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Supporting Information

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Intermolecular [3+2] Cycloaddition of Cyclopropylamines with Olefins by Visible-Light Photocatalysis**

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Supporting Information

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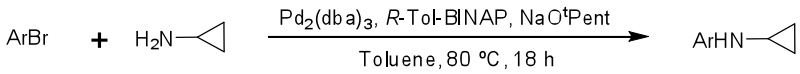
General Considerations

All reactions were carried out under a nitrogen atmosphere unless otherwise stated. Dry solvents were purchased and used as received except THF, CH_2Cl_2, Et_2O, and toluene. They were rigorously purged with argon for 2 h and then further purified by passing through two packed columns of neutral alumina (for THF and Et_2O) or through neutral alumina and copper (II) oxide (for toluene and CH_2Cl_2) under argon from a solvent purification system. Column chromatography was carried out with silica gel (230-400 mesh) and alumina neutral (32-63u). Nuclear magnetic resonance (NMR) spectra were recorded on a Bruker Avance DPX-300, a Bruker Avance DPX-400, or a Bruker Avance DPX-500 spectrometer. All ^{1}H NMR experiments were reported in δ units, parts per million (ppm), and measured relative to the signal for residual chloroform (7.26 ppm) in the deuterated solvent. All ^{13}C NMR experiments were reported in ppm relative to deuterochloroform (77.23 ppm) and obtained with ^{1}H decoupling. All new compounds were characterized by ^{1}H NMR, ^{13}C NMR, IR spectroscopy, and high-resolution mass spectroscopy. The relative configuration of new compounds was established by gCOSY, HMQC, NOESY experiments, and X-ray crystallography. High-resolution mass spectra were recorded on a Bruker Ultraflex II TOF/TOF mass spectrometer. IR spectra were recorded (thin film on NaCl plates) on a PerkinElmer Spectrum 100 series instrument. Melting Points were determined with capillary melting point apparatus-Stuart SMP10 and were uncorrected. Gas Chromatographic analyses were performed on a Shimadzu GC-17A gas chromatography instrument with a FID detector using 15 m x 0.25 mm capillary column Rtx-5 with cross-bond 5% diphenyl-95% dimethyl polysiloxane as a stationary phase. Cyclic voltametry experiments were performed using CH Instruments-Electrochemical Analyzer.

Experimental Procedures and Spectroscopic Data

- ***General procedure 1 (GP1): synthesis of N-arylcyclopropylamines***

All N-arylcyclopropylamines (except **1c**) were synthesized according to a modified procedure of Loeppky and co-workers as described below.[1]



To an oven-dried schlenk tube equipped with a stir bar were added 1 mmol of aromatic bromide, 0.01 mmol of $Pd_2(dba)_3$, 0.03 mmol of (*R*)-Tol-BINAP, 1.5 mmol of NaO^tPent, and 1-2 mL of toluene. After purging with argon for a few seconds, the tube was capped with a Teflon screw cap, wrapped with aluminum foil, and heated at 80 °C for 18 h. The reaction mixture was cooled to room temperature, diluted with ether, filtered through a short pad of silica gel, and concentrated under vacuum. Purification of the residual mass by column chromatography on silica gel afforded *N*-cyclopropylamine.

***N*-Cyclopropylaniline (1a).** Following **GP1** with bromobenzene (527 μL, 5 mmol, 1 equiv.), **1a** was isolated after column chromatography on silica gel (3% EtOAc/hexane) as a colorless liquid (410 mg, 62%). Spectral data correspond to those described in the literature.[2]

4-Chloro-*N*-cyclopropylaniline (1b). Following **GP1** with 4-chlorobromobenzene (574 mg, 3 mmol, 1 equiv.), **1b** was isolated after column chromatography on silica gel (3% EtOAc/hexane) as a colorless oil (325 mg, 65%). Spectral data correspond to those described in the literature.[3]

***N*-Cyclopropyl-2-biphenylamine (1d).** Following **GP1** with 2-bromobiphenyl (173 μL, 1 mmol, 1 equiv.), **1d** was isolated after column chromatography on silica gel (2% EtOAc/hexane) as a colorless liquid (200 mg, 95%). IR ν_{max} (film) 3417, 3058, 3008, 2963, 1603, 1582, 1506, 1489, 1435, 1309, 1286 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.45–7.38 (m, 4H), 7.37–7.33 (m, 1H), 7.30–7.26 (m, 1H), 7.16 (dd, *J* = 8.4, 1.2 Hz, 1H), 7.10 (dd, *J* = 7.6, 1.6 Hz, 1H), 6.82 (dt, *J* = 7.2, 1.2 Hz, 1H), 4.46 (br s, 1H), 2.38 (ddd, *J* = 10.2, 6.8, 3.6 Hz, 1H), 0.73–0.69 (m, 2H), 0.50–0.46 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.5, 139.4, 130.1, 129.3, 128.8, 128.5, 127.3, 127.1, 117.4, 111.7, 25.4, 7.5; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{15}H_{16}N$ 210.128; found 210.128.

***N*-Cyclopropyl-1-napthylamine (1e).** Following **GP1** with 1-bromonapthalene (139 μL, 1 mmol, 1 equiv.), **1e** was isolated after column chromatography on silica gel (3% EtOAc/hexane) as a white solid (182 mg, 99%). Spectral data correspond to those described in the literature.[1]

***N*-Cyclopropyl-3-pyridinamine (1f).** Following **GP1** with 3-bromopyridine (964 μL, 10 mmol, 1 equiv.), **1f** was isolated after column chromatography on silica gel (40% EtOAc/hexane) as an yellow oil (550 mg, 41%). Spectral data correspond to those described in the literature.[1]

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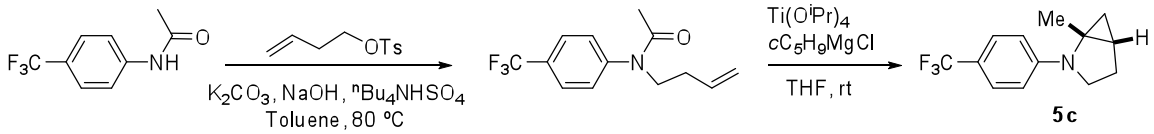
[1] W. Cui, R. N. Loeppky, *Tetrahedron* **2001**, *57*, 2953-2956.
[2] M. Gillaspy, B. A. Lefker, W. A. Hada, D. J. Hoover, *Tetrahedron Lett*. **1995**, *36*, 7399-7402.
[3] R. N. Loeppky, S. Elomari, *J. Org. Chem*. **2000**, *65*, 96-103.

***N*-Cyclopropyl-4-(trifluoromethyl)aniline (1c).** An oven-dried schlenk tube was charged with CuI (58 mg, 0.30 mmol), K_2CO_3 (1.66 g, 12 mmol), proline (138 mg, 1.2 mmol), cyclopropyl amine (832 μL, 12 mmol), 4-iodobenzotrifluoride (882 μL, 6 mmol), DMSO (6 mL) and a stir bar. After purging with argon for a few seconds, the tube was sealed with a Teflon screw cap and wrapped with aluminum foil. The mixture was heated at 70 ^oC for 12 h. The reaction mixture was then cooled to room temperature, quenched with brine and diluted with diethyl ether. The organic layer was separated and the aqueous layer was extracted with diethyl ether. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under vacuum. Purification of the residual mass by silica gel column chromatography (5% EtOAc/hexane) afforded the title compound **1c** (1.05 g, 87%) as a yellowish oil. IR ν_{max} (film) 3414, 3011, 2978, 1619, 1530, 1480, 1454, 1408, 1327 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.41 (d, J = 8.4 Hz, 2H), 6.78 (d, J = 8.4 Hz, 2H), 4.44 (br s, 1H), 2.46 (ddd, J = 9.8, 6.6, 3.4 Hz, 1H), 0.81–0.76 (m, 2H), 0.55–0.51 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 151.2, 126.4 (q, J = 4.0 Hz), 123.7 (q, J = 270.0 Hz), 119.2 (q, J = 32.0 Hz), 112.3, 24.8, 7.5; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{10}H_{11}F_3N$ 202.085; found 202.084.

Synthesis of N-Aryl bicyclic cyclopropylamines.

For the preparation and characterization of compounds **5a**, **5b** and **5g**: see (a) C. Madelaine, Y. Six, O. Buriez, *Angew. Chem. Int. Ed*. **2007**, *46*, 8046 – 8049. For **5e**: see (b) C. Madelaine, A. K. Buzas, J. A. Kowalska-Six, Y. Six, B. Crousse, *Tetrahedron Lett*. **2009**, *50*, 5367-5371.

(1*R*,5*S*)-1-Methyl-2-(4-(trifluoromethyl)phenyl)-2-azabicyclo[3.1.0]hexane (5c).

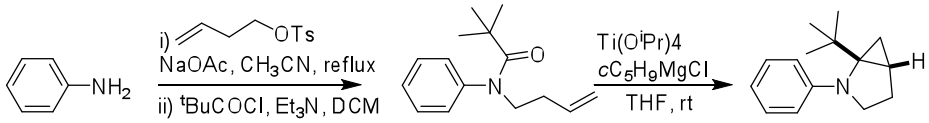


Potassium carbonate (694 mg, 5.02 mmol), tetrabutylammonium hydrogensulfate (84 mg, 0.25 mmol) and ground sodium hydroxide (787 mg, 19.7 mmol) were added to a suspension of 4-(trifluromethyl)acetanilide (1.0 g, 4.9 mmol) in toluene (25 mL). The mixture was stirred at 80 °C for 15 min. But-3-enyl-*p*-toluenesulfonate (1.7 g, 7.4 mmol) was added and stirring was continued at 80 °C for 6 h. After cooling to room temperature, 1 N aqueous HCl solution (30 mL) was added. The organic layer was separated, and the aqueous extracted with diethyl ether (3x50 mL). The combined organic layers were dried with sodium sulfate, filtered and concentrated. Purification of the residual mass by column chromatography on silica gel (20% EtOAc/hexane) afforded *N*-alkyl acetamide (500 mg, 40%) as colorless oil. IR ν_{max} (film) 3078, 2935, 1668, 1614, 1519, 1394, 1326 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, J = 8.8 Hz, 2H), 7.30 (d, J = 8.0 Hz, 2H), 5.78–5.67 (m, 1H), 5.06–5.01 (m, 2H), 3.79 (t, J = 7.4 Hz, 2H), 2.25 (dd, J = 14.4, 6.8 Hz, 2H), 1.83 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.7, 153.6, 146.2, 134.9, 128.7, 126.8, 123.7 (q, J = 269.0 Hz), 117.0, 48.2, 32.2, 22.8; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{13}H_{15}F_3NO$ 258.110; found 258.111.

To a magnetically stirred solution of alkyl acetamide (1.5 g, 5.8 mmol) in THF (50 mL) was added titanium(IV) *iso*-propoxide (3.0 mL, 9.9 mmol), followed by addition of

cyclopentylmagnesium chloride (2.0 M in Et_2O, 11.7 mL, 23.3 mmol) dropwise at rt. After 1 h, water (2 mL) was added at 0 °C and stirring was continued until the color dissipated. Et_2O (50 mL) was then added. The organic layer was separated, and the aqueous phase was extracted with Et_2O (30 mL x 2). The combined organic layers were dried over sodium sulfate and concentrated under reduced pressure. Purification of the crude mass by column chromatography on silica gel (2% EtOAc/hexane) afforded the title compound **5c** (820 mg, 58%) as an yellow oil. IR ν_{max} (film) 3063, 2936, 2876, 1615, 1524, 1483, 1323 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.45 (d, *J* = 8.8 Hz, 2H), 6.86 (d, *J* = 8.4 Hz, 2H), 4.01 (td, *J* = 10.0, 4.4 Hz, 1H), 3.00 (dd, *J* = 17.6, 9.2 Hz, 1H), 2.40–2.31 (m, 1H), 1.94 (ddd, *J* = 12.8, 8.8, 4.4 Hz, 1H), 1.53 (s, 3H), 1.44–1.39 (m, 1H), 0.97 (dd, *J* = 8.8, 5.2 Hz, 1H), 0.69 (t, *J* = 5.2, Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.1, 125.2 (q, *J* = 269.0 Hz), 126.0 (q, *J* = 4.0 Hz), 118.9 (q, *J* = 33.0 Hz), 115.3, 53.7, 43.5, 26.5, 25.4, 21.0, 19.5; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{13}H_{15}F_3N$ 242.115; found 242.115.

(1*R*,5*S*)-1-Tert-butyl-2-phenyl-2-azabicyclo[3.1.0]hexane (5d).



5d

But-3-enyl-*p*-toluenesulfonate (2.0 g, 6 mmol) was added to a mixture of aniline (1.1 mL, 12 mmol) and sodium acetate (492 mg, 6 mmol) in acetonitrile (5.0 mL). After reflux for 48 h, the reaction mixture was cooled to room temperature, diluted with CH_2Cl_2 (25 mL), and then washed with 1 N HCl aqueous solution (2x20 mL) to remove excess aniline. The organic layer was washed with 1 N NaOH aqueous solution (30 mL), dried over sodium sulfate, filtered and concentrated under vacuum. Purification of the residual by column chromatography on silica gel (2% EtOAc/hexane) afforded alkyl aniline (650 mg, 73%) as a colorless liquid. IR ν_{max} (film) 3407, 3052, 2922, 1603, 1506, 1475, 1431, 1318 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.23-7.18 (m, 2H), 6.74 (t, *J* = 7.2 Hz, 1H), 6.64 (d, *J* = 5.6 Hz, 2H), 5.91–5.80 (m, 1H), 5.21–5.13 (m, 2H), 3.68 (br s, 1H), 3.23–3.18 (m, 2H), 2.44–2.40 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.3, 135.8, 129.3, 117.4, 117.1, 112.9, 42.8, 33.6; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{10}H_{14}N$ 148.112; found 148.113.

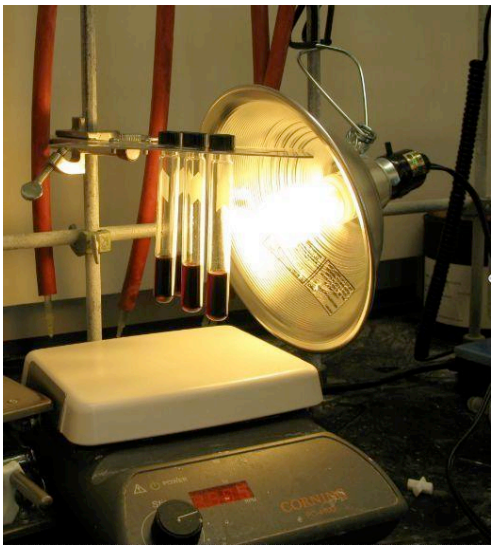
A solution of trimethylacetylchloride (591 μL, 4.8 mmol) in CH_2Cl_2 (5 mL) was added dropwise at 0°C to a mixture of the above alkyl aniline (706 mg, 4.8 mmol) and triethylamine (800 μL, 5.8 mmol) in CH_2Cl_2 (10 mL). The resulting mixture was stirred overnight at room temperature. The solvents were removed under vacuum and the crude product was purified by silica gel column chromatography (2% EtOAc/hexane) to give pivaloyl amide (1.1 g, 99%) as a colorless oil. IR ν_{max} (film) 3064, 2959, 1732, 1634, 1595, 1481, 1398 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.40–7.33 (m, 3H), 7.19 (dd, *J* = 7.2, 2.0 Hz, 2H), 5.75 (dddd, *J* = 17.2, 13.6, 10.4, 6.8 Hz, 1H), 5.04 (d, *J* = 17.2 Hz, 1H), 4.99 (d, *J* = 12.0 Hz, 1H), 3.66 (t, *J* = 7.6 Hz, 2H), 2.29 (dd, *J* = 14.4, 6.8 Hz, 2H), 0.99 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.6, 143.6, 135.6, 129.8, 129.0, 127.9, 116.4, 52.2, 41.0, 31.9, 29.5; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{15}H_{22}NO$ 254.152; found 254.152.

The procedure for the intramolecular Kulinkovich-de Meijere reaction of substrate **5c** was applied to pivaloyl amide (1.04 g, 4.5 mmol) to afford the title compound **5d** (670 mg, 72%) after silica gel column chromatography (2% EtOAc/hexane) as a colorless oil; IR ν_{max} (film) 3036, 2953, 2870, 1597, 1495 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.15 (dd, *J* = 8.8, 7.2 Hz, 2H), 6.87 (dd, *J* = 8.8, .08 Hz, 2H), 6.67 (t, *J* = 7.2 Hz, 1H), 3.93 (ddd, *J* = 10.4, 9.2, 8.0 Hz, 1H), 3.50 (ddd, *J* = 10.8, 8.4, 2.4 Hz, 1H), 2.14–2.06 (m, 1H), 1.73–1.65 (m, 1H), 1.52–1.49 (m, 2H), 0.95 (s, 9H), 0.83 (t, *J* = 10.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 151.0, 128.1, 116.8, 59.9, 55.0, 34.7, 29.4, 28.6, 24.6, 22.7; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{15}H_{22}N$ 216.175; found 216.174.

- ***General procedure 2 (GP2): Visible light mediated [3+2] cycloaddition reaction.***

An oven-dried test tube equipped with a stir bar was charged with $[Ru(bpz)_3](PF_6)_2 \cdot 2H_2O$ **4a** (2 mol%) and cyclopropylamine derivative (0.2 mmol). The tube was sealed with a Teflon screw cap, evacuated and backfilled with nitrogen, before styrene (110 μL, 1.0 mmol) and dry CH_3NO_2 (2 mL) were added to it. The orange reaction mixture was degassed by Freeze-Pump-Thaw cycles and irradiated at room temperature with a 13 W lamp (a compact fluorescent bulb made by GE, white light) at a distance of app. 5 cm. After the reaction was complete as shown by TLC, the mixture was filtered through a short silica pad and eluted with Et_2O (10 mL). The solution was concentrated and the residue was purified by silica gel flash chromatography to afford the corresponding photo-cycloaddition reaction products.

Experimental set-up for [3+2] photo-cycloaddition reactions.

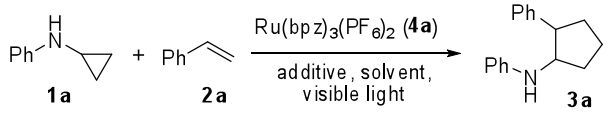


Optimization of the catalyst system.

Following the general procedure **GP2**, a mixture of phenyl cyclopropyl amine **1a** (0.2 mmol, 26 mg), styrene (110 μL, 1.0 mmol), $[Ru(bpz)_3](PF_6)_2 \cdot 2H_2O$ **4a** (3.6 mg, 2 mol%) and solvent (2 mL) was irradiated with the lamp for 12 h. n-Dodecane (45 μL) was added as an internal standard and the reaction mixture was diluted with Et_2O (2 mL) and an aliquot was filtered through a plug

of cotton and analyzed by GC. Six entries from the following table are selected for Table 1 in the manuscript.

Table1.

