), 7.06 – 7.04 (m, 2H, Ph), 6.85 (d, *J* = 4.3 Hz, 1H, pyrr), 6.66 (d, *J* = 4.3 Hz, 1H, pyrr), 3.88 (s, 3H, CH_3-O-Ph), 2.41 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7 (Ph), 131.3 (C–N), 129.5 (Ph), 128.9 (CH=N), 128.0 (pyrr), 127.6 (Ph), 122.8 (pyrr), 116.4 (pyrr), 115.6 (CH=C), 114.8 (Ph), 103.1 (pyrr), 55.4 (CH_3), 14.9 (CH_3). ^{15}N NMR (41 MHz, $CDCl_3$) δ -206.1 (N pyrr), -116.1 (NO). IR (film) 3288, 3045, 2955, 2544, 1762, 1611, 1555, 1464, 1377, 1308, 1249, 1177, 1108, 1032, 882, 836, 793, 716, 604, 578, 516 cm^{-1}. Anal. Calcd for $C_{15}H_{14}N_2O$: C 70.85, H 5.55, N 11.02 %. Found: C 70.59, H 5.18, N 11.28

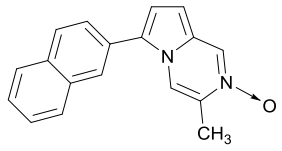


6-(4-chlorophenyl)-3-methylpyrrolo[1,2-a]pyrazine-2-oxide (2h). Glassy brown mass (113 mg, 89% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.50 (s, 1H, CH=N), 7.94 (s, 1H, CH=C); 7.50 – 7.44 (m, 4H, Ph), 6.90 (d, *J* = 4.3 Hz, 1H, pyrr), 6.66 (d, *J* = 4.3 Hz, 1H, pyrr), 2.41 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 134.3 (C–N), 132.0 (Ph), 129.6 (Ph), 129.2 (Ph), 129.0 (CH=N), 128.9 (pyrr), 128.4 (Ph), 126.7 (pyrr), 117.0 (pyrr), 115.6 (CH=C), 103.2 (pyrr), 14.9 (CH_3). ^{15}N NMR (41 MHz, $CDCl_3$) δ -206.8 (N pyrr), -114.7 (NO). IR (film) 3435; 3076; 2969; 2856; 1644; 1515; 1452; 1349; 1321; 1240; 1159; 1093; 1042; 1013; 938; 822; 739; 629; 547; 513;

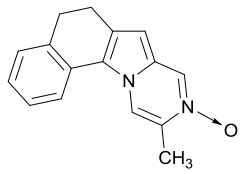
484; 414 cm^{-1}. Anal. Calcd for $C_{14}H_{11}ClN_2O$: C 65.00, H 4.29, N, 10.83 %. Found: C 64.89, H 4.33, N 10.93 %.



6-(4-bromophenyl)-3-methylpyrrolo[1,2-a]pyrazine-2-oxide (2i). Glassy brown mass (129 mg, 87% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (s, 1H, CH=N), 7.94 (s, 1H, CH=C), 7.65–7.63 (m, 2H, Ph), 7.40 – 7.38 (m, 2H, Ph), 6.89 (d, *J* = 4.3 Hz, 1H, pyrr), 6.66 (d, *J* = 4.3 Hz, 1H, pyrr), 2.40 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 132.6 (Ph), 132.0 (C–N), 129.46 (CH=N), 129.43 (Ph), 128.8 (Ph), 128.4 (pyrr), 126.7 (pyrr), 122.3 (pyrr), 116.9 (pyrr), 115.6 (CH=C), 103.1 (pyrr), 14.9 (CH_3). IR (film) 3438; 3044; 2962; 2924; 1900; 1648; 1555; 1513; 1454; 1351; 1325; 1243; 1160; 1094; 1067; 1011; 939; 821; 753; 708; 630; 546; 498; 474; 422 cm^{-1}. Anal. Calcd for $C_{14}H_{11}BrN_2O$: C 55.47, H 3.66, N 9.24 %. Found: C 55.29, H 3.61, N 9.12 %.

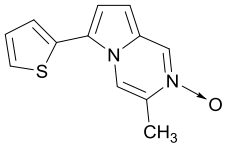


3-methyl-6-(naphthalen-2-yl)pyrrolo[1,2-a]pyrazine-2-oxide (2j). Glassy brown mass (94 mg, 70% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.52 (s, 1H, CH=N), 8.09 (s, 1H, CH=C), 7.99 – 7.97 (m, 2H, naph), 7.91 – 7.89 (m, 2H, naph), 7.63 (d, *J* = 8.6 Hz, 1H, naph), 7.57 – 7.54 (m, 2H, naph), 7.02 (d, *J* = 4.3 Hz, 1H, 3 pyrr), 6.72 (d, *J* = 4.3 Hz, 1H, pyrr), 2.42 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 133.6 (C–N), 132.9, 131.8 (naph), 129.2 (naph), 128.9 (CH=N), 128.3 (naph), 128.0 (naph), 127.9 (naph), 127.8 (naph), 127.0 (pyrr), 126.8 (naph), 125.7 (pyrr), 117.2 (pyrr), 115.8 (CH=C), 103.3 (pyrr), 15.0 (CH_3). IR (film) 3438; 3049; 2923; 2209; 1628; 1506; 1447; 1384; 1319; 1249; 1157; 1086; 1040; 1012; 905; 828; 753; 626; 545; 476; 416. Anal. Calcd for $C_{18}H_{14}N_2O$: C 78.81, H 5.14, N 10.21 %. Found: C 78.74, H, 5.08, N 10.28 %.



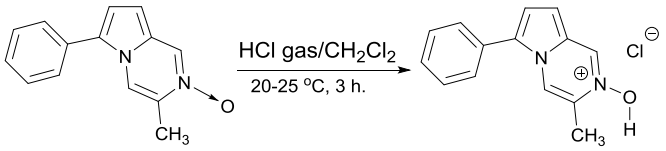
10-methyl-5,6-dihydrobenzo[g]pyrazino[1,2-a]indole 9-oxide (2k). Glassy brown mass (49 mg, 40% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (s, 1H, CH=N), 8.21 (s, 1H, CH=C), 7.61 (d, *J* = 7.7 Hz, 1H, Ph), 7.33 – 7.26 (m, 2H, Ph), 7.18 – 7.15 (m, 1H, Ph), 6.49 (s, 1H, pyrr), 2.89 – 2.84 (m, 4H, indole), 2.47 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 136.7 (C–N), 131.4 (Ph), 131.1 (Ph), 129.0 (Ph), 128.5 (CH=N), 128.3 (Ph), 127.7 (Ph), 126.9 (pyrr), 126.5 (Ph), 123.5 (pyrr), 119.6 (pyrr), 116.0 (CH=C), 101.3 (pyrr), 30.0 (indole), 22.7 (indole), 15.1 (CH_3). ^{15}N NMR (41 MHz, $CDCl_3$) δ -212.6 (N pyrr), -117.9 (NO). IR (film) 3440, 3058, 2932, 1628, 1550,

1501, 1429, 1307, 1153, 1020, 934, 761, 621, 518 cm^{-1}. Anal. Calcd for $C_{16}H_{14}N_2O$: C 76.78, H 5.64, N 11.19 %. Found: C 76.82, H 5.75, N 11.12 %.



3-methyl-6-(thiophen-2-yl)pyrrolo[1,2-a]pyrazine-2-oxide (2l). Glassy brown mass (96 mg, 86% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.50 (s, 1H, CH=N), 8.09 (s, 1H, CH=C); 7.42 (dd, *J* – 1.1, 5.1 Hz, 1H, thienyl), 7.27 (dd, *J* = 1.1, 3.7 Hz, 1H, thienyl), 7.19 (dd, *J* = 3.7, 5.1 Hz, 1H, thienyl), 6.97 (d, *J* = 4.3 Hz, 1H, pyrr), 6.66 (d, *J* = 4.3 Hz, 1H, pyrr), 2.43 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 132.1 (C–N), 131.7 (thienyl), 128.9 (CH=N), 128.3 (pyrr), 128.0 (thienyl), 126.0 (thienyl), 125.8 (thienyl), 121.3 (pyrr), 117.9 (pyrr), 116.2 (CH=C), 103.4 (pyrr), 15.0 (CH_3). ^{15}N NMR (41 MHz, $CDCl_3$) δ -205.9 (N pyrr), -113.5 (NO). IR (film) 3285; 3095; 2975; 2924; 2855; 2625; 2365; 2214; 2117; 1951; 1723; 1655; 1614; 1573; 1458; 1417; 1313; 1243; 1208; 1153; 1044; 964; 893; 845; 791; 702; 623; 531; 468; 416 cm^{-1}. Anal. Calcd for $C_{12}H_{10}N_2OS$: C 62.59, H 4.3, N 12.16 %. Found: C 62.32, H 4.33, N 12.00 %.

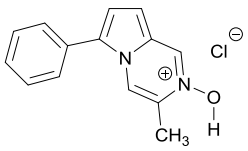
7. General Procedure for Synthesis of salts of 3-Methyl-6-phenylpyrrolo[1,2-a]pyrazine-2-oxide *2c*



2c **3c**

Gaseous HCl was passed through a solution of 3-methyl-6-phenylpyrrolo[1,2-a]pyrazine-2-oxide **2c** (76 mg, 0.34 mmol) in CH_2Cl_2 (10 ml) at 20 – 25 °C for 3 hours. Then the solvent was evaporated to give black crystals.

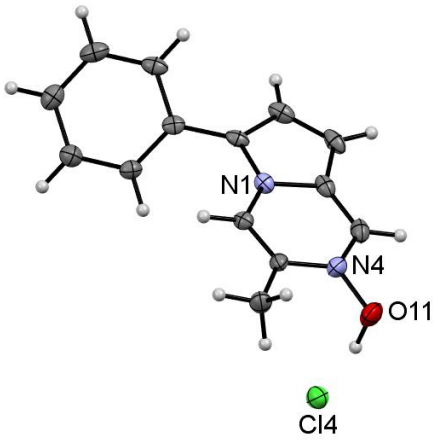
8. Characterization Data of Products *3c*



2-hydroxy-3-methyl-6-phenylpyrrolo[1,2-a]pyrazin-2-ium chloride (3c). Black crystals (87 mg, 99 %). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.29 (s, 1H, CH=N), 8.08 (s, 1H, CH=C); 7.63 – 7.56 (m, 5H, Ph), 7.47 (d, *J* = 4.6 Hz, 1H, pyrr), 7.28 (d, *J* = 4.6 Hz, 1H, pyrr), 2.58 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.5 (C–N), 134.3 (Ph), 130.5 (CH=N), 130.0 (Ph), 129.2 (Ph),

128.37 (Ph), 128.33 (pyrr), 125.6 (pyrr), 121.5 (pyrr), 115.4 (pyrr), 114.5 (CH=C), 15.0 (CH_3). ^{15}N NMR (41 MHz, $CDCl_3$) δ -200.3 (N pyrr), -167.3 (NO). IR (film) 3443; 3123; 3076; 2985; 2924; 1650; 1566; 1451; 1403; 1336; 1236; 1190; 1146; 1083; 1052; 937; 914; 864; 840; 790; 760; 690; 650; 616; 538; 488; 424 cm^{-1}.

9. X-ray Crystallographic Data of Salts of 3-Methyl-6-phenylpyrrolo[1,2-a]pyrazine-2-oxide *3c*



Data were collected on a BRUKER D8 VENTURE PHOTON 100 CMOS diffractometer with MoK_α radiation (λ = 0.71073 Å) using the ϕ and ω scans technique. The structures were solved and refined by direct methods using the SHELX. Data were corrected for absorption effects using the multi-scan method (SADABS). All non-hydrogen atoms were refined anisotropically using SHELX.[1]The coordinates of the hydrogen atoms were calculated from geometrical positions.

Selected bond lengths, bond angles and torsion angles are given in **Table 2.**

Table 1. X-ray crystallographic data, measurement details, and structure refinements for compound ***3c***

CCDC number	**1957957**
Empirical formula	$C_{14}H_{13}N_2O$, Cl
Formula weight / $g{\cdot}mol^{-1}$	260.71
Crystal system	monoclinic
Space group	P $2_1/c$
a / Å	9.4142(15)
b / Å	7.1434(12)
c / Å	18.676(3)
α, в, γ / ˚	90, 99.476(4), 90
Volume / $Å^3$	1238.8(3)
Z	4
Density (calculated) / $g{\cdot}cm^{-3}$	1.398
Absorptions coefficient / mm^{-1}	0.297

Radiation (λ / Å)	MoKα (0.71073)
Temperature / K	100(2)
2Θ range / °	2.85 – 27.00
Crystal size / mm	0.37 × 0.16 × 0.02
Crystal habit	black, plate
F(000)	544
Index ranges	-11<=h<=12, -9<=k<=9, -23<=l<=23
Reflections collected	20463
Independent reflections	2683 [R(int) = 0.1520]
Number of ref. parameters	167
R_1 / wR_2 [$I > 2\sigma(I)$]	0.0577 / 0.0892
R_1 / wR_2 (all data)	0.1365 / 0.1104
Goodness-of-fit on F^2	1.008
Completeness [%]	99.9
Largest diff. peak and hole / e·Å^{-3}	0.372/ -0.278
Weight scheme	$w=1/[\sigma^2(F_o^2)+(0.0279P)^2+1.0063P]$ where $P=(F_o^2+2F_c^2)/3$

Table 2. Selected bond lengths, bond angles and torsion angles for compound **3c**

Bond	*l*, Å	Angle	ϕ, ˚	Torsion angle	θ, ˚
O11-N4	1.383(3)	N4-O11-H11O	100.3(19)	C5-N4-C3-C2	3.8(4)
N4-C5	1.324(3)	C5-N4-C3	123.5(3)	C5-N4-C3-C10	-174.3(3)
N1-C9	1.369(3)	C9-N1-C2	132.0(3)	N4-C3-C2-N1	-0.3(4)
N1-C6	1.414(3)	C2-N1-C6	119.1(2)	C9-N1-C2-C3	179.3(3)
C3-C10	1.489(4)	C2-C3-C10	124.3(3)	C2-N1-C9-C8	175.0(3)
C9-C8	1.400(4)	C3-C2-N1	120.9(3)	C2-N1-C9-C12	-9.0(5)
C12-C13	1.392(4)	N1-C9-C12	124.6(2)	N1-C9-C12-C13	-36.0(4)
C13-C14	1.377(4)	C13-C12-C17	118.6(3)	N1-C9-C12-C17	147.7(3)
C14-C15	1.385(4)	C17-C12-C9	119.4(3)	C17-C12-C13-C14	-0.2(4)
C15-C16	1.380(4)	C13-C14-C15	120.5(3)	C12-C13-C14-C15	0.4(4)
C8-C7	1.367(4)	C7-C8-C9	110.0(3)	N1-C9-C8-C7	0.9(3)
C7-C6	1.398(4)	C5-C6-C7	134.2(3)	C9-C8-C7-C6	-0.7(3)
C6-C5	1.376(4)	C7-C6-N1	107.1(3)	C8-C7-C6-N1	0.2(3)
C17-C16	1.383(4)	C16-C17-C12	120.6(3)	C2-N1-C6-C5	7.7(4)
O11-H11O	1.00(3)	C5-N4-O11	117.9(3)	C2-N1-C6-C7	-176.0(2)
N4-C3	1.390(3)	O11-N4-C3	118.5(2)	C3-N4-C5-C6	-1.2(4)
N1-C2	1.386(3)	C9-N1-C6	108.8(2)	N1-C6-C5-N4	-4.5(4)
C3-C2	1.337(4)	C2-C3-N4	118.1(3)	C9-C12-C17-C16	176.3(3)
C9-C12	1.463(4)	N4-C3-C10	117.6(3)	C12-C17-C16-C15	0.0(4)
C12-C17	1.400(4)	N1-C9-C8	106.7(3)	O11-N4-C3-C2	-172.3(3)
		C8-C9-C12	128.5(3)	O11-N4-C3-C10	9.6(4)
		C13-C12-C9	121.8(3)	C10-C3-C2-N1	177.6(3)
		C14-C13-C12	120.4(3)	C6-N1-C2-C3	-5.3(4)
		C16-C15-C14	119.9(3)	C6-N1-C9-C8	-0.7(3)
		C8-C7-C6	107.4(3)	C6-N1-C9-C12	175.2(2)
		C5-C6-N1	118.6(3)	C8-C9-C12-C13	139.0(3)

		N4-C5-C6	119.3(3)	C8-C9-C12-C17	-37.2(4)
		C15-C16-C17	120.0(3)	C9-C12-C13-C14	-176.5(3)
				C13-C14-C15-C16	-0.4(4)
				C12-C9-C8-C7	-174.9(3)
				C8-C7-C6-C5	175.6(3)
				C9-N1-C6-C5	-175.9(3)
				C9-N1-C6-C7	0.3(3)
				O11-N4-C5-C6	174.9(3)
				C7-C6-C5-N4	-179.5(3)
				C13-C12-C17-C16	0.0(4)
				C14-C15-C16-C17	0.2(5)

Reference

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10. Computational details

The structural parameters of the studied systems were optimized using the density functional theory (DFT) at the B3LYP[1,2] level of theory with the 6-31+G* basis set. The vibrational corrections to enthalpies and Gibbs free energies were calculated at the same level of theory (B3LYP/6-31+G*) at a standard temperature 298.15 K.

For all stationary points the number of negative eigenvalues of the Hessian matrix was analyzed; the connection of the transition states found with the corresponding PES minima was proved by the reaction coordinate following using the local quadratic approximation algorithm (LQA)[3]. Further, the energies at the stationary points were refined by using the double-hybrid functional B2PLYP[4] in combination with the extended 6-311+G**. Such a combined B2PLYP/6-311+G**//B3LYP/6-31+G* method provides accuracy comparable to CCSD(T)/6-311+G**//CCSD/6-31G* and CBS-Q//B3 approaches[5]. For all models solvation energy in ethanol was computed additionally by the polarizable dielectric model using the IEFPCM model.[6]

To estimate activation free energy in the solution we have used approach, which based upon results by Wertz. Being applied to ethanol solution this approach suggests that the entropy in ethanol solution S_{sol} can be obtain from S_{harm}, the entropy found in the harmonic approximation for ideal gas, as $S_{sol} = 0.69S_{harm} - 2.52 cal \cdot mol^{-1} \cdot K^{-1}$.

Note that complex **III** is unstable and corresponds to a shallow minimum on the PES as predicted by the B3LYP/6-31+G* approach. After applying the vibrational corrections, B2PLYP energy refinement, and adding solvation energy correction its Gibbs free energy become higher than that of $TS_{III \rightarrow IV}$. The same is true for $TS_{VIII \rightarrow IX}$.

All calculations were carried out using the GAUSSIAN 09 program package.[7]

MaSK[8] and ChemCraft[9] programs were used to visualize molecular structures.

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Wertz method for ethanol solutions

Wertz[1] approach suggests that all solutes lose the same fraction of entropy when dissolved in water. Abraham[2] have shown that it takes place for other solvents. Wertz also argues that the same amount of entropy is lost when the ions are solvated. This allows one to introduce appropriate corrections for an arbitrary solvent. Previously, we used this method for a DMSO solution.[3]

Wertz method for ethanol solutions is composed of several steps. In the first stage a solute is treated as an ideal gas and compressed from 1atm to a hypothetical ideal gas state with the concentration equal to that of the liquid state (d=0.789 g/ml, 298 K, 17.126 M). This entropy change can be estimated as

$$\Delta S_1 = -R\, ln\frac{P_2}{P_1} = -R\, ln(22.4 \cdot 17.126) = -49.47 \text{ J mol}^{-1} \text{ K}^{-1}.$$

The next step is the conversion of this hypothetical state to the final liquid state. The fraction of entropy lost in second step is defined as a coefficient, α.

$$\alpha = \frac{\Delta S_2}{S_g} = \frac{S_g - S_l^0}{S_g} = \frac{S_g^0 + \Delta S_1 - S_l^0}{S_g},$$

$$\Delta S_2 = \alpha S_g = \alpha S_g^0 + \alpha \Delta S_1$$

The entropy of liquid ethanol S_l^0 = 159.86 J mol^{-1} K^{-1} (standard state).[11] The entropy of vaporization can be estimated from the normal heat of vaporization (42.3 kJ/mol) and boiling temperature (351.5 K at 1 atm) as ΔS_{vap}^0 = 120.34 J mol^{-1} K^{-1}, therefore, S_g^0 = 280.20 J mol^{-1} K^{-1}, $S_g = S_g^0 + \Delta S_1 = 230.73$ J mol^{-1} K^{-1} , and α = 0.307.

The entropy change from the gas state of *any* given molecule **M** in standard state to its 1 M state in ethanol is composed of three steps. The first is the compression of ideal **M** gas in standard state to a hypothetical ideal gas state with the concentration equal to that of the *solvent* liquid state (17.126 M) that gives the same ΔS_1 = –49.47 J mol^{-1} K^{-1}. Conversion of the hypothetical ideal gas state to a hypothetical liquid state brings $\Delta S_2 = \alpha S_g = \alpha S_g^0 + \alpha \Delta S_1$. The fraction of entropy loss in this step is assumed to be equal to α. Finally, expansion of the hypothetical liquid state to the 1M state in ethanol results in $\Delta S_3 = R\, ln(17.126) = 23.62$ J mol^{-1} K^{-1}. The calculated gas phase entropy of **M** in standard state is then converted to the corresponding entropy in its 1 M state in ethanol according to the following equation: $S_l^0 = S_g^0 + \Delta S_1 - \Delta S_2 + \Delta S_3 = 0.69 \times S_g^0 - 10.52$ J mol^{-1} K^{-1},

For a bimolecular reaction it results in changing

$$T\Delta S_l = 0.69 \times T\Delta S_g - 0.75 \text{ kcal/mol}.$$

References:

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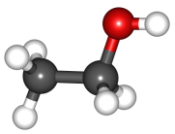
Total energies, enthalpies, and Gibbs free energies (a.u.) calculated in the frame of B2PLYP/6-311+G//B3LYP/6-31+G*, Cartesian coordinates (Å) of stationary points**

Cartesian coordinates

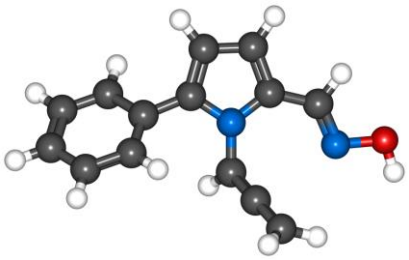
H	-1.9658580	0.3740080	0.0000000
O	-1.2010950	-0.2215020	0.0000000
C	0.0000000	0.5565580	0.0000000
H	0.0368920	1.2039410	0.8901310
H	0.0368920	1.2039410	-0.8901310
C	1.1787700	-0.4024880	0.0000000
H	1.1522260	-1.0439810	-0.8878060
H	1.1522260	-1.0439810	0.8878060
H	2.1237640	0.1536700	0.0000000



Ethanol

	a.u.
E(B2PLYP)	-154.9489424
E(B2PLYP)+*ZPE*	-154.8689104
E(B2PLYP)+H_{corr}	-154.8636784
E(B2PLYP)+G_{corr}	-154.8943034

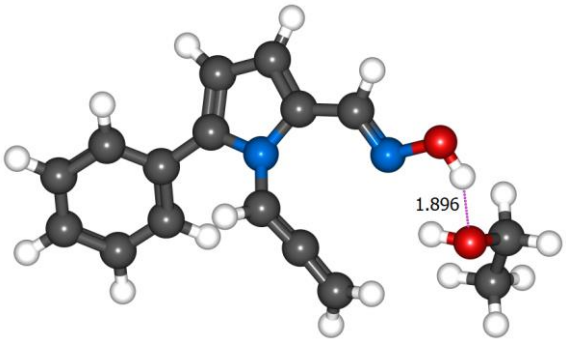
H	-1.0532260	-2.9605800	-0.8990980
C	-0.3276490	-2.2098410	-0.6160360
C	-0.6356060	-0.9190390	-0.2038230
N	0.5622800	-0.2460980	0.0163180
C	0.6367620	1.0831980	0.5332120
H	0.0378620	1.2628860	1.4232800
C	1.3509490	2.0390670	-0.0083110
C	2.0949620	2.9911110	-0.5031270
H	3.1363850	3.0959690	-0.2027700
H	1.7117600	3.6969380	-1.2383250
C	1.0755260	-2.3273160	-0.6498080
H	1.6513200	-3.2013180	-0.9264560
C	1.6243430	-1.1136690	-0.2430470
C	3.0416350	-0.9104990	-0.0414050
H	3.6624230	-1.7578070	-0.3464020
N	3.6098370	0.1203260	0.4764250
O	5.0105540	-0.0942140	0.5296620
H	5.3347550	0.7106560	0.9634280
C	-1.9697880	-0.3194920	-0.0390870
C	-2.9876120	-1.0754970	0.5743130
C	-2.2915010	0.9629130	-0.5231590
C	-4.2812460	-0.5678720	0.6992660
C	-3.5844310	1.4716120	-0.3892300
C	-4.5850750	0.7105290	0.2218710
H	-2.7519360	-2.0612760	0.9661550
H	-1.5326440	1.5543340	-1.0247790
H	-5.0499620	-1.1681890	1.1794970
H	-3.8123350	2.4624750	-0.7742820
H	-5.5912730	1.1088090	0.3234920



(*E*)-*N*-hydroxy-5-phenyl-1-(1-propadienyl-1*H*-pyrrol-2-yl)methanimine (I)

	a.u.
E(B2PLYP)	-724.8716926
E(B2PLYP)+*ZPE*	-724.6457226
E(B2PLYP)+H_{corr}	-724.6295716
E(B2PLYP)+G_{corr}	-724.6890876

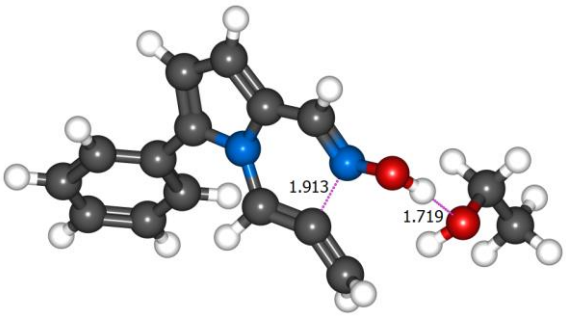
C	-1.9175100	2.2050920	-0.9639560
C	-1.8978830	0.9652640	-0.3421020
N	-0.6162020	0.7600540	0.1716020
C	0.1627680	1.8899350	-0.1132370
C	-0.6395600	2.7823750	-0.8149710
H	-2.7580210	2.6144650	-1.5083660
H	-0.3037700	3.7331930	-1.2090080
C	1.5464410	2.1420370	0.2234780
N	2.4261890	1.2451510	0.4967610
O	3.6664540	1.8329830	0.7844620
C	-0.3815400	-0.2141420	1.1923280
C	0.6225780	-1.0530540	1.2747060
C	1.5648770	-1.9382580	1.4689800
H	3.5716780	-0.7434210	0.1192890
H	2.4708930	-1.6972590	2.0224820
H	1.4802080	-2.9502840	1.0746010
H	1.8516710	3.1914730	0.1898720
H	-1.1585700	-0.2467070	1.9546130
H	4.2602820	1.0499180	0.8111950
O	4.5288260	-0.7581970	0.3093040
C	5.2520060	-0.9842080	-0.9097030
H	6.3072820	-0.8986710	-0.6333450
H	5.0277060	-0.1852040	-1.6315010
C	4.9629880	-2.3531660	-1.5148420
H	3.9068800	-2.4453300	-1.7985750
H	5.1994130	-3.1501350	-0.8011770
H	5.5660900	-2.5058200	-2.4187800
C	-2.9936650	-0.0081730	-0.2264170
C	-2.7943890	-1.3905600	-0.4078010
C	-4.3027460	0.4502030	0.0178110
C	-3.8670640	-2.2803460	-0.3405880
C	-5.3751380	-0.4407250	0.0750710
C	-5.1621350	-1.8112270	-0.0997660
H	-1.7983350	-1.7651040	-0.6217940
H	-4.4713620	1.5117980	0.1774620
H	-3.6915930	-3.3431630	-0.4878790
H	-6.3766990	-0.0642850	0.2676960
H	-5.9960850	-2.5064510	-0.0494030



