Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information for

One-Pot Three-Component Reaction of Quinone Monoacetals, Proline and Naphthols to Afford *N*-Aryl-2-Arylpyrrolidines

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1. General Information

Unless otherwise specified, all reactions were performed under dry nitrogen atmosphere. Anhydrous solvents were distilled prior to use: THF, dioxane and toluene were distilled from sodium using benzophenone as the indicator; MeCN, DMF and DMSO were distilled from CaH_2 under appropriate pressure; Et_3N was distilled from KOH. *p*-Quinone monoacetals and *p*-quinol ethers were prepared following known method.[1] L-proline and naphtholswere purchased from commercial source and used as recieved. Thin layer chromatography was performed on precoated glass-backed plates and visualized with UV light at 254 nm. Flash chromatography was performed on silica gel using petroleum ether and EtOAc as eluent. ^{1}H NMR spectra were recorded on a Bruker Ascend™ 400 spectrometer at 400 MHz. ^{13}C NMR spectra were recorded on a Bruker Ascend™ 400 spectrometer at 100 MHz. Spectra were obtained in $CDCl_3$. Chemical shifts are expressed in ppm and *J* values are given in Hz. Proton chemical shifts are reported relative to internal tetramethylsilane (TMS, δ 0.0 ppm), or with the solvent reference relative to TMS employed as an internal standard ($CDCl_3$, δ 7.26 ppm). Carbon chemical shifts were reported in ppm (δ) relative to TMS with the respective solvent resonance as the internal standard ($CDCl_3$, δ 77.0 ppm). HRMS analysis was performed on an Agilent 6540 UHD accurate-mass quadrupole time-of-flight (Q-TOF) mass spectrometer in the electrospray ionization mode (positive mode). The X-Ray crystallographic analysis was performed on a Bruker SMART APEX II CCD diffractometer using a graphite-monochromated Mo K_α (λ = 0.71073 Å) radiation. Melting points were determined with a Shanghai Jingke WRS-2A digital melting point apparatus instrument, and were uncorrected. Optical rotation was determined using a Shanghai Jingmi WZZ-2B digital polarimeter.

2. Starting Materials

The structures of *p*-quinone monoacetals **1a-1h**, *p*-quinol ethers **1i-1l** and naphthols **3a-3m** used in this study are shown in Figure S1.

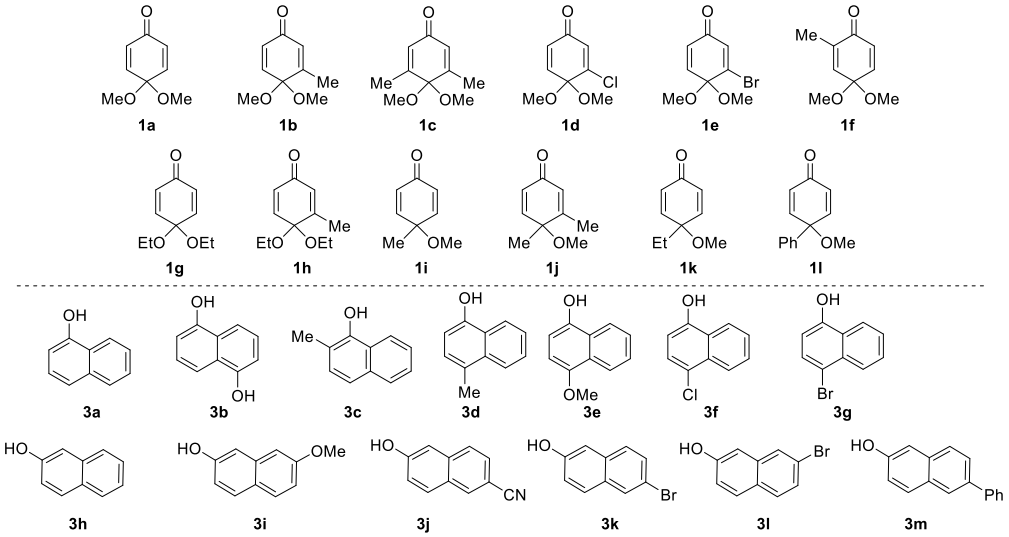
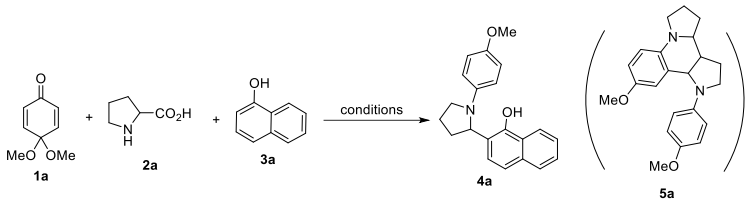


Figure S1 The structure of substrates **1** and **3**

1a,[2] **1b**,[2] **1c**,[2] **1d**,[3] **1e**,[4] **1f**,[5] **1g**,[2] **1i**,[5] **1j**,[5] **1k**[5] and **1l**[6] were known compounds, and were synthesized *via* the oxidation of the corresponding phenols by $PhI(OAc)_2$ following literature procedures.[1] **1h** is a new compound (33% yield). Yellow liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 6.73 (d, J = 10.0 Hz, 1H), 6.33 (dd, J_1 = 10.0 Hz, J_2 = 2.0 Hz, 1H), 6.19 (s, 1H), 3.48–3.40 (m, 2H), 3.30–3.22 (m, 2H), 1.94 (d, J = 1.2 Hz, 3H), 1.20 (t, J = 7.0 Hz, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 185.2, 157.0, 145.6, 131.8, 129.6, 94.8, 58.9, 16.9, 15.4. HRMS (ESI/Q-TOF) *m/z*: $[M + H]^+$ calcd for $C_{11}H_{17}O_3$ 197.1178, found 197.1179.

3. Results on the optimization of the reaction

Table S1. Optimization on the reaction conditions[a]



Entry	**1a**/**2a**/**3a**	Solvent	Base	Tempt (°C)	Yield (%)[b]
1	1/1/1	MeCN	-	100	29[c]
2	1/1/1	MeCN	Et_3N	100	44
3	1/1/1	MeCN	Et_3N	80	50
4	1/1/1	MeCN	Et_3N	60	63
5	1/1/1	MeCN	Et_3N	rt	trace
6	1/1/1	MeCN	DBU[d]	60	38
7	1/1/1	MeCN	K_2CO_3[d]	60	51(63)[e]
8	1/1/1	MeCN	NaOH[d]	60	23
9	1/1/1	MeCN	Pyridine[f]	60	35
10	1/1/1	Dioxane	Et_3N	60	28
11	1/1/1	Toluene	Et_3N	60	30
12	1/1/1	DMF	Et_3N	60	43
13	1/1/1	DMSO	Et_3N	60	40
14	1/1/1	EtOH	Et_3N	60	58
15	1/1/1	DCE	Et_3N	60	54
16	1/1/1	EtOAc	Et_3N	60	27
17	1/1/1	THF	Et_3N	60	25
18	1/1.2/1	MeCN	Et_3N	60	68
19	1/1.5/1	MeCN	Et_3N	60	72
20	1/2/1	MeCN	Et_3N	60	72
21[c]	1.2/1.5/1	MeCN	Et_3N	60	67
22	1.5/1.5/1	MeCN	Et_3N	60	65
23	1.5/2/1	MeCN	Et_3N	60	63
24	1/1.5/1	MeCN	Et_3N[g]	60	71
25	1/1.5/1	MeCN	Et_3N[h]	60	74
26	1/1.5/1	MeCN	Et_3N[h,i]	60	72
27	**1/1.5/1.2**	**MeCN**	**Et_3N[h]**	**60**	**77**
28	1/1.5/1.2	MeCN	Et_3N[h,i]	60	75
29	1/1.5/1.5	MeCN	Et_3N[h]	60	73
30	1/1/1.5	MeCN	Et_3N	60	66
31	1.5/1/1	MeCN	Et_3N	60	61

[a] Unless otherwise noted, a mixture of **1a** (0.2-0.3 mmol), **2a** (0.2-0.4 mmol) and **3a** (0.2-0.3 mmol) in the solvent (2 mL) with Et_3N (2 mL) was charged to a 10 mL screw-capped Schlenk tube under N_2 and heated for 12 h. [b]Isolated yields. [c]**5a** was obtained in 34% yield based on **1a**. [d] 0.4 mmol base was added. [e] **1a**/**2a**/**3a**: 1/1.5/1.2, 5 equiv K_2CO_3. [f] 1 mL pyridine was used; **5a** was obtained in ca.10% yield based on **1a**. [g]1 mL. [h]0.5 mL. [i]**1a** in MeCN (1 mL) was slowly added to a mixture of **2a** and **3a** in MeCN (1 mL) and Et_3N (0.5 mL) *via* a syringe pump over 10 h (flow rate: 0.1 mL/h).

4. Crystal structure determination of 4a and 6d

The well-shaped single crystals were selected for X-ray diffraction study. The unit cell parameters and intensity data were collected at 296(2) K on a Bruker SMART APEX II CCD diffractometer using a graphite-monochromated Mo K_α (λ = 0.71073 Å) radiation. The structure was solved by direct methods and refined on F^2 by full-matrix least squares procedures using SHELXTL software. All non-hydrogen atoms were refined anisotropically. All H atoms were located from a difference map and refined isotropically. ORTEP representation (30% probability level) of the molecular structures and CCDC numbers for compounds **4a** and **6d** are presented in Table S2. Crystallographic data are listed in Table S3. These data can be obtained free of charge from the Cambridge Crystallographic Date Center via www.ccdc.cam.ac.uk.

Table S2 Molecular structures of **4a** and **6d**

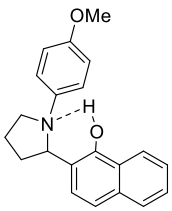
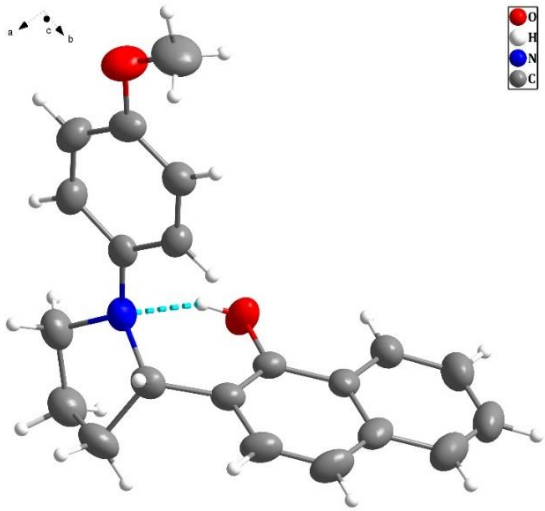
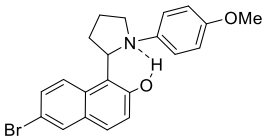
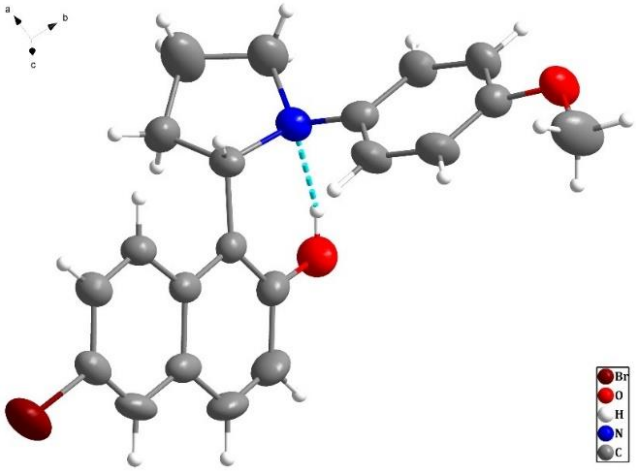
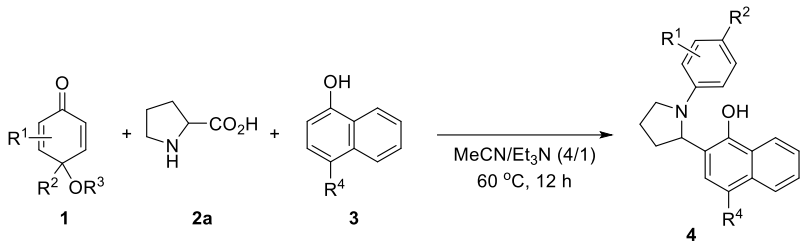
Compound	X-Ray structure	CCDC Number
 **4a**		**2032905**
 **6d**		**2032906**

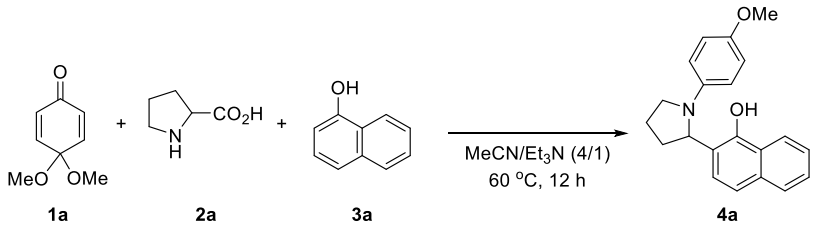
Table S3 Crystal data and structure refinements for the products **4a** and **6d**

Compound	**4a**	**6d**
Empirical formula	$C_{21}H_{21}NO_2$	$C_{21}H_{20}BrNO_2$
Formula weight	319.39	398.29
Crystal system	Monoclinic	Orthorhombic
Space group	$P2_1/n$	$P2_12_12_1$
a / Å	7.064(3)	7.5488(8)
b / Å	23.992(9)	14.1447(14)
c / Å	9.994(4)	17.0775(18)
β / (°)	98.766(4)	90
V / Å^3	1674.0(10)	1823.5(3)
Z	4	4
D_c / (g.cm^{-3})	1.267	1.451
μ / mm^{-1}	0.081	2.268
F(000)	680	816
Crystal size / mm^3	0.11×0.09×0.07	0.15×0.11×0.09
θ range / (°)	1.698-25.003	1.869-25.002
Reflections collected	10867	13075
Independent reflections	2936 [R_{int}= 0.0470]	3193 [R_{int}= 0.0308]
Reflections observed (I>2σ(I))	2035	2818
Data/restraints/parameters	2936/6/219	3193/0/229
Goodness-of-fit on F^2	1.045	1.024
R_1/wR_2 (I>2σ(I))	0.0536/0.1162	0.0289/0.0636
R_1/wR_2 (all data)	0.0873/0.1298	0.0367/0.0661
$(\Delta\rho)_{max}$, $(\Delta\rho)_{min}$ / (e·Å^{-3})	0.167, -0.206	0.294, -0.310

5. Experimental details and characterization data of the products

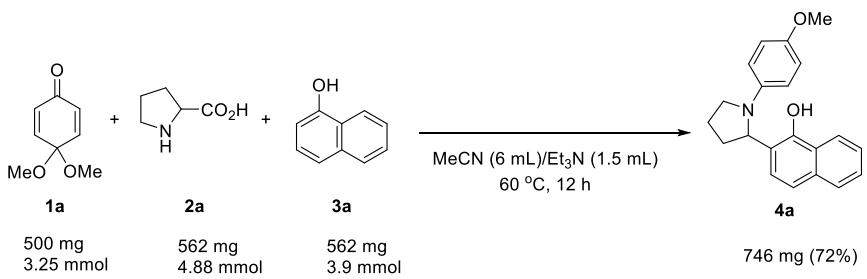


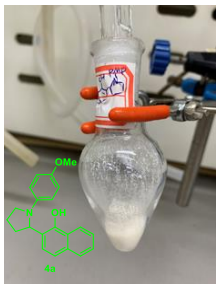
General procedure for the three-component reaction: To an oven-dried Schlenk tube (10 mL) were added QMA **1** (0.2 mmol), L-proline **2a** (1.5 equiv), α-naphthol **3** (1.2 equiv), MeCN (2 mL) and Et_3N (0.5 mL). The tube was sealed and the resulting mixture was stirred and heated to 60 °C for 12 h. After the reaction was cooled down to room temperature, silica gel (ca. 200 mg) was added and the volatiles were removed in vacuo to afford a dry powder. The residue was purified by column chromatography on silica gel (PE/EtOAc) to afford the pure product **4**.

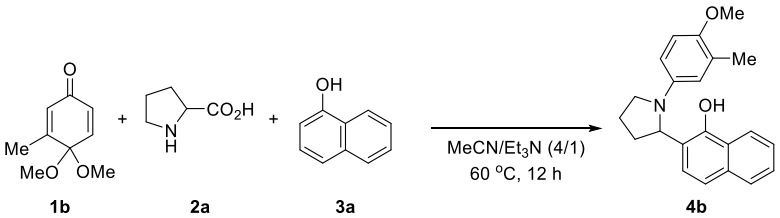


2-(1-(4-methoxyphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4a). Following the general procedure, the reaction of **1a** (30.9 mg, 0.2 mmol), **2a** (34.7 mg, 0.3 mmol) and **3a** (34.7 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4a** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 49.2 mg, 77%. Mp: 110–111 °C. $[\alpha]_D^{21}$ = 0 (c 0.25, EtOH). ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.80 (br, 1H), 8.15–8.13 (m, 1H), 7.75–7.72 (m, 1H), 7.43–7.38 (m, 2H), 7.36 (d, J = 8.4 Hz, 1H), 7.20 (d, J = 8.4 Hz, 1H), 6.86 (d, J = 9.2 Hz, 2H), 6.73 (d, J = 9.2 Hz, 2H), 4.58–4.55 (m, 1H), 3.93–3.88 (m, 1H), 3.68 (s, 3H), 3.22 (dd, J_1 = 17.2 Hz, J_2 = 7.6 Hz, 1H), 2.51–2.41 (m, 1H), 2.25–2.11 (m, 2H), 2.07–2.02 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 154.3, 151.9, 142.6, 133.5, 127.3, 126.0, 125.7, 125.4, 125.0, 122.1, 119.2, 119.1, 117.9, 114.5, 67.3, 55.6, 53.4, 35.5, 24.3. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{21}H_{22}NO_2$ 320.1651, found 320.1653. *The structure of this compound was further determined by single crystal X-ray diffraction.*

Procedure on 3.25 mmol scale: To a oven-dried Schlenk tube (25 mL) were added **1a** (500 mg, 3.25 mmol), **2a** (562 mg, 4.88 mmol) and **3a** (562 mg, 3.90 mmol), MeCN (6 mL) and Et_3N (1.5 mL). The tube was sealed and the resulting mixture was heated at 60 °C for 12 h. The reaction mixture was cooled down. The solvent was removed in vacuo, and the residue was purified by column chromatography on silica gel (PE/EtOAc = 60/1) to afford the pure product **4a**. Yield: 746 mg, 72%.

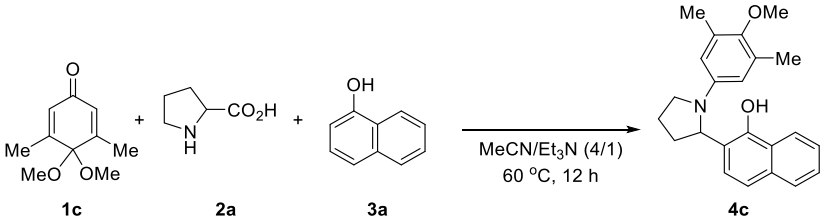






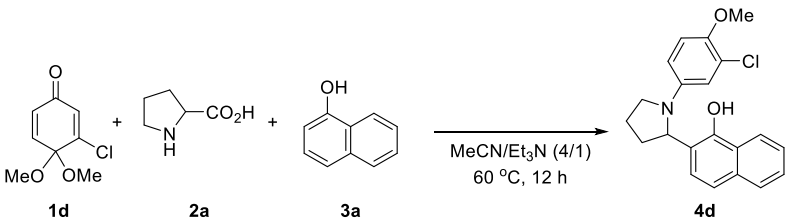
1b 2a 3a 4b

2-(1-(4-methoxy-3-methylphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4b). Following the general procedure, the reaction of **1b** (33.7 mg, 0.2 mmol), **2a** (34.6 mg, 0.3 mmol) and **3a** (34.6 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4b** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 46.9 mg, 70%. Mp: 113–115 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.92 (br, 1H), 8.16–8.13 (m, 1H), 7.75–7.72 (m, 1H), 7.43–7.38 (m, 2H), 7.35 (d, J = 8.8 Hz, 1H), 7.20 (d, J = 8.4 Hz, 1H), 6.77 (d, J = 2.8 Hz, 1H), 6.69 (dd, J_1 = 8.8 Hz, J_2 = 2.8 Hz, 1H), 6.62 (d, J = 8.4 Hz, 1H), 4.57 (dd, J_1 = 8.4 Hz, J_2 = 6.4 Hz, 1H), 3.93–3.88 (m, 1H), 3.69 (s, 3H), 3.22 (dd, J_1 = 16.8 Hz, J_2 = 7.2 Hz, 1H), 2.47–2.40 (m, 1H), 2.24–2.14 (m, 2H), 2.12 (s, 3H), 2.06–2.01 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 152.6, 152.0, 142.2, 133.5, 127.4, 127.2, 125.9, 125.7, 125.4, 124.9, 122.1, 119.9, 119.3, 119.0, 114.6, 110.8, 67.2, 55.7, 53.5, 35.5, 24.3, 16.6. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{24}NO_2$ 334.1807, found 334.1809.



1c 2a 3a 4c

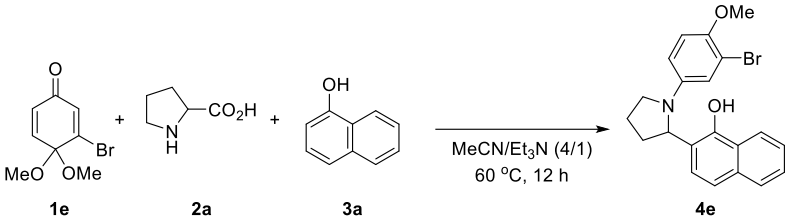
2-(1-(4-methoxy-3,5-dimethylphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4c). Following the general procedure, the reaction of **1c** (36.5 mg, 0.2 mmol), **2a** (34.5 mg, 0.3 mmol) and **3a** (34.7 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4c** as a white solid, which was purified by column chromatography (PE/EtOAc = 70/1). Yield: 45.2 mg, 65%. Mp: 118–120 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.64 (br, 1H), 8.16–8.14 (m, 1H), 7.76–7.74 (m, 1H), 7.45–7.39 (m, 2H), 7.37 (d, J = 8.4 Hz, 1H), 7.21 (d, J = 8.8 Hz, 1H), 6.55 (s, 2H), 4.64–4.61 (m, 1H), 3.93–3.87 (m, 1H), 3.61 (s, 3H), 3.25 (dd, J_1 = 17.2 Hz, J_2 = 7.6 Hz, 1H), 2.49–2.39 (m, 1H), 2.22–2.10 (m, 2H), 2.16 (s, 6H), 2.06–2.00 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 151.9, 151.2, 144.7, 133.5, 131.2, 127.3, 126.0, 125.7, 125.4, 124.9, 122.1, 119.4, 119.2, 116.7, 66.9, 59.8, 53.1, 35.7, 24.4, 16.4. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{23}H_{26}NO_2$ 348.1964, found 348.1968.



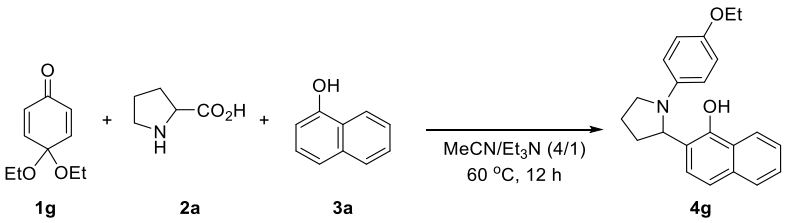
1d 2a 3a 4d

2-(1-(3-chloro-4-methoxyphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4d). Following the general procedure, the reaction of **1d** (37.7 mg, 0.2 mmol), **2a** (34.5 mg, 0.3 mmol) and **3a** (34.8 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4d** as a white solid, which was purified by column

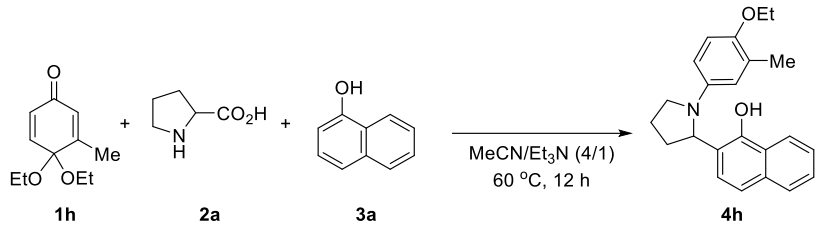
chromatography (PE/EtOAc = 60/1). Yield: 42.3 mg, 60%. Mp: 123–125 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.26 (br, 1H), 8.15–8.13 (m, 1H), 7.76–7.74 (m, 1H), 7.45–7.40 (m, 2H), 7.38 (d, J = 8.4 Hz, 1H), 7.20 (d, J = 8.8 Hz, 1H), 6.97 (d, J = 2.0 Hz, 1H), 6.74–6.69 (m, 2H), 4.56 (dd, J_1 = 8.0 Hz, J_2 = 6.4 Hz, 1H), 3.92–3.87 (m, 1H), 3.75 (s, 3H), 3.22 (dd, J_1 = 16.4 Hz, J_2 = 7.2 Hz, 1H), 2.51–2.42 (m, 1H), 2.23–2.13 (m, 2H), 2.09–2.03 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 151.6, 149.5, 143.1, 133.6, 127.3, 126.1, 125.6, 125.3, 125.1, 122.9, 122.0, 119.4, 118.8, 115.6, 113.1, 67.1, 56.6, 53.2, 35.5, 24.3. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{21}H_{21}ClNO_2$ 354.1261, found 354.1264.



2-(1-(3-bromo-4-methoxyphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4e). Following the general procedure, the reaction of **1e** (46.7 mg, 0.2 mmol), **2a** (34.6 mg, 0.3 mmol) and **3a** (34.8 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4e** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 43.8 mg, 55%. Mp: 133–135 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.25 (br, 1H), 8.14 (d, J = 6.4 Hz, 1H), 7.74 (d, J = 8.0 Hz, 1H), 7.43–7.36 (m, 3H), 7.19 (d, J = 8.4 Hz, 1H), 7.14 (d, J = 2.0 Hz, 1H), 6.76 (d, J = 8.8 Hz, 1H), 6.66 (d, J = 9.2 Hz, 1H), 4.55 (t, J = 6.8 Hz, 1H), 3.89–3.86 (m, 1H), 3.73 (s, 3H), 3.21 (d, J = 8.4 Hz, 1H), 2.50–2.41 (m, 1H), 2.24–2.11 (m, 2H), 2.07–2.02 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 151.6, 150.5, 143.4, 133.6, 127.3, 126.1, 125.6, 125.3, 125.1, 122.0, 121.7, 119.4, 118.8, 116.4, 112.8, 112.2, 67.1, 56.7, 53.2, 35.5, 24.3. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{21}H_{21}BrNO_2$ 398.0756, found 398.0759.

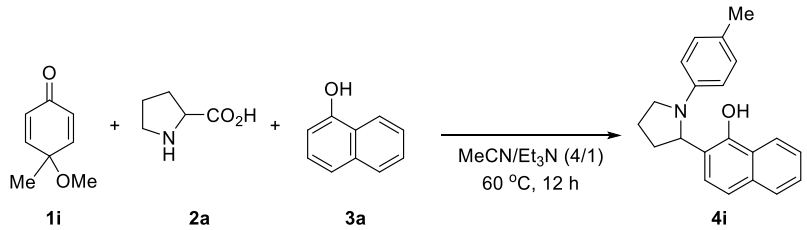


2-(1-(4-ethoxyphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4g). Following the general procedure, the reaction of **1g** (36.5 mg, 0.2 mmol), **2a** (34.5 mg, 0.3 mmol) and **3a** (34.7 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4g** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 51.3 mg, 77%. Mp: 114–116 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.86 (br, 1H), 8.16–8.13 (m, 1H), 7.74–7.72 (m, 1H), 7.42–7.37 (m, 2H), 7.35 (d, J = 8.0 Hz, 1H), 7.18 (d, J = 8.0 Hz, 1H), 6.83 (d, J = 9.2 Hz, 2H), 6.71 (d, J = 9.2 Hz, 2H), 4.54 (dd, J_1 = 8.0 Hz, J_2 = 6.0 Hz, 1H), 3.89–3.84 (m, 1H), 3.86 (q, J = 7.2 Hz, 2H), 3.18 (dd, J_1 = 16.8 Hz, J_2 = 7.6 Hz, 1H), 2.48–2.38 (m, 1H), 2.22–2.09 (m, 2H), 2.04–1.98 (m, 1H), 1.30 (t, J = 7.2 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 153.6, 152.0, 142.5, 133.6, 127.3, 126.0, 125.8, 125.4, 125.0, 122.1, 119.3, 119.1, 117.9, 115.2, 67.4, 63.8, 53.3, 35.6, 24.4, 15.0. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{24}NO_2$ 334.1807, found 334.1808.



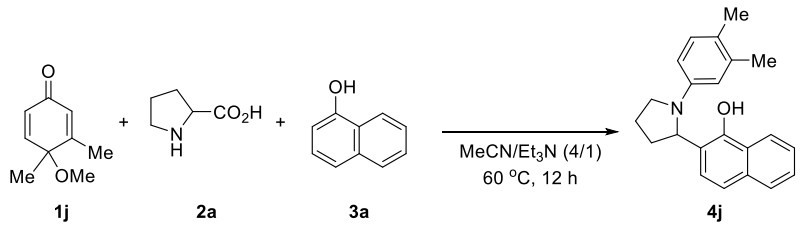
1h 2a 3a 4h

2-(1-(4-ethoxy-3-methylphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4h). Following the general procedure, the reaction of **1h** (39.3 mg, 0.2 mmol), **2a** (34.6 mg, 0.3 mmol) and **3a** (34.8 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4h** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 47.2 mg, 68%. Mp: 117–118 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ = 10.96 (br, 1H), 8.16–8.13 (m, 1H), 7.75–7.73 (m, 1H), 7.43–7.38 (m, 2H), 7.35 (d, J = 8.4 Hz, 1H), 7.20 (d, J = 8.4 Hz, 1H), 6.76 (d, J = 2.8 Hz, 1H), 6.66 (dd, J_1 = 8.8 Hz, J_2 = 2.8 Hz, 1H), 6.60 (d, J = 8.8 Hz, 1H), 4.57 (dd, J_1 = 8.0 Hz, J_2 = 6.4 Hz, 1H), 3.92–3.85 (m, 1H), 3.88 (q, J = 7.2 Hz, 2H), 3.21 (dd, J_1 = 16.8 Hz, J_2 = 7.6 Hz, 1H), 2.49–2.40 (m, 1H), 2.22–2.10 (m, 2H), 2.12 (s, 3H), 2.06–2.00 (m, 1H), 1.32 (t, J = 7.2 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 152.0, 151.9, 142.1, 133.5, 127.7, 127.2, 125.9, 125.7, 125.4, 124.9, 122.1, 119.7, 119.3, 119.0, 114.6, 112.1, 67.2, 64.0, 53.4, 35.5, 24.3, 16.6, 15.0. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{23}H_{26}NO_2$ 348.1964, found 348.1967.



1i 2a 3a 4i

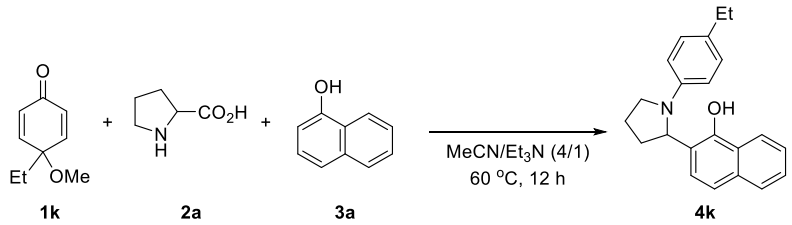
2-(1-(p-tolyl)pyrrolidin-2-yl)naphthalen-1-ol (4i). Following the general procedure, the reaction of **1i** (27.7 mg, 0.2 mmol), **2a** (34.6 mg, 0.3 mmol) and **3a** (34.7 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4i** as a yellow liquid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 31.8 mg, 52%. ^1H NMR ($CDCl_3$, 400 MHz): δ = 10.49 (br, 1H), 8.14–8.12 (m, 1H), 7.75–7.73 (m, 1H), 7.44–7.39 (m, 2H), 7.37 (d, J = 8.0 Hz, 1H), 7.21 (d, J = 8.4 Hz, 1H), 6.98 (d, J = 8.4 Hz, 2H), 6.80 (d, J = 8.8 Hz, 2H), 4.62 (dd, J_1 = 8.4 Hz, J_2 = 6.0 Hz, 1H), 3.95–3.90 (m, 1H), 3.27 (dd, J_1 = 16.8 Hz, J_2 = 7.6 Hz, 1H), 2.51–2.41 (m, 1H), 2.23–2.12 (m, 2H), 2.21 (s, 3H), 2.07–2.02 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 151.8, 146.5, 133.5, 130.0, 129.6, 127.2, 126.0, 125.6, 125.4, 125.0, 122.1, 119.3, 119.2, 116.4, 66.9, 52.8, 35.6, 24.4, 20.4. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{21}H_{22}NO$ 304.1701, found 304.1708.



1j 2a 3a 4j

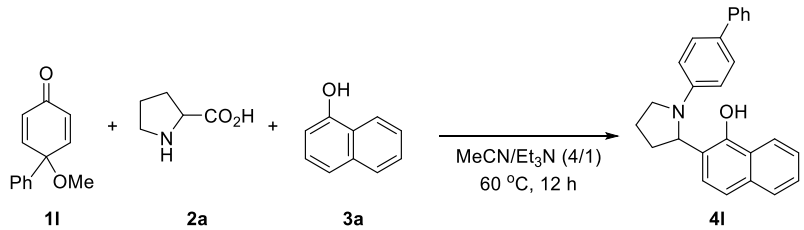
2-(1-(3,4-dimethylphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4j). Following the general procedure, the reaction of **1j** (30.5 mg, 0.2 mmol), **2a** (34.5 mg, 0.3 mmol) and **3a** (34.8 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4j** as a yellow liquid, which was purified by column

chromatography (PE/EtOAc = 60/1). Yield: 34.8 mg, 55%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.57 (br, 1H), 8.14–8.12 (m, 1H), 7.75–7.73 (m, 1H), 7.44–7.39 (m, 2H), 7.37 (d, J = 8.4 Hz, 1H), 7.22 (d, J = 8.4 Hz, 1H), 6.91 (d, J = 8.0 Hz, 1H), 6.72 (d, J = 2.4 Hz, 1H), 6.63 (dd, J_1 = 8.4 Hz, J_2 = 2.8 Hz, 1H), 4.63 (dd, J_1 = 8.4 Hz, J_2 = 6.0 Hz, 1H), 3.96–3.91 (m, 1H), 3.30–3.24 (m, 1H), 2.47–2.40 (m, 1H), 2.23–2.16 (m, 2H), 2.14 (s, 3H), 2.12 (s, 3H), 2.05–2.00 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 151.8, 146.9, 137.2, 133.5, 130.1, 128.9, 127.2, 125.9, 125.7, 125.4, 124.9, 122.1, 119.4, 119.1, 118.0, 113.8, 66.8, 52.8, 35.6, 24.4, 20.2, 18.8. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{24}NO$ 318.1858, found 318.1861.



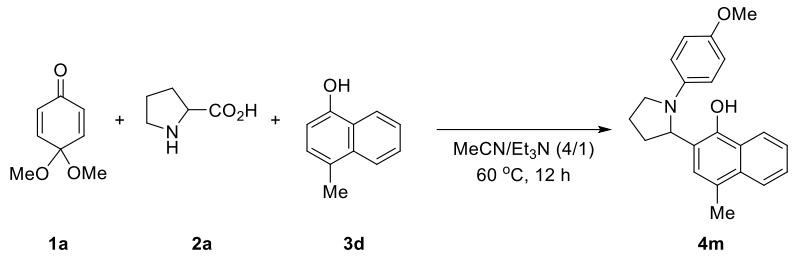
1k 2a 3a 4k

2-(1-(4-ethylphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4k). Following the general procedure, the reaction of **1k** (30.4 mg, 0.2 mmol), **2a** (34.7 mg, 0.3 mmol) and **3a** (34.7 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4k** as a yellow liquid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 31.5 mg, 50%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.48 (br, 1H), 8.14–8.12 (m, 1H), 7.76–7.73 (m, 1H), 7.44–7.39 (m, 2H), 7.37 (d, J = 8.4 Hz, 1H), 7.22 (d, J = 8.4 Hz, 1H), 7.01 (d, J = 8.4 Hz, 2H), 6.83 (d, J = 8.8 Hz, 2H), 4.66–4.62 (m, 1H), 3.97–3.92 (m, 1H), 3.32–3.26 (m, 1H), 2.51 (q, J = 7.6 Hz, 2H), 2.47–2.42 (m, 1H), 2.25–2.13 (m, 2H), 2.09–2.01 (m, 1H), 1.14 (t, J = 7.6 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 151.8, 146.7, 136.5, 133.5, 128.4, 127.2, 126.0, 125.6, 125.4, 125.0, 122.1, 119.4, 119.2, 116.4, 66.9, 52.7, 35.6, 27.9, 24.4, 15.7. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{24}NO$ 318.1858, found 318.1860.



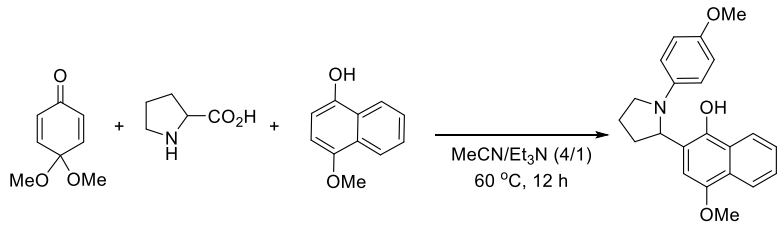
1l 2a 3a 4l

2-(1-([1,1'-biphenyl]-4-yl)pyrrolidin-2-yl)naphthalen-1-ol (4l). Following the general procedure, the reaction of **1l** (40.2 mg, 0.2 mmol), **2a** (34.7 mg, 0.3 mmol) and **3a** (34.6 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4l** as a yellow slurry solid, which was purified by column chromatography (PE/EtOAc = 50/1). Yield: 42.5 mg, 58%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.02 (br, 1H), 8.16–8.13 (m, 1H), 7.77–7.75 (m, 1H), 7.48–7.39 (m, 7H), 7.35 (t, J = 7.6 Hz, 2H), 7.26–7.23 (m, 2H), 6.94 (d, J = 8.8 Hz, 2H), 4.72 (dd, J_1 = 8.0 Hz, J_2 = 6.0 Hz, 1H), 4.01–3.95 (m, 1H), 3.40–3.34 (m, 1H), 2.51–2.44 (m, 1H), 2.27–2.17 (m, 2H), 2.10–2.04 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 151.5, 148.1, 140.8, 133.6, 133.3, 128.7, 127.8, 127.3, 126.6, 126.5, 126.1, 125.6, 125.4, 125.1, 122.0, 119.5, 119.4, 116.4, 66.7, 52.5, 35.7, 24.5. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{26}H_{24}NO$ 366.1858, found 366.1861.



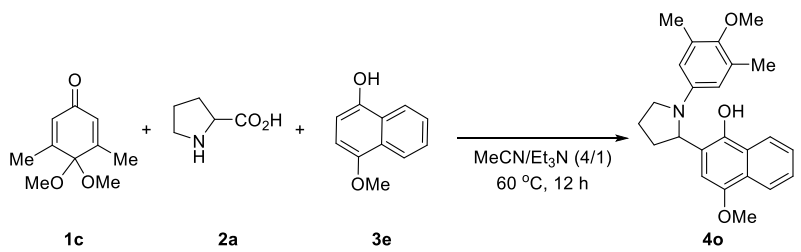
1a 2a 3d 4m

2-(1-(4-methoxyphenyl)pyrrolidin-2-yl)-4-methylnaphthalen-1-ol (4m). Following the general procedure, the reaction of **1a** (30.9 mg, 0.2 mmol), **2a** (34.7 mg, 0.3 mmol) and **3d** (38.0 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4m** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 54.8 mg, 82%. Mp: 112–114 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.56 (br, 1H), 8.17 (d, J = 9.6 Hz, 1H), 7.87 (d, J = 8.4 Hz, 1H), 7.48–7.40 (m, 2H), 7.02 (s, 1H), 6.85 (d, J = 8.0 Hz, 2H), 6.73 (d, J = 8.8 Hz, 2H), 4.51 (t, J = 7.2 Hz, 1H), 3.91–3.67 (m, 1H), 3.67 (s, 3H), 3.20 (q, J = 8.0 Hz, 1H), 2.61 (s, 3H), 2.47–2.40 (m, 1H), 2.22–2.10 (m, 2H), 2.05–2.00 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 154.2, 150.3, 142.7, 132.4, 126.1, 125.8, 125.6, 125.0, 124.7, 123.8, 122.5, 118.6, 117.8, 114.6, 67.3, 55.6, 53.2, 35.6, 24.3, 18.8. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{24}NO_2$ 334.1807, found 334.1808.



1a 2a 3e 4n

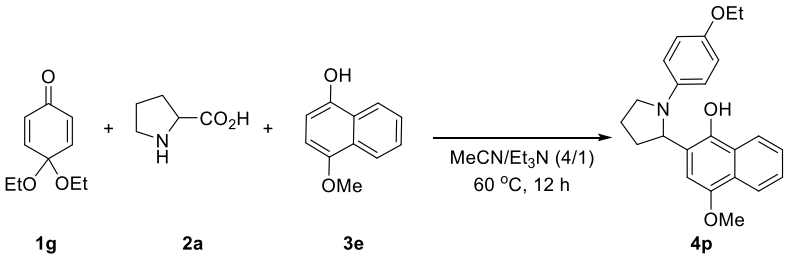
4-methoxy-2-(1-(4-methoxyphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4n). Following the general procedure, the reaction of **1a** (30.9 mg, 0.2 mmol), **2a** (34.6 mg, 0.3 mmol) and **3e** (41.8 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4n** as a white solid, which was purified by column chromatography (PE/EtOAc = 50/1). Yield: 50.3 mg, 72%. Mp: 128–130 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.26 (br, 1H), 8.17–8.13 (m, 1H), 8.12–8.09 (m, 1H), 7.46–7.41 (m, 2H), 6.86–6.83 (m, 2H), 6.76–6.73 (m, 2H), 6.52 (s, 1H), 4.49 (dd, J_1 = 8.4 Hz, J_2 = 6.0 Hz, 1H), 3.98 (s, 3H), 3.91–3.86 (m, 1H), 3.68 (s, 3H), 3.21 (q, J = 8.0 Hz, 1H), 2.49–2.42 (m, 1H), 2.24–2.13 (m, 2H), 2.07–2.01 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 154.1, 148.8, 145.4, 142.7, 126.3, 125.7, 125.4, 125.3, 121.9, 121.5, 118.1, 117.6, 114.5, 103.6, 67.7, 55.9, 55.6, 53.0, 35.5, 24.4. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{24}NO_3$ 350.1756, found 350.1753.



