

Cu(I)-Catalyzed Intramolecular Oxidative C–H Amination of 2-Aminoacetophenones: a Convenient Route toward Isatins

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General. All reactions were conducted under an oxygen atmosphere on a dual-manifold Schlenk line unless otherwise mentioned and in oven-dried glass wares. All solvents were dried according to known methods and distilled prior to use.¹ 2-Aminoacetophenones **1** were synthesized according to the literature procedures.² Other reagents were commercially available and used as purchased.

Table. Optimization Studies for the Formation of *N*-Methylisatin **2a.^a**

entry	[Cu]/L, mol% ^b	Cu source	ligand	solvent	yield % ^c
1	10	Cu(OAc) ₂	bpy	DMSO	12
2	10	Cu(OH) ₂	bpy	DMSO	20
3	10	CuO	bpy	DMSO	5
4	10	Cu ₂ O	bpy	DMSO	trace
5	10	CuCl	bpy	DMSO	3
6	10	CuCl ₂	bpy	DMSO	10
7	10	CuBr	bpy	DMSO	13
8	10	CuI	L1	DMSO	70
9	10	CuI	L2	DMSO	27
10	10	CuI	L3	DMSO	85
11	10	CuI	L4	DMSO	86
12	10	CuI	dppe	DMSO	69
13	10	CuI	TMEDA	DMSO	47
14	10	CuI	bpy	DMF	68
15	5	CuI	bpy	DMF	22
16	20	CuI	bpy	DMF	67
17	20	CuI	bpy	DMF	59 ^d
18	10	CuI	bpy	DMF	31 ^e
19	10	CuI	bpy	DMAc	65
20	10	CuI	bpy	<i>o</i> -DCB	47
21	10	CuI	bpy	<i>o</i> -xylene	26
22	10	CuI	bpy	DMSO	91 (89)^f
23	—	—	—	DMSO	N.R.

^a Unless otherwise mentioned, all reactions were carried out using **1a** (0.3 mmol), CuI, ligand in 0.6 mL solvent.

^b The ratio of Cu source and ligand was 1:1. ^c Yields were determined by the ¹H NMR integration method using CH₂Br₂ as the internal standard. ^d 1.2 mL DMF was used. ^e Reaction was carried out for 120 °C. ^f Isolated yield. bpy = 2,2'-bipyridine. DMAc = *N,N*-dimethylacetamide. *o*-DCB = *o*-dichlorobenzene.

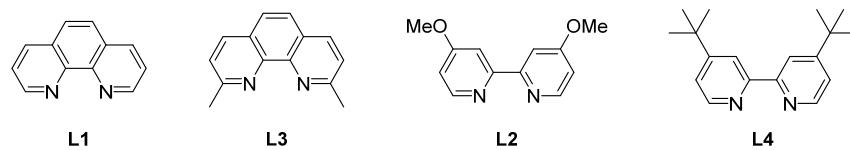
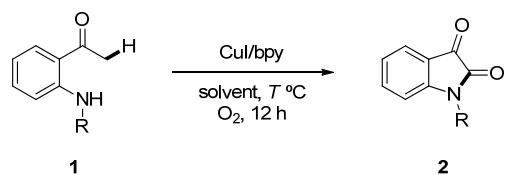


Table. Optimization Studies for the Formation of *N*-Tolylisatin 2m.^a

entry	CuI/bpy, mol% ^b	solvent	yield % ^c
1	10	DMF	trace
2	10	DMSO	trace
3	10	<i>o</i> -xylene	74
4	10	Ph-Cl	73
5	10	<i>o</i> -DCB	75
6	10	2-ethoxyethanol	complicated
7	10	AcOH	complicated
8	10	<i>o</i> -DCB	66 ^d
9	10	<i>o</i> -DCB ^e	66
10	5	<i>o</i> -DCB	72
11	10	<i>o</i>-DCB	77 (72)^{f,g}
12	—	<i>o</i> -DCB	N.R.

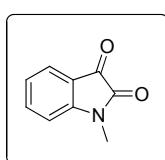
^a Unless otherwise mentioned, all reactions were carried out using **1m** (0.3 mmol) in 0.6 mL solvent. ^b The ratio of Cu source and ligand was 1:1. ^c Yields were determined by the ¹H NMR integration method using CH₂Br₂ as the internal standard. ^d Reaction was carried out for 120 °C, 24 h. ^e 1.2 mL *o*-DCB was used. ^f Reaction was carried out for 3 h. ^g Isolated yield.

General Procedure for the Copper-Catalyzed Synthesis of Isatines:



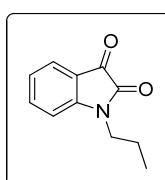
A sealed tube containing CuI (0.030 mmol, 10.0 mol%), 2,2'-bipyridine (10.0 mol%) was evacuated and purged with oxygen gas three times. Then, DMSO or *o*-DCB (0.6 mL), 2-aminoacetophenone **1** (0.30 mmol), were sequentially added to the system via a syringe under an oxygen atmosphere and the reaction mixture was allowed to stir at 140 °C for 3–12 h. When the reaction was completed, the mixture was cooled and diluted with CH₂Cl₂ (10 mL). The mixture was filtered through a Celite and silica gel pads and washed with EA (50 mL). The combined filtrate was concentrated and the residue was purified by a silica gel column using hexane–EtOAc as eluent to give pure **2a** in 89%.

1-Methylindoline-2,3-dione (2a)



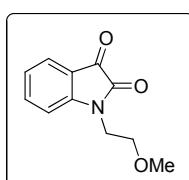
red solid; **m.p.** 121 – 122 °C; **¹H NMR** (400 MHz, CDCl₃): δ 7.64 – 7.59 (m, 2H), 7.14 (td, *J* = 7.4, 0.8 Hz, 1H), 6.91 (d, *J* = 8.0 Hz, 1H), 3.26 (s, 3H); **¹³C NMR** (100 MHz, CDCl₃): δ 183.2, 158.0, 151.2, 138.3, 124.9, 123.6, 117.1, 109.9, 26.0; **IR** (neat, cm⁻¹): 1728, 1606, 1469, 1327, 1112, 1089; **HRMS** (EI⁺) calcd for C₉H₇NO₂: 161.0477, found: 161.0474.

1-Propylindoline-2,3-dione (2b)



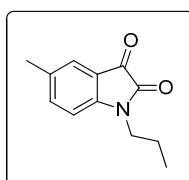
red solid; **m.p.** 66 – 68 °C; **¹H NMR** (400 MHz, CDCl₃): δ 7.61 – 7.57 (m, 2H), 7.11 (t, *J* = 7.4 Hz, 1H), 6.91 (d, *J* = 8.0 Hz, 1H), 3.70 (t, *J* = 7.2 Hz, 2H), 1.75 (sextet, *J* = 7.4 Hz, 2H), 1.00 (t, *J* = 7.4 Hz, 3H); **¹³C NMR** (100 MHz, CDCl₃): δ 183.5, 158.1, 150.9, 138.3, 125.2, 123.5, 117.4, 110.1, 41.6, 20.5, 11.2; **IR** (neat, cm⁻¹): 2962, 1728, 1614, 1471, 1342, 1128, 1093; **HRMS** (EI⁺) calcd for C₁₁H₁₁NO₂: 189.0790, found: 189.0785.

1-(2-Methoxyethyl)indoline-2,3-dione (2c)



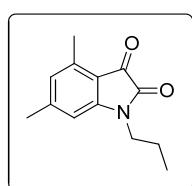
red solid; **m.p.** 75 – 76 °C; **¹H NMR** (400 MHz, CDCl₃): δ 7.60 – 7.56 (m, 2H), 7.10 (td, *J* = 8.0, 0.8 Hz, 1H), 7.05 (dd, *J* = 8.4, 0.8 Hz, 1H), 3.91 (t, *J* = 5.4 Hz, 2H), 3.66 (t, *J* = 5.4 Hz, 2H), 3.34 (s, 3H); **¹³C NMR** (100 MHz, CDCl₃): δ 183.3, 158.3, 151.4, 138.2, 125.0, 123.5, 117.4, 111.0, 69.8, 58.9, 40.3; **IR** (neat, cm⁻¹): 2929, 2894, 2832, 1743, 1614, 1471, 1344, 1118, 1093; **HRMS** (EI⁺) calcd for C₁₁H₁₁NO₃: 205.0739, found: 205.0738.

5-Methyl-1-propylindoline-2,3-dione (2d)



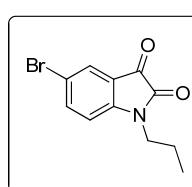
red solid; **m.p.** 78 – 79 °C; **¹H NMR** (400 MHz, CDCl₃): δ 7.41 – 7.37 (m, 2H), 6.79 (d, *J* = 8.0 Hz, 1H), 3.67 (t, *J* = 7.2 Hz, 2H), 2.33 (s, 3H), 1.73 (sextet, *J* = 7.4 Hz, 2H), 0.99 (t, *J* = 7.4 Hz, 3H); **¹³C NMR** (100 MHz, CDCl₃): δ 183.8, 158.2, 148.8, 138.6, 133.3, 125.6, 117.4, 110.0, 41.7, 20.53, 20.50, 11.2; **IR** (neat, cm⁻¹): 2966, 2875, 1730, 1619, 1492, 1344, 1207, 1122; **HRMS** (EI⁺) calcd for C₁₂H₁₃NO₂: 203.0946, found: 203.0949.

4,6-Dimethyl-1-propylindoline-2,3-dione (2e)



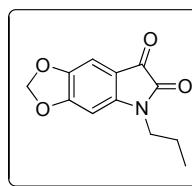
red solid; **m.p.** 110 – 112 °C; **1H NMR** (400 MHz, CDCl₃): δ 6.68 (d, *J* = 0.8 Hz, 1H), 6.50 (s, 1H), 3.65 (t, *J* = 7.2 Hz, 2H), 2.52 (s, 3H), 2.38 (s, 3H), 1.72 (sextet, *J* = 7.4 Hz, 2H), 0.99 (t, *J* = 7.4 Hz, 3H); **13C NMR** (100 MHz, CDCl₃): δ 183.2, 158.7, 151.3, 149.6, 141.0, 126.3, 113.5, 108.2, 41.4, 22.6, 20.6, 17.8, 11.2; **IR** (neat, cm⁻¹): 3056, 2962, 2875, 1731, 1616, 1596, 1456, 1261, 1149; **HRMS** (EI⁺) calcd for C₁₃H₁₅NO₂: 217.1103, found: 217.1100.

5-Bromo-1-propylindoline-2,3-dione (2f)



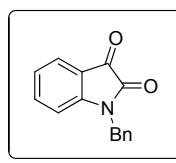
red solid; **m.p.** 124 – 125 °C; **1H NMR** (400 MHz, CDCl₃): δ 7.71 – 7.68 (m, 2H), 6.82 (dd, *J* = 8.0, 0.8 Hz, 1H), 3.69 (t, *J* = 7.4 Hz, 2H), 1.73 (sextet, *J* = 7.4 Hz, 2H), 0.99 (t, *J* = 7.4 Hz, 3H); **13C NMR** (100 MHz, CDCl₃): δ 182.3, 157.3, 149.7, 140.4, 127.9, 118.5, 116.2, 111.9, 41.8, 20.4, 11.2; **IR** (neat, cm⁻¹): 3079, 2971, 2873, 1736, 1606, 1465, 1432, 1330, 1178, 1116; **HRMS** (EI⁺) calcd for C₁₁H₁₀BrNO₂: 266.9895, found: 266.9873.