Complex of (*E*)-*N*-hydroxy-5-phenyl-1-(1-propadienyl-1*H*-pyrrol-2-yl)methanimine and ethanol (II)

	a.u.
E(B2PLYP)	-879.8323502
E(B2PLYP)+*ZPE*	-879.5238892
E(B2PLYP)+H_{corr}	-879.5021462
E(B2PLYP)+G_{corr}	-879.5772362

C	-2.1462710	2.1866100	-0.9747100
C	-1.9609410	0.9367700	-0.3686000
N	-0.6421410	0.8628700	0.0405600
C	0.0000290	2.0609500	-0.3014600
C	-0.9351110	2.8894600	-0.9315000
H	-3.0665310	2.5114200	-1.4418600
H	-0.7258410	3.8661900	-1.3475600
C	1.3584990	2.2668700	0.0321700
N	2.0778590	1.2655400	0.4492600
O	3.3437290	1.6006010	0.8802000
C	-0.0995610	-0.0606700	0.9538100
C	1.2063590	-0.2511700	1.2243900
C	2.0385090	-1.1243200	1.8338300
H	3.7418090	-1.1891090	0.6038400
H	2.7417890	-0.8060200	2.6011000
H	1.8960900	-2.1931900	1.6893800
H	1.8106690	3.2534200	-0.0608200
H	-0.8372710	-0.5871800	1.5484700
H	3.8963290	0.7968710	0.6607100
O	4.5308990	-0.7381890	0.2192400
C	4.6751990	-1.0911690	-1.1648600
H	5.4340590	-0.4083490	-1.5596400
H	3.7349090	-0.8955590	-1.7001600
C	5.1100600	-2.5408290	-1.3459300
H	4.3515400	-3.2325990	-0.9592300
H	6.0498400	-2.7308490	-0.8161000
H	5.2582400	-2.7644890	-2.4101000
C	-2.9441610	-0.1404100	-0.1914100
C	-2.6131710	-1.4959100	-0.3854300
C	-4.2781110	0.1819590	0.1232100
C	-3.5832900	-2.4908300	-0.2649900
C	-5.2481910	-0.8149110	0.2361100
C	-4.9052500	-2.1564510	0.0461200

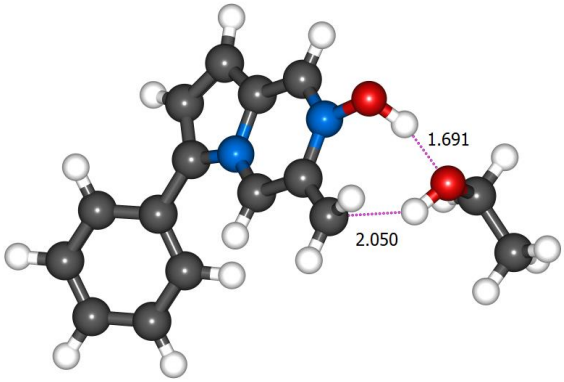


Transition state of (*E*)-*N*-hydroxy-5-phenyl-1-(1-propadienyl-1*H*-pyrrol-2-yl)methanimine cyclization ($TS_{II \rightarrow III}$)

*I*441 cm^{-1}

	a.u.
E(B2PLYP)	-879.8079054
E(B2PLYP)+*ZPE*	-879.4998474
E(B2PLYP)+H_{corr}	-879.4797914
E(B2PLYP)+G_{corr}	-879.5493574

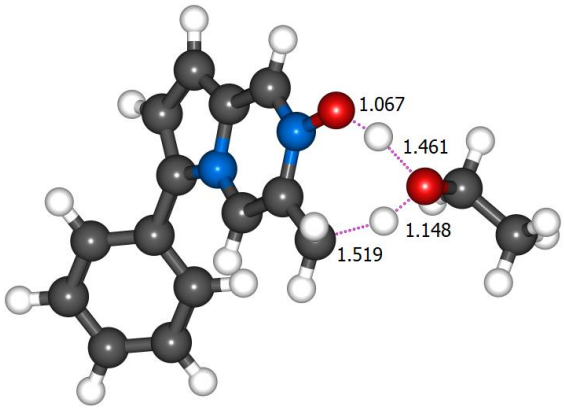
H	-1.5953700	-1.7682800	-0.6501800
H	-4.5470910	1.2209290	0.2938100
H	-3.3073300	-3.5303400	-0.4237800
H	-6.2713010	-0.5430810	0.4835100
H	-5.6591800	-2.9336410	0.1398400
C	-2.0531160	2.1212210	-1.0969450
C	-1.8919430	0.8937960	-0.3964670
N	-0.5906520	0.8474660	0.0476220
C	0.0720950	2.0340880	-0.3817510
C	-0.8634430	2.8234560	-1.1017880
H	-2.9742380	2.4171680	-1.5823080
H	-0.6507270	3.7711590	-1.5765420
C	1.3939750	2.1879870	-0.0353320
N	2.0290680	1.2581060	0.6928280
O	3.3490840	1.5263910	1.0025910
C	0.0571940	-0.0486750	0.8555470
C	1.4160330	0.0914110	1.2221590
C	2.1554390	-0.8206960	1.9674840
H	3.6211540	-1.1950100	0.5833710
H	3.0337530	-0.4830530	2.5078490
H	1.6189000	-1.6636260	2.3915200
H	1.9832360	3.0499940	-0.3209490
H	-0.5224230	-0.8693350	1.2490860
H	3.8653100	0.7724590	0.5784170
O	4.3458450	-0.7608430	0.0514440
C	4.3660510	-1.2645990	-1.2905810
H	5.0073560	-0.5794710	-1.8547260
H	3.3566190	-1.2146260	-1.7251720
C	4.9108720	-2.6869110	-1.3586630
H	4.2709320	-3.3800750	-0.7995890
H	5.9193880	-2.7328270	-0.9335690
H	4.9547960	-3.0303850	-2.4002530
C	-2.8989760	-0.1454270	-0.1732590
C	-2.6025850	-1.5230290	-0.2299200
C	-4.2397400	0.2322320	0.0496760
C	-3.6051110	-2.4789910	-0.0625740
C	-5.2400500	-0.7256460	0.2106010
C	-4.9284520	-2.0879480	0.1609360
H	-1.5894680	-1.8509710	-0.4430980
H	-4.4901970	1.2878330	0.1129570
H	-3.3512010	-3.5347680	-0.1178000
H	-6.2643760	-0.4066520	0.3867550
H	-5.7066120	-2.8348120	0.2938760



Complex of (2-hydroxy-6-phenyl-pyrrolo[1,2-a]pyrazin-2-ium-3-yl)methanide and ethanol (III)

	a.u.
E(B2PLYP)	-879.839915
E(B2PLYP)+*ZPE*	-879.529205
E(B2PLYP)+H_{corr}	-879.509511
E(B2PLYP)+G_{corr}	-879.578197

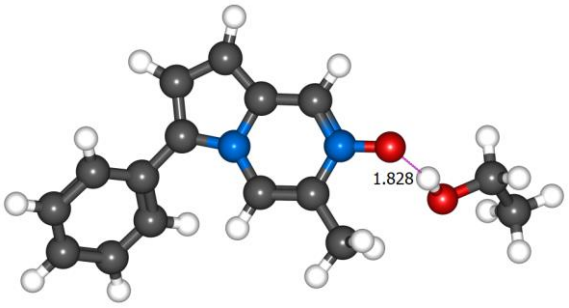
C	-2.1022880	2.1824800	-0.9953320
C	-1.9152560	0.9267330	-0.3714100
N	-0.6032140	0.8655840	0.0290650
C	0.0432410	2.0691180	-0.3478030
C	-0.9066000	2.8900490	-0.9915820
H	-3.0374700	2.5026360	-1.4361150
H	-0.7116050	3.8656560	-1.4148100
C	1.3873880	2.2006270	-0.0407750
N	2.0382410	1.2396060	0.6159470
O	3.3673090	1.4669540	0.8675640
C	0.0754100	-0.0713010	0.7807470
C	1.4209290	0.0593480	1.1002830
C	2.2320020	-0.9229100	1.7579170
H	3.4027240	-1.1200680	0.8106150
H	2.8706160	-0.5180760	2.5487070
H	1.6623490	-1.7902760	2.0927210
H	1.9731680	3.0690700	-0.3141480
H	-0.4916920	-0.9173800	1.1389270
H	3.8728760	0.6017780	0.5024150
O	4.2945850	-0.7607710	0.1840420
C	4.2545120	-1.2494810	-1.1503530
H	4.7033240	-0.4905640	-1.8066050
H	3.2067760	-1.3817110	-1.4732200
C	5.0093960	-2.5695610	-1.2858400
H	4.5574400	-3.3405960	-0.6509000
H	6.0532820	-2.4445490	-0.9768580
H	4.9919870	-2.9243910	-2.3251970
C	-2.9022170	-0.1411300	-0.1687630



Transition state of proton transfer in complex of (2-hydroxy-6-phenyl-pyrrolo[1,2-a]pyrazin-2-ium-3-yl)methanide and ethanol ($TS_{III \rightarrow IV}$)

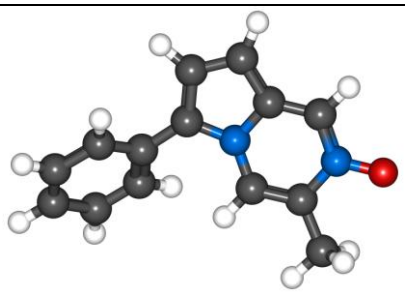
*I*996 cm^{-1}

	a.u.
E(B2PLYP)	-879.8346155
E(B2PLYP)+*ZPE*	-879.5288335

C	-2.6001240	-1.4977120	-0.3986120	E(B2PLYP)+H_{corr}	-879.5101295
C	-4.2151100	0.1948570	0.2142240	E(B2PLYP)+G_{corr}	-879.5762375
C	-3.5767600	-2.4819150	-0.2418680		
C	-5.1908800	-0.7908160	0.3643870		
C	-4.8754860	-2.1343620	0.1415790		
H	-1.6059550	-1.7822670	-0.7321930		
H	-4.4622480	1.2350810	0.4090330		
H	-3.3239790	-3.5221940	-0.4304400		
H	-6.1967300	-0.5093290	0.6654770		
H	-5.6341450	-2.9027600	0.2638690		
C	-2.2360230	2.2119170	-0.8994810		
C	-2.1344440	0.9210210	-0.3715610		
N	-0.8252050	0.7708000	0.0561910		
C	-0.1094870	1.9564080	-0.2090650		
C	-0.9914990	2.8582610	-0.8100830		
H	-3.1377800	2.6165650	-1.3406570		
H	-0.7416120	3.8535870	-1.1504390		
C	1.2430290	2.0085870	0.1609210		
N	1.8435490	0.9854010	0.7774800		
O	3.1014300	1.0464740	1.1170770		
C	-0.2013430	-0.2546450	0.7341480		
C	1.1077720	-0.1791800	1.0964250		
C	1.8356940	-1.2616050	1.8281360		
H	2.6641160	-1.6549250	1.2289640		
H	2.2662860	-0.8768760	2.7587850		
H	1.1453440	-2.0774750	2.0621640		
H	1.8678890	2.8723000	-0.0245820		
H	-0.8025530	-1.1209940	0.9739320		
H	4.1504640	-0.1621100	0.2338870		
O	4.5672040	-0.9135450	-0.2444530		
C	5.8655120	-0.5355630	-0.6867860		
H	6.4910690	-0.2317290	0.1682820		
H	5.8041540	0.3254490	-1.3726420		
C	6.5007960	-1.7206250	-1.3990300		
H	5.8914900	-2.0238360	-2.2584190		
H	6.5832250	-2.5773990	-0.7202700		
H	7.5051650	-1.4634040	-1.7580750		
C	-3.1620540	-0.1239970	-0.2694290		
C	-2.9128220	-1.4576990	-0.6479310		
C	-4.4556010	0.2143630	0.1714430		
C	-3.9207890	-2.4204460	-0.5751310		
C	-5.4645780	-0.7475500	0.2321840		
C	-5.2004810	-2.0705400	-0.1344350		
H	-1.9369790	-1.7359390	-1.0375840		
H	-4.6600820	1.2361550	0.4798830		
H	-3.7089780	-3.4426520	-0.8783060		
H	-6.4559360	-0.4650210	0.5772080		
H	-5.9848530	-2.8207690	-0.0807750		

Complex of 3-methyl-6-phenyl-pyrrolo[1,2-a]pyrazine-2-oxide and ethanol (IV)

	a.u.
E(B2PLYP)	-879.8994755
E(B2PLYP)+ZPE	-879.5871015
E(B2PLYP)+H_{corr}	-879.5670115
E(B2PLYP)+G_{corr}	-879.6385575

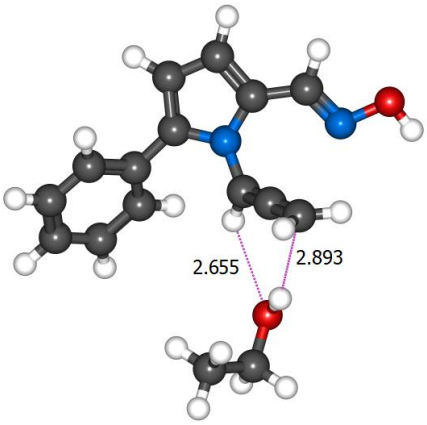
C	-0.5395920	2.3928970	-0.1866700		
C	-0.7296600	1.0127440	-0.0891080		
N	0.5366000	0.4423790	-0.0549710		
C	1.5092850	1.4586670	-0.1375020		
C	0.8371050	2.6803310	-0.2236990		
H	-1.3455110	3.1116140	-0.2619450		
H	1.3028980	3.6515250	-0.3172940		
C	2.8639510	1.0866000	-0.1057440		
N	3.2433560	-0.1922080	0.0311260		
O	4.4861860	-0.5405750	0.0501300		
C	0.9407690	-0.8609270	0.1340500		
C	2.2566840	-1.2003320	0.1750920		
C	2.7600560	-2.5935950	0.3729890		
H	3.3794160	-2.9069370	-0.4742270		
H	3.3944520	-2.6546550	1.2637600		
H	1.9185500	-3.2845240	0.4808230		
H	3.6699400	1.8042770	-0.1824450		
H	0.1628650	-1.6019830	0.2594630		
C	-1.9819840	0.2474970	-0.0444810		

3-methyl-6-phenyl-pyrrolo[1,2-a]pyrazine-2-oxide (V)

	a.u.
E(B2PLYP)	-724.9369745
E(B2PLYP)+ZPE	-724.7064955
E(B2PLYP)+H_{corr}	-724.6922665
E(B2PLYP)+G_{corr}	-724.7467525

C	-2.1835440	-0.9084740	-0.8245740
C	-3.0451150	0.6997830	0.7610150
C	-3.3998570	-1.5922850	-0.7890600
C	-4.2642970	0.0217090	0.7850700
C	-4.4458590	-1.1315940	0.0158530
H	-1.3986600	-1.2524900	-1.4932580
H	-2.9023050	1.5817050	1.3797350
H	-3.5351040	-2.4783130	-1.4043810
H	-5.0702510	0.3887040	1.4155900
H	-5.3931250	-1.6636480	0.0406600

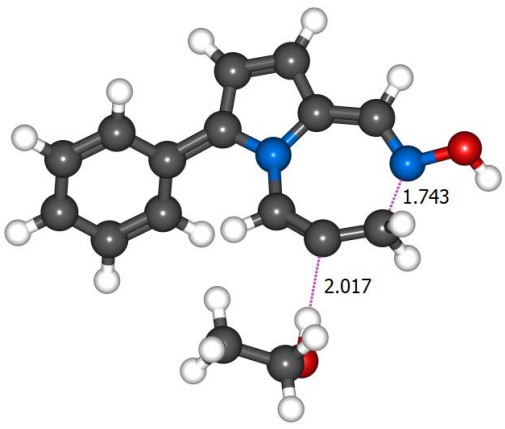
C	0.9257770	-3.0635860	-0.1716050
C	0.1643840	-1.9179190	0.0032660
N	1.0374670	-0.8343720	0.0963470
C	2.3482820	-1.3028770	-0.0120080
C	2.2852220	-2.6816480	-0.1786990
H	0.5289780	-4.0682260	-0.2334700
H	3.1454560	-3.3359370	-0.2418460
C	3.5808310	-0.5640850	0.1558730
N	3.6818660	0.6555270	0.5486790
O	5.0496220	1.0146030	0.6367840
C	0.6122890	0.5245950	-0.0200640
C	1.0942280	1.3600810	-0.9076940
C	1.6066860	2.2374860	-1.7315520
H	-0.3723080	3.3489450	0.0615970
H	4.4898950	-1.1405460	-0.0375320
H	-0.1623480	0.8479590	0.6674680
H	2.4931790	2.8090560	-1.4574680
H	1.1929290	2.4023400	-2.7254800
H	5.0109840	1.9160750	0.9935140
O	-1.0027030	3.3629800	0.8011340
C	-2.0922010	4.2275340	0.4703440
H	-1.7280710	5.2542680	0.3091820
H	-2.7232520	4.2410390	1.3646640
C	-2.8912070	3.7491720	-0.7389210
H	-3.2670830	2.7329320	-0.5772920
H	-2.2742810	3.7445000	-1.6470140
H	-3.7465000	4.4129030	-0.9207110
C	-1.3027160	-1.8069980	0.0852390
C	-2.1024470	-2.4464790	-0.8791040
C	-1.9401740	-1.1304600	1.1416140
C	-3.4953770	-2.4070300	-0.7930900
C	-3.3324740	-1.0831560	1.2209570
C	-4.1161970	-1.7208500	0.2544160
H	-1.6226090	-2.9643270	-1.7052460
H	-1.3441910	-0.6629260	1.9208440
H	-4.0953810	-2.9057160	-1.5502480
H	-3.8048400	-0.5576470	2.0470560
H	-5.2006670	-1.6861300	0.3196340



Complex of (*E*)-*N*-hydroxy-5-phenyl-1-(1-propadienyl-1*H*-pyrrol-2-yl)methanimine and ethanol (VI)

	a.u.
E(B2PLYP)	-879.823839
E(B2PLYP)+*ZPE*	-879.516978
E(B2PLYP)+H_{corr}	-879.494347
E(B2PLYP)+G_{corr}	-879.573108

C	-1.2208280	-2.9003080	-0.4965490
C	-1.1987420	-1.5383140	-0.1452840
N	0.1070680	-1.1424550	0.0237570
C	0.9277630	-2.2517030	-0.2023920
C	0.0962480	-3.3435750	-0.5305140
H	-2.1175870	-3.4860980	-0.6461770
H	0.4481030	-4.3460670	-0.7397860
C	2.3284860	-2.3857320	-0.0879980
N	3.2244710	-1.5324340	0.3360780
O	4.5444910	-2.0030980	0.1166790
C	0.5231960	0.2546800	0.1095530
C	1.7522070	0.7319960	0.2091700
C	3.0470570	0.2012340	0.3562410
H	1.8234800	2.7229520	0.5234880
H	2.7232010	-3.3617970	-0.3639760
H	-0.3453520	0.8988030	0.0332600
H	3.5093310	0.4125090	1.3243570



Transition state of (*E*)-*N*-hydroxy-5-phenyl-

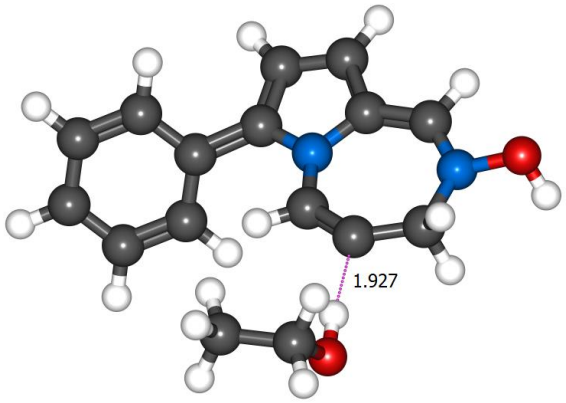
H	3.7437460	0.4217730	-0.4579070
H	5.0392790	-1.6999770	0.8993320
O	1.8714780	3.6942190	0.7215680
C	1.9204690	4.4075370	-0.5037530
H	2.6726360	3.9678160	-1.1805750
H	2.2621040	5.4201810	-0.2557090
C	0.5659590	4.4752440	-1.2120030
H	-0.1860480	4.9277000	-0.5548470
H	0.2195730	3.4714760	-1.4872760
H	0.6334920	5.0763410	-2.1296370
C	-2.3749720	-0.6766560	0.0564150
C	-3.4430360	-0.7492370	-0.8570240
C	-2.5010550	0.1657770	1.1770380
C	-4.5990580	0.0070340	-0.6621910
C	-3.6584340	0.9207240	1.3688990
C	-4.7097530	0.8461320	0.4504510
H	-3.3528780	-1.3876830	-1.7317490
H	-1.6972630	0.2172710	1.9053560
H	-5.4098930	-0.0533340	-1.3835060
H	-3.7387290	1.5663110	2.2393880
H	-5.6087560	1.4380820	0.6007860

1-(1-propadienyl-1*H*-pyrrol-2-yl)methanimine cyclization ($TS_{VI \rightarrow VII}$)

*I*310 cm^{-1}

	a.u.
E(B2PLYP)	-879.7816216
E(B2PLYP)+*ZPE*	-879.4729766
E(B2PLYP)+H_{corr}	-879.4523756
E(B2PLYP)+G_{corr}	-879.5255646

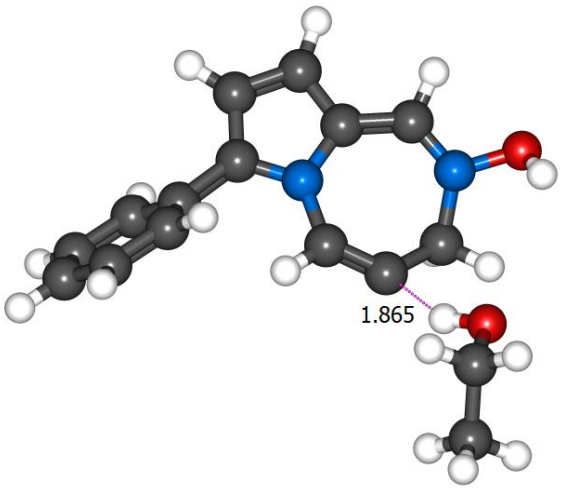
C	-1.4656550	-2.8357850	-0.3974330
C	-1.3401130	-1.4552040	-0.1173830
N	-0.0140460	-1.1474300	0.0174340
C	0.7205630	-2.3203460	-0.1541840
C	-0.1898620	-3.3743320	-0.4139230
H	-2.4050500	-3.3590570	-0.5137660
H	0.0892960	-4.4084920	-0.5728630
C	2.1033420	-2.5175790	-0.0555150
N	3.0677530	-1.6775910	0.2430070
O	4.3568700	-2.2383470	0.0646380
C	0.5305060	0.2123610	0.0858090
C	1.7932860	0.6121030	0.1770570
C	3.0438120	-0.1216560	0.3124520
H	2.1788650	2.4811830	0.4454780
H	2.4500650	-3.5325040	-0.2287440
H	-0.2864400	0.9211920	0.0071280
H	3.5182820	0.1016610	1.2779970
H	3.7593820	0.1485130	-0.4743050
H	4.8494270	-1.9835080	0.8676650
O	2.4617060	3.4282590	0.6174830
C	2.3549880	4.1598820	-0.5894120
H	2.7632130	3.5795050	-1.4350920
H	2.9860860	5.0514290	-0.4762140
C	0.9182300	4.5833620	-0.9069540
H	0.5048860	5.1765850	-0.0825100
H	0.2769240	3.7046560	-1.0489190
H	0.8792820	5.1872650	-1.8248430
C	-2.4529910	-0.5065210	0.0487030
C	-3.5324060	-0.5542520	-0.8528240
C	-2.5101530	0.3979600	1.1256140
C	-4.6318290	0.2890830	-0.6912440
C	-3.6126830	1.2373830	1.2857730
C	-4.6747060	1.1887360	0.3778600
H	-3.4948440	-1.2417470	-1.6936040
H	-1.6971390	0.4327400	1.8443170
H	-5.4513840	0.2479690	-1.4039250
H	-3.6414450	1.9296960	2.1228890
H	-5.5299420	1.8475990	0.5028860



Complex of 2-hydroxy-7-phenyl-3H-pyrrolo[1,2-a][1,4]diazepin-2-ium-4-ide *(planar)* and ethanol (VII)

	a.u.
E(B2PLYP)	-879.7823659
E(B2PLYP)+*ZPE*	-879.4725649
E(B2PLYP)+H_{corr}	-879.4518069
E(B2PLYP)+G_{corr}	-879.5250529

C	-2.2911870	-2.2858220	-0.5148840
C	-1.8924360	-0.9729020	-0.1845240
N	-0.5362500	-0.9467840	-0.0160180
C	-0.0494470	-2.2324860	-0.2698290
C	-1.1458170	-3.0649340	-0.5946090
H	-3.3127420	-2.5892380	-0.7010130
H	-1.0749800	-4.1151220	-0.8486880
C	1.2871960	-2.6549250	-0.2707950
N	2.3333230	-2.0352810	0.2161260
O	3.5465800	-2.7312670	0.0683160
C	0.2712270	0.2482250	0.2432680
C	1.5310820	0.3407150	0.6767630
C	2.3544150	-0.8293700	1.1113360
H	3.0194830	1.3481240	0.1777900
H	1.5041530	-3.6217160	-0.7158990
H	-0.3242660	1.1297110	0.0368680
H	2.0648360	-1.1770820	2.1165160
H	3.4173260	-0.5732710	1.1537750
H	4.1549970	-2.0774050	-0.3301340
O	3.9540060	1.4550730	-0.1844000
C	4.0796120	2.7430620	-0.7646130
H	3.2083000	2.9626830	-1.4045640
H	4.9608620	2.7101470	-1.4185180
C	4.2472500	3.8486980	0.2795630
H	5.1257310	3.6525570	0.9056190
H	3.3688170	3.9011750	0.9338560
H	4.3754590	4.8273980	-0.2039160
C	-2.7882650	0.1982550	-0.0611070
C	-2.7012490	1.2926260	-0.9390640
C	-3.8062030	0.1838540	0.9063950
C	-3.6037840	2.3520040	-0.8398160
C	-4.7079370	1.2462250	1.0044770
C	-4.6078560	2.3336620	0.1335240
H	-1.9331470	1.3069830	-1.7075030
H	-3.8805460	-0.6583230	1.5893560
H	-3.5246330	3.1909080	-1.5262690
H	-5.4851850	1.2239810	1.7639340
H	-5.3082720	3.1611720	0.2101950

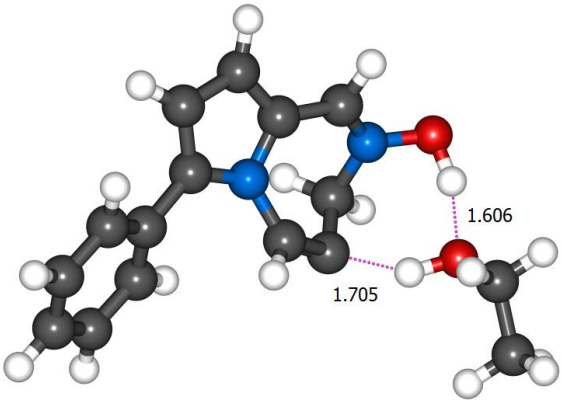


Transition state of conformation change of 2-hydroxy-7-phenyl-3H-pyrrolo[1,2-a][1,4]diazepin-2-ium-4-ide in complex with ethanol ($TS_{VII \rightarrow VIII}$)