1c 2a 3e 4o

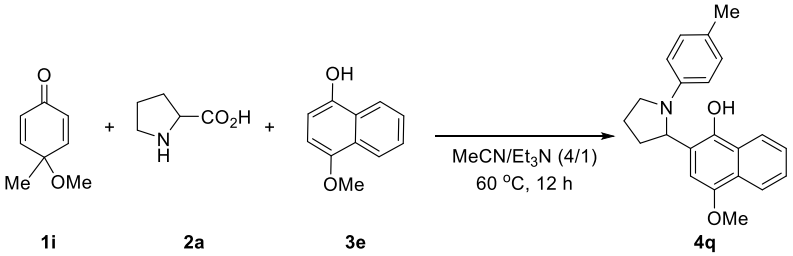
4-methoxy-2-(1-(4-methoxy-3,5-dimethylphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4o). Following the general procedure, the reaction of **1c** (36.6 mg, 0.2 mmol), **2a** (34.8 mg, 0.3 mmol) and **3e** (42.0 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4o** as a yellow liquid, which was

purified by column chromatography (PE/EtOAc = 80/1). Yield: 49.0 mg, 65%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.11 (br, 1H), 8.17–8.14 (m, 1H), 8.13–8.09 (m, 1H), 7.47–7.43 (m, 2H), 6.54 (s, 3H), 4.56 (dd, J_1 = 8.8 Hz, J_2 = 5.6 Hz, 1H), 3.99 (s, 3H), 3.91–3.86 (m, 1H), 3.61 (s, 3H), 3.25 (dd, J_1 = 16.8 Hz, J_2 = 7.6 Hz, 1H), 2.49–2.40 (m, 1H), 2.23–2.13 (m, 2H), 2.17 (s, 6H), 2.07–2.01 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 151.0, 148.8, 145.4, 144.7, 131.3, 126.3, 125.7, 125.4, 125.3, 121.8, 121.5, 118.3, 116.4, 103.6, 67.2, 59.8, 56.0, 52.8, 35.7, 24.5, 16.5. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{24}H_{28}NO_3$ 378.2069, found 378.2071.



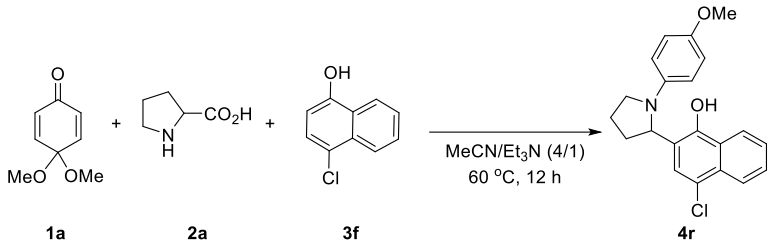
1g 2a 3e 4p

2-(1-(4-ethoxyphenyl)pyrrolidin-2-yl)-4-methoxynaphthalen-1-ol (4p). Following the general procedure, the reaction of **1g** (36.5 mg, 0.2 mmol), **2a** (34.5 mg, 0.3 mmol) and **3e** (41.9 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4p** as a yellow liquid, which was purified by column chromatography (PE/EtOAc = 90/1). Yield: 50.8 mg, 70%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.29 (br, 1H), 8.18–8.13 (m, 1H), 8.12–8.08 (m, 1H), 7.45–7.40 (m, 2H), 6.84–6.80 (m, 2H), 6.74–6.70 (m, 2H), 6.50 (s, 1H), 4.47 (dd, J_1 = 8.4 Hz, J_2 = 6.0 Hz, 1H), 3.96 (s, 3H), 3.89–3.83 (m, 1H), 3.86 (q, J = 6.8 Hz, 2H), 3.18 (dd, J_1 = 16.8 Hz, J_2 = 7.6 Hz, 1H), 2.46–2.39 (m, 1H), 2.21–2.11 (m, 2H), 2.04–1.98 (m, 1H), 1.30 (t, J = 6.8 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 153.4, 148.8, 145.5, 142.7, 126.3, 125.8, 125.4, 125.3, 121.9, 121.5, 118.2, 117.6, 115.3, 103.6, 67.7, 63.8, 55.9, 53.0, 35.5, 24.4, 15.0. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{23}H_{26}NO_3$ 364.1913, found 364.1915.



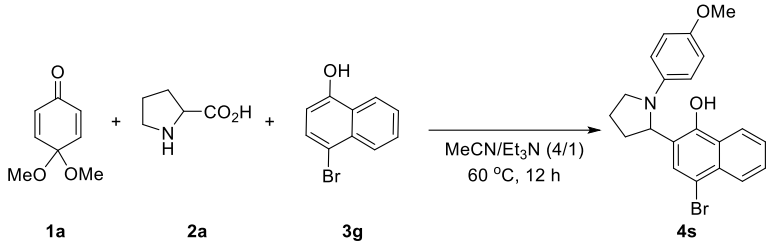
1i 2a 3e 4q

4-methoxy-2-(1-(p-tolyl)pyrrolidin-2-yl)naphthalen-1-ol (4q). Following the general procedure, the reaction of **1i** (27.7 mg, 0.2 mmol), **2a** (34.7 mg, 0.3 mmol) and **3e** (41.9 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4q** as a yellow liquid, which was purified by column chromatography (PE/EtOAc = 90/1). Yield: 42.6 mg, 64%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 9.95 (br, 1H), 8.17–8.13 (m, 1H), 8.11–8.07 (m, 1H), 7.46–7.41 (m, 2H), 6.99 (d, J = 8.4 Hz, 2H), 6.79 (d, J = 8.4 Hz, 2H), 6.98 (s, 1H), 4.55 (dd, J_1 = 8.4 Hz, J_2 = 5.6 Hz, 1H), 3.99 (s, 3H), 3.94–3.89 (m, 1H), 3.27 (dd, J_1 = 16.4 Hz, J_2 = 7.2 Hz, 1H), 2.52–2.42 (m, 1H), 2.25–2.16 (m, 2H), 2.21 (s, 3H), 2.08–2.02 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 148.8, 146.5, 145.3, 129.8, 129.7, 126.3, 125.7, 125.4, 125.3, 121.9, 121.5, 118.2, 116.2, 103.5, 67.2, 55.9, 52.5, 35.6, 24.4, 20.4. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{24}NO_2$ 334.1807, found 334.1810.



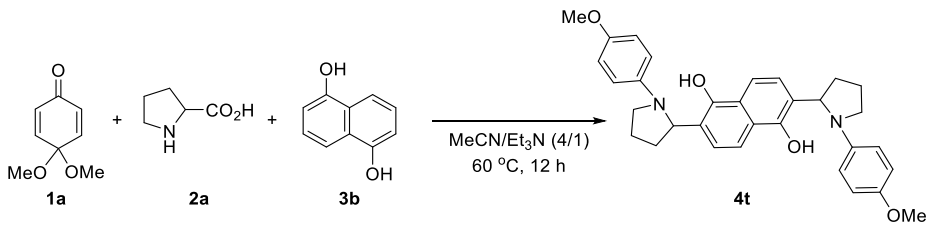
1a 2a 3f 4r

4-chloro-2-(1-(4-methoxyphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4r). Following the general procedure, the reaction of **1a** (30.8 mg, 0.2 mmol), **2a** (34.8 mg, 0.3 mmol) and **3f** (43.0 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4r** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 56.6 mg, 80%. Mp: 120–122 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ = 10.97 (br, 1H), 8.18 (dd, J_1 = 14.8 Hz, J_2 = 8.4 Hz, 2H), 7.59–7.54 (m, 1H), 7.50–7.46 (m, 1H), 7.33 (s, 1H), 6.89–6.86 (m, 2H), 6.79–6.76 (m, 2H), 4.53 (dd, J_1 = 8.0 Hz, J_2 = 6.4 Hz, 1H), 3.94–3.89 (m, 1H), 3.70 (s, 3H), 3.26–3.20 (m, 1H), 2.53–2.44 (m, 1H), 2.26–2.12 (m, 2H), 2.10–2.03 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 154.5, 151.3, 142.2, 130.4, 127.1, 126.5, 125.7, 125.4, 124.0, 122.5, 121.8, 119.5, 118.0, 114.6, 67.0, 55.5, 53.4, 35.5, 24.3. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{21}H_{21}ClNO_2$ 354.1261, found 354.1263.



1a 2a 3g 4s

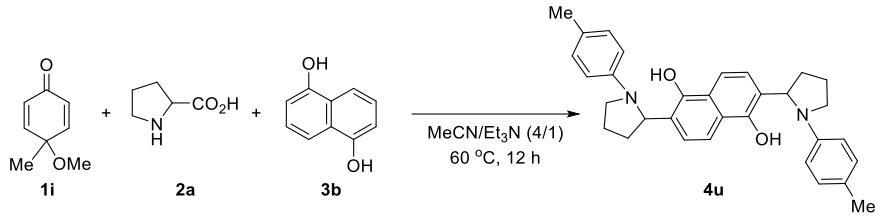
4-bromo-2-(1-(4-methoxyphenyl)pyrrolidin-2-yl)naphthalen-1-ol (4s). Following the general procedure, the reaction of **1a** (30.8 mg, 0.2 mmol), **2a** (34.8 mg, 0.3 mmol) and **3g** (53.5 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4s** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 55.7 mg, 70%. Mp: 130–132 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ = 11.00 (br, 1H), 8.16 (d, J = 8.0 Hz, 1H), 8.09 (d, J = 8.4 Hz, 1H), 7.55–7.37 (m, 3H), 6.86–6.84 (m, 2H), 6.75–6.73 (m, 2H), 4.59–4.49 (m, 1H), 3.91–3.86 (m, 1H), 3.68 (s, 3H), 3.20 (q, J = 8.0 Hz, 1H), 2.51–2.41 (m, 1H), 2.23–2.10 (m, 2H), 2.08–2.00 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 154.5, 152.0, 142.2, 131.6, 129.0, 127.4, 126.7, 126.6, 125.7, 122.5, 120.2, 118.0, 114.6, 111.7, 66.9, 55.5, 53.4, 35.5, 24.3. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{21}H_{21}BrNO_2$ 398.0756, found 398.0759.



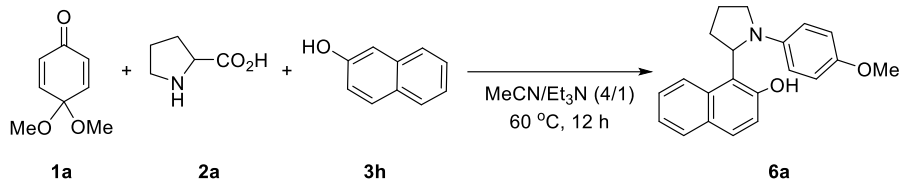
1a 2a 3b 4t

2,6-bis(1-(4-methoxyphenyl)pyrrolidin-2-yl)naphthalene-1,5-diol (4t). Following the general procedure, the reaction of **1a** (61.9 mg, 0.4 mmol), **2a** (69.2 mg, 0.6 mmol) and **3b** (32.1 mg, 0.2 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4t** as a white solid, which was purified by column chromatography (PE/EtOAc = 20/1). Yield: 45.9 mg, 45%. Mp: 223–225 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ = 10.68 (br, 2H), 7.65 (dd, J_1 = 8.4 Hz, J_2 = 2.0 Hz, 2H), 7.14 (d, J = 8.8 Hz, 2H), 6.86 (d, J = 9.2 Hz, 4H), 6.73 (dd, J_1 = 9.2 Hz, J_2 = 2.0 Hz, 4H), 4.55 (dd, J_1 = 8.0 Hz, J_2 = 6.4 Hz, 2H), 3.93–3.87 (m, 2H), 3.69 (s, 6H), 3.22 (dd, J_1 = 16.4 Hz, J_2 = 7.6 Hz, 2H), 2.47–2.40 (m, 2H), 2.25–2.11 (m, 4H), 2.08–1.99 (m, 2H). ^{13}C NMR

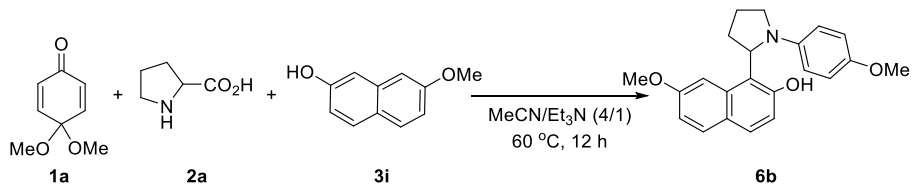
($CDCl_3$, 100 MHz): δ = 154.1, 151.6, 142.6, 125.4, 124.8, 119.5, 117.8, 114.5, 113.3, 67.2, 55.6, 53.3, 35.4, 24.3. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{32}H_{35}N_2O_4$ 511.2597, found 511.2601.



2,6-bis(1-(p-tolyl)pyrrolidin-2-yl)naphthalene-1,5-diol (4u). Following the general procedure, the reaction of **1i** (55.5 mg, 0.4 mmol), **2a** (69.3 mg, 0.6 mmol) and **3b** (32.3 mg, 0.2 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4u** as a white solid, which was purified by column chromatography (PE/EtOAc = 20/1). Yield: 45.8 mg, 48%. Mp: 236–238 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 10.41 (br, 2H), 7.65 (d, J = 8.0 Hz, 2H), 7.15 (d, J = 8.8 Hz, 2H), 6.97 (d, J = 6.4 Hz, 4H), 6.79 (d, J = 8.4 Hz, 4H), 4.60 (t, J = 6.8 Hz, 2H), 3.92–3.89 (m, 2H), 3.29–3.21 (m, 2H), 2.49–2.39 (m, 2H), 2.21 (s, 6H), 2.21–2.10 (m, 4H), 2.07–2.01 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 151.5, 146.5, 129.92, 129.90, 129.61, 129.60, 125.4, 124.8, 119.63, 119.60, 116.4, 113.4, 66.86, 66.83, 52.75, 52.72, 35.59, 35.56, 24.4, 20.4. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{32}H_{35}N_2O_2$ 479.2699, found 479.2701.

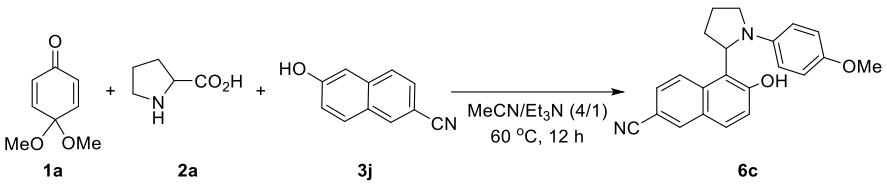


3-(1-(4-methoxyphenyl)pyrrolidin-2-yl)naphthalen-2-ol (6a). ***2 mmol scale.*** Following the general procedure, to a oven-dried Schlenk tube (25 mL) were added **1a** (308.0 mg, 2 mmol), **2a** (346.0 mg, 3 mmol) and **3h** (432.1 mg, 3 mmol) in MeCN (4 mL) and Et_3N (1 mL) at 60 °C for 12 h afforded **6a** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 383.3 mg, 60%. Mp: 165–166 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 11.46 (br, 1H), 7.88 (d, J = 8.8 Hz, 1H), 7.79 (d, J = 8.4 Hz, 1H), 7.65 (d, J = 8.8 Hz, 1H), 7.49 (t, J = 7.8 Hz, 1H), 7.34 (t, J = 7.4 Hz, 1H), 7.00 (d, J = 8.8 Hz, 1H), 6.82–6.79 (m, 2H), 6.74–6.70 (m, 2H), 5.22 (dd, J_1 = 8.4 Hz, J_2 = 5.6 Hz, 1H), 3.94–3.89 (m, 1H), 3.68 (s, 3H), 3.26–3.19 (m, 1H), 2.65–2.55 (m, 1H), 2.26–2.19 (m, 1H), 2.17–2.06 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 155.3, 154.4, 142.6, 131.6, 129.1, 129.0, 128.9, 126.6, 122.7, 121.2, 119.9, 117.7, 116.1, 114.6, 63.4, 55.6, 53.0, 34.4, 24.6. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{21}H_{22}NO_2$ 320.1651, found 320.1654.



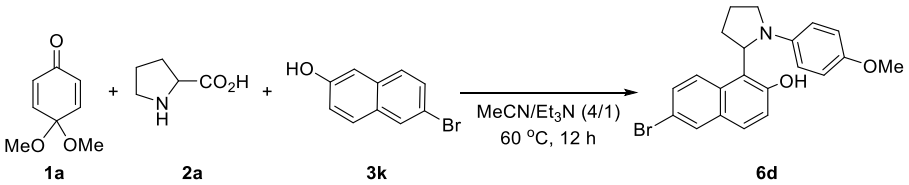
7-methoxy-1-(1-(4-methoxyphenyl)pyrrolidin-2-yl)naphthalen-2-ol (6b). Following the general procedure, the reaction of **1a** (31.0 mg, 0.2 mmol), **2a** (34.7 mg, 0.3 mmol) and **3i** (52.2 mg, 0.3 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **6b** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 40.5 mg, 58%. Mp: 174–176 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ =

11.45 (br, 1H), 7.69 (d, J = 8.8 Hz, 1H), 7.57 (d, J = 8.8 Hz, 1H), 7.16 (d, J = 1.6 Hz, 1H), 7.02 (dd, J_1 = 8.8 Hz, J_2 = 2.0 Hz, 1H), 6.86 (d, J = 8.8 Hz, 1H), 6.81 (d, J = 9.2 Hz, 2H), 6.74 (d, J = 9.2 Hz, 2H), 5.12 (dd, J_1 = 8.8 Hz, J_2 = 5.2 Hz, 1H), 3.92 (s, 3H), 3.92–3.87 (m, 1H), 3.69 (s, 3H), 3.25–3.19 (m, 1H), 2.66–2.56 (m, 1H), 2.27–2.20 (m, 1H), 2.18–2.11 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 158.3, 155.9, 154.4, 142.7, 132.7, 130.6, 128.8, 124.2, 117.6, 117.4, 115.3, 114.6, 114.0, 101.3, 63.7, 55.6, 55.3, 52.8, 34.1, 24.6. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{24}NO_3$ 350.1756, found 350.1758.



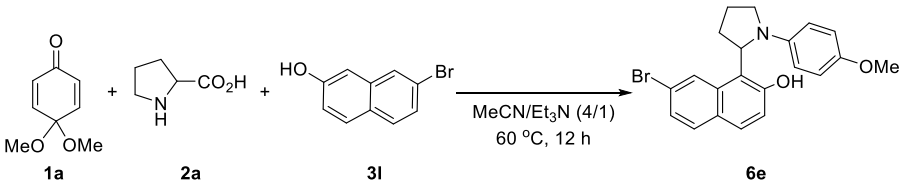
1a 2a 3j 6c

6-hydroxy-5-(1-(4-methoxyphenyl)pyrrolidin-2-yl)-2-naphthonitrile (6c). Following the general procedure, the reaction of **1a** (30.9 mg, 0.2 mmol), **2a** (34.6 mg, 0.3 mmol) and **3j** (50.8 mg, 0.3 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **6c** as a white solid, which was purified by column chromatography (PE/EtOAc = 30/1). Yield: 37.2 mg, 54%. Mp: 160–162 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 12.03 (br, 1H), 8.15 (d, J = 1.2 Hz, 1H), 7.94 (d, J = 8.8 Hz, 1H), 7.69 (d, J = 8.8 Hz, 1H), 7.63 (dd, J_1 = 9.2 Hz, J_2 = 2.0 Hz, 1H), 7.10 (d, J = 8.8 Hz, 1H), 6.82–6.78 (m, 2H), 6.76–6.72 (m, 2H), 5.18 (dd, J_1 = 8.8 Hz, J_2 = 6.0 Hz, 1H), 3.96–3.91 (m, 1H), 3.70 (s, 3H), 3.25 (dd, J_1 = 16.4 Hz, J_2 = 9.2 Hz, 1H), 2.66–2.57 (m, 1H), 2.27–2.20 (m, 1H), 2.18–2.06 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 158.3, 154.8, 142.1, 135.0, 133.3, 129.7, 127.7, 127.4, 122.2, 121.8, 119.6, 118.0, 116.7, 114.6, 105.8, 63.3, 55.5, 53.3, 34.3, 24.5. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{21}N_2O_2$ 345.1603, found 345.1604.



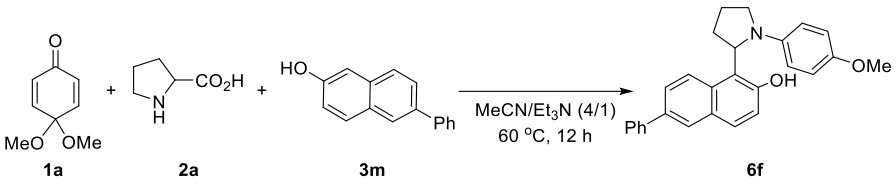
1a 2a 3k 6d

6-bromo-1-(1-(4-methoxyphenyl)pyrrolidin-2-yl)naphthalen-2-ol (6d). Following the general procedure, the reaction of **1a** (30.8 mg, 0.2 mmol), **2a** (34.7 mg, 0.3 mmol) and **3k** (66.9 mg, 0.3 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **6d** as a white solid, which was purified by column chromatography (PE/EtOAc = 90/1). Yield: 40.0 mg, 50%. Mp: 185–186 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 11.51 (br, 1H), 7.92 (d, J = 2.0 Hz, 1H), 7.75 (d, J = 9.2 Hz, 1H), 7.54 (d, J = 8.8 Hz, 2H), 7.01 (d, J = 8.8 Hz, 1H), 6.79–6.76 (m, 2H), 6.74–6.71 (m, 2H), 5.14 (dd, J_1 = 8.8 Hz, J_2 = 6.0 Hz, 1H), 3.93–3.88 (m, 1H), 3.68 (s, 3H), 3.21 (dd, J_1 = 16.0 Hz, J_2 = 9.2 Hz, 1H), 2.62–2.53 (m, 1H), 2.27–2.18 (m, 1H), 2.15–2.07 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 155.6, 154.6, 142.4, 130.9, 130.2, 130.1, 129.7, 128.1, 123.0, 121.0, 117.8, 116.5, 116.2, 114.6, 63.3, 55.5, 53.1, 34.3, 24.5. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{21}H_{21}BrNO_2$ 398.0756, found 398.0757. *The structure of this compound was further determined by single crystal X-ray diffraction.*



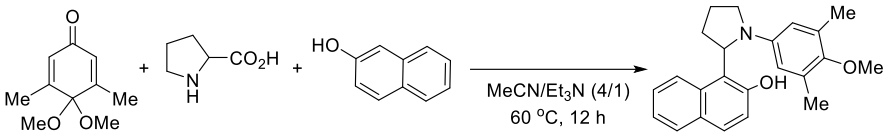
1a 2a 3l 6e

7-bromo-1-(1-(4-methoxyphenyl)pyrrolidin-2-yl)naphthalen-2-ol (6e). Following the general procedure, the reaction of **1a** (30.9 mg, 0.2 mmol), **2a** (34.6 mg, 0.3 mmol) and **3l** (67.0 mg, 0.3 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **6e** as a white solid, which was purified by column chromatography (PE/EtOAc = 90/1). Yield: 43.0 mg, 54%. Mp: 177–179 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ = 11.63 (br, 1H), 8.02 (s, 1H), 7.62 (dd, J_1 = 14.8 Hz, J_2 = 8.4 Hz, 2H), 7.40 (dd, J_1 = 8.8 Hz, J_2 = 2.0 Hz, 1H), 7.00 (d, J = 8.8 Hz, 1H), 6.81–6.78 (m, 2H), 6.75–6.71 (m, 2H), 5.10 (dd, J_1 = 8.8 Hz, J_2 = 5.6 Hz, 1H), 3.94–3.89 (m, 1H), 3.69 (s, 3H), 3.26–3.19 (m, 1H), 2.67–2.58 (m, 1H), 2.28–2.19 (m, 1H), 2.16–2.06 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 156.2, 154.6, 142.3, 132.9, 130.7, 128.9, 127.3, 125.9, 123.5, 121.2, 120.3, 117.9, 115.5, 114.6, 63.3, 55.5, 53.1, 34.3, 24.5. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{21}H_{21}BrNO_2$ 398.0756, found 398.0758.



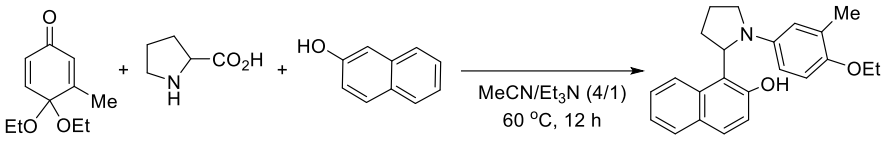
1a 2a 3m 6f

1-(1-(4-methoxyphenyl)pyrrolidin-2-yl)-6-phenylnaphthalen-2-ol (6f). Following the general procedure, the reaction of **1a** (31.1 mg, 0.2 mmol), **2a** (34.6 mg, 0.3 mmol) and **3m** (66.2 mg, 0.3 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **6f** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 39.7 mg, 50%. Mp: 181–183 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ = 11.47 (br, 1H), 7.99 (d, J = 1.2 Hz, 1H), 7.96 (d, J = 8.8 Hz, 1H), 7.76 (dd, J_1 = 8.8 Hz, J_2 = 1.6 Hz, 1H), 7.72–7.70 (m, 3H), 7.48 (t, J = 7.6 Hz, 2H), 7.36 (d, J = 7.2 Hz, 1H), 7.03 (d, J = 8.8 Hz, 1H), 6.83 (d, J = 9.2 Hz, 2H), 6.73 (d, J = 8.8 Hz, 2H), 5.24 (dd, J_1 = 8.4 Hz, J_2 = 5.6 Hz, 1H), 3.95–3.90 (m, 1H), 3.68 (s, 3H), 3.23 (dd, J_1 = 16.0 Hz, J_2 = 8.8 Hz, 1H), 2.67–2.58 (m, 1H), 2.30–2.21 (m, 1H), 2.19–2.10 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 155.4, 154.5, 142.6, 141.0, 135.4, 130.8, 129.4, 129.2, 128.9, 127.2, 127.1, 127.0, 126.1, 121.8, 120.3, 117.8, 116.2, 114.6, 63.4, 55.6, 53.1, 34.4, 24.5. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{27}H_{26}NO_2$ 396.1964, found 396.1965.



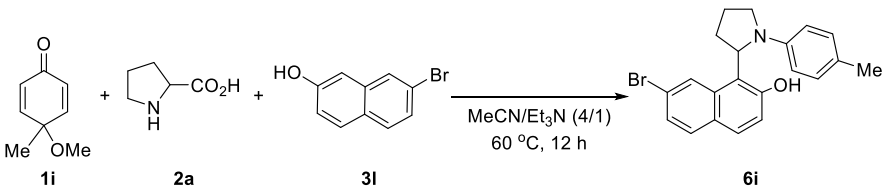
1c 2a 3h 6g

1-(1-(4-methoxy-3,5-dimethylphenyl)pyrrolidin-2-yl)naphthalen-2-ol (6g). Following the general procedure, the reaction of **1c** (36.5 mg, 0.2 mmol), **2a** (34.5 mg, 0.3 mmol) and **3h** (43.3 mg, 0.3 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **6g** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 44.3 mg, 64%. Mp: 172–173 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ = 11.36 (br, 1H), 7.87 (d, J = 8.4 Hz, 1H), 7.79 (d, J = 8.0 Hz, 1H), 7.65 (d, J = 8.8 Hz, 1H), 7.52–7.48 (m, 1H), 7.34 (t, J = 7.4 Hz, 1H), 7.00 (d, J = 9.2 Hz, 1H), 6.51 (s, 2H), 5.26 (dd, J_1 = 8.8 Hz, J_2 = 4.8 Hz, 1H), 3.91–3.86 (m, 1H), 3.62 (s, 3H), 3.28–3.22 (m, 1H), 2.62–2.52 (m, 1H), 2.29–2.17 (m, 1H), 2.15–2.06 (m, 2H), 2.13 (s, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 155.2, 151.5, 144.7, 131.6, 131.4, 129.1, 129.0, 126.5, 122.6, 121.3, 119.8, 116.6, 116.3, 63.3, 59.8, 52.7, 34.8, 24.6, 16.4. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{23}H_{26}NO_2$ 348.1964, found 348.1967.



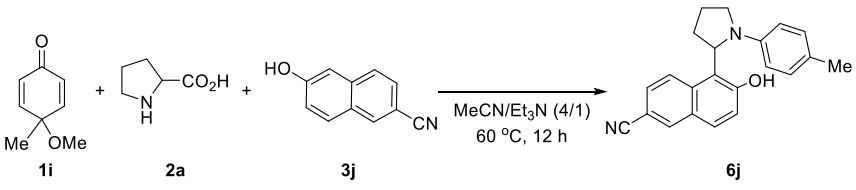
1h 2a 3h 6h

1-(1-(4-ethoxy-3-methylphenyl)pyrrolidin-2-yl)naphthalen-2-ol (6h). Following the general procedure, the reaction of **1h** (39.5 mg, 0.2 mmol), **2a** (34.8 mg, 0.3 mmol) and **3h** (43.4 mg, 0.3 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **6h** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 36.1 mg, 52%. Mp: 168–170 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ = 11.60 (br, 1H), 7.89 (d, J = 8.8 Hz, 1H), 7.78 (d, J = 8.0 Hz, 1H), 7.64 (d, J = 9.2 Hz, 1H), 7.51–7.47 (m, 1H), 7.33 (t, J = 7.2 Hz, 1H), 7.00 (d, J = 8.8 Hz, 1H), 6.75 (s, 1H), 6.62–6.57 (m, 2H), 5.22 (dd, J_1 = 8.8 Hz, J_2 = 5.2 Hz, 1H), 3.93–3.86 (m, 1H), 3.88 (q, J = 6.8 Hz, 2H), 3.26–2.19 (m, 1H), 2.64–2.54 (m, 1H), 2.27–2.18 (m, 1H), 2.16–2.04 (m, 2H), 2.11 (s, 3H), 1.33 (t, J = 6.8 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 155.3, 152.2, 142.1, 131.6, 129.1, 128.91, 128.88, 127.8, 126.5, 122.6, 121.3, 119.9, 119.7, 116.3, 114.4, 112.2, 64.1, 63.3, 53.1, 34.4, 24.5, 16.6, 15.0. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{23}H_{26}NO_2$ 348.1964, found 348.1965.



1i 2a 3l 6i

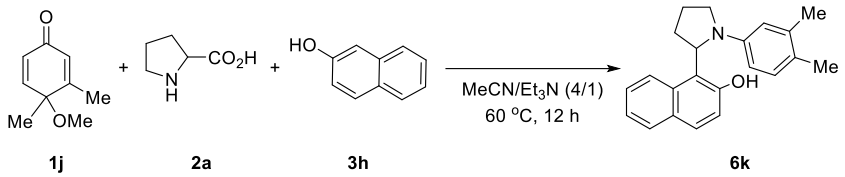
7-bromo-1-(1-(p-tolyl)pyrrolidin-2-yl)naphthalen-2-ol (6i). Following the general procedure, the reaction of **1i** (27.6 mg, 0.2 mmol), **2a** (34.6 mg, 0.3 mmol) and **3l** (66.9 mg, 0.3 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **6i** as a slurry solid, which was purified by column chromatography (PE/EtOAc = 90/1). Yield: 45.8 mg, 60%. Mp: 188–190 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ = 11.35 (br, 1H), 8.02 (s, 1H), 7.64 (d, J = 8.4 Hz, 1H), 7.60 (d, J = 8.8 Hz, 1H), 7.41 (dd, J_1 = 8.8 Hz, J_2 = 2.0 Hz, 1H), 6.99 (d, J = 5.6 Hz, 1H), 6.97 (d, J = 5.2 Hz, 2H), 6.74 (d, J = 8.8 Hz, 2H), 5.14 (dd, J_1 = 8.8 Hz, J_2 = 5.6 Hz, 1H), 3.95–3.90 (m, 1H), 3.29–3.23 (m, 1H), 2.67–2.57 (m, 1H), 2.27–2.19 (m, 1H), 2.22 (s, 3H), 2.16–2.06 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 156.1, 146.3, 132.9, 130.7, 129.8, 128.9, 127.3, 126.0, 123.7, 121.2, 120.3, 116.5, 115.6, 63.0, 52.6, 34.5, 24.5, 20.5. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{21}H_{21}BrNO$ 382.0807, found 382.0810.



1i 2a 3j 6j

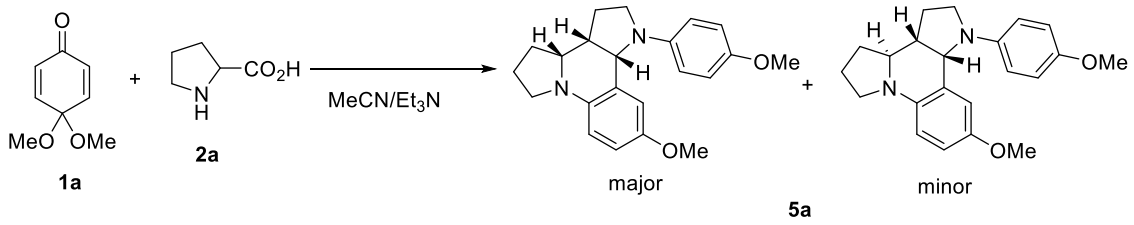
6-hydroxy-5-(1-(p-tolyl)pyrrolidin-2-yl)-2-naphthonitrile (6j). Following the general procedure, the reaction of **1i** (27.9 mg, 0.2 mmol), **2a** (34.8 mg, 0.3 mmol) and **3j** (50.9 mg, 0.3 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **6j** as a white solid, which was purified by column chromatography (PE/EtOAc = 30/1). Yield: 34.1 mg, 52%. Mp: 163–165 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ = 11.73 (br, 1H), 8.15 (d, J = 1.6 Hz, 1H), 7.94 (d, J = 8.8 Hz, 1H), 7.69 (d, J = 8.8 Hz, 1H), 7.63 (dd, J_1 = 8.8 Hz, J_2 = 1.6 Hz, 1H), 7.09 (d, J = 8.8 Hz, 1H), 6.99 (d, J = 8.4 Hz, 2H), 6.73 (d, J = 8.4 Hz, 2H), 5.22 (dd, J_1 = 8.8 Hz, J_2 = 5.6

Hz, 1H), 3.98–3.93 (m, 1H), 3.31–3.25 (m, 1H), 2.66–2.56 (m, 1H), 2.29–2.20 (m, 1H), 2.22 (s, 3H), 2.18–2.04 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 158.2, 146.1, 135.0, 133.3, 131.1, 129.8, 129.6, 127.8, 127.4, 122.3, 121.7, 119.6, 116.8, 116.5, 105.8, 63.0, 52.7, 34.5, 24.5, 20.5 HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{21}N_2O$ 329.1654, found 329.1655.



1-(1-(3,4-dimethylphenyl)pyrrolidin-2-yl)naphthalen-2-ol (6k). Following the general procedure, the reaction of **1j** (30.6 mg, 0.2 mmol), **2a** (34.7 mg, 0.3 mmol) and **3h** (43.4 mg, 0.3 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **6k** as a white solid, which was purified by column chromatography (PE/EtOAc = 60/1). Yield: 38.6 mg, 61%. Mp: 167–169 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 11.25 (br, 1H), 7.89 (d, J= 8.4 Hz, 1H), 7.78 (d, J= 8.0 Hz, 1H), 7.64 (d, J= 8.8 Hz, 1H), 7.52–7.47 (m, 1H), 7.34 (t, J= 7.4 Hz, 1H), 6.99 (d, J= 8.8 Hz, 1H), 6.89 (d, J= 8.0 Hz, 1H), 6.70 (d, J= 2.4 Hz, 1H), 6.57 (dd, J_1= 8.0 Hz, J_2= 2.4 Hz, 1H), 5.27 (dd, J_1 = 8.8 Hz, J_2 = 5.2 Hz, 1H), 3.95–3.90 (m, 1H), 3.30–3.23 (m, 1H), 2.63–2.53 (m, 1H), 2.27–2.18 (m, 1H), 2.16–2.04 (m, 2H), 2.123 (s, 3H), 2.119 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 155.2, 146.9, 137.3, 131.6, 130.2, 129.2, 129.1, 128.9, 126.5, 122.6, 121.3, 119.9, 118.0, 116.3, 113.7, 63.1, 52.5, 34.6, 24.6, 20.2, 18.8. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{24}NO$ 318.1858, found 318.1860.

The reaction of 1a and 2a at 120 °C and 60 °C



5a: 120 °C, 0.5 h, 67%, dr: 1/0.42
60 °C, 12 h, 43%, dr: 1/0.52

A mixture of **1a** (30.8 mg, 0.2 mmol), **2a** (34.5 mg, 0.3 mmol), MeCN (2 mL) and Et_3N (0.5 mL) was heated to 120 °C for 0.5 h in a closed tube. After the reaction was cooled to room temperature, the solvent was removed and the residue was purified to afford **5a** in 67% yield (23.4 mg) as a mixture of diastereo isomers (1/0.42 dr, Figure S1). Similarly, the reaction at 60 °C for 12 h afforded **5a** in 43% yield (14.8 mg) as a mixture of diastereo isomers (1/0.52 dr, **Figure S2**). The structures of the diastereo isomers were assigned based on known similar compounds reported in literatures.[7] The major isomer was obtained after several times of washing with PE and characterized. **5a** (major isomer): ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 6.95 (d, J= 2.8 Hz, 1H), 6.87 (d, J= 7.6 Hz, 2H), 6.76 (d, J= 8.4 Hz, 2H), 6.69 (d, J= 8.4 Hz, 1H), 6.36 (d, J= 8.8 Hz, 1H), 5.02 (d, J= 7.2 Hz, 1H), 3.78 (s, 3H), 3.58 (s, 3H), 3.58–3.55 (m, 1H), 3.44–3.36 (m, 2H), 3.22–3.13 (m, 2H), 2.55–2.49 (m, 1H), 2.08–2.06 (m, 1H), 2.02–1.83 (m, 4H), 1.73–1.66 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 150.9, 150.8, 143.9, 138.4, 125.2, 115.2, 115.0, 113.5, 112.3, 111.3, 58.4, 57.2, 56.1, 55.7, 48.2, 47.1, 40.6, 29.9, 23.3, 23.0. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{27}N_2O_2$ 351.2073, found 351.2075.