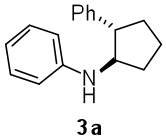


Entry	Conditions[a]	t [h]	Conv. of **1a** [%]	Yield of **3a** [%]
1	**4a** (2 mol%), Air, CH_3NO_2	12	100	21
2	**4a (2 mol%), CH_3NO_2**	**3**	**100**	**96**
3	**4a** (1 mol%), CH_3NO_2	6	100	86
4	**4a** (2 mol%), DMF	12	38	20
5	**4a** (2 mol%), CH_3CN	12	49	31
6	Without **4a**, CH_3NO_2	12	25	16
7[a]	Without **4a**, CH_3NO_2	12	15	<1
8[b]	Without **4a**, CH_3NO_2	12	14	0
9	**4a** (2 mol%), CH_3NO_2, light bulb off	12	35	9
10	$[Ru(bpy)_3](PF_6)_2$ (2 mol%), CH_3NO_2	12	100	79
11	$[Ir(dtbbpy)(ppy)_2]PF_6 \cdot H_2O$ (2 mol%), CH_3NO_2	12	100	73
12	1,4-DCB, UV Light	1	73	12
13	CAN, $NaHCO_3$	12	48	<1

[a] Reaction mixture was irradiated by a 13 W GE florescent light bulb filtered by a 420 nm filter. [b] Reaction was performed inside a dark cabinet. DCB = Dichlorobenzene, CAN = ceric ammonium nitrate.

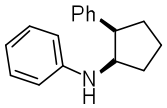
Following **GP2** with cyclopropyl amine **1a** (26 mg, 0.2 mmol), cycloadduct **3a** was obtained after silica gel column chromatography (1.5% Et_2O/hexane) as a separable mixture of two diastereoisomers.

Data for **3a-*trans***: colorless oil (19 mg, 42%); IR ν_{max} (film) 3404, 3025, 2958, 1601, 1504, 1427, 1319 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.30 (d, J = 6.8 Hz, 2H), 7.22 (d, J = 8.0 Hz, 3H), 7.13 (t, J = 7.2 Hz, 2H), 6.67 (t, J = 7.2 Hz, 1H), 6.50 (d, J = 8.0 Hz, 2H), 4.02 (dd, J = 12.0, 6.0 Hz, 1H), 3.46 (dd, J = 14.4, 7.2 Hz, 1H), 2.20–2.08 (m, 3H), 2.04–1.95 (m, 1H), 1.88–1.77 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.5, 140.6, 129.1, 128.7, 128.3, 126.5, 117.8, 17.1, 113.4, 57.7, 48.0, 31.8, 28.8, 22.1; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{17}H_{20}N$ 238.159; found 238.158.



3a

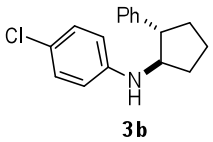
Data for **3a-*cis***: colorless oil (21 mg, 45%); IR ν_{max} (film) 3414, 3027, 2954, 1601, 1504, 1317 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.38–7.32 (m, 4H), 7.29–7.25 (m, 1H), 7.21–7.16 (m, 2H), 6.73 (t, *J* = 7.6 Hz, 1H), 6.60 (d, *J* = 8.4 Hz, 2H), 3.91 (br s, 1H), 3.85 (dd, *J* = 14.0, 6.4 Hz, 1H), 2.98 (dd, *J* = 15.6, 7.6 Hz, 1H), 2.41 (ddd, *J* = 20.4, 14.8, 7.2 Hz, 1H), 2.31–2.23 (m, 1H), 1.98–1.90 (m, 2H), 1.86–1.78 (m, 1H), 1.71–1.63 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.0, 143.8, 129.2, 128.6, 127.4, 126.5, 117.2, 113.5, 61.6, 53.1, 33.5, 23.4; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{17}H_{20}N$ 238.159; found 238.159.



3a

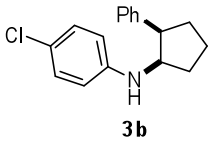
Following **GP2** with cyclopropyl amine **1b** (34mg, 0.2 mmol), cycloadduct **3b** was obtained after silica gel column chromatography (1.5% Et_2O/hexane) as a separable mixture of two diastereoisomers.

Data for **3b-*trans***: colorless oil (21 mg, 39%); IR ν_{max} (film) 3407, 3027, 2959, 2873, 1599, 1495, 1320 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.32 (d, *J* = 7.2 Hz, 2H), 7.26 (d, *J* = 7.2 Hz, 1H), 7.21 (d, *J* = 7.6 Hz, 2H), 7.07 (dd, *J* = 6.4, 2.0 Hz, 2H), 6.40 (dd, *J* = 7.6, 2.0 Hz, 2H), 3.97 (dd, *J* = 12.0, 6.0 Hz, 1H), 3.46 (dd, *J* = 14.4, 7.2 Hz, 1H), 2.23–2.08 (m, 3H), 2.04–1.94 (m, 1H), 1.89–1.73 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.3, 140.6, 128.9, 128.6, 128.4, 126.6, 121.5, 114.4, 57.7, 47.9, 31.8, 28.9, 22.1; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{17}H_{19}ClN$ 272.120; found 272.119.



3b

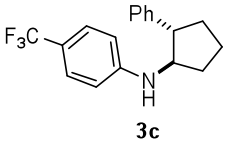
Data for **3b-*cis***: colorless oil (23 mg, 43%); IR ν_{max} (film) 3410, 3027, 2956, 2871, 1599, 1495, 1318 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.38–7.25 (m, 5H), 7.10 (dd, *J* = 8.8 Hz, 2H), 6.48 (d, *J* = 8.8 Hz, 2H), 3.86 (br s, 1H), 3.79 (dd, *J* = 14.4, 7.2 Hz, 1H), 2.93 (dd, *J* = 16.8, 8.4 Hz, 1H), 2.38 (ddd, *J* = 20.8, 14.4, 7.6 Hz, 1H), 2.30–2.21 (m, 1H), 1.97–1.77 (m, 3H), 1.63 (ddd, *J* = 20.8, 14.4, 6.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.5, 143.6, 129.0, 128.7, 127.4, 126.6, 121.7, 114.5, 61.8, 53.2, 33.5, 33.4, 23.4; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{17}H_{19}ClN$ 272.120; found 272.119.



3b

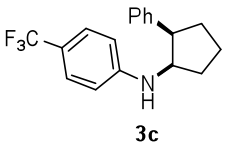
Following **GP2** with cyclopropyl amine **1c** (40 mg, 0.2 mmol), cycloadduct **3c** was obtained after silica gel column chromatography (2.0% Et_2O/hexane) as a separable mixture of two diastereoisomers.

Data for **3c-*trans***: colorless oil (24 mg, 39%); IR ν_{max} (film) 3411, 3029, 2961, 2876, 1616, 1532, 1493, 1327 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.32–7.17 (m, 7H), 6.44 (d, *J* = 8.4 Hz, 2H), 4.02 (dd, *J* = 12.0, 6.0 Hz, 1H), 3.65 (br s, 1H), 3.46 (dd, *J* = 14.8, 7.6 Hz, 1H), 2.22–2.08 (m, 3H), 2.01–1.93 (m, 1H), 1.88–1.71 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.2, 140.4, 128.6, 128.5, 126.7, 126.4 (q, *J* = 4.0 Hz), 123.8 (q, *J* = 269 Hz), 118.3 (q, *J* = 32.0 Hz), 112.2, 57.1, 47.9, 31.8, 28.9, 22.1; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{18}H_{19}F_3N$ 306.146; found 306.147.



3c

Data for **3c-*cis***: colorless oil (26 mg, 43%); IR ν_{max} (film) 3414, 3028, 2958, 2873, 1617, 1531, 1492, 1323 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.33–7.12 (m, 7H), 6.49 (d, *J* = 8.8 Hz, 2H), 4.10

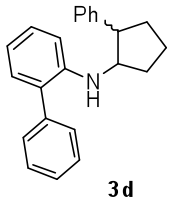


3c

(br s, 1H), 3.82 (dd, *J* = 14.2, 7.0 Hz, 1H), 2.91 (dd, *J* = 17.4, 8.2 Hz, 1H), 2.37 (ddd, *J* = 20.8, 14.6, 7.6 Hz, 1H), 2.22 (dddd, *J* = 15.4, 12.2, 7.6, 3.4 Hz, 1H), 1.95–1.86 (m, 2H), 1.85–1.74 (m, 1H), 1.64–1.57 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.4, 143.3, 128.7, 127.3, 126.6, 126.4 (q, *J* = 4.0 Hz), 123.7 (q, *J* = 269 Hz), 118.5 (q, *J* = 33.0 Hz), 112.3, 61.1, 53.2, 33.4, 33.2, 23.2; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{18}H_{19}F_3N$ 306.146; found 306.147.

Following **GP2** with cyclopropyl amine **1d** (30 mg, 0.15 mmol), cycloadduct **3d** (36 mg, 80%) was obtained after silica gel column chromatography (3% EtOAc/hexane) as an inseparable mixture of two diastereoisomers.

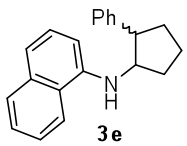
Data for **3d**: colorless oil; IR ν_{max} (film) 3419, 3058, 2956, 2870, 1581, 1525, 1479, 1408, 1346 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$, a mixture of diastereomers) δ 7.44–7.17 (m, 8H), 7.07–6.96 (m, 3H), 6.75–6.69 (m, 2H), 6.64 (d, *J* = 8.0 Hz, 1H), 4.15 (br s, 1H), 4.00 (dd, *J* = 11.0, 5.4 Hz, 0.4 H), 3.72 (dd, *J* = 15.0, 7.4 Hz, 0.6H), 3.42 (dd, *J* = 15.4, 7.8 Hz, 0.4H), 2.77 (dd, *J* = 16.8, 8.0 Hz, 0.6H), 2.37 (td, *J* = 13.6, 6.8, Hz, 0.6 H), 2.17–1.74 (m, 4.8), 1.59–1.50 (0.6 H); ^{13}C NMR (100 MHz, $CDCl_3$, a mixture of diastereomers) δ 145.1, 145.0, 143.5, 140.6, 139.5, 139.3, 130.2, 130.1, 129.4, 129.1, 128.9, 128.7, 128.6, 128.5, 128.5, 128.41, 128.40, 127.7, 127.6, 127.5, 127.1, 126.7, 126.5, 126.3, 116.7, 116.2, 111.3, 110.4, 62.5, 57.6, 53.1, 48.4, 33.5, 32.6, 32.2, 28.7, 23.2, 22.4 HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{23}H_{24}N$ 314.190; found 314.191.



3d

Following **GP2** with cyclopropyl amine **1e** (36 mg, 0.2 mmol), cycloadduct **3e** (43 mg, 75%) was obtained after silica gel column chromatography (2% EtOAc/hexane) as an inseparable mixture of two diastereoisomers.

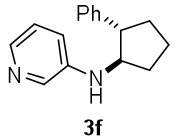
Data for **3e**: colorless oil; IR ν_{max} (film) 3419, 3058, 2956, 2870, 1581, 1525, 1479, 1408, 1346 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$, a mixture of diastereomers) δ 7.80–7.71 (m, 2H), 7.45–7.36 (m, 2H), 7.35–7.17 (m, 7H), 6.62 (d, *J* = 7.2 Hz, 0.4 H), 6.56(d, *J* = 7.6 Hz, 0.6 H), 4.52 (br s, 1H), 4.13 (dd, *J* = 11.2, 6.0 Hz, 0.4 H), 3.97 (dd, *J* = 14.0, 7.2 Hz, 0.6H), 3.57 (dd, *J* = 15.6, 7.6 Hz, 0.4H), 3.13 (dd, *J* = 16.0, 7.6 Hz, 0.6H), 2.53–2.44 (1H), 2.33–2.18 (m, 2H), 2.07–1.69 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$, a mixture of diastereomers) δ 143.8, 143.0, 140.6, 134.5, 128.8, 128.7, 128.6, 127.5, 126.9, 126.7, 126.6, 125.8, 125.7, 124.8, 124.6, 123.9, 123.7, 120.1, 119.9, 117.0, 105.0, 61.9, 57.5, 53.3, 48.8, 33.7, 33.4, 32.1, 29.0, 23.7, 22.8; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{21}H_{22}N$ 288.175; found 288.173.



3e

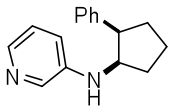
Following **GP2** with cyclopropyl amine **1f** (27 mg, 0.2 mmol), cycloadduct **3f** (34 mg, 71%) was obtained after silica gel column chromatography (37% EtOAc/hexane) as a mixture of two diastereoisomers.

Data for **3f-*trans***: colorless oil; IR ν_{max} (film) 3404, 3261, 3028, 2956, 1587, 1482 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 4.4 Hz, 1H), 7.83 (d, *J* = 2.4 Hz, 1H), 7.29 (d, *J* = 7.2 Hz, 2H), 7.22–7.17 (m, 3H), 6.98 (dd, *J* = 8.2, 4.6 Hz, 1H), 6.71 (ddd, *J* = 4.0, 2.8, 1.2 Hz, 1H), 3.98 (t, *J* = 6.0 Hz, 1H), 3.48 (br s, 1H), 3.44 (dd, *J* = 14.8, 8.0 Hz, 1H), 2.19–2.08 (m, 3H), 2.01–1.93 (m, 1H), 1.87–1.71 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.8, 140.3, 138.0, 136.0, 128.6, 128.4, 126.7, 123.6, 119.1, 57.2, 48.1, 31.9, 29.0, 22.1; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{16}H_{19}N_2$ 239.154; found 239.153.



3f

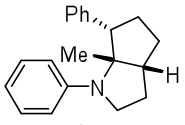
Data for **3f-*cis***: colorless oil; IR ν_{max} (film) 3414, 3027, 2954, 2872, 1584, 1452, 1417, 1321 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.05 ((br s, 1H), 7.82 (br s, 1H), 7.31–7.18 (m, 4H), 7.22–7.18 (m, 1H), 7.02 (br s, 1H), 6.76 (d, *J* = 8.0 Hz, 1H), 4.52 (br s, 1H), 3.76 (dd, *J* = 14.6, 7.4 Hz, 1H), 2.95 (dd, *J* = 8.0, 17.4 Hz, 1H), 2.33 (ddd, *J* = 20.4, 14.4, 7.2 Hz, 1H), 2.26–2.18 (m, 1H), 1.93–1.75 (m, 3H), 1.64 (ddd, *J* = 20.4, 14.4, 7.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.7, 143.3, 135.7, 134.4, 128.7, 127.3, 126.6, 124.1, 119.9, 61.5, 53.2, 33.3, 33.1, 33.2; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{16}H_{19}N_2$ 239.154; found 239.153.



3f

Following **GP2** with bicyclic amine **5a** (50 mg, 0.29 mmol), cycloadduct **6a** (62 mg, 77%) was obtained after silica gel column chromatography (1% EtOAc/hexane) as a mixture of two diastereoisomers.

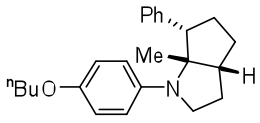
Data for **6a-α** (major isomer): colorless oil; IR ν_{max} (film) 3025, 2952, 1599, 1503, 1454, 1343 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.21 (d, *J* = 7.2 Hz, 2H), 7.13–7.09 (m, 2H), 7.06–7.02 (m, 1H), 6.84–6.80 (m, 2H), 6.44 (t, *J* = 7.2 Hz, 1H), 6.21 (d, *J* = 8.0 Hz, 2H), 3.52 (dt, *J* = 9.6, 2.0 Hz, 1H), 3.32 (dt, *J* = 9.6, 6.4 Hz, 1 H), 2.95 (dd, *J* = 10.4, 7.2 Hz, 1H), 2.59–2.53 (m, 1H), 2.17–2.02 (m, 3H), 1.97–1.82 (m, 2H), 1.75–1.70 (m, 1H), 1.48 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.2, 143.5, 129.4, 127.8, 127.5, 126.0, 115.5, 114.8, 74.0, 57.8, 55.9, 50.5, 36.2, 28.7, 28.6, 27.2; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{20}H_{24}N$ 278.190; found 278.191.



6a-α

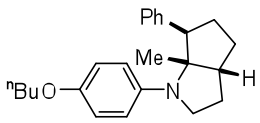
Following **GP2** with bicyclic amine **5b** (50 mg, 0.2 mmol), cycloadduct **6b** (54 mg, 74%) was obtained after neutral alumina column chromatography (0.5% Et_2O/hexane) as a mixture of two diastereoisomers.

Data for **6b-α** (major isomer): colorless oil; IR ν_{max} (film) 3026, 2954, 1602, 1513, 1475, 1267 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.25–7.22 (m, 2H), 7.16–7.12 (m, 2H), 7.09–7.05 (m, 1H), 6.42 (d, *J* = 9.2 Hz, 2H), 6.10 (d, *J* = 9.2 Hz, 2H), 3.76 (t, *J* = 6.4 Hz, 2H), 3.47–3.42 (m, 1H), 3.25 (dt, *J* = 9.6, 6.4 Hz, 1H), 2.87 (dd, *J* = 10.8, 7.2 Hz, 1H), 2.53 (dd, *J* = 7.6, 15.6 Hz, 1H), 2.11–1.98 (m, 3H), 1.95–1.79 (m, 2H), 1.73–1.61 (m, 3H), 1.46–1.37 (m, 2H), 1.38 (s, 3H), 0.93 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.4, 143.5, 140.8, 129.5, 127.9, 126.0, 116.2, 114.0, 74.0, 68.0, 58.1, 55.7, 51.0, 36.0, 31.6, 29.1, 28.8, 27.0, 19.3, 13.9; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{24}H_{32}NO$ 350.248; found 350.249.



6b-α

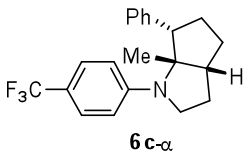
Data for **6b-β** (minor isomer): colorless oil; IR ν_{max} (film) 3059, 2931, 1637, 1512, 1463 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.30–7.25 (m, 2H), 7.21–7.17 (m, 3H), 6.80 (d, *J* = 9.2 Hz, 2H), 6.62 (d, *J* = 9.2 Hz, 2H), 3.91 (t, *J* = 6.4 Hz, 2H), 3.53 (t, *J* = 6.8 Hz, 1H), 3.46 (dt, *J* = 9.6, 6.4 Hz, 1H), 3.28 (t, *J* = 8.0 Hz, 1H), 2.52 (dd, *J* = 7.6, 15.2 Hz, 1H), 2.20–2.06 (m, 2H), 2.02–1.94 (m, 1H), 1.88–1.78 (m, 2H), 1.76–1.69 (m, 2H), 1.55–1.43 (m, 3H), 1.20 (s, 3H), 0.97 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.6, 144.5, 140.2, 129.4, 128.0,125.9, 115.7, 115.4, 75.0, 68.5, 54.1, 52.7, 48.6, 34.9, 31.6, 30.8, 28.3, 23.3, 19.3, 13.9 ; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{24}H_{32}NO$ 350.248; found 350.249.



6b-β

Following **GP2** with bicyclic amine **5c** (48 mg, 0.2 mmol), cycloadduct **6c** (48mg, 69%) was obtained after silica gel column chromatography (1.5% Et_2O/hexane) as a separable mixture of two diastereoisomers.

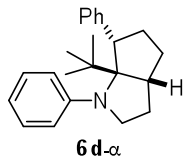
Data for **6c-α** (major isomer): colorless oil; IR ν_{max} (film) 3028, 2955, 2872, 1615, 1525, 1455, 1360, 1322 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.15 (d, *J* = 7.2 Hz, 2H), 7.12–7.06 (m, 3H), 7.02 (d, *J* = 8.4 Hz, 2H), 6.22 (d, *J* = 8.4 Hz, 2H), 3.55 (ddd, *J* = 10.0, 7.6, 2.4 Hz, 1H), 3.36 (td, *J* = 9.6, 6.8 Hz, 1H), 3.00 (dd, *J* = 10.8, 7.6 Hz, 1H), 2.60 (dd, *J* = 15.6, 7.6 Hz, 1H), 2.20–1.86 (m, 5H), 1.79–1.71 (m, 1H), 1.54 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.4, 142.7, 129.2, 128.0, 126.5, 126.3, 125.1 (q, *J* = 252 Hz), 124.7 (q, *J* = 4.0Hz), 113.8, 74.5, 57.6, 55.8, 50.8, 35.8, 28.5, 27.2; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{21}H_{23}F_3N$ 346.178; found 346.179.