*I*65 cm^{-1}

	a.u.
E(B2PLYP)	-879.778406
E(B2PLYP)+*ZPE*	-879.468302
E(B2PLYP)+H_{corr}	-879.448566
E(B2PLYP)+G_{corr}	-879.518588

C	-2.0257010	-2.2939610	-0.6695310
C	-1.8311190	-0.9723310	-0.2272050
N	-0.4993850	-0.7972340	0.0568900
C	0.1666240	-2.0104950	-0.2217400
C	-0.7877030	-2.9339120	-0.6824470
H	-2.9855050	-2.7347710	-0.9035310
H	-0.5832910	-3.9645770	-0.9434990
C	1.5659420	-2.1879080	-0.1330390
N	2.3391920	-1.4719470	0.6460270
O	3.7058780	-1.5379610	0.4772350
C	0.1942580	0.4906720	0.1211960
C	1.3421140	0.7248920	0.7759220
C	1.8217750	-0.4708360	1.5935310
H	2.9082820	1.2531780	0.3575630
H	2.0656760	-2.9431760	-0.7313300
H	-0.3164640	1.2344100	-0.4856790
H	1.0254100	-0.9658700	2.1714900
H	2.6516570	-0.2400670	2.2640010
H	3.9553020	-0.5545240	0.2868430
O	3.9137800	1.0429830	0.1294720
C	4.2567130	1.6565240	-1.1148460
H	3.4486250	1.4917340	-1.8445930
H	5.1515260	1.1444120	-1.4886600
C	4.5273750	3.1488560	-0.9498980
H	5.3389030	3.3147500	-0.2324380
H	3.6341530	3.6664220	-0.5817970
H	4.8134600	3.5971950	-1.9106020
C	-2.8466480	0.0774450	-0.0759110
C	-2.7761500	1.0426120	0.9471480
C	-3.9548870	0.0998860	-0.9448790
C	-3.7829360	1.9968510	1.0925680
C	-4.9605490	1.0544100	-0.7951920
C	-4.8784580	2.0080560	0.2240010
H	-1.9354960	1.0404750	1.6335900

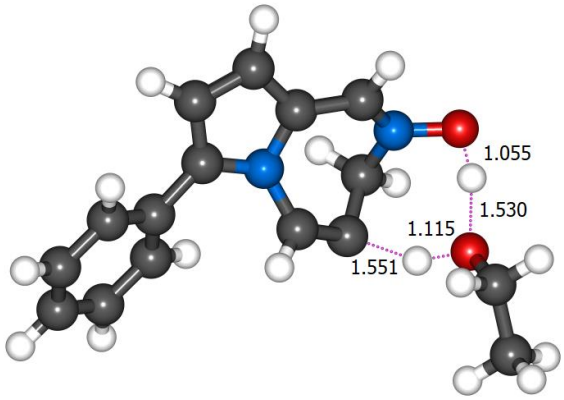


Complex of 2-hydroxy-7-phenyl-3H-pyrrolo[1,2-a][1,4]diazepin-2-ium-4-ide *(boat)* and ethanol (VIII)

	a.u.
E(B2PLYP)	-879.8000856
E(B2PLYP)+*ZPE*	-879.4892266
E(B2PLYP)+H_{corr}	-879.4701746
E(B2PLYP)+G_{corr}	-879.5369846

H	-4.0156620	-0.6248880	-1.7521820
H	-3.7118470	2.7318320	1.8901290
H	-5.8044190	1.0585650	-1.4803250
H	-5.6601300	2.7544310	0.3388800

C	-2.0141650	-2.3074480	-0.6417370
C	-1.8175130	-0.9821040	-0.2162770
N	-0.4827110	-0.8043380	0.0565050
C	0.1828540	-2.0215970	-0.2145840
C	-0.7750380	-2.9479590	-0.6567790
H	-2.9753600	-2.7512870	-0.8638740
H	-0.5732530	-3.9815460	-0.9080090
C	1.5870020	-2.1903370	-0.1438350
N	2.3598770	-1.4711690	0.6320390
O	3.7196070	-1.4810810	0.4390110
C	0.2099540	0.4787230	0.1050560
C	1.3571010	0.7051330	0.7643090
C	1.8277560	-0.4870590	1.5887600
H	2.7629850	1.2378880	0.3819230
H	2.0888910	-2.9295470	-0.7601680
H	-0.2852280	1.2188820	-0.5184990
H	1.0275980	-0.9883350	2.1531620
H	2.6502550	-0.2509790	2.2660570
H	3.9268330	-0.4617170	0.2640500
O	3.8369190	1.0606620	0.1396830
C	4.1594400	1.6700190	-1.1076430
H	3.3185200	1.5479750	-1.8103740
H	5.0198170	1.1345390	-1.5302360
C	4.4917780	3.1500530	-0.9374390
H	5.3350500	3.2762840	-0.2489320
H	3.6332430	3.6950560	-0.5284010
H	4.7582370	3.6011010	-1.9027240
C	-2.8304380	0.0710490	-0.0703890
C	-3.9409670	0.0890790	-0.9364620
C	-2.7545990	1.0445550	0.9442840
C	-4.9438330	1.0473320	-0.7917770
C	-3.7584090	2.0027640	1.0844720
C	-4.8563960	2.0094070	0.2190110
H	-4.0056420	-0.6422500	-1.7375180
H	-1.9127010	1.0455650	1.6292780
H	-5.7896720	1.0478110	-1.4744720
H	-3.6832720	2.7441120	1.8757390
H	-5.6358330	2.7586940	0.3298220

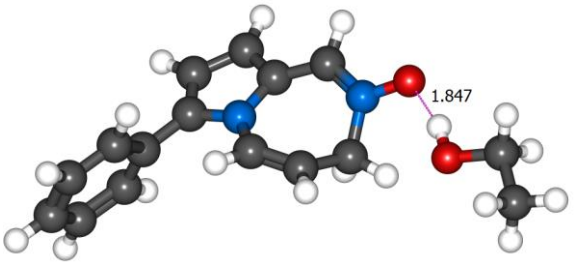


Transition state of proton transfer in complex of 2-hydroxy-7-phenyl-3H-pyrrolo[1,2-a][1,4]diazepin-2-ium-4-ide *(boat)* and ethanol ($TS_{VIII \rightarrow IX}$)

*I*338 cm^{-1}

	a.u.
E(B2PLYP)	-879.7995341
E(B2PLYP)+*ZPE*	-879.4913651
E(B2PLYP)+H_{corr}	-879.4730031
E(B2PLYP)+G_{corr}	-879.5382581

C	2.4462290	2.2789610	0.0146550
C	2.2663550	0.9076630	-0.0446010
N	0.8954570	0.6620700	-0.1246220
C	0.2156820	1.8935750	-0.1363500
C	1.1767530	2.8953040	-0.0613570
H	3.4065320	2.7723700	0.0850870
H	0.9658820	3.9567740	-0.0646860
C	-1.1969890	2.0854800	-0.3350930
N	-2.1589790	1.2765320	0.0431840
O	-3.4069150	1.5018370	-0.2094100
C	0.3042040	-0.6049150	-0.2713800
C	-0.9460500	-0.8965260	0.1101440
C	-1.8285230	0.0609310	0.8538330
H	-1.3430730	-1.8794710	-0.1224630
H	-1.5371870	3.0012090	-0.8064150
H	0.9409890	-1.3467950	-0.7371760
H	-1.3364140	0.4239720	1.7657270
H	-2.7838840	-0.3907370	1.1129040
H	-4.4696390	-0.0088600	-0.1779390
O	-4.8236410	-0.9145820	-0.0345740
C	-6.2461770	-0.8892280	-0.0914940
H	-6.5839560	-0.5339620	-1.0783780
H	-6.6492930	-0.1968550	0.6651920
C	-6.7679880	-2.2959670	0.1600180
H	-6.4504870	-2.6535880	1.1464990
H	-6.3812950	-2.9896970	-0.5954420
H	-7.8642030	-2.3145280	0.1203730
C	3.2900920	-0.1610050	-0.0223650
C	3.5309230	-0.9693270	-1.1478870

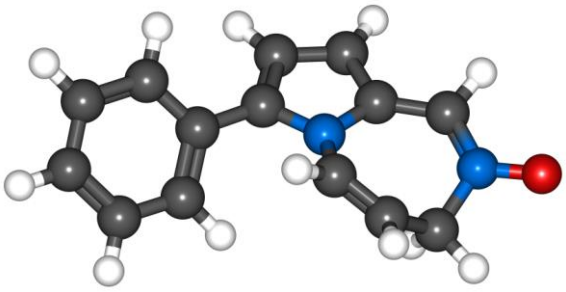


Complex of 7-phenyl-3H-pyrrolo[1,2-a][1,4]diazepine 2-oxide and ethanol (XI)

	a.u.
E(B2PLYP)	-879.8728064
E(B2PLYP)+*ZPE*	-879.5595124
E(B2PLYP)+H_{corr}	-879.5395444
E(B2PLYP)+G_{corr}	-879.6120354

C	4.0820110	-0.3491830	1.1227080
C	4.5261910	-1.9481450	-1.1225170
C	5.0837370	-1.3229500	1.1447480
C	5.3049940	-2.1283900	0.0247060
H	2.9513540	-0.8125540	-2.0546700
H	3.9044020	0.2707320	1.9974590
H	4.7013780	-2.5613550	-2.0028000
H	5.6872420	-1.4545240	2.0392040
H	6.0820910	-2.8880590	0.0428520

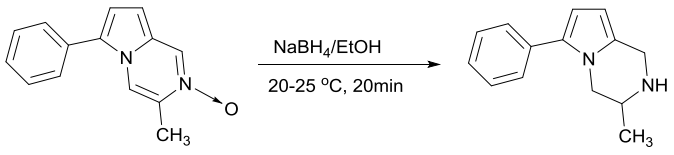
C	0.3772470	2.2296970	0.3614610
C	0.6854630	0.9027290	0.1009520
N	-0.5210940	0.2179040	-0.0735450
C	-1.5860980	1.1266180	0.0766230
C	-1.0265750	2.3727420	0.3429750
H	1.1012680	2.9985050	0.5965810
H	-1.5919550	3.2770740	0.5265400
C	-2.9814470	0.8530940	-0.1254350
N	-3.5950960	-0.3067580	0.0037930
O	-4.8452900	-0.4800950	-0.2132870
C	-0.6395480	-1.0581160	-0.6513350
C	-1.7020040	-1.8528380	-0.4700430
C	-2.8229670	-1.5056460	0.4640680
H	-1.7580590	-2.7815010	-1.0291290
H	-3.6390100	1.6814180	-0.3637160
H	0.1928360	-1.3454630	-1.2847540
H	-2.4438980	-1.2705930	1.4674560
H	-3.5649080	-2.2981540	0.5363680
C	2.0017900	0.2556840	0.0507060
C	3.0900750	0.9403050	-0.5256980
C	2.2349570	-1.0182720	0.6061060
C	4.3644090	0.3738690	-0.5423770
C	3.5091050	-1.5869140	0.5781070
C	4.5800170	-0.8947640	0.0051770
H	2.9246220	1.9154800	-0.9756920
H	1.4206920	-1.5549640	1.0848960
H	5.1885810	0.9194100	-0.9950020
H	3.6671270	-2.5689280	1.0169480
H	5.5718070	-1.3386670	-0.0136500



7-phenyl-3H-pyrrolo[1,2-a][1,4]diazepine 2-oxide (X)

	a.u.
E(B2PLYP)	-724.9138477
E(B2PLYP)+*ZPE*	-724.6823377
E(B2PLYP)+H_{corr}	-724.6684167
E(B2PLYP)+G_{corr}	-724.7224127

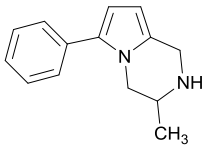
11. General Procedure Reduction of 3-methyl-6-phenylpyrrolo[1,2-a]pyrazine-2-oxide *2c*



2c **4c:** 36%

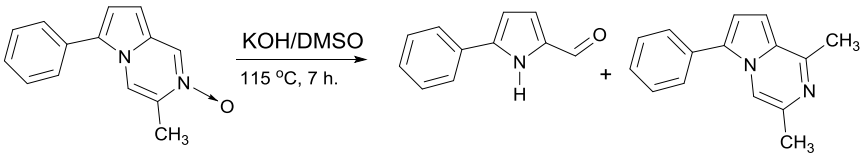
3-Methyl-6-phenylpyrrolo[1,2-a]pyrazine-2-oxide **2c** (101 mg, 0.45 mmol), $NaBH_4$ (255 mg, 6.75 mmol) in EtOH (not absolute) (4 ml) was charged into a flat-bottomed flask. The mixture was stirred to 20–25 ^{o}C for 20 min. At the end of time, filtered and washed with water. A pure white powder was obtained.

12. Characterization Data of Products *4c*



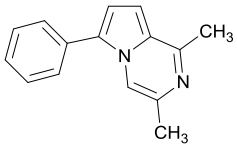
3-methyl-6-phenyl-1,2,3,4-tetrahydropyrrolo[1,2-a]pyrazine (4c). White powder (35 mg, 37 %). ^{1}H NMR (400 MHz, DMSOd_6) δ 7.43 – 7.36 (m, 4H, Ph), 7.27 – 7.23 (m, 1H, Ph), 6.15 (d, *J* – 3.5 Hz, 1H, pyrr), 5.86 (d, *J* = 3.5 Hz, 1H, pyrr), 4.22 (d, *J* = 14.8 Hz, 2H, CH_2), 3.97 – 3.93 (m 2H, CH_2), 3.91 (br s, 1H, NH), 3.72 – 3.66 (m, 1H, CH), 1.18 (d, *J* = 6.1 Hz, 3H, CH_3). ^{13}C NMR (100 MHz, DMSOd_6) δ 132.7 (Ph), 131.3 (Ph), 127.9 (Ph), 127.4 (pyrr), 127.2 (Ph), 125.7 (pyrr), 107.9 (pyrr), 103.3 (pyrr), 57.0 (CH–NH), 54.5 (CH_2–NH), 46.7 (CH_2–CH), 15.7 (CH_3). ^{15}N NMR (41 MHz, DMSOd_6) δ -231.2 (N pyrr), -341.9 (NO). IR (film) 3427; 3237; 2920; 1961; 1643; 1513; 1474; 1445; 1383; 1324; 1242; 1158; 1082; 1023; 981; 921; 871; 819; 752; 698; 621; 599; 550; 512 cm^{-1}. Anal. Calcd for $C_{15}H_{14}N_2$: C 79.28, H 7.69, N 13.26 %. Found: C 79.21, H 7.60, N 13.20 %.

13. General Procedure Reduction of 3-Methyl-6-phenylpyrrolo[1,2-a]pyrazine-2-oxide *2c*



3-Methyl-6-phenylpyrrolo[1,2-a]pyrazine-2-oxide **2c** (81 mg, 0.361 mmol), KOH (25 mg, 0.361 mmol) and DMSO (2 ml) were charged into a round bottom flask under stirring. The mixture was stirred at 115 ^{o}C for 7 hours. At the end of time, the mixture was cooled, diluted with H_2O (4 ml) and extracted with CH_2Cl_2 (5 x 50 mL). The CH_2Cl_2 extract was washed with H_2O until the aqueous layer had become neutral, and subsequently dried (K_2CO_3). The CH_2Cl_2 extract evaporated in vacuo gave the mixture *NH*-pyrrole-2-carbaldehyde ***5c*** and 1-methyl-3-methylpyrrolo[1,2-a]pyrazine ***6c***. The mixture was separated using flash chromatography (SiO_2, eluent hexane/diethyl ether 4:1).

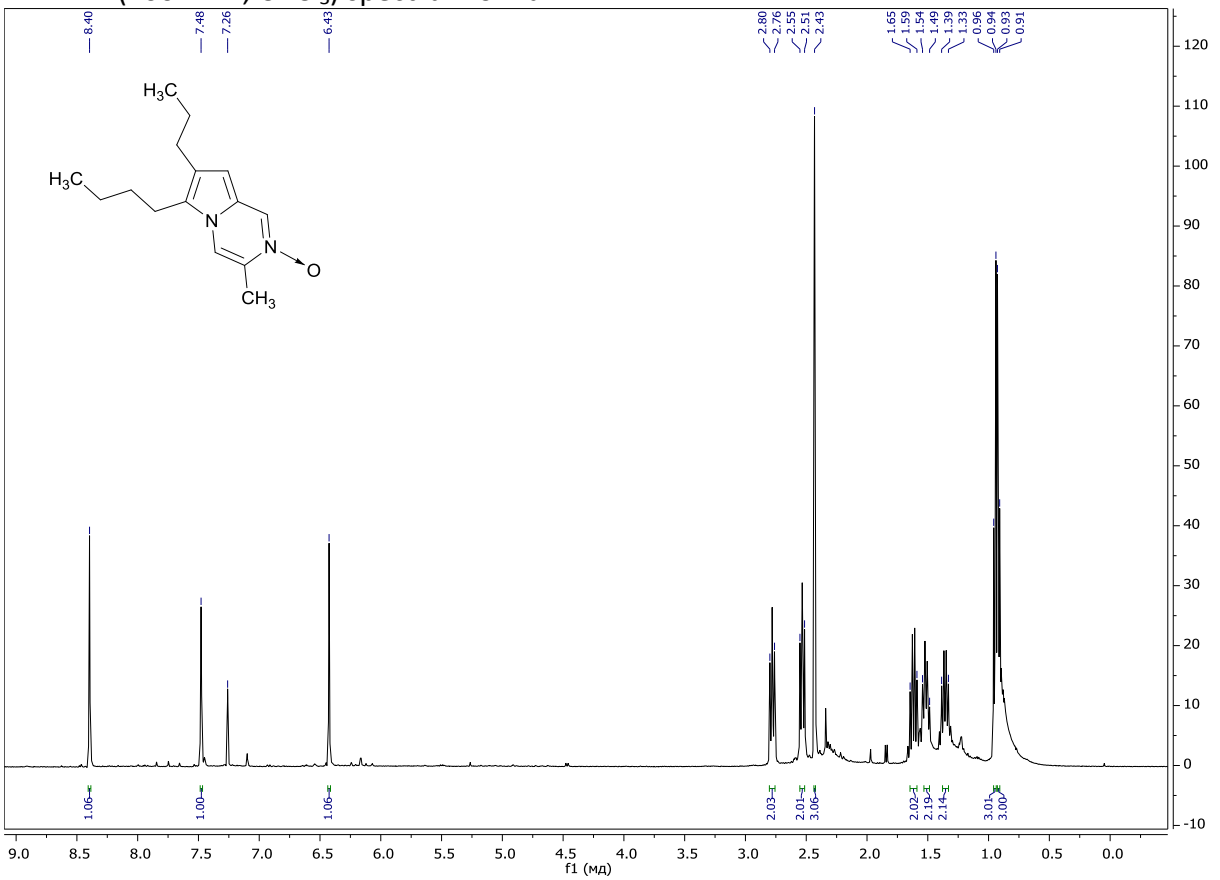
14. Characterization Data of Products *6c*



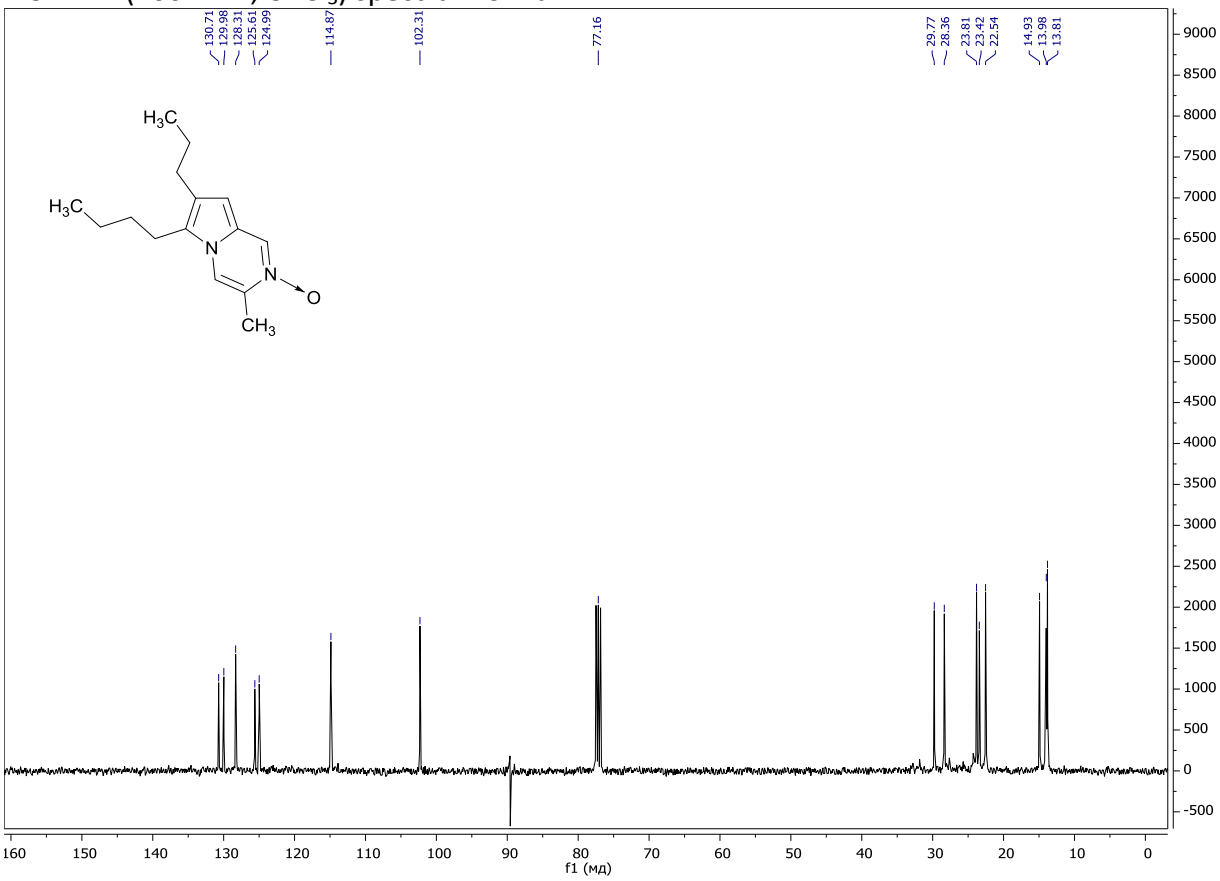
1,3-dimethyl-6-phenylpyrrolo[1,2-a]pyrazine (6c). Orange oil (8 mg, 9 %. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (s, 1H, C = CH); 7.58 – 7.55 (m, 2H, Ph), 7.51 – 7.49 (m, 2H, Ph) 7.42 – 7.39 (m, 1H, Ph), 6.89 (d, *J* = 4.2 Hz, 1H, pyrr), 6.83 (d, *J* = 4.2 Hz, 1H, pyrr), 2.69 (s, 3H, CH_3), 2.38 (s, 3H, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.9 (CH=N), 144.9 (C–N), 136.1 (Ph), 131.4 (pyrr), 129.2 (Ph), 128.2 (Ph), 128.0 (pyrr), 115.1 (pyrr), 111.7 (CH=C), 104.2 (pyrr), 21.6 (CH_3), 21.1 (CH_3). ^{15}N NMR (41 MHz, $CDCl_3$) δ -196 (N pyrr), -87.9 (NO). IR (film) 3427; 3237; 2920; 1970; 1513; 1425; 1355; 1285; 1285; 1158; 1010; 996; 920; 842; 830; 714; 674; 602; 523; 502; 450 cm^{-1}. Anal. Calcd for $C_{15}H_{14}N_2$: C 81.05, H 6.35, N 12.60 %. Found: C 81.51, H 6.77, N 12.89 %.

15. NMR spectra of the obtained compounds

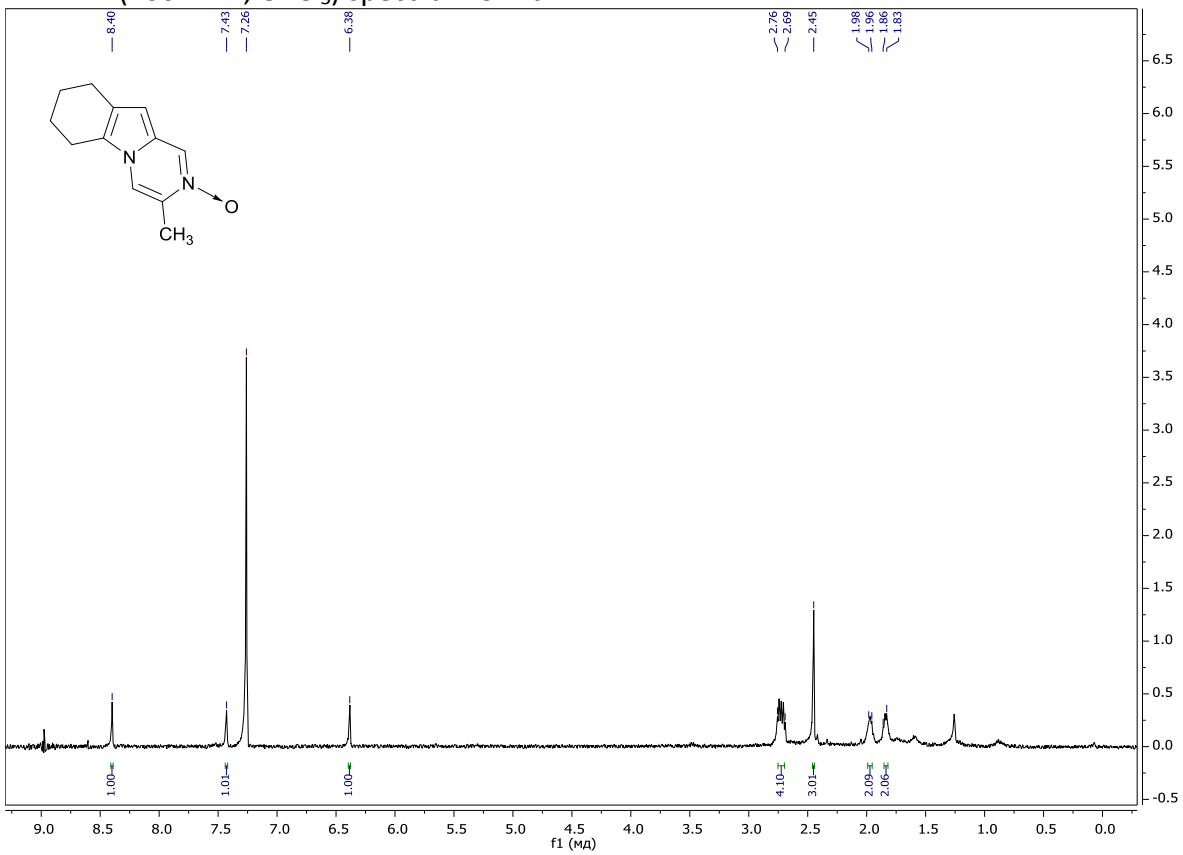
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2a