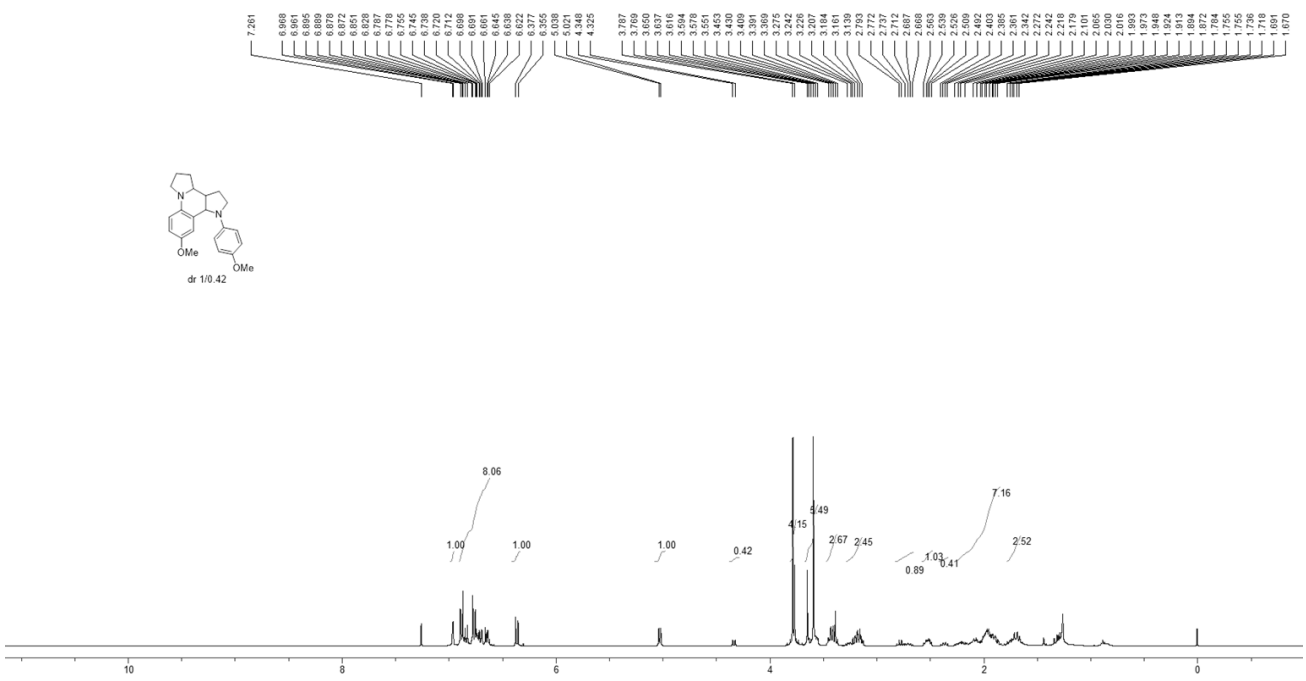


Figure S2

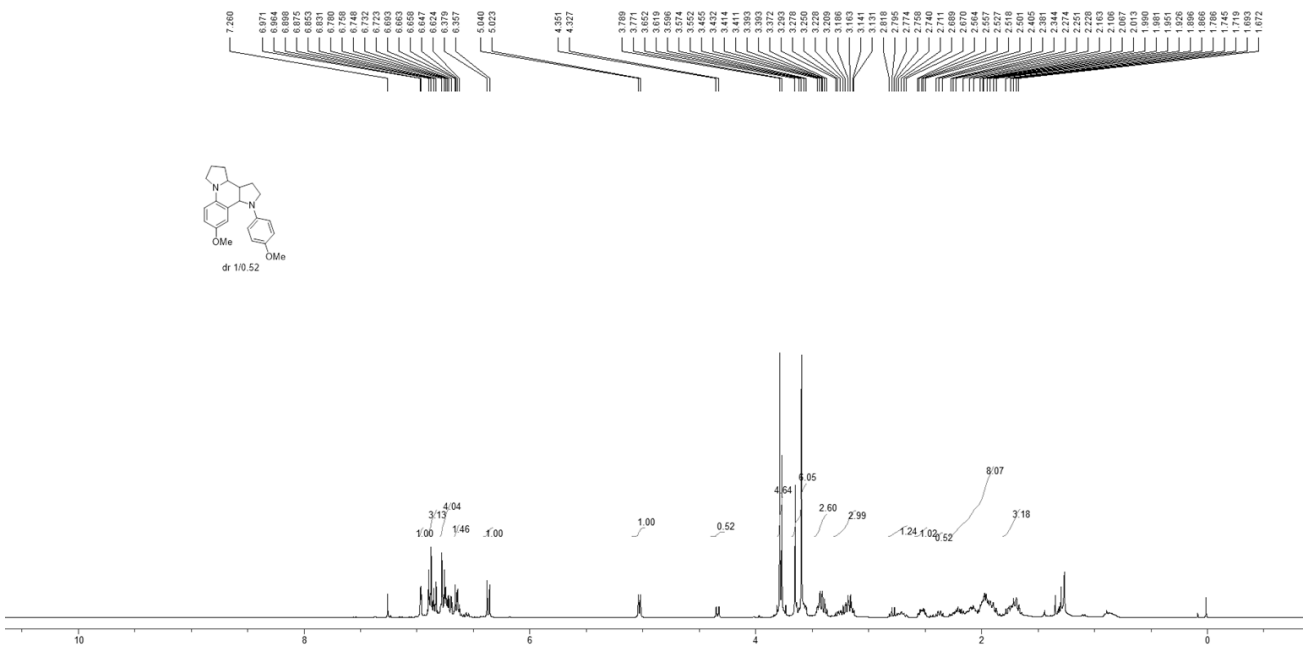
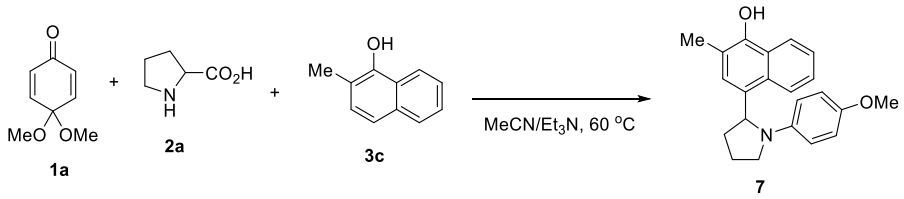


Figure S3

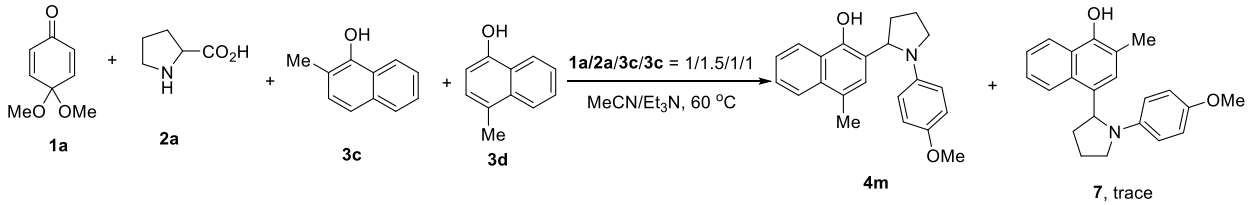
The reaction of 2-methyl-1-naphthols (3b) with 1a and 2a



1a 2a 3c 7

The reaction of **1a** (61.7 mg, 0.4 mmol), **2a** (69.2 mg, 0.6 mmol) and **3c** (75.5 mg, 0.48 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded 4-(1-(4-methoxyphenyl)pyrrolidin-2-yl)-2-methylnaphthalen-1-ol (**7**) in 15% yield (20.0 mg). brown liquid. ^{1}H NMR (DMSO-d_6, 400 MHz): δ = 8.87 (br, 1H), 8.28–8.25 (m, 1H), 8.09–8.07 (m, 1H), 7.49–7.47 (m, 2H), 6.97 (s, 1H), 6.67 (d, J= 9.0 Hz, 2H), 6.31 (d, J= 9.0 Hz, 2H), 5.20 (d, J= 8.0 Hz, 1H), 3.74–3.70 (m, 1H), 3.57 (s, 3H), 3.32–3.26 (m, 1H), 2.52–2.43 (m, 1H), 2.23 (s, 3H), 1.96–1.88 (m, 2H), 1.78–1.74 (m, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz): δ = 150.8, 149.1, 142.3, 130.3, 130.0, 126.54, 126.49, 125.5, 124.8, 123.4, 123.1, 117.5, 115.1, 113.2, 60.0, 55.8, 49.6, 34.9, 23.6, 17.2. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{22}H_{24}NO_2$ 334.1807, found 334.1808.

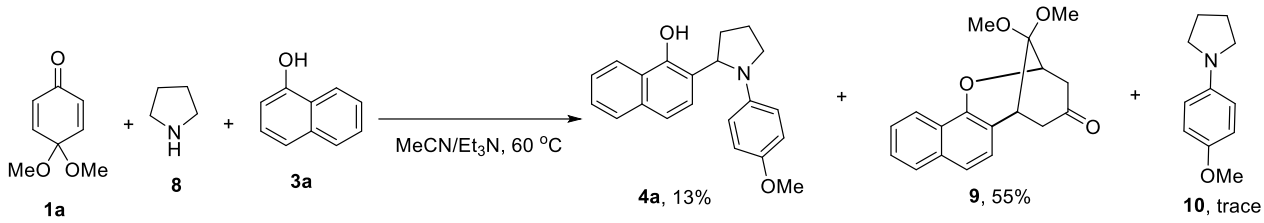
The competitive reaction of 3b and 3c in equivalent molar ratio with 1a and 2a



1a 2a 3c 3d 4m 7, trace

The reaction of **1a** (30.9 mg, 0.2 mmol), **2a** (34.7 mg, 0.3 mmol), **3c** (31.7 mg, 0.2 mmol) and **3d** (31.7 mg, 0.2 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4m** in 78% yield (52.2 mg). **7** was detected by TLC, yet was not obtained after column chromatography on silica gel due to a very low yield.

The reaction of QMA 1a, pyrrolidine (8) and 1-naphthols (3a)



1a 8 3a 4a, 13% 9, 55% 10, trace

The reaction of **1a** (30.8 mg, 0.2 mmol), pyrrolidine (**8**) (21.7 mg, 0.3 mmol), **3a** (34.6 mg, 0.24 mmol) in MeCN (2 mL) and Et_3N (0.5 mL) at 60 °C for 12 h afforded **4a** in 13% yield (8.4 mg), 13,13-dimethoxy-2,3,5,6-tetrahydro-4H-2,6-methanonaphtho[1,2-b]oxocin-4-one (**9**) in 55% yield (32.7 mg), and 1-(4-methoxyphenyl)pyrrolidine (**10**) (ca. 1.2 mg, yield < 4%). 13,13-dimethoxy-2,3,5,6-tetrahydro-4H -2,6-methanonaphtho[1,2-b]oxocin-4-one (**9**): orange oil. ^{1}H NMR (DMSO-d_6, 400 MHz): δ = 8.05–8.02 (m, 1H), 7.84–7.82 (m, 1H), 7.51–7.48 (m, 2H), 7.45 (d, J = 8.4 Hz, 2H), 7.22 (d, J = 8.4 Hz, 2H), 5.08-5.06 (m, 1H), 3.63–3.61 (m, 1H), 3.45 (s, 3H), 3.26 (s, 3H), 3.00–2.95 (m, 2H), 2.54–2.49 (m, 1H), 2.44–2.39 (m, 1H). ^{13}C NMR (DMSO-d_6, 100 MHz): δ = 207.9, 145.9, 133.7, 128.0, 127.6, 126.7, 126.1, 124.3, 121.7, 121.1, 118.5, 96.5, 72.1, 48.94, 48.86, 45.6, 45.5, 38.1. HRMS (ESI/Q-TOF) m/z: $[M + H]^+$ calcd for $C_{18}H_{19}O_4$ 299.1283, found 299.1288.

6. References

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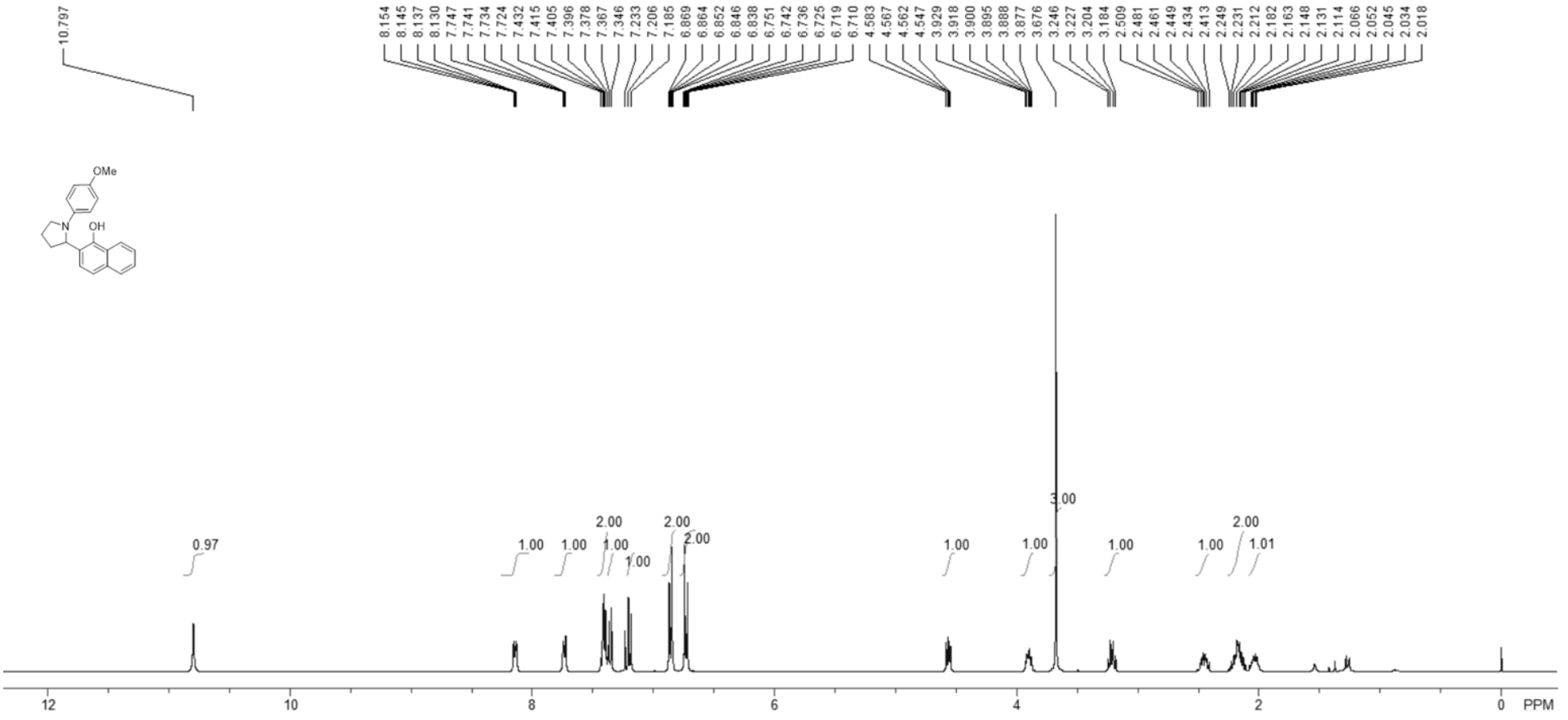
7. Copies of ^{1}H and ^{13}C NMR spectra

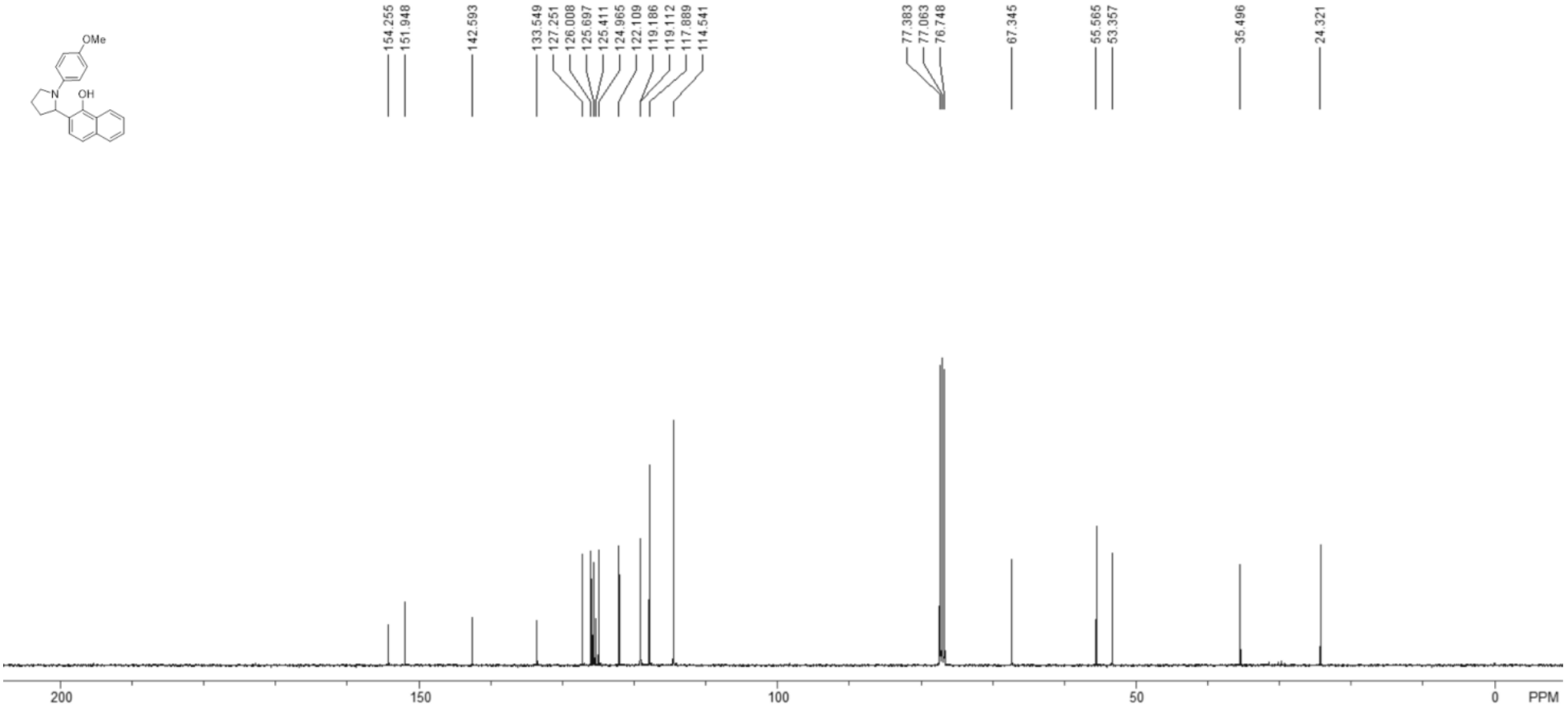
^{1}H NMR of 4a

400 MHz, $CDCl_3$



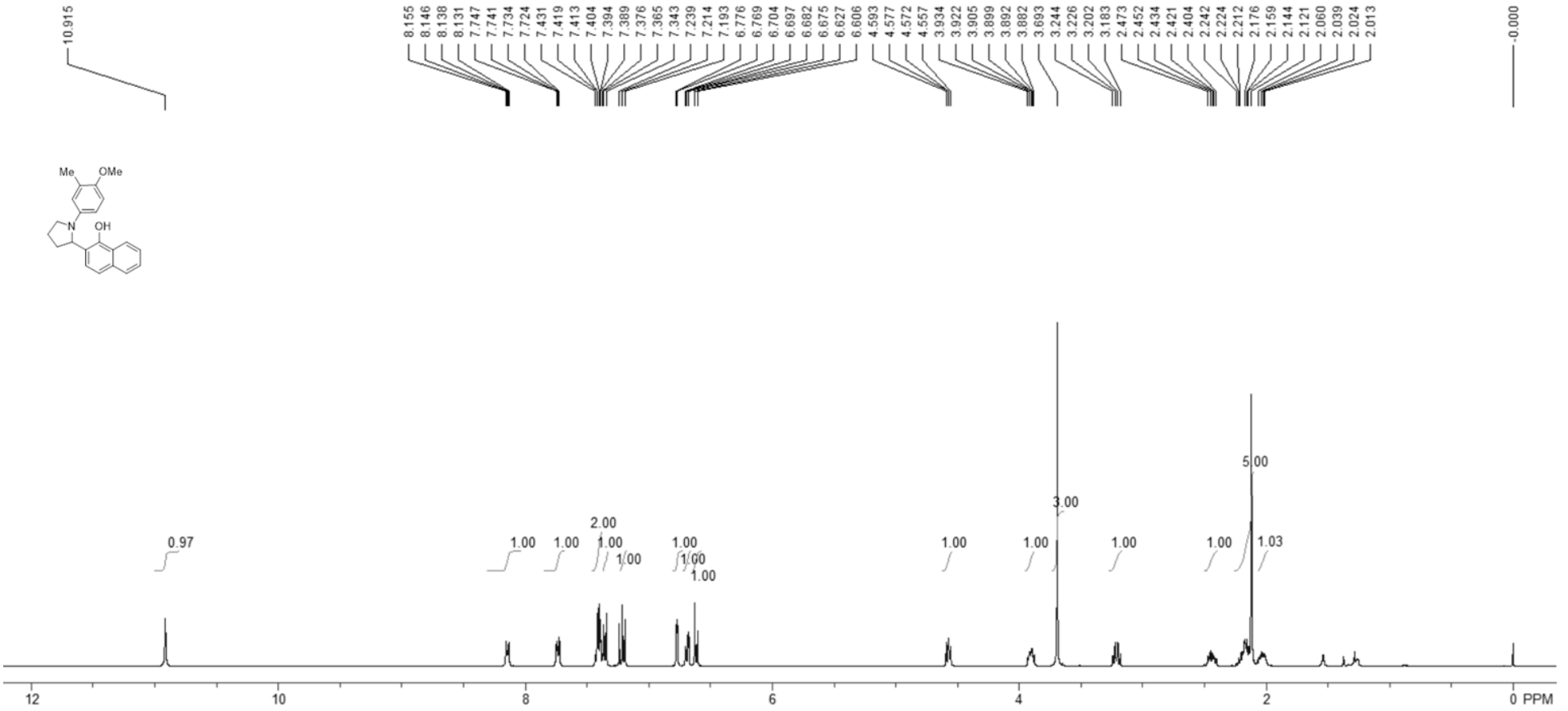
^{13}C NMR of 4a

100 MHz, $CDCl_3$



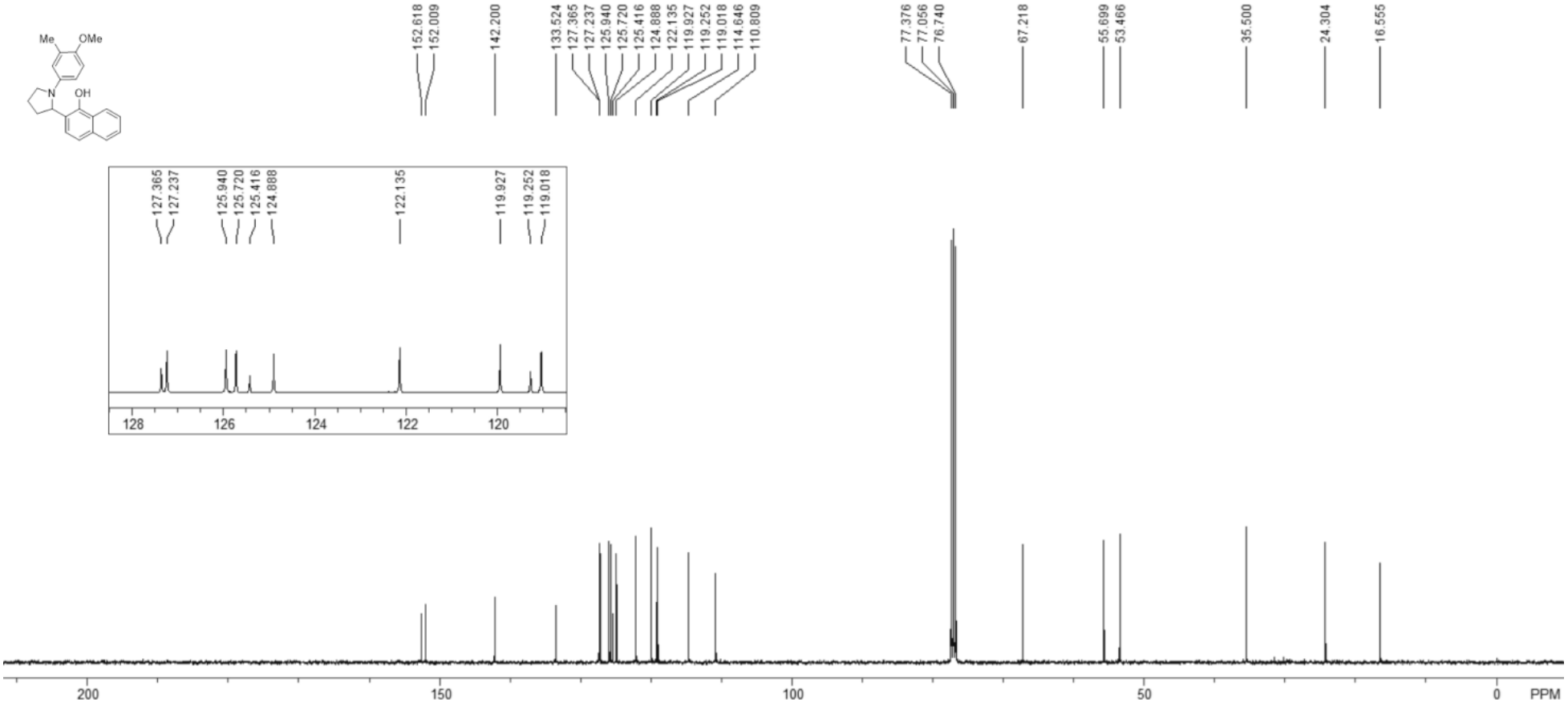
^{1}H NMR of 4b

400 MHz, $CDCl_3$



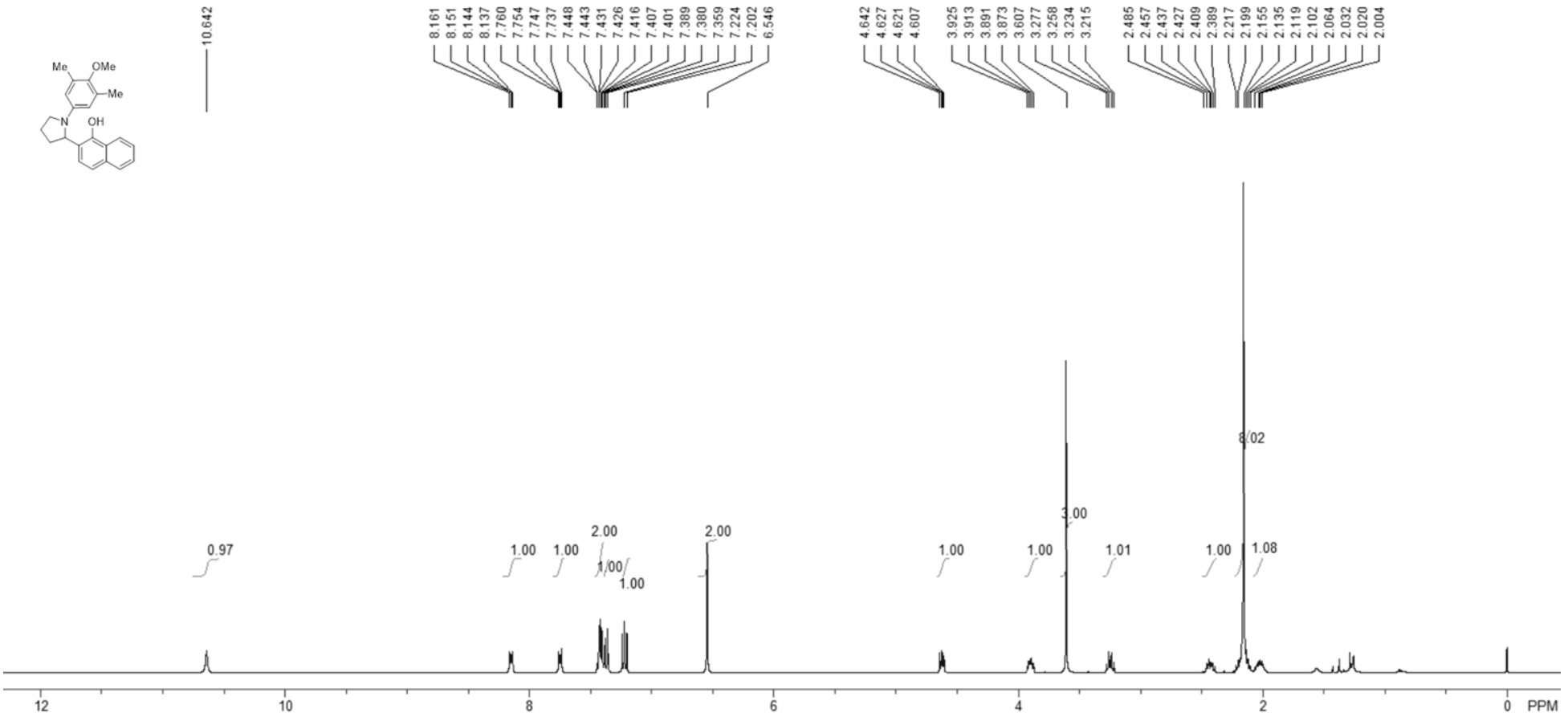
^{13}C NMR of 4b

100 MHz, $CDCl_3$



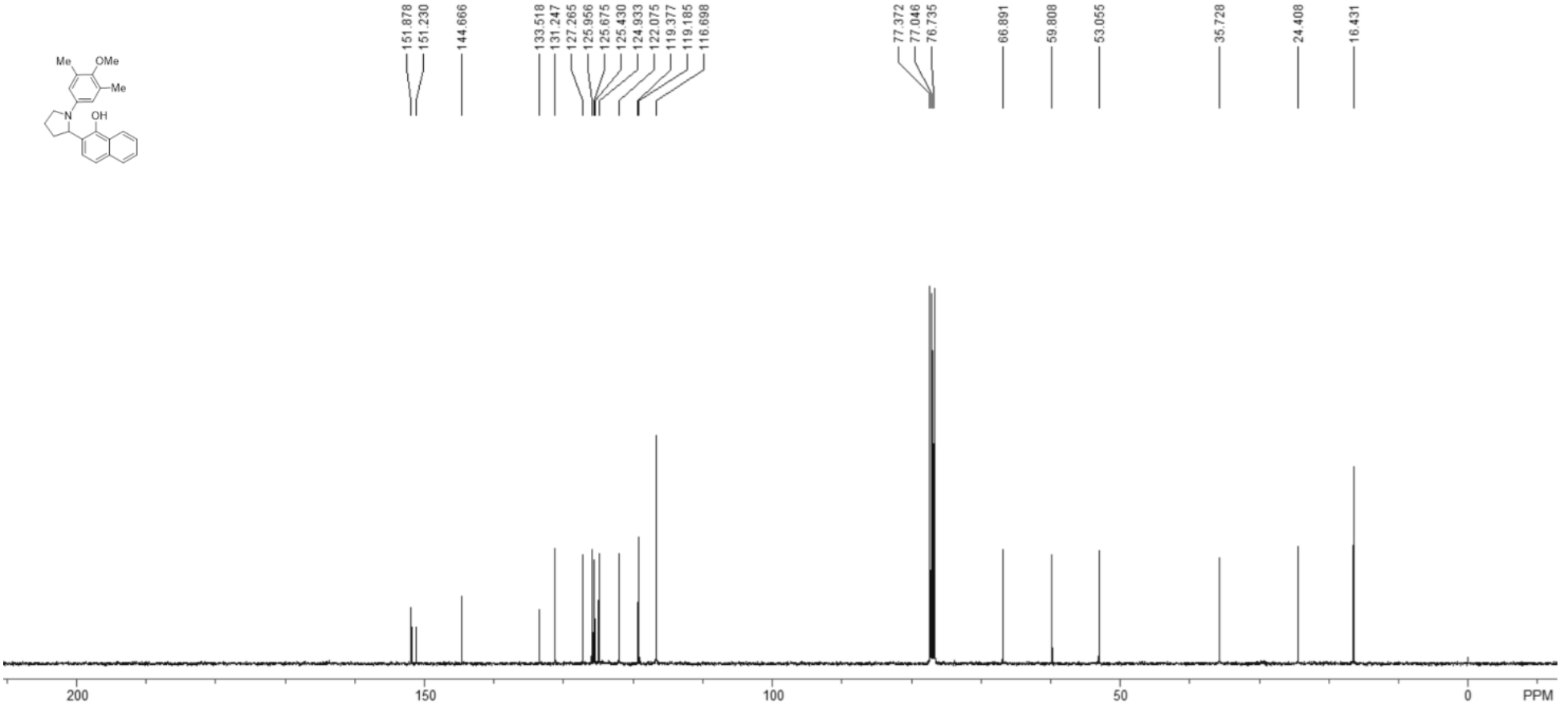
^{1}H NMR of 4c

400 MHz, $CDCl_3$



^{13}C NMR of 4c

100 MHz, $CDCl_3$



^{1}H NMR of 4d

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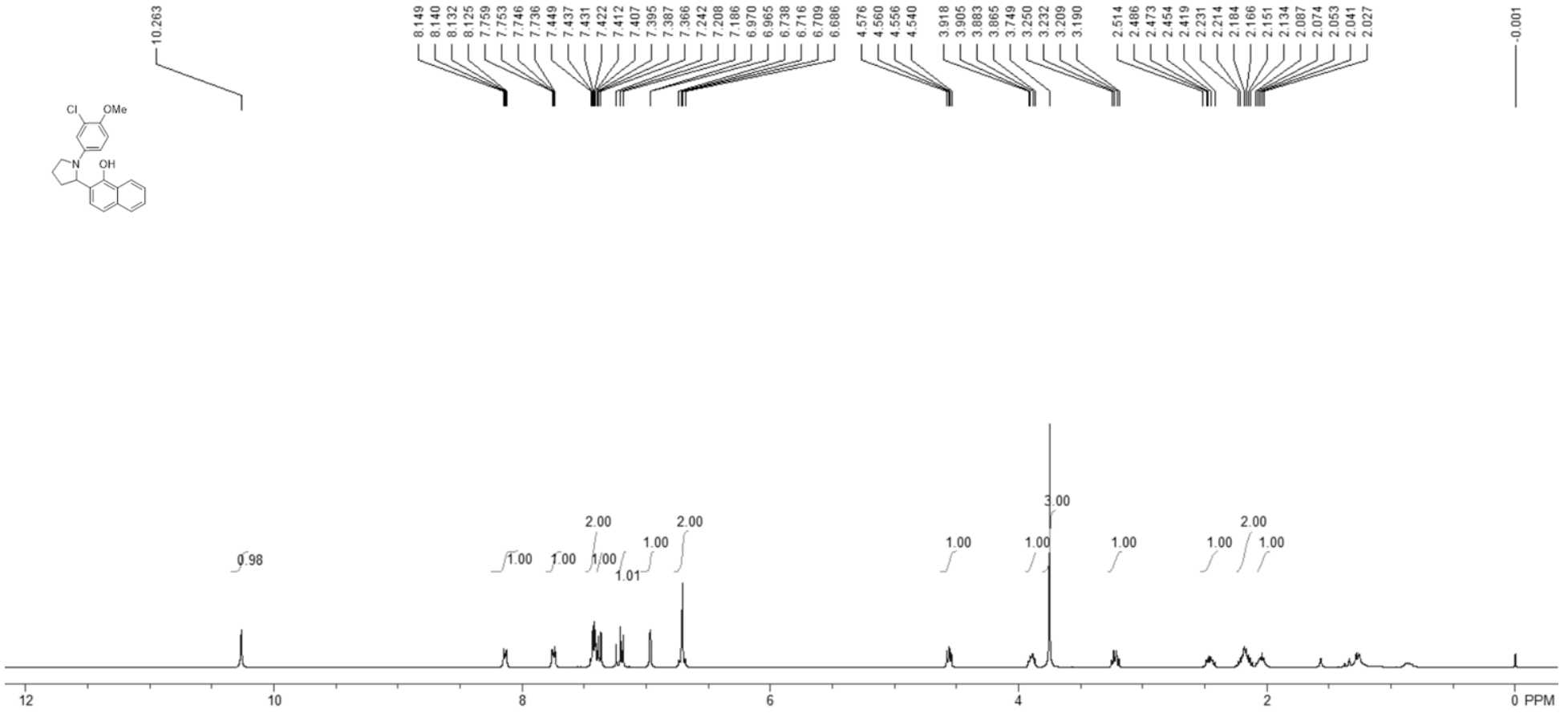
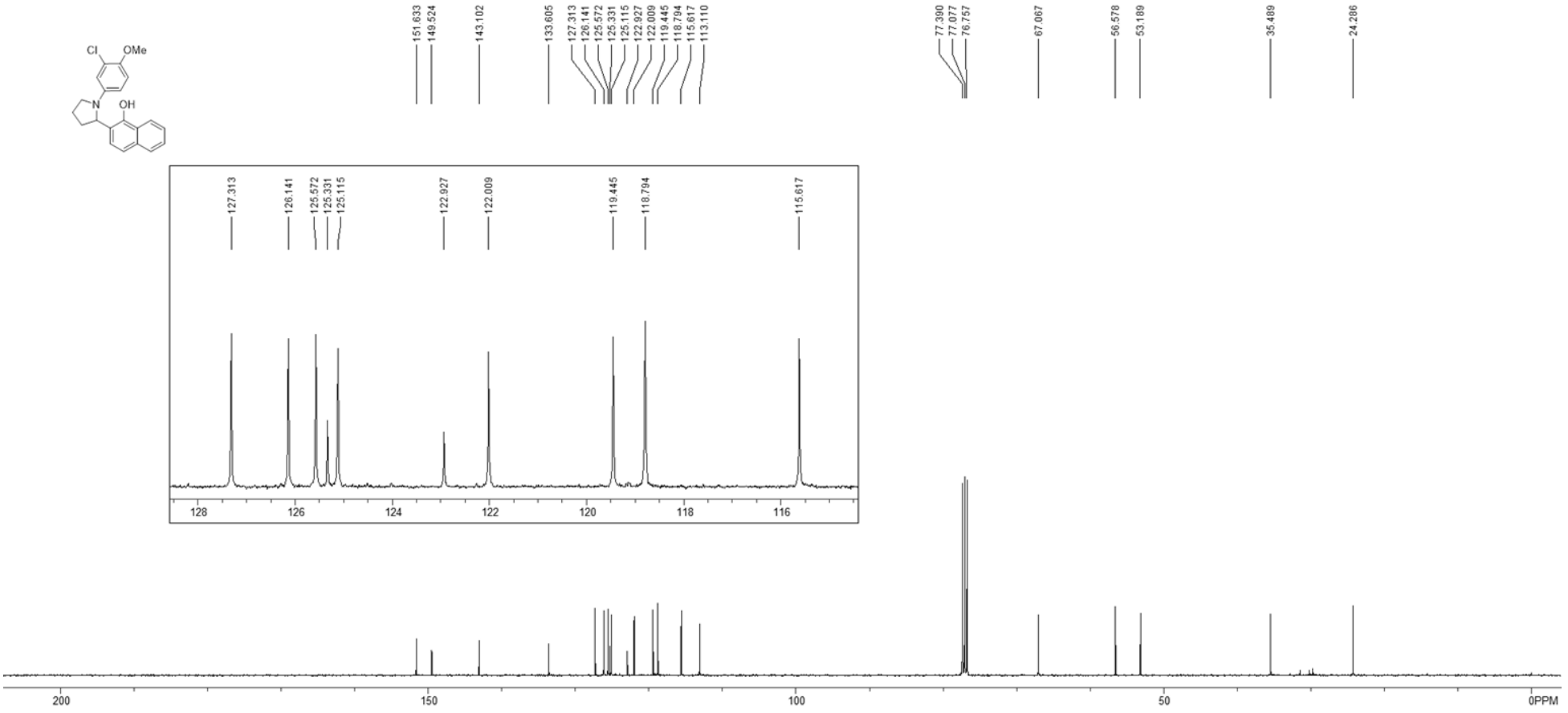