5-Propyl-5*H*-[1,3]dioxolo[4,5-*f*]indole-6,7-dione (2g)



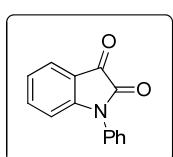
dark red solid; **m.p.** 130 – 131 °C; **1H NMR** (400 MHz, CDCl₃): δ 7.03 (s, 1H), 6.43 (s, 1H), 6.06 (s, 2H), 3.62 (t, *J* = 7.4 Hz, 2H), 1.70 (sextet, *J* = 7.4 Hz, 2H), 0.98 (t, *J* = 7.4 Hz, 3H); **13C NMR** (100 MHz, CDCl₃): δ 180.9, 159.1, 156.5, 150.7, 144.2, 110.2, 104.8, 102.6, 93.2, 41.7, 20.7, 11.2; **IR** (neat, cm⁻¹): 2925, 1720, 1610, 1475, 1245, 1118, 1031; **HRMS** (EI⁺) calcd for C₁₂H₁₁NO₄: 233.0688, found: 233.0686.

1-Benzylindoline-2,3-dione (2h)



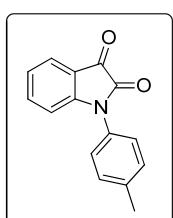
red solid; **m.p.** 122 – 123 °C; **1H NMR** (400 MHz, CDCl₃): δ 7.61 (dd, *J* = 7.2, 0.8 Hz, 1H), 7.48 (td, *J* = 8.0, 1.2 Hz, 2H), 7.36 – 7.30 (m, 4H), 7.09 (t, *J* = 7.6 Hz, 1H), 6.78 (d, *J* = 7.6 Hz, 1H), 4.94 (s, 2H); **13C NMR** (100 MHz, CDCl₃): δ 183.1, 158.2, 150.6, 138.3, 134.4, 128.9, 128.0, 127.3, 125.2, 123.7, 117.5, 110.9, 43.9; **IR** (neat, cm⁻¹): 3454, 3029, 1731, 1612, 1471, 1349, 1176, 1002; **HRMS** (EI⁺) calcd for C₁₅H₁₁NO₂: 237.0790, found: 237.0789.

1-Phenylindoline-2,3-dione (2l)



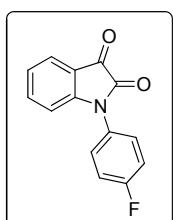
red solid; **m.p.** 128 – 129 °C; **¹H NMR** (400 MHz, CDCl₃): δ 7.70 (dd, *J* = 7.2, 0.8 Hz, 1H), 7.58 – 7.52 (m, 3H), 7.47 (d, *J* = 6.8 Hz, 1H), 7.42 (d, *J* = 7.2 Hz, 2H), 7.18 (t, *J* = 7.6 Hz, 1H), 6.90 (d, *J* = 7.6 Hz, 1H); **¹³C NMR** (100 MHz, CDCl₃): δ 182.8, 157.2, 151.5, 138.3, 132.8, 129.9, 128.7, 125.9, 125.5, 124.2, 117.4, 111.2; **IR** (neat, cm⁻¹): 3060, 1739, 1608, 1498, 1465, 1365, 1301, 1193, 929; **HRMS** (EI⁺) calcd for C₁₄H₉NO₂: 223.0633, found: 223.0625.

1-(*p*-Tolyl)indoline-2,3-dione (2m)



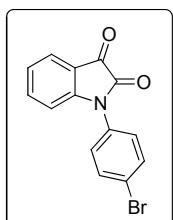
red solid; **m.p.** 131 – 132 °C; **¹H NMR** (400 MHz, CDCl₃): δ 7.68 (d, *J* = 7.6 Hz, 1H), 7.53 (t, *J* = 7.8 Hz, 1H), 7.36 (d, *J* = 8.4 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.16 (t, *J* = 7.4 Hz, 1H), 6.87 (d, *J* = 7.6 Hz, 1H), 2.43 (s, 3H); **¹³C NMR** (100 MHz, CDCl₃): δ 183.0, 157.4, 151.8, 138.9, 138.3, 130.5, 130.1, 125.7, 125.4, 124.1, 117.3, 111.2, 21.2; **IR** (neat, cm⁻¹): 2919, 1737, 1612, 1515, 1465, 1365, 1299, 1180, 1093, 927; **HRMS** (EI⁺) calcd for C₁₅H₁₁NO₂: 237.0790, found: 237.0789.

1-(4-Fluorophenyl)indoline-2,3-dione (2n)



red solid; **m.p.** 222 – 224 °C; **¹H NMR** (400 MHz, CDCl₃): δ 7.71 (d, *J* = 7.2 Hz, 1H), 7.55 (t, *J* = 7.8 Hz, 1H), 7.43 – 7.39 (m, 2H), 7.28 – 7.23 (m, 2H), 7.19 (t, *J* = 7.6 Hz, 1H), 7.85 (d, *J* = 8.4 Hz, 1H); **¹³C NMR** (100 MHz, DMSO-d₆): δ 182.7, 161.4 (d, *J* = 243.9 Hz), 157.6, 151.2, 138.0, 129.6, 129.0 (d, *J* = 9.3 Hz), 124.7, 123.7, 117.6, 116.7 (d, *J* = 22.5 Hz), 110.7; **IR** (neat, cm⁻¹): 1735, 1606, 1508, 1461, 1361, 1288, 1182, 1097; **HRMS** (EI⁺) calcd for C₁₄H₈FNO₂: 241.0539, found: 241.0537.

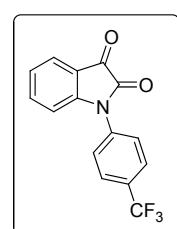
1-(4-Bromophenyl)indoline-2,3-dione (2o)



red solid; **m.p.** 169 – 170 °C; **¹H NMR** (400 MHz, CDCl₃): δ 7.72 – 7.68 (m, 3H), 7.56 (t, *J* = 7.8 Hz, 1H), 7.32 (d, *J* = 8.0 Hz, 2H), 7.20 (t, *J* = 7.6 Hz, 1H), 6.90 (d, *J* = 8.4 Hz, 1H); **¹³C NMR** (100 MHz, CDCl₃): δ 182.3, 157.1, 151.0, 138.4, 133.1, 131.8, 127.5, 125.7, 124.5, 122.4, 117.5, 110.7; **IR** (neat, cm⁻¹): 1737, 1610, 1494, 1465,

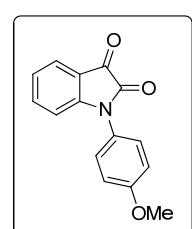
1363, 1294, 1180, 1012, 925; **HRMS** (EI^+) calcd for $\text{C}_{14}\text{H}_8\text{BrNO}_2$: 300.9738, found: 300.9743.

1-(4-(Trifluoromethyl)phenyl)indoline-2,3-dione (2p)



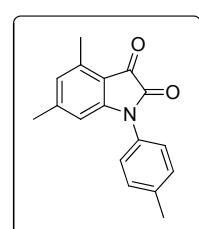
red solid; **m.p.** 171 – 173 °C; **$^1\text{H NMR}$** (400 MHz, CDCl_3): δ 7.83 (d, $J = 8.0$ Hz, 2H), 7.74 (dd, $J = 7.2, 0.8$ Hz, 1H), 7.62 – 7.57 (m, 3H), 7.23 (t, $J = 7.6$ Hz, 1H), 6.97 (d, $J = 8.0$ Hz, 1H); **$^{13}\text{C NMR}$** (100 MHz, CDCl_3): δ 182.0, 157.0, 150.6, 138.4, 136.1, 130.5 (q, $J = 32.8$ Hz), 127.0 (q, $J = 3.6$ Hz), 126.0, 125.8, 124.7, 123.5 (q, $J = 270.8$ Hz), 117.5, 111.1; **IR** (neat, cm^{-1}): 3095, 1743, 1606, 1469, 1373, 1317, 1160, 1114, 925; **HRMS** (EI^+) calcd for $\text{C}_{15}\text{H}_8\text{F}_3\text{NO}_2$: 291.0507, found: 291.0502.

1-(4-Methoxyphenyl)indoline-2,3-dione (2q)



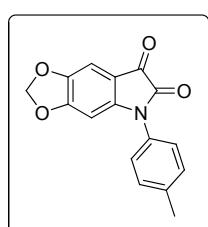
red solid; **m.p.** 155 – 156 °C; **$^1\text{H NMR}$** (400 MHz, CDCl_3): δ 7.68 (d, $J = 7.6$ Hz, 1H), 7.53 (t, $J = 7.6$ Hz, 1H), 7.32 (d, $J = 8.8$ Hz, 2H), 7.15 (t, $J = 7.6$ Hz, 1H), 7.06 (d, $J = 8.4$ Hz, 2H), 6.83 (d, $J = 7.6$ Hz, 1H), 3.87 (s, 3H); **$^{13}\text{C NMR}$** (100 MHz, CDCl_3): δ 183.1, 159.6, 157.6, 152.0, 138.3, 127.4, 125.4, 125.3, 124.1, 117.4, 115.2, 111.1, 55.5; **IR** (neat, cm^{-1}): 2917, 2840, 1731, 1608, 1513, 1465, 1297, 1251, 1184, 1027; **HRMS** (EI^+) calcd for $\text{C}_{15}\text{H}_{11}\text{NO}_3$: 253.0739, found: 253.0736.

4,6-Dimethyl-1-(*p*-tolyl)indoline-2,3-dione (2r)



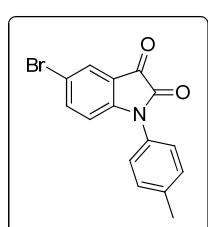
red solid; **m.p.** 156 – 157 °C; **$^1\text{H NMR}$** (400 MHz, CDCl_3): δ 7.35 (d, $J = 8.8$ Hz, 2H), 7.27 – 7.25 (m, 2H), 6.72 (s, 1H), 6.44 (s, 1H), 2.58 (s, 3H), 2.43 (s, 3H), 2.30 (s, 3H); **$^{13}\text{C NMR}$** (100 MHz, CDCl_3): δ 182.6, 158.1, 152.3, 149.7, 141.3, 138.7, 130.43, 130.39, 126.9, 126.1, 113.6, 109.3, 22.7, 21.2, 18.1; **IR** (neat, cm^{-1}): 2921, 2852, 1747, 1731, 1614, 1513, 1363, 1276, 1164, 941; **HRMS** (EI^+) calcd for $\text{C}_{17}\text{H}_{15}\text{NO}_2$: 265.1103, found: 265.1106.

5-(*p*-Tolyl)-5*H*-[1,3]dioxolo[4,5-*f*]indole-6,7-dione (2s**)**



dark red solid; **m.p.** 180 – 182 °C; **¹H NMR** (400 MHz, CDCl₃): δ 7.34 (d, *J* = 8.0 Hz, 2H), 7.26 – 7.23 (m, 2H), 7.09 (s, 1H), 6.37 (s, 1H), 6.05 (s, 2H), 2.42 (s, 3H); **¹³C NMR** (100 MHz, CDCl₃): δ 180.2, 158.4, 156.4, 151.5, 144.7, 138.8, 130.5, 130.1, 125.9, 110.3, 104.5, 102.6, 94.2, 21.2; **IR** (neat, cm⁻¹): 2917, 1737, 1716, 1610, 1469, 1382, 1253, 1232, 1157, 1039, 945; **HRMS** (EI⁺) calcd for C₁₆H₁₁NO₄: 281.0688, found: 281.0689.