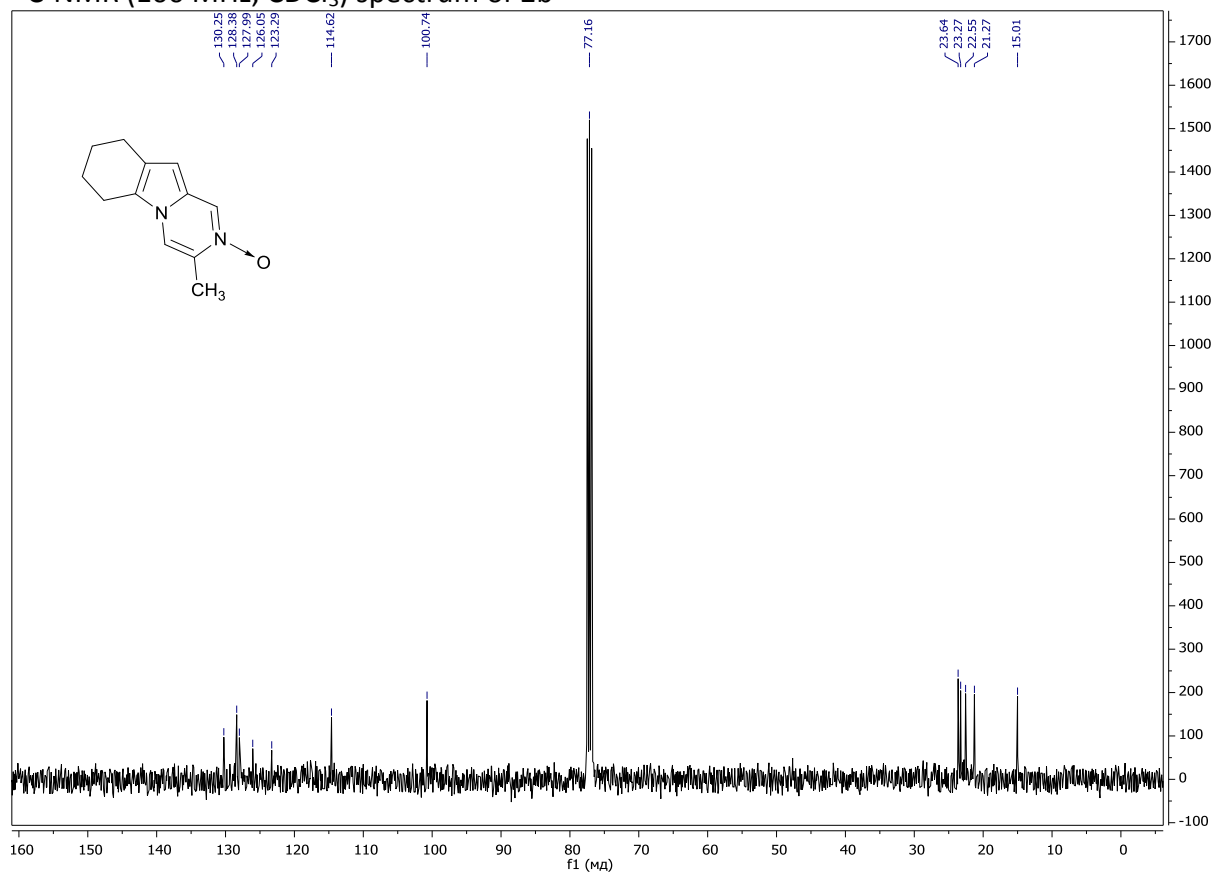
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2a



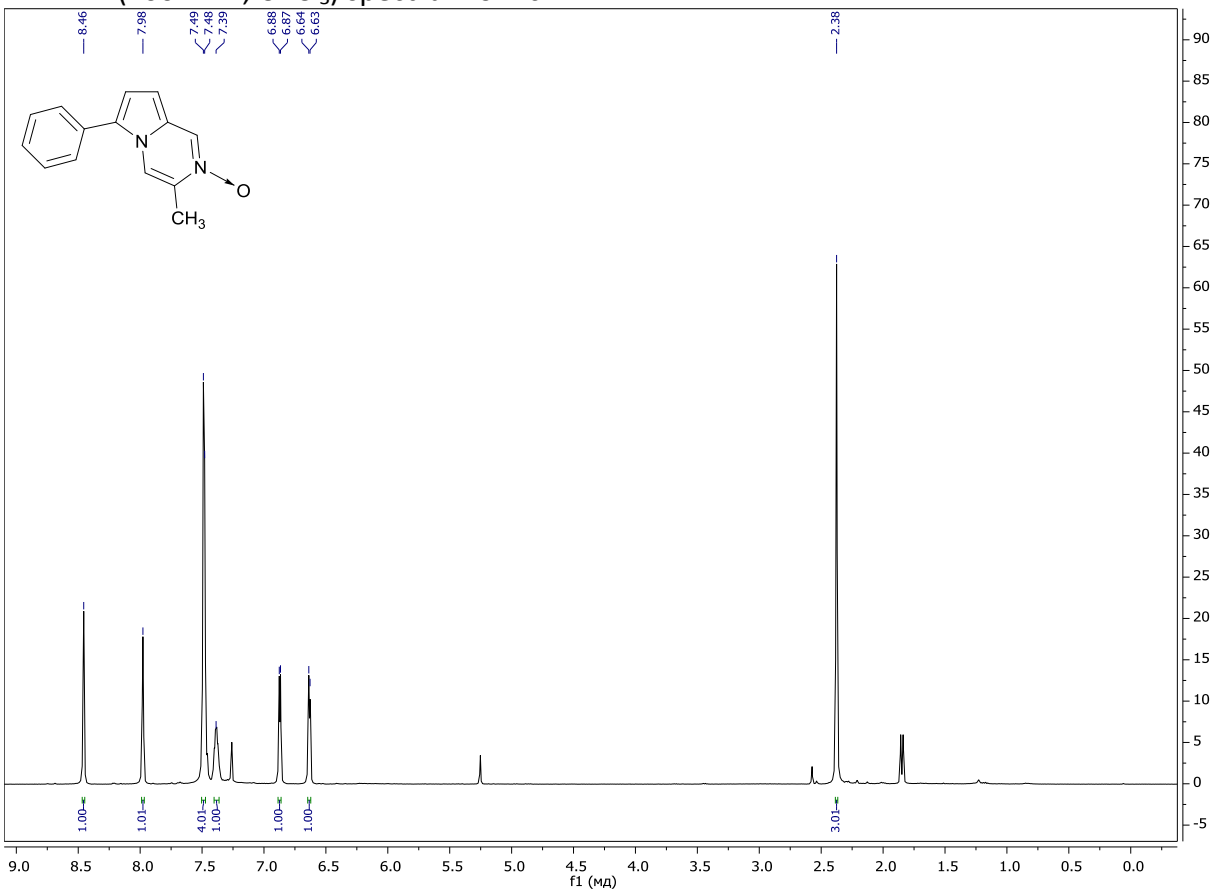
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2b



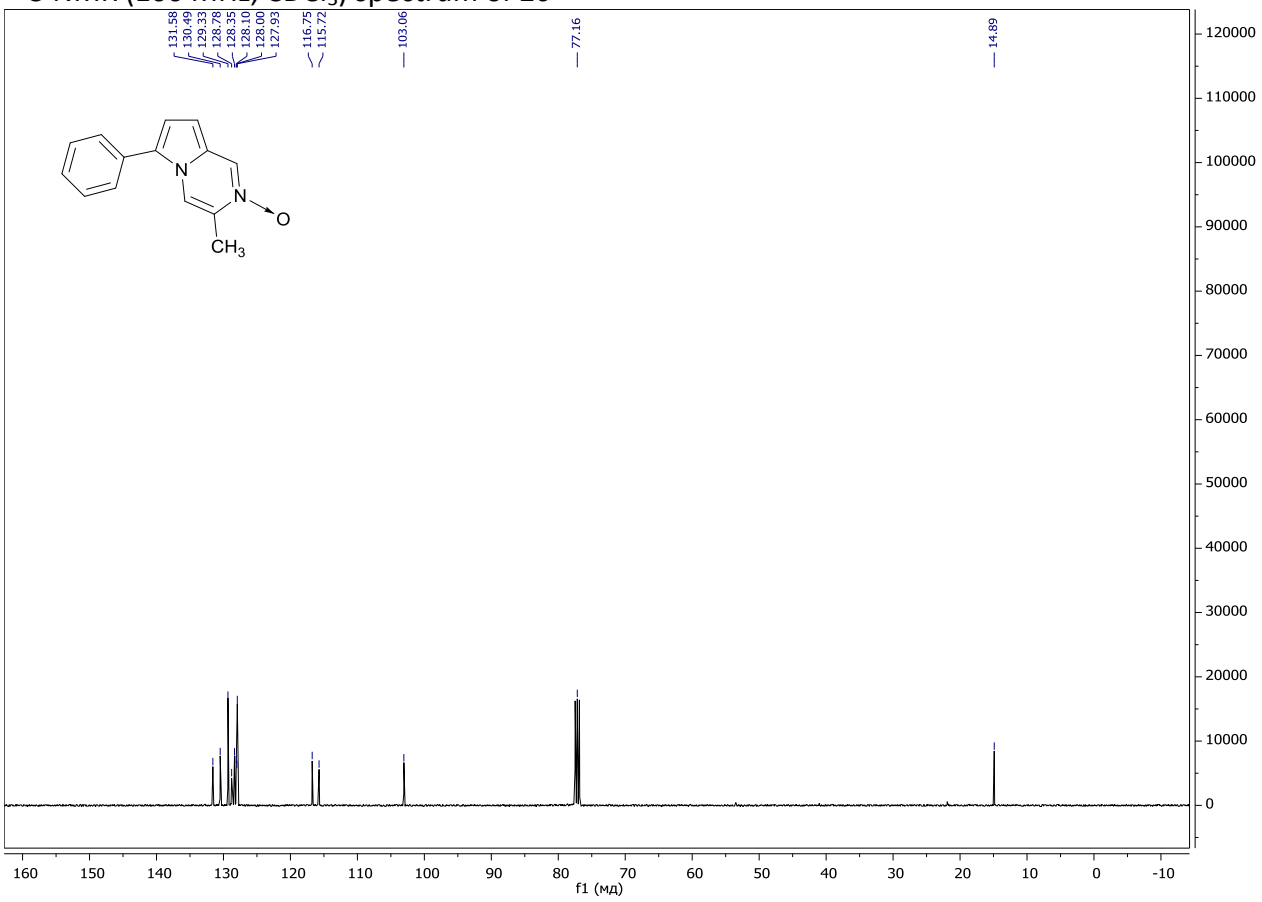
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2b



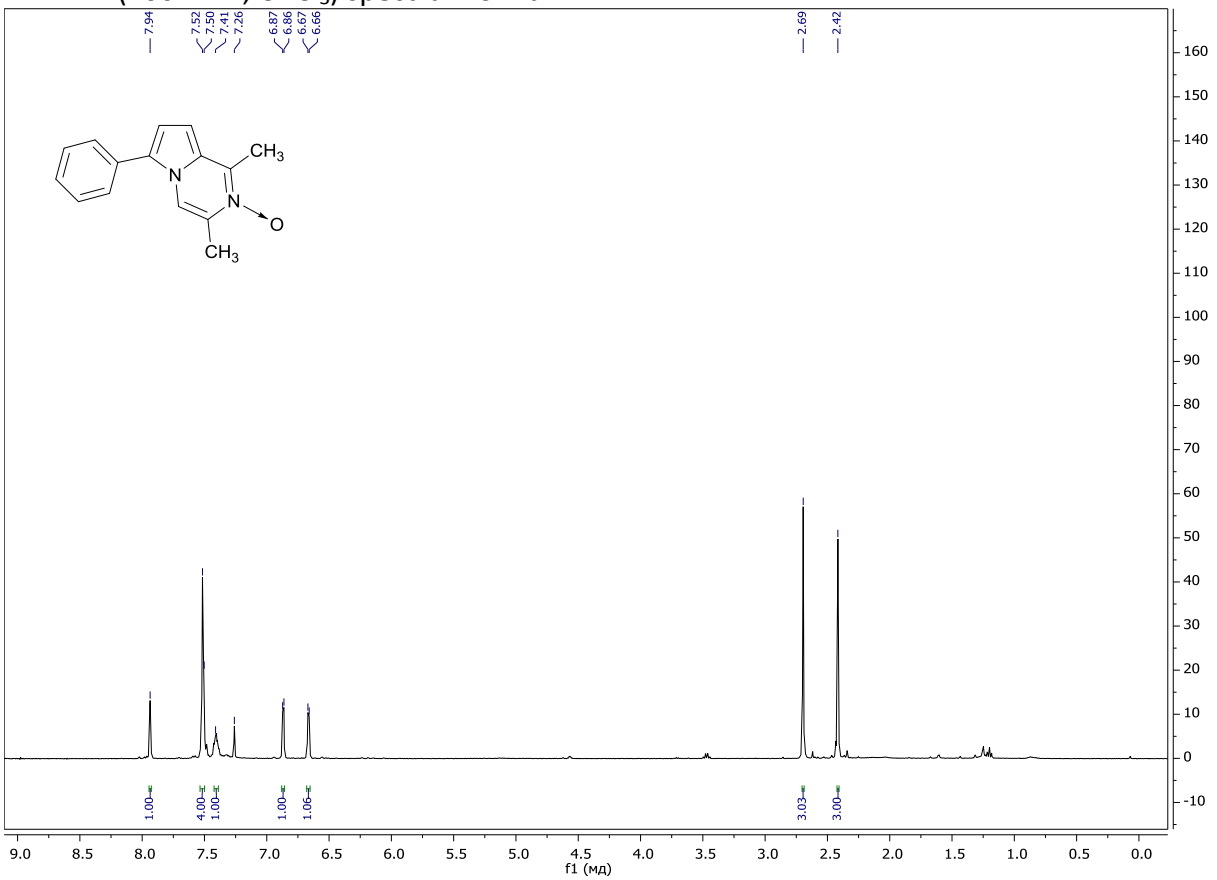
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2c



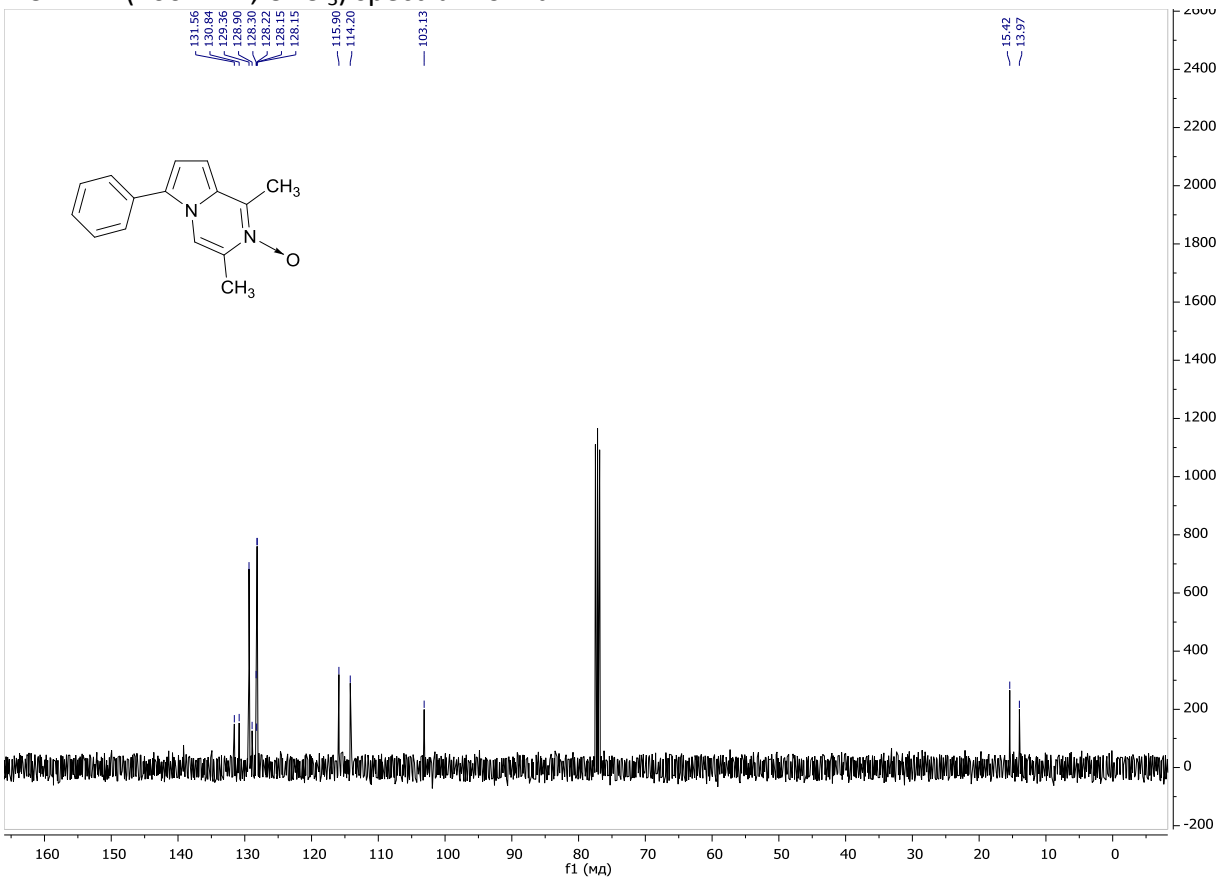
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2c



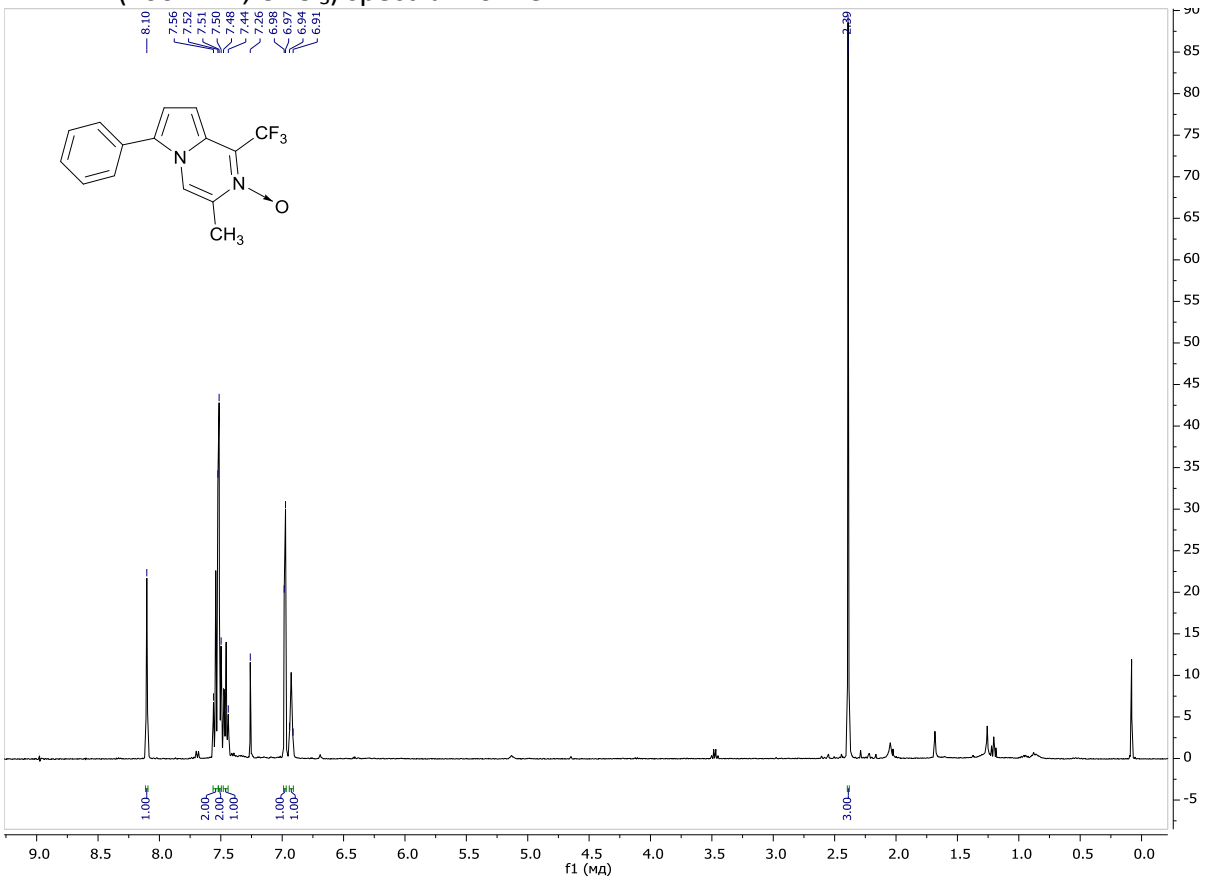
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2d



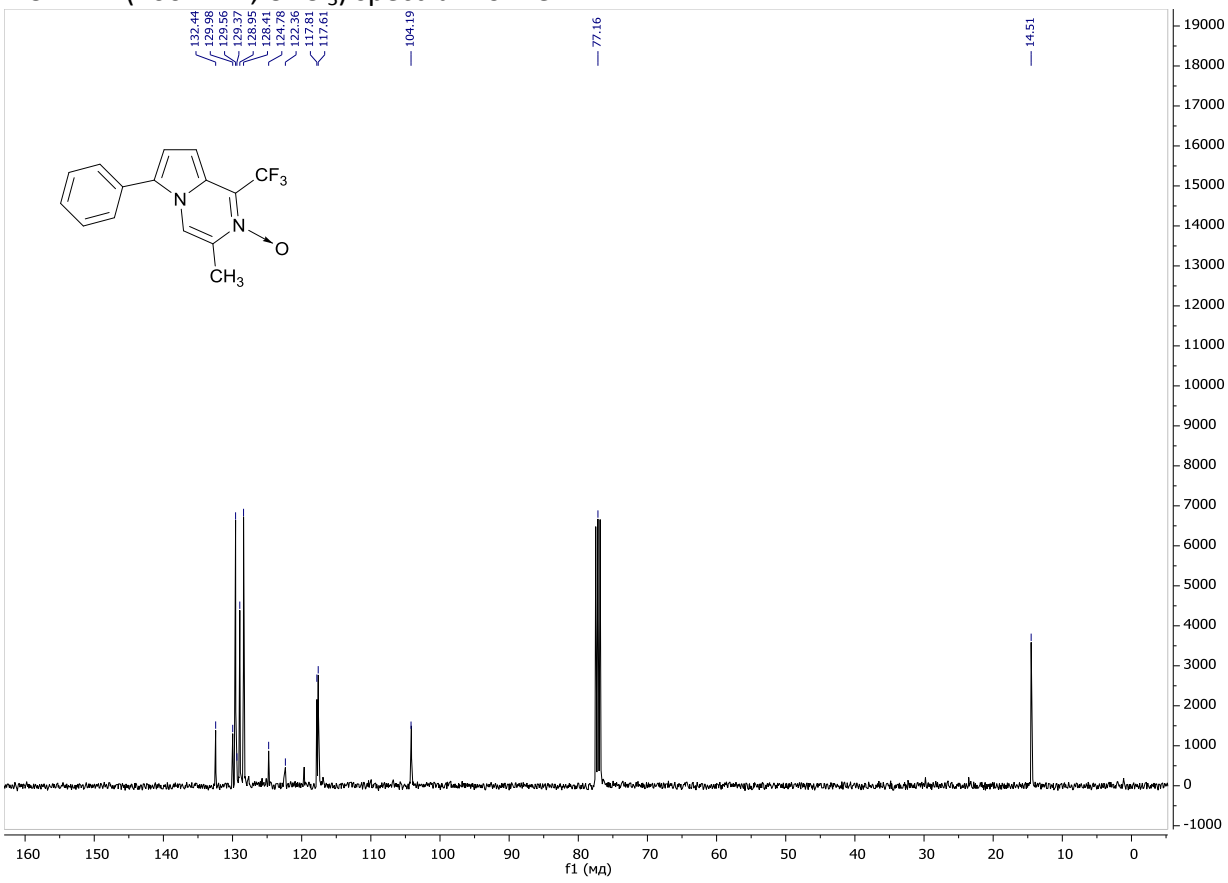
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2d



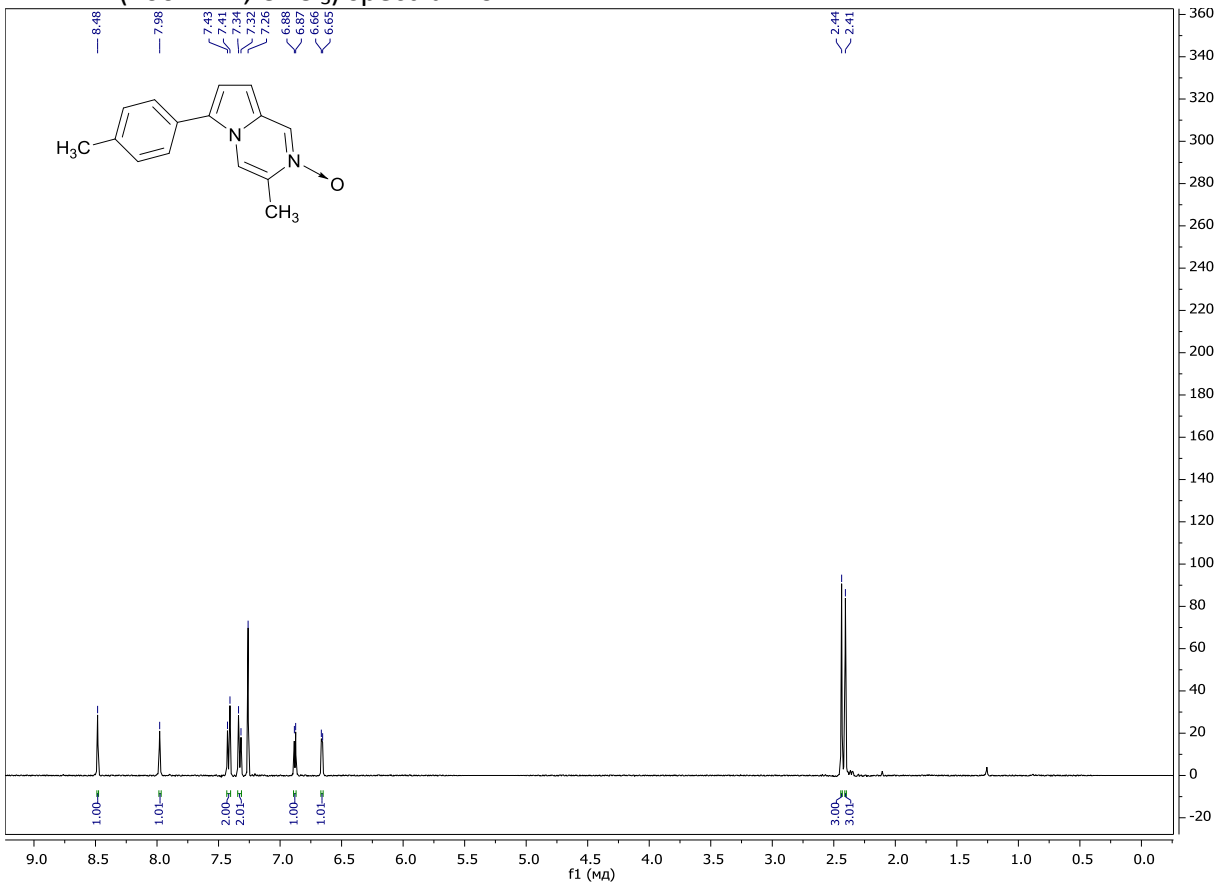
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2e