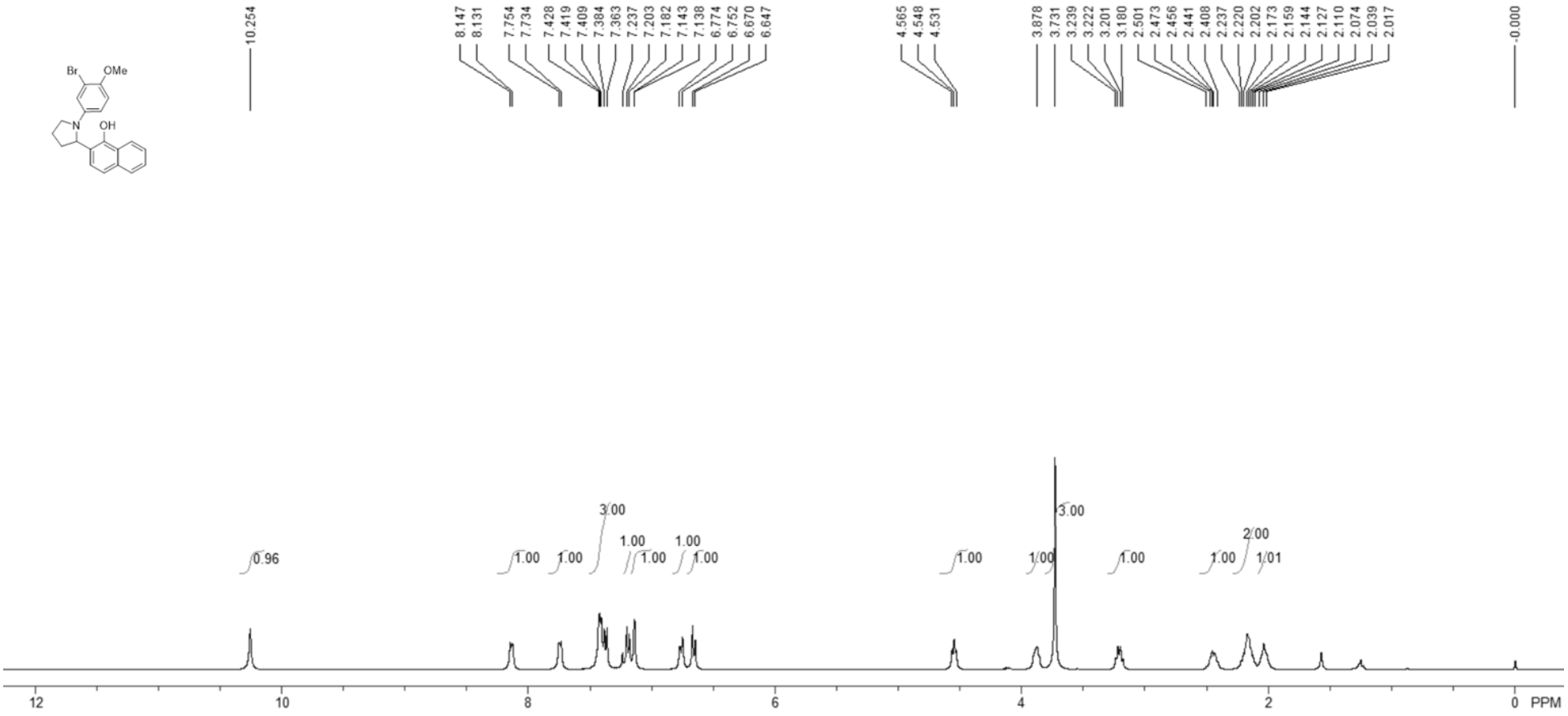
^{13}C NMR of 4d

100 MHz, $CDCl_3$



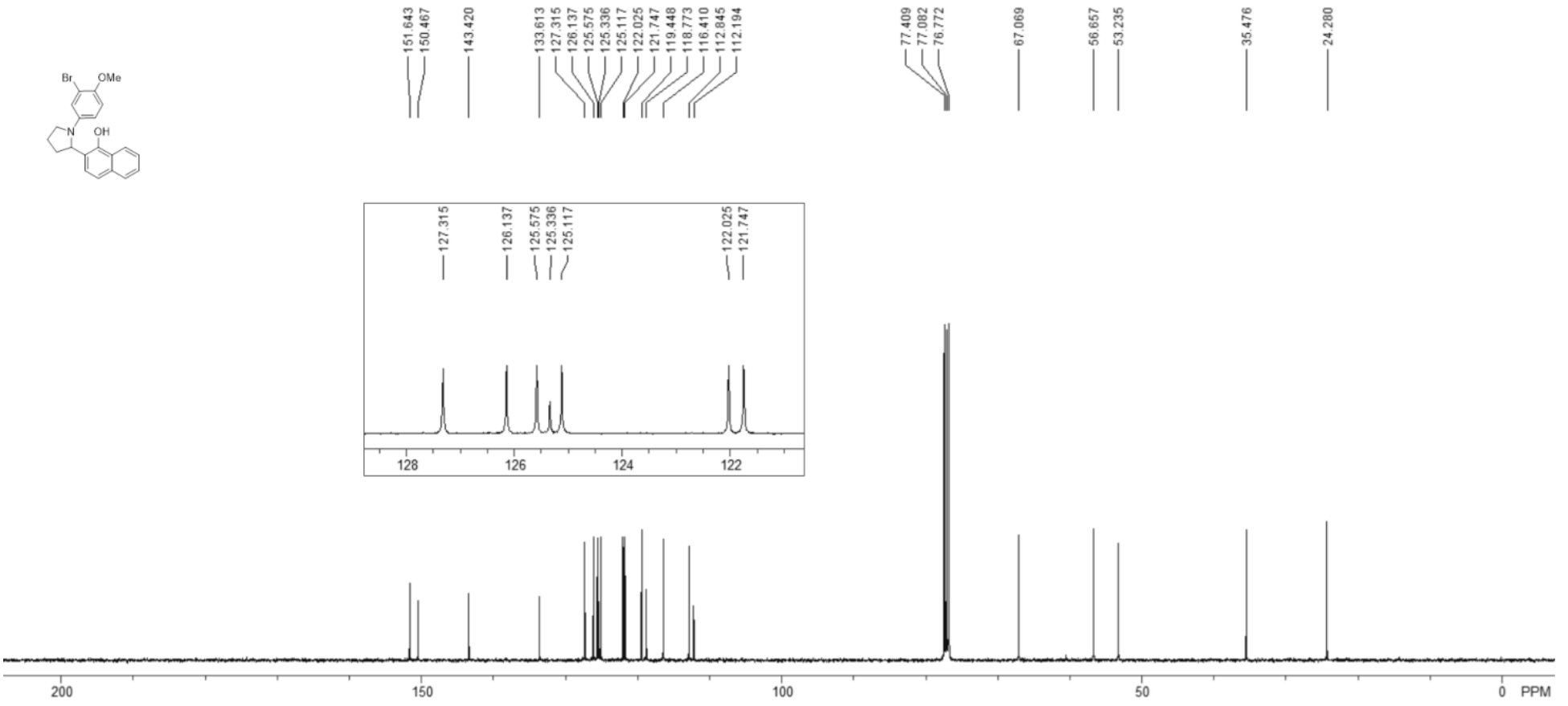
^{1}H NMR of 4e

400 MHz, $CDCl_3$



^{13}C NMR of 4e

100 MHz, $CDCl_3$



^{1}H NMR of 4g

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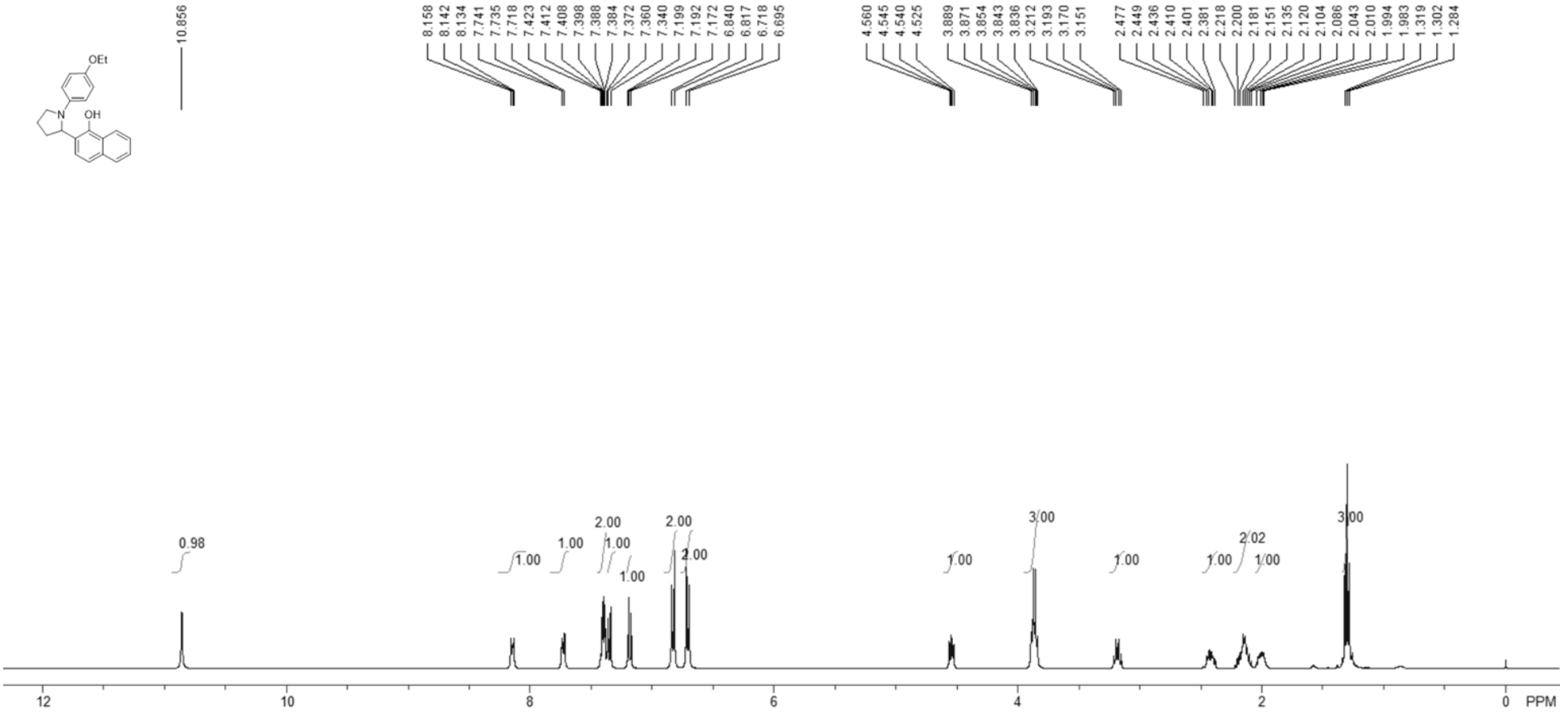
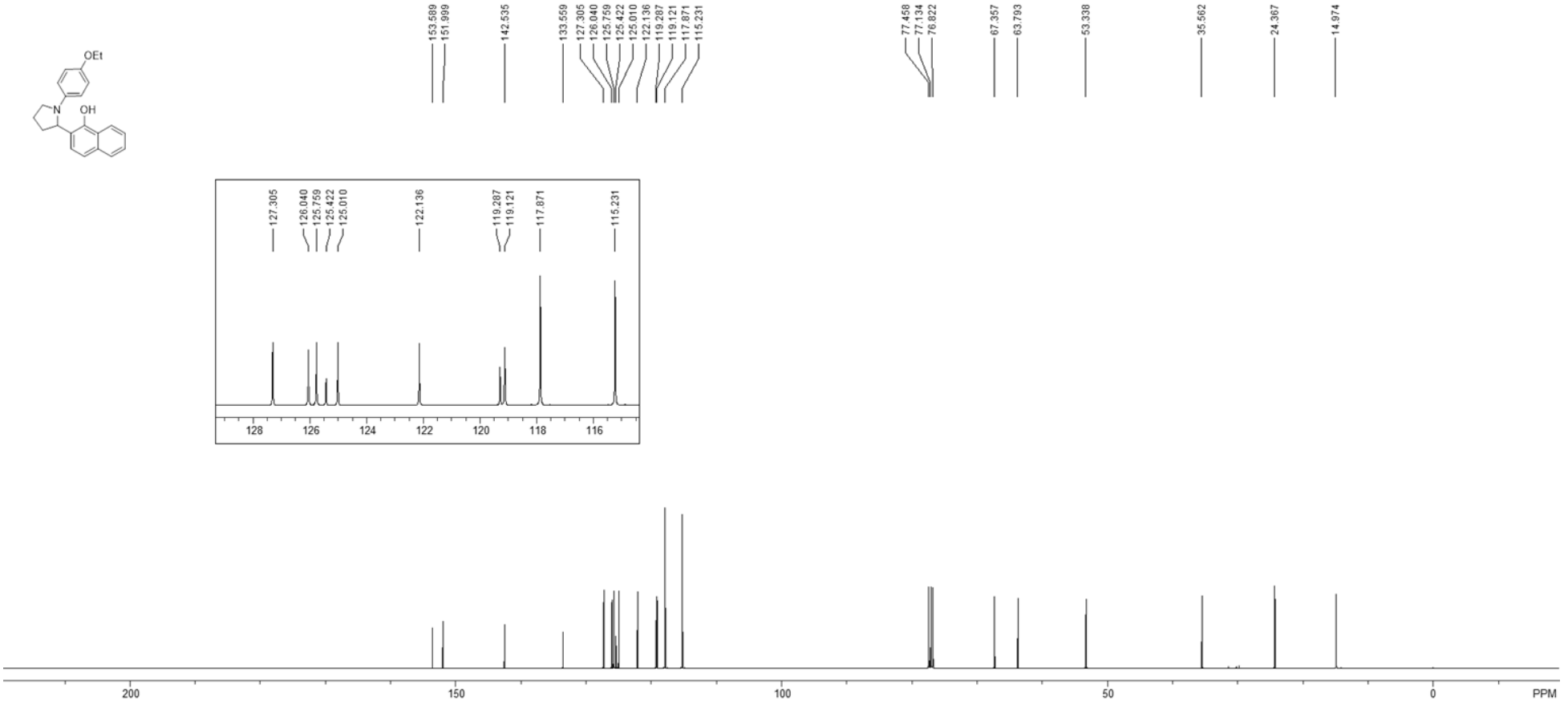


^{13}C NMR of 4g

100 MHz, $CDCl_3$



^{1}H NMR of 4h

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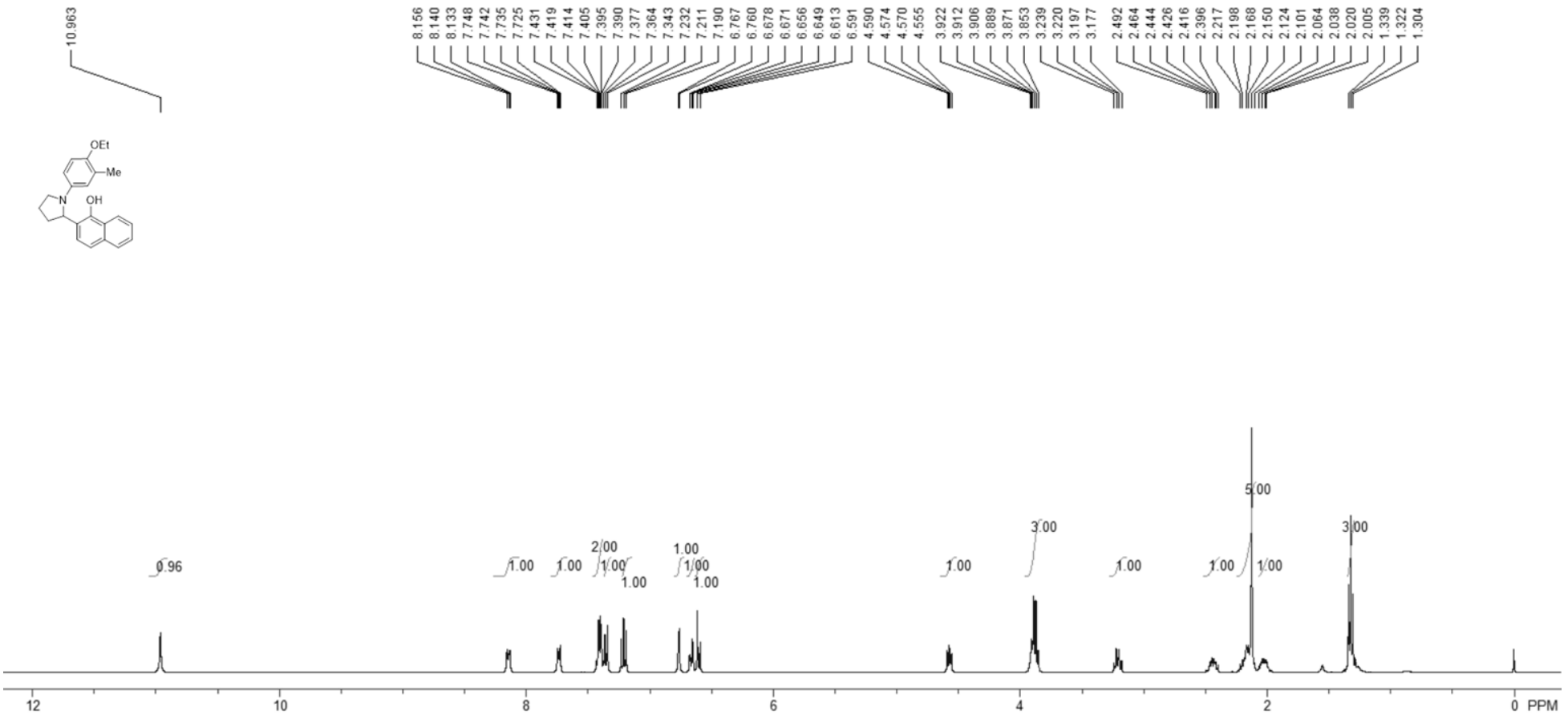
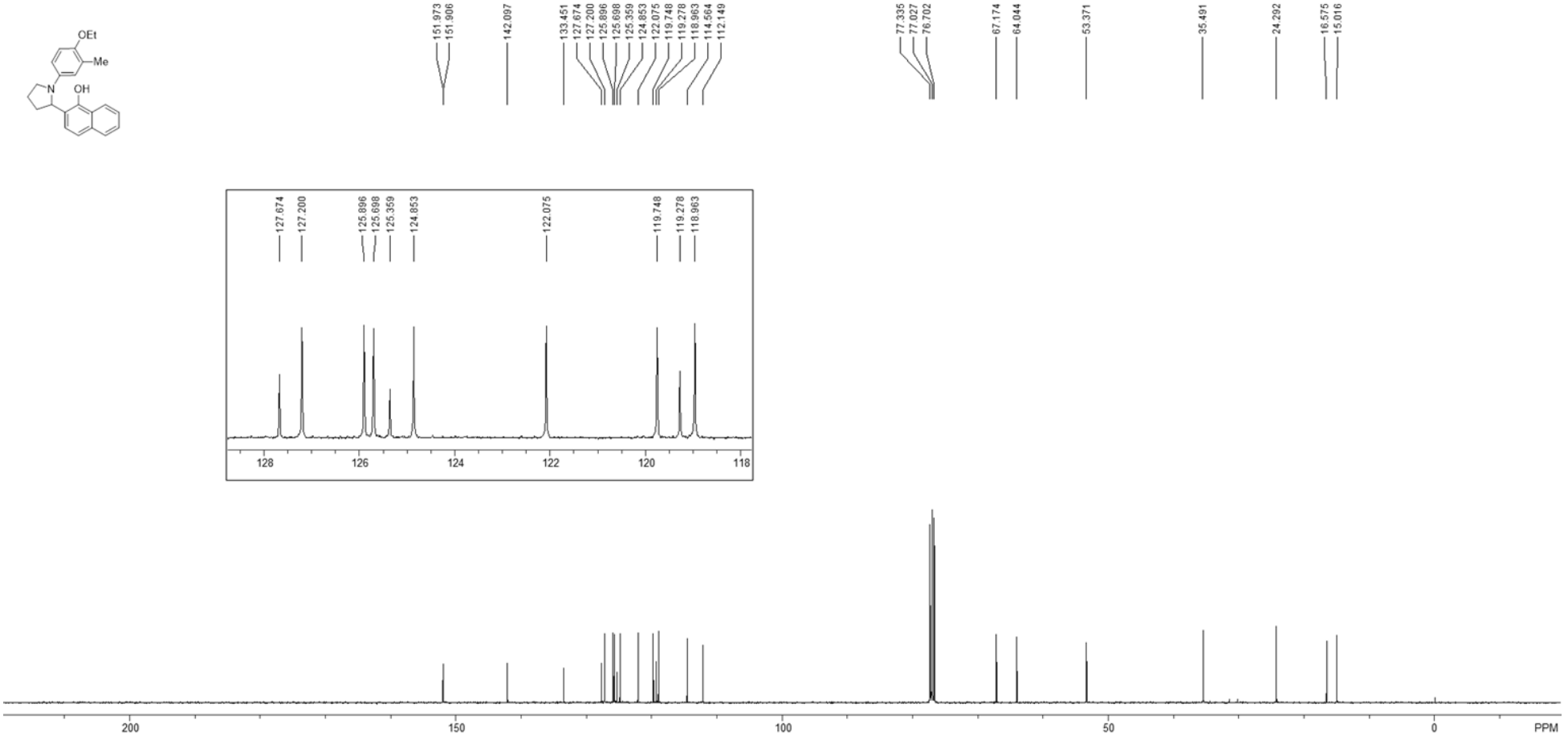


^{13}C NMR of 4h

100 MHz, $CDCl_3$



^{1}H NMR of 4i

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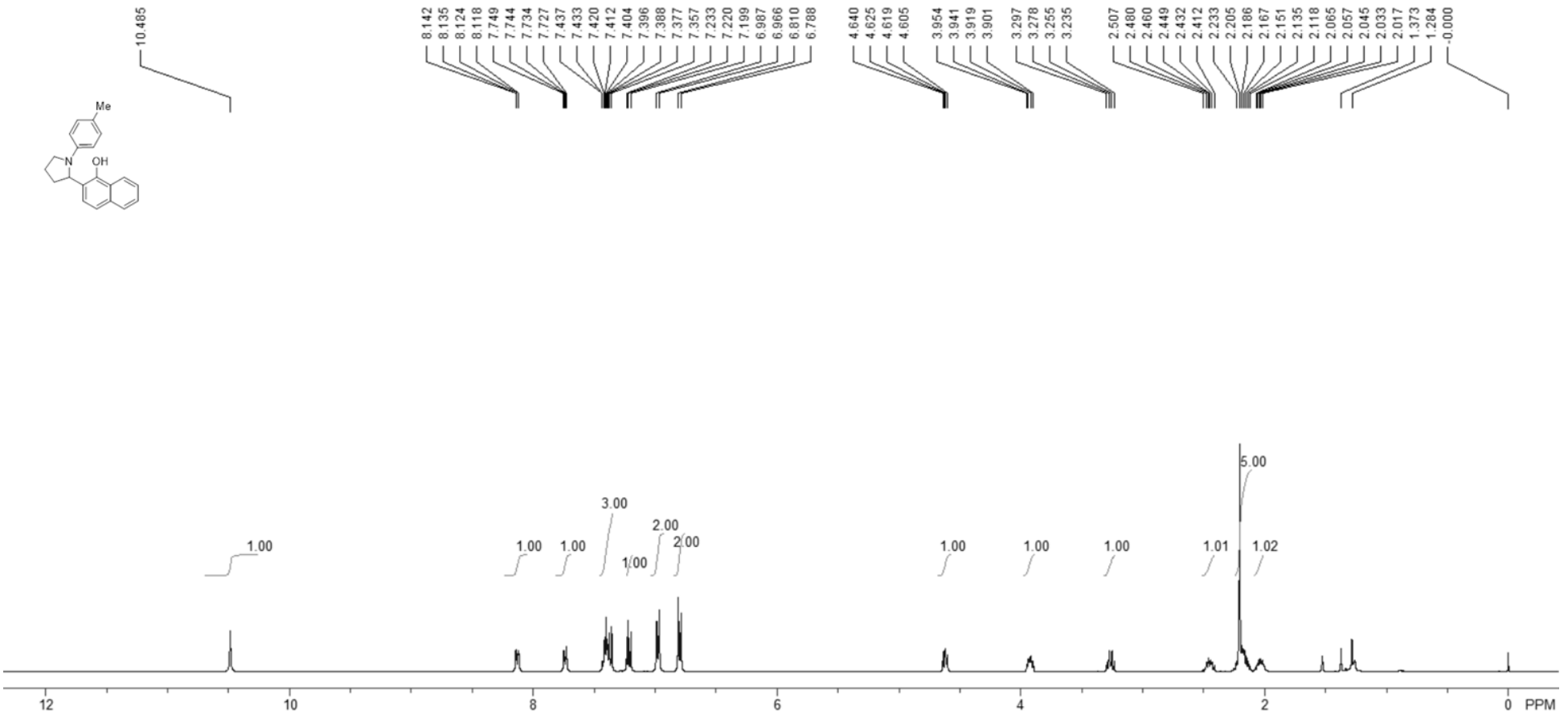
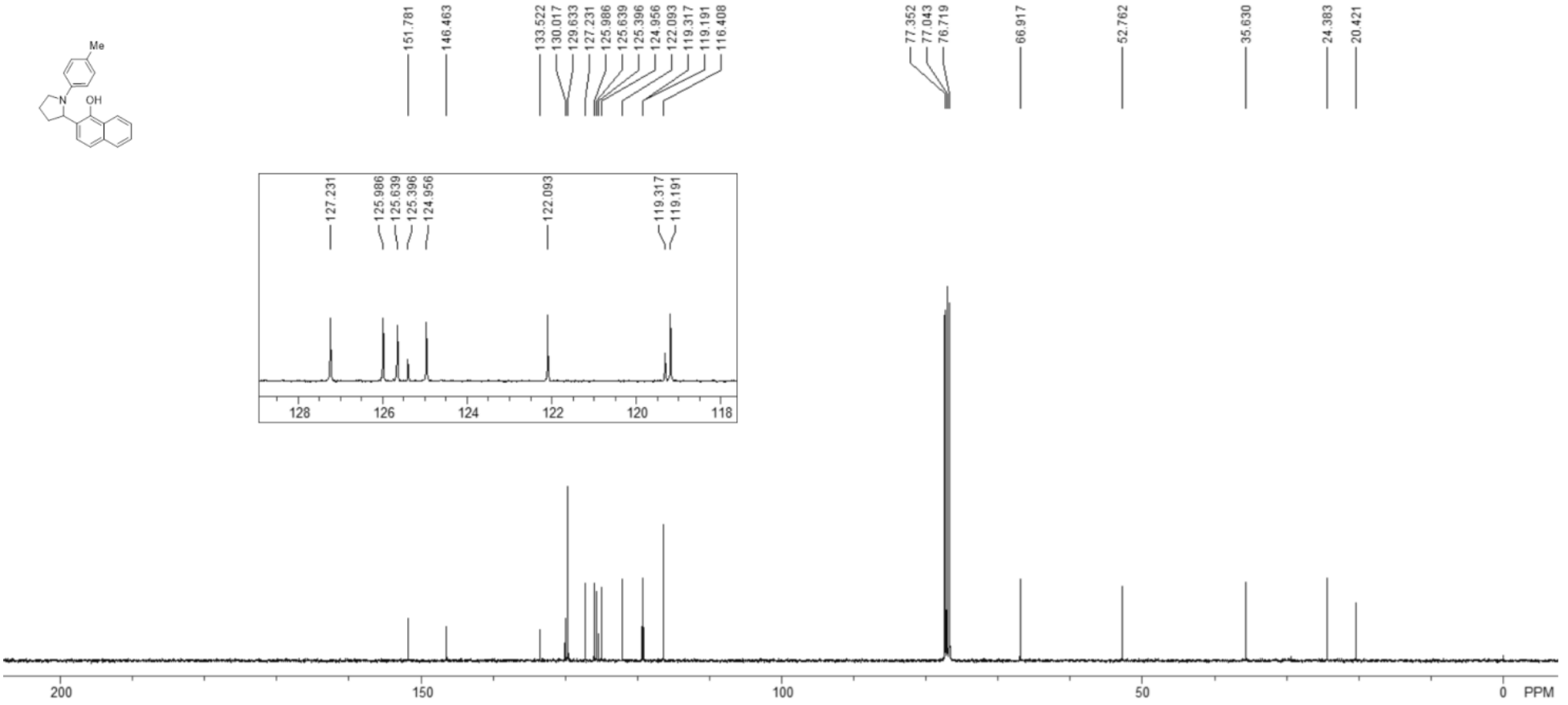