6c-α

Following **GP2** with bicyclic amine **5d** (43 mg, 0.2 mmol), cycloadduct **6d** (18 mg, 28%) was obtained after silica gel column chromatography (0.5% Et_2O/hexane) as a single diastereoisomer.

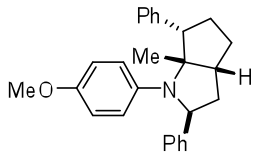
Data for **6d-α**: crystalline solid: mp 124-126 °C; IR ν_{max} (plate) 3063, 2954, 2868, 1597, 1494, 1340 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.37 (d, *J* = 6.8 Hz, 2H), 7.20 (t, *J* = 7.2 Hz, 2H), 7.15 (d, *J* = 7.6 Hz, 1H), 6.69 (dd, *J* = 8.8, 7.2 Hz, 2H), 6.45 (t, *J* = 6.8 Hz, 1H), 6.04 (d, *J* = 8.4 Hz, 2H), 3.58–3.50 (m, 1H), 3.39 (dd, *J* = 11.2, 7.6 Hz, 1H), 3.35 (t, *J* = 7.6 Hz, 1H), 3.03 (td, *J* = 11.6, 7.2 Hz, 1H), 2.28–2.20 (m, 1H), 2.16–2.0 (m, 2H), 1.98–1.90 (m, 1H), 1.80–1.71 (m, 1H), 1.68–1.63 (m, 1H), 1.00 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.2, 146.3, 130.1, 128.5, 126.6, 125.9, 118.8, 116.9, 85.0, 54.2, 52.0, 51.1, 44.4, 38.6, 30.0, 29.5, 28.7; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{23}H_{30}N$ 320.237; found 320.236.



6d-α

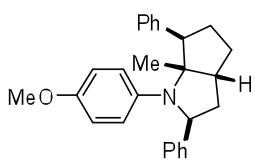
Following **GP2** with bicyclic amine **5e** (56 mg, 0.2 mmol), cycloadduct **6e** (56 mg, 72%) was obtained after neutral alumina column chromatography (2% Et_2O/hexane) as a mixture of two diastereoisomers.

Data for **6e-α** (major isomer): colorless oil; IR ν_{max} (film) 3026, 2950, 2868, 1601, 1512, 1452, 1242 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.22 (d, *J* = 4.8 Hz, 4H), 7.16–7.11 (m, 1H), 6.98 (d, *J* = 4.4 Hz, 4H), 6.96–6.91 (m, 1H), 6.21 (s, 4H), 4.95 (t, *J* = 6.4 Hz, 1H), 3.55 (s, 3H), 3.17 (t, *J* = 8.8 Hz, 1H), 2.58 (dd, *J* = 14.4, 6.8 Hz, 1H), 2.38–2.32 (m, 1H), 2.16–2.09 (m, 2H), 2.02–1.94 (m, 2H), 1.97 (s, 3H), 1.69–1.64 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.7, 144.6, 142.2, 138.9, 128.8, 128.3, 127.9, 127.5, 125.3, 118.4, 113.1, 75.0, 66.3, 57.2, 55.4, 52.4, 40.2, 33.9, 29.5, 28.4; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{27}H_{30}NO$ 384.232; found 384.233.



6e-α

Data for **6e-β** (minor isomer): colorless oil; IR ν_{max} (film) 3059, 2948, 1636, 1510, 1452 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.30 (d, *J* = 7.2 Hz, 2H), 7.24–7.19 (m, 4H), 7.17–7.11 (m, 2H), 6.96 (d, *J* = 6.8 Hz, 2H), 6.73 (d, *J* = 9.2 Hz, 2H), 6.66 (d, *J* = 9.2 Hz, 2H), 4.80 (dd, *J* = 10.4, 5.6 Hz, 1H), 3.70 (s, 3H),

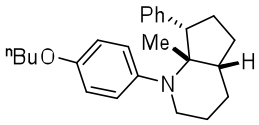


6e-β

3.46 (t, *J* = 6.8 Hz, 1H), 2.52 (dd, *J* = 15.6, 7.6 Hz, 1H), 2.31–2.25 (m, 1H), 2.14 (dd, *J* = 12.4, 6.0 Hz, 1H), 2.01–1.93 (m, 1H), 1.88–1.82 (m, 2H), 1.65–1.56 (m, 1H), 1.39 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.8, 144.2, 143.9, 139.1, 129.1, 128.3, 127.8,126.6, 126.5, 125.8, 121.1, 113.8, 77.1, 63.7, 55.4, 52.7, 52.0, 41.4, 33.4, 31.7, 27.5; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{27}H_{30}NO$ 384.232; found 384.233.

Following **GP2** with bicyclic amine **5f** (50 mg, 0.19 mmol), cycloadduct **6f** (41 mg, 58%) was obtained after neutral alumina column chromatography (1% Et_2O/hexane) as a mixture of two diastereoisomers.

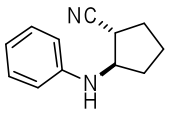
Data for **6f-α** (major isomer): colorless oil; IR ν_{max} (film) 3028, 2958, 2934, 1607, 1507, 1465, 1240 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18–7.13 (m, 2H), 7.11 (d, *J* = 8.8 Hz, 3H), 6.91 (d, *J* = 6.8 Hz, 2H), 6.83 (d, *J* = 8.8 Hz, 2H), 3.96 (t, *J* = 6.6 Hz, 2H), 3.32 (dd, *J* = 8.8, 2.0 Hz, 1H), 3.25 (dt, *J* = 12.0, 2.8 Hz, 1H), 2.80(td, *J* = 11.6, 3.2 Hz, 1H), 2.62–2.53 (m, 1H), 2.34–2.25 (m, 1H), 2.12–2.05 (m, 1H), 2.01–1.83 (m, 3H), 1.81–1.76 (m, 2H), 1.71–1.66 (m, 2H), 1.59–1.44 (m, 4H), 1.00 (t, *J* = 7.6 Hz, 3H), 0.73 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.1, 145.3, 143.9, 129.5, 128.9, 127.6, 125.6, 113.9, 67.8, 67.6, 53.5, 49.9, 43.8, 31.5, 29.1, 27.9, 23.0, 22.1, 19.3, 14.7, 13.9; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{25}H_{34}NO$ 364.264; found 364.265.



6f-α

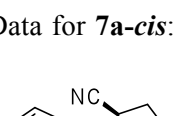
Following **GP2** with cyclopropyl amine **1a** (32 mg, 0.25 mmol) and acrylonitrile (83 μL, 1.25 mmol), cycloadduct **7a** (24 mg, 52%) was obtained after silica gel column chromatography (10% Et_2O/hexane) as a mixture of two diastereoisomers.

Data for **7a-*trans***: colorless oil; IR ν_{max} (film) 3386, 2972, 2237, 1604, 1512, 1498, 1314 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (d, *J* = 8.6, 8.0 Hz, 2H), 6.77 (tt, *J* = 7.2, 0.8 Hz, 1H), 6.67 (dd, *J* = 7.6, 1.2 Hz, 2H), 4.19 (br s, 1H), 3.97 (td, *J* = 8.8, 6.8 Hz, 1H), 3.26 (ddd, *J* = 10.8, 6.8, 4.0 Hz, 1H), 2.21–1.95 (m, 4H), 1.79–1.69 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.3, 129.4, 120.2, 118.5, 113.7, 56.9, 34.2, 31.1, 28.7, 21.2; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{12}H_{15}N_2$ 187.123; found 187.122.



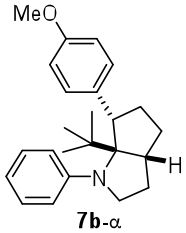
7a-*trans*

Data for **7a-*cis***: colorless oil; IR ν_{max} (film) 3378, 2963, 2237, 1603, 1505, 1317 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.23 (dd, *J* = 8.4, 7.2 Hz, 2H), 6.80 (td, *J* = 7.2, 0.8 Hz, 1H), 6.68 (dd, *J* = 7.6, 0.8 Hz, 2H), 4.29 (br s, 1H), 4.14 (td, *J* = 6.8, 4.4 Hz, 1H), 2.79 (dt, *J* = 8.0, 4.0 Hz, 1H), 2.34 (ddd, *J* = 20.8, 14.0, 7.2 Hz, 1H), 2.16–1.99 (m, 2H), 1.91 (dd, *J* = 15.0, 7.4 Hz, 2H), 1.60 (ddd, *J* = 20.8, 12.4, 7.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.5, 129.6, 122.1, 118.9, 113.8, 59.7, 35.2, 33.2, 29.6, 23.6; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{12}H_{15}N_2$ 187.123; found 187.122.



7a-*cis*

Following **GP2** with bicyclic amine **5d** (50 mg, 0.23 mmol) and 1-methoxy-4-vinylbenzene (156 μL, 1.2 mmol), cycloadduct **7b** (24 mg, 30%) was obtained after silica gel column chromatography (2% EtOAc/hexane) as a single diastereoisomer.

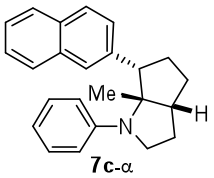


7b-α

Data for **7b-α**: colorless oil; IR ν_{max} (film) 2950, 2812, 1632, 1598, 1503, 1349 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.28 (d, *J* = 8.8 Hz, 2H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.73 (dd, *J* = 8.8, 7.2 Hz, 2H), 6.46 (t, *J* = 7.2 Hz, 1H), 6.08 (d, *J* = 8.8 Hz, 2H), 3.74 (s, 3H), 3.56–3.50 (m, 1H), 3.35 (dd, *J* = 11.6, 8.0 Hz, 1H), 3.32 (t, *J* = 8.4 Hz, 1H), 3.00 (dt, *J* = 11.6, 6.8 Hz, 1H), 2.22–2.15 (m, 1H), 2.11–2.00 (m, 2H), 1.97–1.86 (m, 1H), 1.77–1.67 (m, 1H), 1.62 (dd, *J* = 12.8, 7.2 Hz, 1H), 0.98 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.0, 148.3, 138.4, 130.9, 126.7, 118.9, 117.0, 114.2, 84.7, 55.3, 54.2, 52.0, 50.2, 44.3, 38.5, 29.8, 29.6, 28.7; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{24}H_{32}NO$ 350.248; found 350.249.

Following **GP2** with bicyclic amine **5a** (35 mg, 0.2 mmol) and 2-vinyl naphthalene (62 mg, 0.4 mmol), cycloadduct **7c** (48 mg, 72%) was obtained after silica gel column chromatography (1% Et_2O/hexane) as a separable mixture of two diastereoisomers.

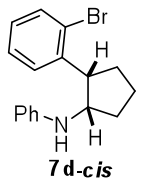
Data for **7c-α** (major isomer): colorless oil; IR ν_{max} (film) 3056, 2952, 1599, 1503, 1459, 1349 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.72–7.65 (m, 3H), 7.55 (d, *J* = 8.4 Hz, 1H), 7.39–7.33 (m, 3H), 6.70 (dd, *J* = 7.2, 6.8 Hz, 2H), 6.32 (t, *J* = 6.8 Hz, 1H), 6.25 (d, *J* = 8.4 Hz, 2H), 3.54 (dt, *J* = 8.0, 2.4 Hz, 1H), 3.35 (dt, *J* = 10.0, 6.4 Hz, 1H), 3.16 (dd, *J* = 10.0, 8.0 Hz, 1H), 2.64–2.57 (m, 1H), 2.19–2.09 (m, 3H), 2.05–1.88 (m, 2H), 1.81–1.75 (m, 1H), 1.54 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.1, 141.3, 133.3, 132.0, 128.9, 127.9, 127.6, 127.5, 127.4, 127.3, 125.4, 124.9, 115.6, 114.8, 74.2, 57.9, 55.9, 50.6, 36.2, 28.9, 28.7, 27.2; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{24}H_{26}N$ 328.206; found 328.207.



7c-α

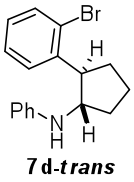
Following **GP2** with cyclopropyl amine **1a** (26 mg, 0.2 mmol) and 1-bromo-2-vinylbenzene (78 μL, 0.6 mmol), cycloadduct **7d** was obtained after silica gel column chromatography (2% Et_2O/hexane) as a separable mixture of two diastereoisomers

Data for **7d-*cis*** (major isomer): colorless oil (33 mg, 54%); IR ν_{max} (film) 3404, 3051, 2957, 1601, 1504, 1470, 1265 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.53 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.39 (dd, *J* = 7.6, 1.6 Hz, 1H), 7.29 (dd, *J* = 7.6, 1.2 Hz, 1H), 7.09–7.03 (m, 3H), 6.61 (t, *J* = 7.2 Hz, 1H), 6.43 (d, *J* = 8.0 Hz, 2H), 4.21 (dt, *J* = 6.4, 3.6 Hz, 1H), 3.71 (dt, *J* = 11.2, 6.8 Hz, 1H), 3.35 (br s, 1H), 2.27–2.15 (m, 2H), 2.06–1.94 (m, 2H), 1.89–1.76 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.6, 139.4, 133.0, 129.1, 128.9, 128.2, 127.2, 126.2, 116.9, 113.2, 55.1, 49.0, 33.4, 29.3, 22.7; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{17}H_{19}BrN$ 316.069; found 316.070.



7d-*cis*

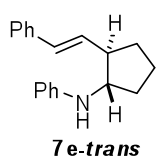
Data for **7d-*trans*** (minor isomer): colorless oil (17 mg, 27%); IR ν_{max} (film) 3405, 3018, 2871,1602, 1436, 1316 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.54 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.29–7.26 (m, 2H), 7.15–7.05 (m, 3H), 6.67 (t, *J* = 7.6 Hz, 1H), 6.57 (d, *J* = 8.0 Hz, 2H), 3.87 (dt, *J* = 15.6, 7.2 Hz, 1H), 3.49 (dt, *J* = 18.0, 8.4 Hz, 1H), 2.42 (dt, *J* = 13.2, 7.2 Hz, 1H), 2.35–2.27 (m, 1H), 1.95–1.84 (m, 2H), 1.69–1.59 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.4, 142.5, 132.9, 129.1, 127.9, 127.8, 127.5, 125.4, 121.5, 117.8, 113.5, 61.5, 51.3, 33.1, 32.5, 23.0; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{17}H_{19}BrN$ 316.069; found 316.070.



7d-*trans*

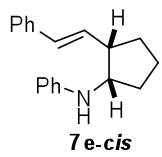
Following **GP2** with cyclopropyl amine **1a** (106 mg, 0.8 mmol) and 1-phenyl-1,3-butadiene (452 μL, 3.2 mmol), cycloadduct **7e** was obtained after silica gel column chromatography (1.5% Et_2O/hexane) as a separable mixture of two diastereoisomers.

Data for **7e-*trans*** (major isomer): colorless oil (57 mg, 27%); IR ν_{max} (film) 3402, 3024, 2870, 1601, 1429, 1315cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36–7.33 (m, 2H), 7.31–7.25 (m, 2H), 7.20–7.13 (m, 3H), 6.68 (t, *J* = 7.2 Hz, 1H), 6.61 (d, *J* = 8.4 Hz, 2H), 6.47 (d, *J* = 15.6 Hz, 1H), 6.21 (dd, *J* = 16.0, 8.0 Hz, 1H), 3.78 (brs, 1H), 3.53 (dd, *J* = 14.4, 7.2 Hz, 1H), 2.53 (p, *J* = 8.0 Hz, 1H), 2.29 (dt, *J* = 14.0, 7.6 Hz, 1H), 2.01 (dt, *J* = 12.8, 6.4 Hz, 1H), 1.84–1.77 (m, 2H), 1.65–1.56 (m, 1H), 1.54–1.47 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.2, 137.4, 132.6, 130.1, 129.2, 128.5, 127.1, 126.1, 117.1, 113.4, 60.34, 50.9, 33.1, 31.0, 22.8; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{19}H_{22}N$ 264.175; found 264.176.



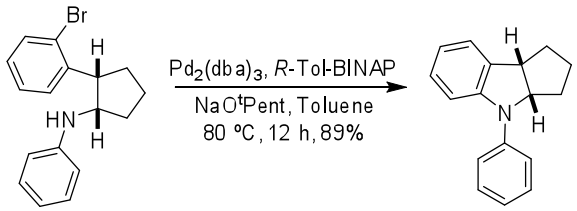
7e-*trans*

Data for **7e-*cis*** (minor isomer): colorless oil (27 mg, 13%); IR ν_{max} (film) 3403, 3052, 2957, 1602, 1504, 1448 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33–7.27 (m, 4H), 7.23–7.19 (m, 1H), 7.17–7.12 (m, 2H), 6.66 (ddt, *J* = 7.6, 1.2, 0.8 Hz, 1H), 6.602 (dd, *J* = 8.4, 0.8 Hz, 2H), 6.43 (dd, *J* = 8.0, .08 Hz, 1H), 6.24 (dd, *J* = 16.0, 7.6 Hz, 1H), 3.87 (dd, *J* = 12.4, 6.4 Hz, 1H), 3.74 (br s, 1H), 2.96 (td, *J* = 13.2, 6.8 Hz, 1H), 2.16–2.08 (m, 1H), 2.01–1.93 (m, 1H), 1.91–1.72 (m, 3H), 1.68–1.61 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.0, 137.5, 131.5, 129.9, 129.2, 128.6, 127.2, 126.2, 117.0, 113.3, 57.8, 46.5, 31.9, 29.4, 21.7; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{19}H_{22}N$ 264.175; found 264.175.



7e-*cis*

(3a*S*,8b*S*)-4-phenyl-1,2,3,3a,4,8b-hexahydrocyclopenta[*b*]indole (8)[4]**:**



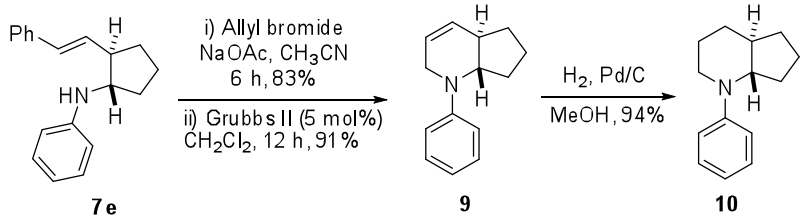
7d **8**

An oven-dried schlenk tube was charged with cyclopentyl annulated aromatic bromide **7d-*cis*** (32 mg, 0.1 mmol), $Pd_2(dba)_3$ (2 mg, 0.002 mmol), *R*-Tol-BINAP (4 mg, 0.006 mmol), NaO^{t}Pent (16.5 mg, 0.15 mmol), toluene (1 mL) and a stir bar. After purging with argon for a few seconds, the tube was sealed with a Teflon screw cap and wrapped with aluminum foil. The mixture was heated at 80 ^{o}C for 18 h. The resulting mixture was then cooled to room temperature, diluted with ether, filtered through a short pad of silica gel and concentrated under vacuum. Purification of the

[4] O. Miyata, N. Takeda, Y. Kimura, Y. Takemoto, N. Tohnai, M. Miyatac, T. Naito, *Tetrahedron* **2006**, *62*, 3629-3647.

residual mass by column chromatography (2% Et_2O/hexane) afforded the dihydro indole derivative **8** (21 mg, 89%) as colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32–7.27 (m, 4H), 7.12 (d, *J* = 7.6 Hz, 1H), 7.07–7.00 (m, 2H), 6.96 (tt, *J* = 7.2, 1.6 Hz, 1H), 6.73 (td, *J* = 7.2, 1.6 Hz, 1H), 4.76 (ddd, *J* = 8.8, 6.4, 2.4 Hz, 1H), 3.84 (dt, *J* = 8.8, 2.8 Hz, 1H), 2.09–2.01 (m, 1H), 1.96–1.80 (m, 3H), 1.68–1.62 (m, 1H), 1.58–1.51 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.3, 143.5, 135.0, 129.2,127.2, 124.7, 121.2, 119.1, 118.7, 108.2, 68.8, 45.6, 34.9, 34.1, 24.5.