5-Bromo-1-(*p*-tolyl)indoline-2,3-dione (2t**)**

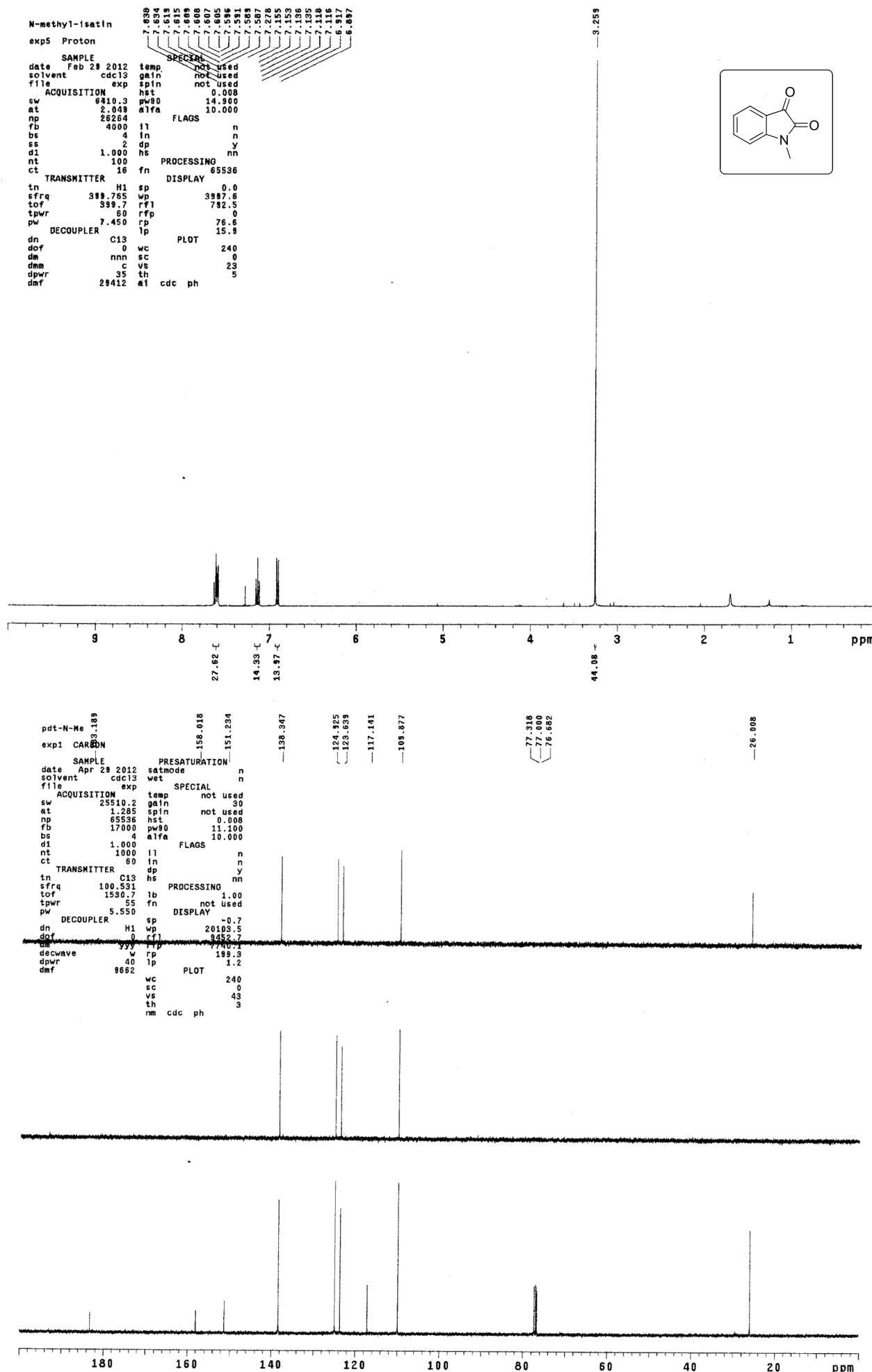


red solid; **m.p.** 192 – 194 °C; **¹H NMR** (400 MHz, CDCl₃): δ 7.79 (d, *J* = 2.0 Hz, 1H), 7.63 (dd, *J* = 8.8, 2.0 Hz, 1H), 7.36 (d, *J* = 8.8 Hz, 2H), 7.27 – 7.25 (m, 2H), 6.78 (d, *J* = 8.4 Hz, 1H), 2.43 (s, 3H); **¹³C NMR** (100 MHz, CDCl₃): δ 181.9, 156.6, 150.6, 140.5, 139.3, 130.7, 129.8, 128.1, 125.7, 118.6, 116.9, 113.0, 21.2; **IR** (neat, cm⁻¹): 2923, 1745, 1604, 1467, 1436, 1290, 1189, 1122; **HRMS** (EI⁺) calcd for C₁₅H₁₀BrNO₂: 314.9895, found: 314.9890.

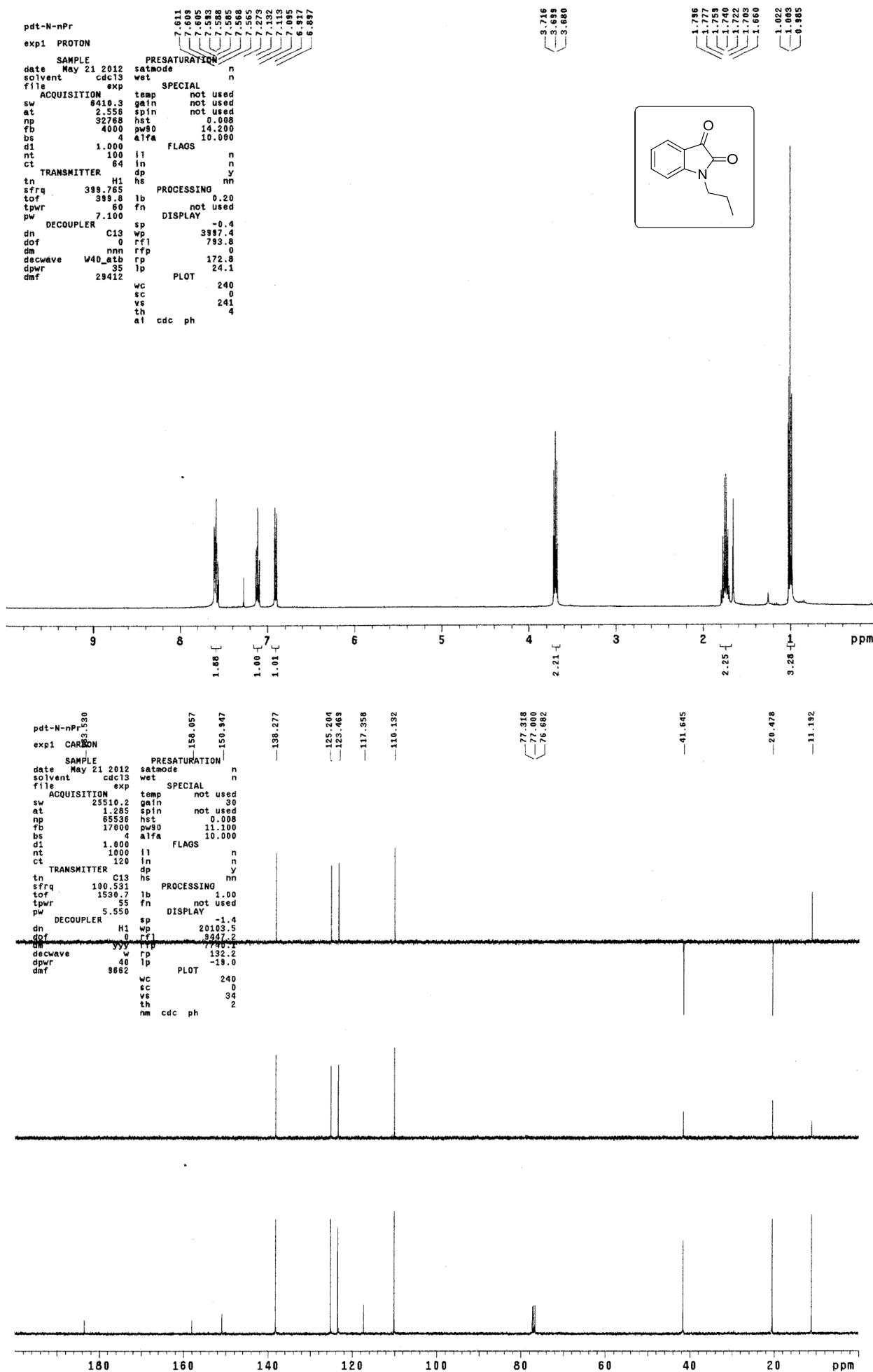
References:

1. Perrin, D. D.; Armarego, W. L. F. *In Purification of Laboratory Chemicals*, 3rd ed.; Pergamon Press: New York, 1988.
2. Sugasawa, T.; Toyoda, T.; Adachi, M.; Sasakura, K. *J. Am. Chem. Soc.* **1978**, *100*, 4842.

¹H and ¹³C NMR spectra of compound 2a

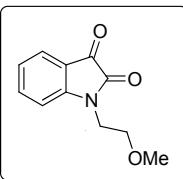
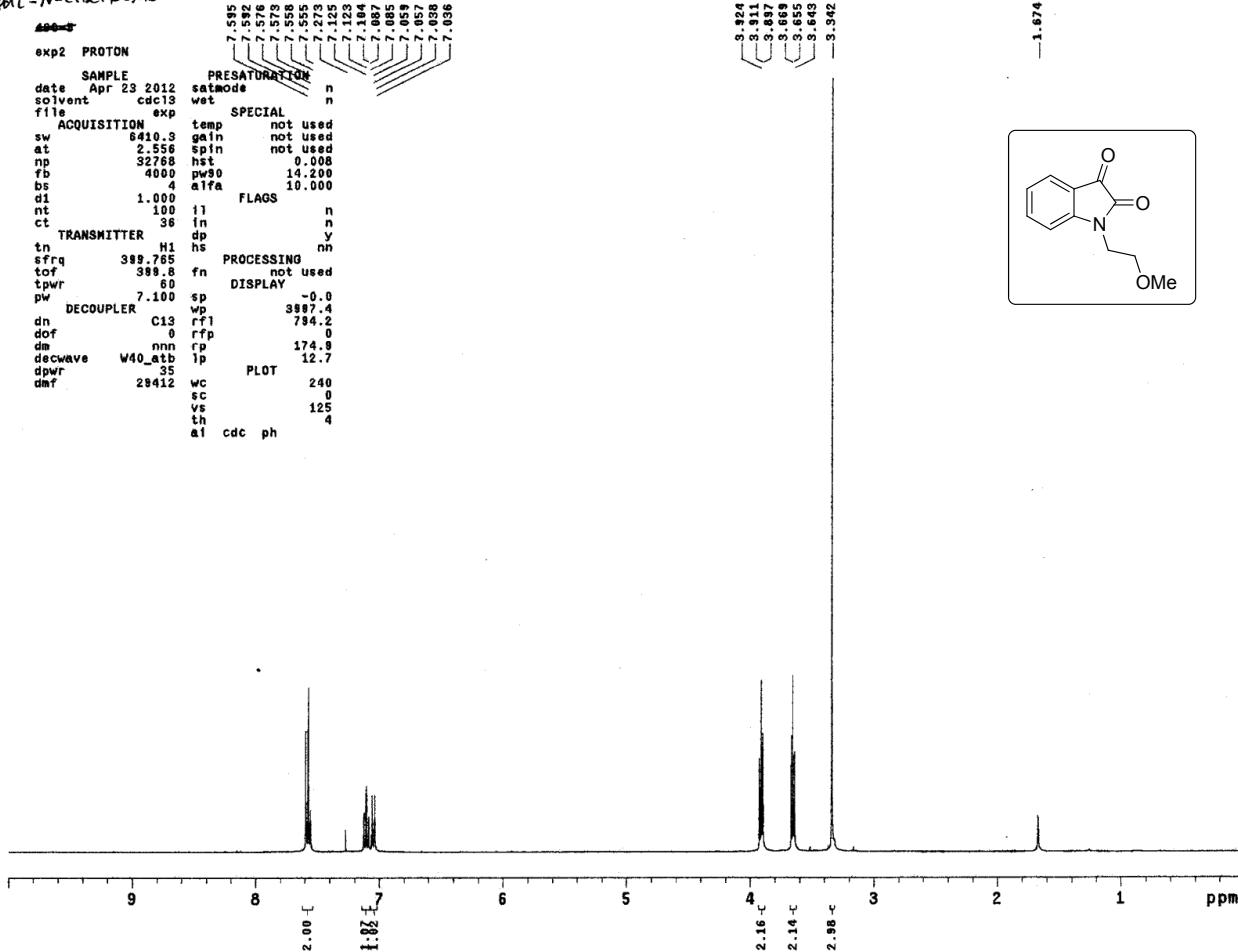