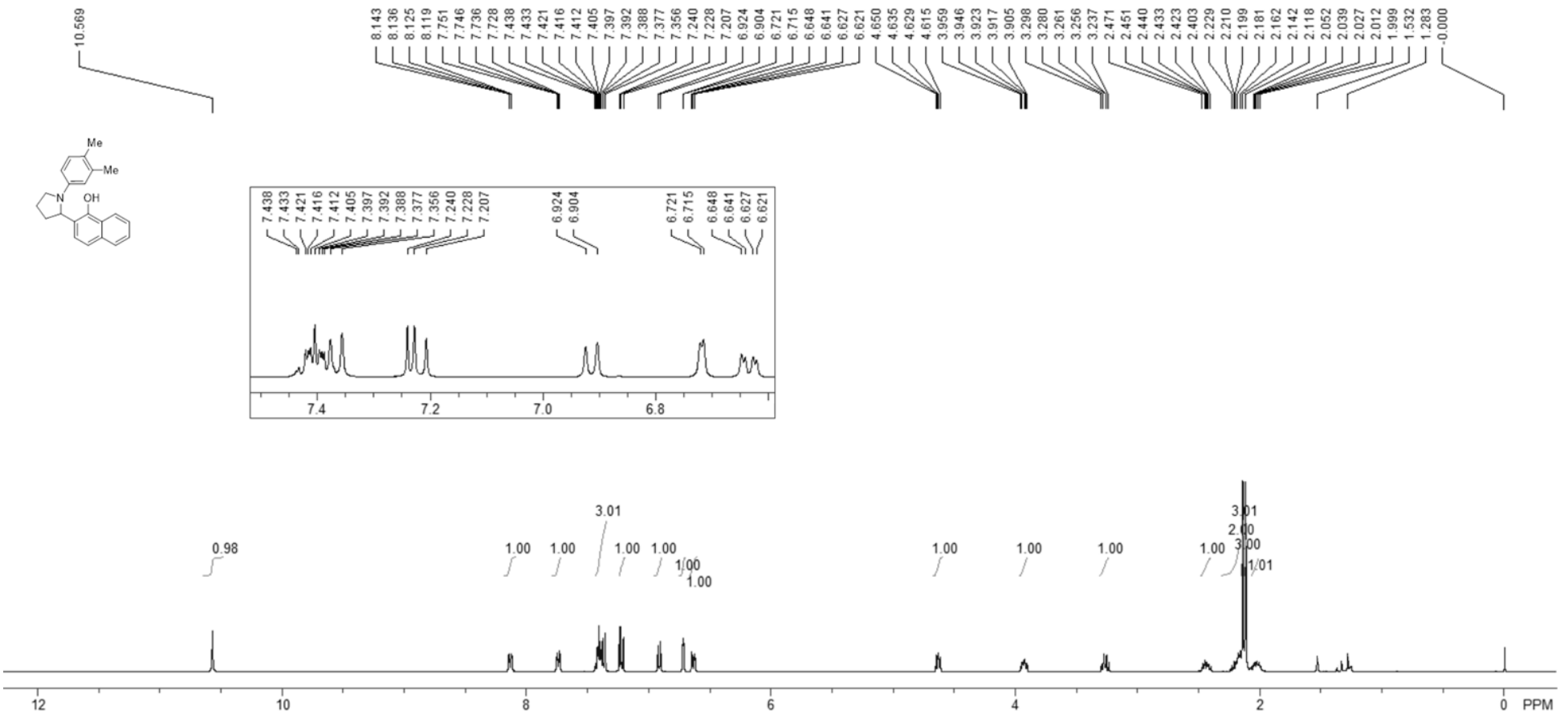
^{13}C NMR of 4i

100 MHz, $CDCl_3$



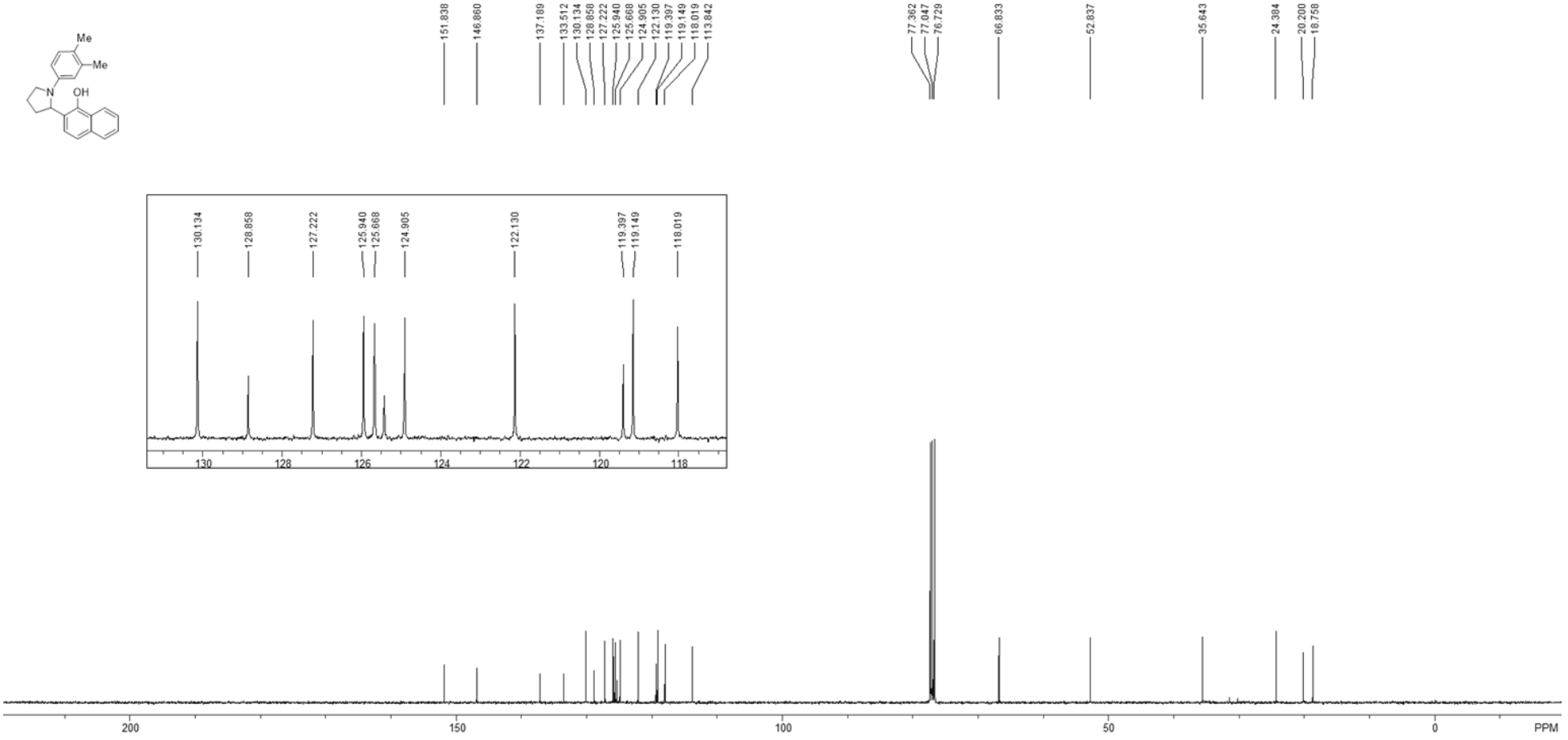
^{1}H NMR of 4j

400 MHz, $CDCl_3$



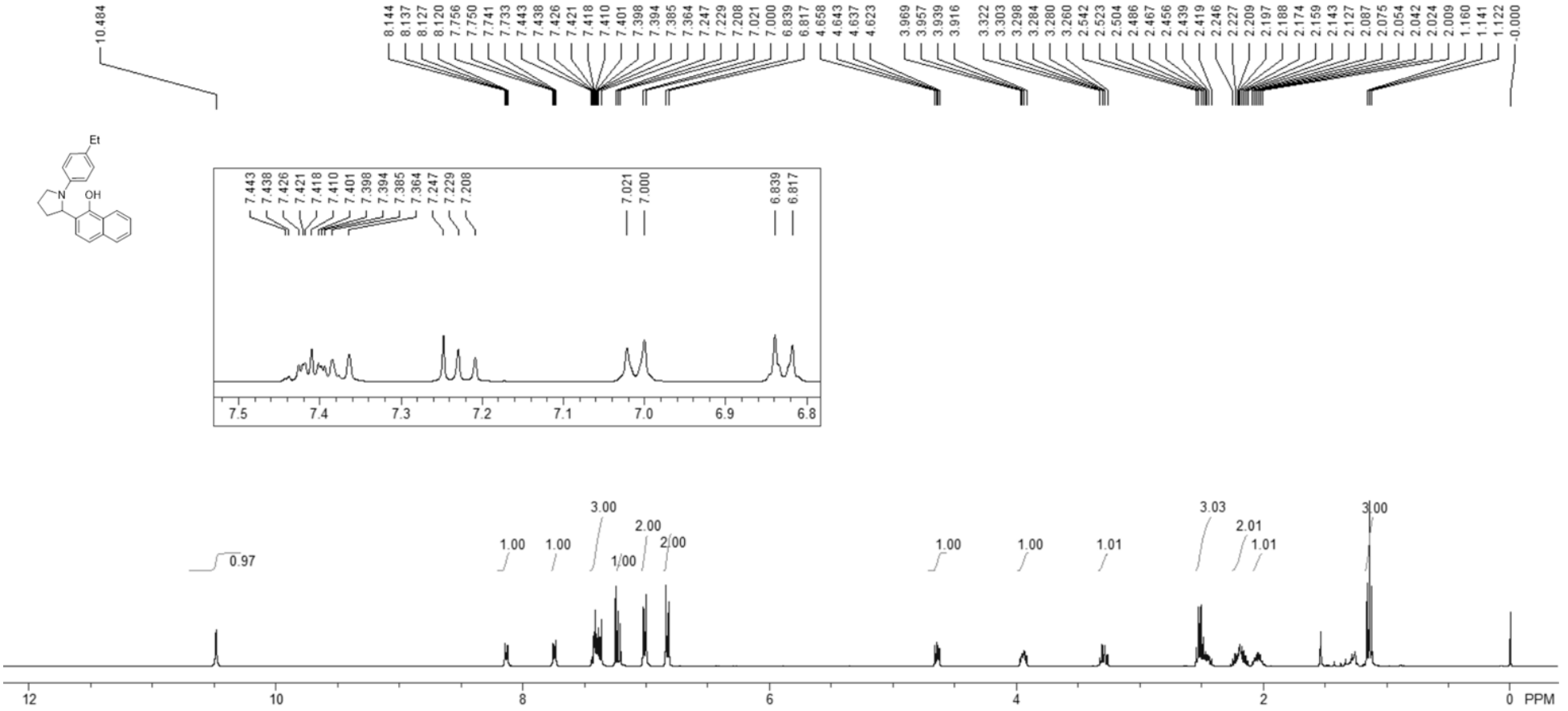
^{13}C NMR of 4j

100 MHz, $CDCl_3$



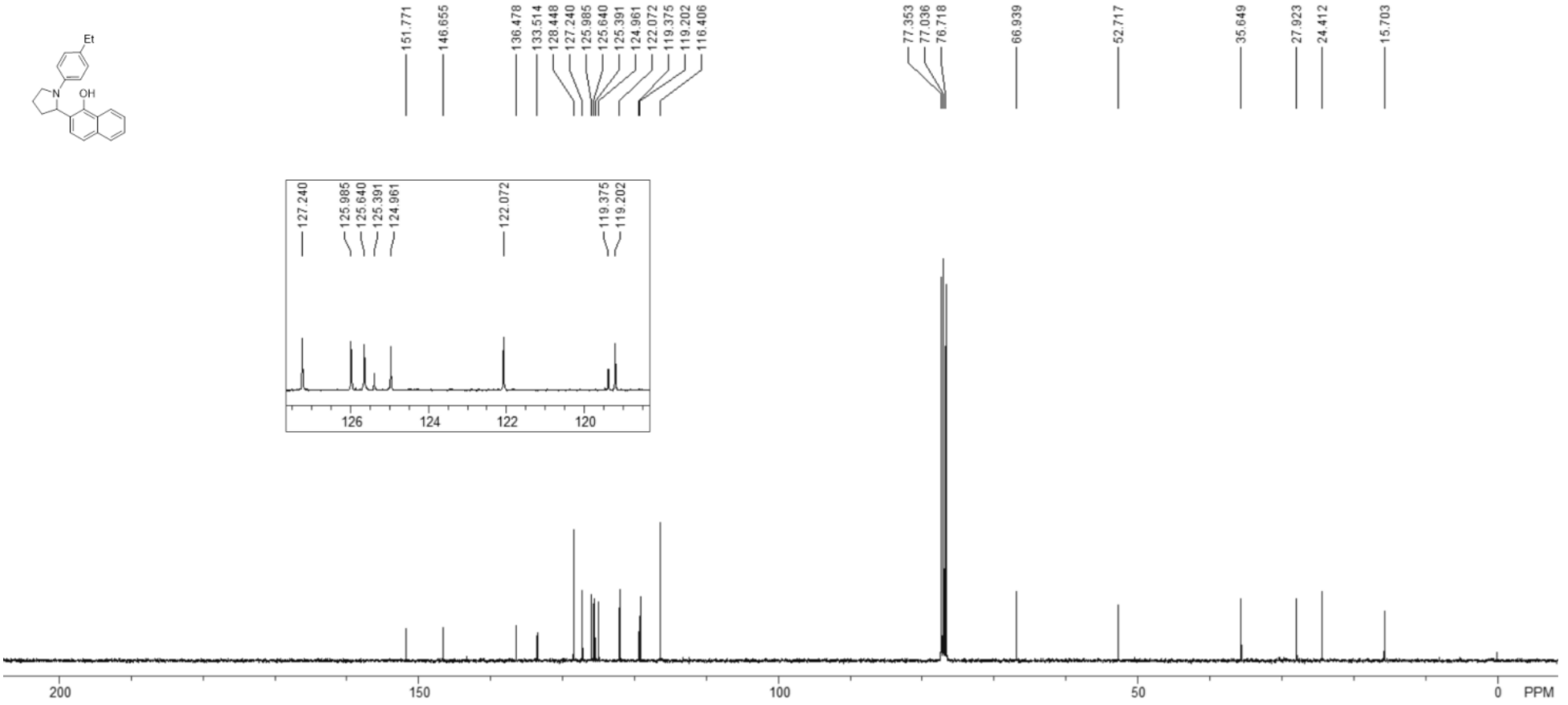
^{1}H NMR of 4k

400 MHz, $CDCl_3$



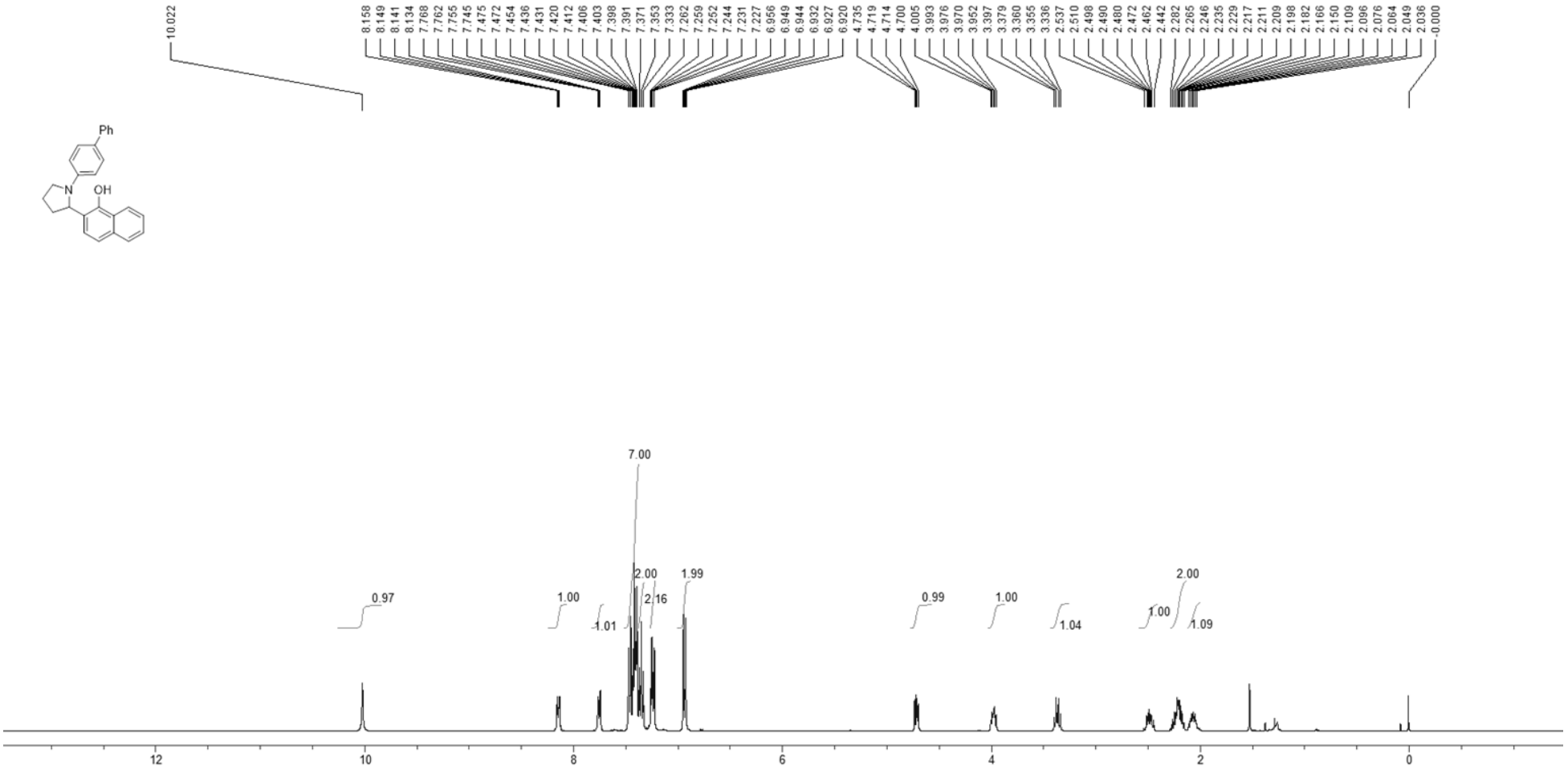
^{13}C NMR of 4k

100 MHz, $CDCl_3$



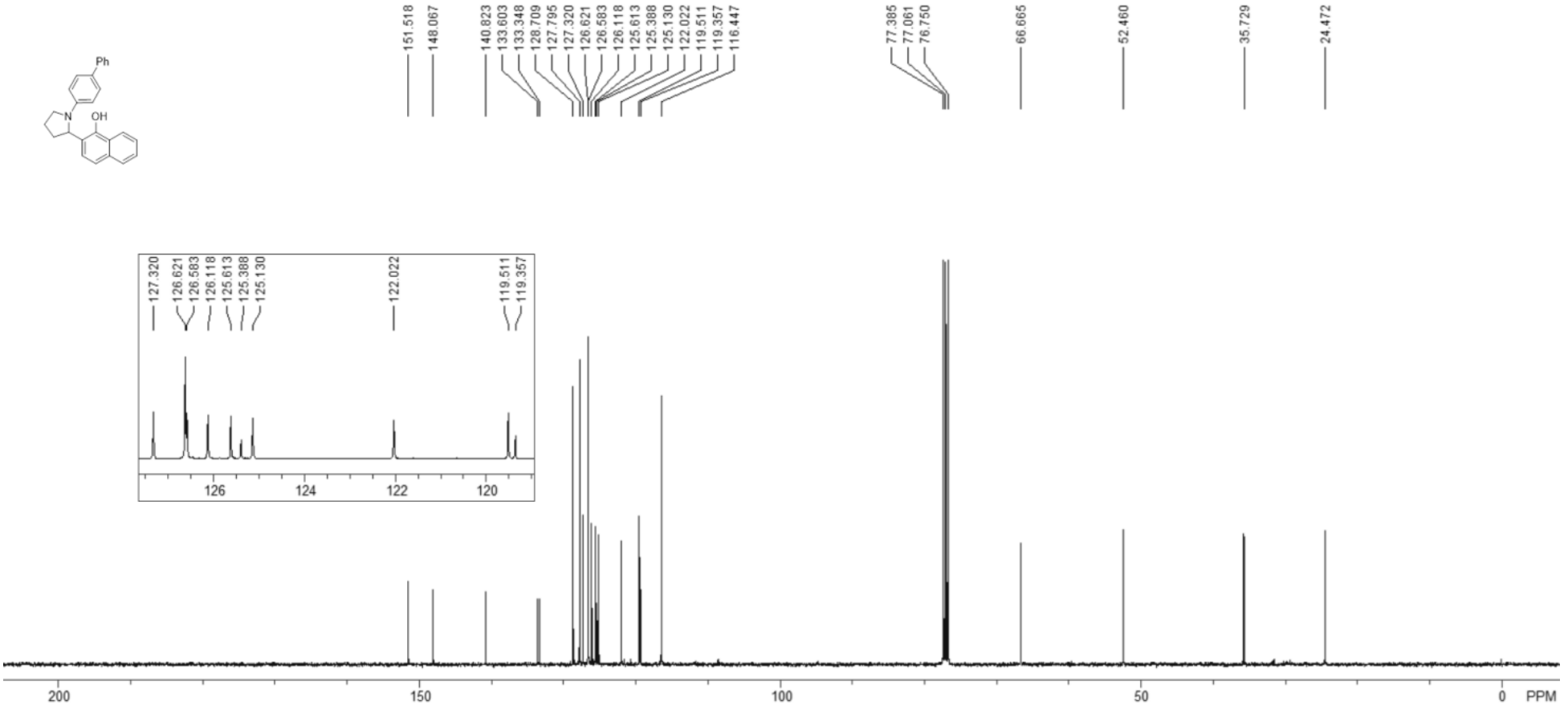
^{1}H NMR of 4l

400 MHz, $CDCl_3$



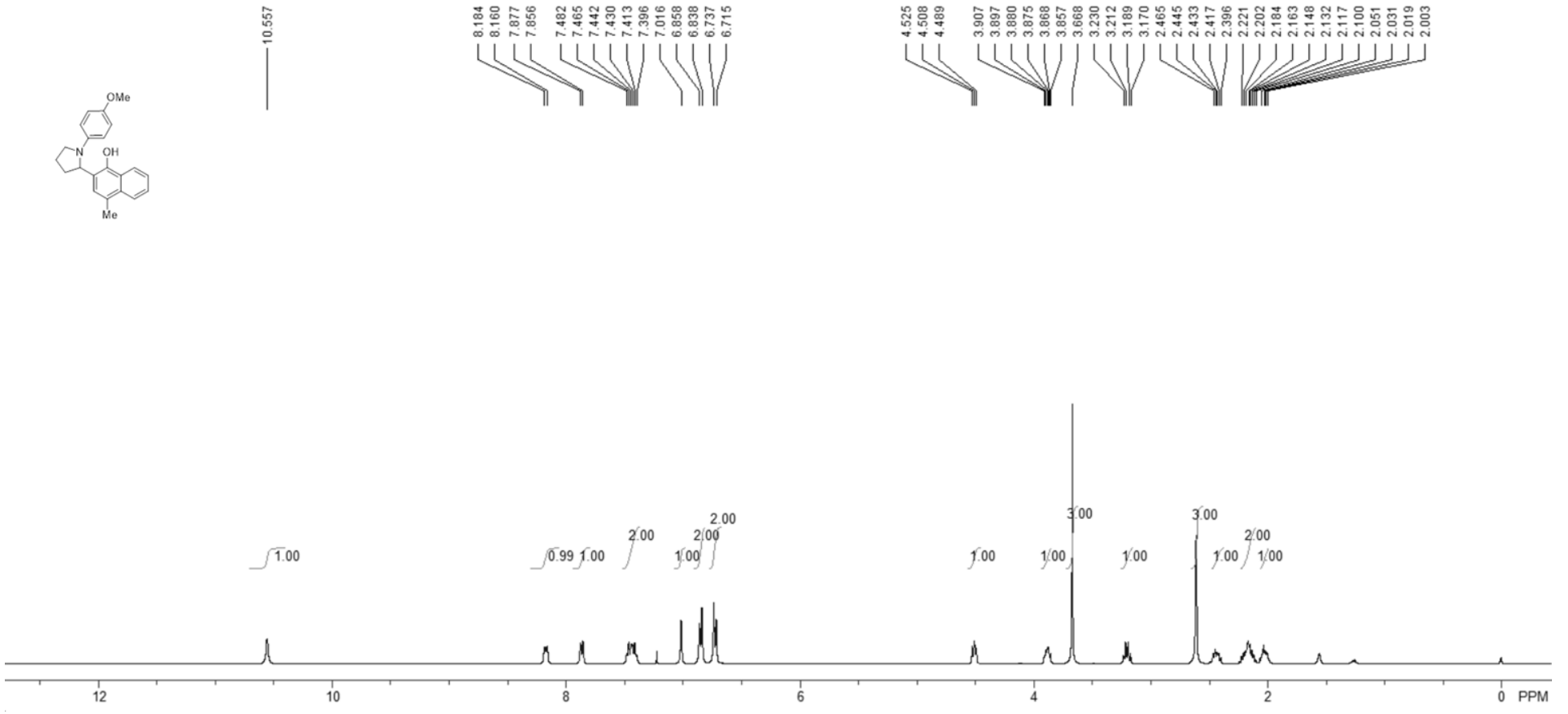
^{13}C NMR of 4l

100 MHz, $CDCl_3$



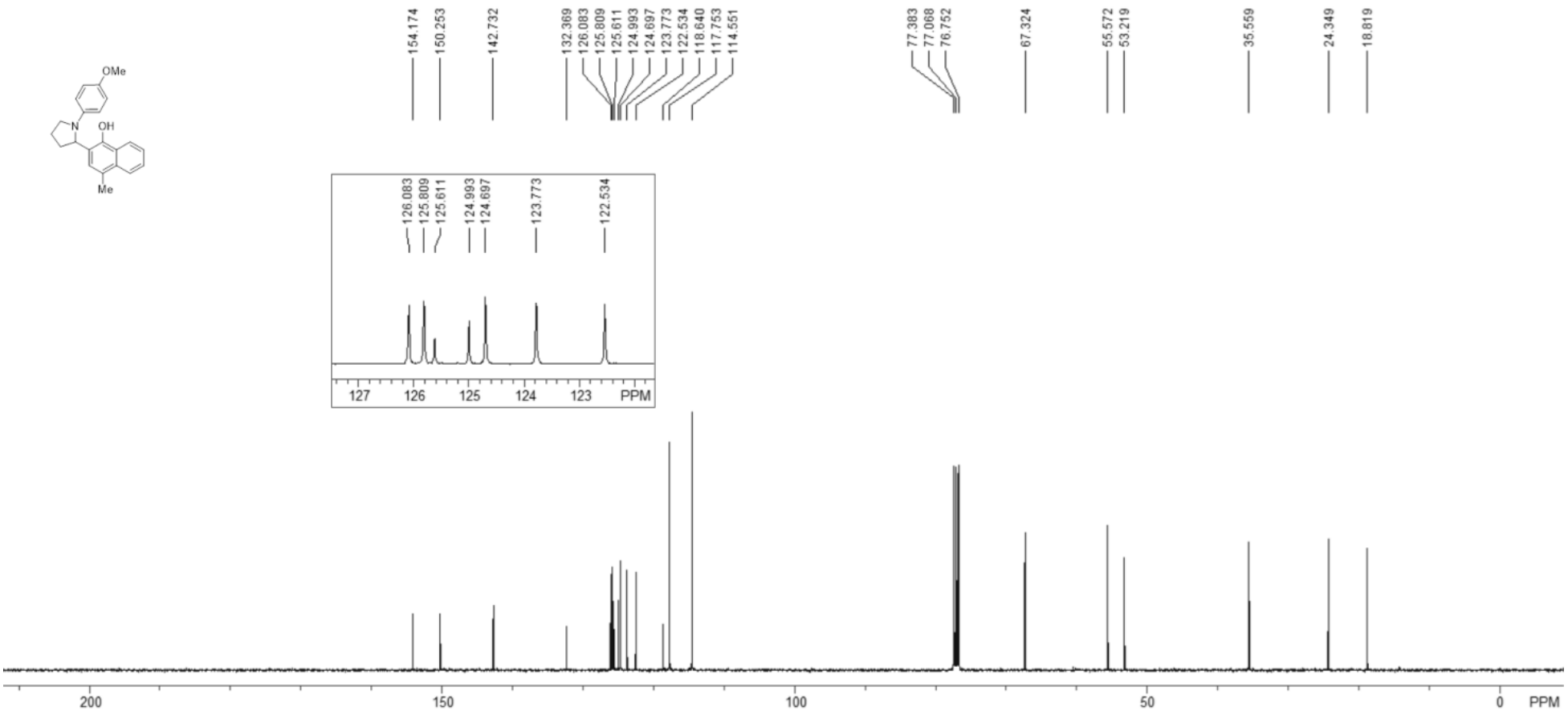
^{1}H NMR of 4m

400 MHz, $CDCl_3$



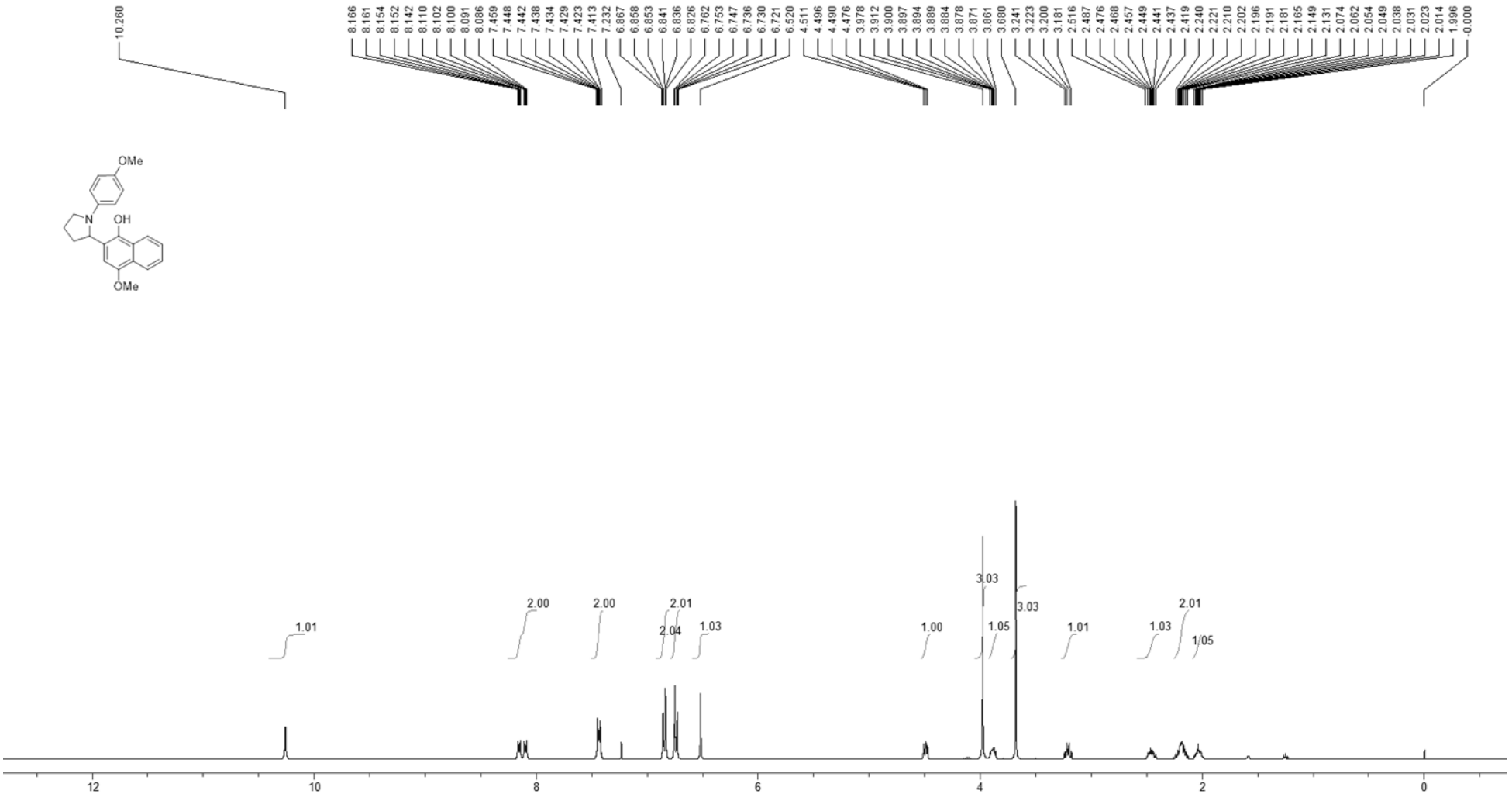
^{13}C NMR of 4m

100 MHz, $CDCl_3$



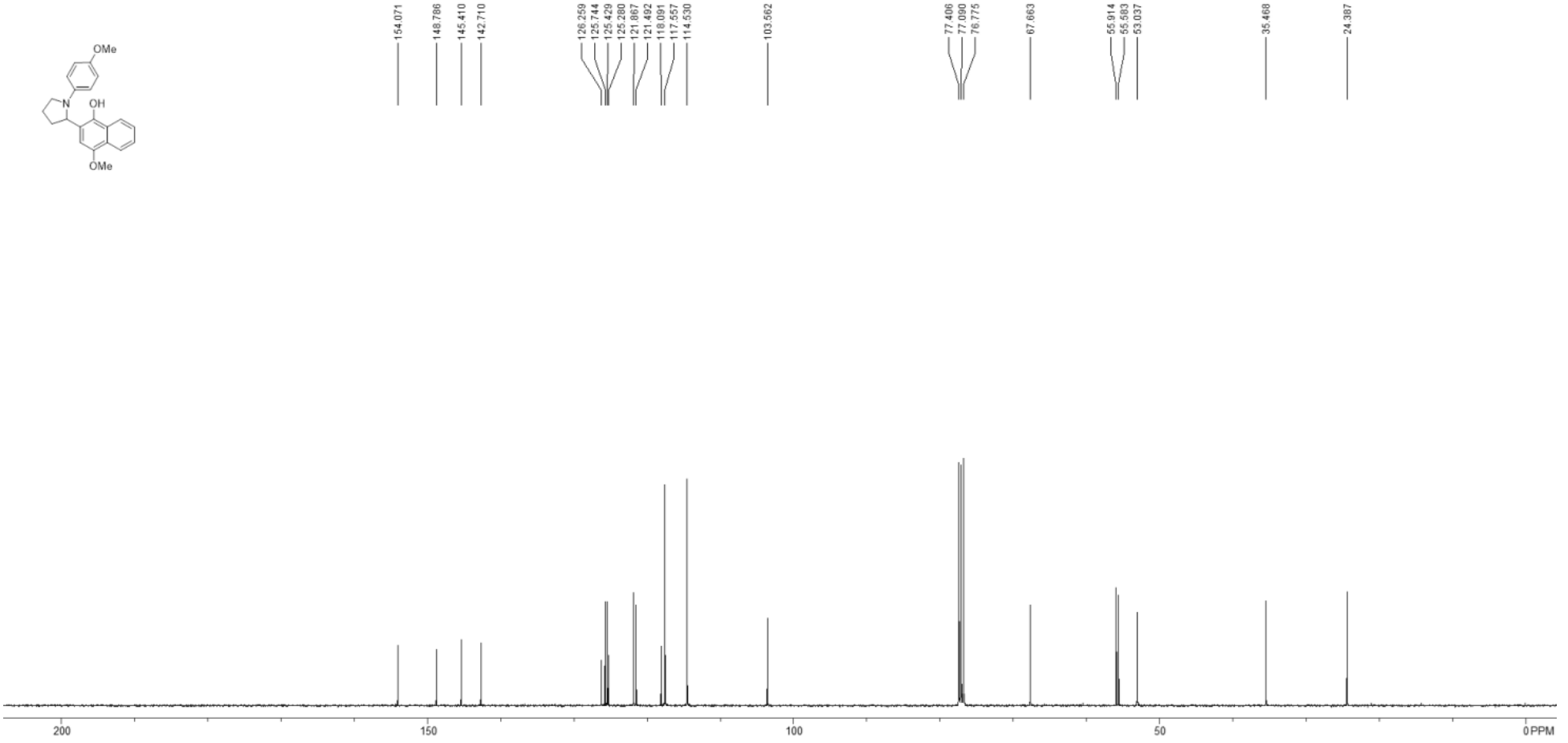
^{1}H NMR of 4n

400 MHz, $CDCl_3$



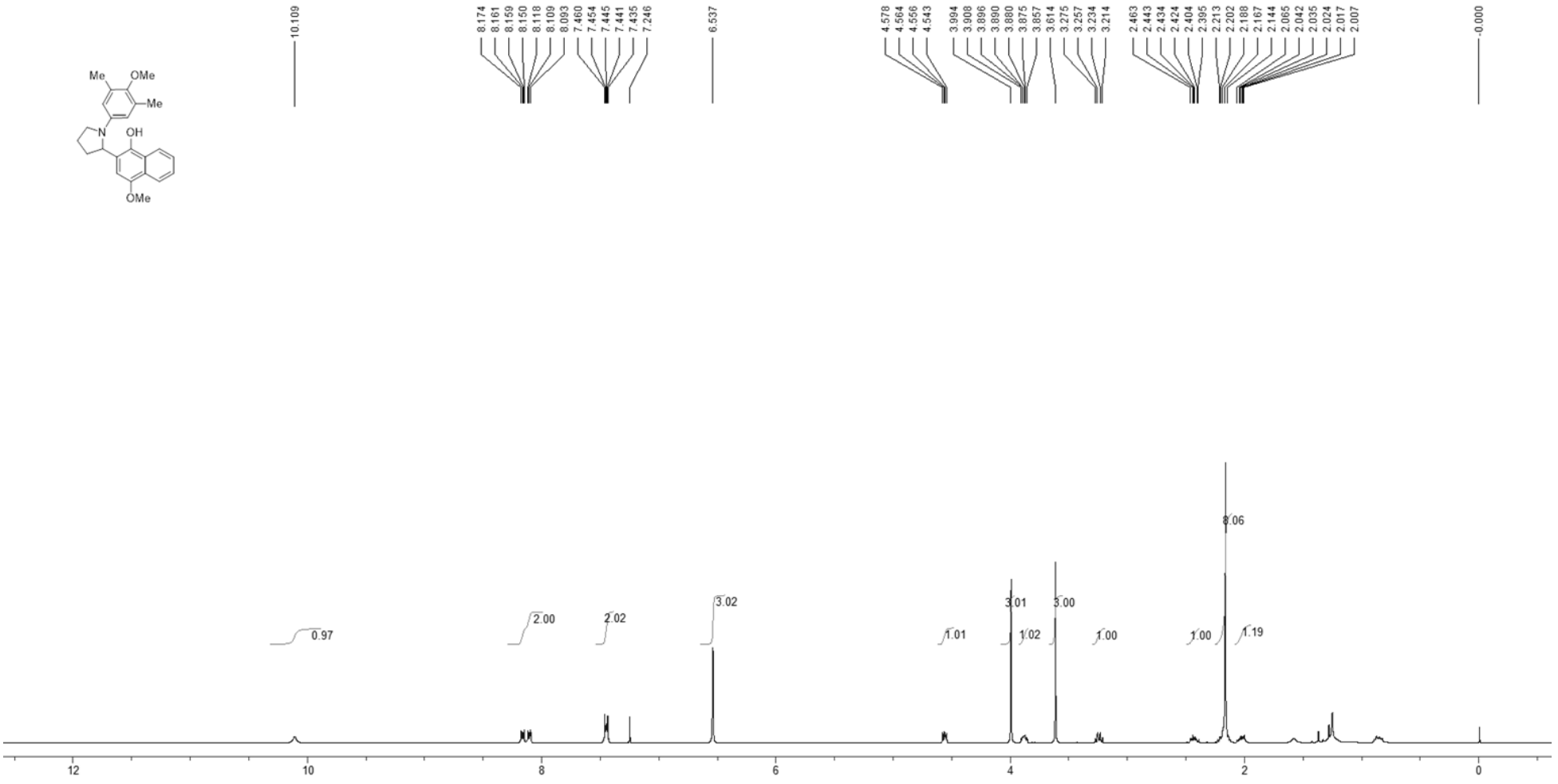
^{13}C NMR of 4n

100 MHz, $CDCl_3$



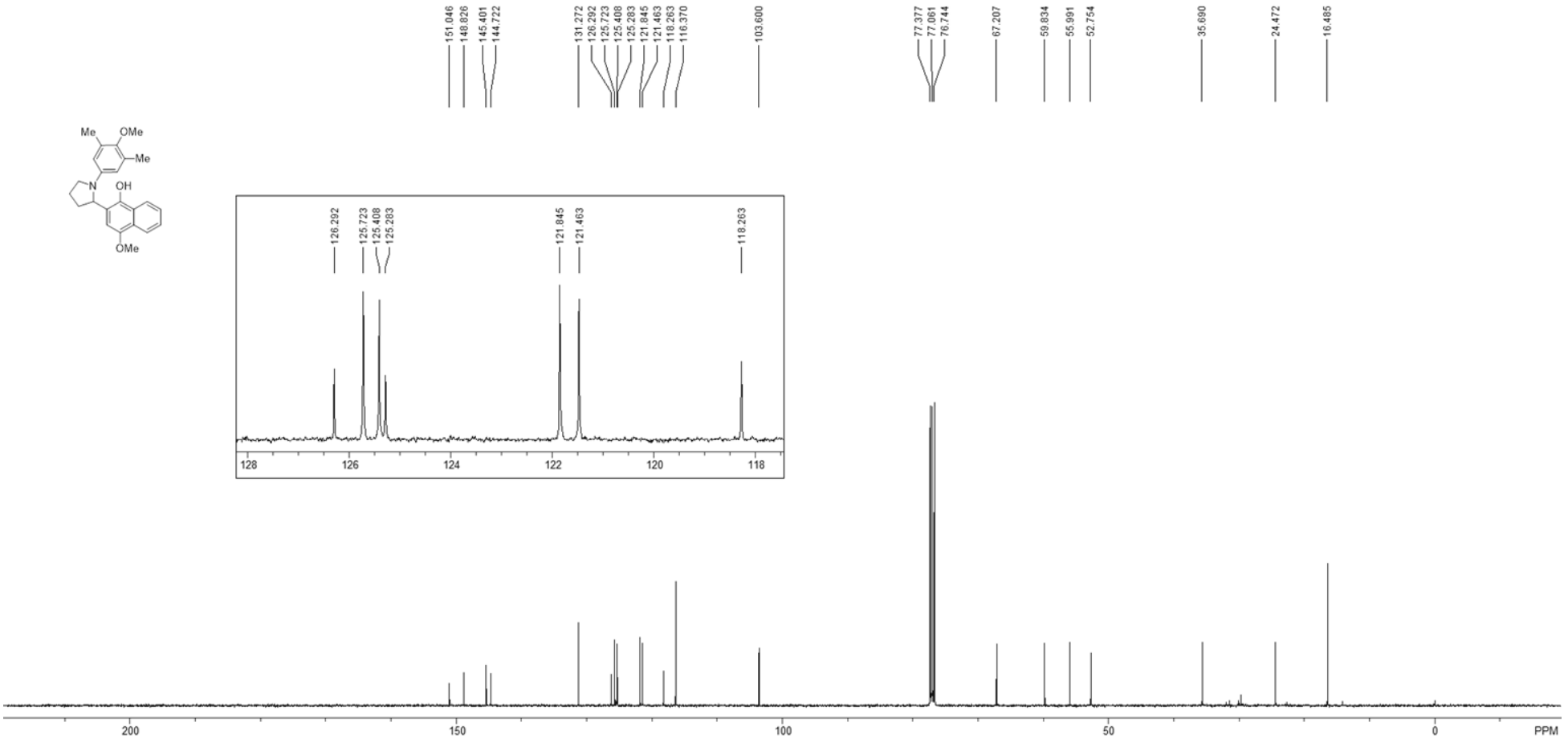
^{1}H NMR of 4o

400 MHz, $CDCl_3$



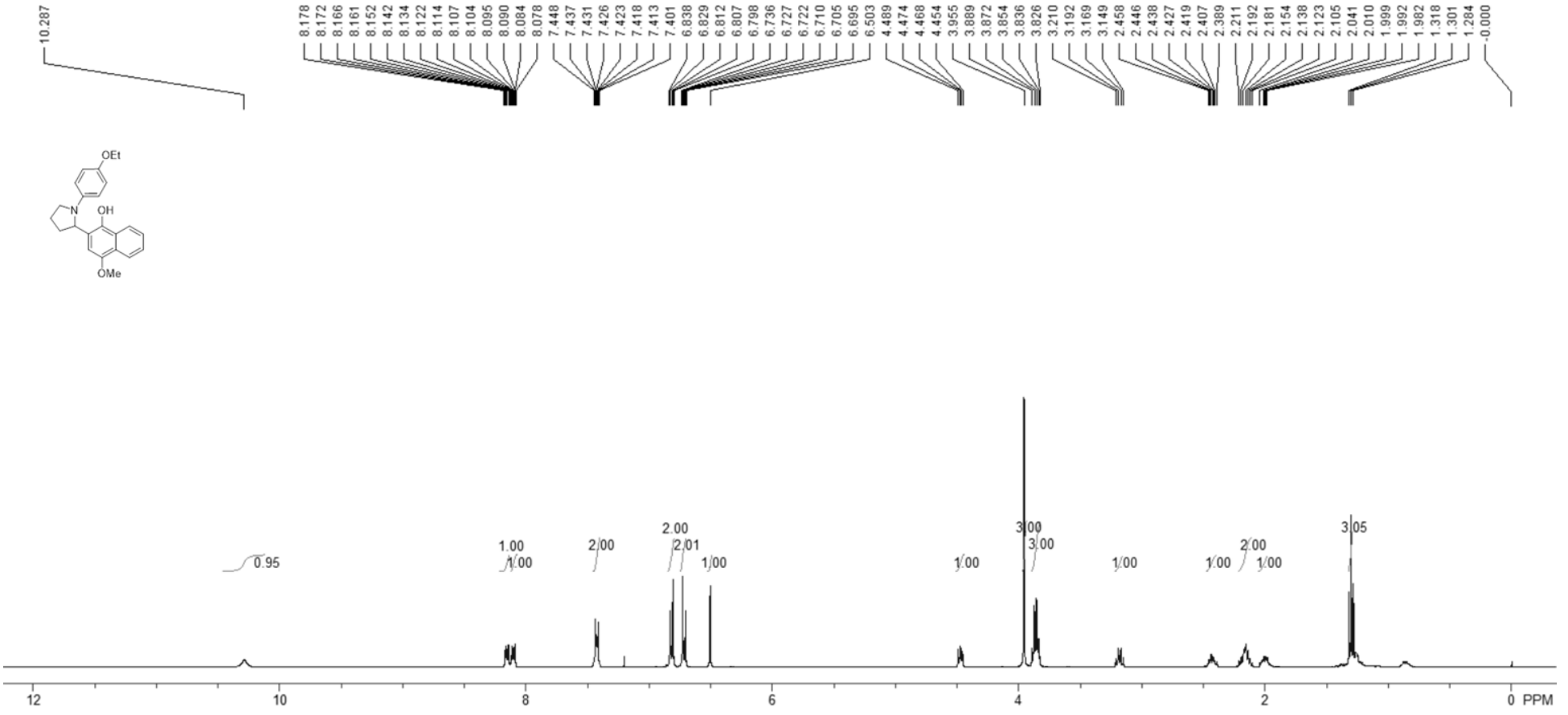
^{13}C NMR of 4o

100 MHz, $CDCl_3$



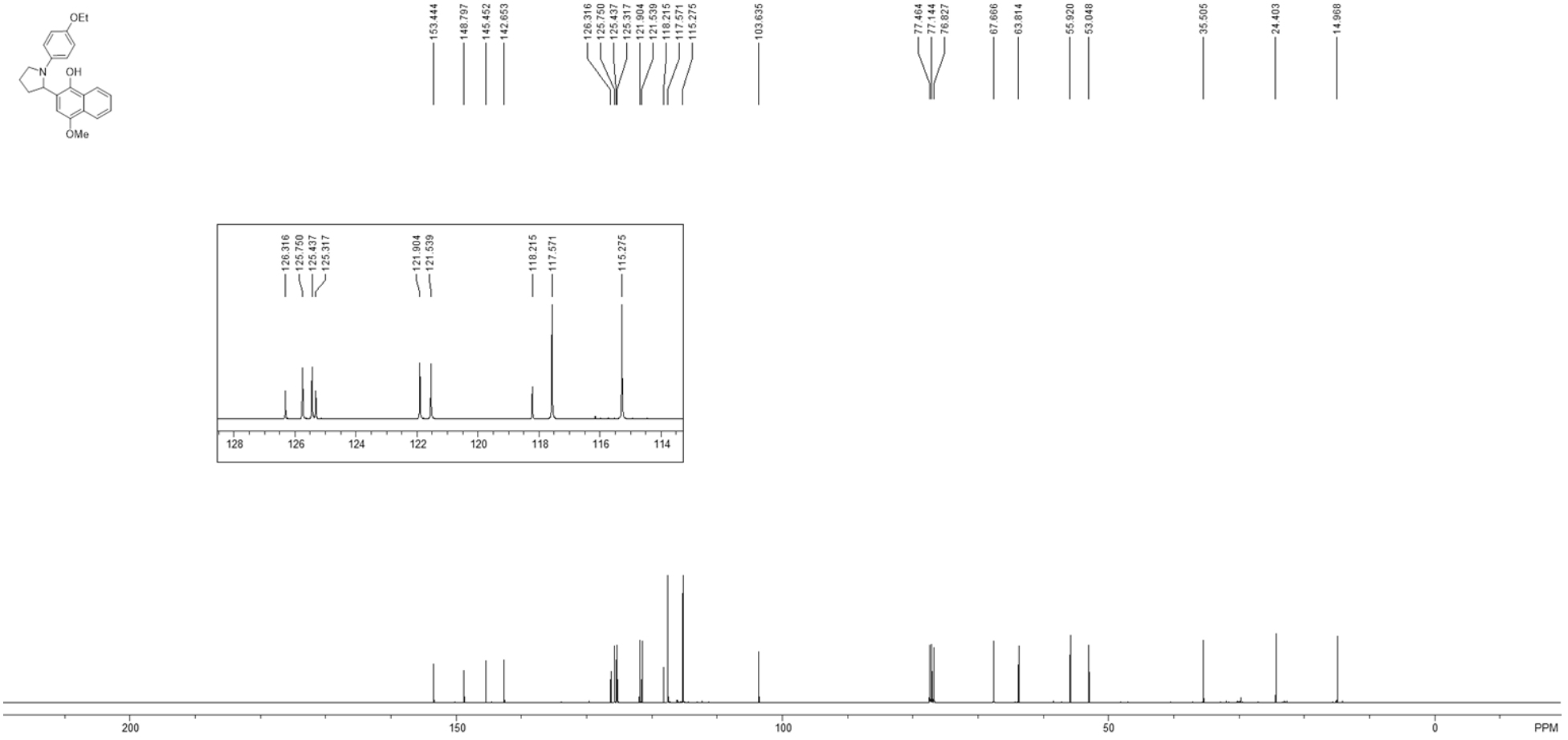
^{1}H NMR of 4p