Synthesis of (4aR,7aS)-1-Phenyloctahydro-1H-cyclopenta[b]pyridine[5]:



7e **9** **10**

Allyl bromide (165 µL, 1.9 mmol) was added to a mixture of cyclopentyl annulated amine **7e-*trans*** (250 mg, 0.95 mmol) and sodium acetate (156 mg, 1.9 mmol) in acetonitrile (4.0 mL) under a N_2 atmosphere. After stirring at room temperature for 6 h, the reaction mixture was diluted with CH_2Cl_2 (5.0 mL), and then filtered through a sintered glass funnel. The residual mass obtained after removal of the solvent was purified by silica gel column chromatography (2% Et_2O/hexane) to afford *N*-allyl compound (240 mg, 83%) as a colorless oil. IR ν_{max} (film) 3027, 2952, 2871IR ν_{max} (film) 3024, 2955, 2870, 1597, 1503, 1398 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29–7.23 (m, 4H), 7.21–7.15 (m, 3H), 6.80 (d, *J* = 8.4 Hz, 2H), 6.67 (t, *J* = 7.2 Hz, 1H), 6.37 (d, *J* = 16.0 Hz, 1H), 6.21 (dd, *J* = 16.0, 7.6 Hz, 1H), 5.96–5.87 (m, 1H), 5.27 (dd, *J* = 17.2, 1.6 Hz, 1H), 5.17 (dd, *J* = 10.0, 1.6 Hz, 1H), 4.09 (dd, *J* = 17.2, 8.4 Hz, 1H), 3.99–3.82 (m, 2 H), 2.80 (dt, *J* = 16.8, 8.4 Hz, 1H), 2.10–1.95 (m, 2H), 1.81–1.74 (m, 2H), 1.71–1.56 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.8, 137.7, 136.4, 133.3, 129.8, 128.9, 128.4, 126.9, 126.0, 116.5, 115.7, 113.8, 65.5, 48.8, 46.3, 31.0, 28.2, 22.6; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{22}H_{26}N$ 304.206; found 304.205.

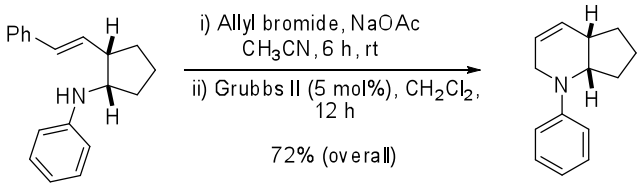
To a solution of the above diene (100 mg, 0.33 mmol) in degassed dichloromethane (33 mL) was added Grubbs 2nd generation catalyst (14 mg, 0.016 mmol) under an Ar atmosphere. The mixture was stirred at room temperature for 12 h. The residual mass obtained after removal of the solvent was purified by silica gel column chromatography (5% Et_2O/hexane) to afford **9** (60 mg, 91%) as a colorless liquid. IR ν_{max} (film) 3027, 2952, 2871, 1597, 1492 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32–7.27 (m, 2H), 7.14–7.11 (m, 2H), 7.03 (tt, *J* = 7.6, 1.2 Hz, 1H), 5.98 (dd, *J* = 9.6, 2.0 Hz, 1H), 5.73–5.68 (m, 1H), 3.91 (ddd, *J* = 17.2, 5.6, 2.8 Hz, 1H), 3.55 (ddt, *J* = 17.2, 4.0, 2.8 Hz, 1H), 2.88–2.82 (m, 1H), 2.35–2.27 (m, 1H), 2.04–1.96 (m, 1H), 1.94–1.86 (m, 1H), 1.78–1.69 (m, 2H), 1.40–1.28 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.0, 129.0, 128.7, 125.8, 122.9,

[5] R. A. Bunce, D. M. Herron, J. R. Lewis, S. V. Kotturi, *J. Heterocyclic Chem*. **2003**, *40*, 113-120.

122.8, 64.3, 56.4, 44.1, 29.4, 26.7, 20.6; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{14}H_{18}N$ 200.143; found 200.143.

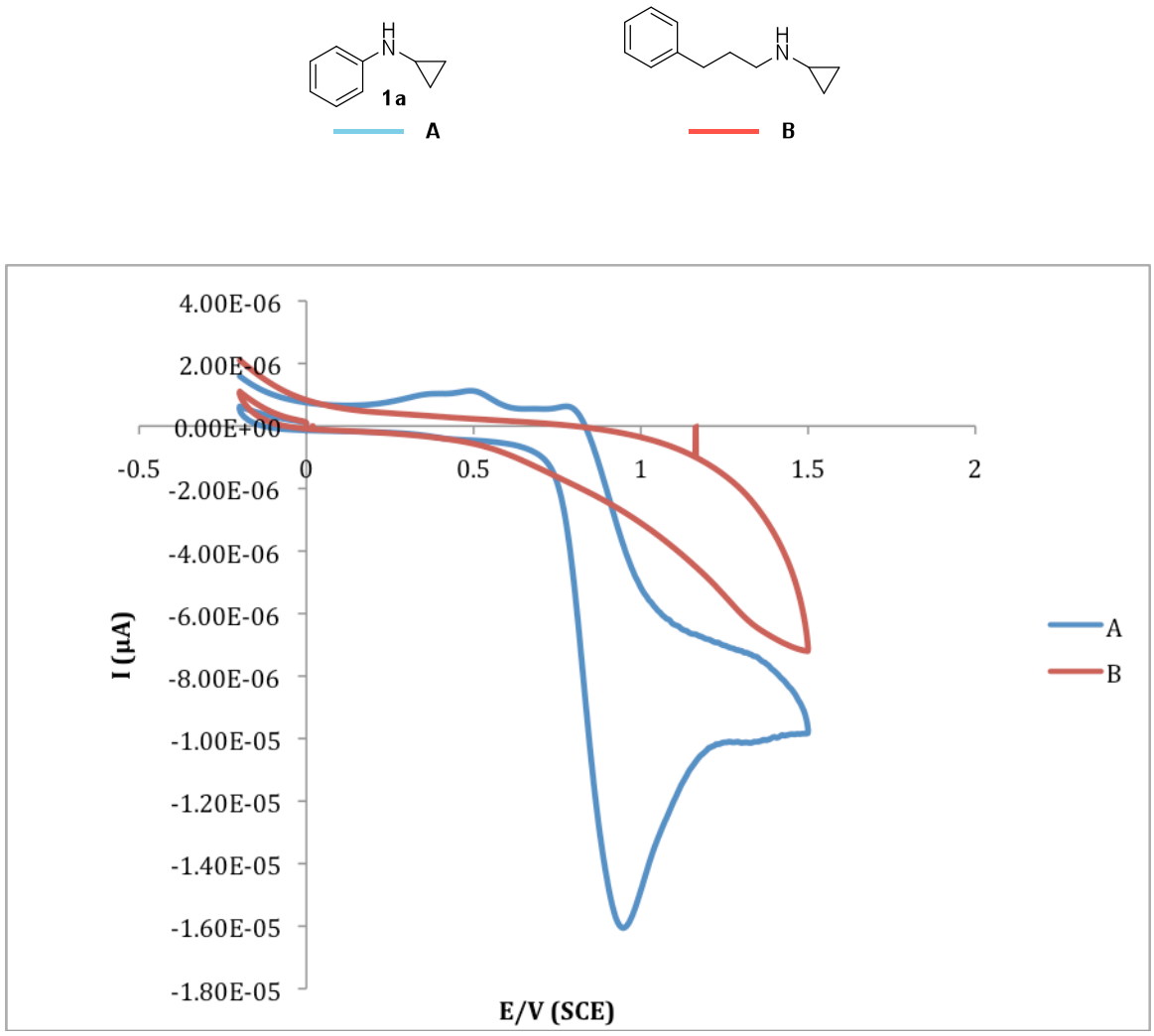
To a solution of cyclohexene derivative **9** (20 mg, 0.1 mmol) in 1 mL of methanol was added 5 mg of 10% palladium-on-carbon. The mixture was stirred under a balloon of hydrogen at room temperature for 12 h. After the solvent was removed, the residue was diluted with ether and the suspension was filtered through a pad of Celite topped with a layer of magnesium sulfate to remove the catalyst. The filtrate was concentrated under reduced pressure and purified by silica gel column chromatography (5% Et_2O/hexane) to give the title compound **10** (19 mg, 94%) as colorless liquid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 (t, *J* = 7.8 Hz, 2H), 7.11 (d, *J* = 8.0 Hz, 2H), 7.03 (t, *J* = 7.6 Hz, 1H), 3.31 (dt, *J* = 12.0, 3.2 Hz, 1H), 2.63–2.57 (m, 1H), 2.37 (ddd, *J* = 16.4, 10.4, 6.0 Hz, 1H), 1.98–1.90 (m, 2H), 1.83–1.74 (m, 3H), 1.69–1.52 (m, 3H), 1.36–1.23 (m, 2H), 1.16–1.05 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.2, 128.6, 123.4, 123.1, 67.4, 57.9, 45.4, 30.3, 29.8, 29.0, 26.9, 20.0.

(4a*S*,7a*S*)-1-Phenyl-2,4a,5,6,7,7a-hexahydro-1*H*-cyclopenta[*b*]pyridine:



Following the above procedure for the conversion of **7e-*trans*** to **9**, **7e-*cis*** was also converted to the title compound. IR ν_{max} (film) 3026, 2956, 2868, 1598, 1503, 1452, 1394, 1301 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ (extra peaks in aromatic region for rotamers) 7.29–7.23 (m, 2H), 7.09–7.06 (m) and 6.95–6.90 (m, total 2 H), 6.76–6.74 (m, 1H), 5.79 (ddt, *J* = 10.0, 4.0, 2.4 Hz, 1H), 5.62 (ddd, *J* = 10.0, 4.4, 2.0 Hz, 1H), 4.35 (dd, *J* = 15.6, 8.4 Hz, 1H), 3.88–3.81 (m, 1H), 3.50 (ddd, *J* = 17.2, 5.6, 2.4 Hz, 1H), 2.83–2.77 (m, 1H), 1.85–1.73 (m, 2H), 1.72–1.66 (m, 1H), 1.62–1.51 (m, 2H), 1.47–1.39 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (extra peaks for rotamers) 150.1, 129.3, 129.2, 129.1, 123.5, 121.0, 117.8, 117.6, 114.3, 57.3, 42.7, 38.0, 29.8, 23.2, 21.7; HRMS (ESI) *m/z* $[M+H]^+$, calc'd for $C_{14}H_{18}N$ 200.143; found 200.143.

***Cyclic Voltammogram of N-cyclopropylaniline A and N-(3-phenylpropyl)cyclopropanamine B*[6]**



Cyclic voltametry experiments were performed using CH Instruments-Electrochemical Analyzer, on solutions of the aminocyclopropanes under study in MeCN (c ~ 2.10^{-3} mol.L^{-1}), contained in a three electrode cell at room temperature under an argon atmosphere.

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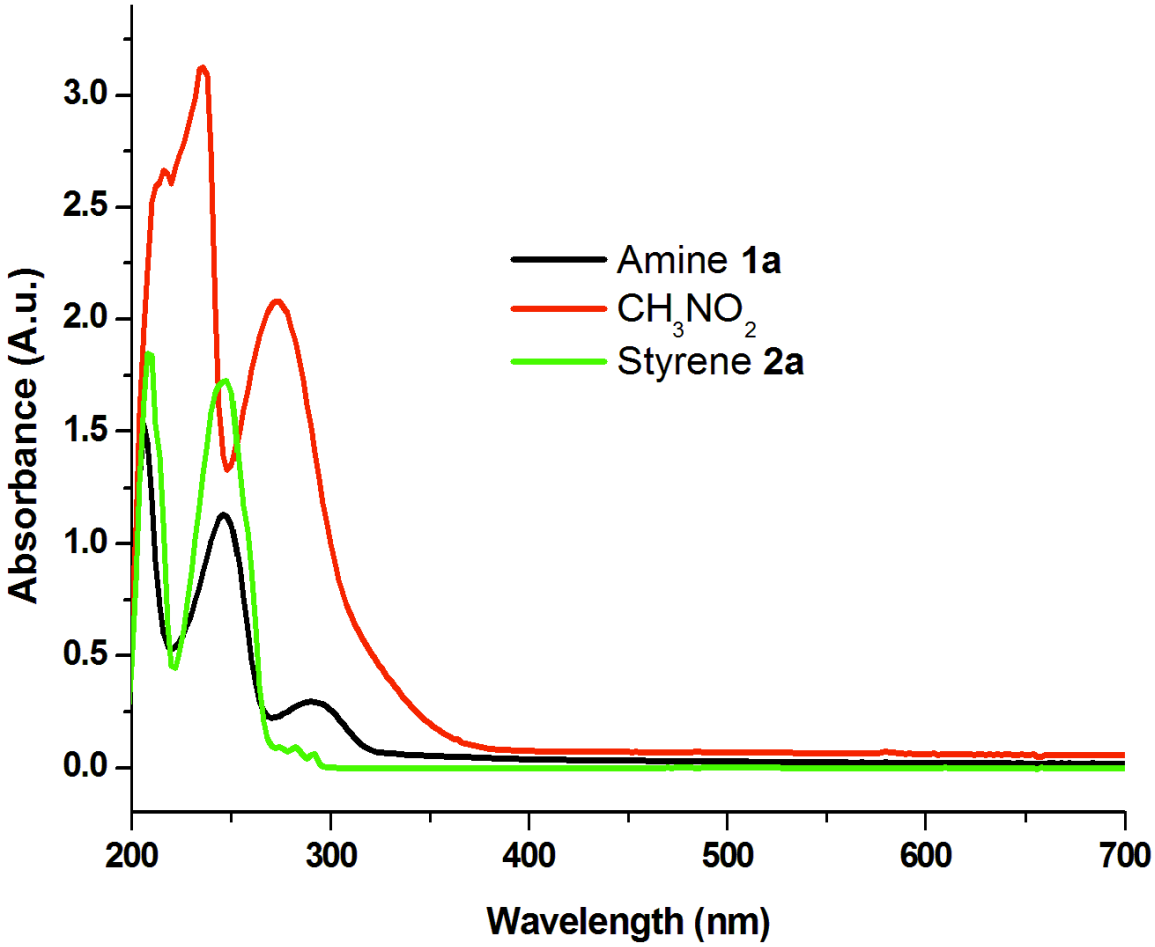
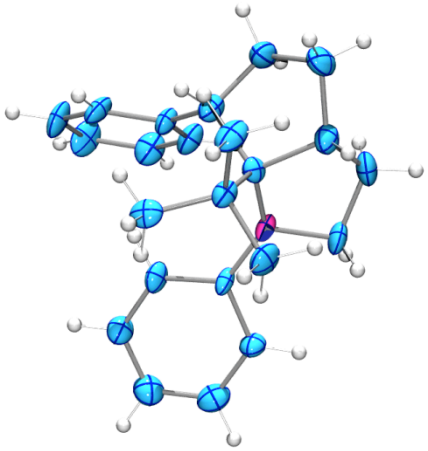
[6] R. N. Salvatore, A. S. Nagle, K. W. Jung, *J. Org. Chem*. **2002**, *67*, 674–683.