¹H and ¹³C NMR spectra of compound **2b**



¹H and ¹³C NMR spectra of compound **2c**

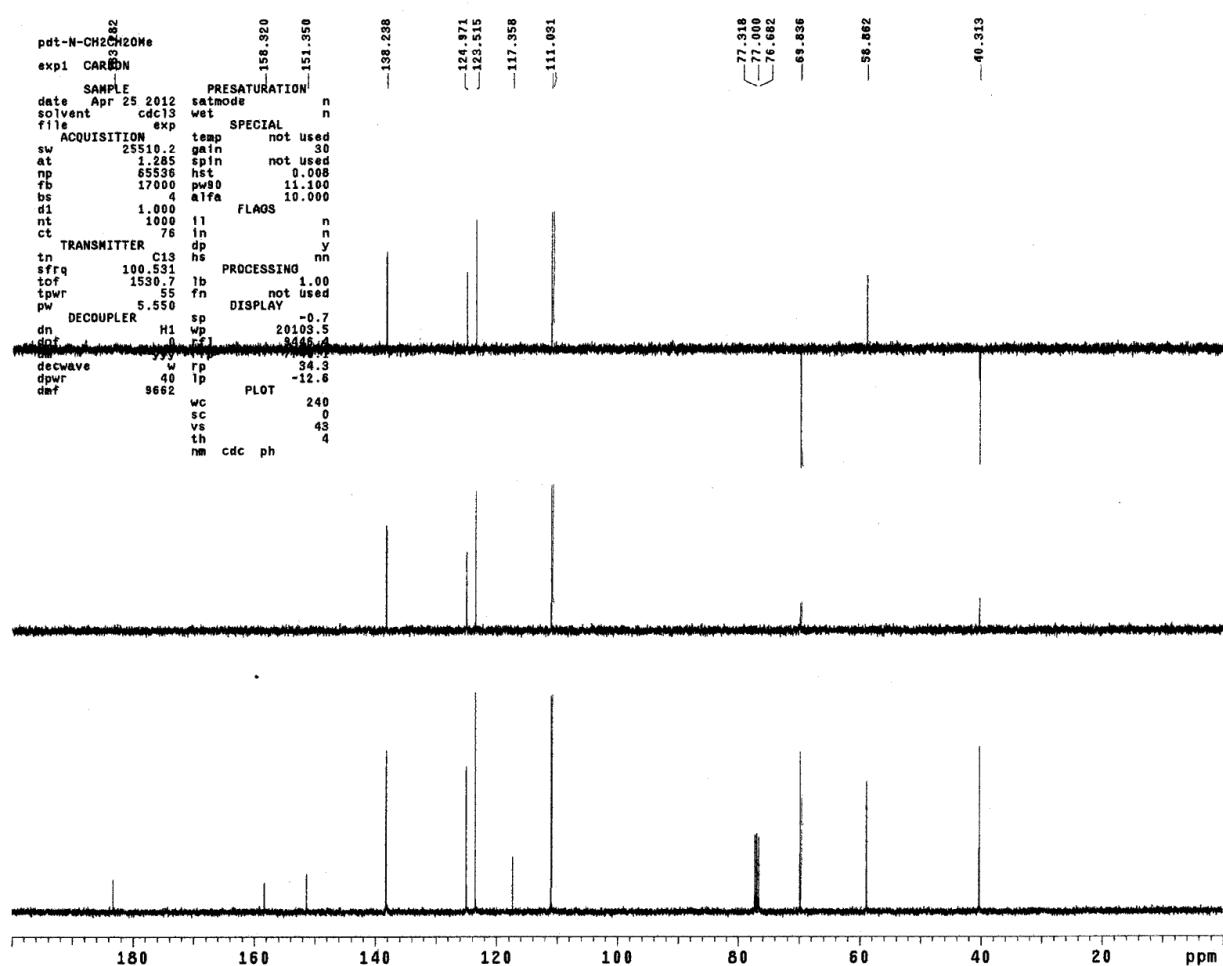
alt-*N*-C₆H₅C₆H₄OCH₃



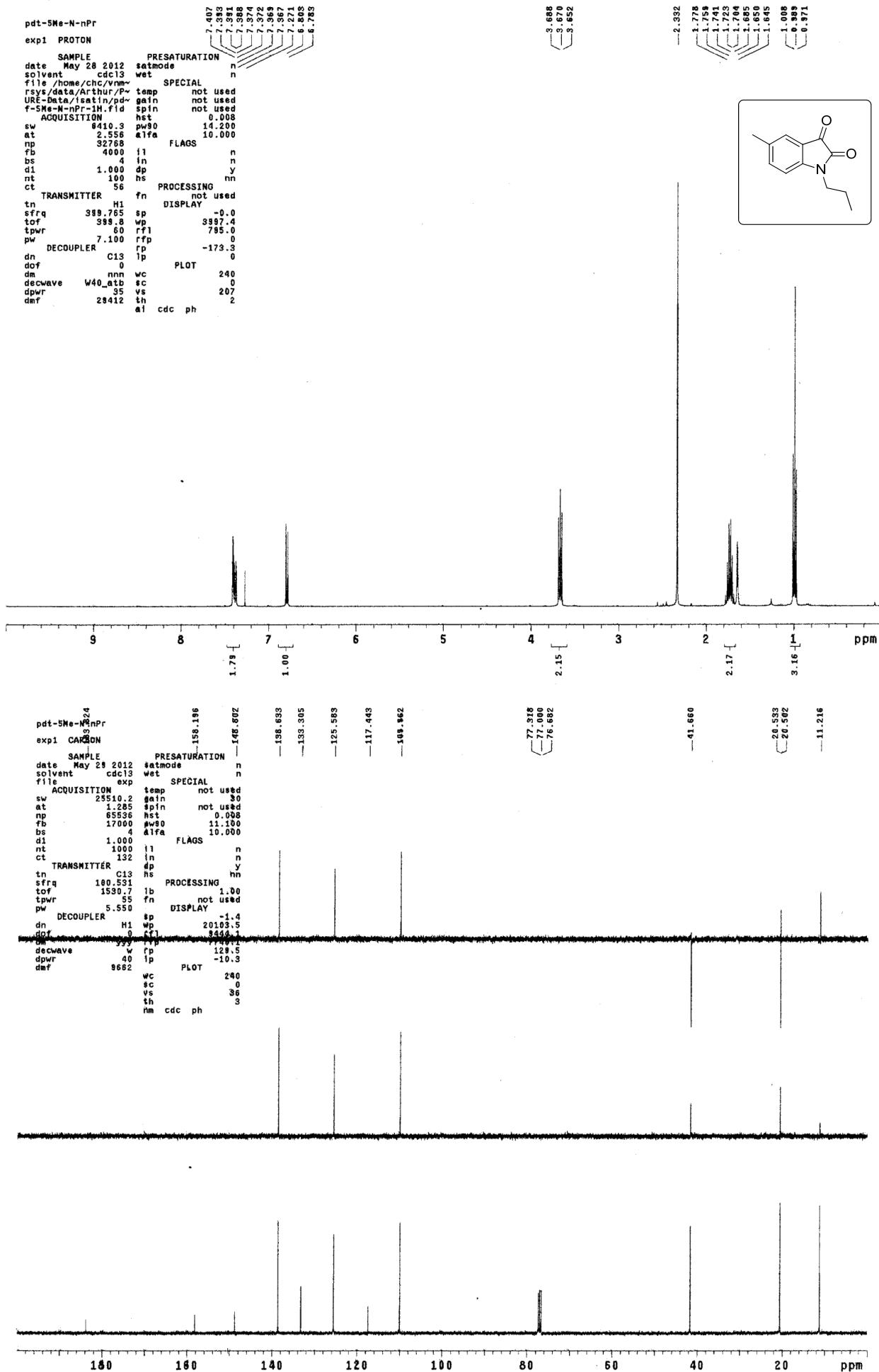
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3
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4
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file exp SPECI
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fb 17000 pw90
bs 4 alfa
d1 1.000 alfa
nt 1000 11
ct 76 11
tn C13 dp
TRANSMITTER hs
sfrq 100.531 PROCES
tof 1530.7 lb
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decwave w rp
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nm cdc p