400 MHz, $CDCl_3$



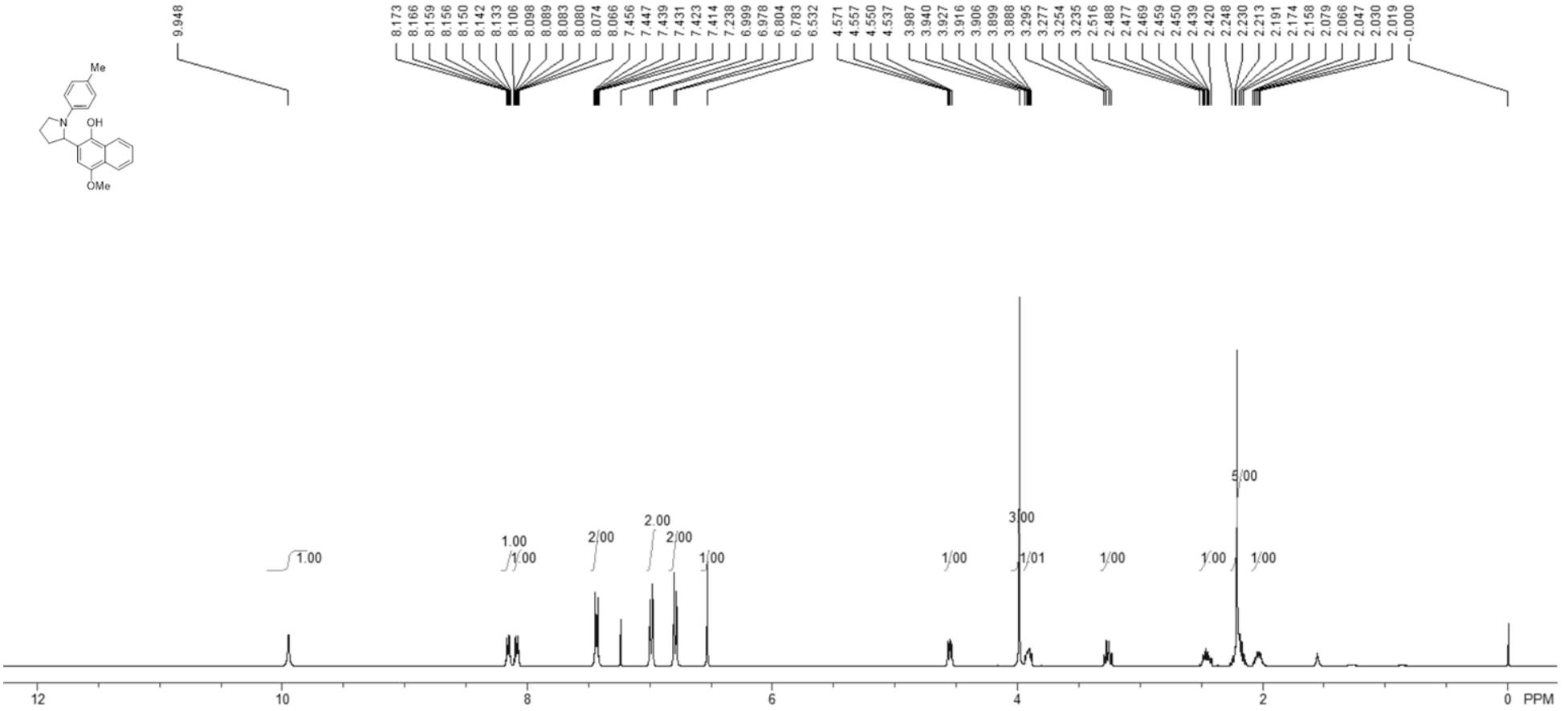
^{13}C NMR of 4p

100 MHz, $CDCl_3$



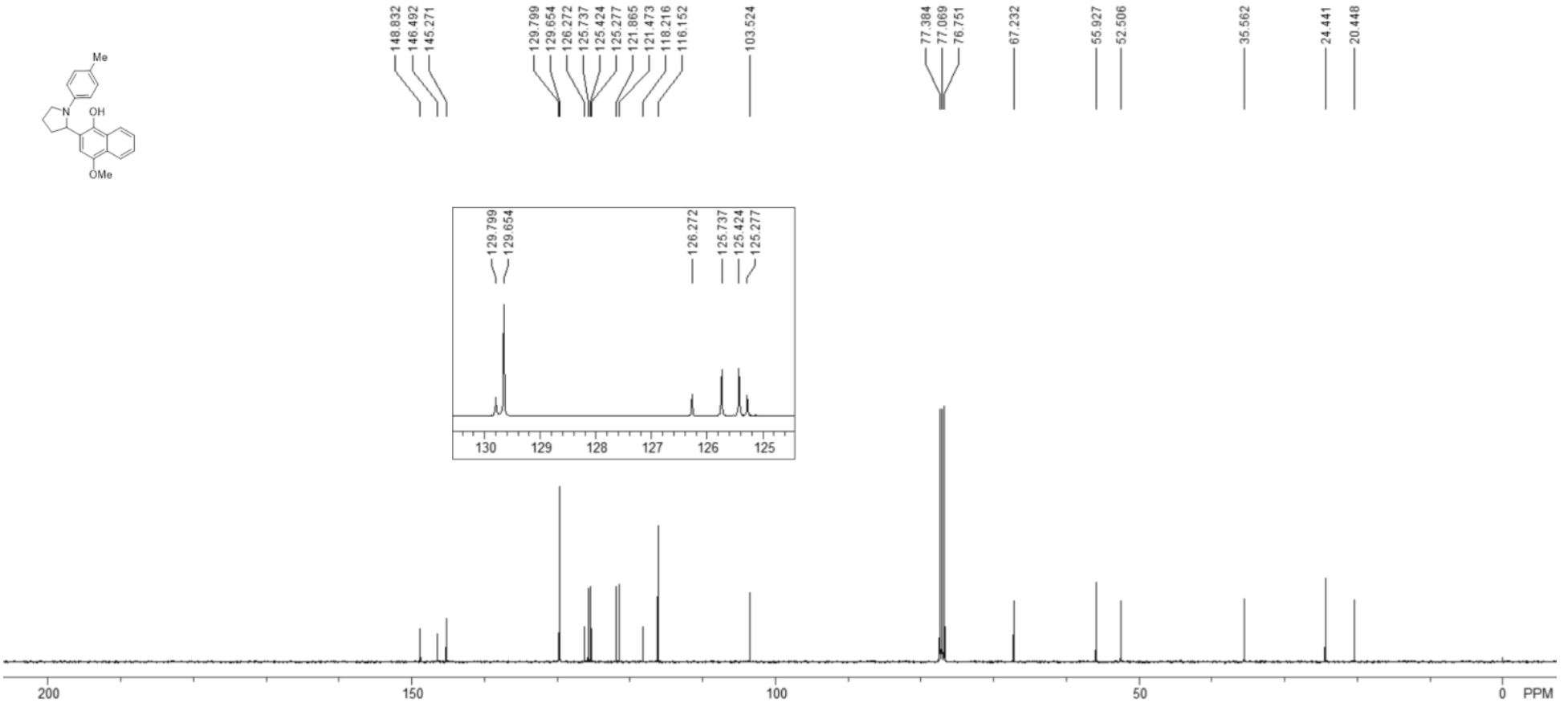
^{1}H NMR of 4q

400 MHz, $CDCl_3$



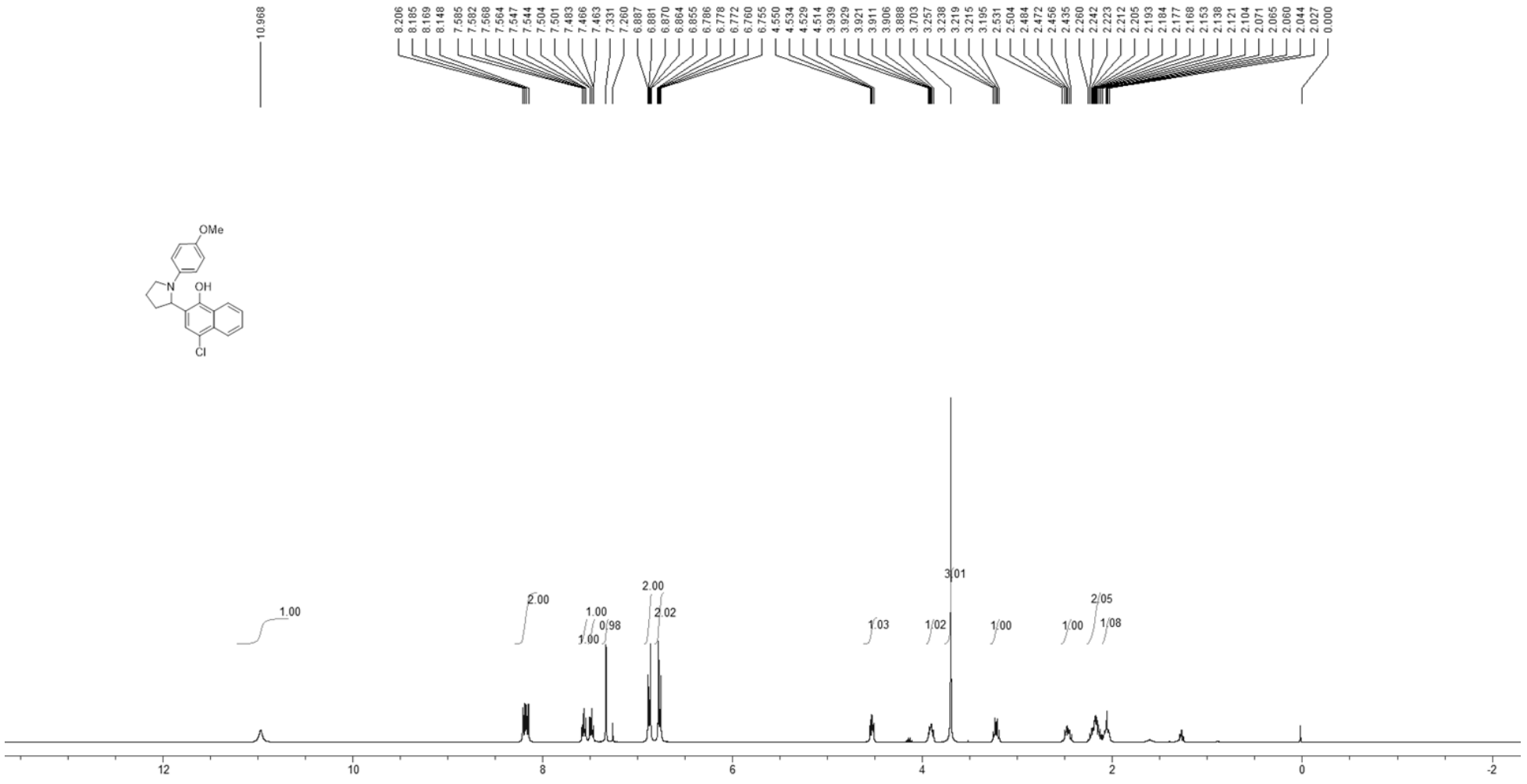
^{13}C NMR of 4q

100 MHz, $CDCl_3$



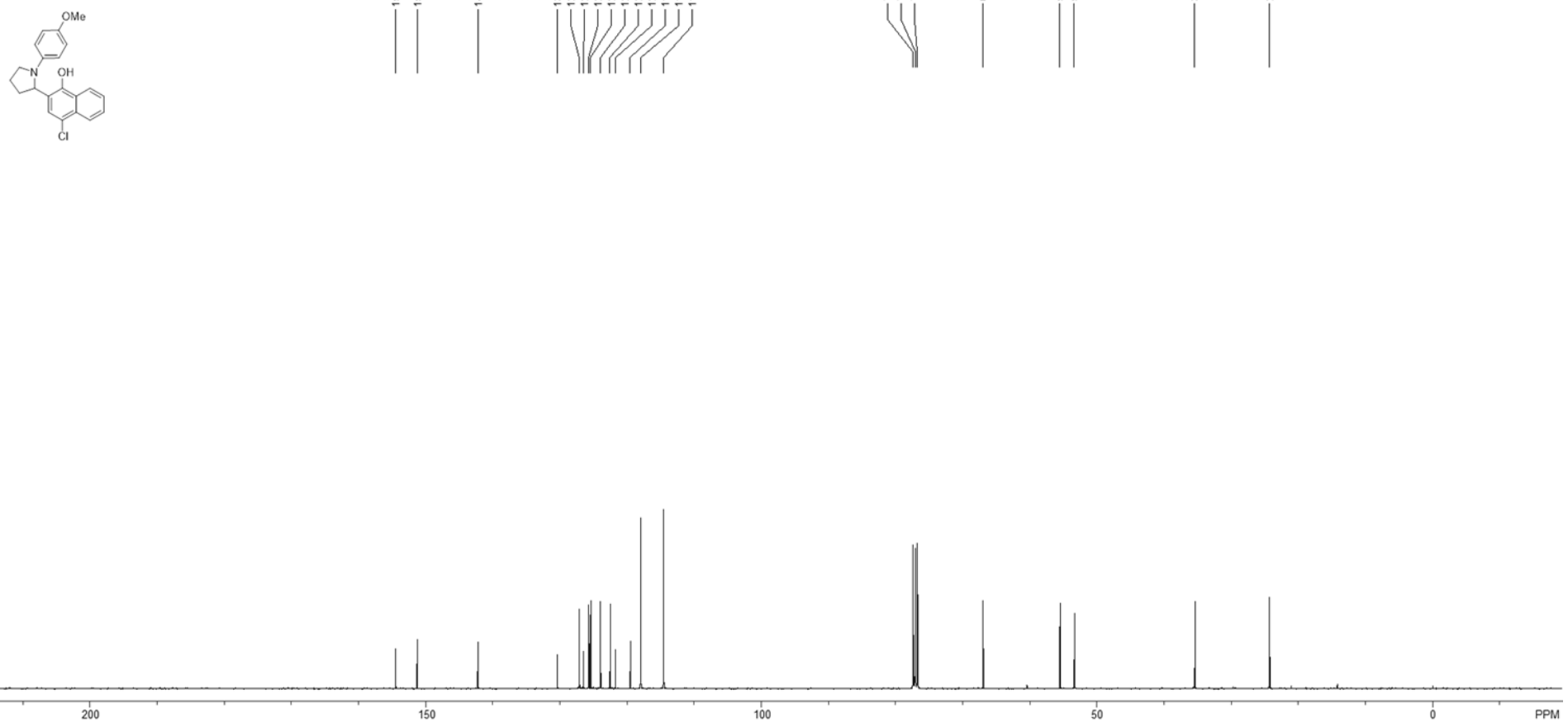
^{1}H NMR of 4r

400 MHz, $CDCl_3$



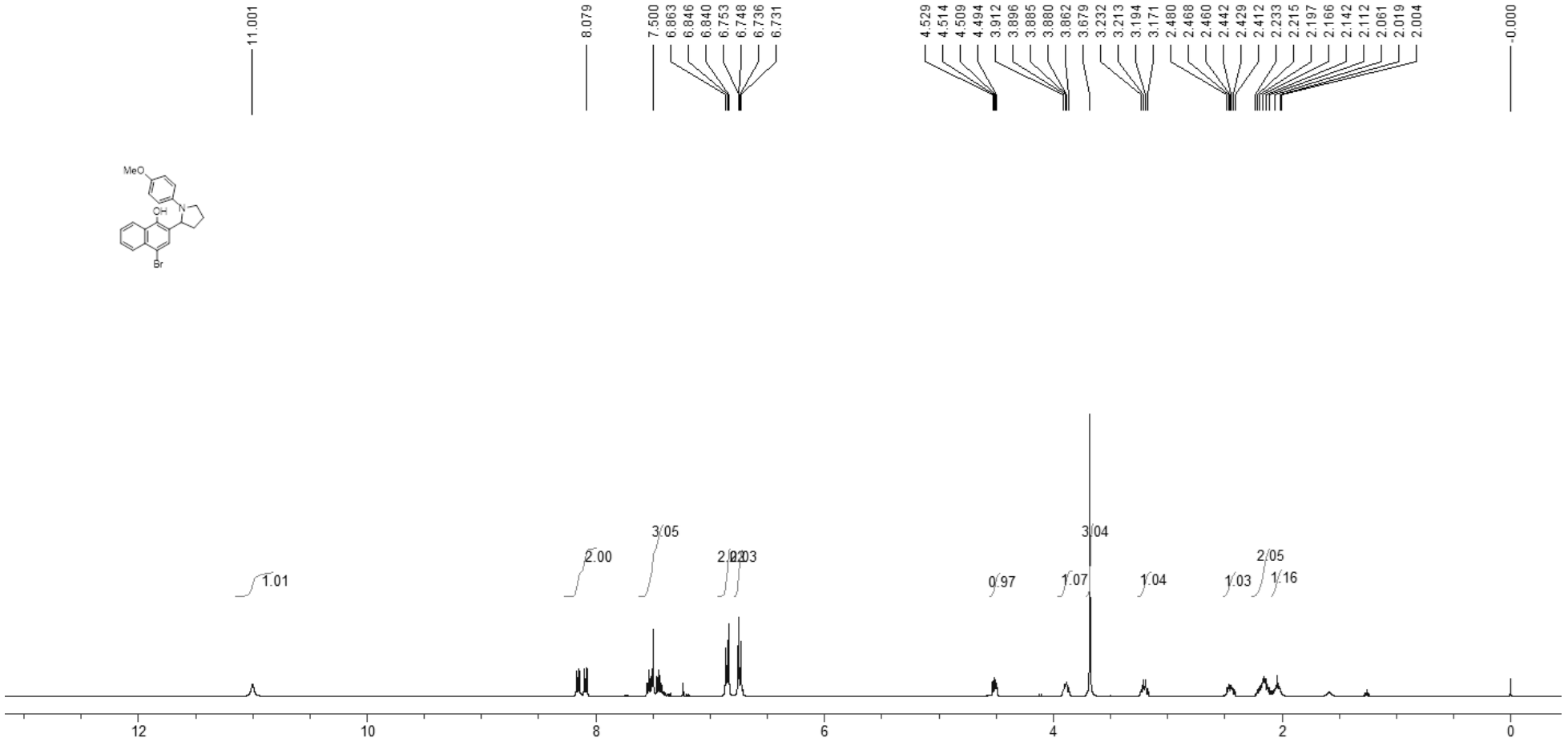
^{13}C NMR of 4r

100 MHz, $CDCl_3$



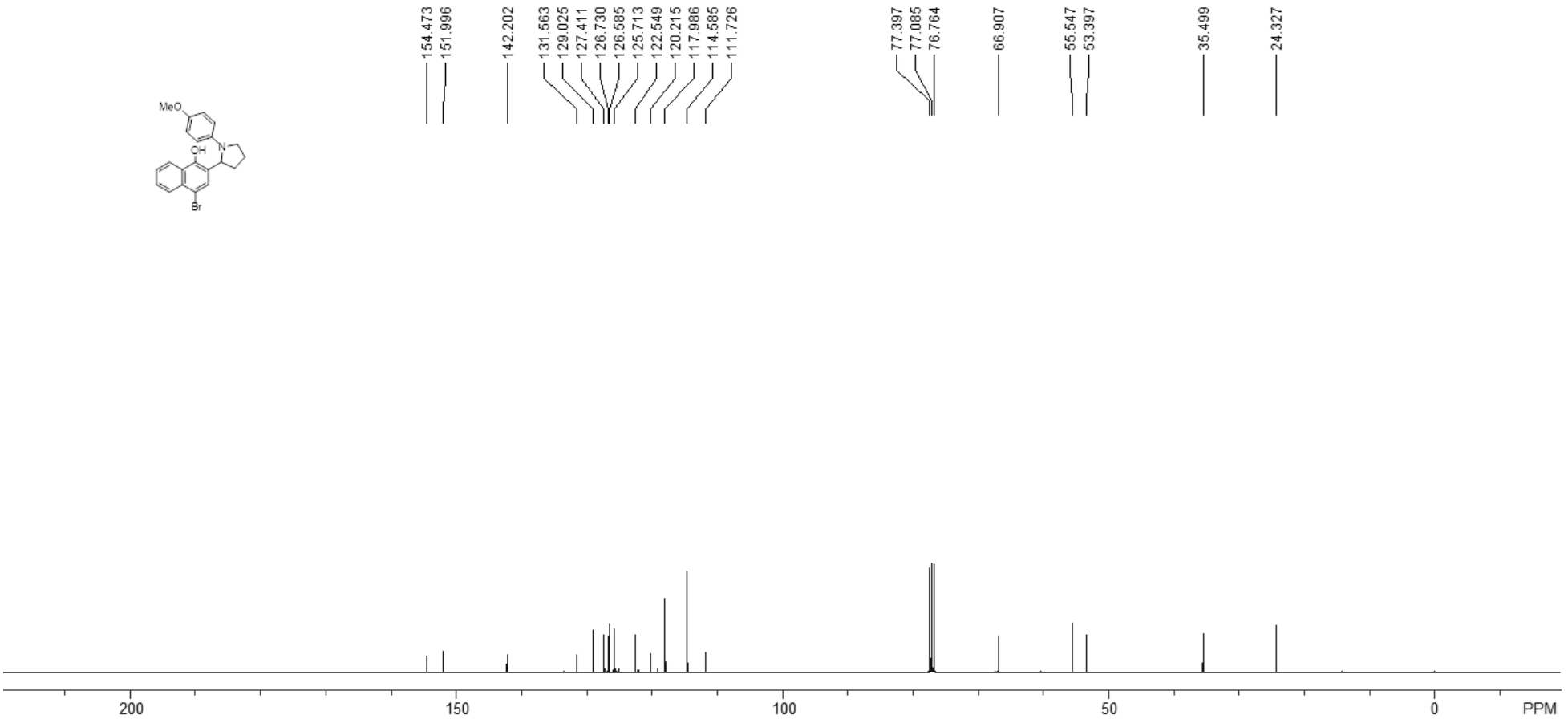
^{1}H NMR of 4s

400 MHz, $CDCl_3$



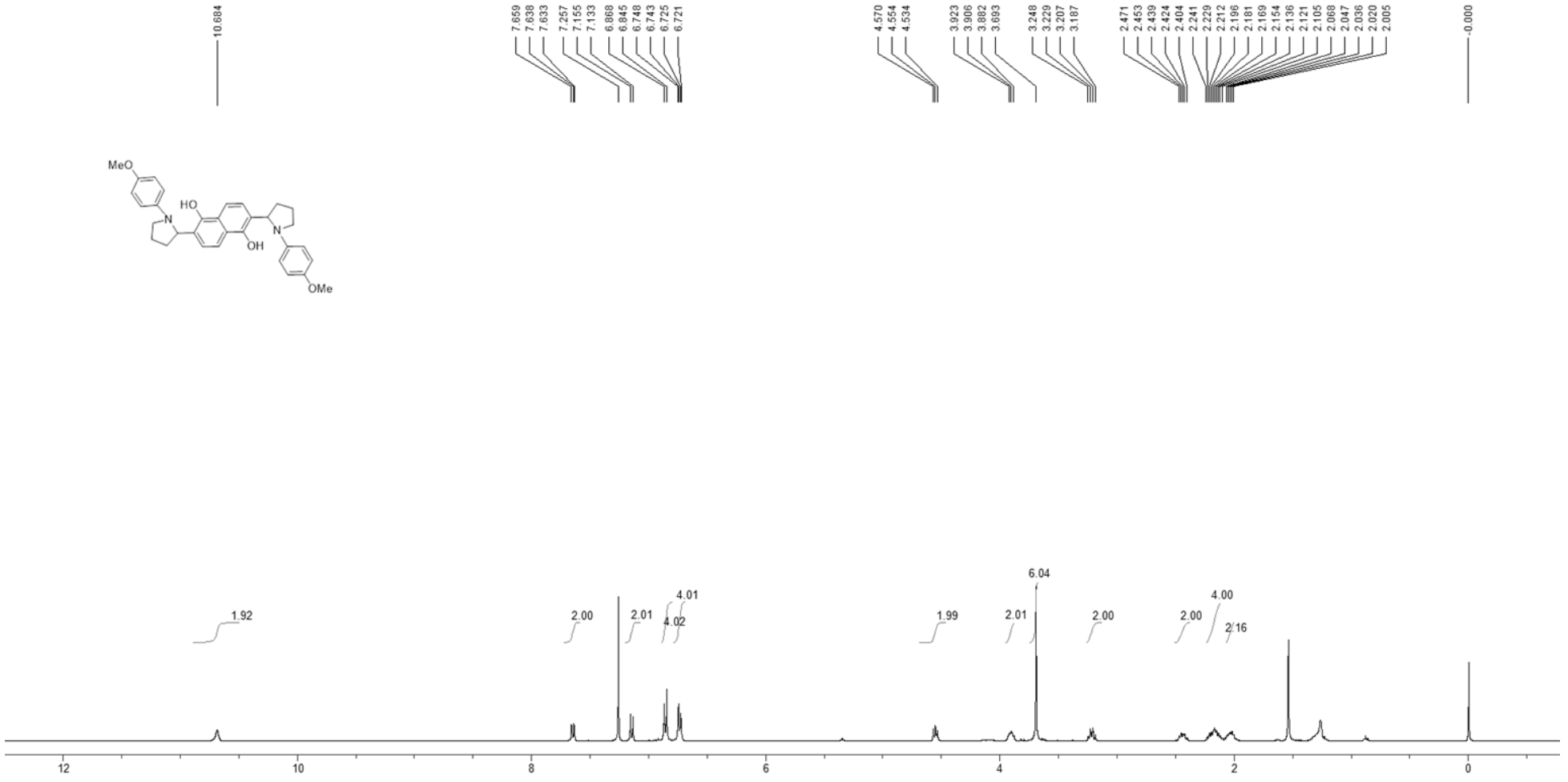
^{13}C NMR of 4s

100 MHz, $CDCl_3$



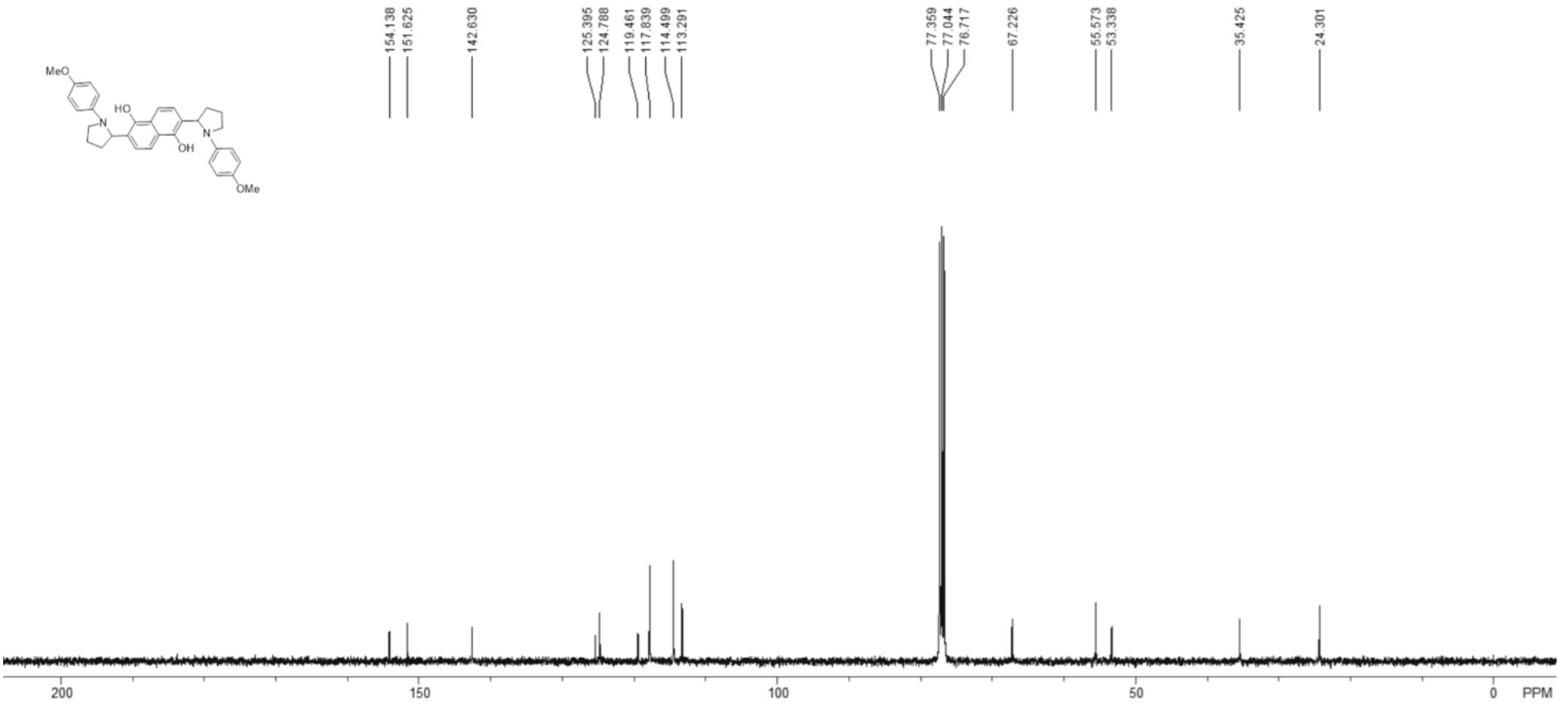
^{1}H NMR of 4t

400 MHz, $CDCl_3$



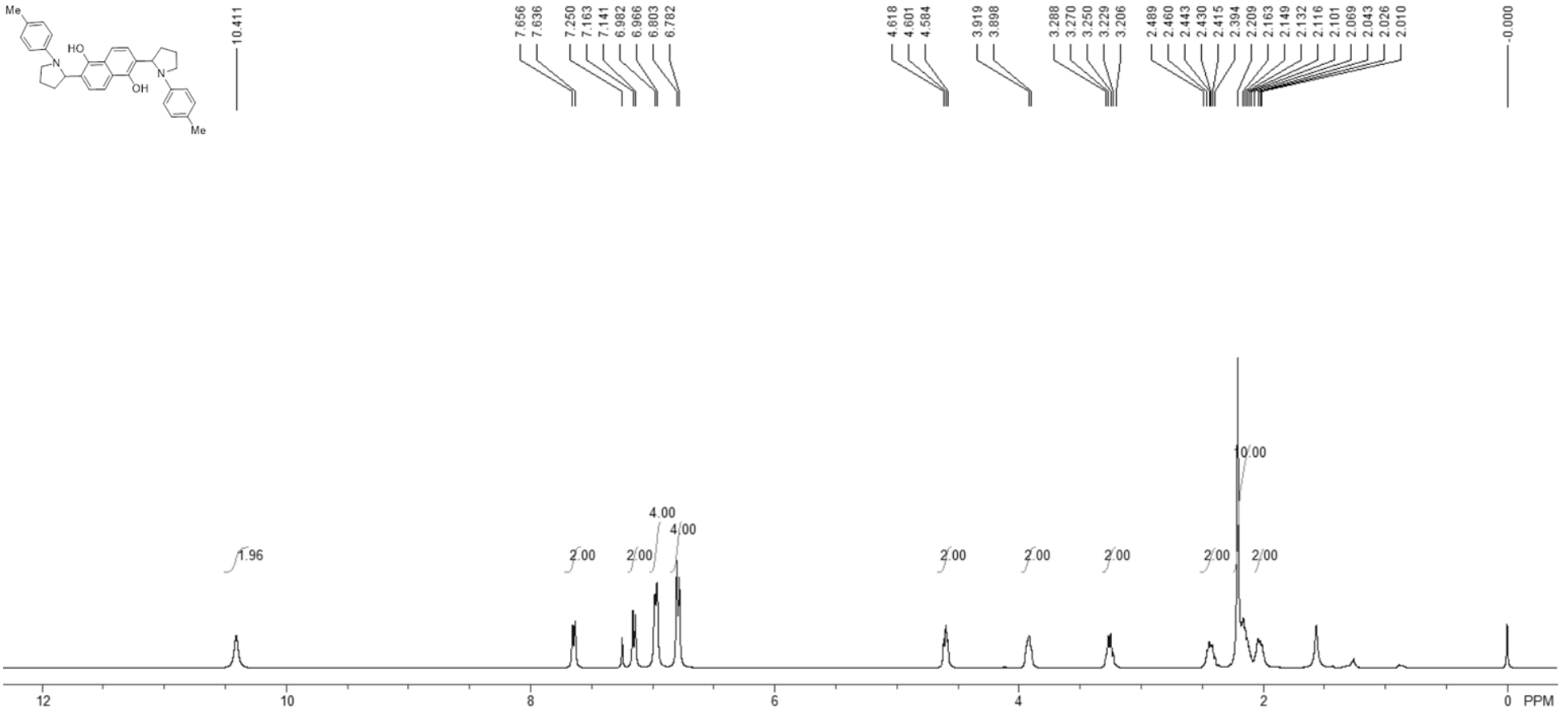
^{13}C NMR of 4t

100 MHz, $CDCl_3$



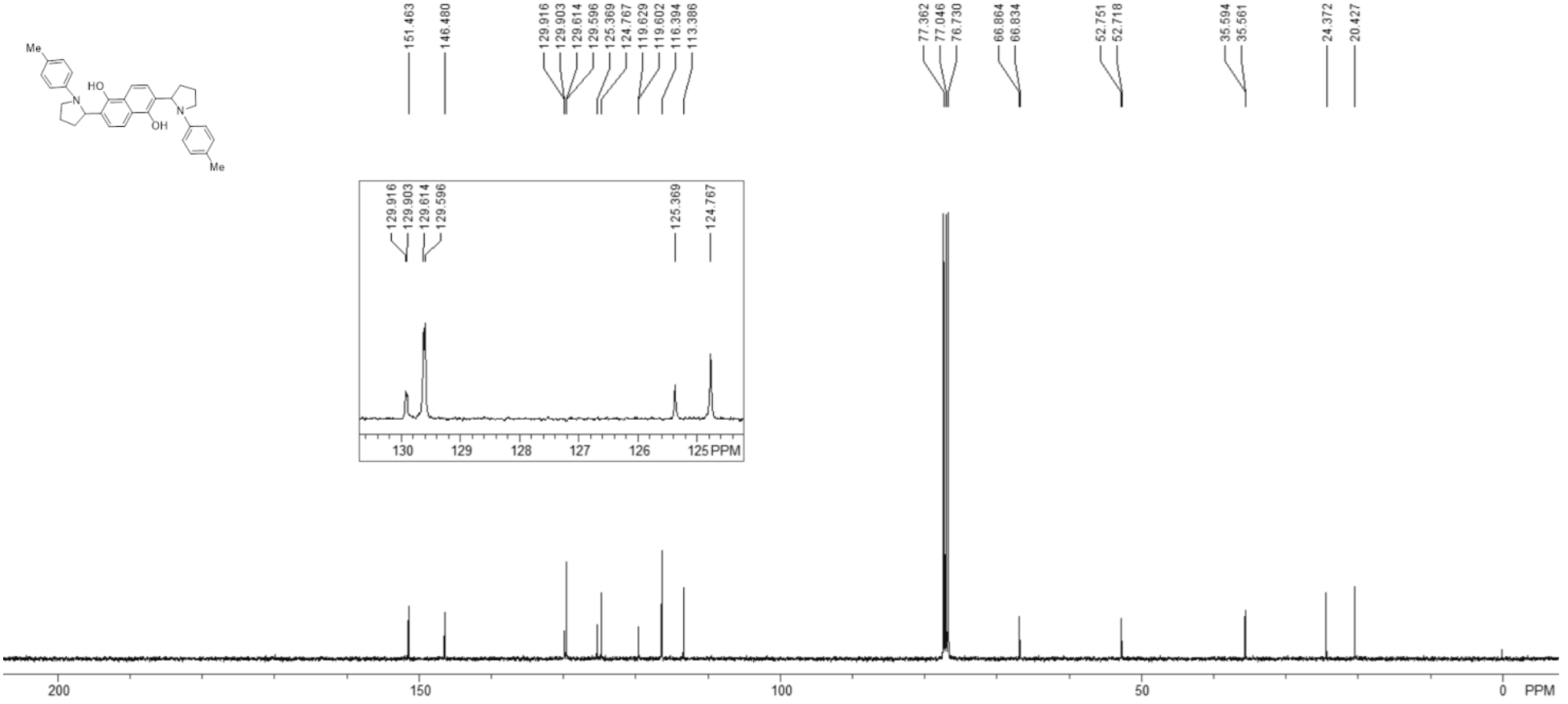
^{1}H NMR of 4u

400 MHz, $CDCl_3$



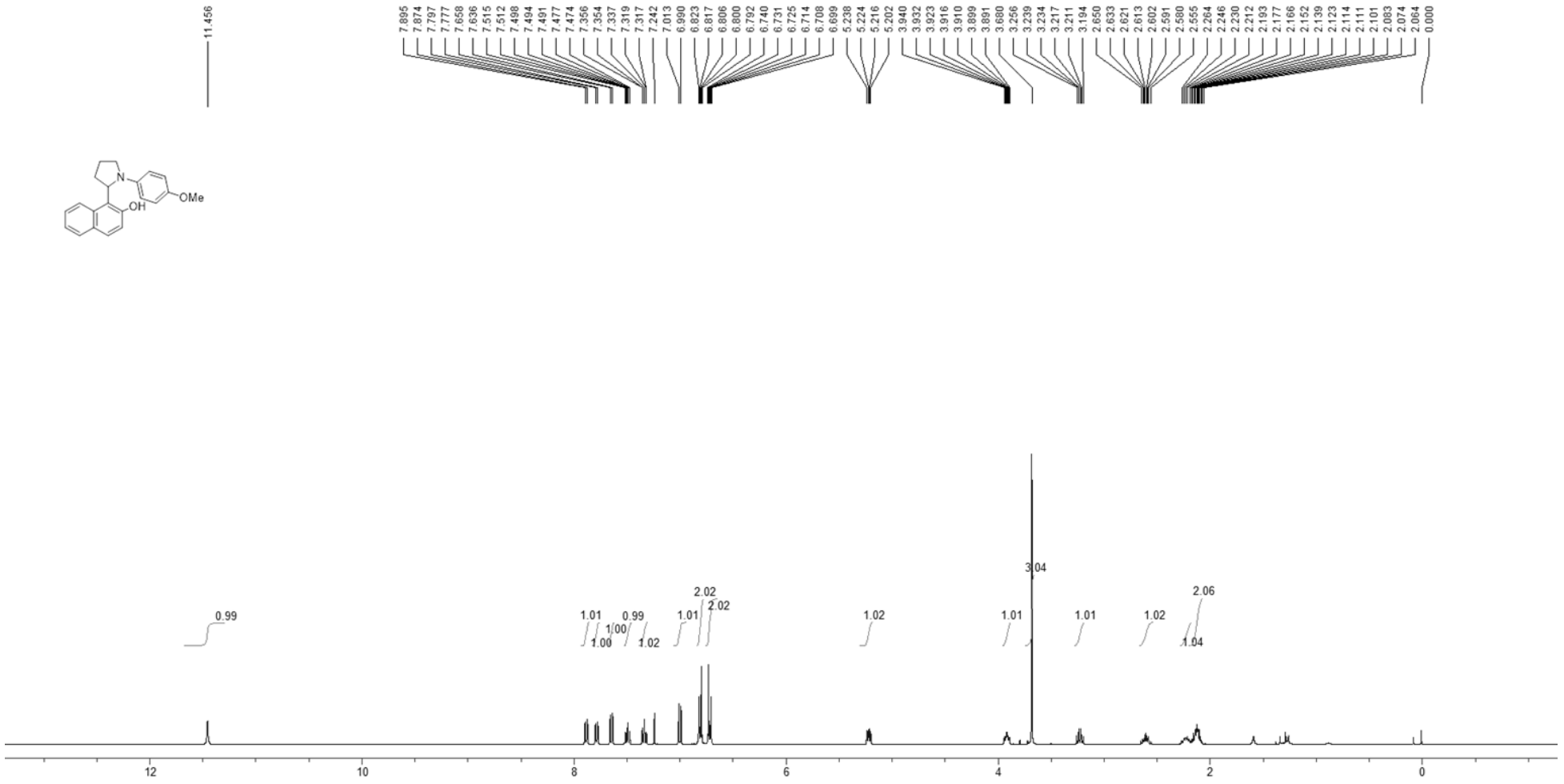
^{13}C NMR of 4u

100 MHz, $CDCl_3$



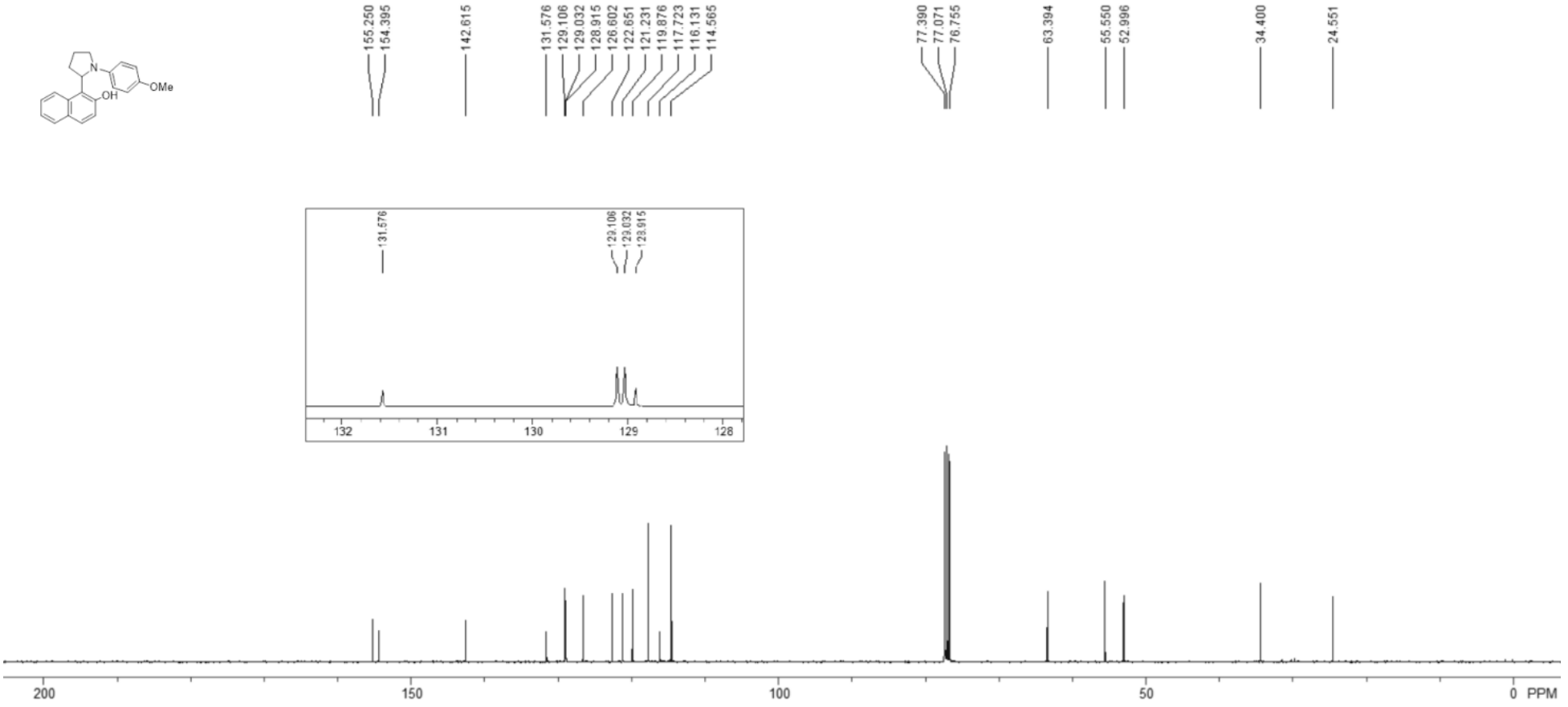
^{1}H NMR of 6a

400 MHz, $CDCl_3$



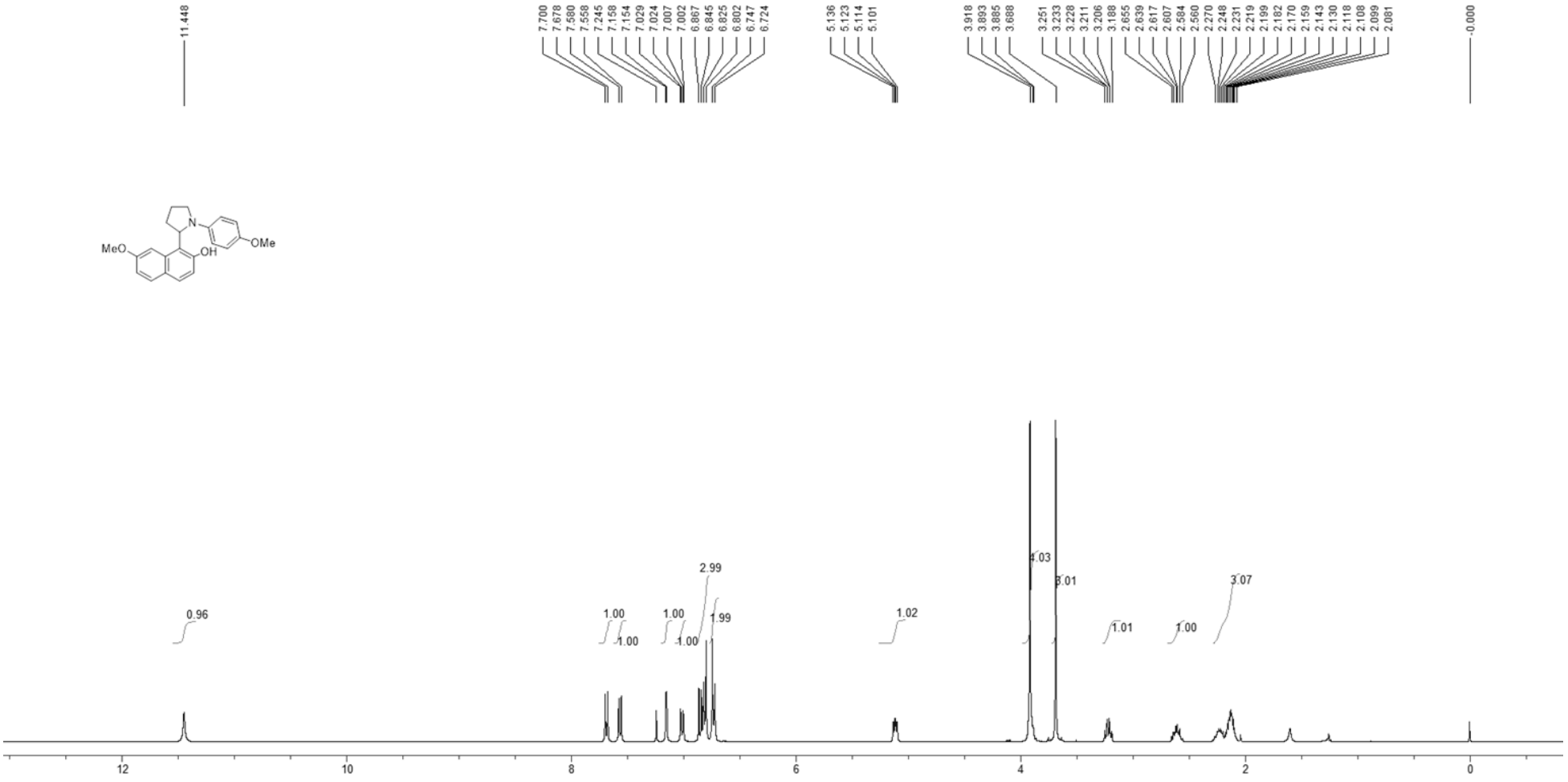
^{13}C NMR of 6a

100 MHz, $CDCl_3$



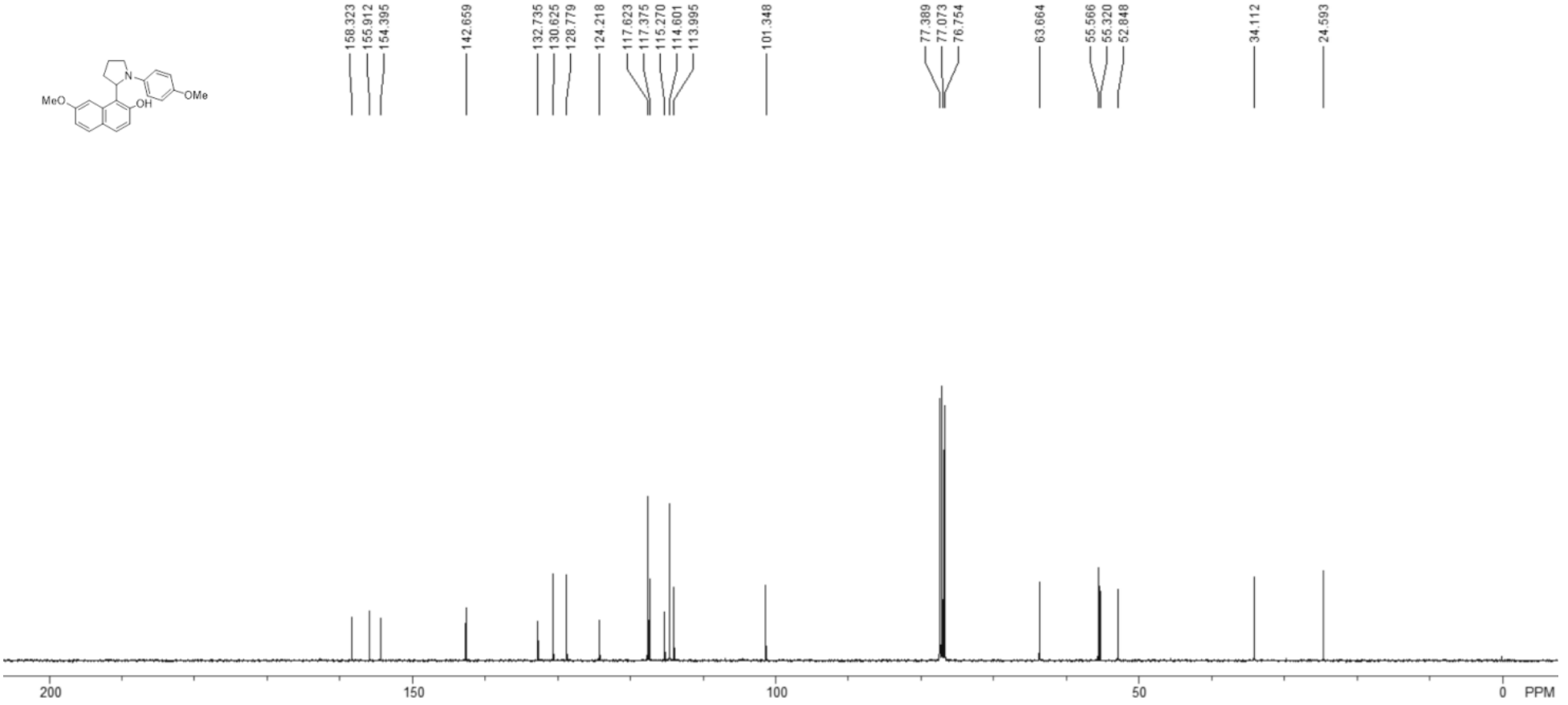
^{1}H NMR of 6b