UV-Vis Absorbtion Spectra

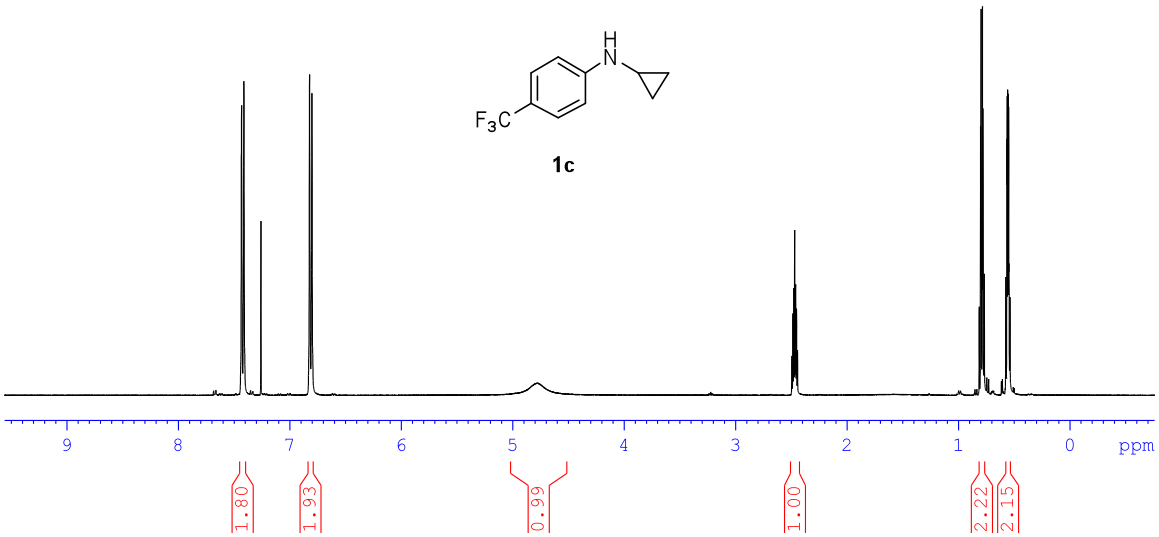


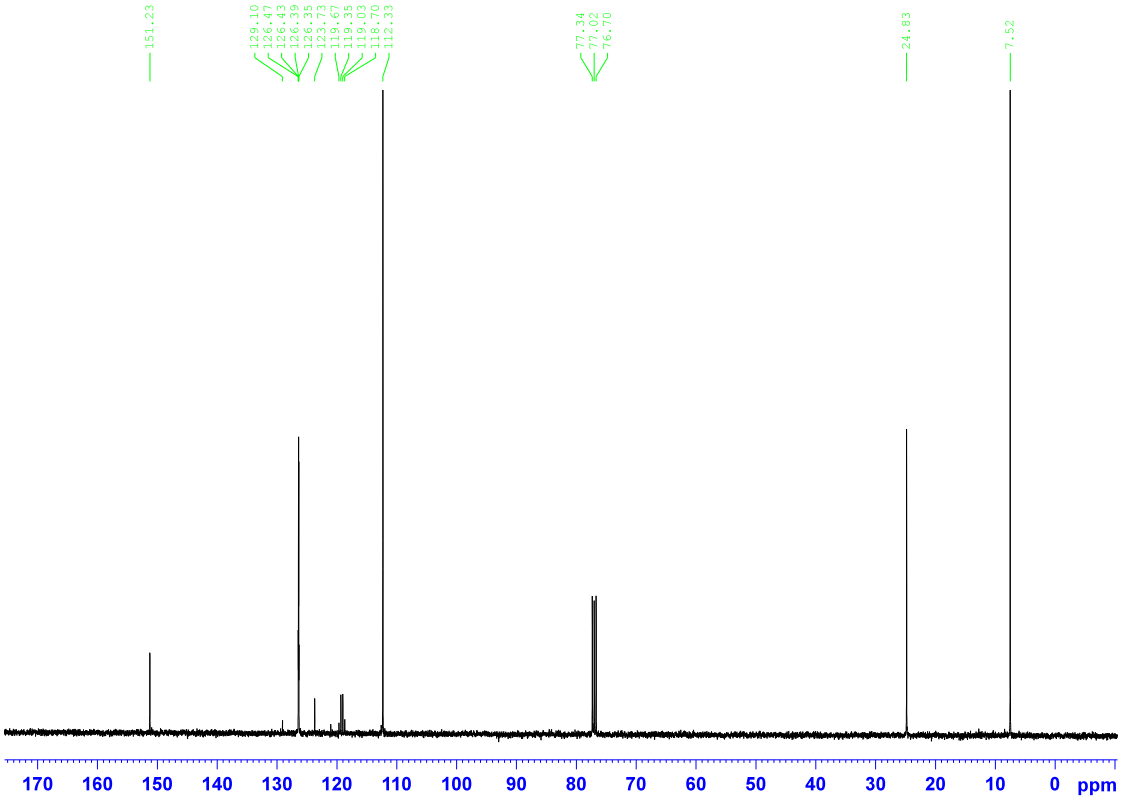


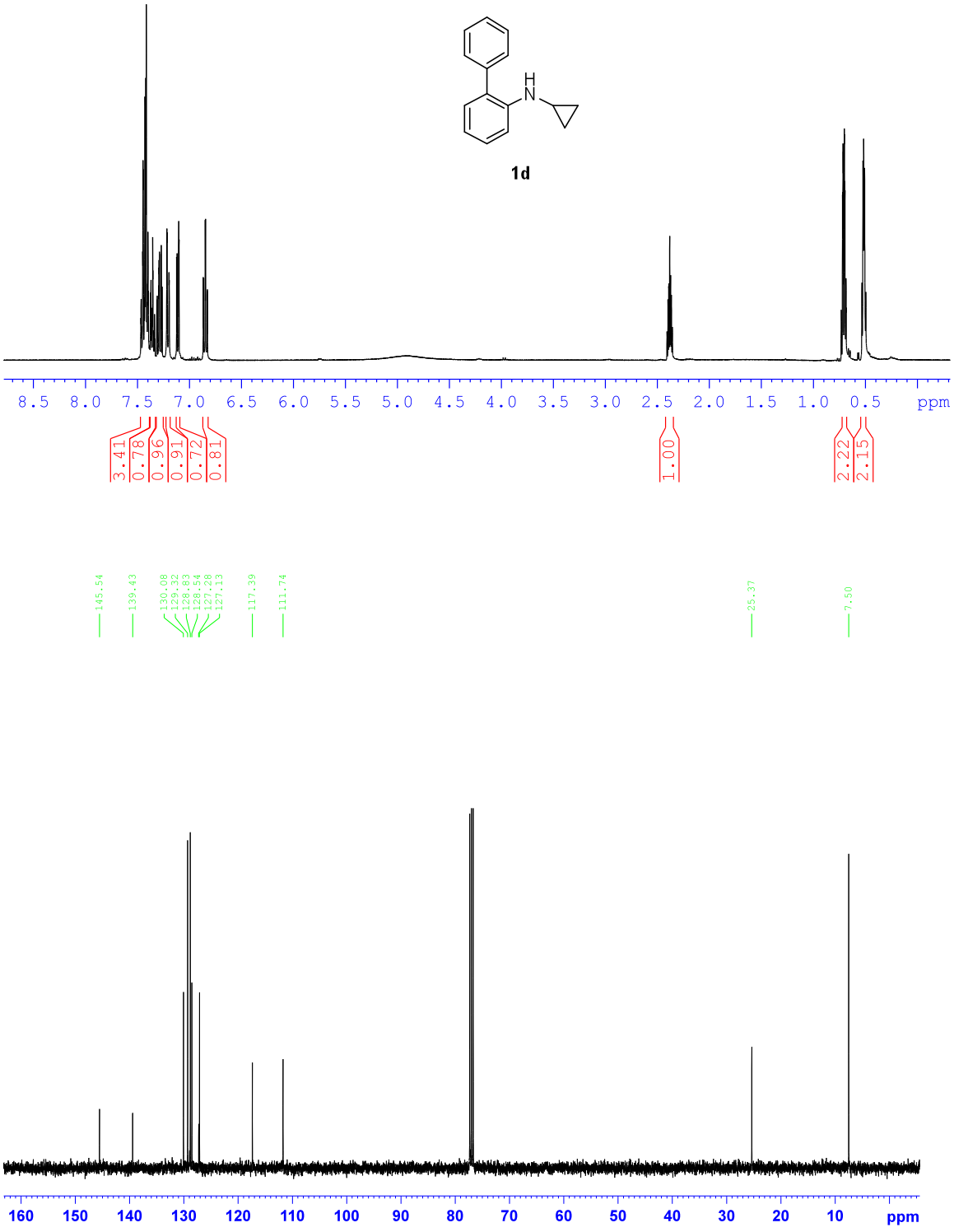
ORTEP Plot of **6d**

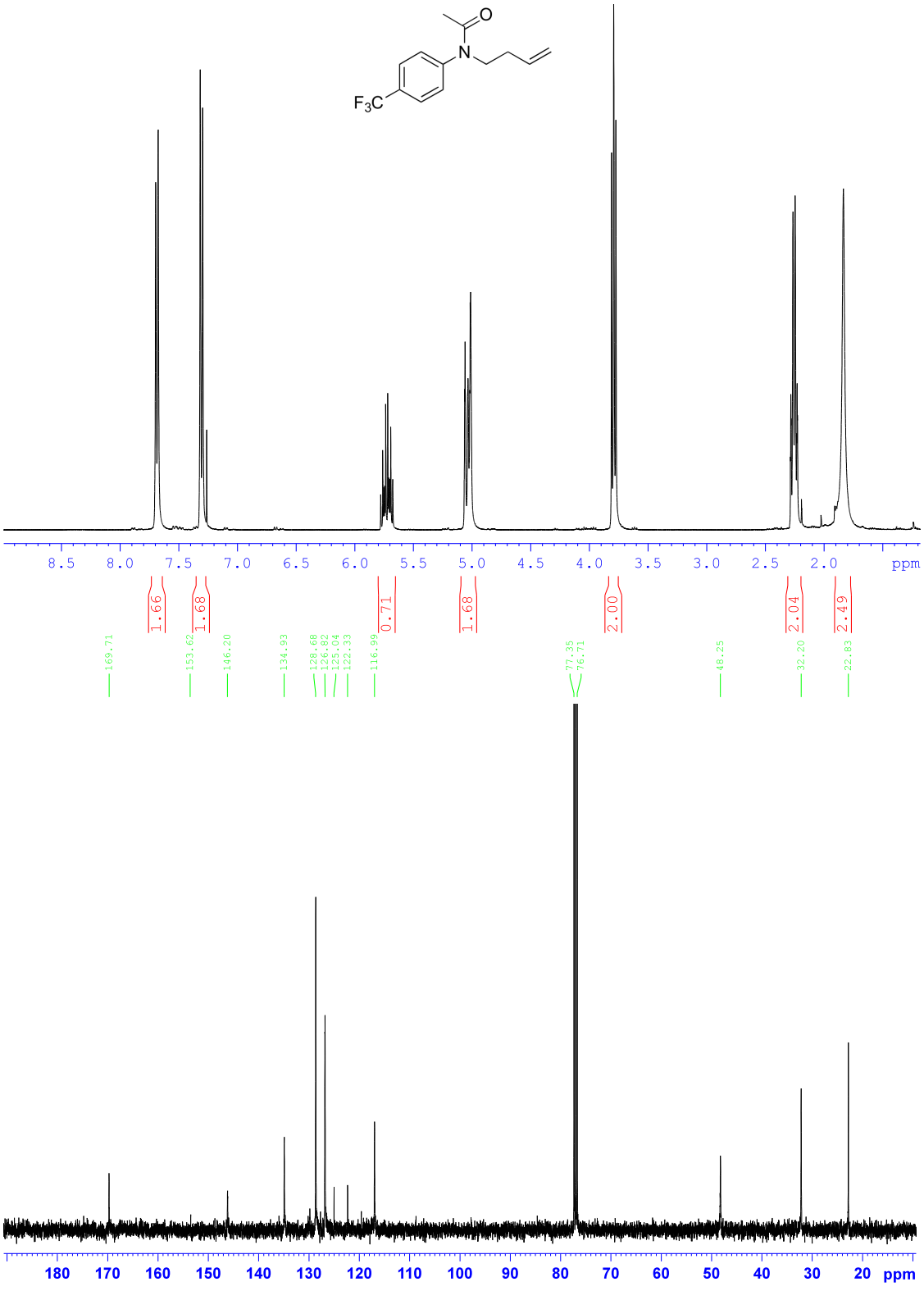
Crystal data for 6d: X-ray single crystal data were collected using MoKα (λ = 0.71073 Å) radiation on a BRUKER SMART X2S diffractometer equipped with a CCD area detector. Data collection, data reduction, structure solution/refinement were carried out using the software package of SMART APEX. The structure was solved by direct method and refined in a routine manner. Non-hydrogen atoms were treated anisotropically. All hydrogen atoms were geometrically fixed. CCDC (CCDC No: 839339) contains the supplementary crystallographic data of **6d**. These data can be obtained free of charge via www.ccdc.cam.ac.uk/conts/retrieving.html (or from the Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB21EZ, UK; fax: (+44) 1223-336-033; or deposit@ccdc.cam.ac.uk).

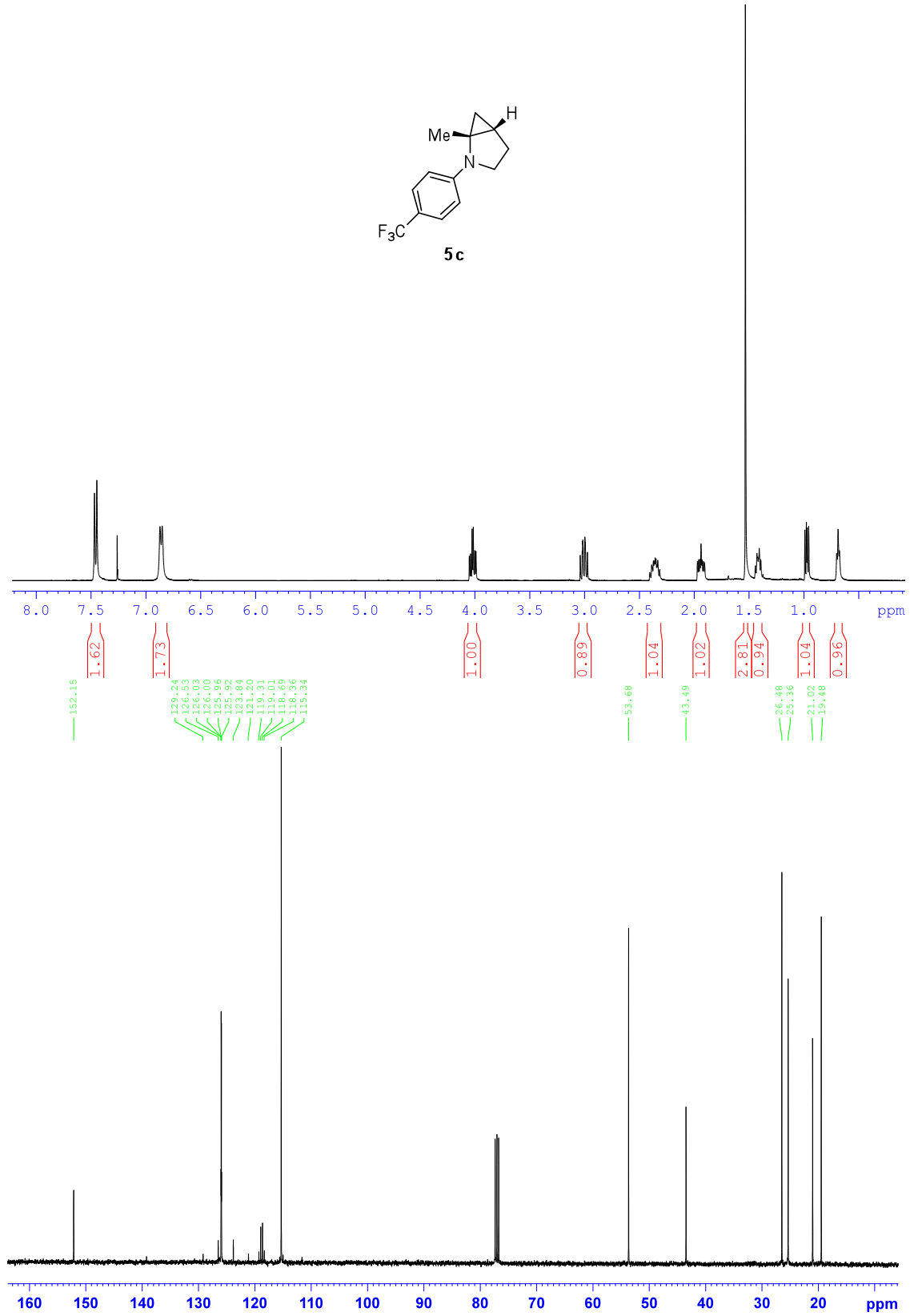
Compound **6d**: $C_{23}H_{29}N$, *FM* = 319.47, triclinic space group P-1, *a* = 12.712(2), *b* = 14.542(2), *c* = 21.139(4) Å. *V* = 3721.6(11) Å^3, *T* = 199 K, *Z* = 8. D_c = 1.140 g cm^{-3}. *F* (000) = 1392.0, *λ* (Mo–Kα) = 0.71073 Å, μ = 0.065 mm^{-1}, $2\theta_{max}$ = 50.2°, 35978 collected reflections measured, 12993 observed (I>2σ (I)) 877 parameters; R_{int} = 0.1061, R_1 = 0.1061; wR_2 = 0.3556 (I>2σ (I)), R_1 = 0.2724; wR_2 = 0.3556 (all data) with GOF = 0.659

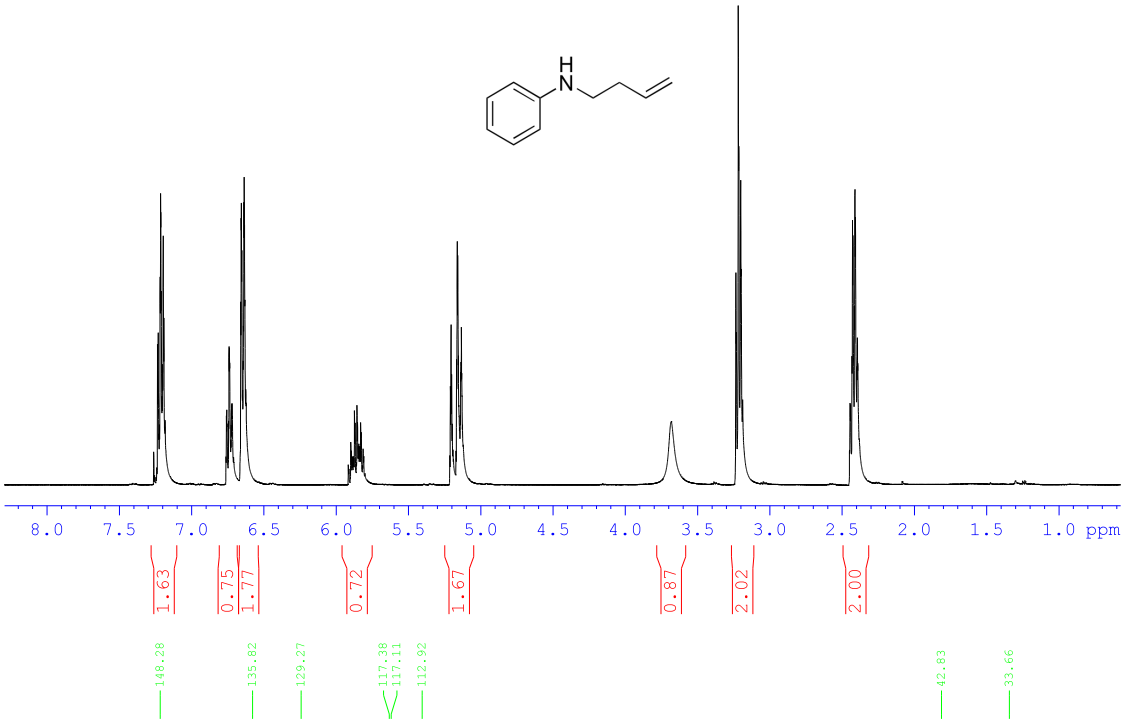

H
N
F3C
1c
9
8
7
6
5
4
3
2
1
0
ppm
1.80
1.93
0.99
1.00
2.22
2.15

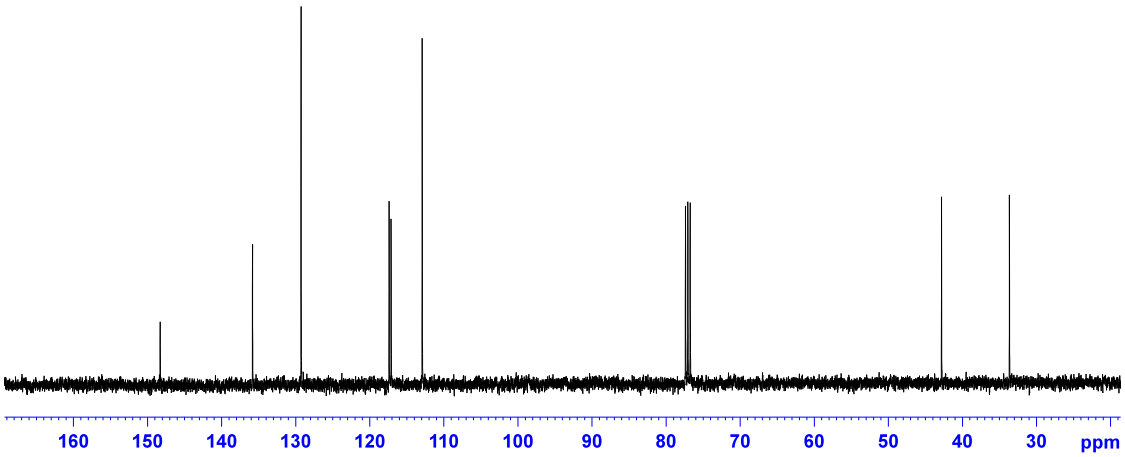

151.23
129.10
126.17
126.43
126.39
126.35
123.73
119.67
119.35
119.03
118.70
112.33
77.34
77.02
76.70
24.83
7.52
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