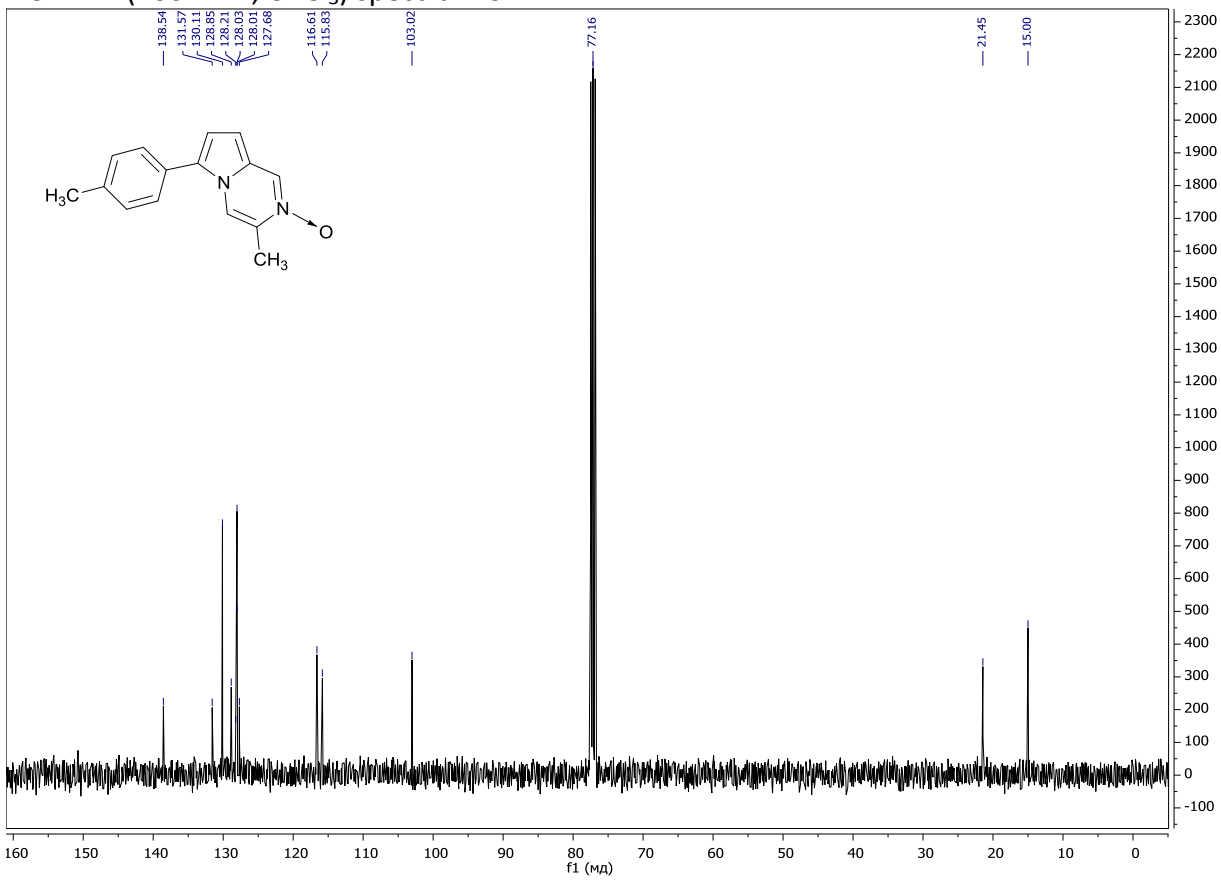
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2e



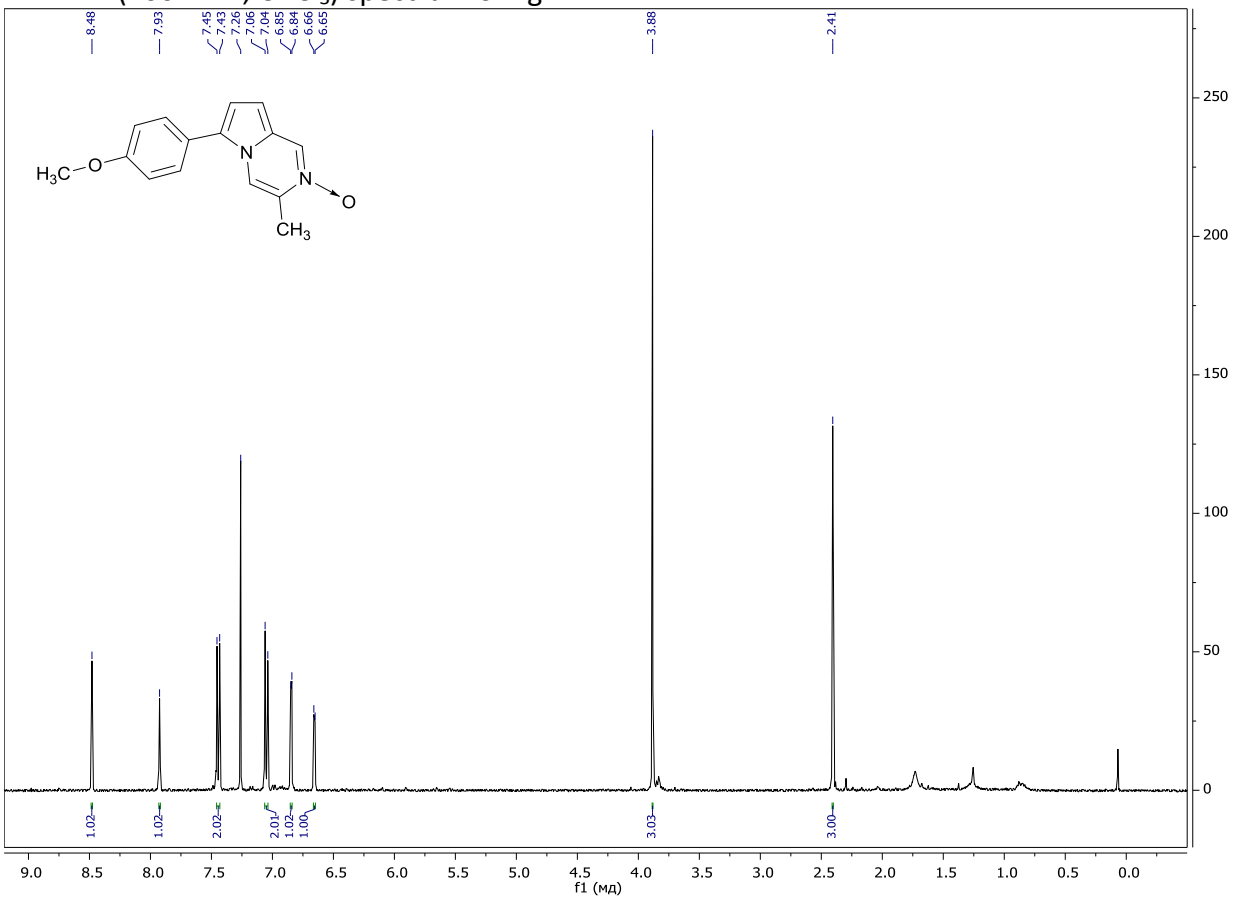
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2f



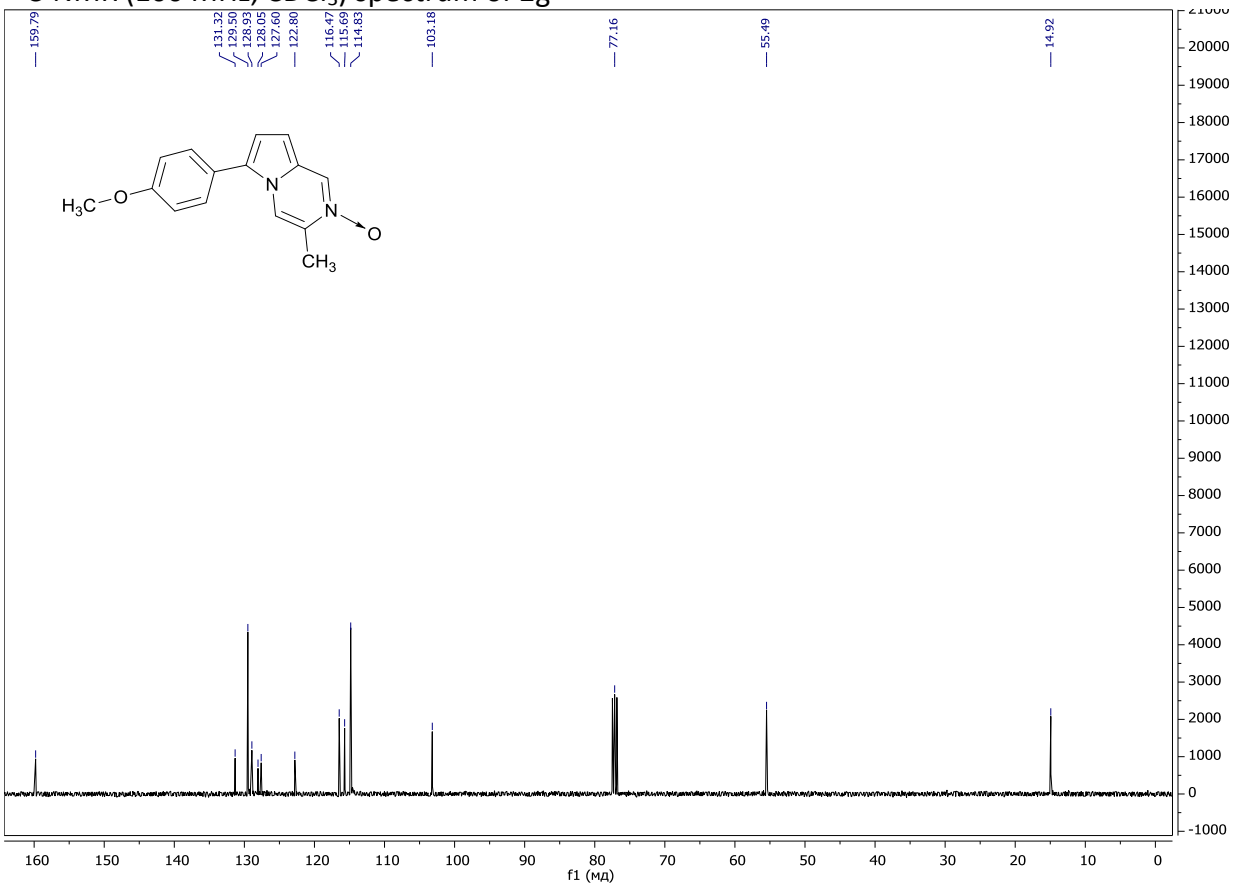
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2f



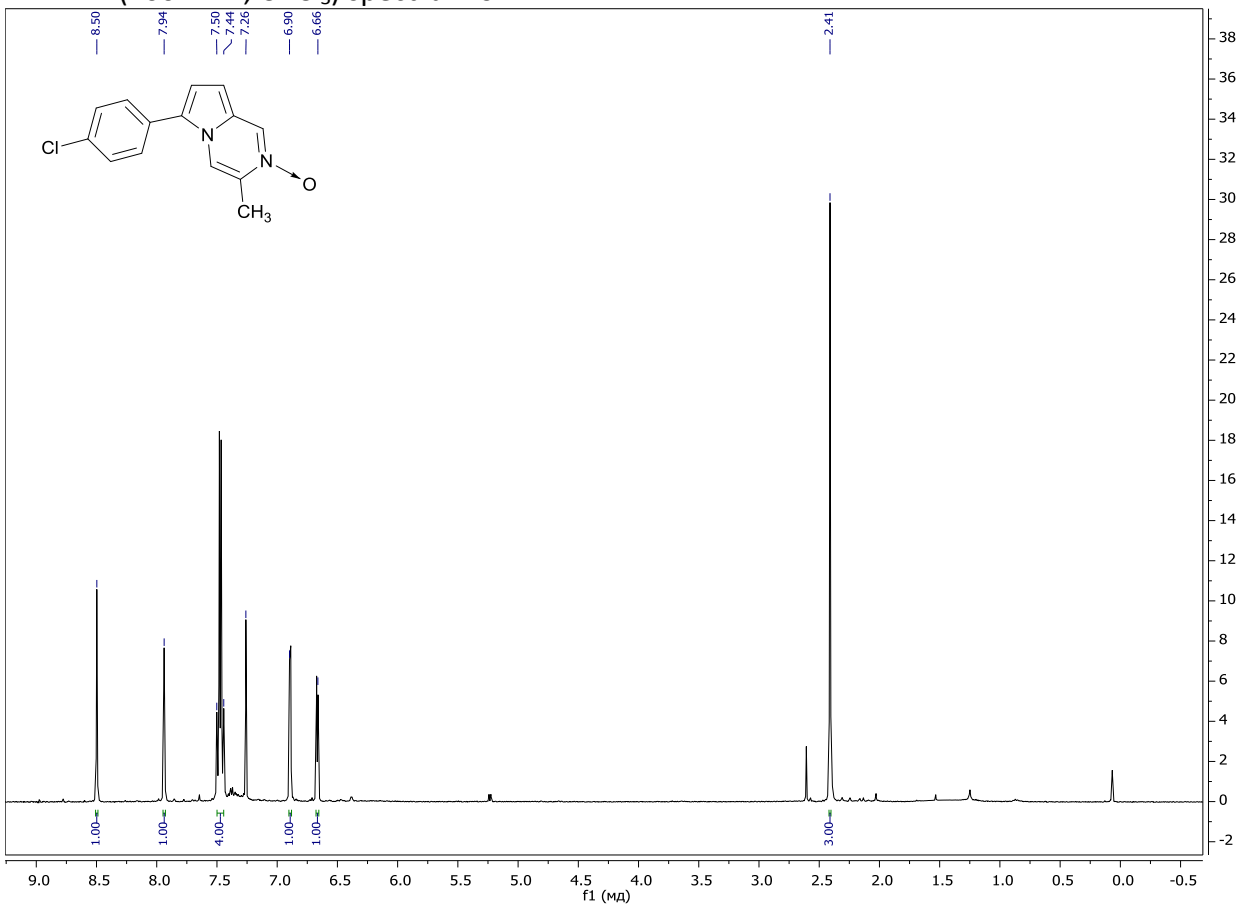
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2g



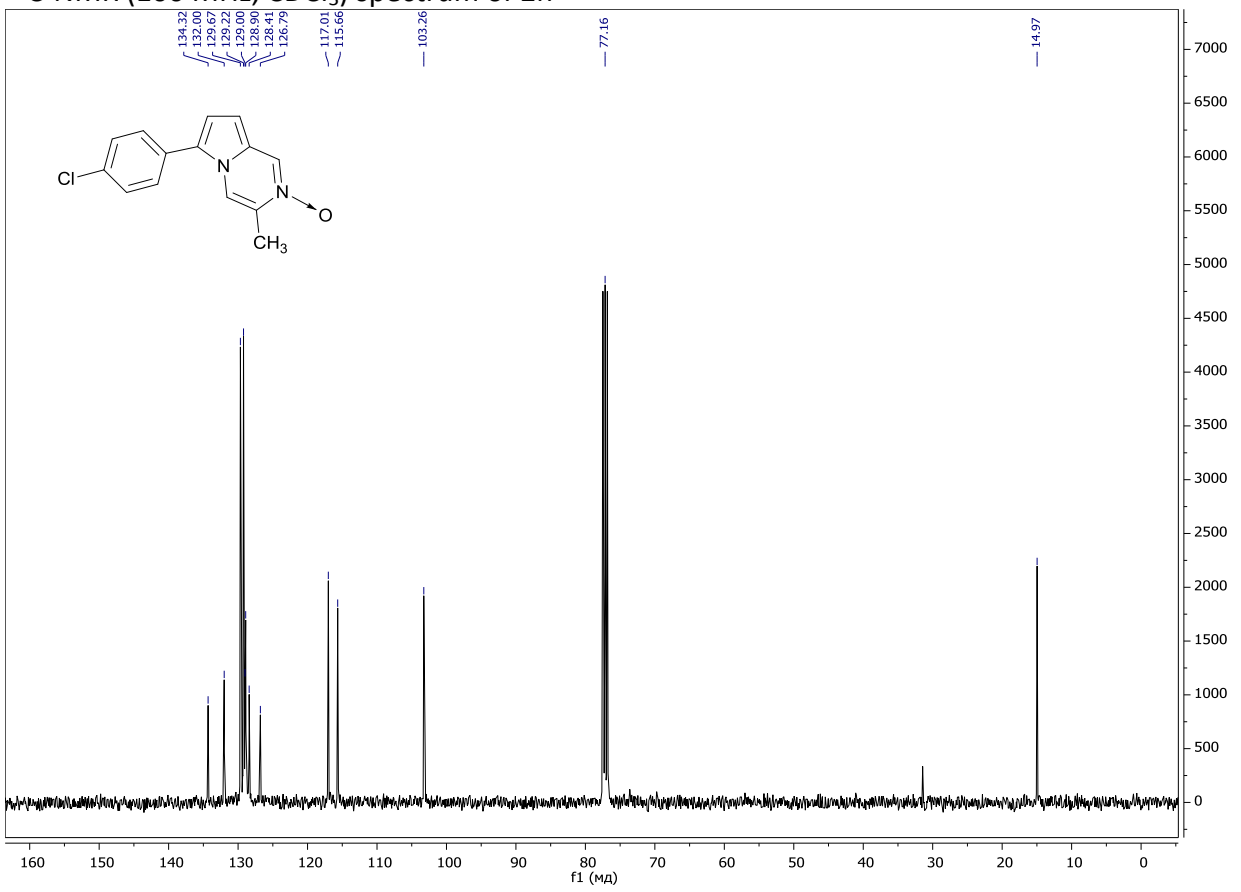
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2g



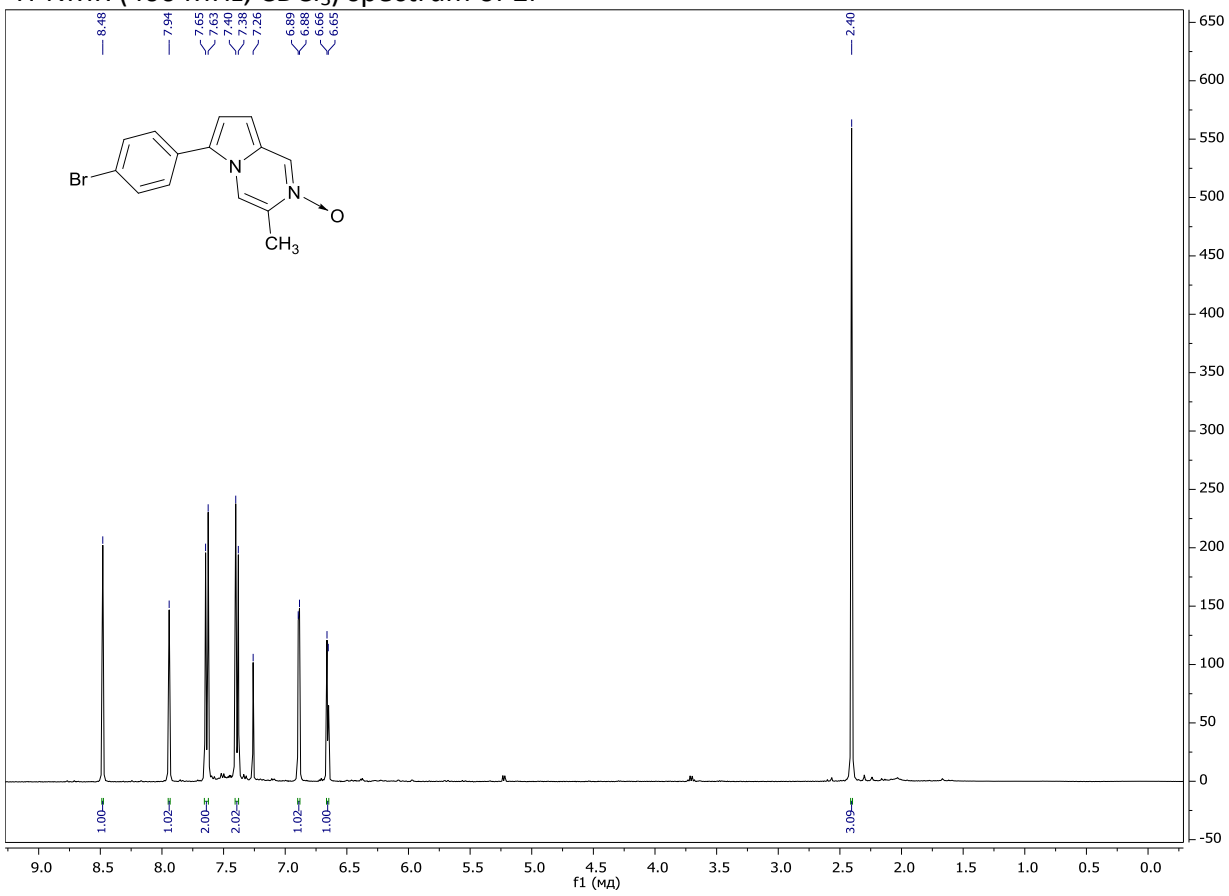
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2h



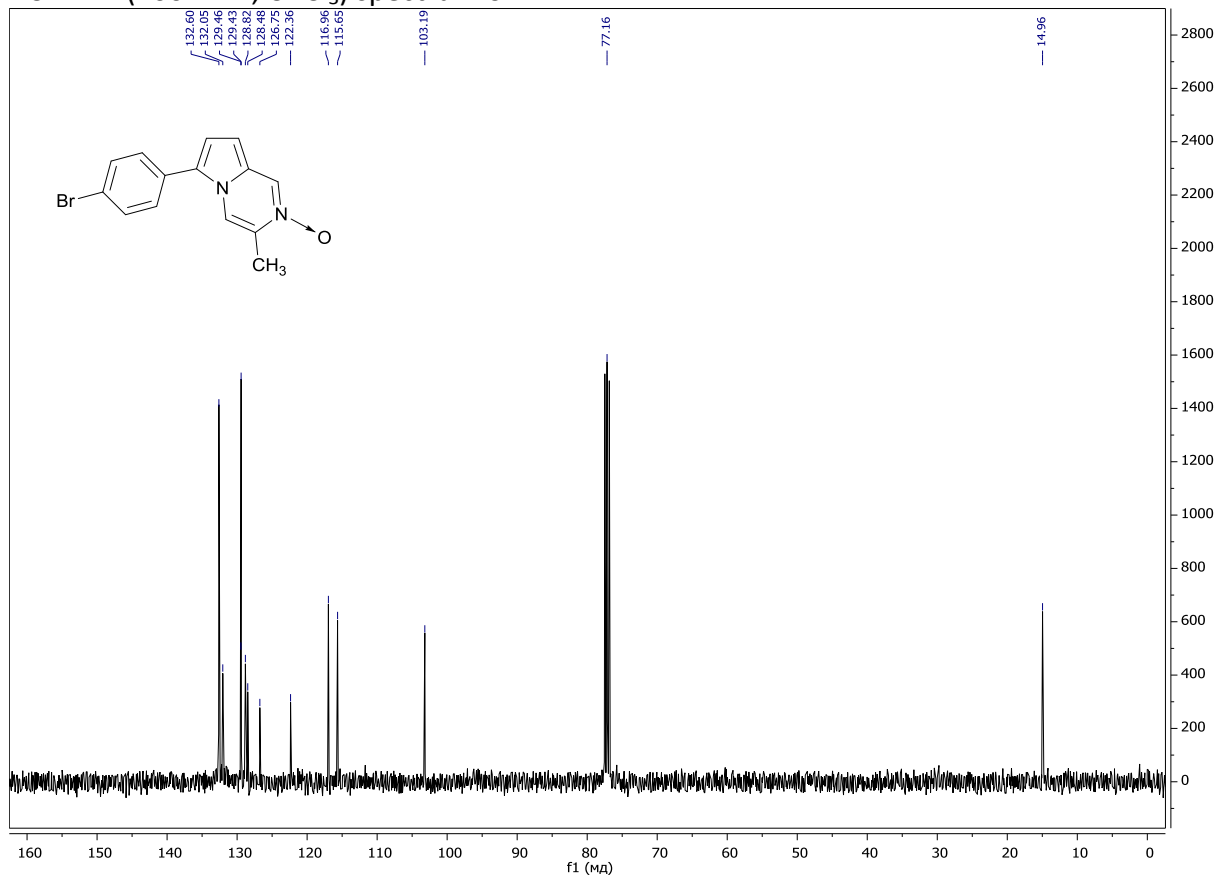
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2h



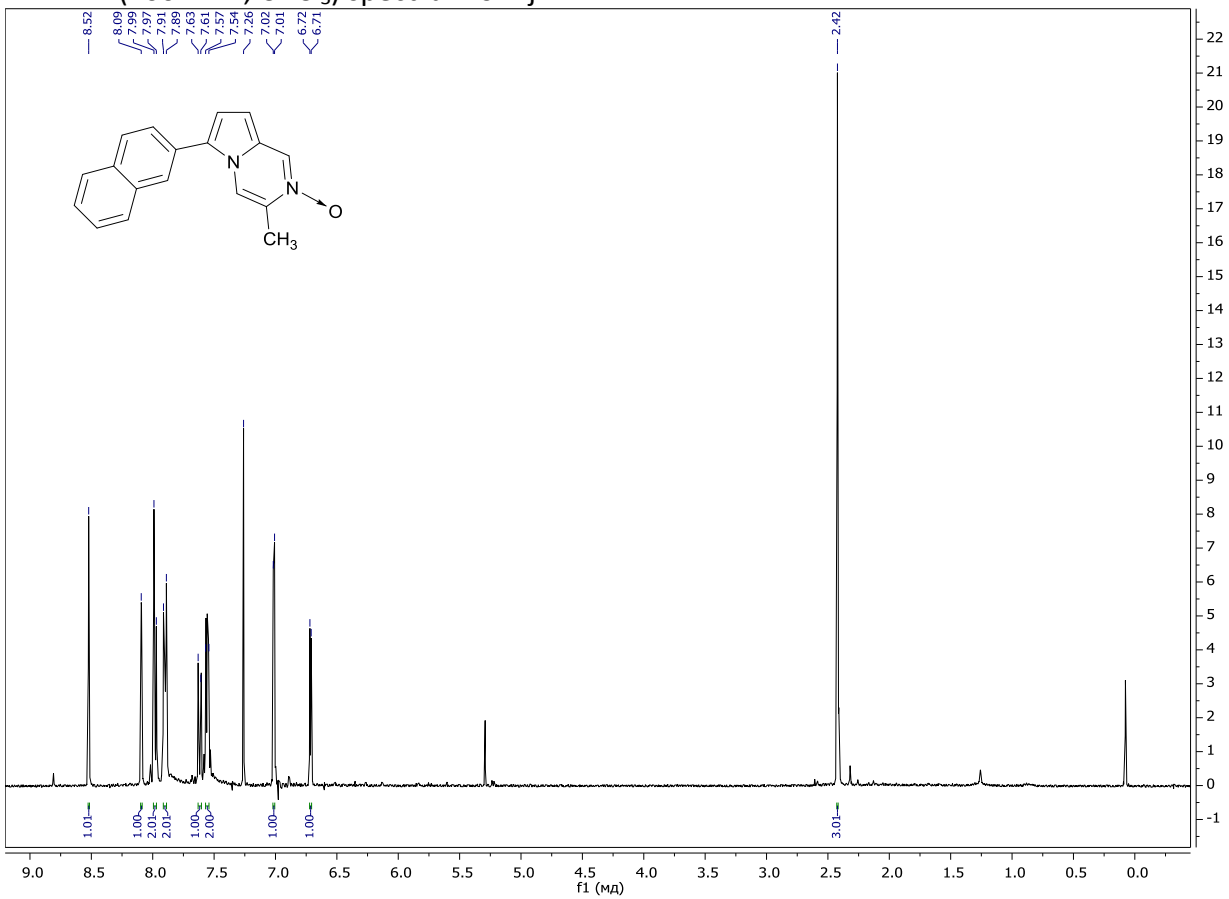
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2i