400 MHz, $CDCl_3$



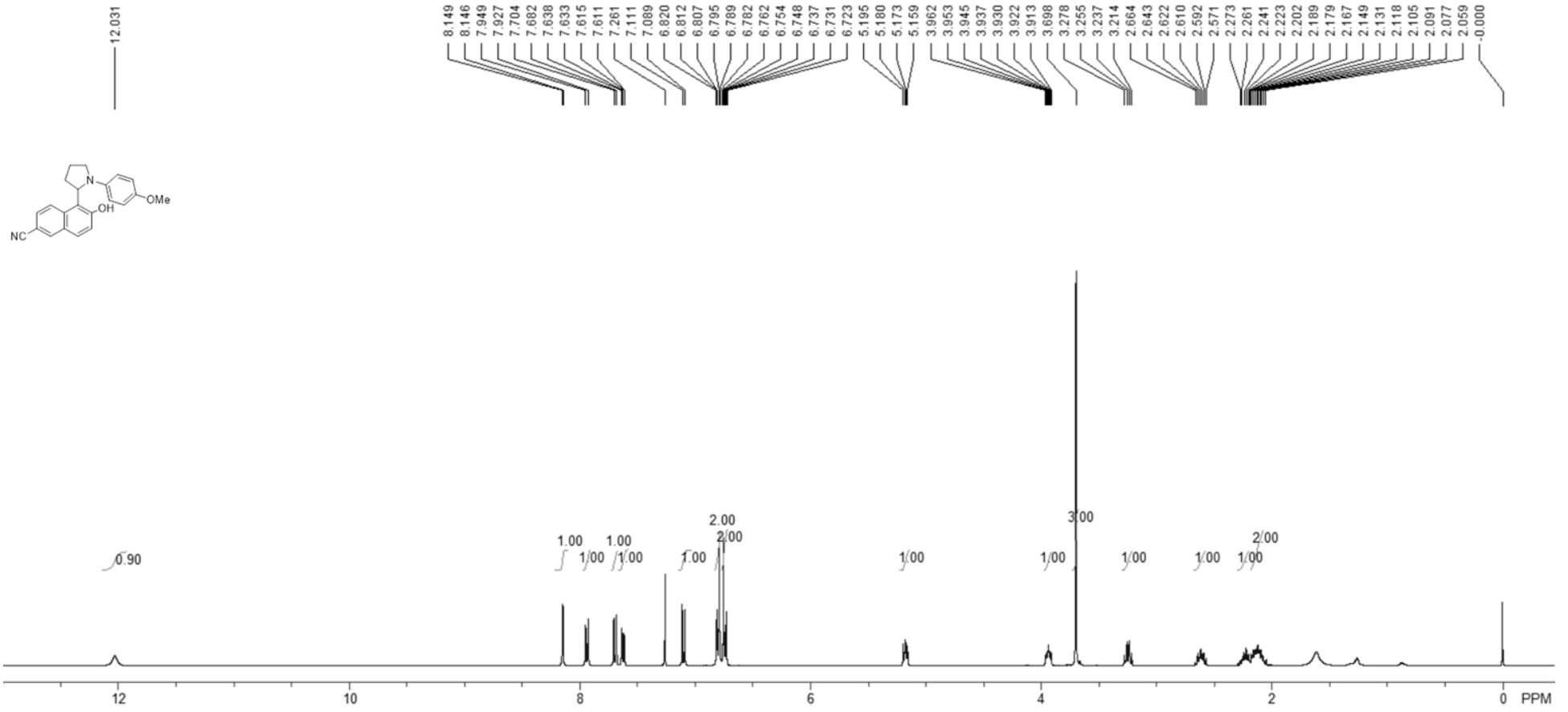
^{13}C NMR of 6b

100 MHz, $CDCl_3$



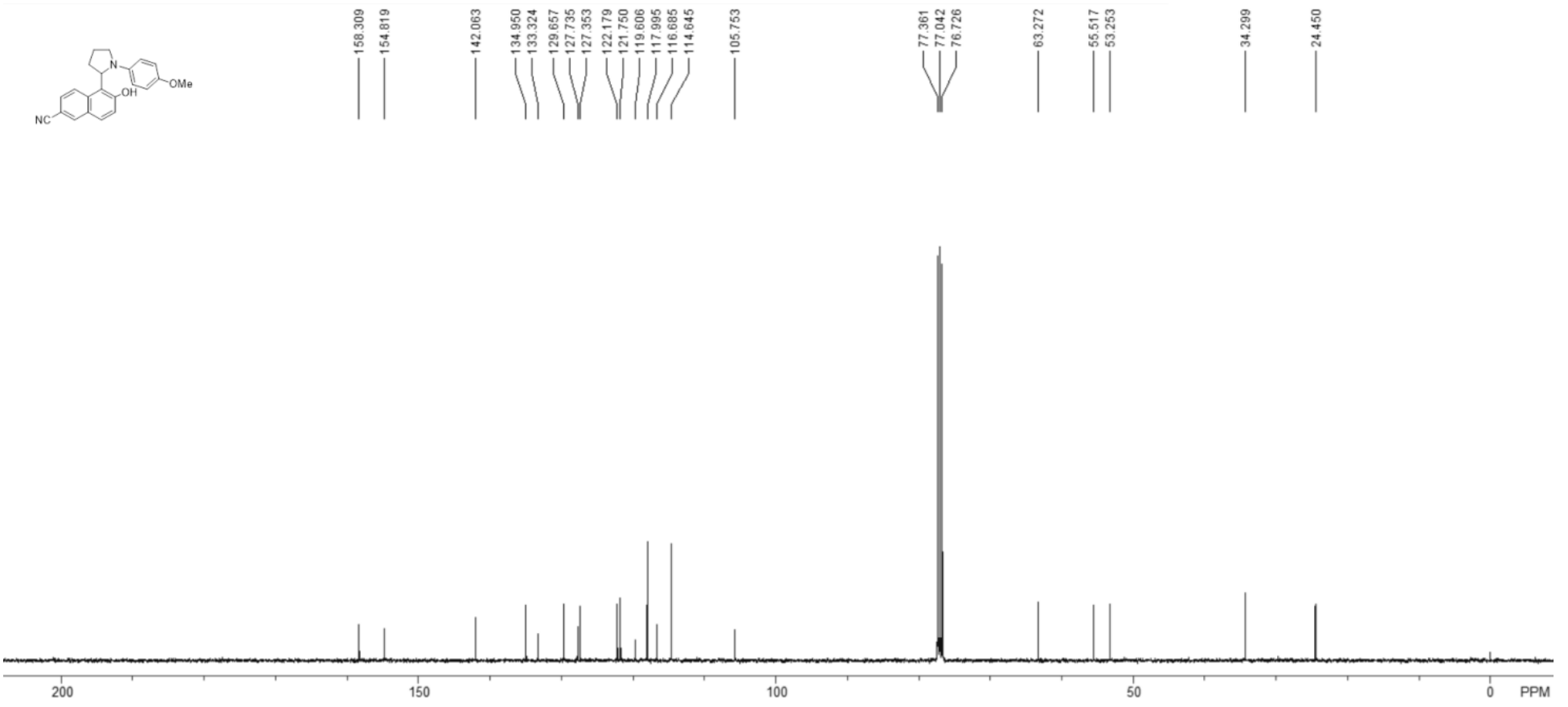
^{1}H NMR of 6c

400 MHz, $CDCl_3$



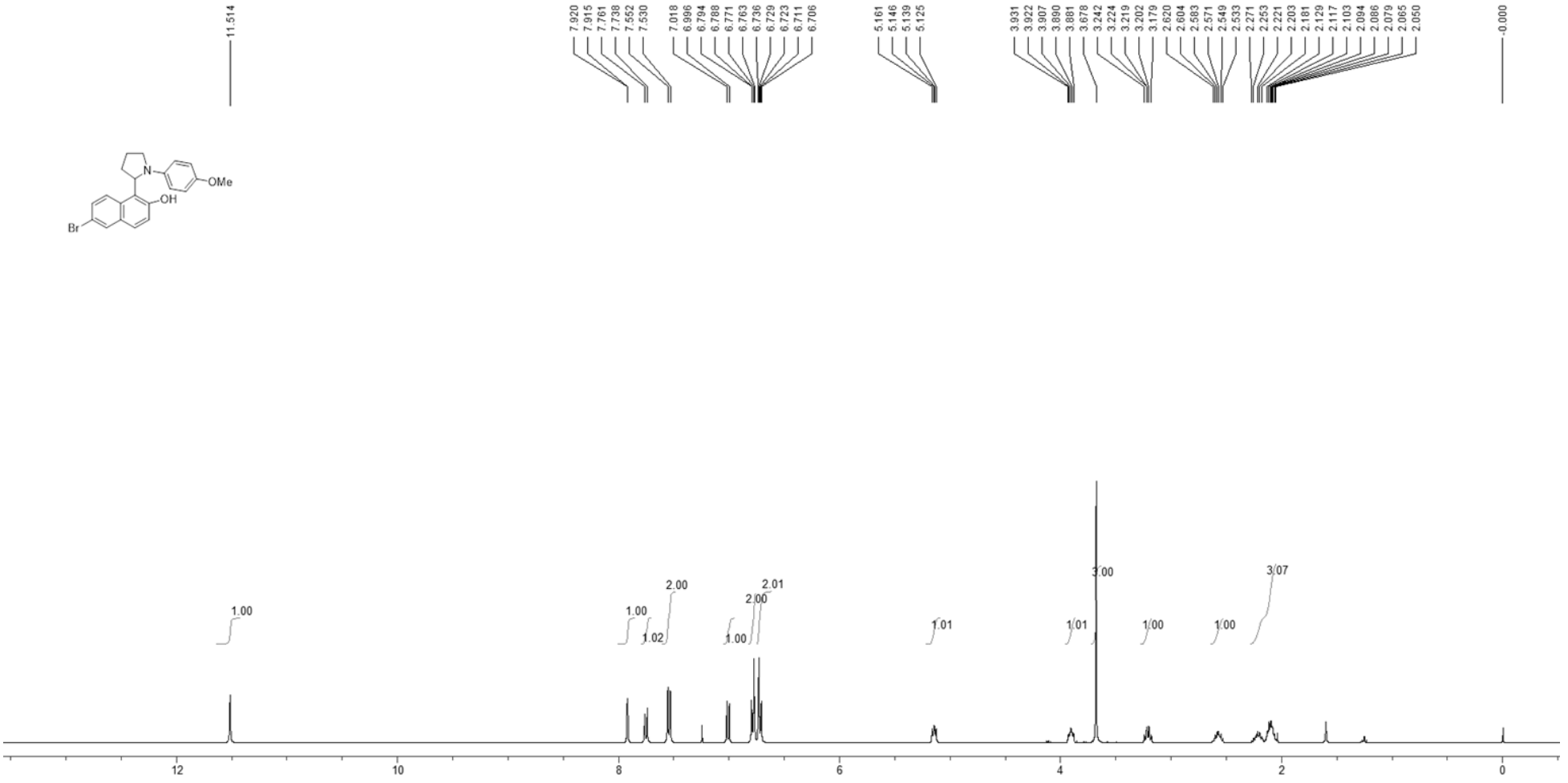
^{13}C NMR of 6c

100 MHz, $CDCl_3$



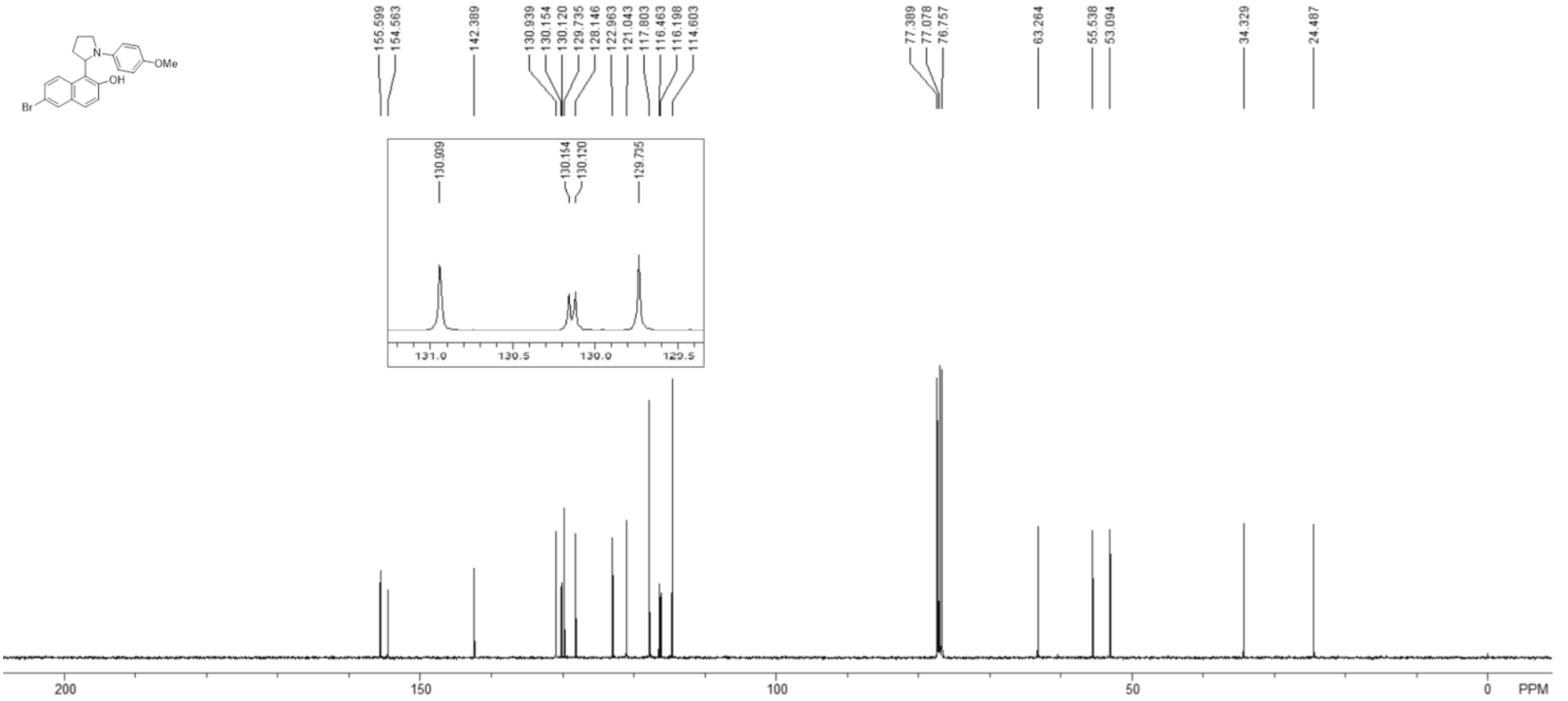
^{1}H NMR of 6d

400 MHz, $CDCl_3$



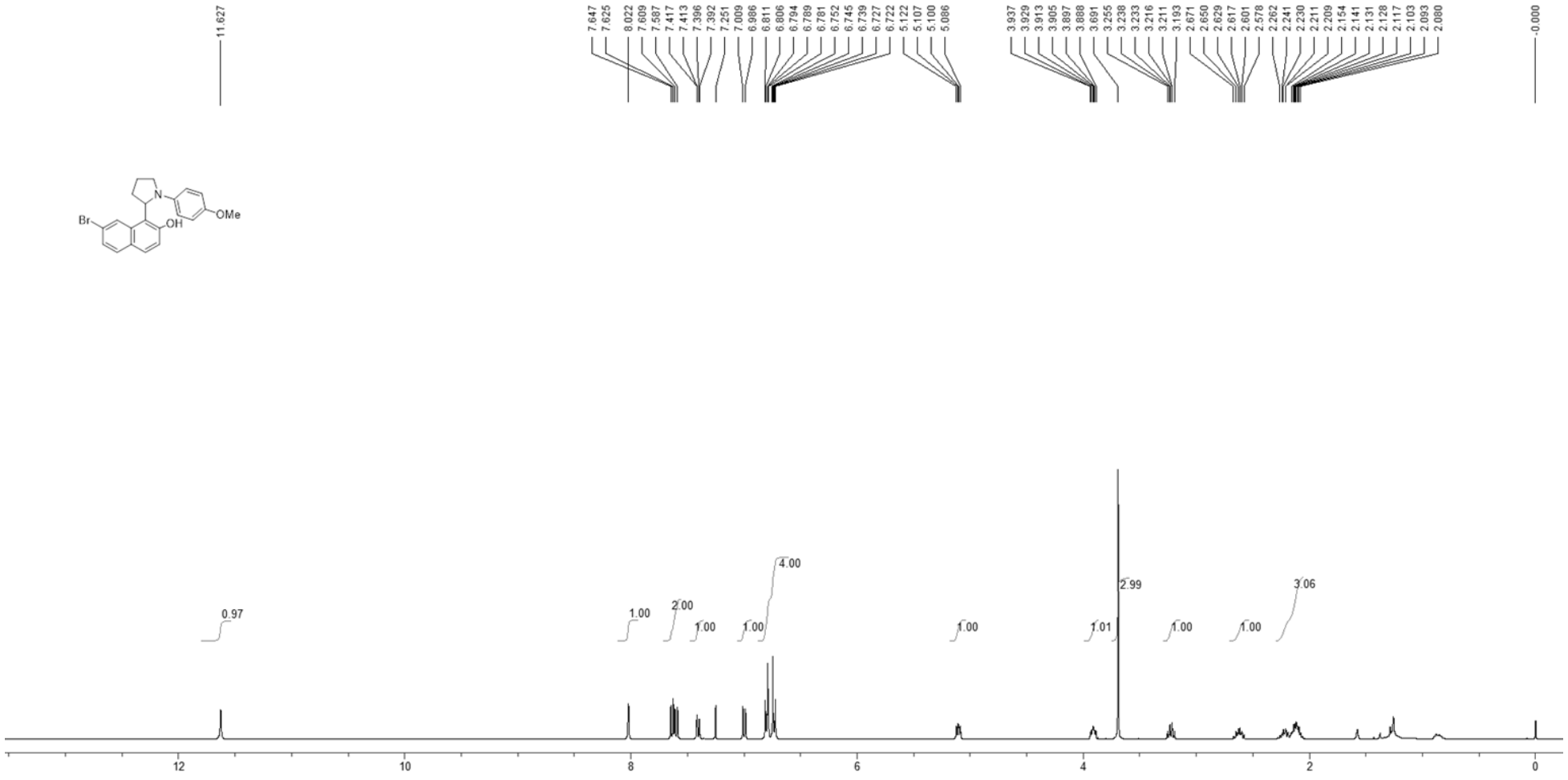
^{13}C NMR of 6d

100 MHz, $CDCl_3$



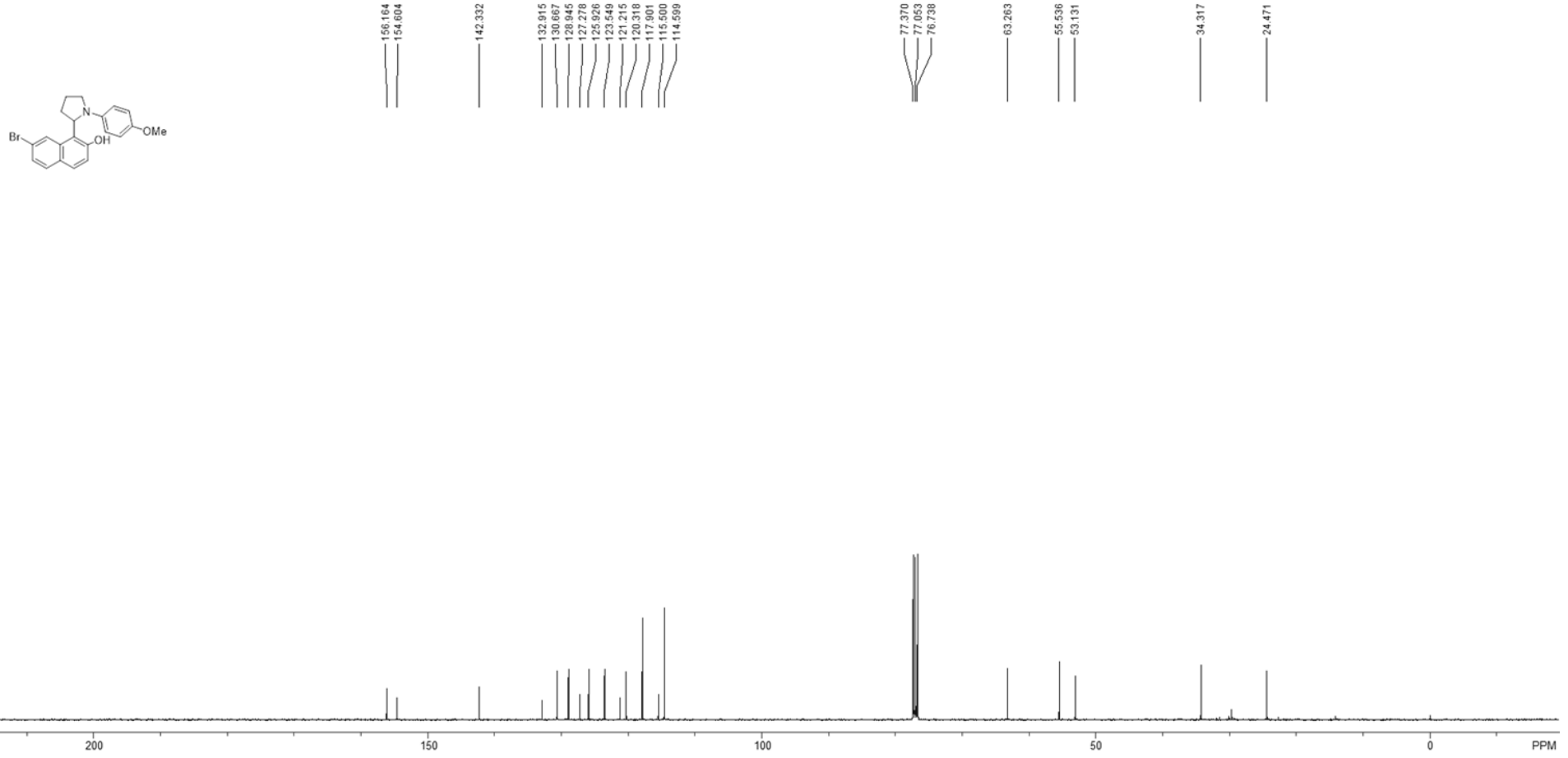
^{1}H NMR of 6e

400 MHz, $CDCl_3$



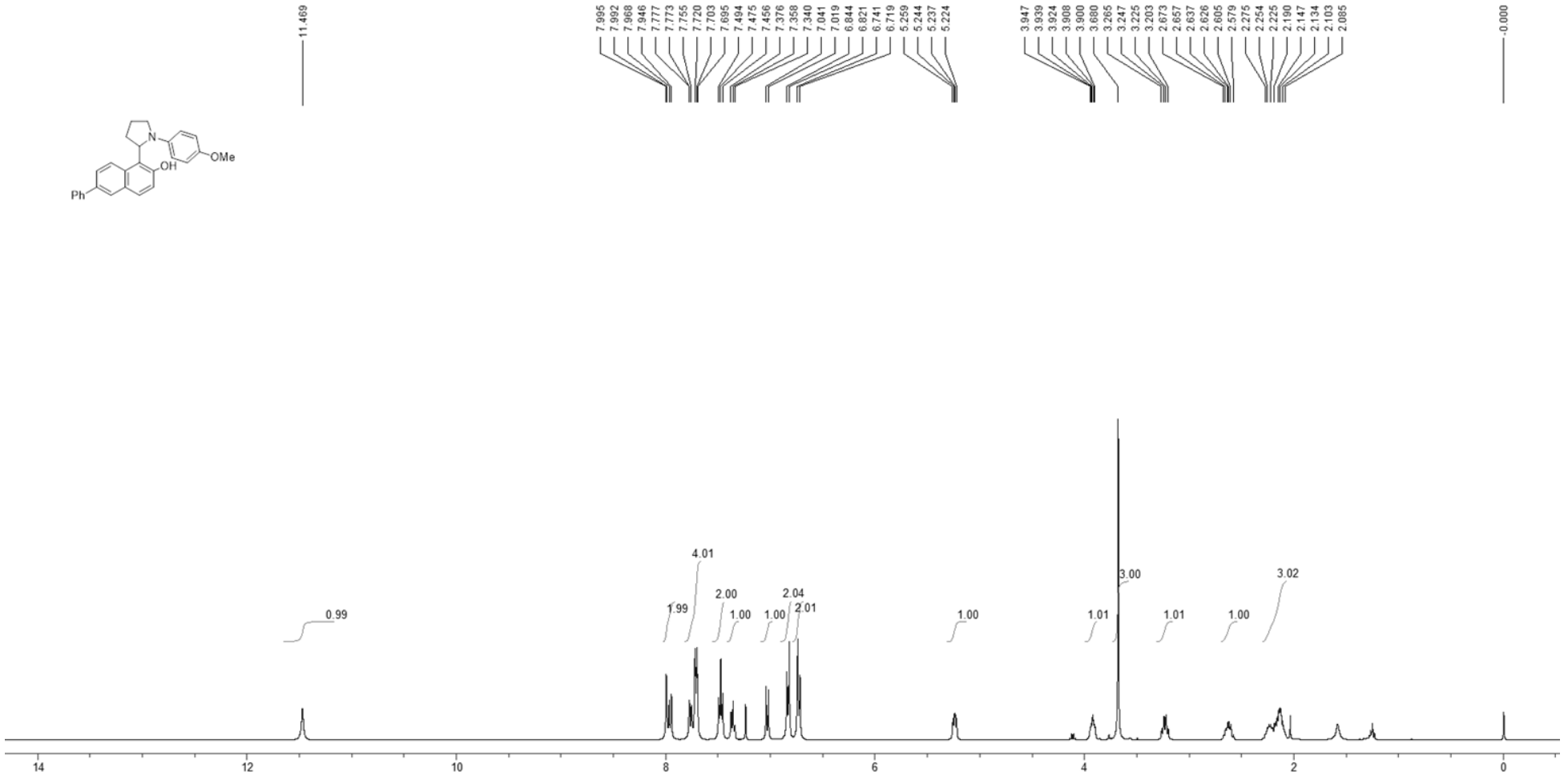
^{13}C NMR of 6e

100 MHz, $CDCl_3$



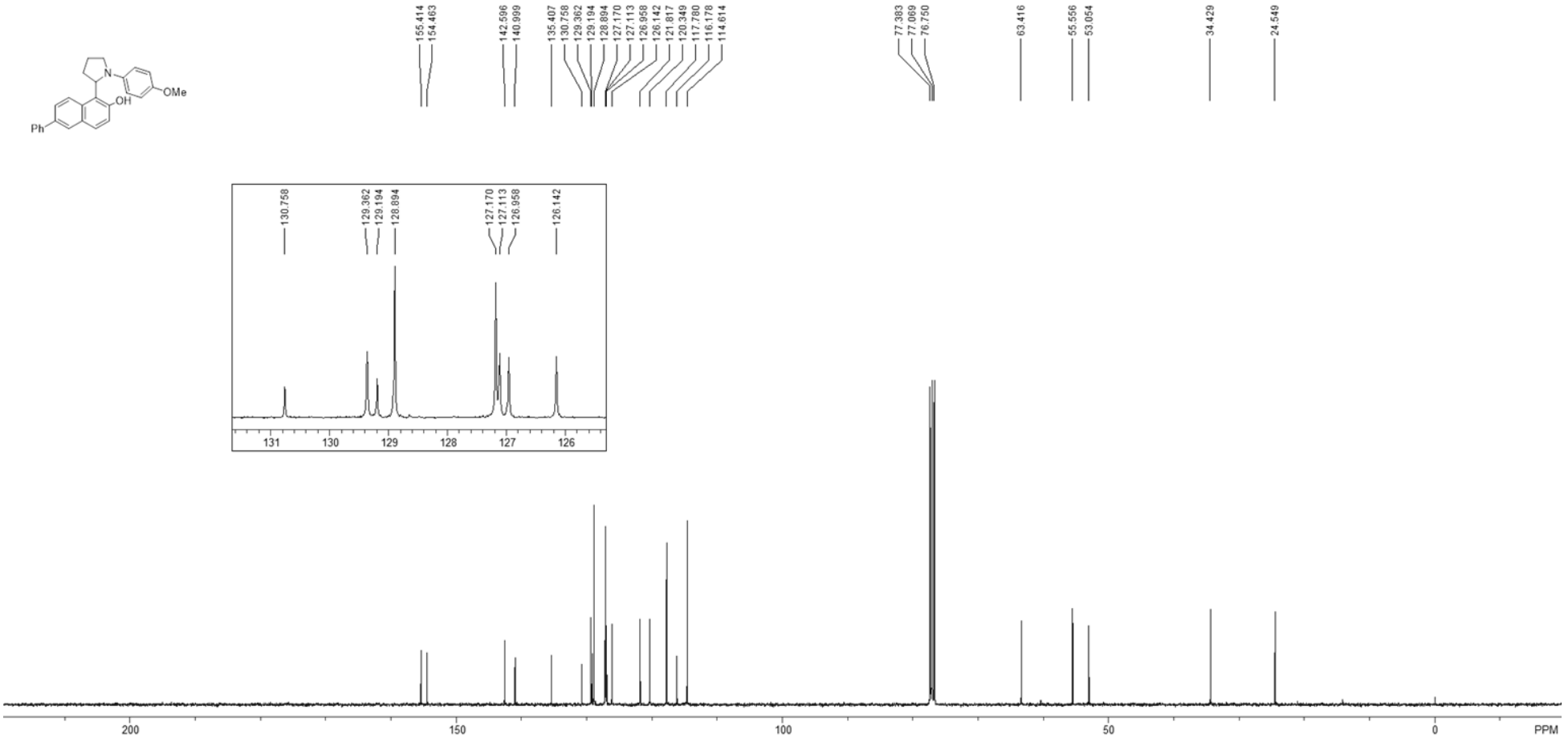
^{1}H NMR of 6f

400 MHz, $CDCl_3$



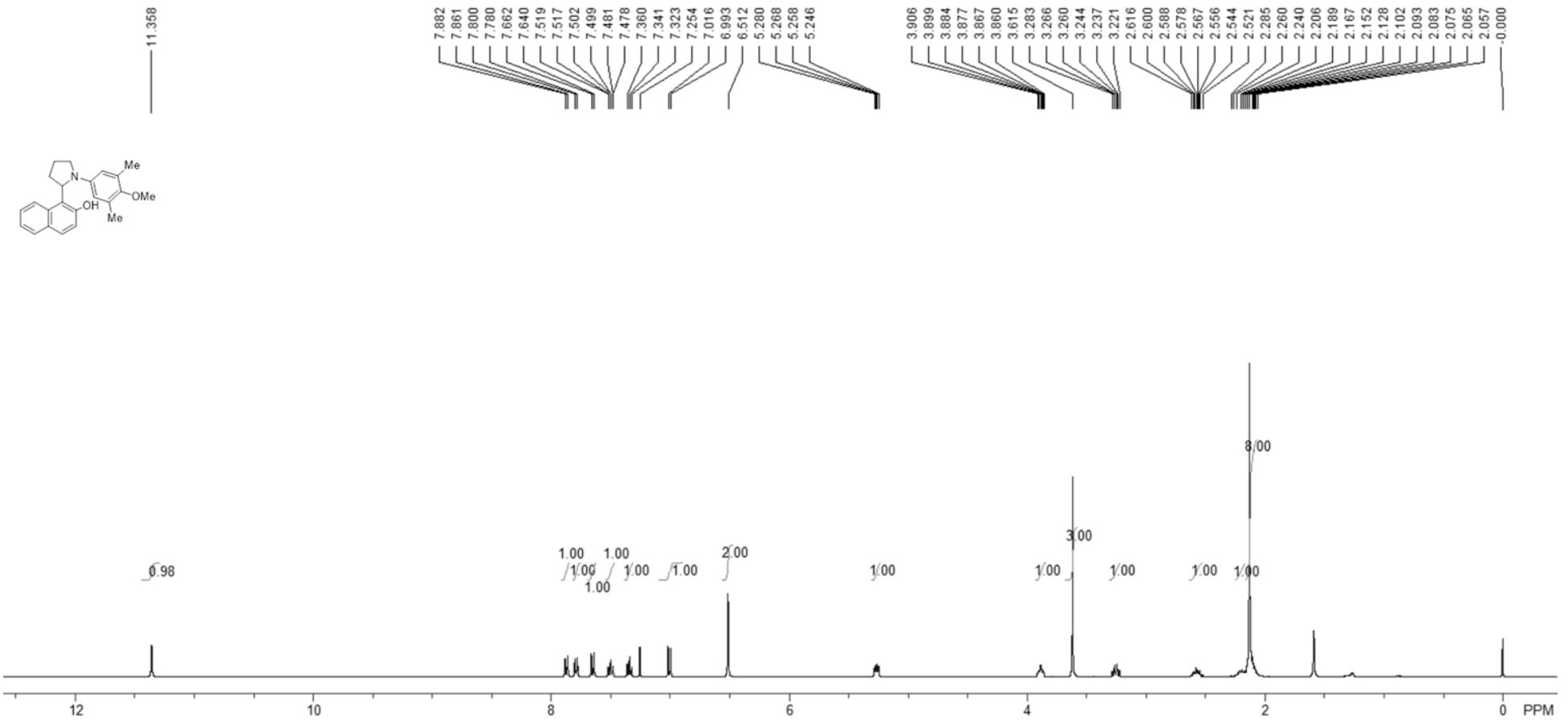
^{13}C NMR of 6f

100 MHz, $CDCl_3$



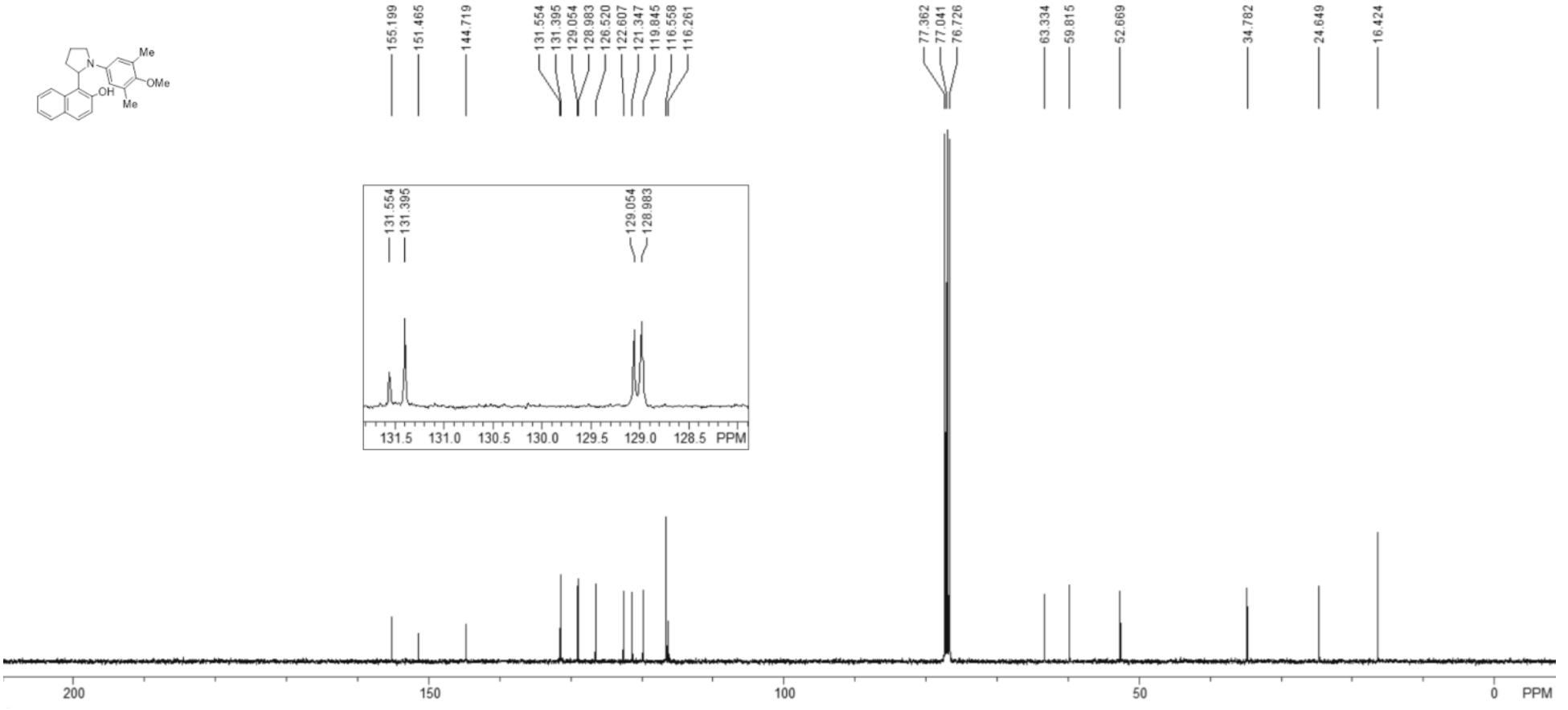
^{1}H NMR of 6g

400 MHz, $CDCl_3$



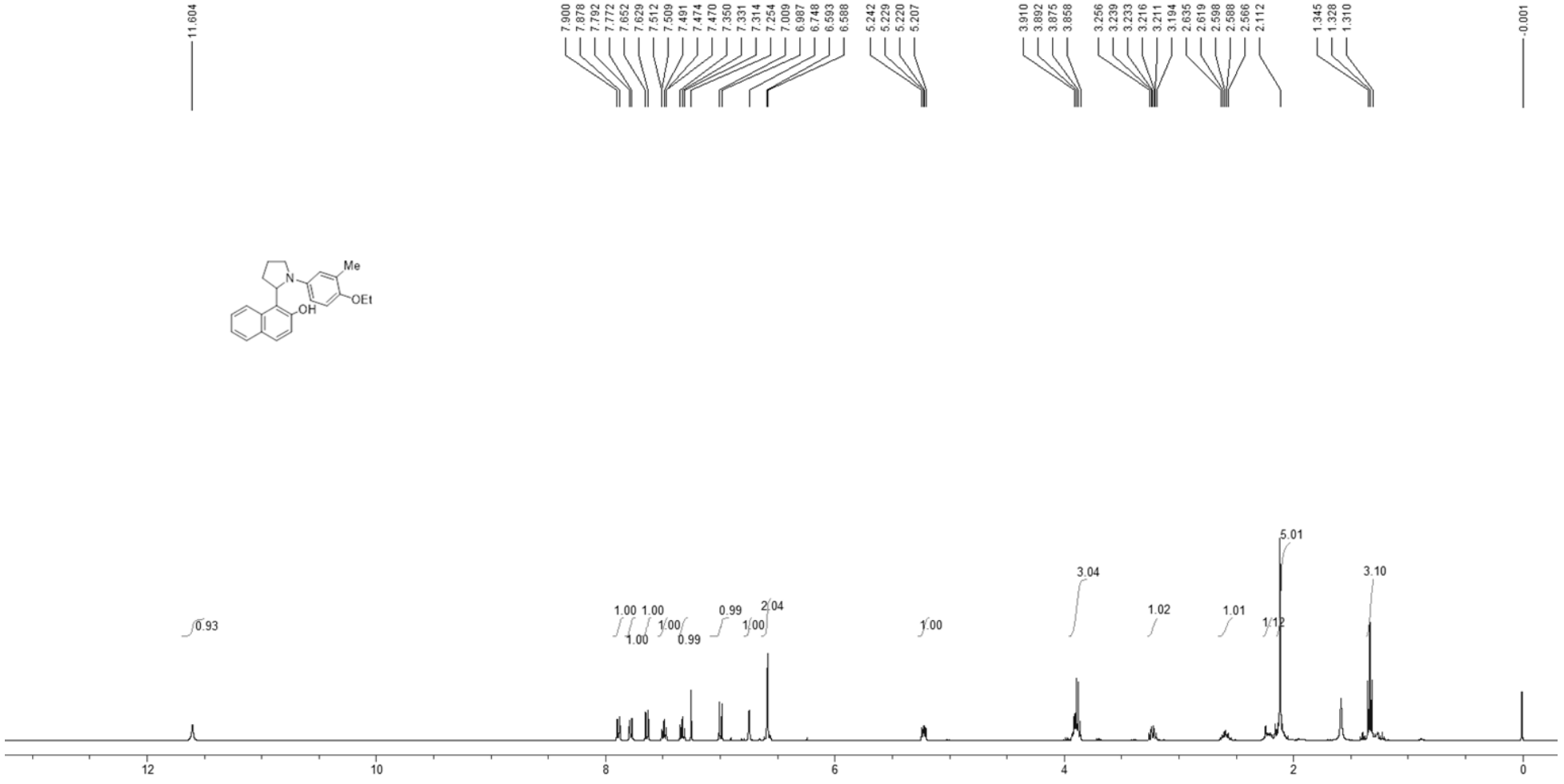
^{13}C NMR of 6g

100 MHz, $CDCl_3$



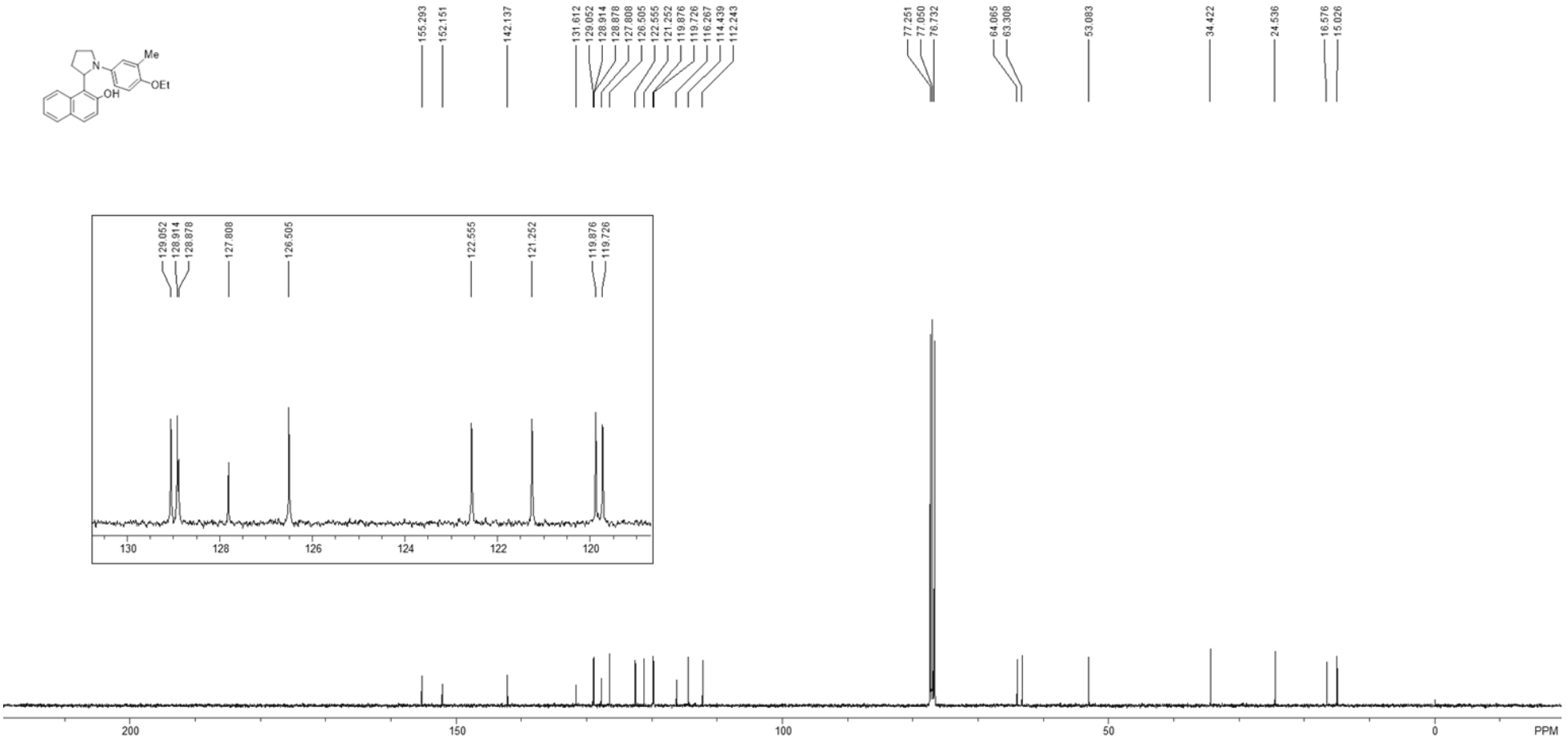
^{1}H NMR of 6h

400 MHz, $CDCl_3$



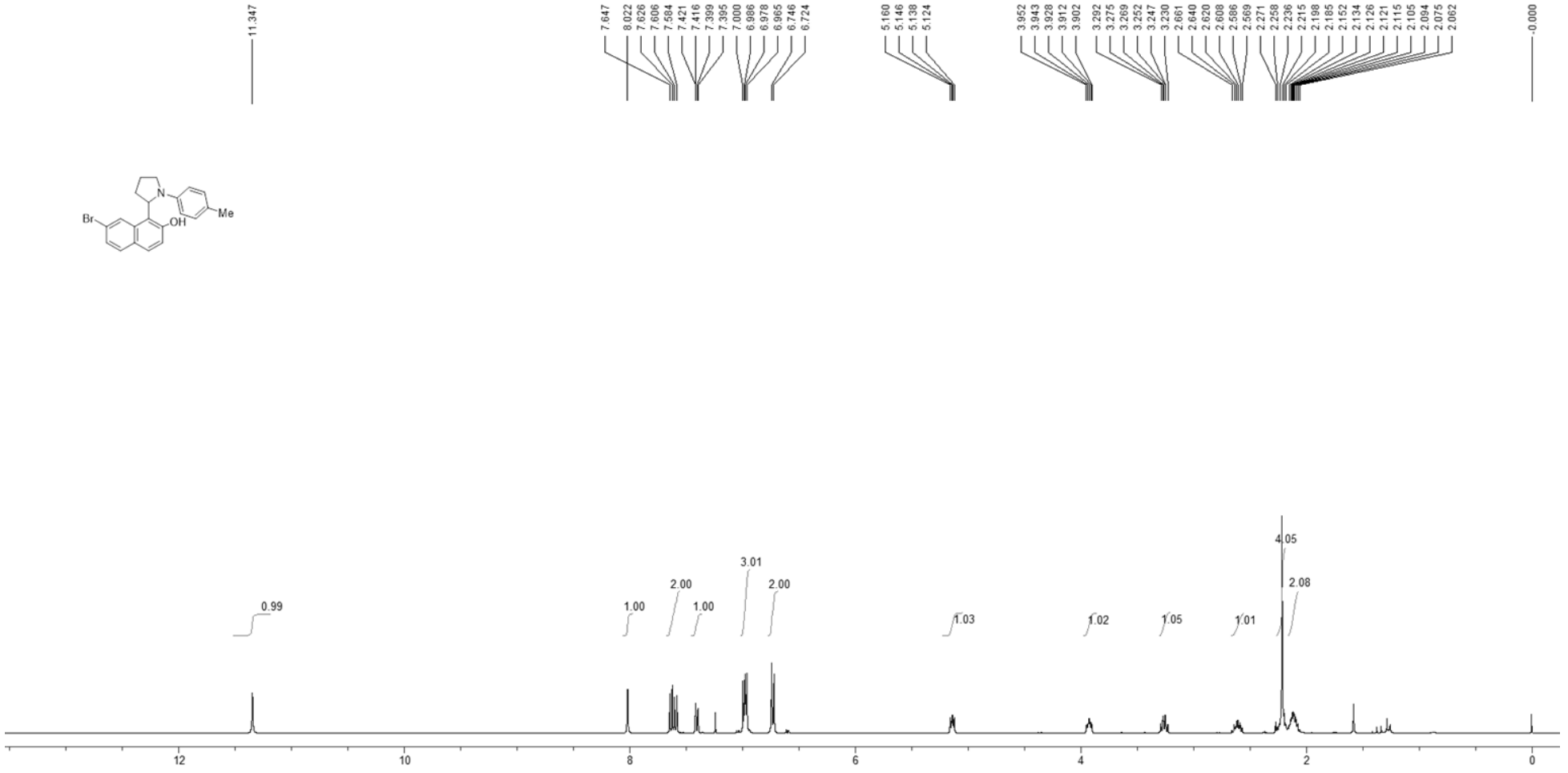
^{13}C NMR of 6h

100 MHz, $CDCl_3$



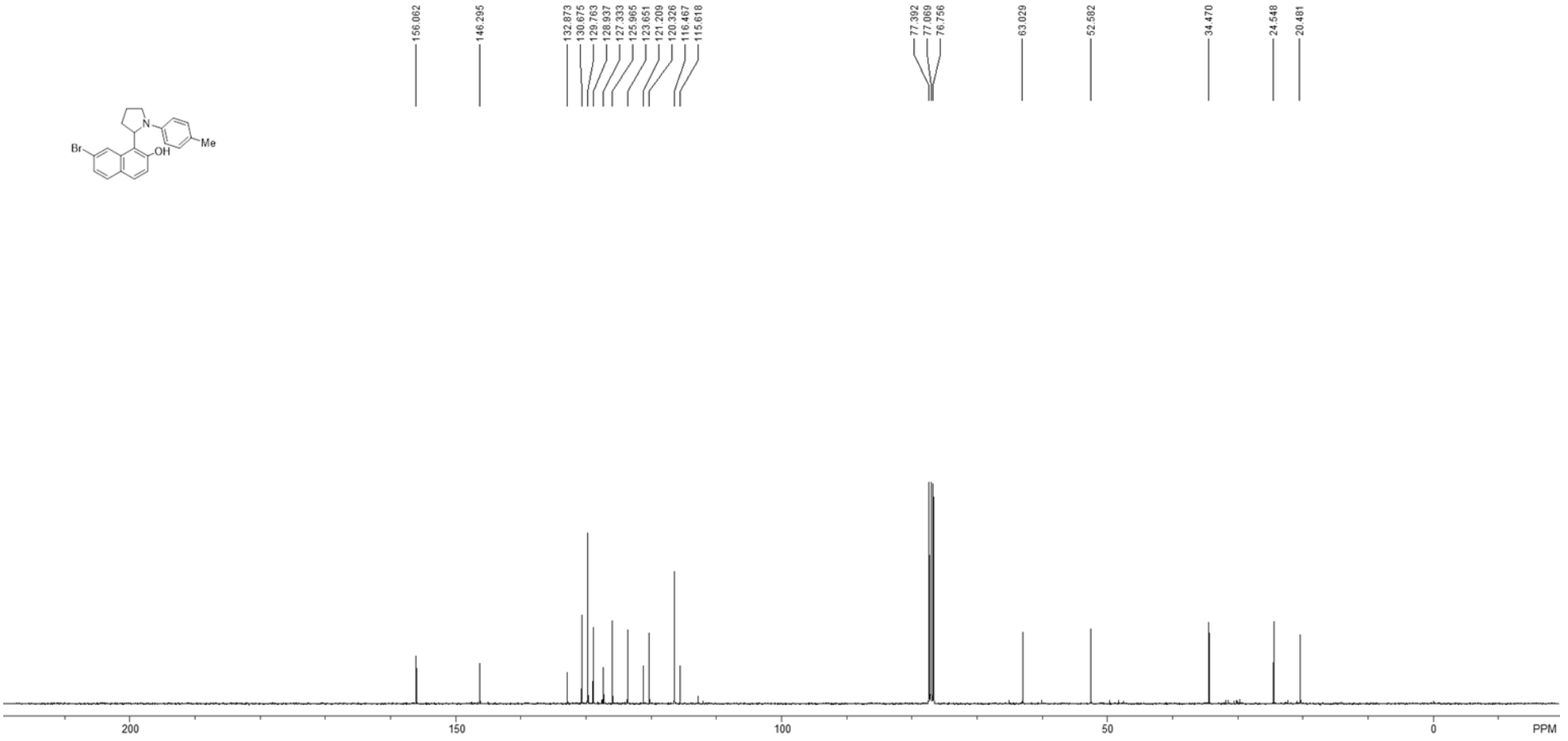