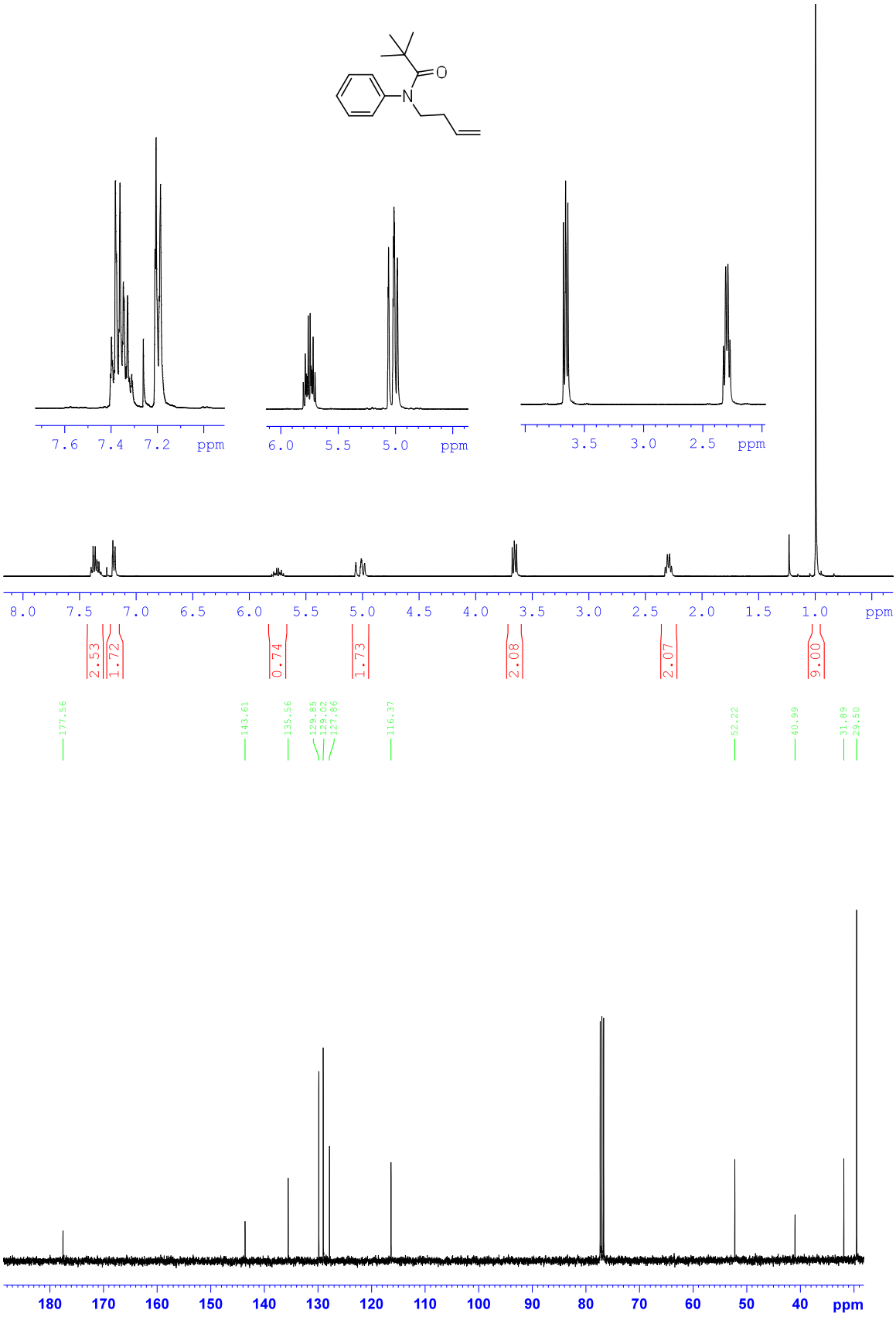

1d
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
3.41
0.78
0.96
0.91
0.72
0.81
1.00
2.22
2.15
145.54
139.43
130.08
129.32
128.83
128.34
127.28
127.13
117.39
111.74
25.37
7.50
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

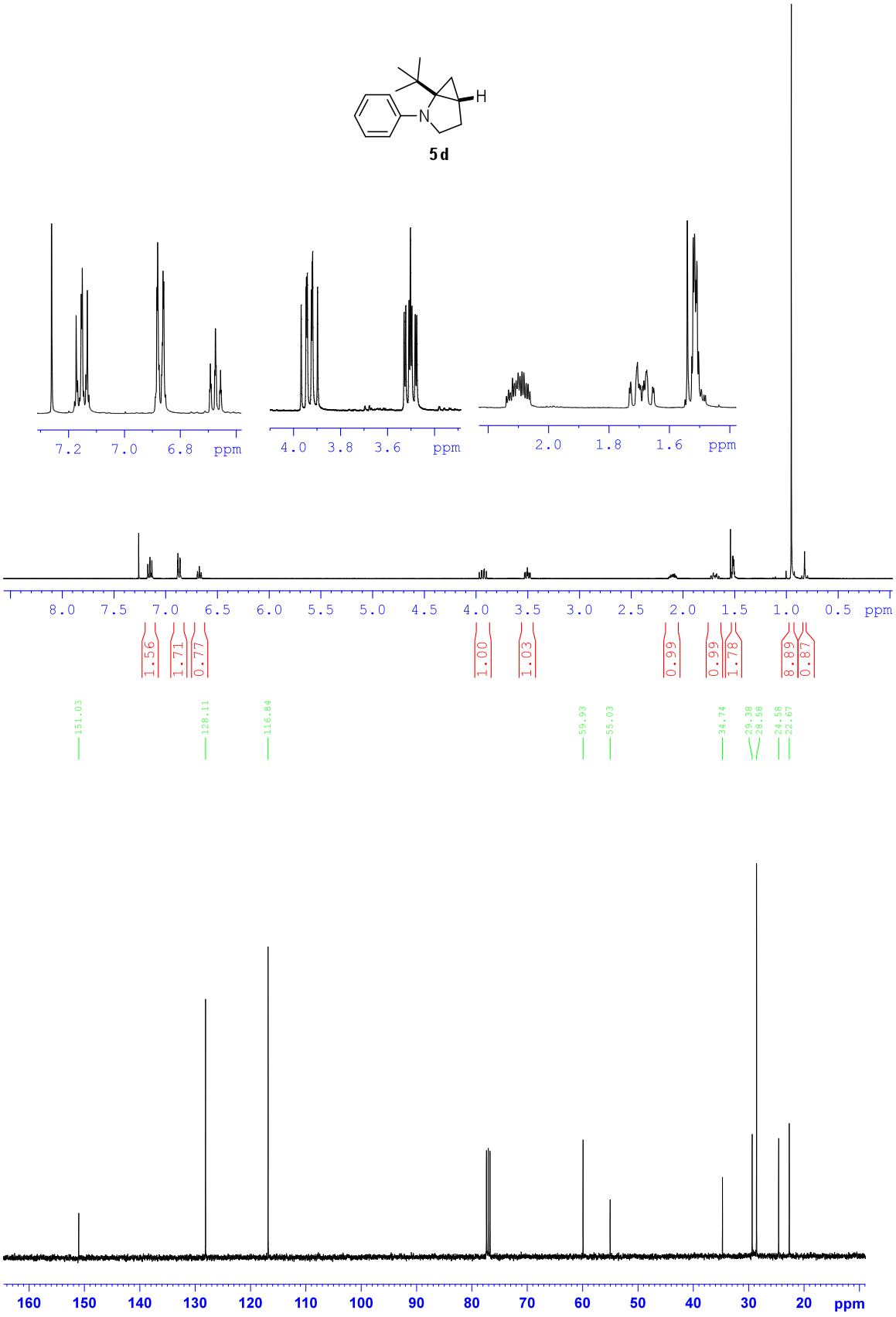

O
N
F3C
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 ppm
1.66
1.68
0.71
1.68
2.00
2.04
2.49
169.71
153.62
146.20
134.93
128.68
126.82
125.04
122.33
116.99
77.35
76.71
48.25
32.20
22.83
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 ppm

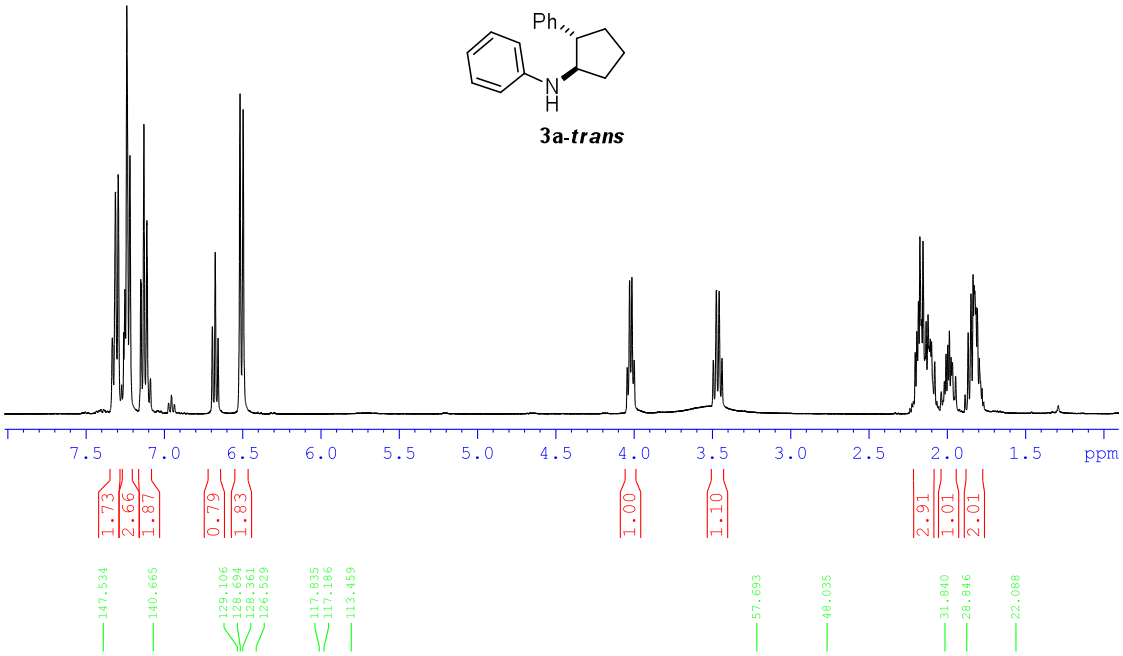

Me
H
N
F3C
5c
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
1.62
1.73
1.00
0.89
1.04
1.02
2.81
0.94
1.04
0.96
152.15
129.24
126.53
126.03
126.00
125.96
123.84
121.20
119.31
119.01
118.69
118.36
115.34
53.68
43.49
26.48
25.36
21.02
19.48
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm


H
N
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0 ppm
1.63
0.75
1.77
0.72
1.67
0.87
2.02
2.00
148.28
135.82
129.27
117.38
117.11
112.92
42.83
33.66

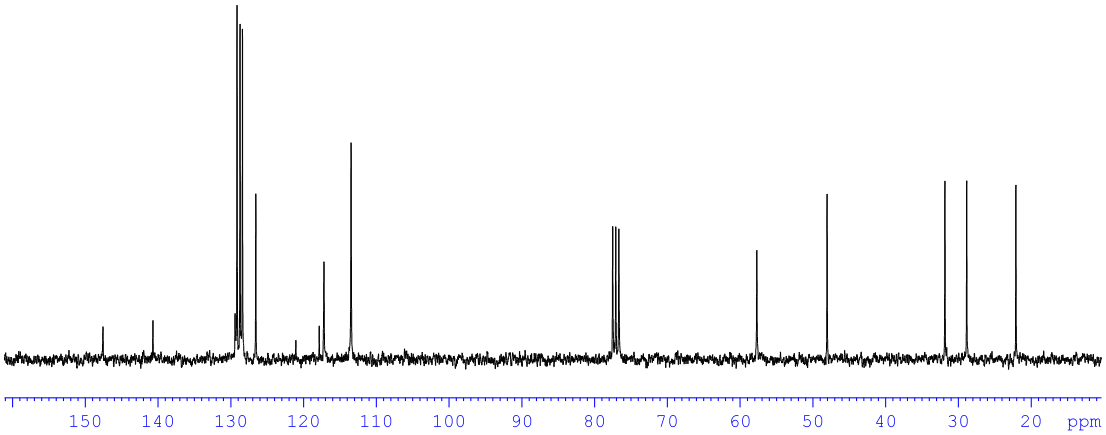

160
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm


O
N
7.6 7.4 7.2 ppm
6.0 5.5 5.0 ppm
3.5 3.0 2.5 ppm
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 ppm
2.53
1.72
0.74
1.73
2.08
2.07
9.00
177.56
143.61
135.56
129.85
129.02
127.86
116.37
52.22
40.99
31.89
29.50
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 ppm

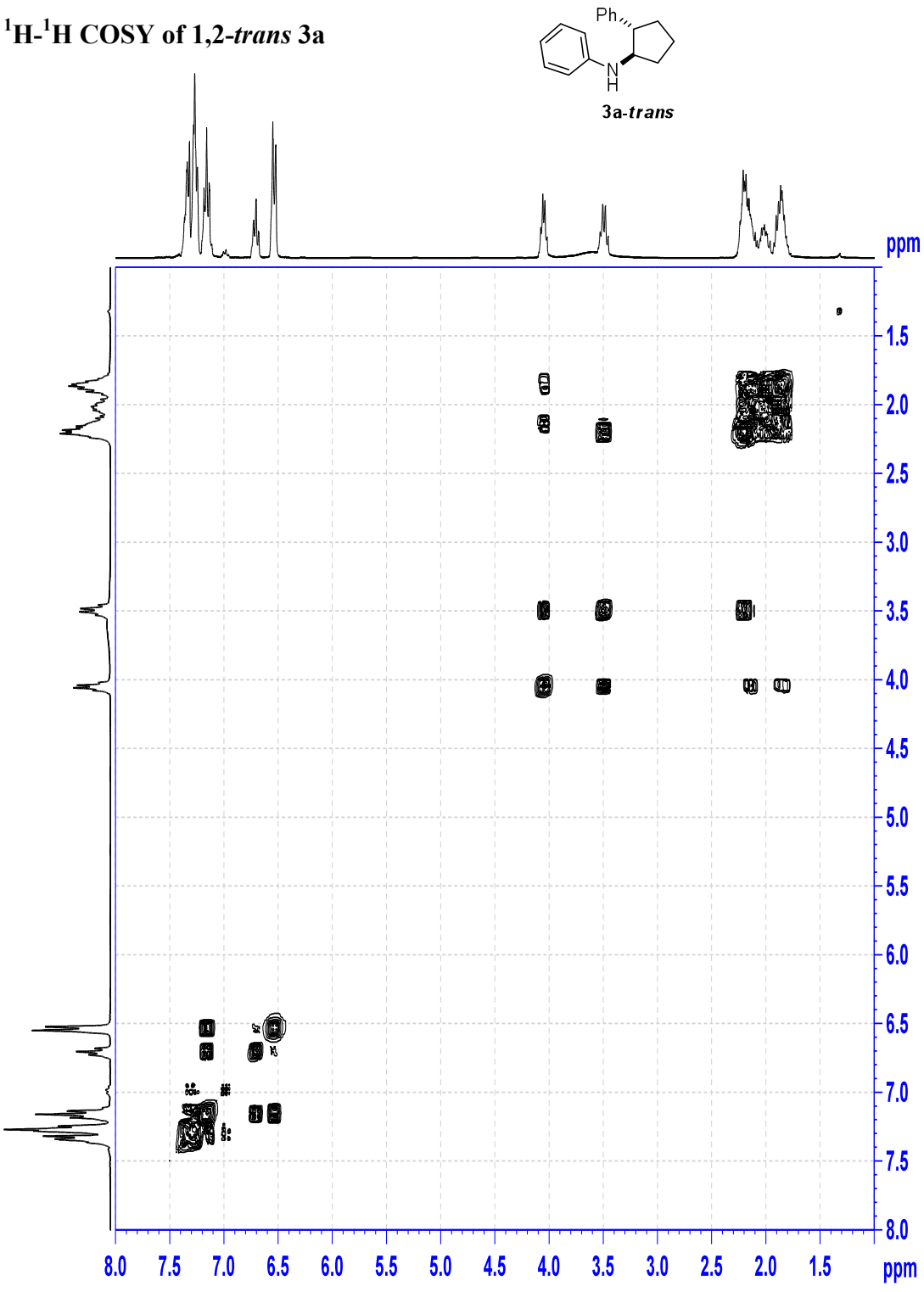

H
N
5d
7.2 7.0 6.8 ppm
4.0 3.8 3.6 ppm
2.0 1.8 1.6 ppm
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.56
1.71
0.77
1.00
1.03
0.99
0.99
1.78
8.89
0.87
151.03
128.11
116.84
59.93
55.03
34.74
29.38
28.58
24.58
22.67
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 ppm


Ph
N
H
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
1.73
2.66
1.87
0.79
1.83
1.00
1.10
2.91
1.01
2.01
147.534
140.665
129.106
128.694
128.361
126.529
117.835
117.186
113.459
57.693
48.035
31.840
28.846
22.088