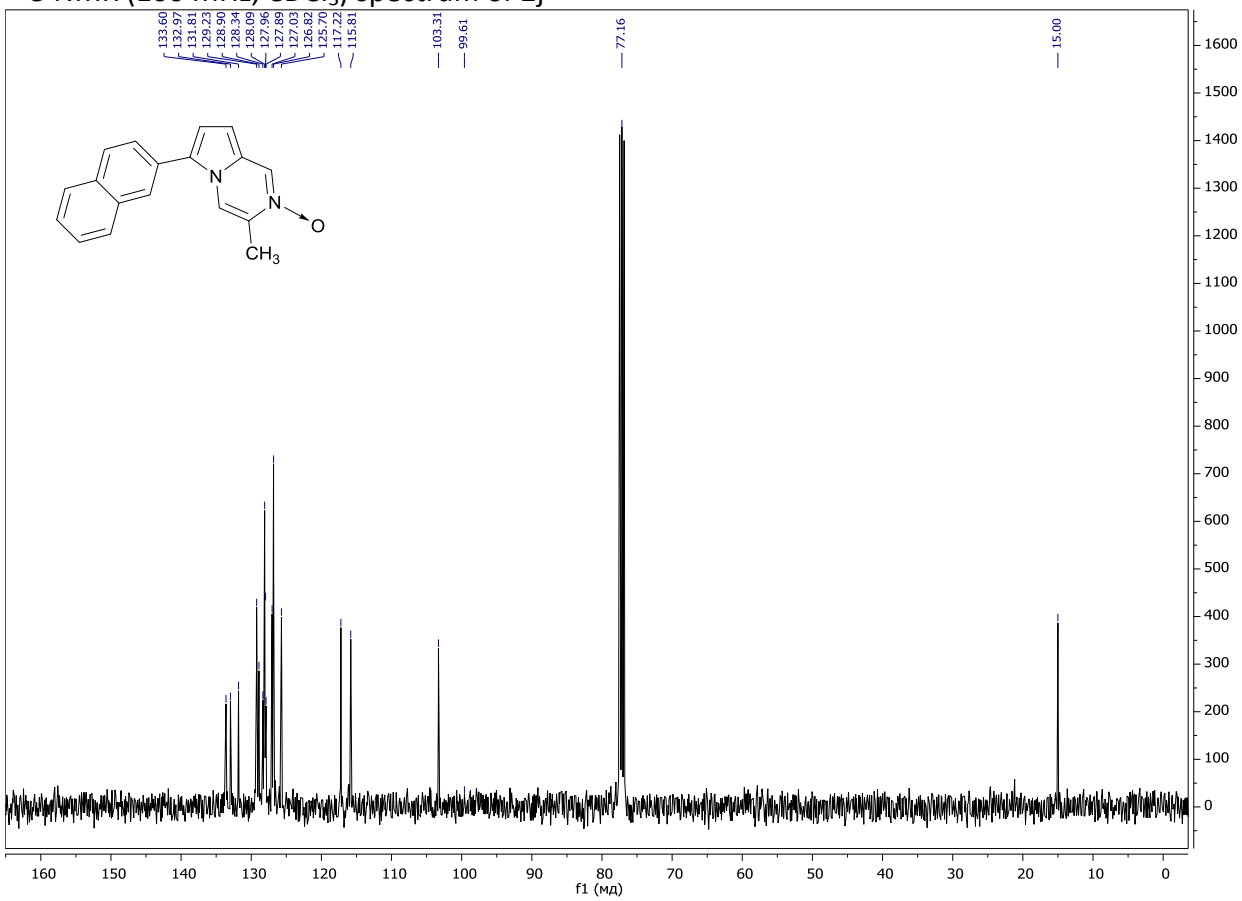
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2i



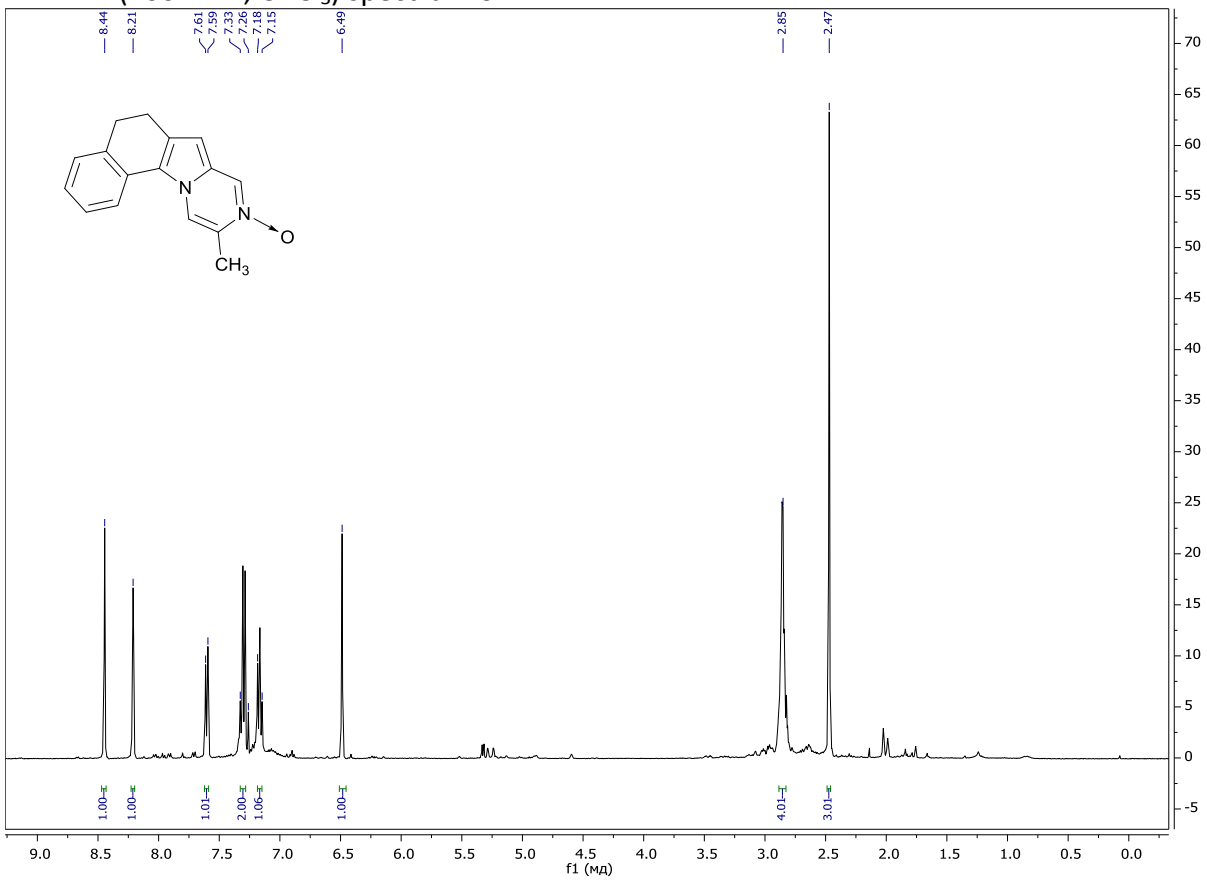
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2j



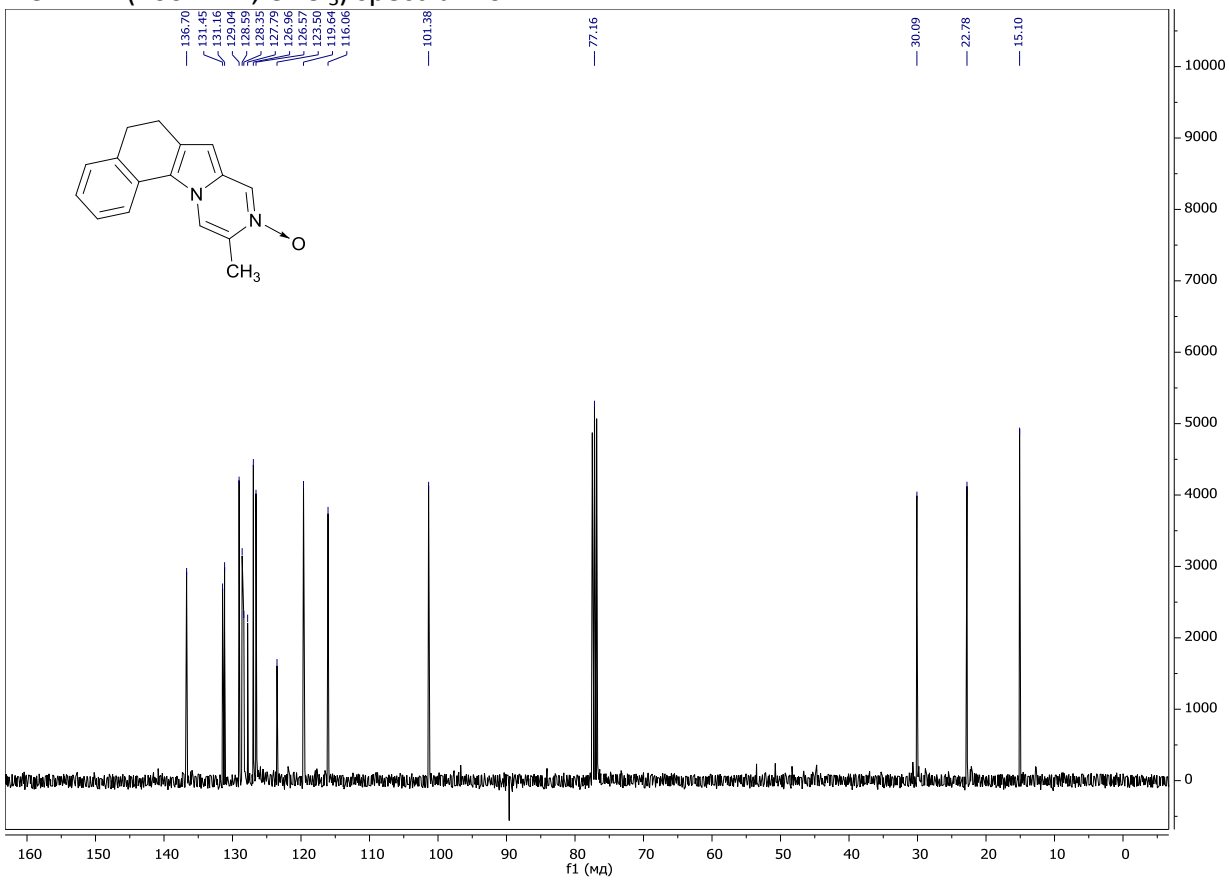
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2j



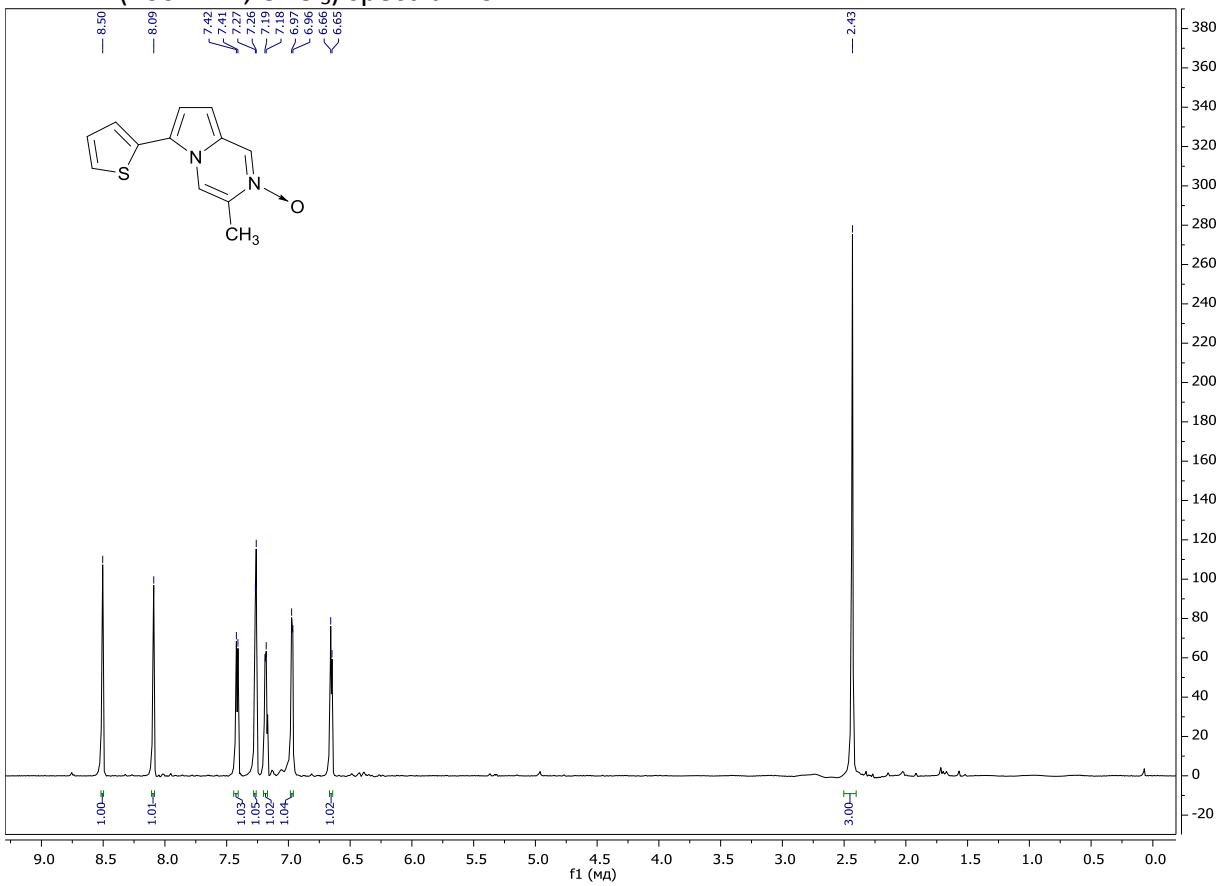
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2k



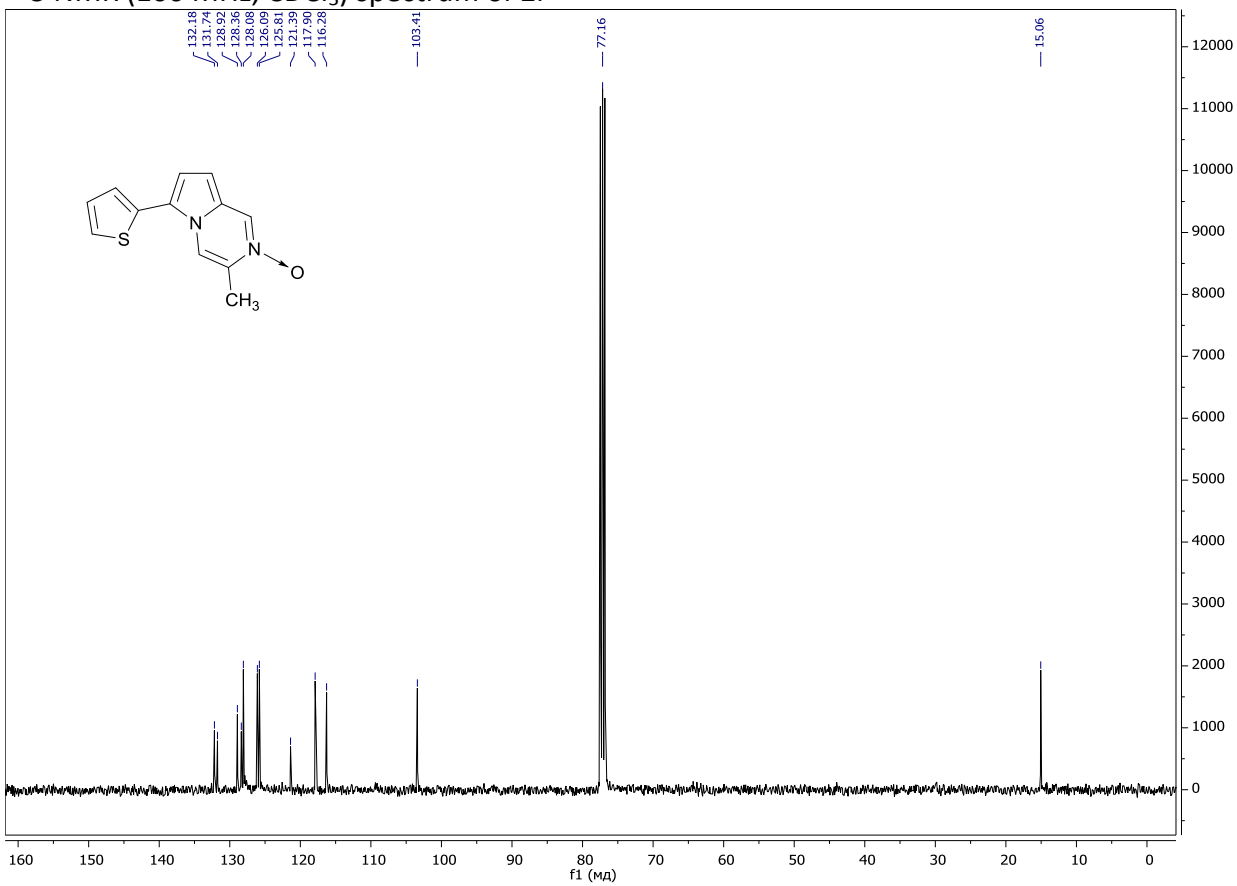
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2k



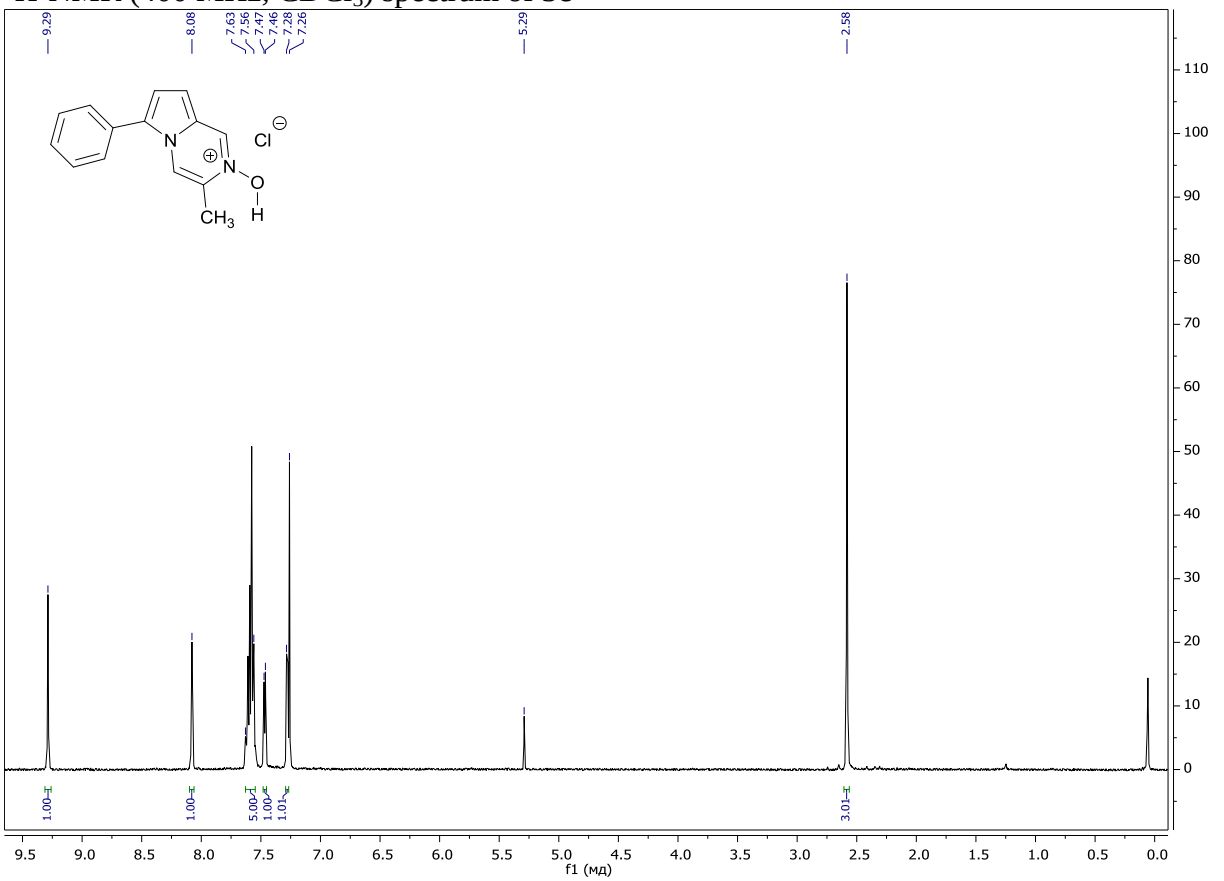
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 2l



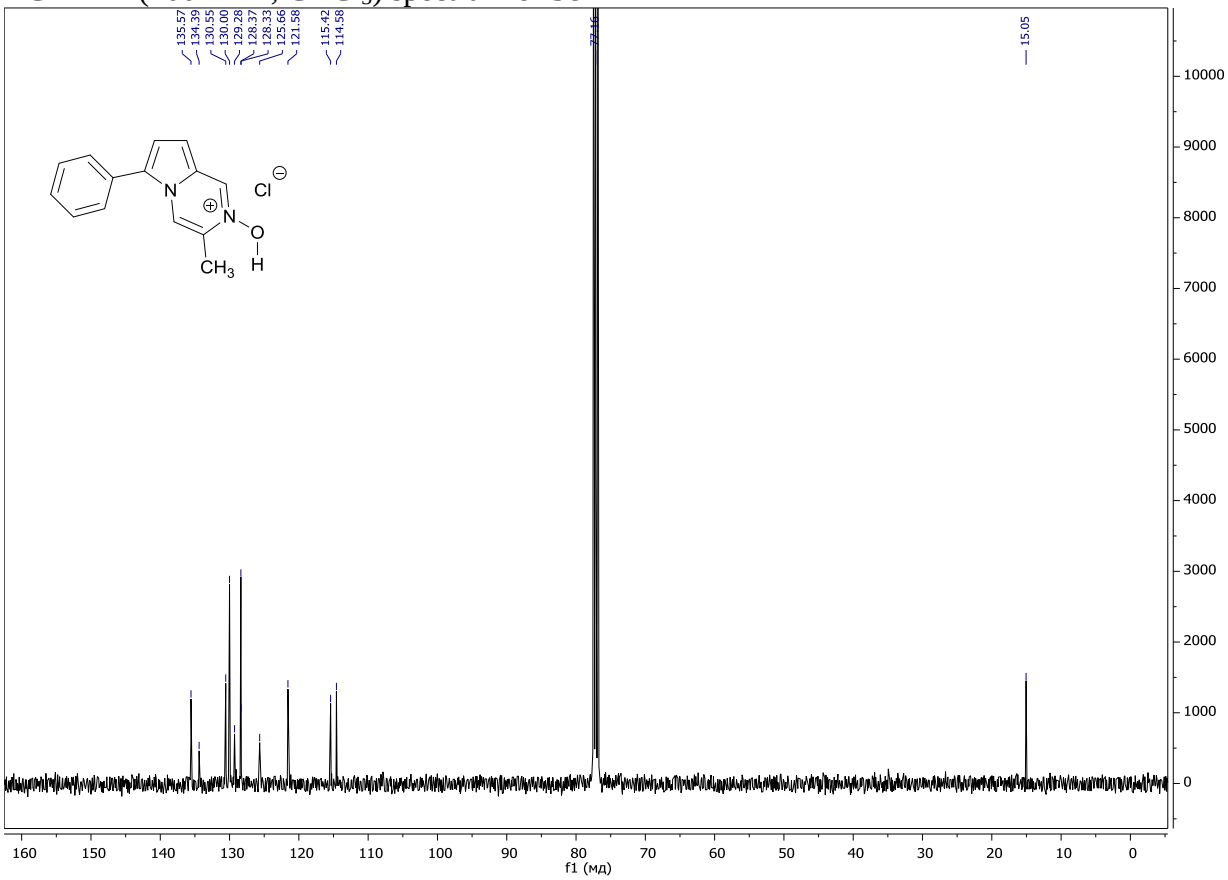
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 2l



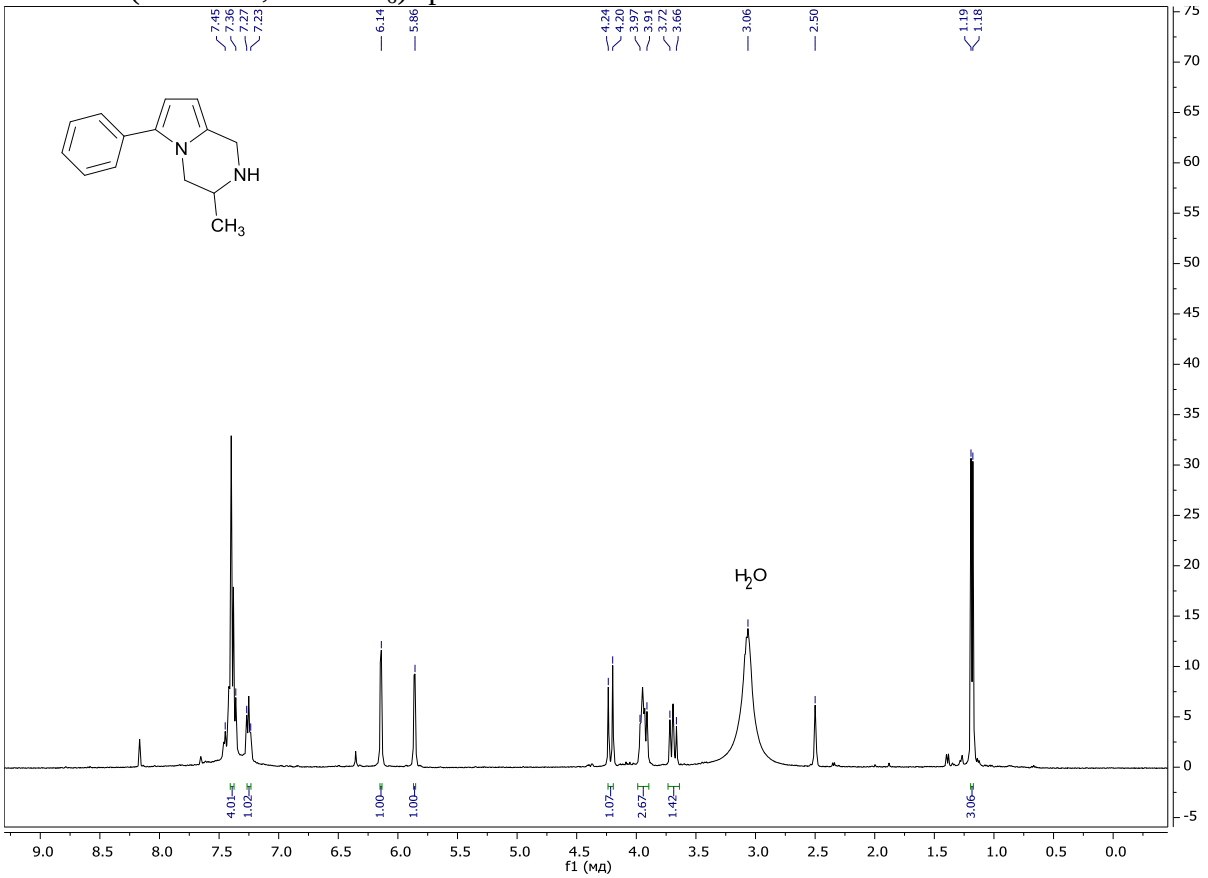
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 3c



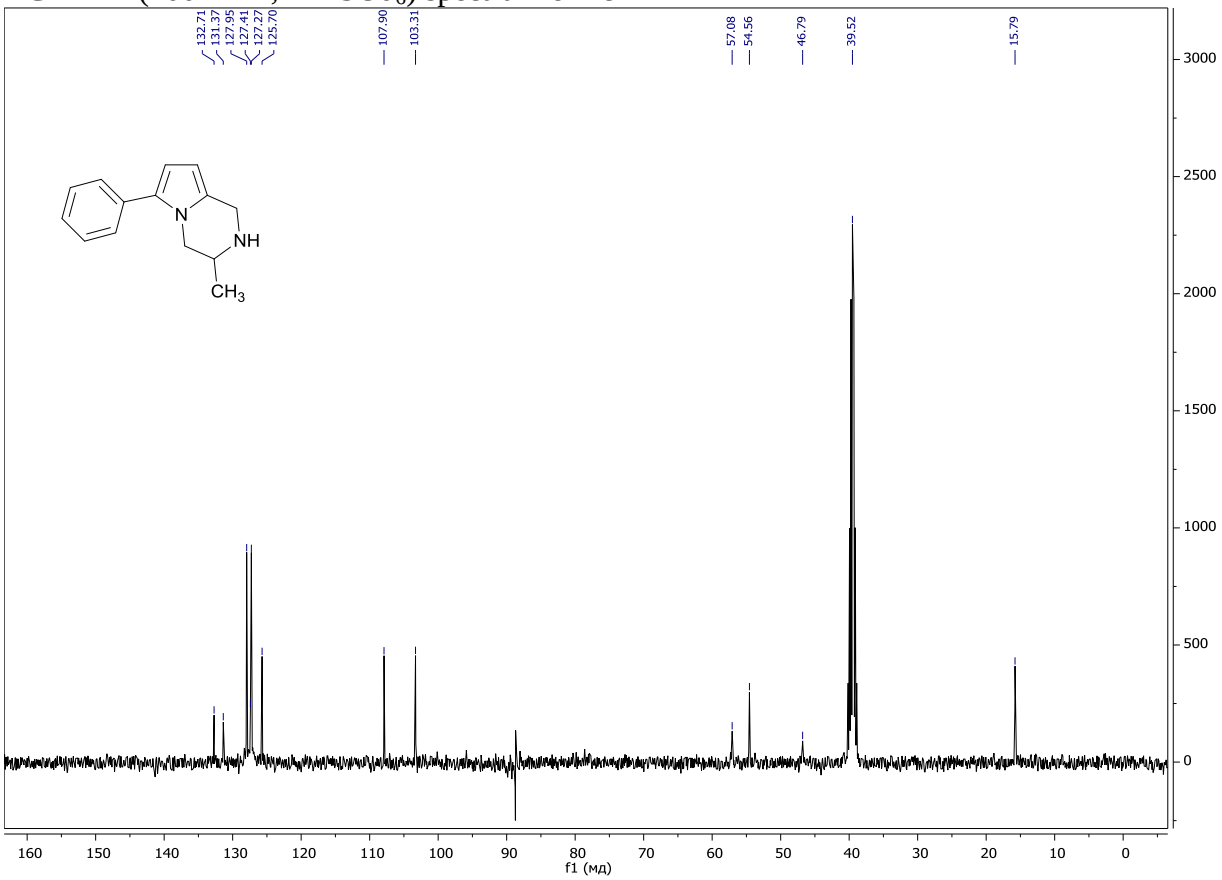
^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 3c