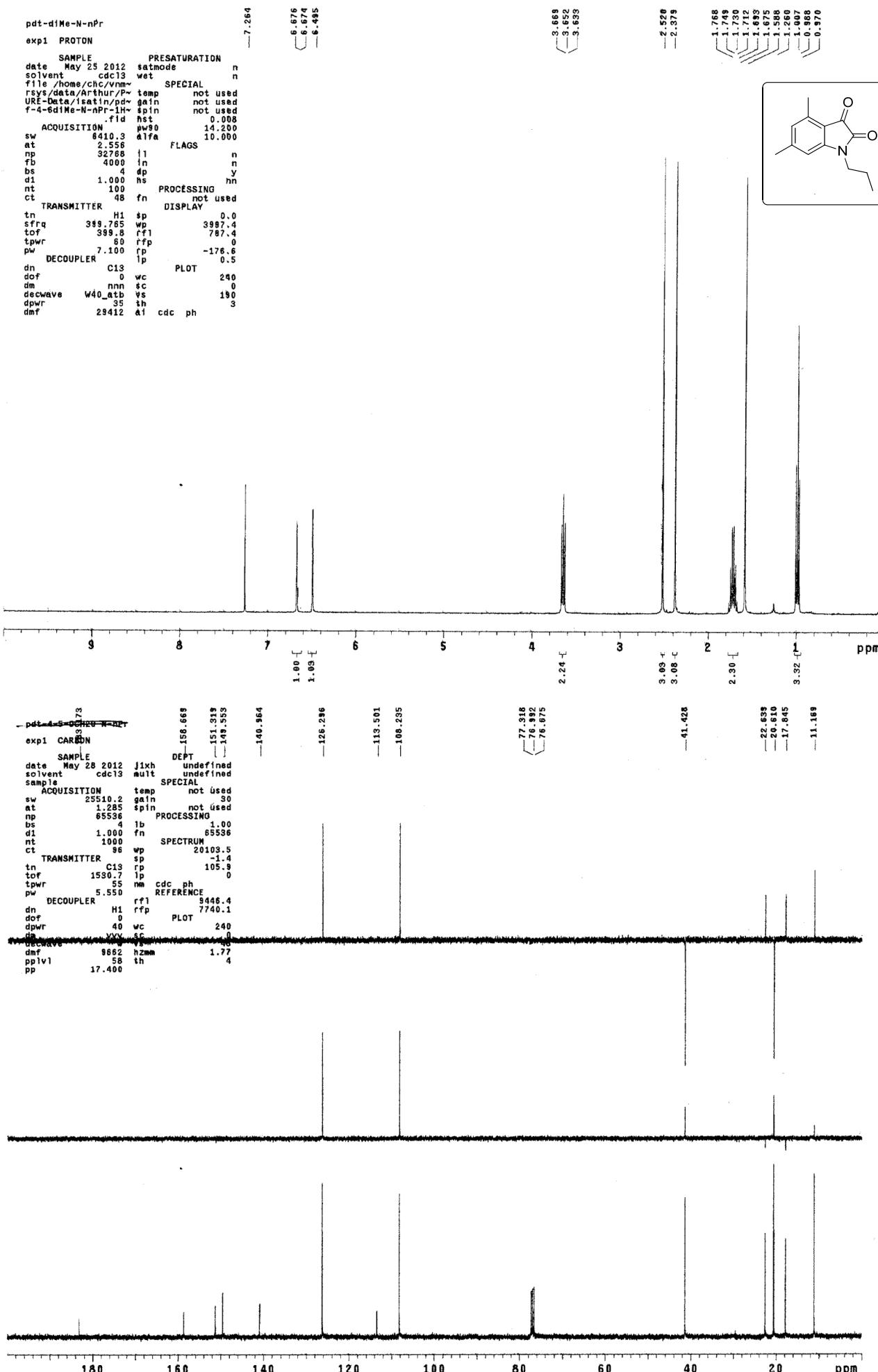
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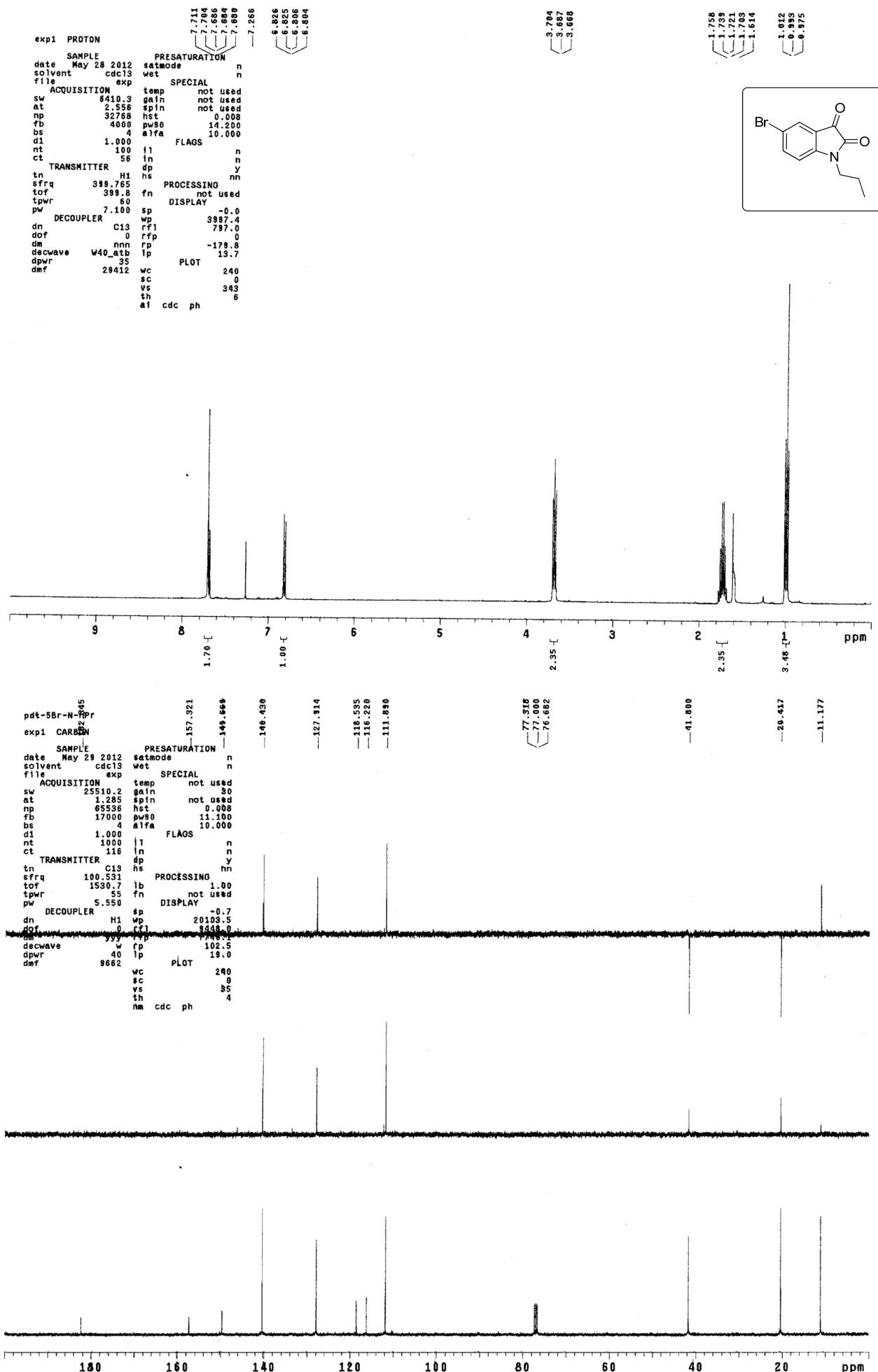
¹H and ¹³C NMR spectra of compound 2d



¹H and ¹³C NMR spectra of compound 2e



¹H and ¹³C NMR spectra of compound 2f



¹H and ¹³C NMR spectra of compound **2g**

—7.21

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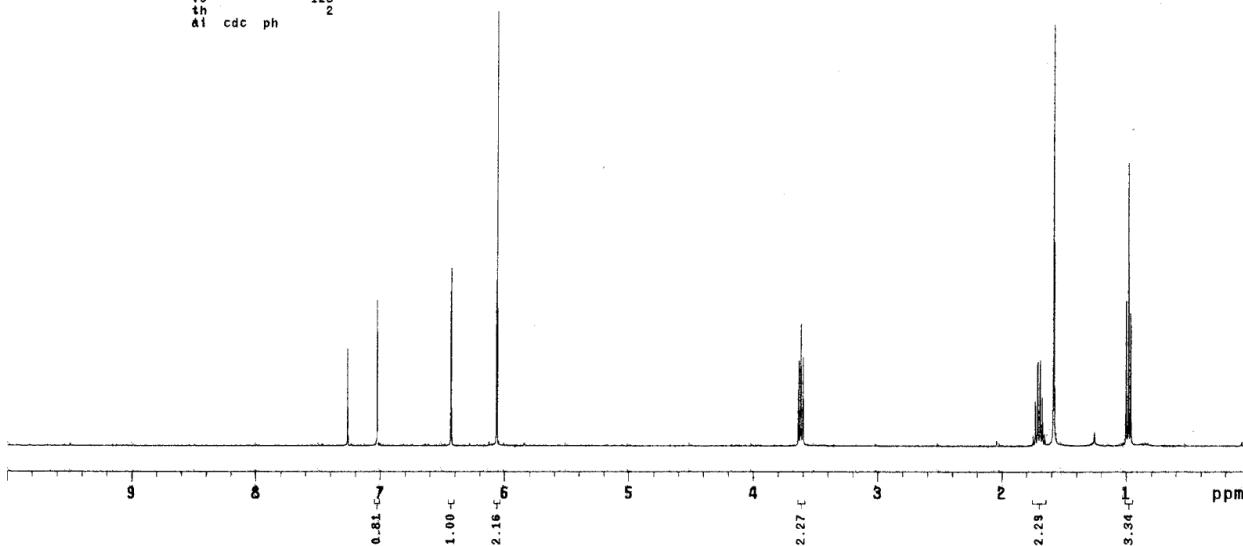
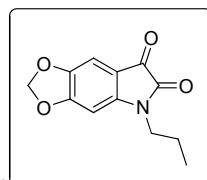
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file exp SPECIAL

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bs 4 alfa 10.000
d1 1.000 FLAGS
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ct 44 ln n

TRANSMITTER dp y
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tof 389.8 fn not used
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      wp 3897.4
      C13 rrf1 788.2
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      th 2
      ai cdc ph

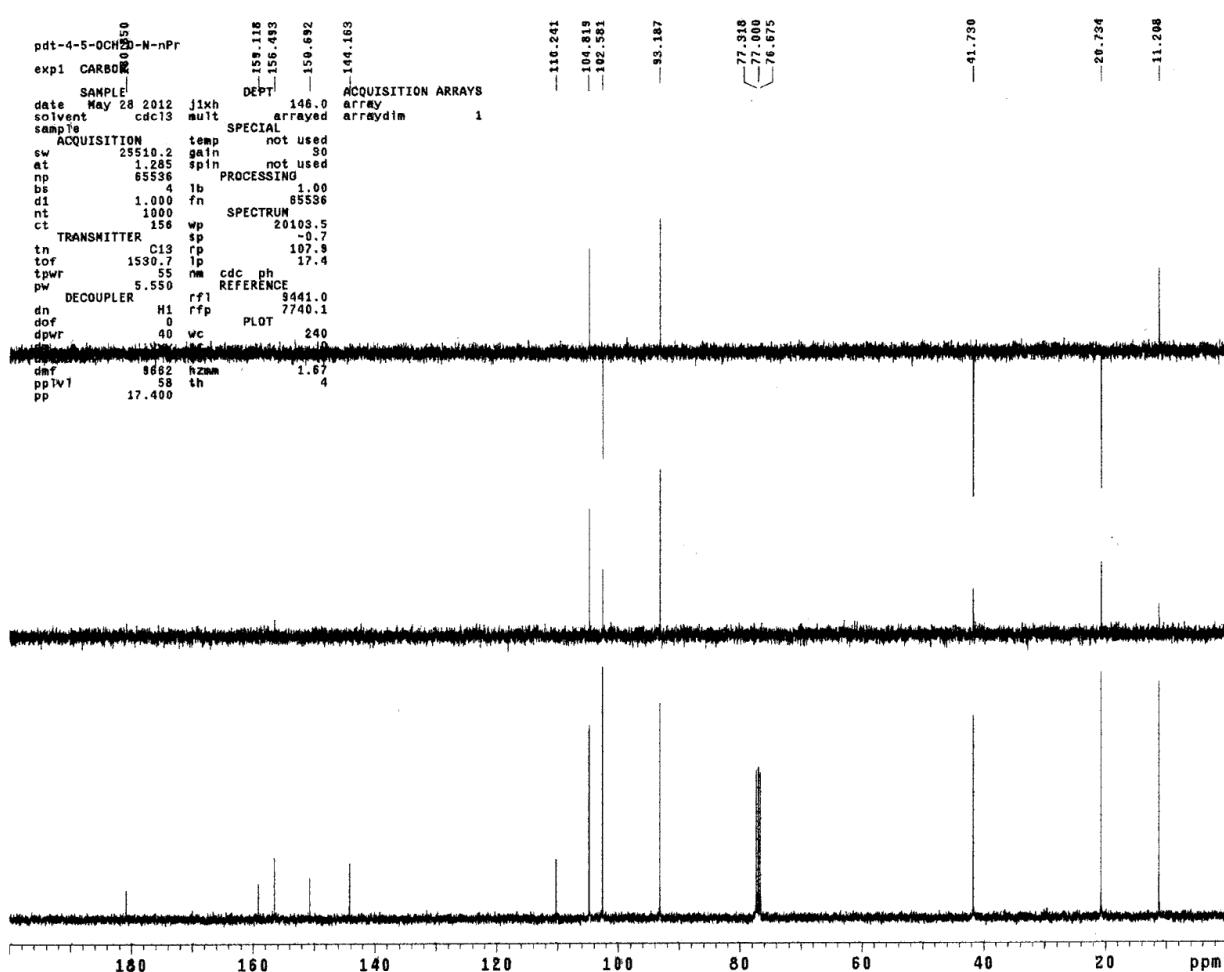
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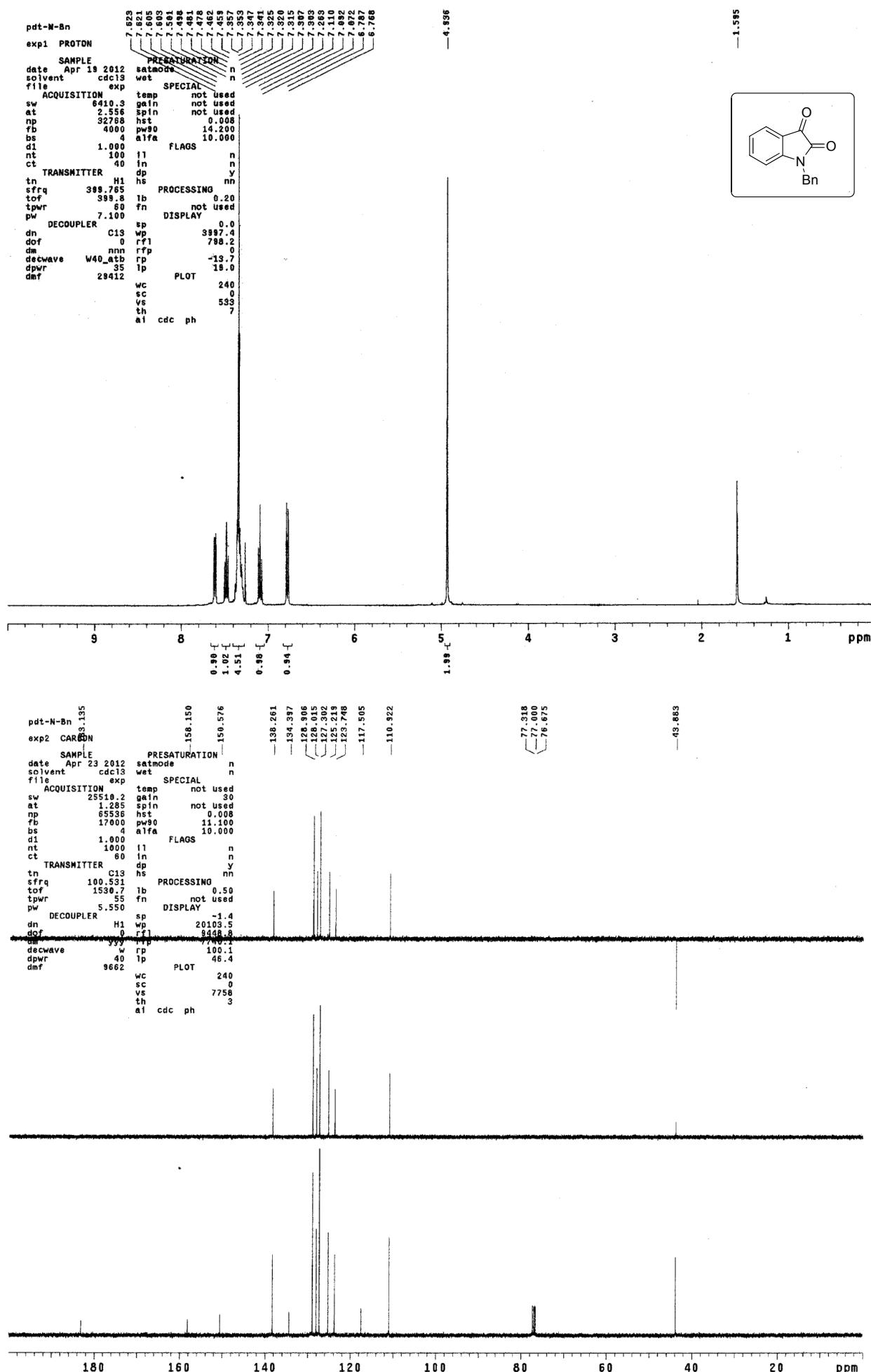
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SAMPLE                         —        array
date May 28 2012      j1xh    146.0      array
solvent cdc13      mult     arrayd1m      1
sample
ACQUISITION      temp      not used
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at      1.245      spin      not used
pp      65536      PROCESSING
bs      4      lb      1.00
d1      1.000      fn      65536
nt      1000      SPECTRUM
ct      156      wp      20103.5
TRANSMITTER      sp      -0.7
tn      C13      rp      102.8
tof      1530.7      tp      17.4
tpwr      55      nmdc      ph
pw      5.550      REFERENCE
DECOUPLER      rfi      9441.0
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pp