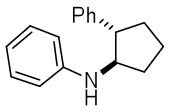
3a-*trans*


150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

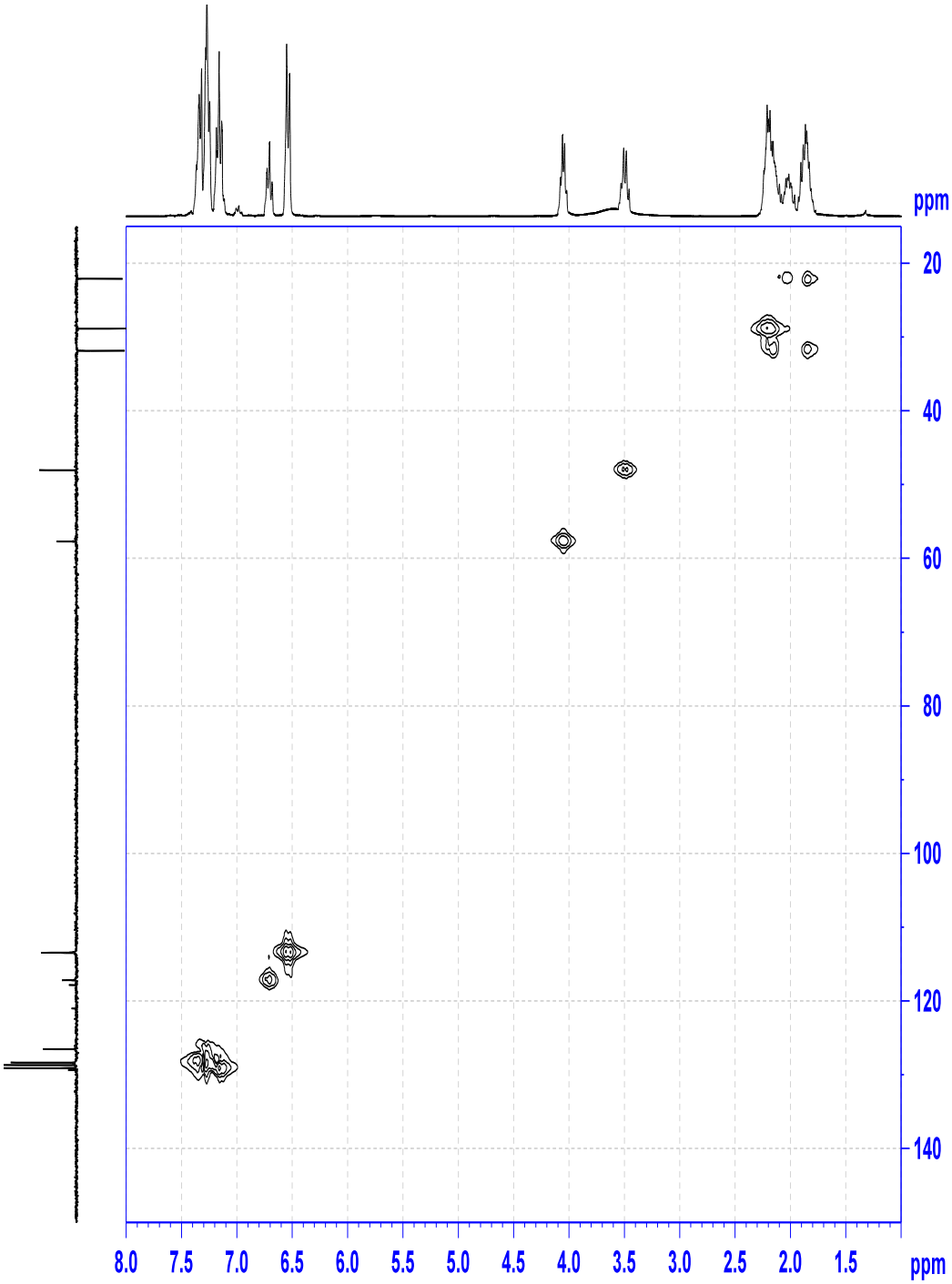
^{1}H-^{1}H COSY of 1,2-*trans* 3a



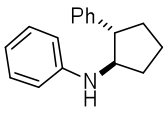
^{1}H-^{13}C HMQC of 1,2-*trans* 3a



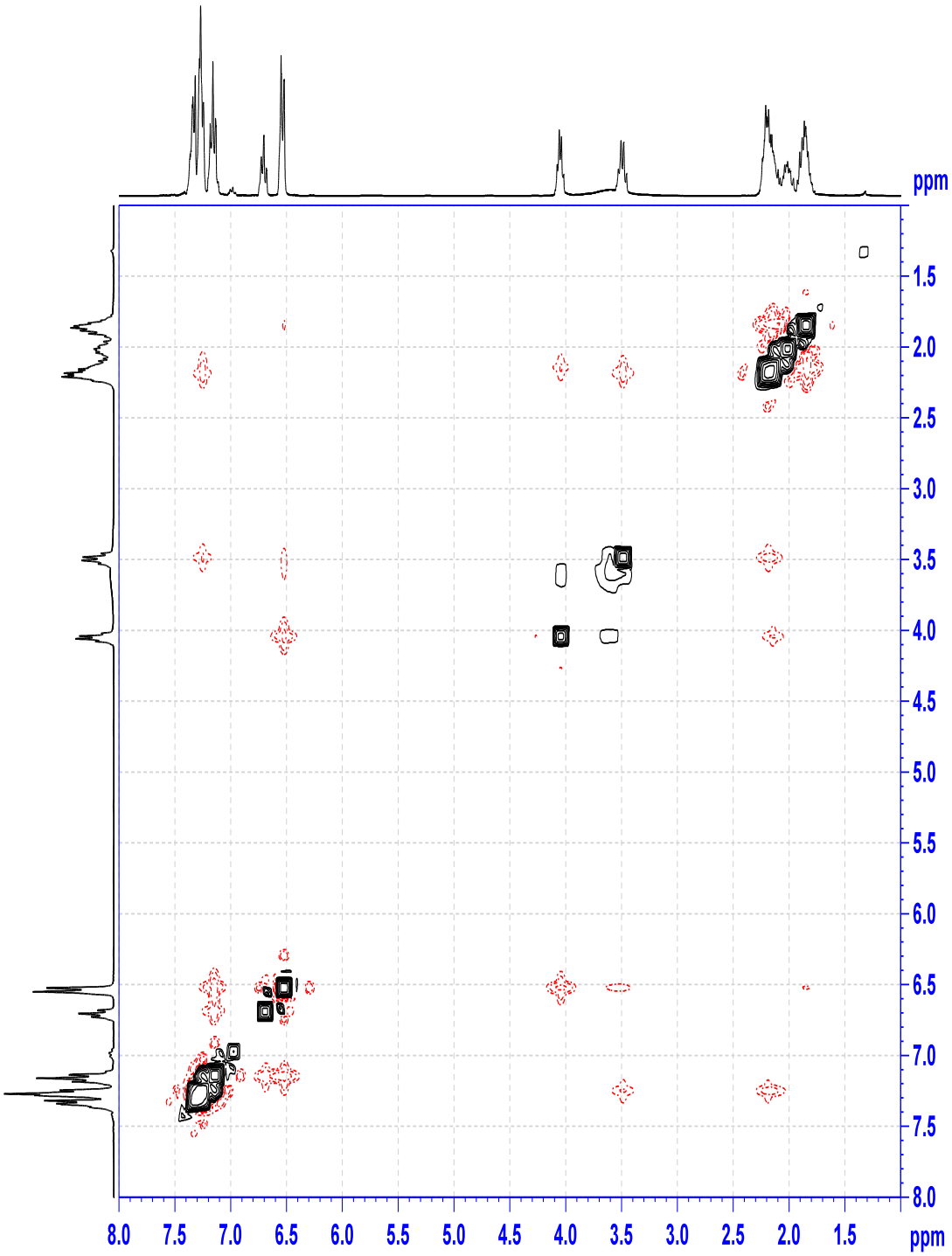
3a-*trans*

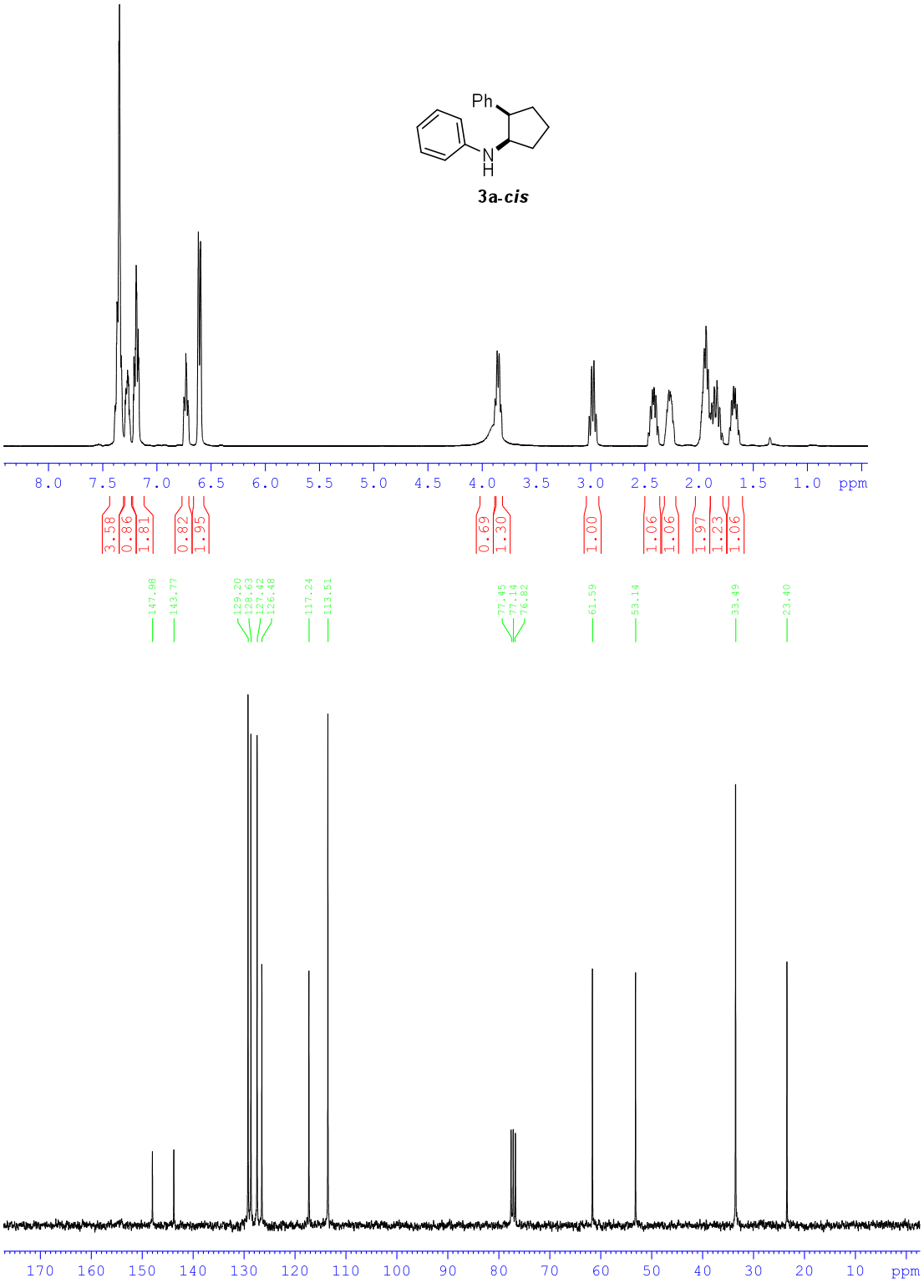


^{1}H-^{1}H NOESY of 1,2-*trans* 3a

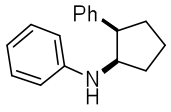


3a-*trans*

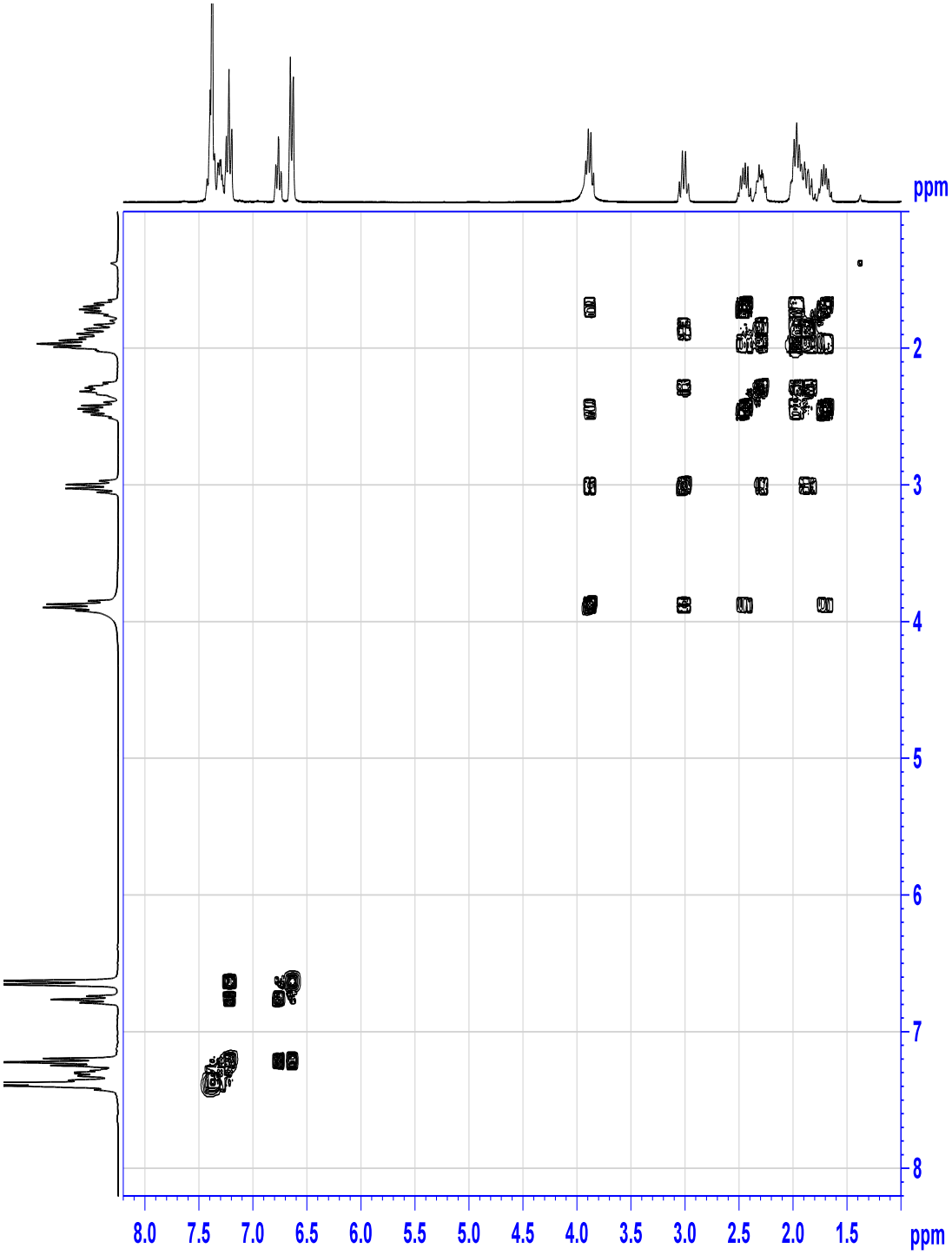



Ph
N
H
3a-cis
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 ppm
3.58 0.86 1.81 0.82 1.95 0.69 1.30 1.00 1.06 1.06 1.97 1.23 1.06
147.98 143.77 129.20 128.63 127.42 126.48 117.24 113.51 77.45 77.14 76.82 61.59 53.14 33.49 23.40
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