^{1}H NMR of 6i

400 MHz, $CDCl_3$



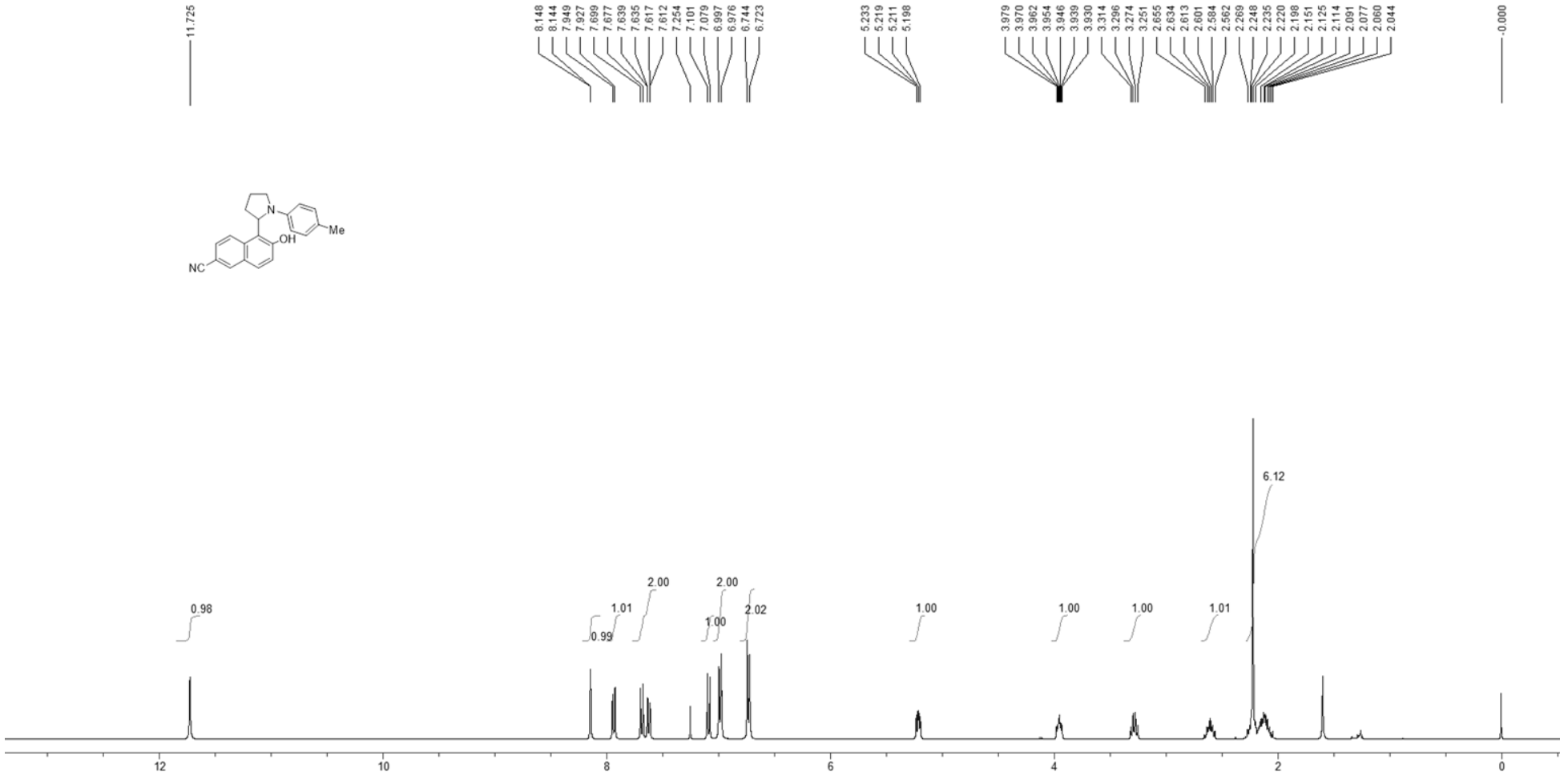
^{13}C NMR of 6i

100 MHz, $CDCl_3$



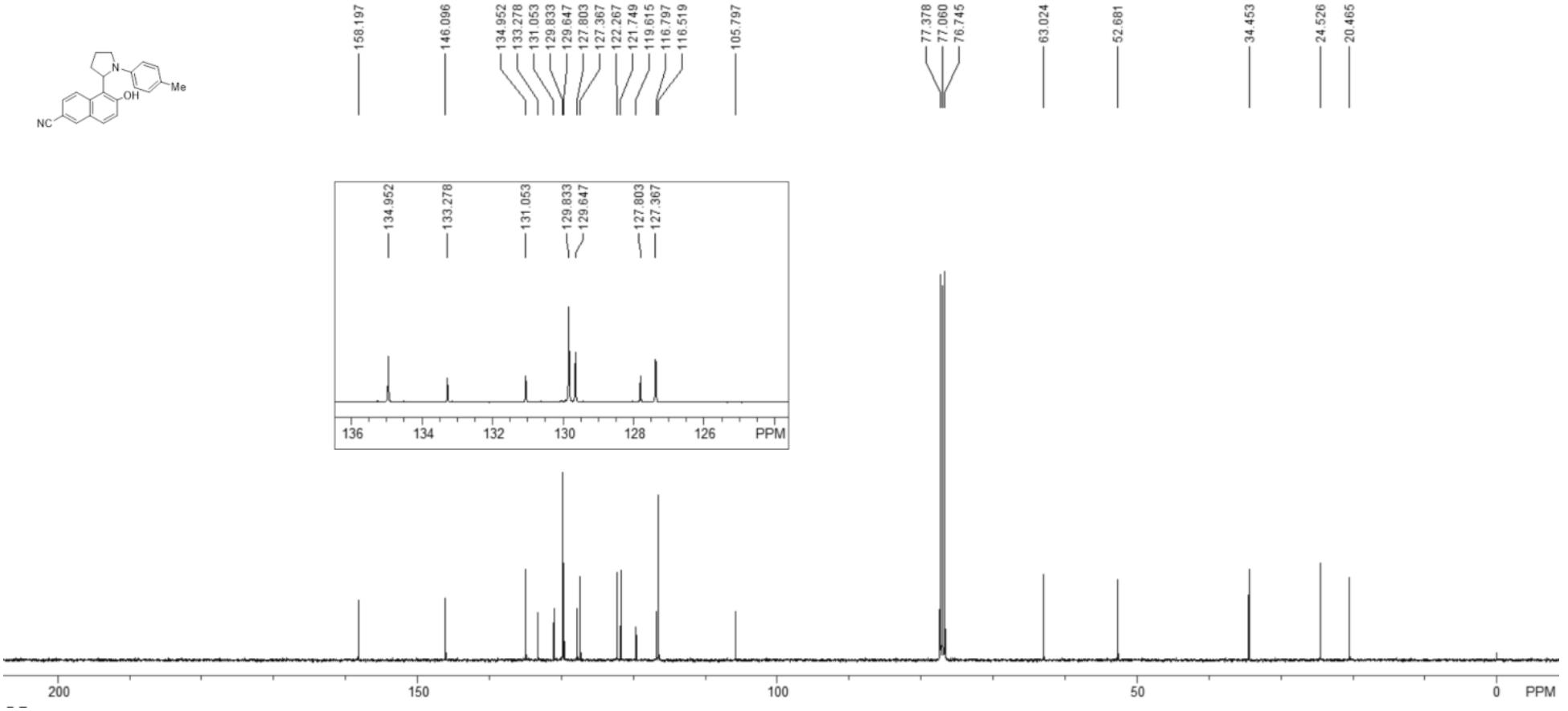
^{1}H NMR of 6j

400 MHz, $CDCl_3$



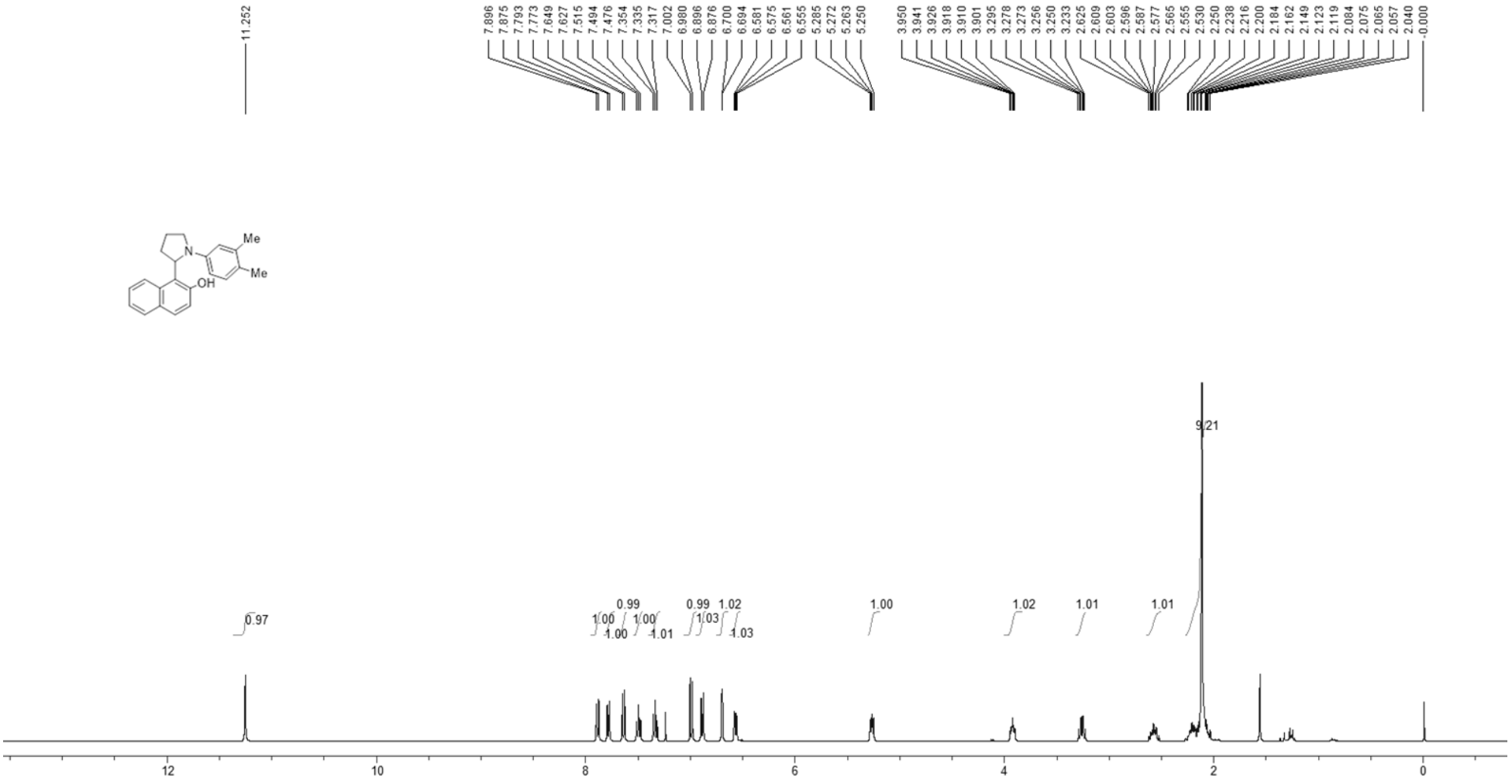
^{13}C NMR of 6j

100 MHz, $CDCl_3$



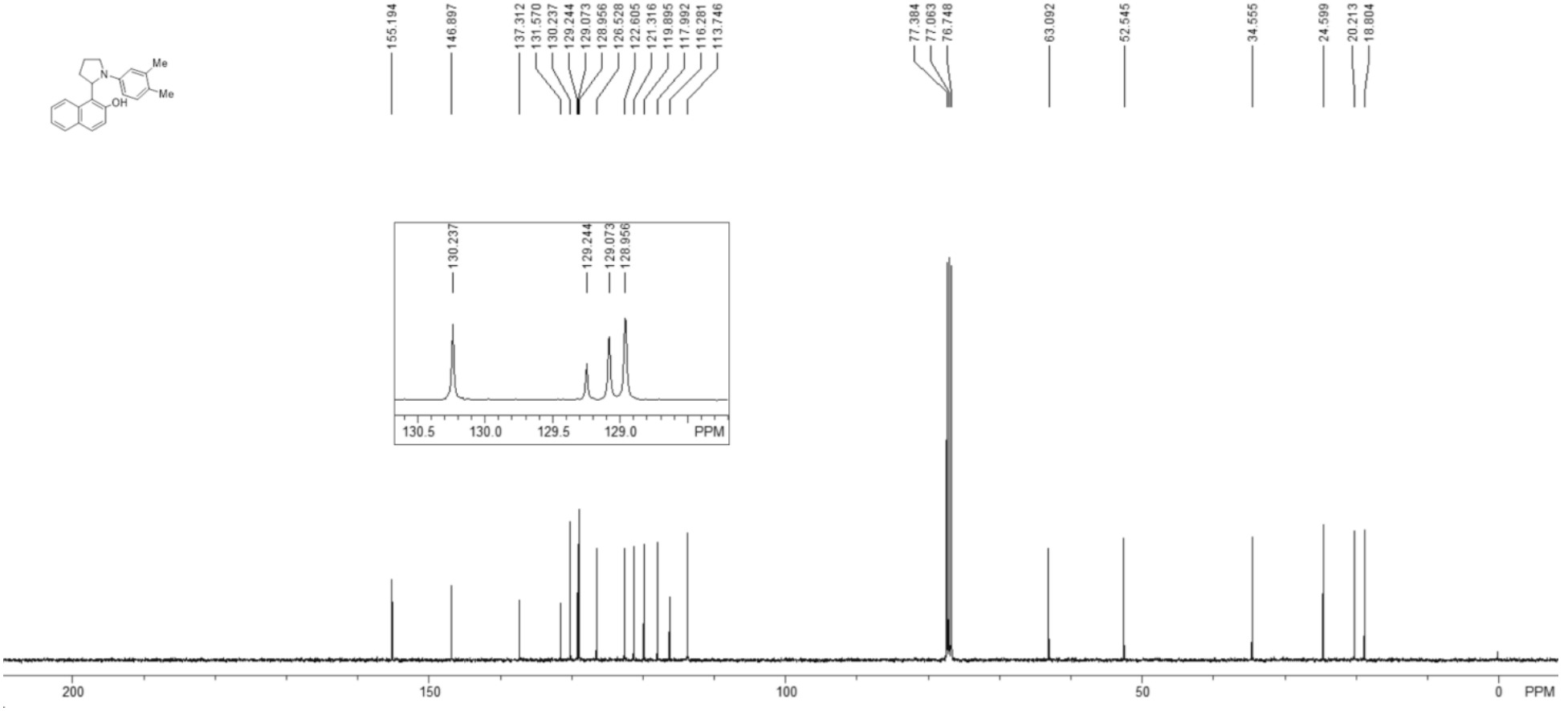
^{1}H NMR of 6k

400 MHz, $CDCl_3$



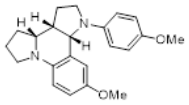
^{13}C NMR of 6k

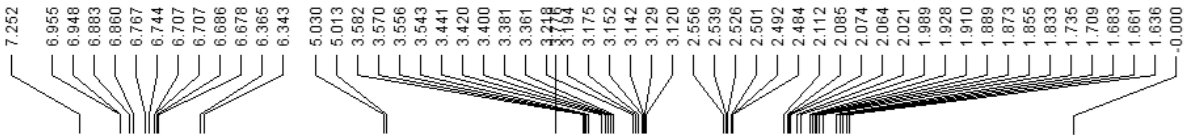
100 MHz, $CDCl_3$

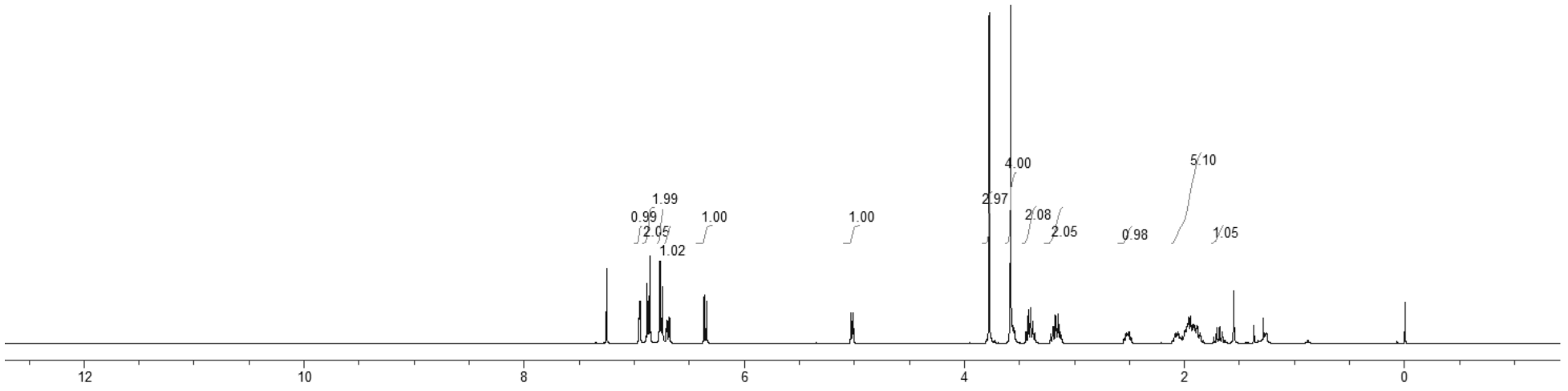


^{1}H NMR of 5a (major isomer)

400 MHz, $CDCl_3$

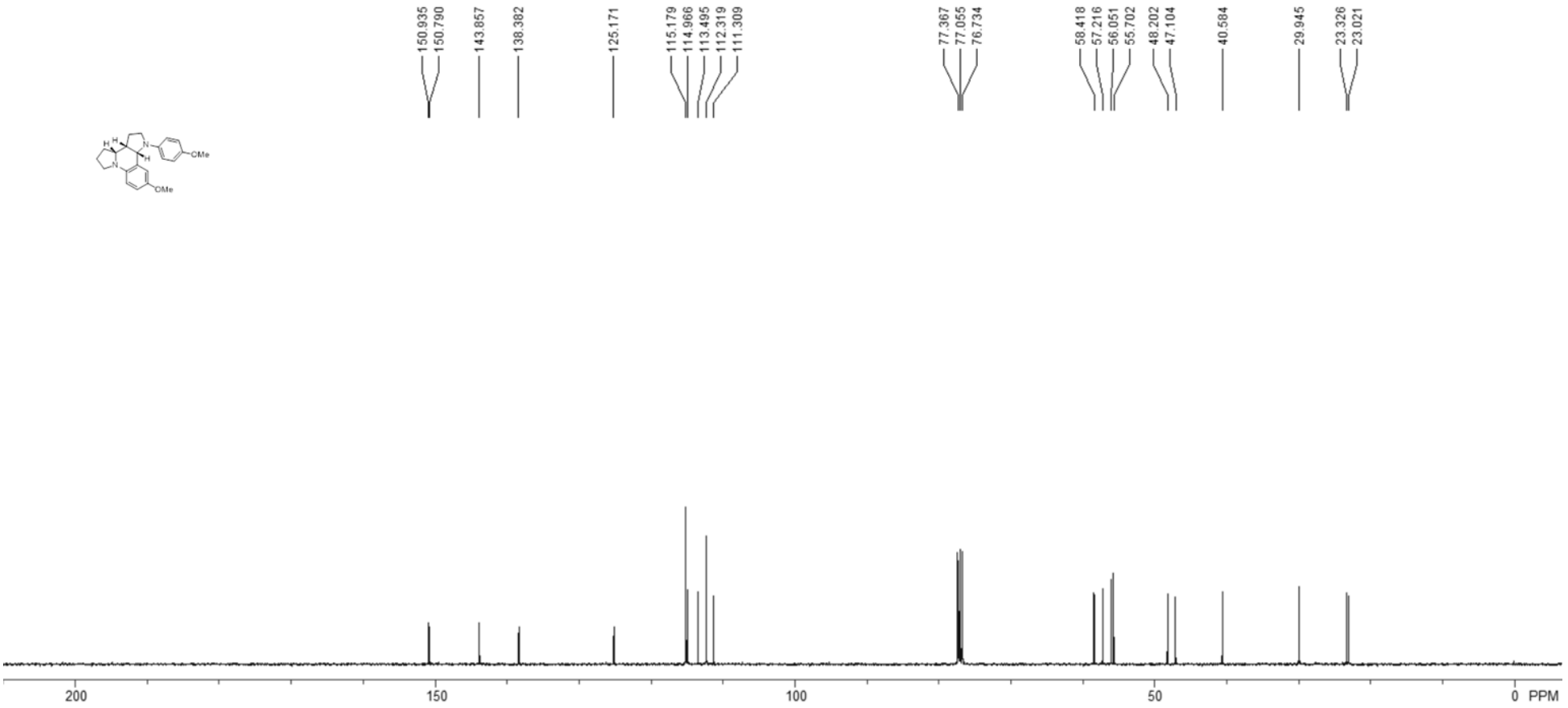






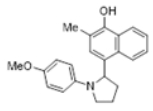
^{13}C NMR of 5a (major isomer)

100 MHz, $CDCl_3$



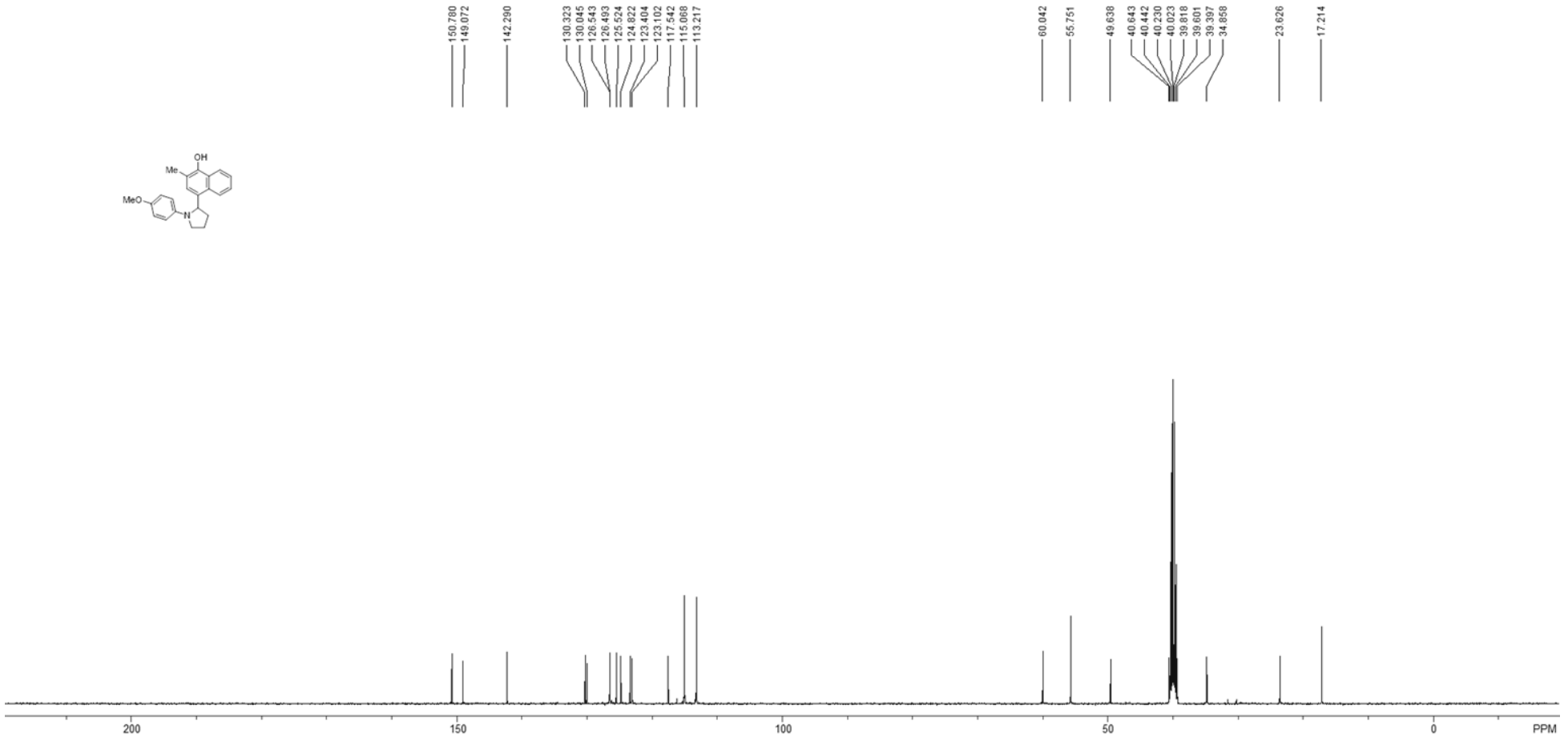
^{1}H NMR of 7

400 MHz, DMSO-d_6



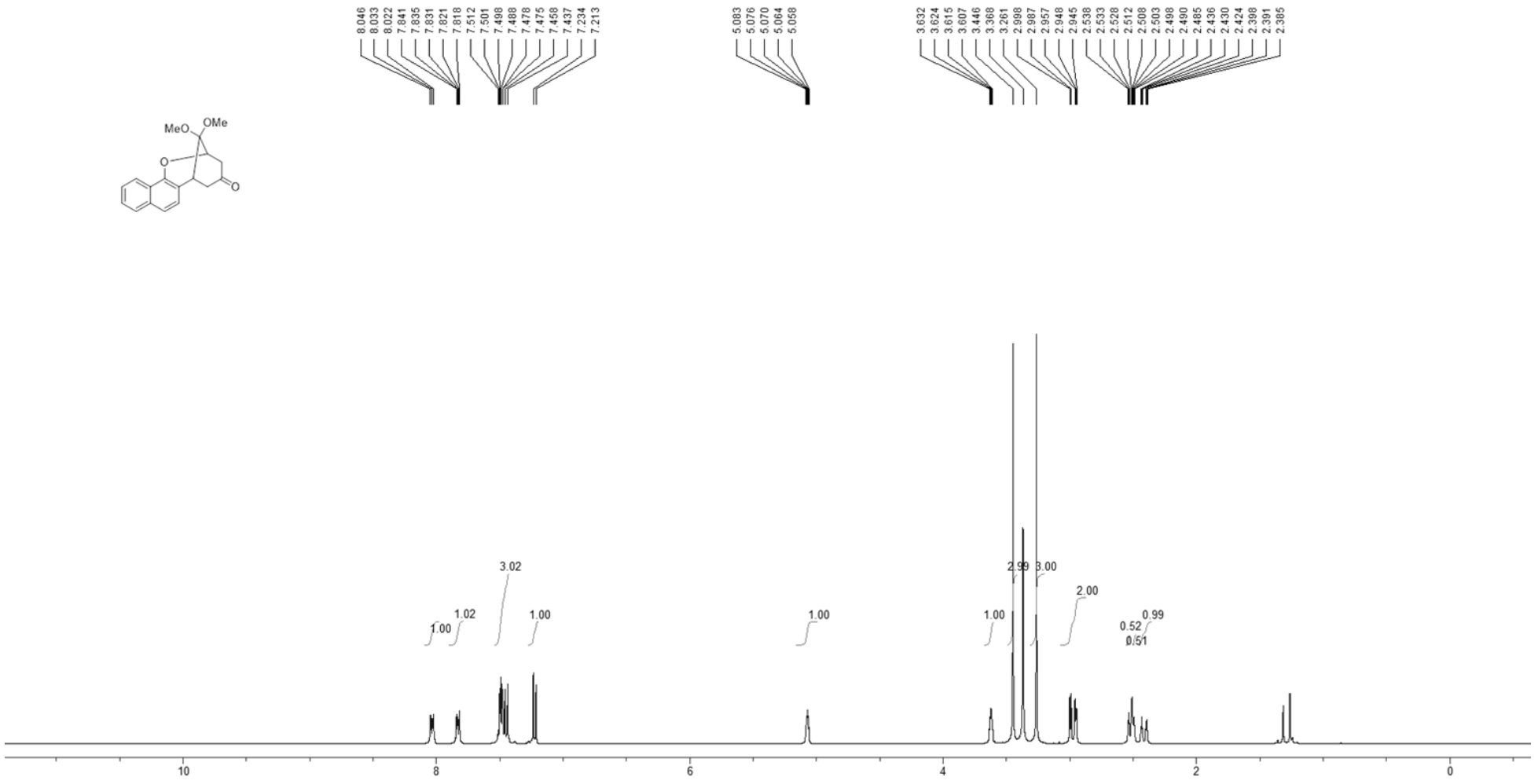
^{13}C NMR of 7

100 MHz, DMSO-d$_6$



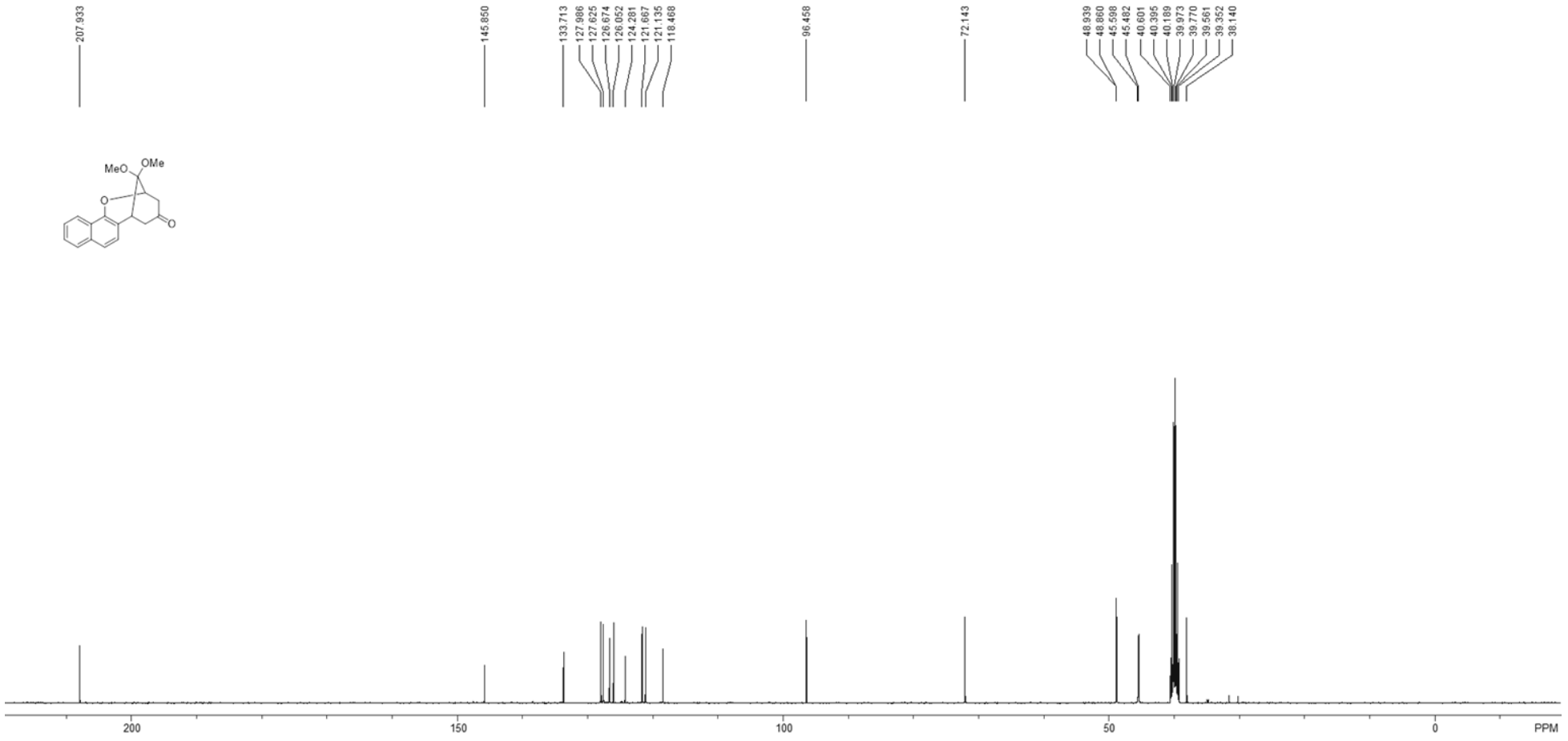
^{1}H NMR of 9

400 MHz, DMSO-d_6



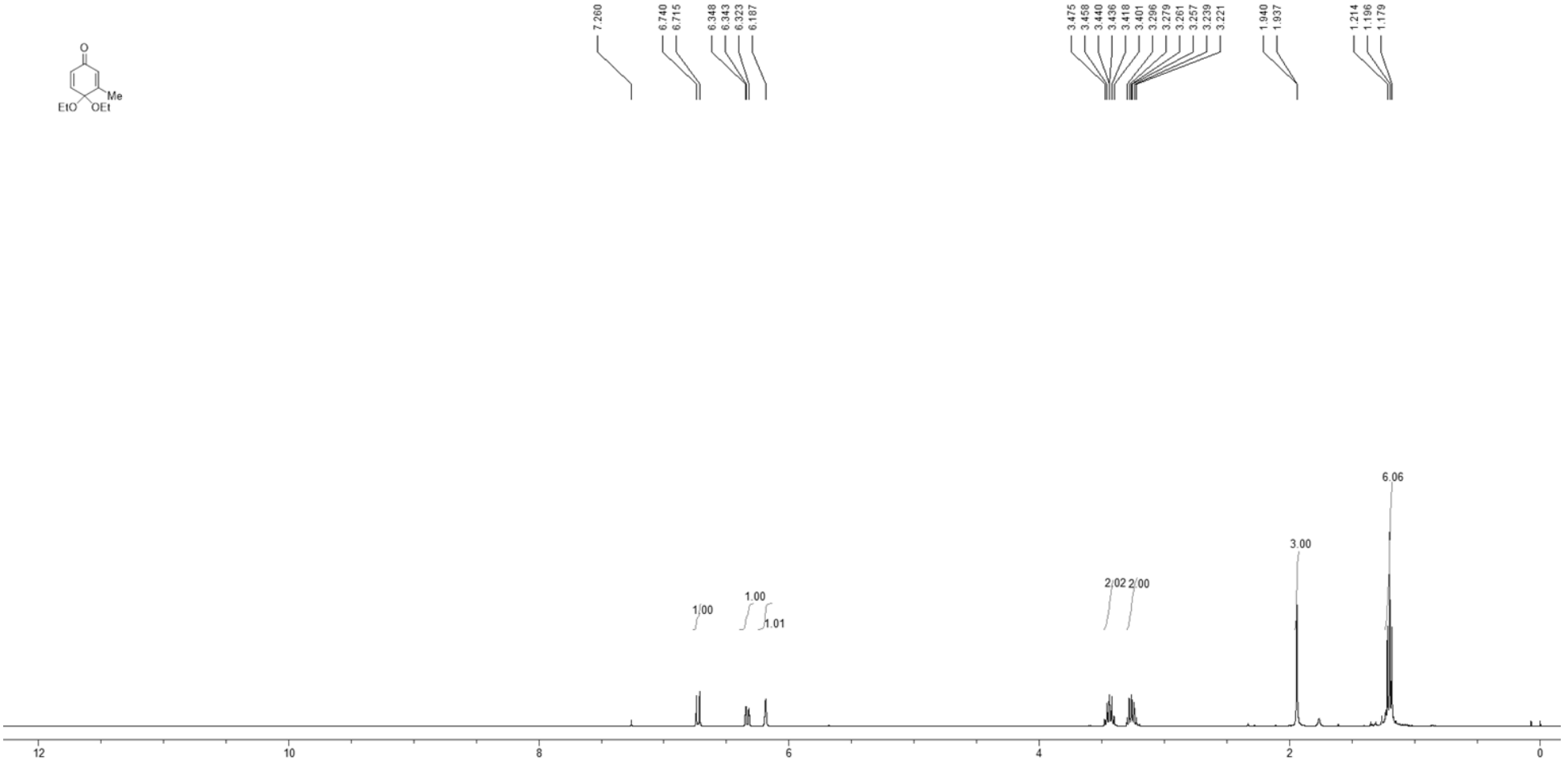
^{13}C NMR of 9

100 MHz, DMSO-d_6



^{1}H NMR of 1h

400 MHz, $CDCl_3$



^{13}C NMR of 1h

100 MHz, $CDCl_3$