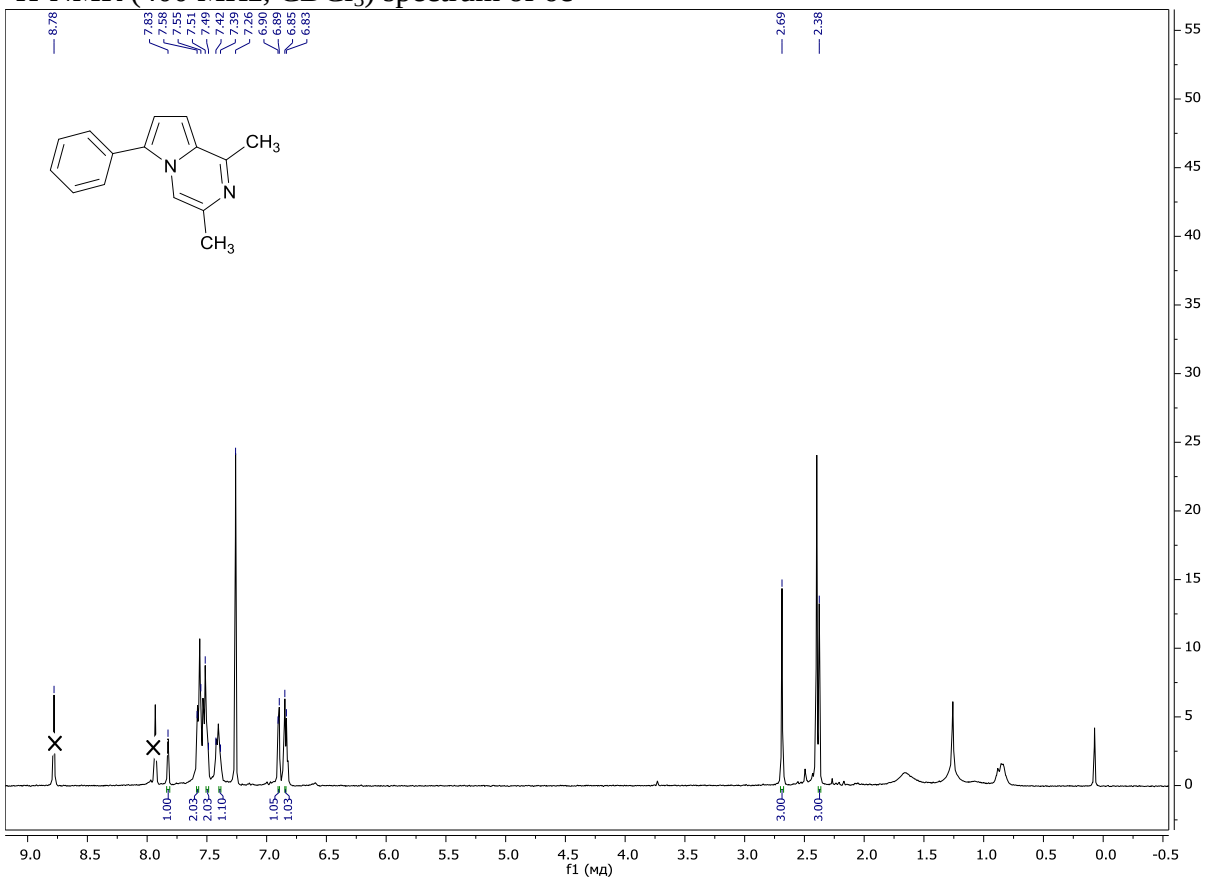
^{1}H-NMR (400 MHz, DMSOd_6) spectrum of 4c



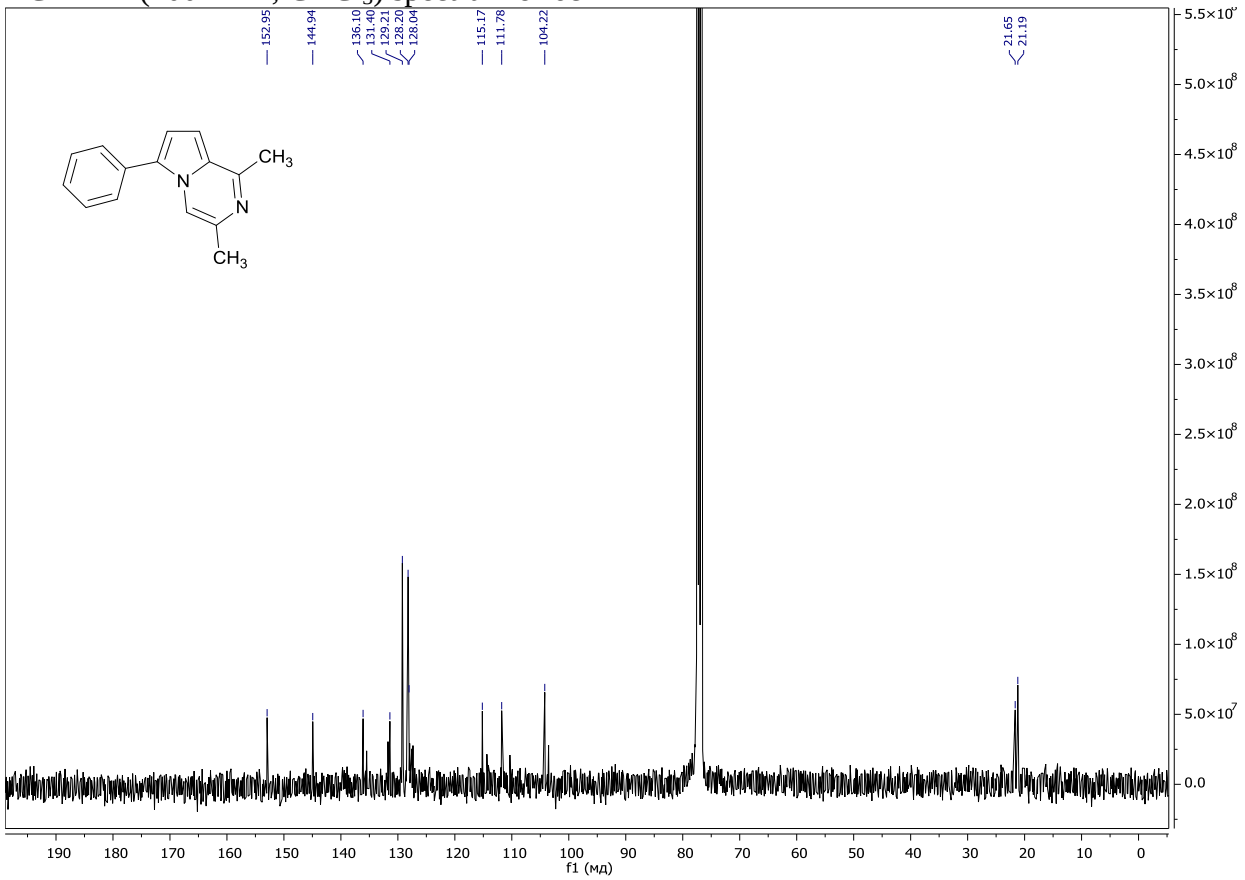
^{13}C-NMR (100 MHz, DMSOd_6) spectrum of 4c



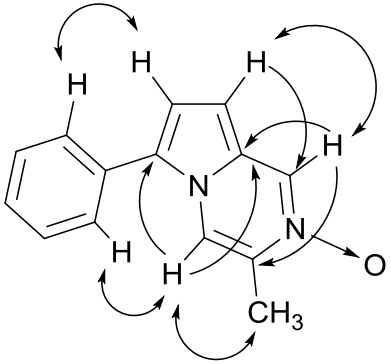
^{1}H-NMR (400 MHz, $CDCl_3$) spectrum of 6c

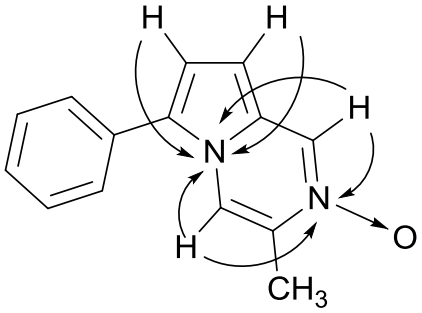


^{13}C-NMR (100 MHz, $CDCl_3$) spectrum of 6c



16. 2D NMR spectra



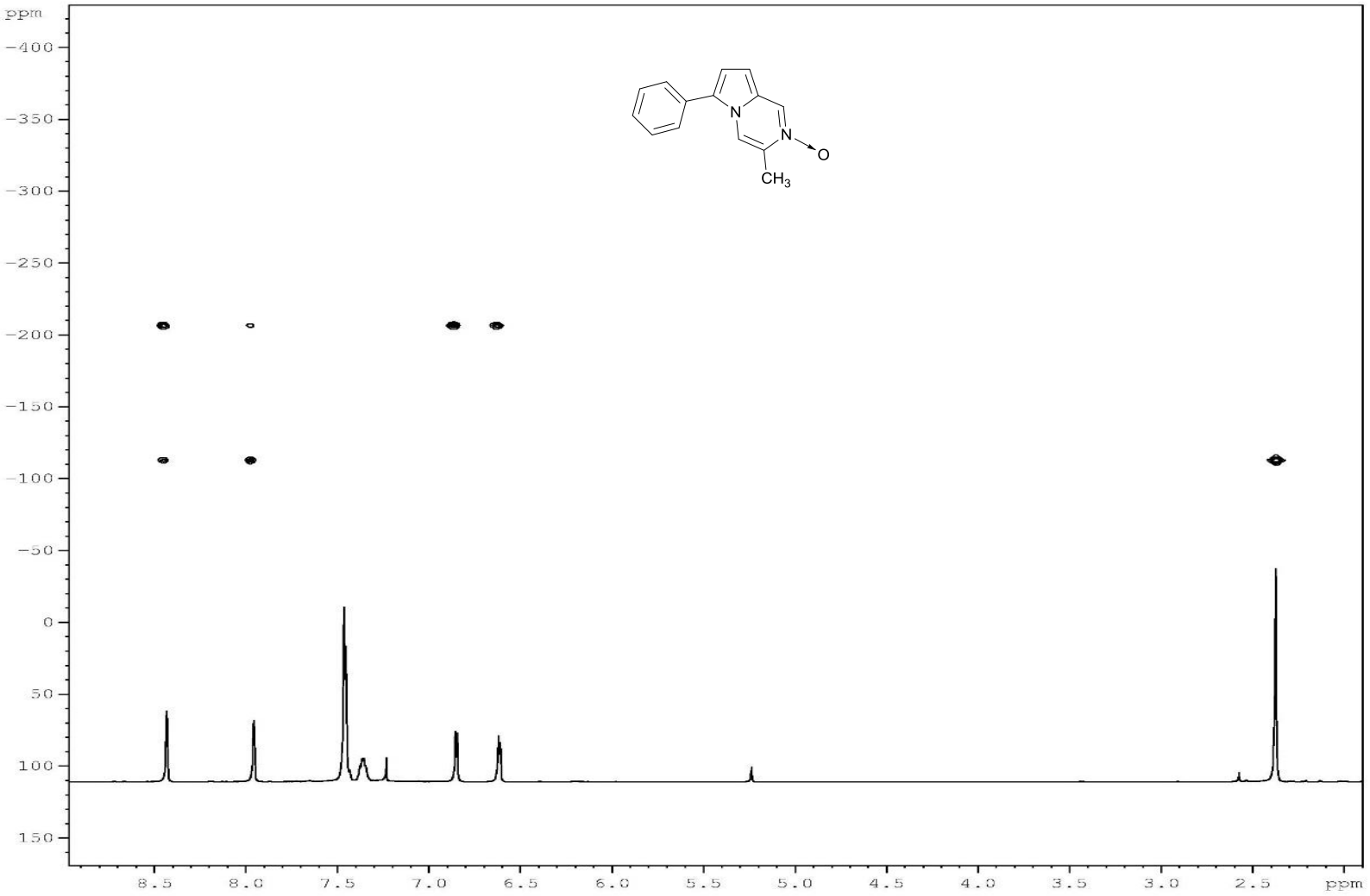


↔ NOESY

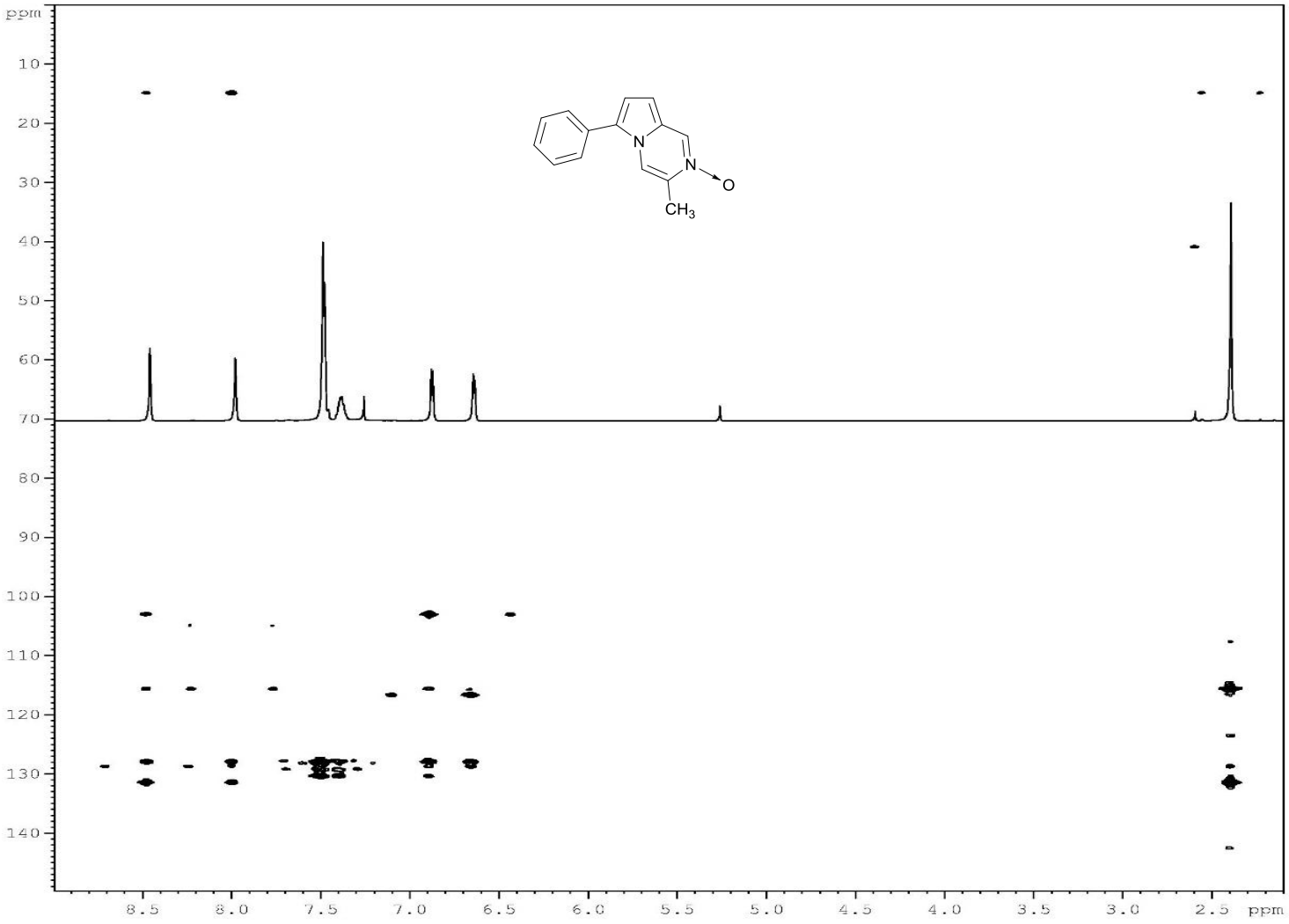
← ^{1}H-^{13}C HMBC correlations

^{1}H-^{13}C HMBC correlations

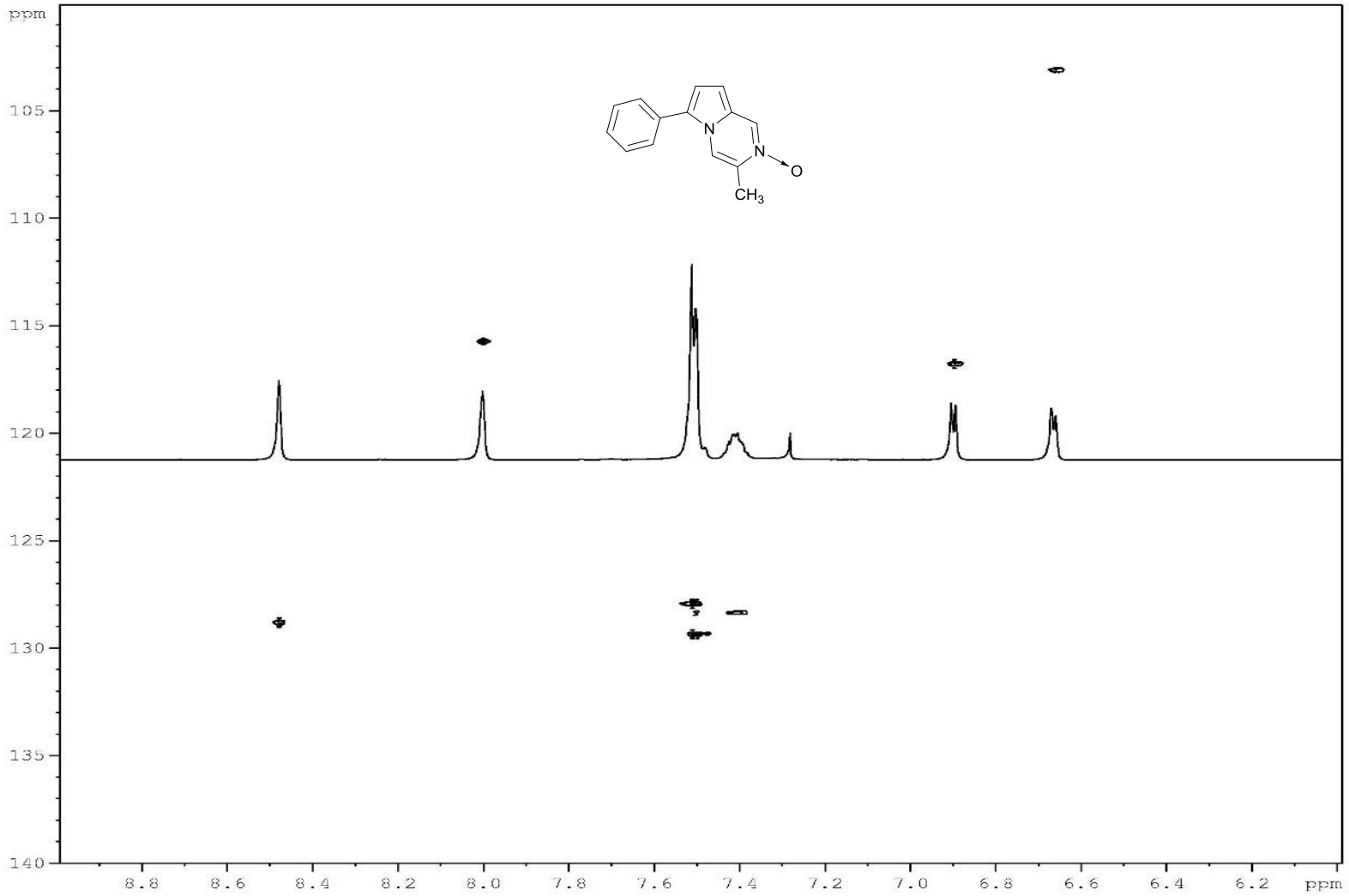
2D ^{1}H-^{15}N HMBC spectrum of **2c** ($CDCl_3$)



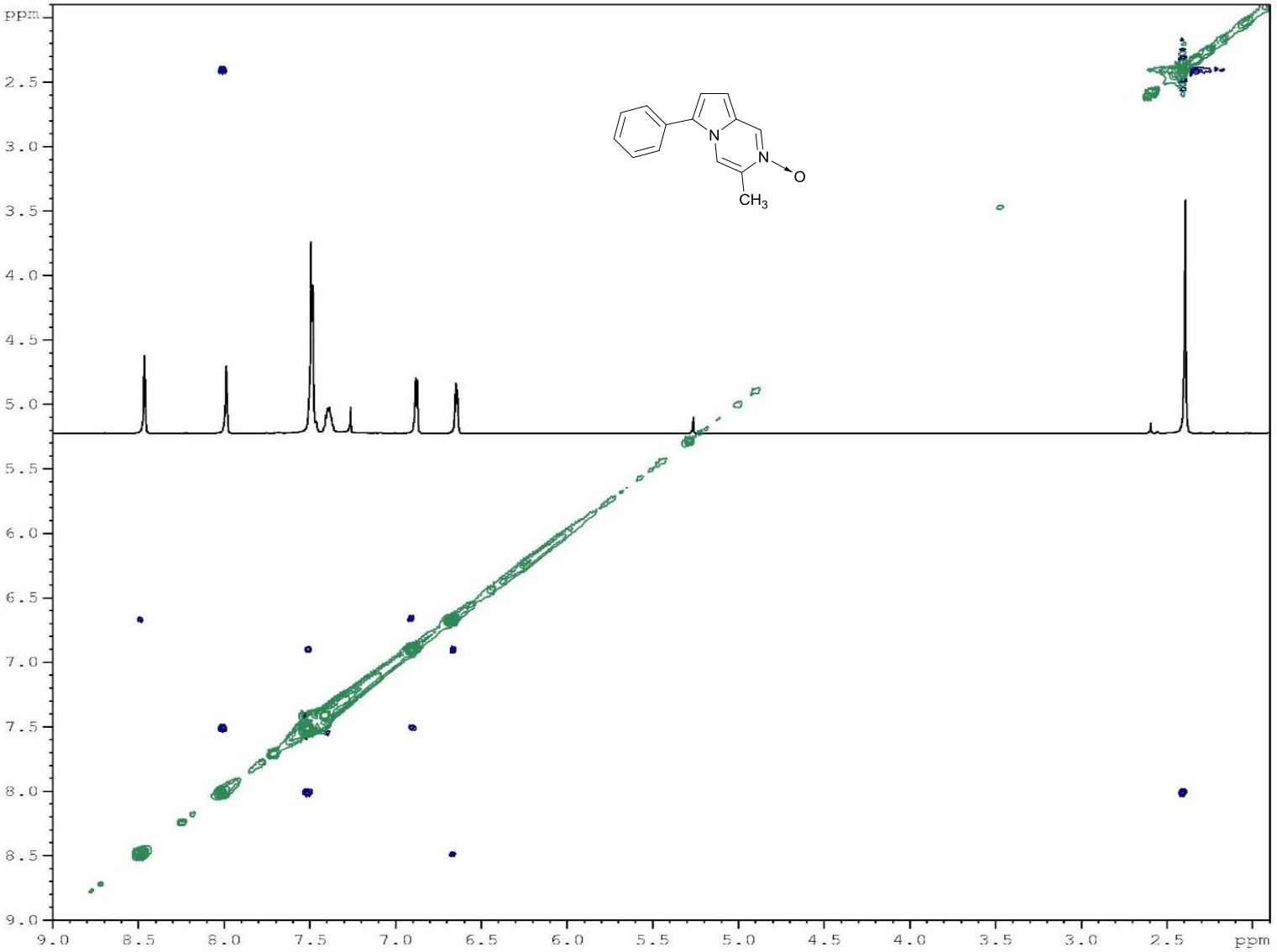
2D ^{1}H-^{13}C HMBC spectrum of **2c** ($CDCl_3$)



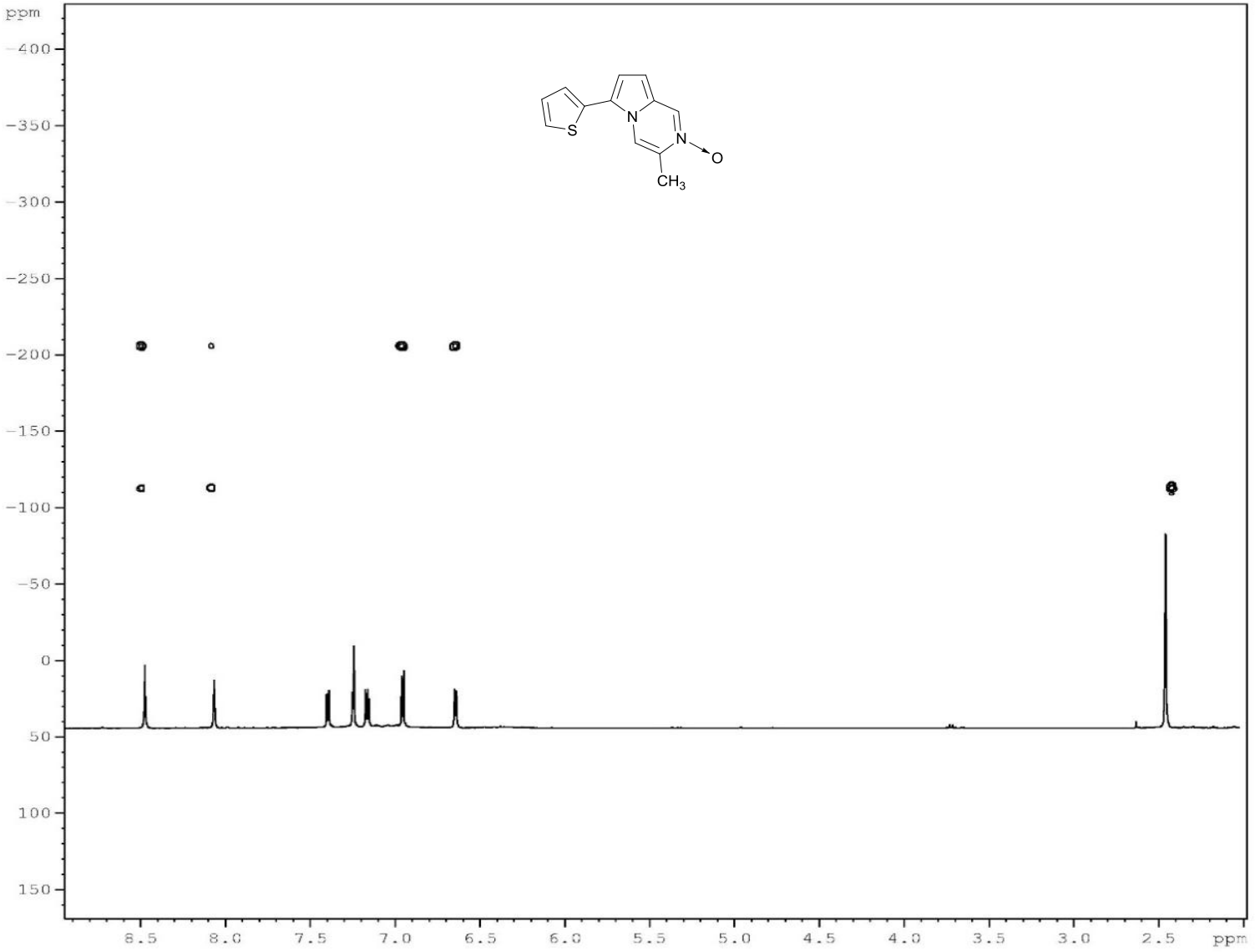
2D ^{1}H-^{13}C HSQC spectrum of **2c** ($CDCl_3$)