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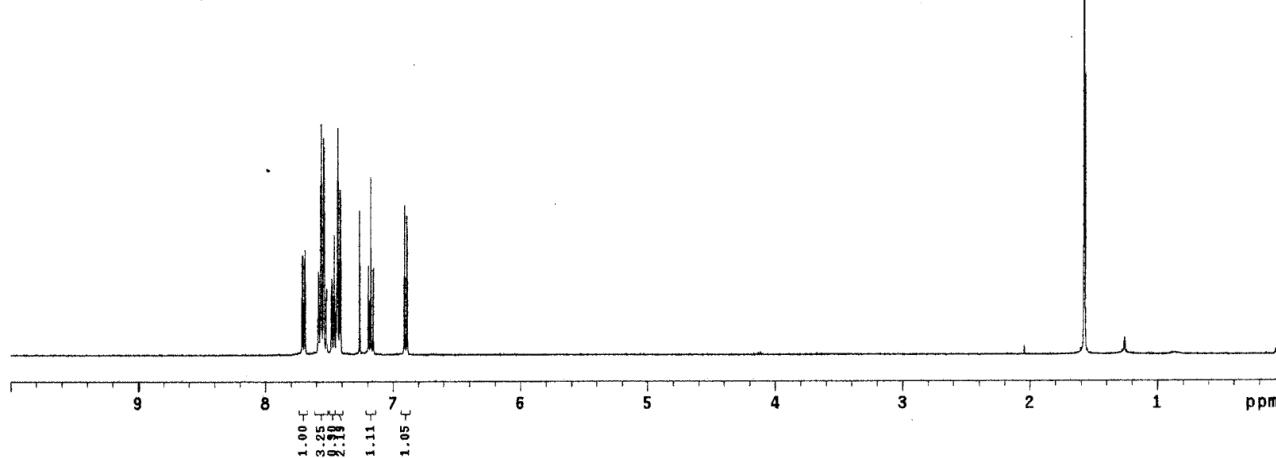
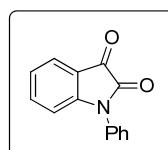
¹H and ¹³C NMR spectra of compound 2h



¹H and ¹³C NMR spectra of compound 2I

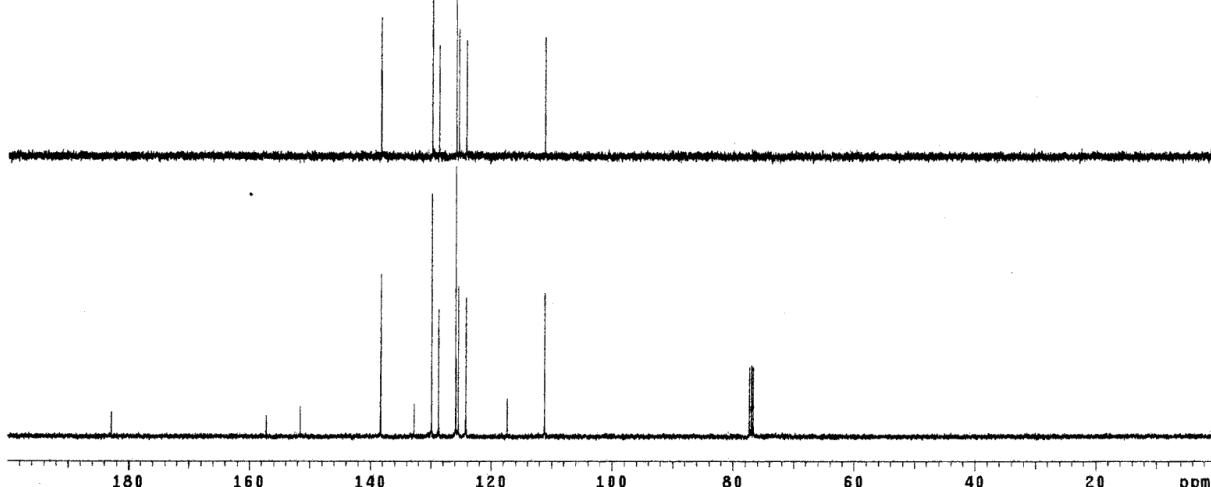
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bs 4 alfa 10.000
d1 1.000 FLAGS
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ct 36 in
TRANSMITTER H1 hs nn
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dm nnn rp 89.6
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sc 0
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th 387
a1 cdc ph 6

1.577

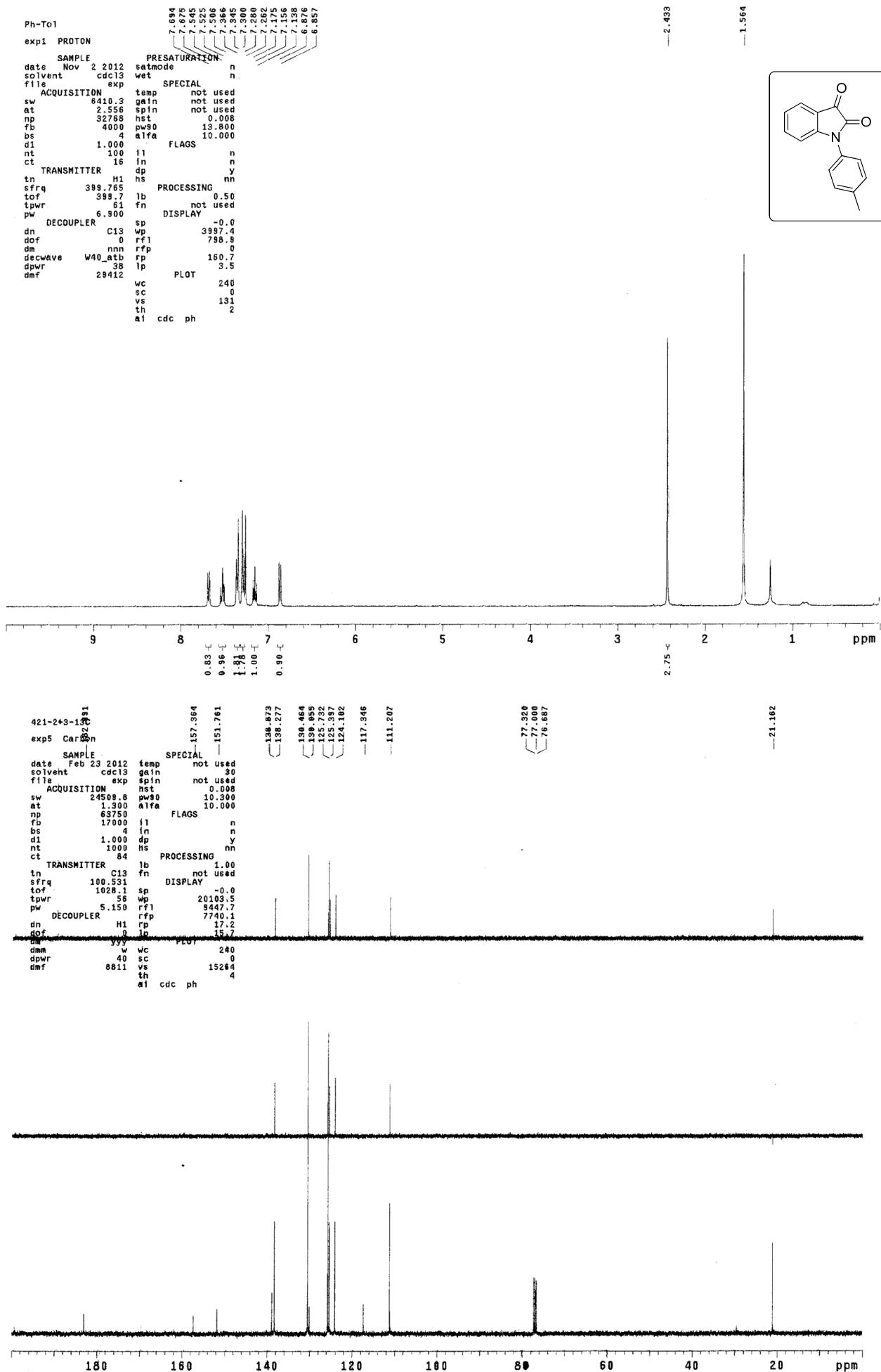


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bs 4 alfa 10.000
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ct 88 in
TRANSMITTER C13 hs nn
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dpwr -40 1p 73.2
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vs 53
th 3
a1 cdc ph

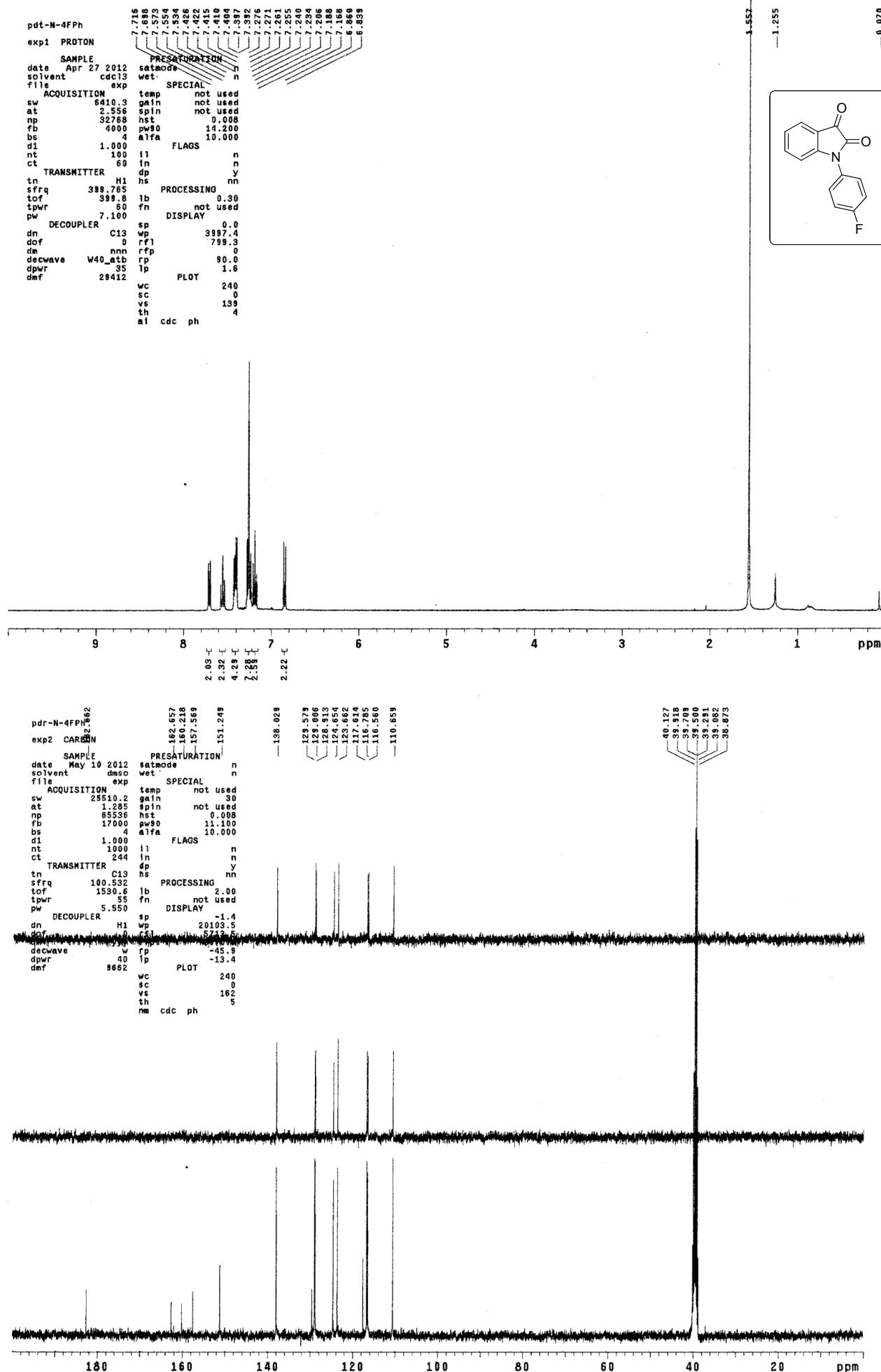
77.948
77.900
76.675



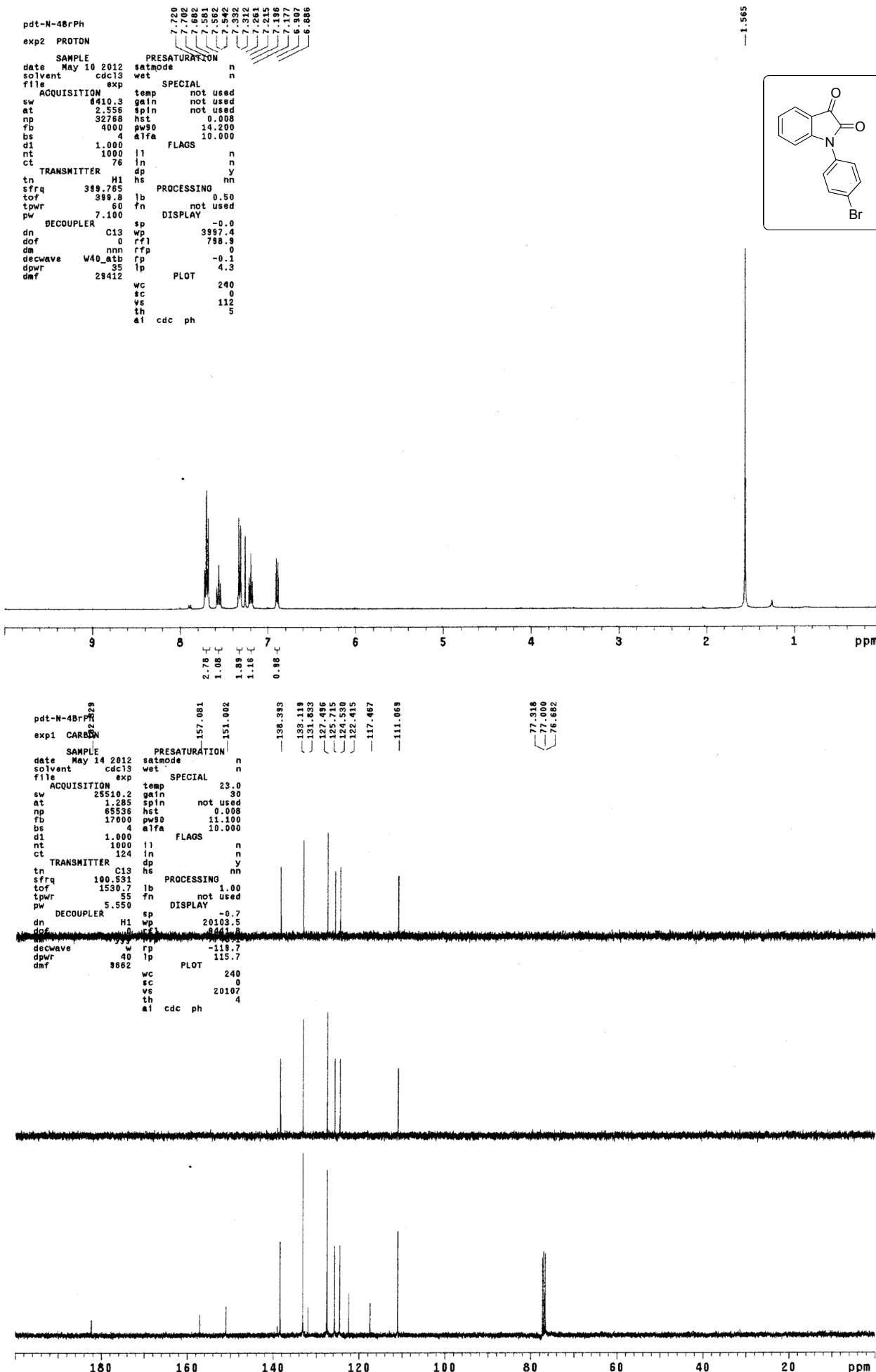
¹H and ¹³C NMR spectra of compound 2m



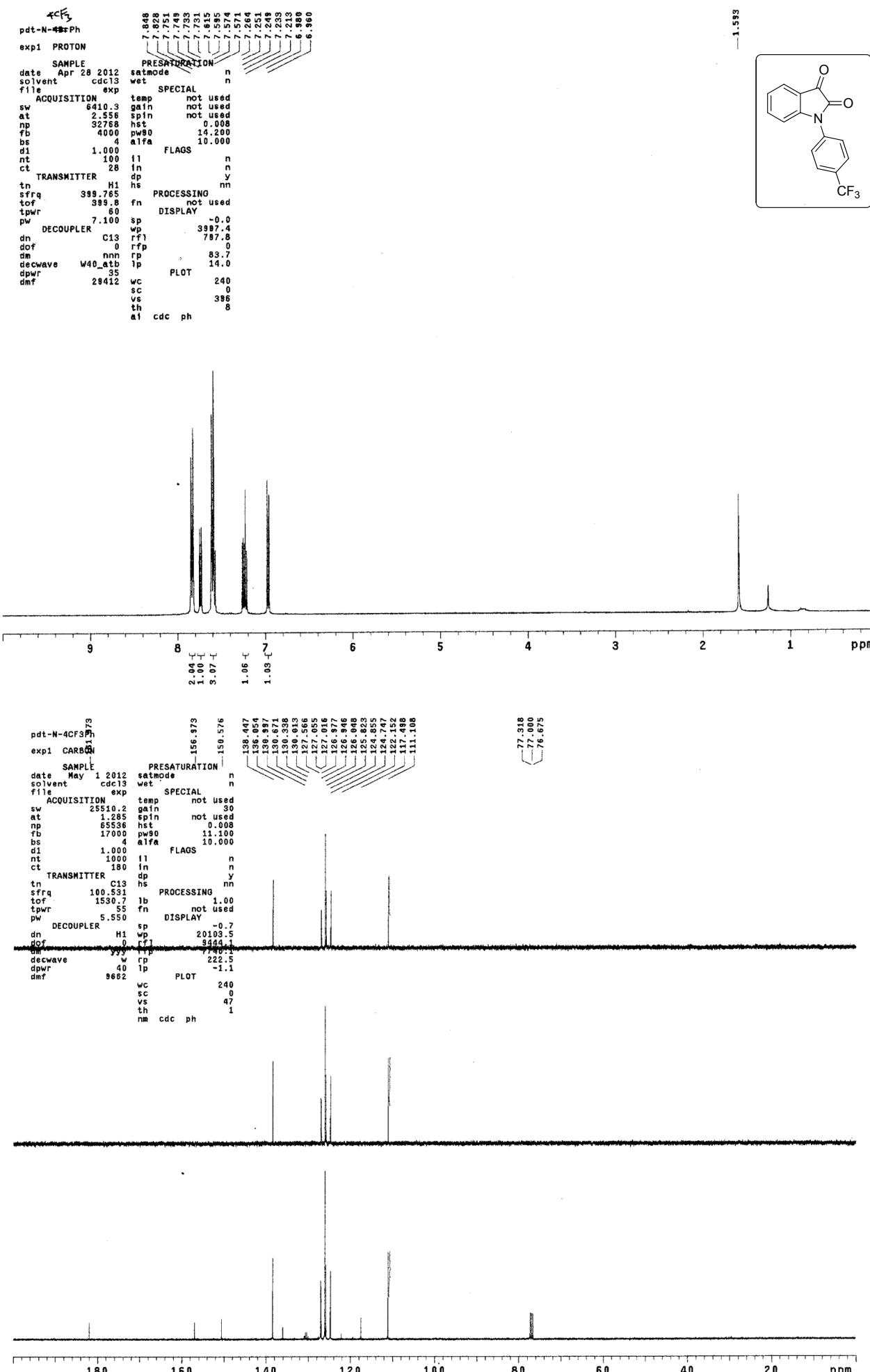
¹H and ¹³C NMR spectra of compound 2n



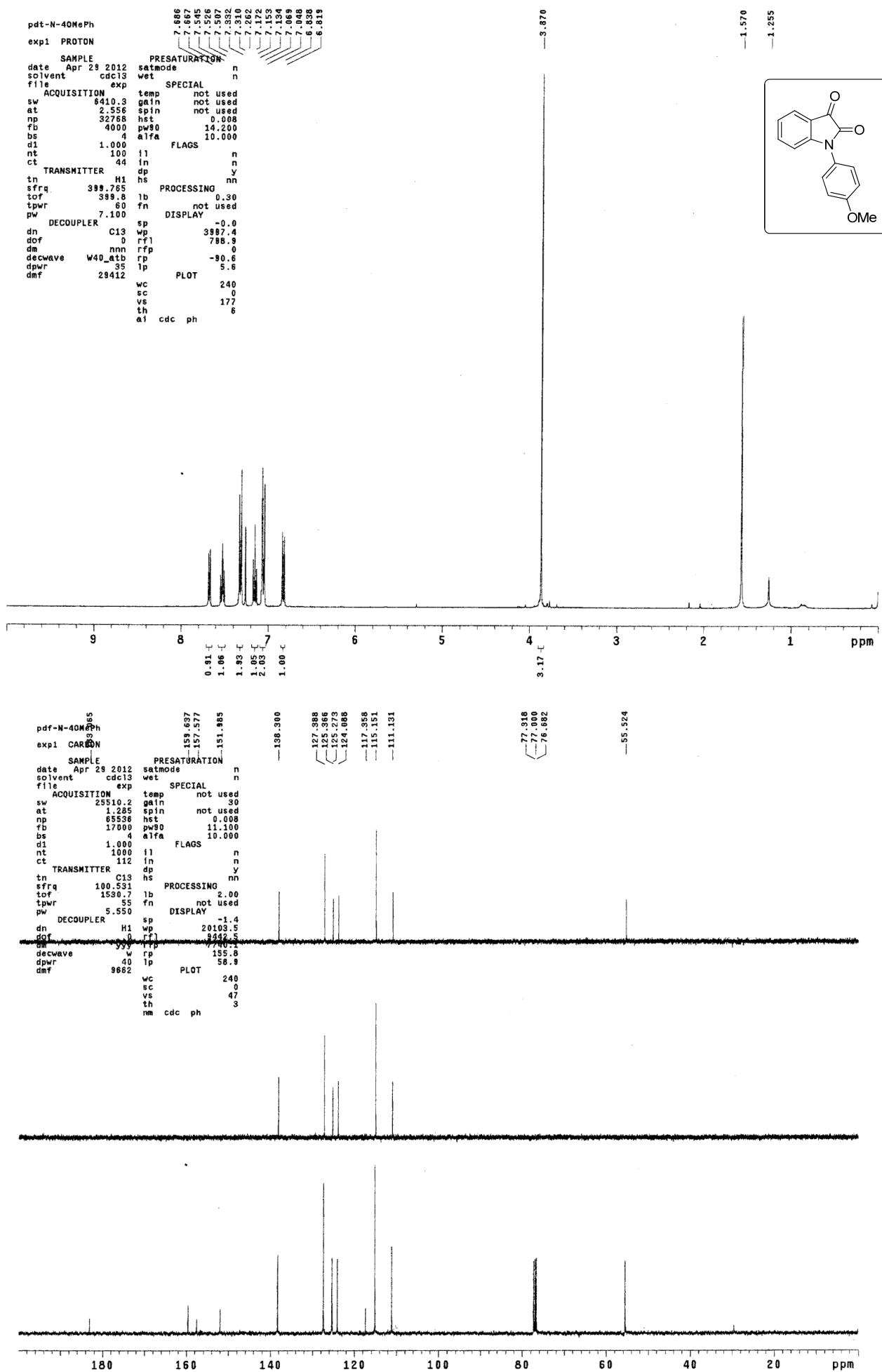
¹H and ¹³C NMR spectra of compound 2o