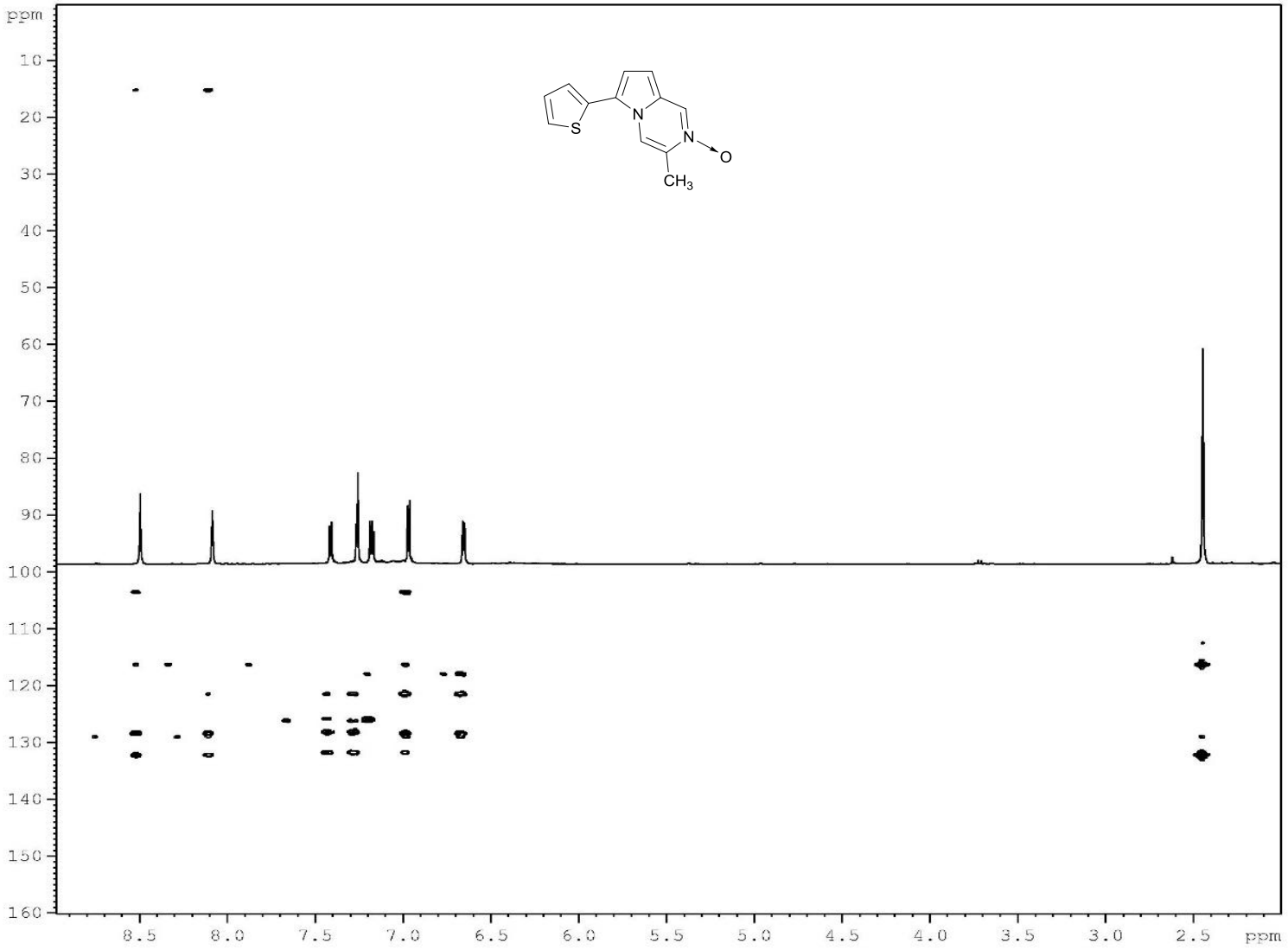
2D NOESY spectrum of **2c** ($CDCl_3$)



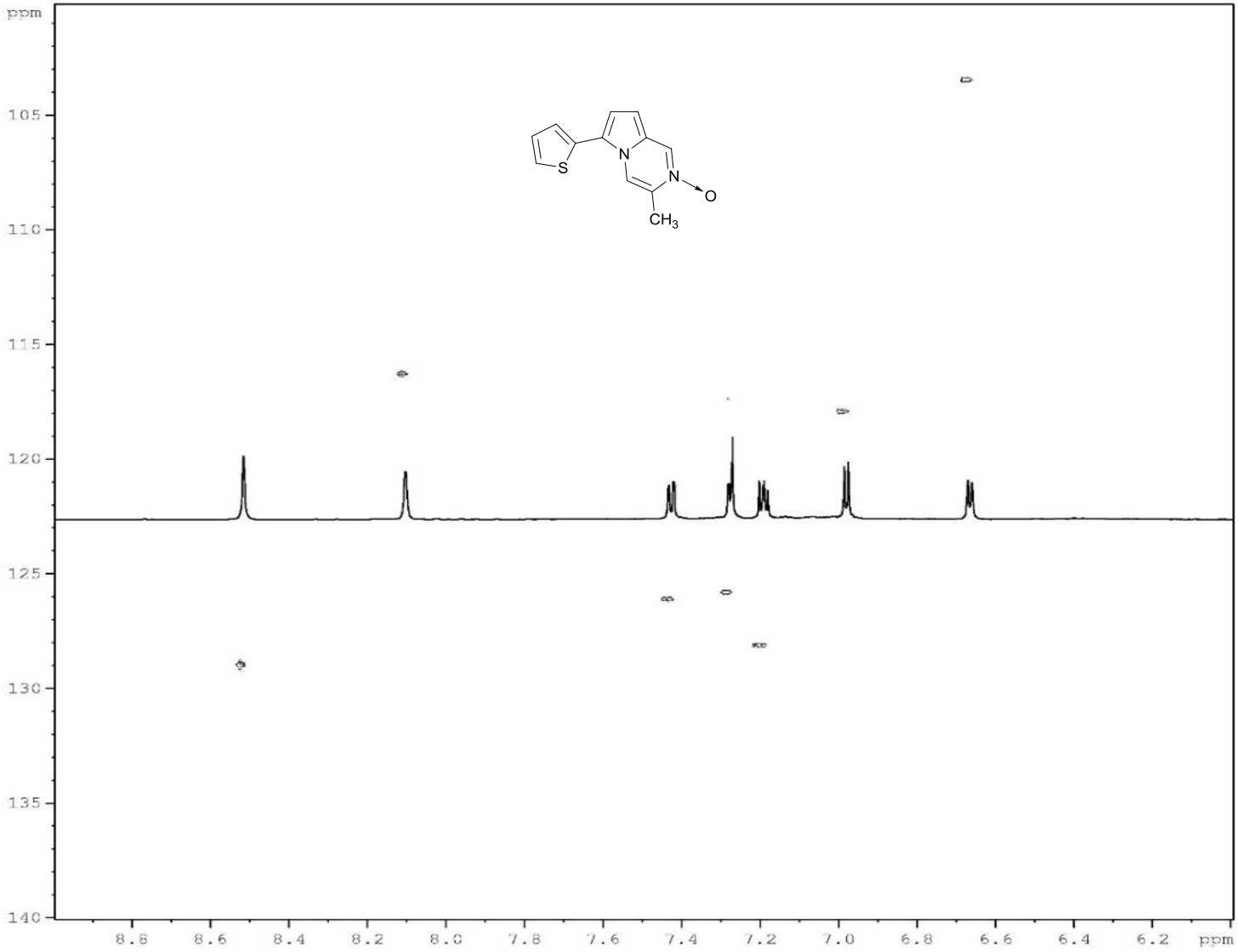
2D ^{1}H-^{15}N HMBC spectrum of **2l** ($CDCl_3$)



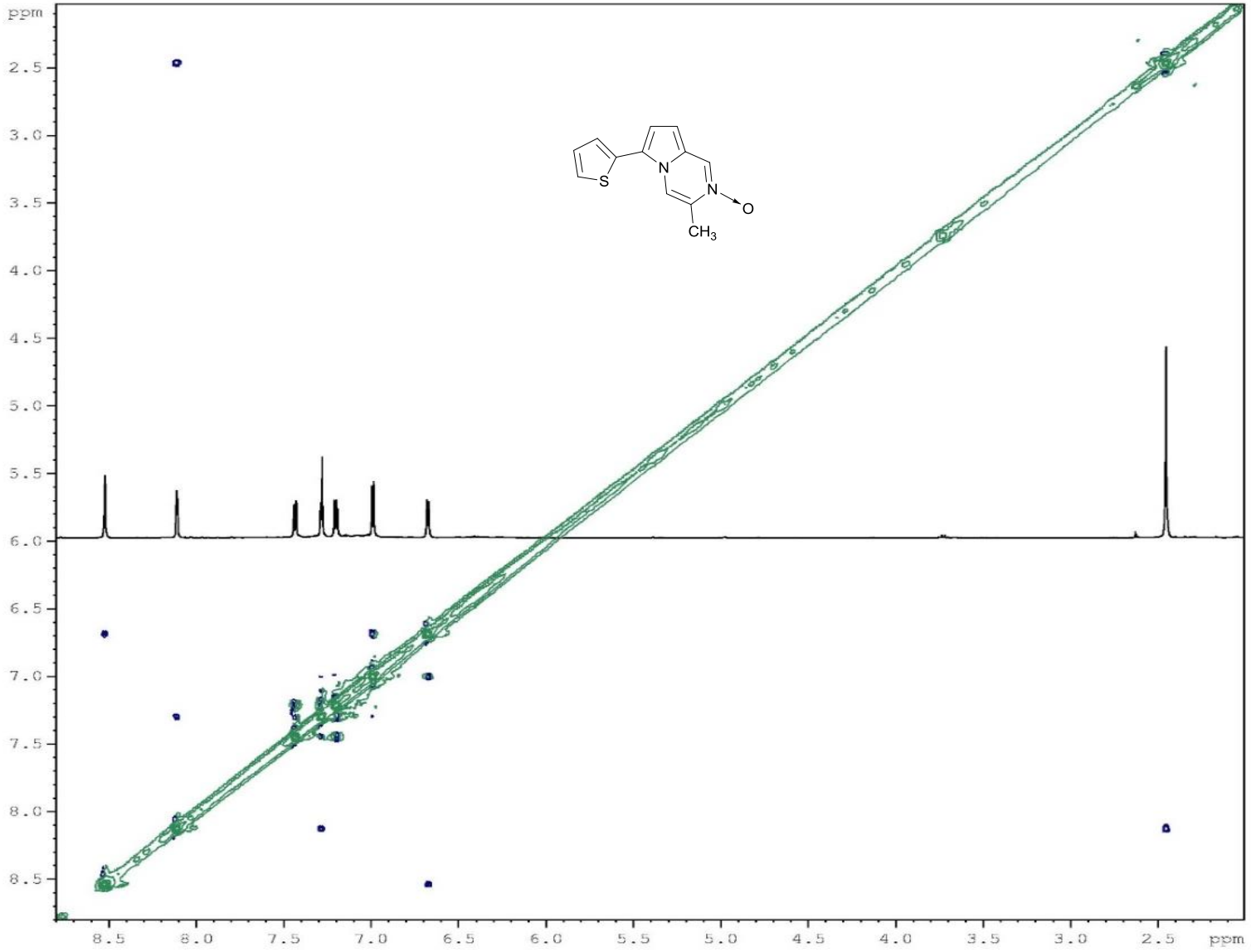
2D ^{1}H-^{13}C HMBC spectrum of **2l** ($CDCl_3$)



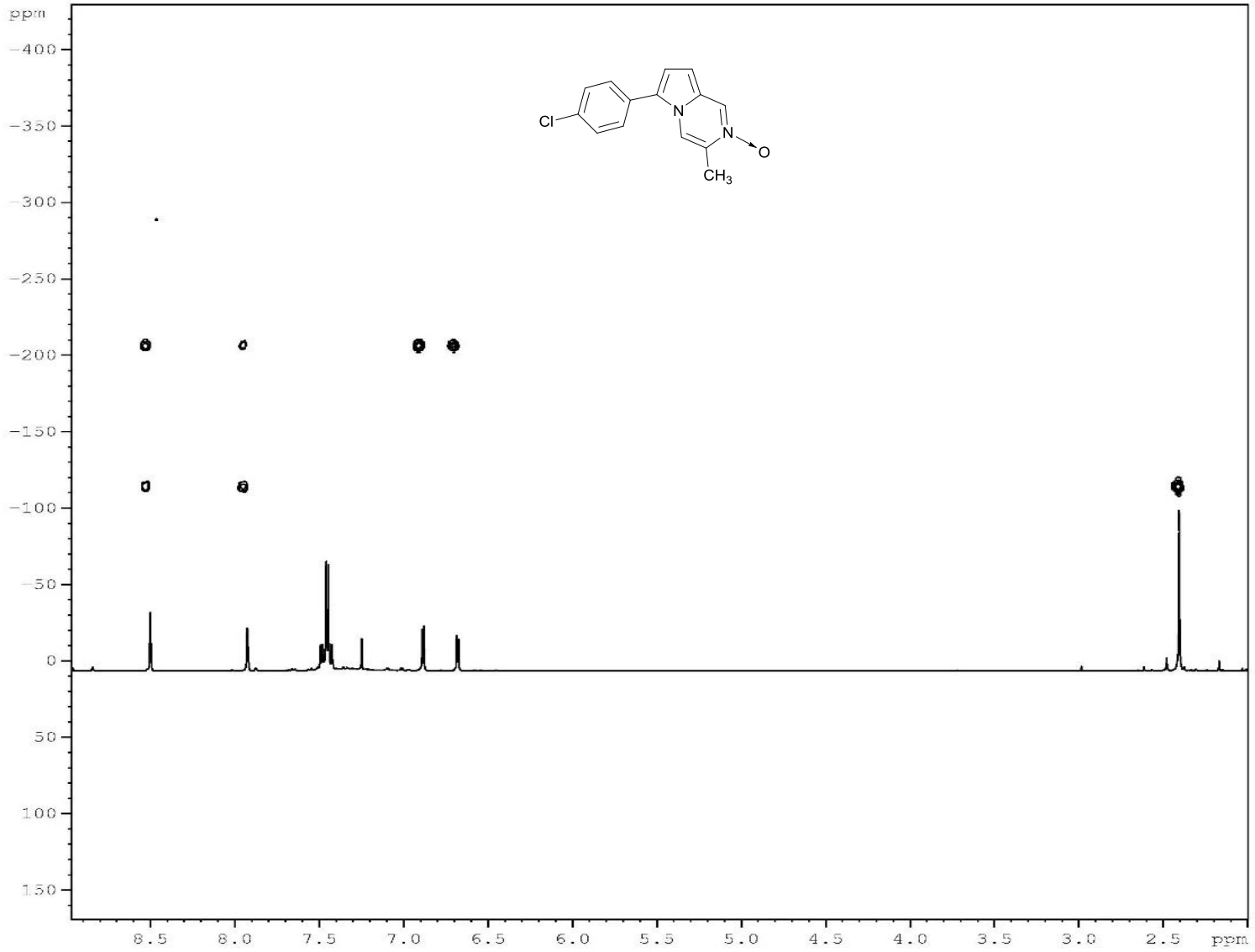
2D ^{1}H-^{13}C HSQC spectrum of **2l** ($CDCl_3$)



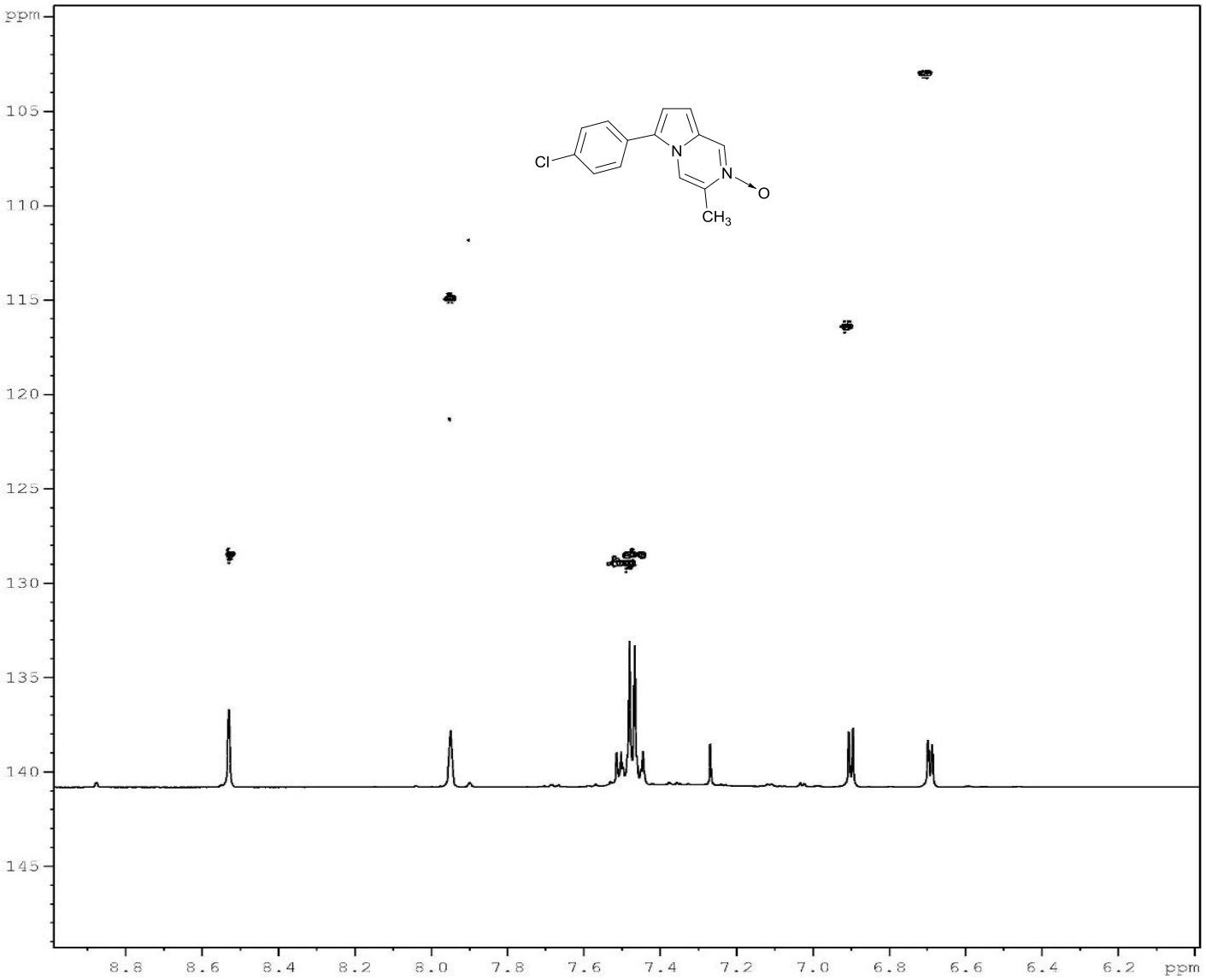
2D NOESY spectrum of **2l** ($CDCl_3$)



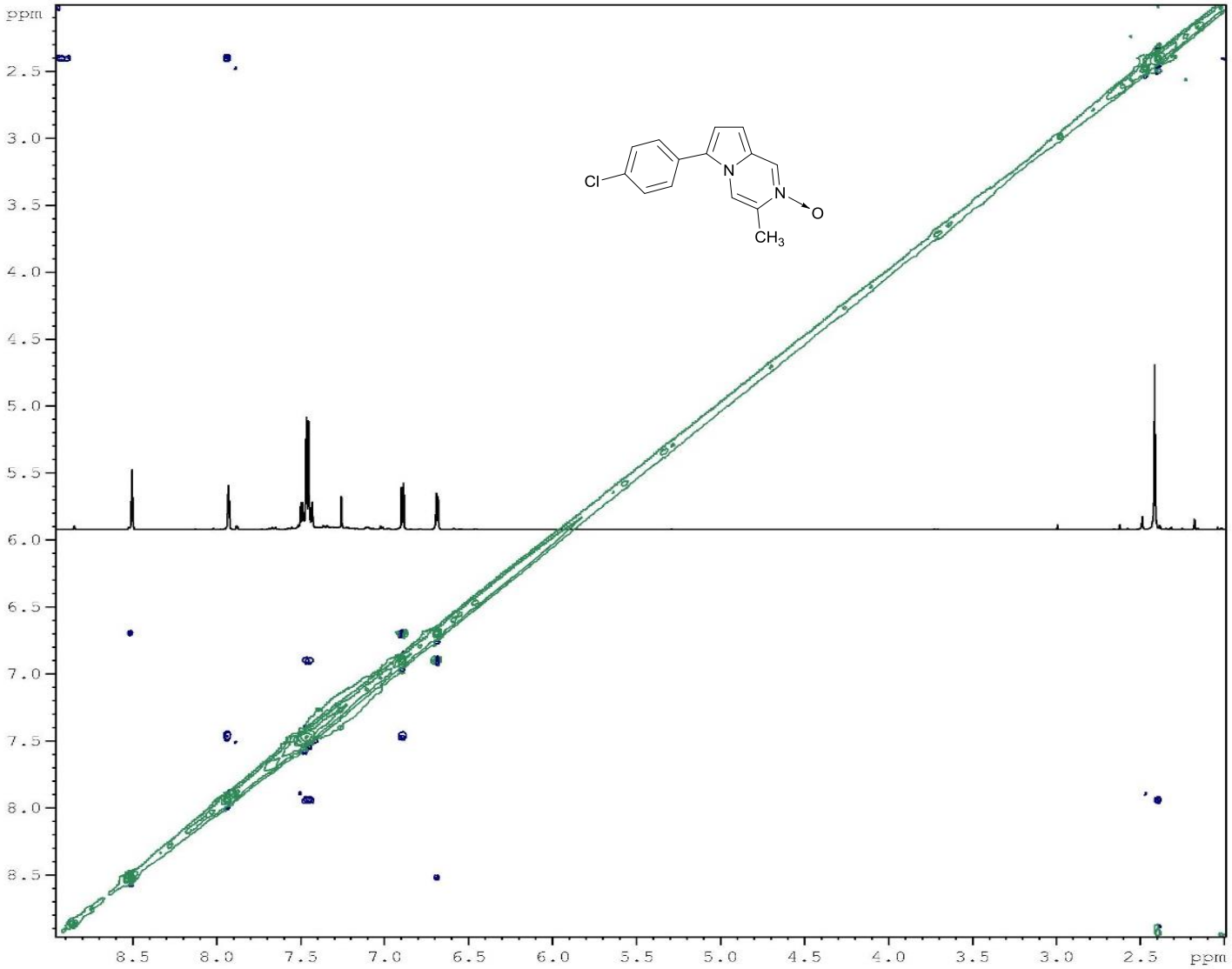
2D ^{1}H-^{15}N HMBC spectrum of **2h** ($CDCl_3$)



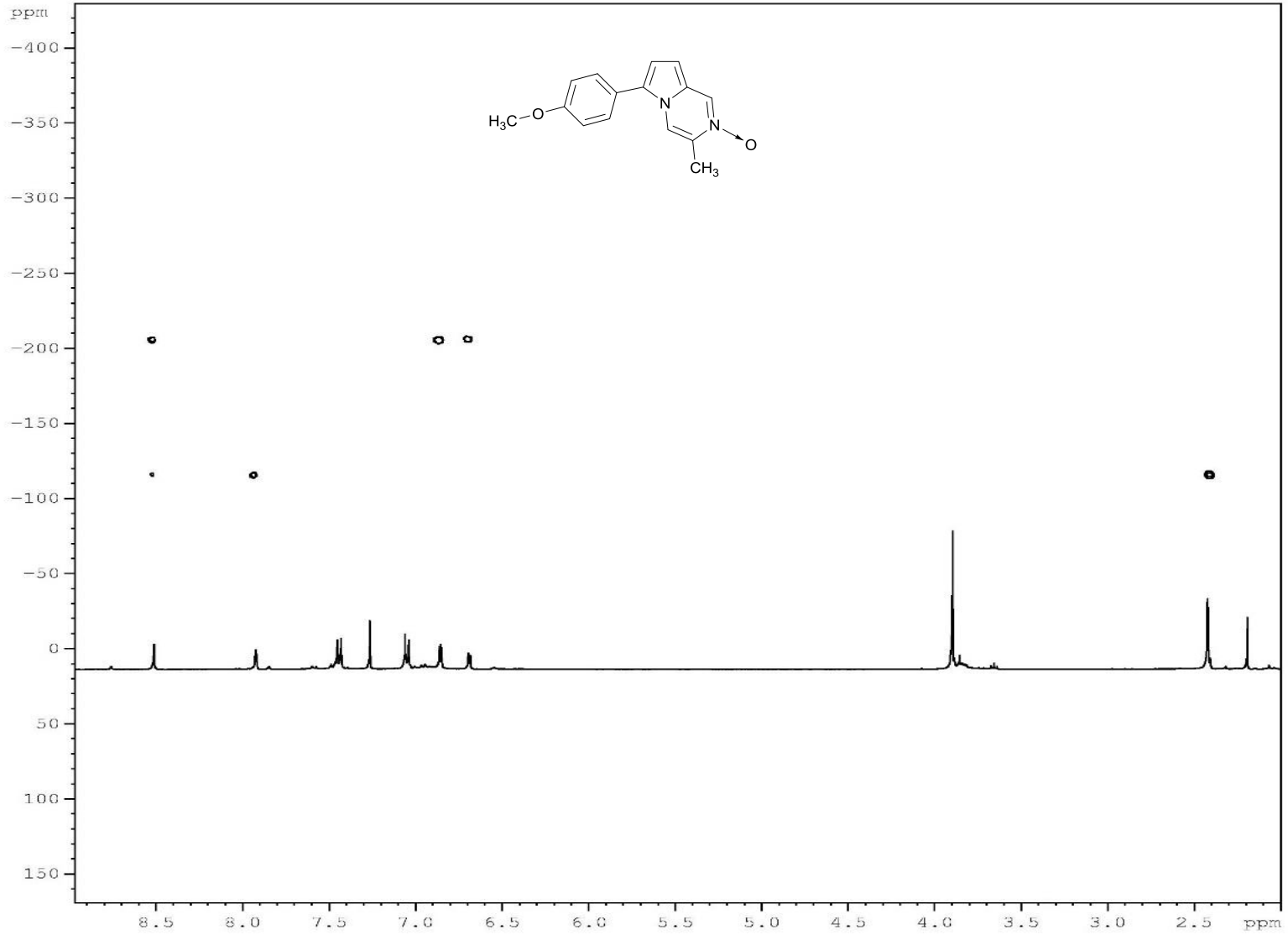
2D ^{1}H-^{13}C HSQC spectrum of **2h** ($CDCl_3$)



2D NOESY spectrum of **2h** ($CDCl_3$)



2D ^{1}H-^{15}N HMBC spectrum of **2g** ($CDCl_3$)



17. ^{1}H-NMR monitoring of intermediate formation

T = +25°C

☆ CD_3OD