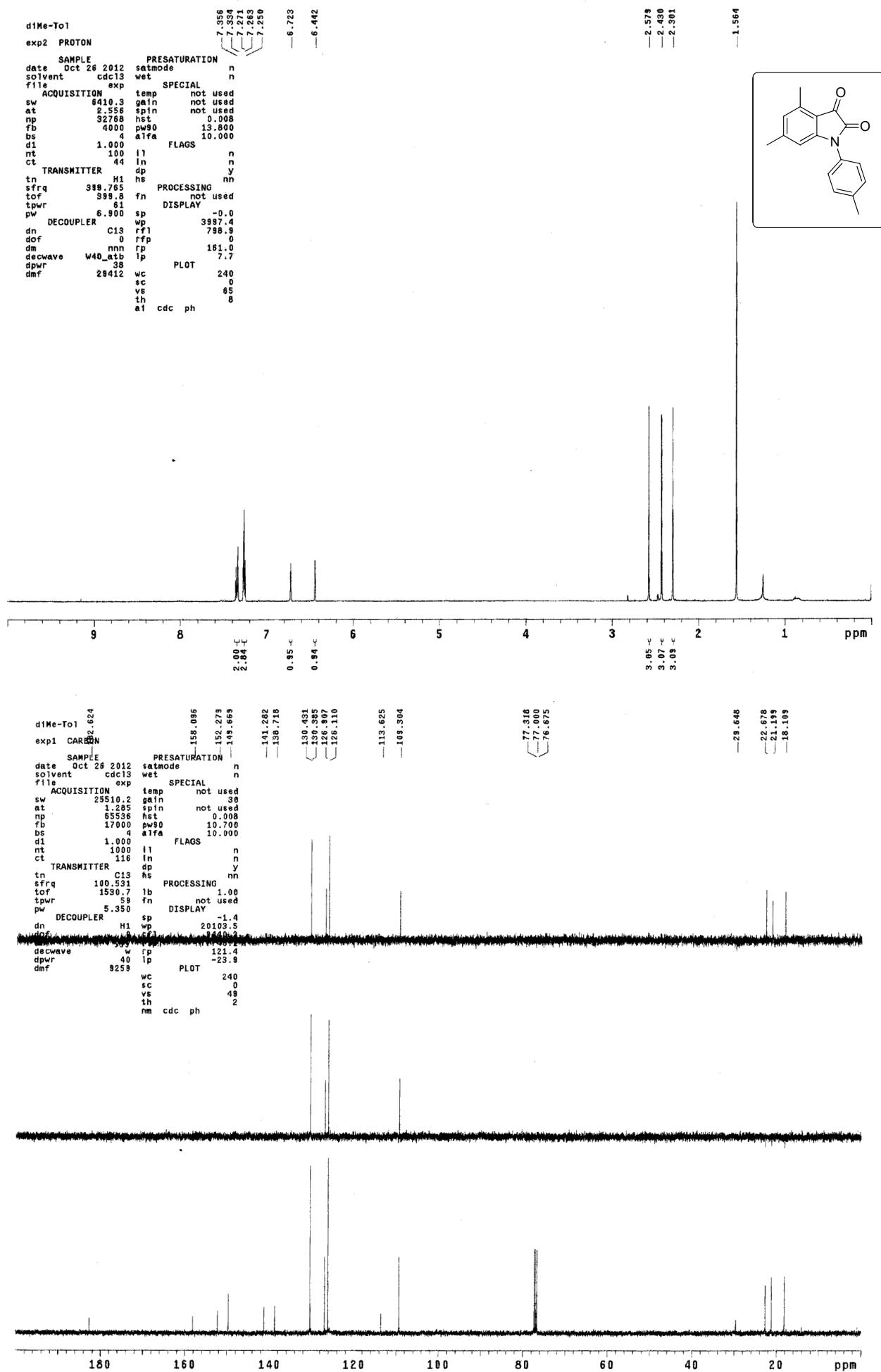
¹H and ¹³C NMR spectra of compound 2p



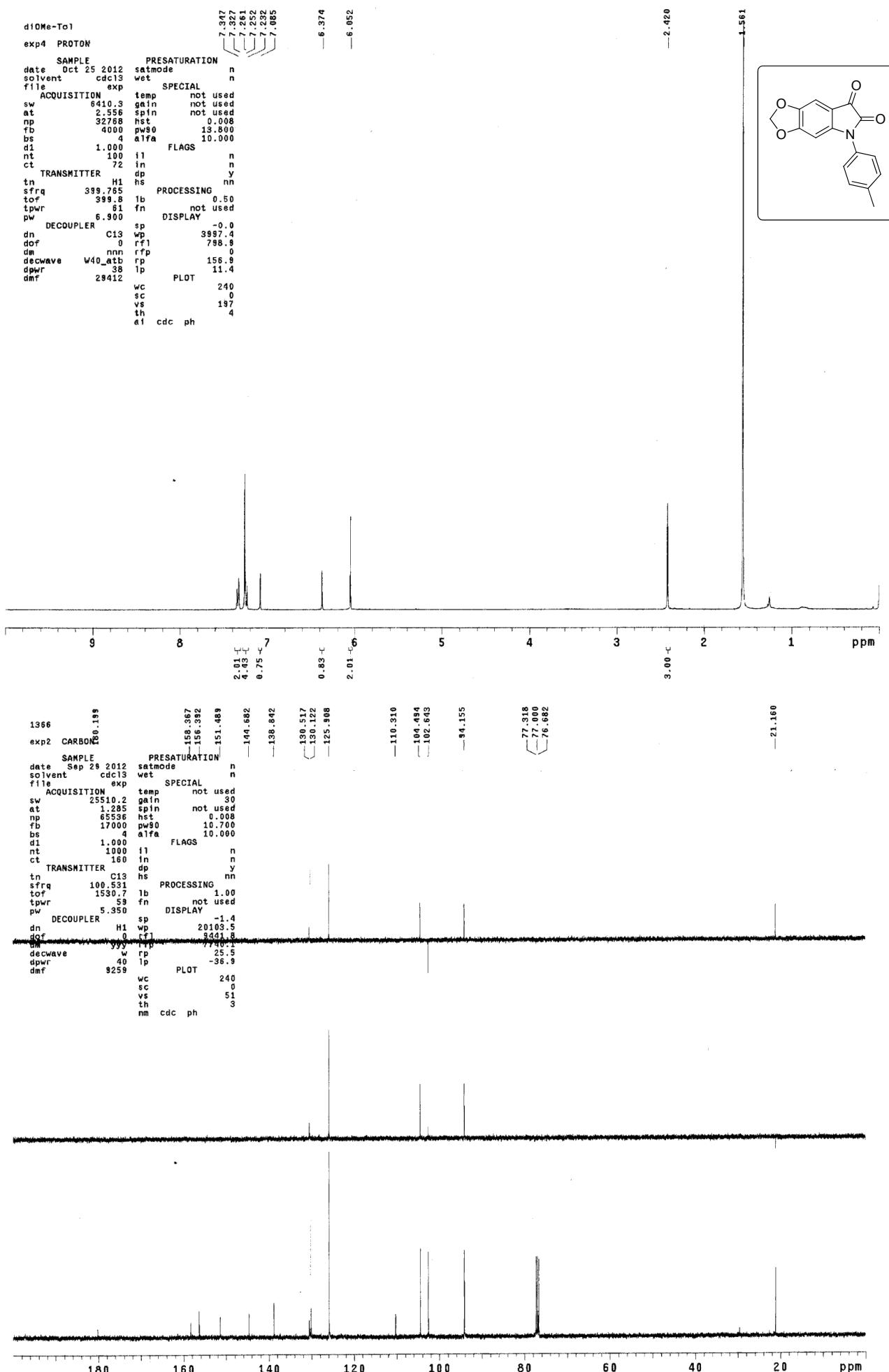
¹H and ¹³C NMR spectra of compound 2q



¹H and ¹³C NMR spectra of compound 2r



¹H and ¹³C NMR spectra of compound 2s



¹H and ¹³C NMR spectra of compound 2t