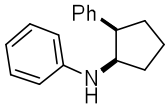
^{1}H-^{1}H COSY of 1,2-*cis* 3a



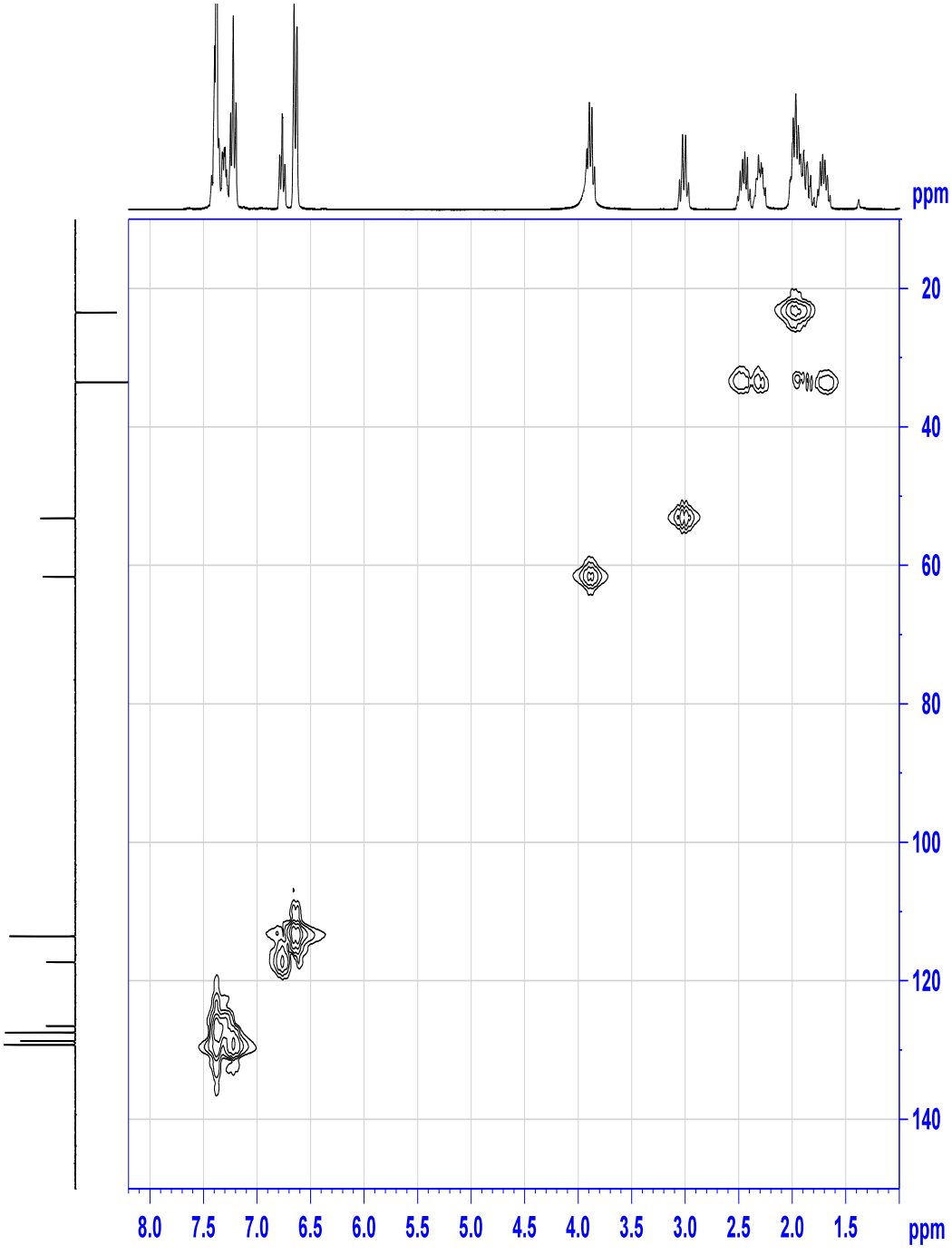
3a-*cis*



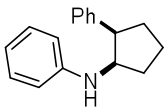
^{1}H-^{13}C HMQC of 1,2-*cis* 3a



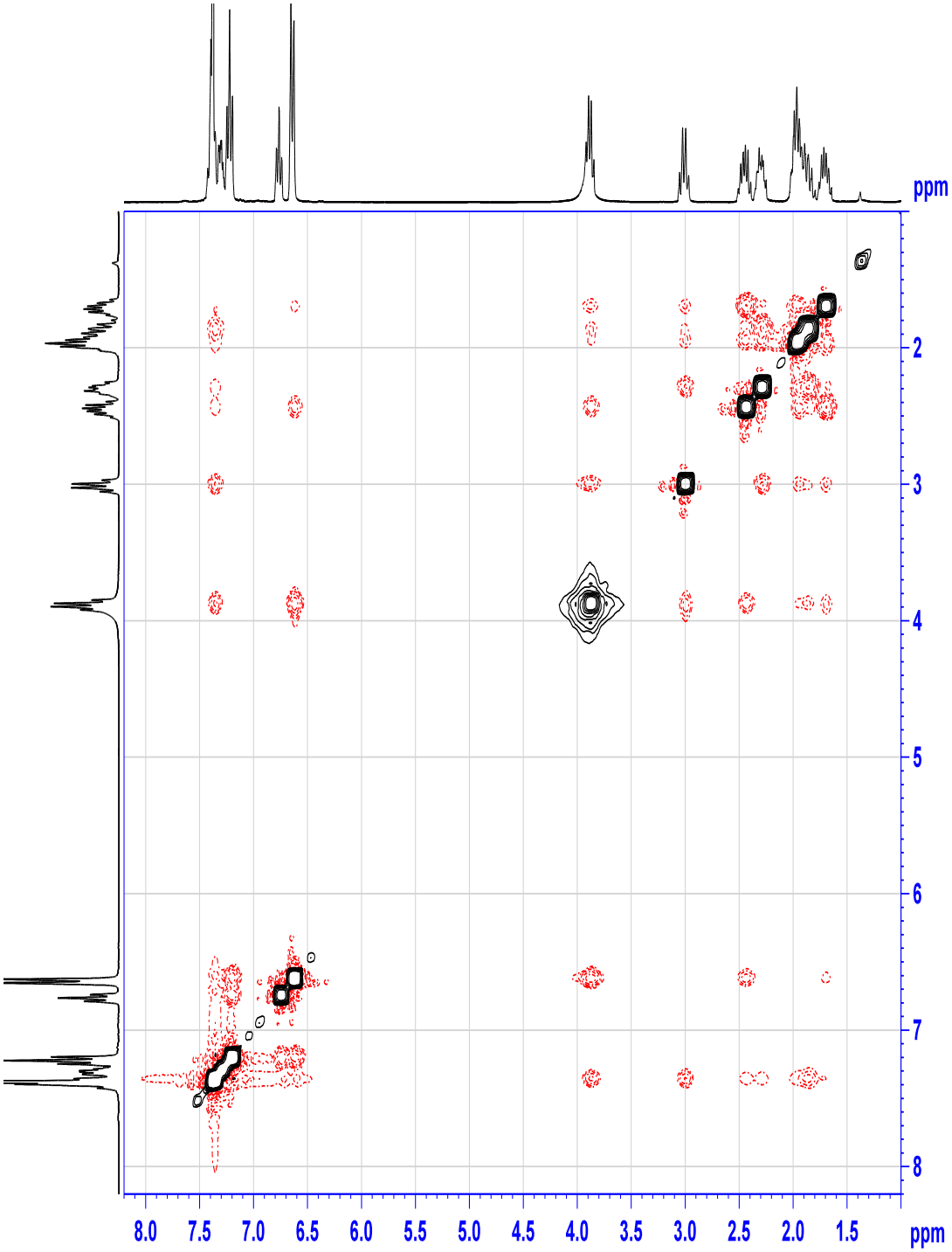
3a-*cis*

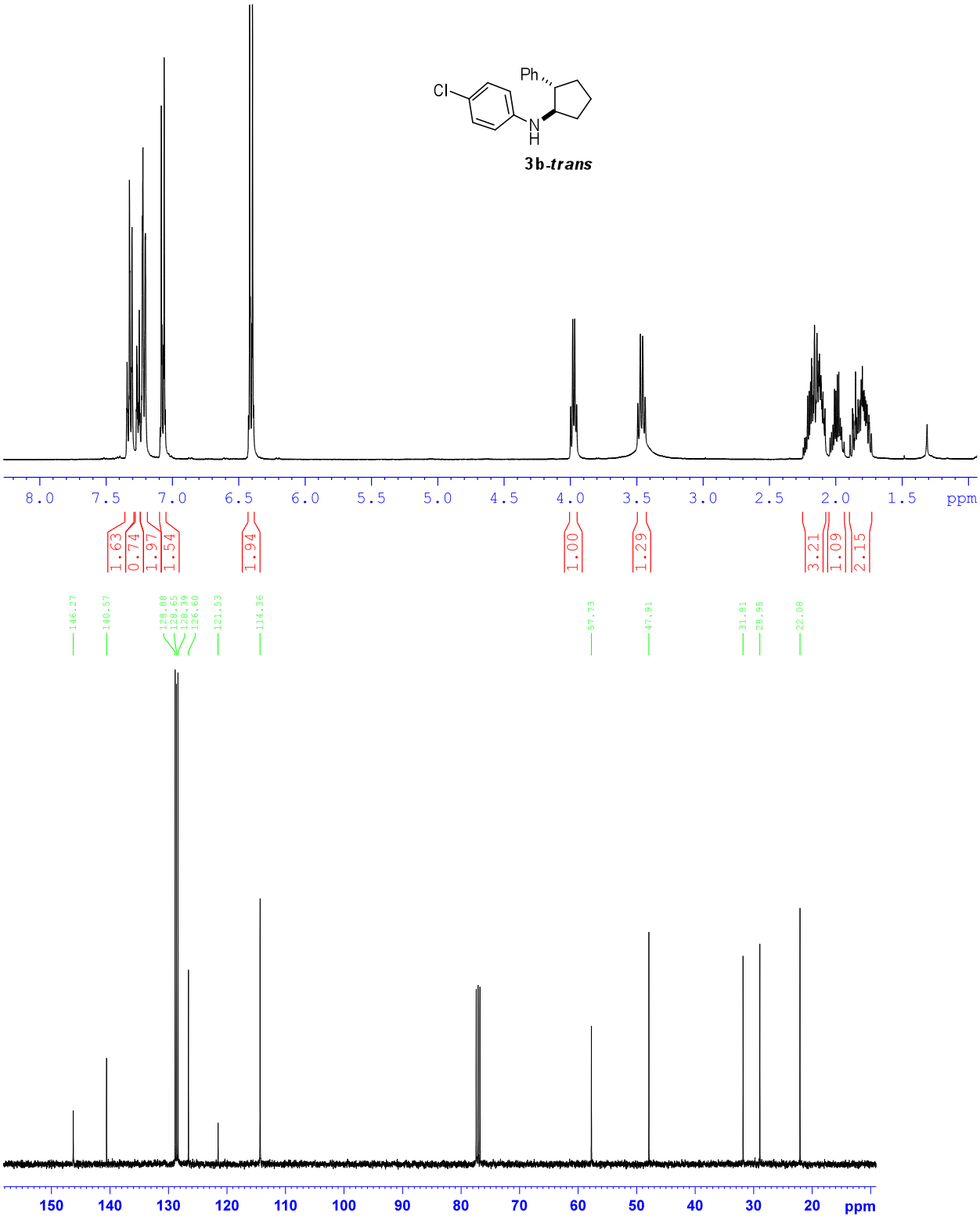


^{1}H-^{1}H NOESY of 1,2-*cis* 3a



3a-*cis*




Cl
Ph
N
H
3b-trans
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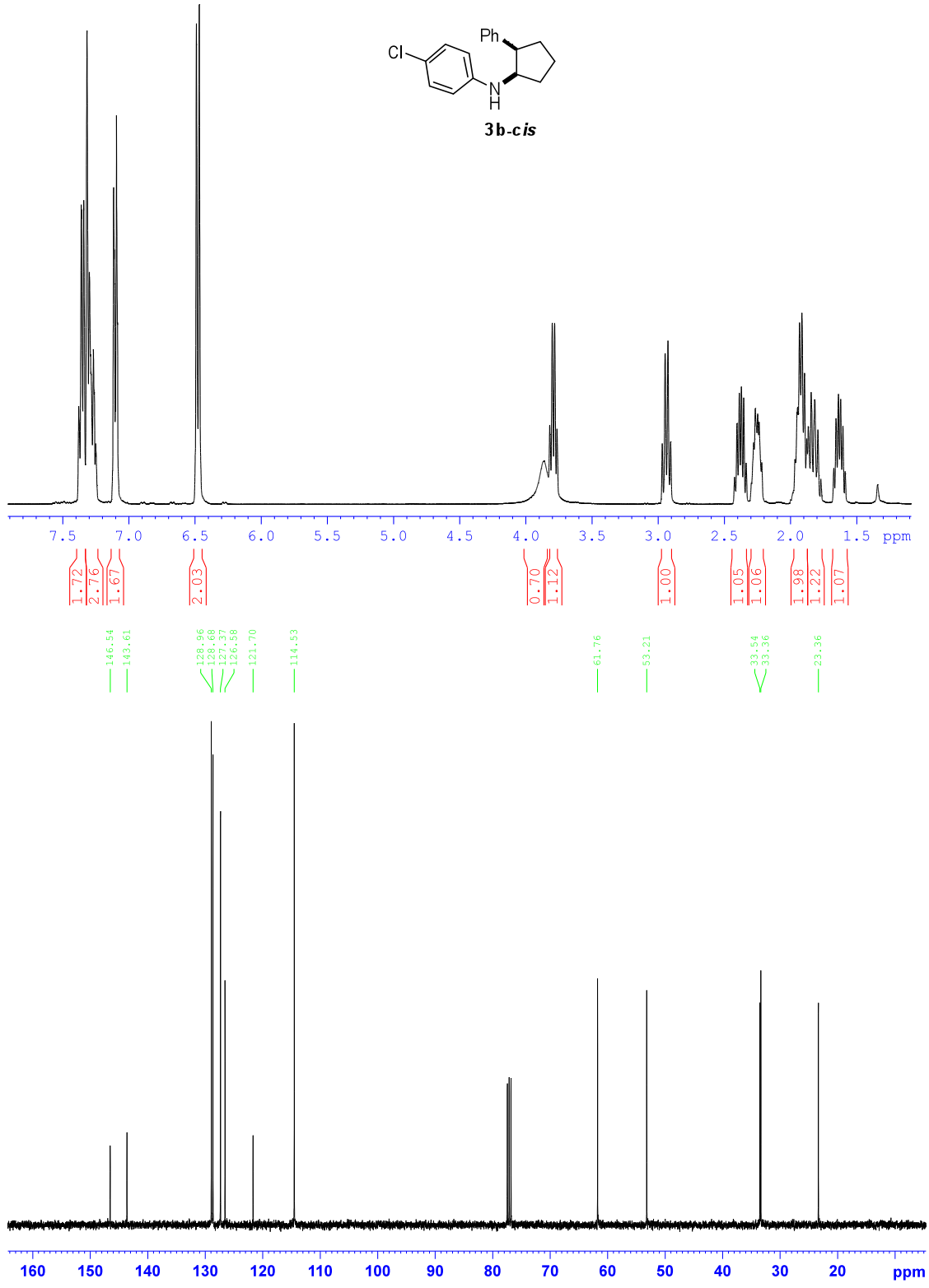
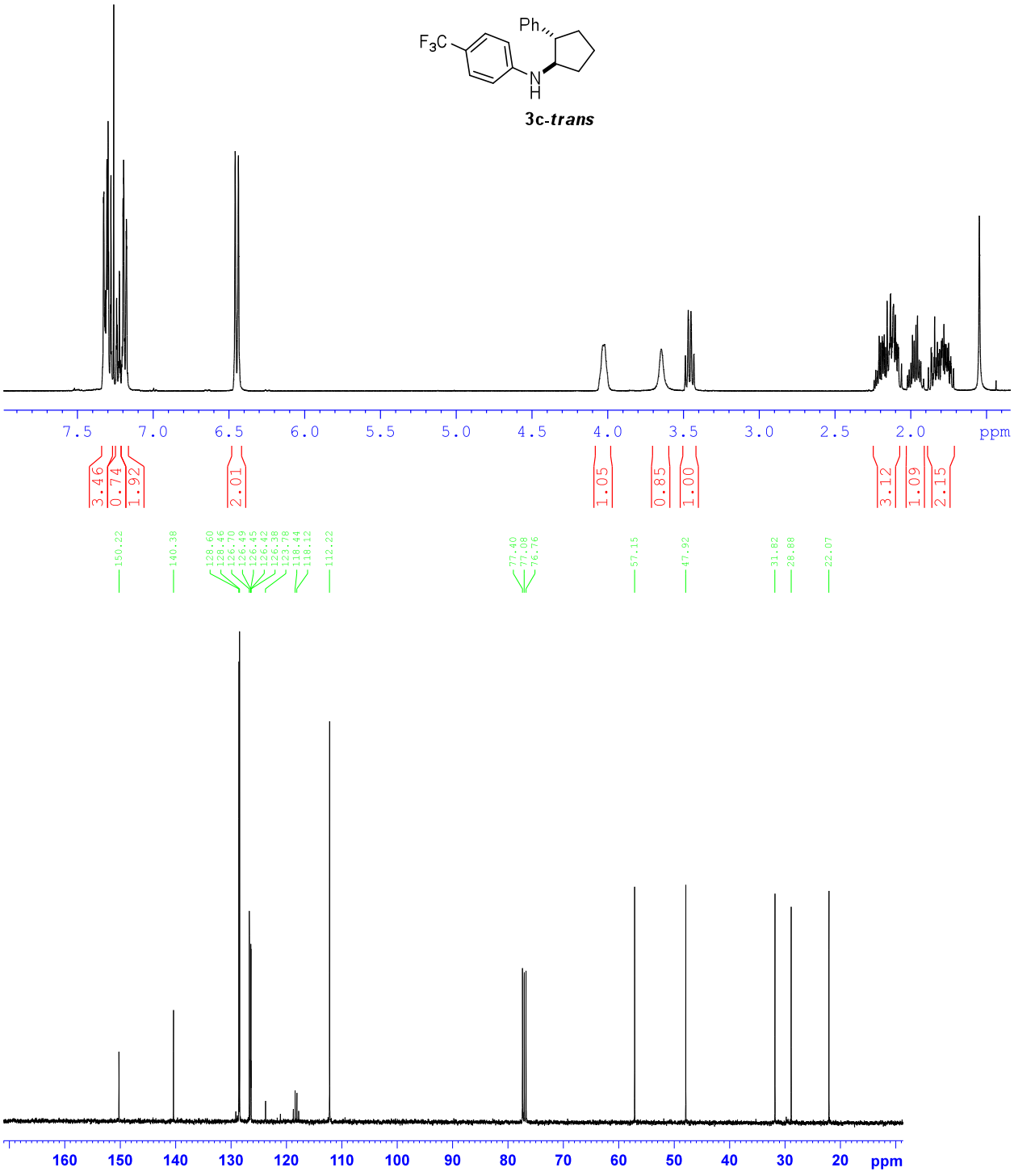
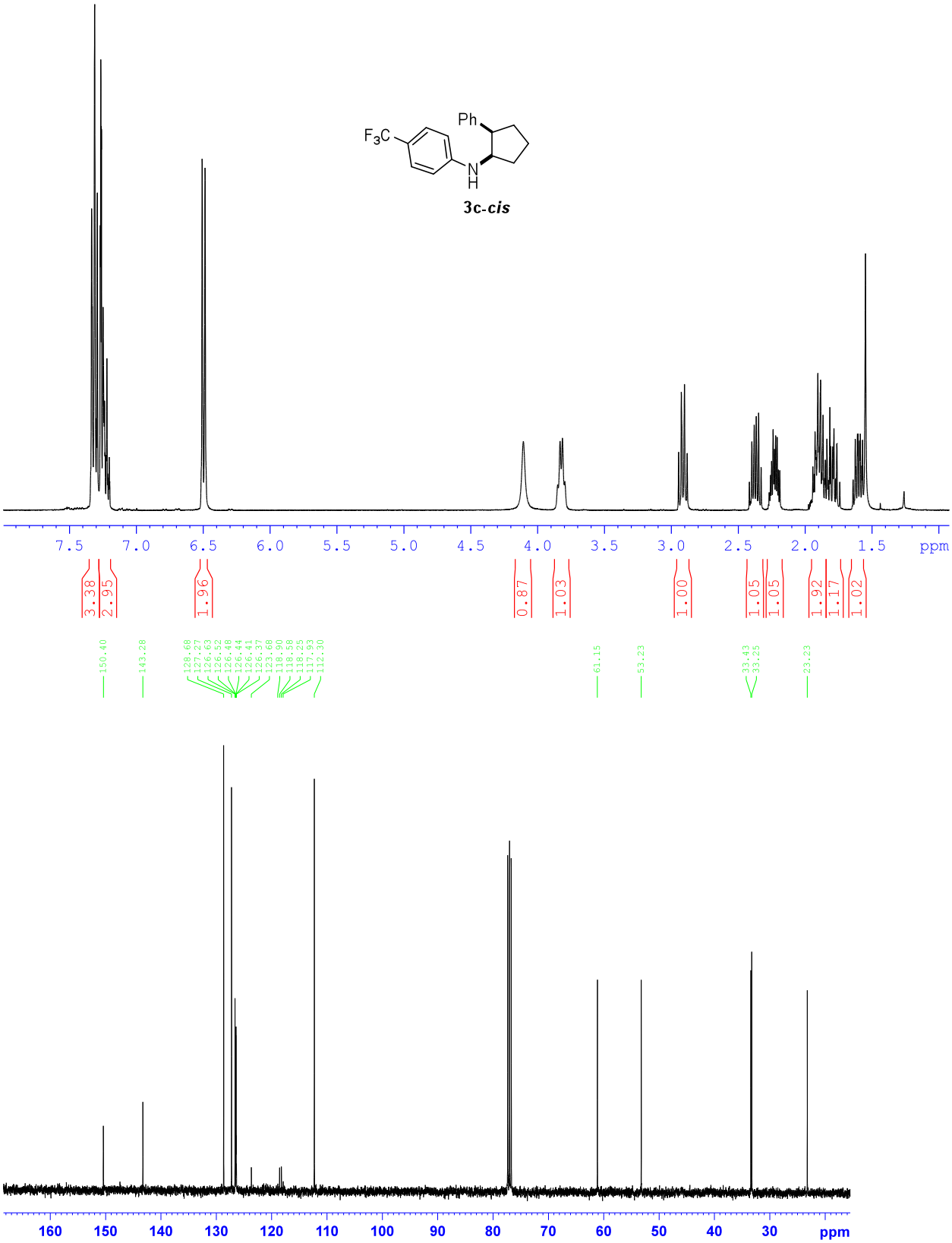
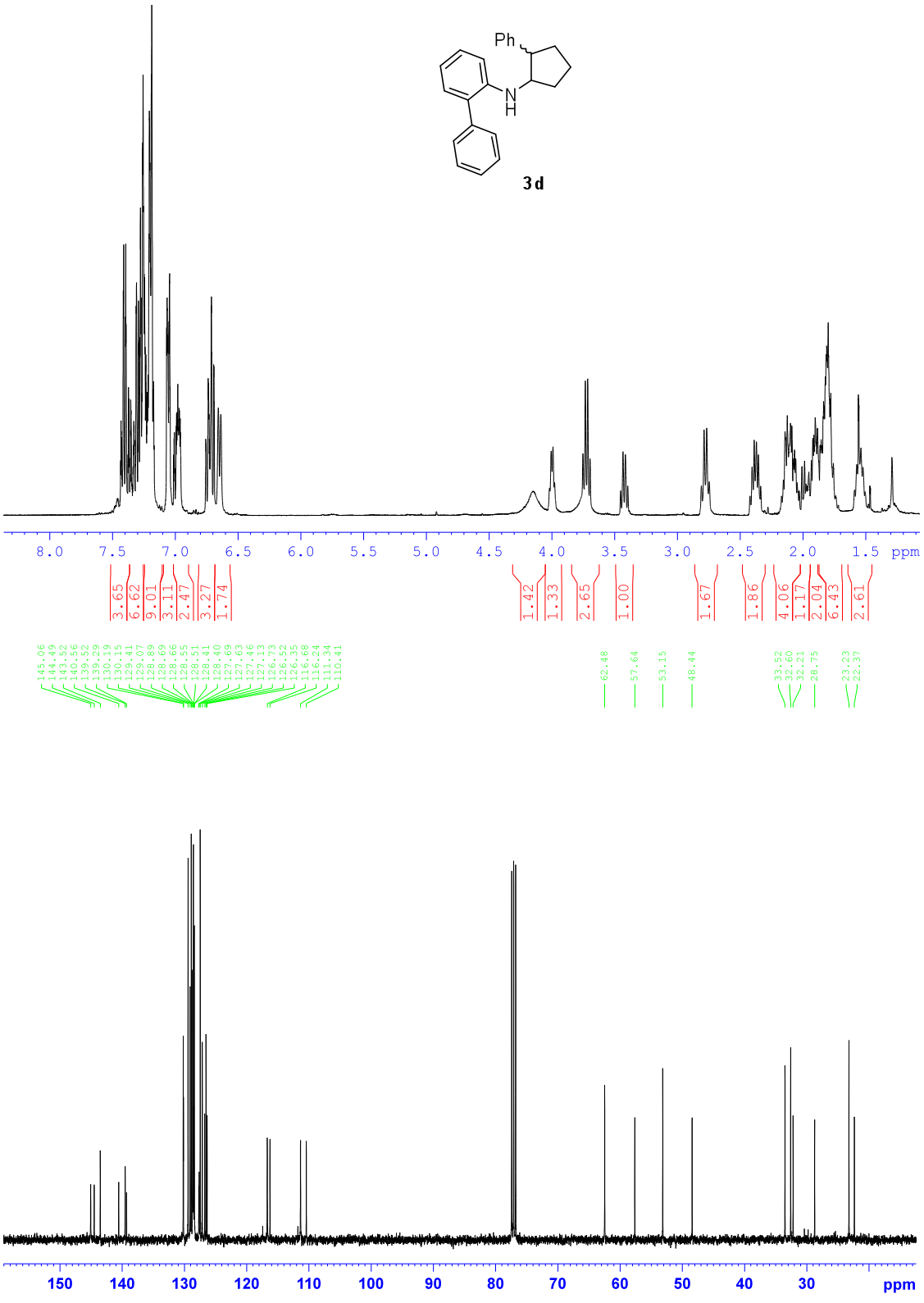
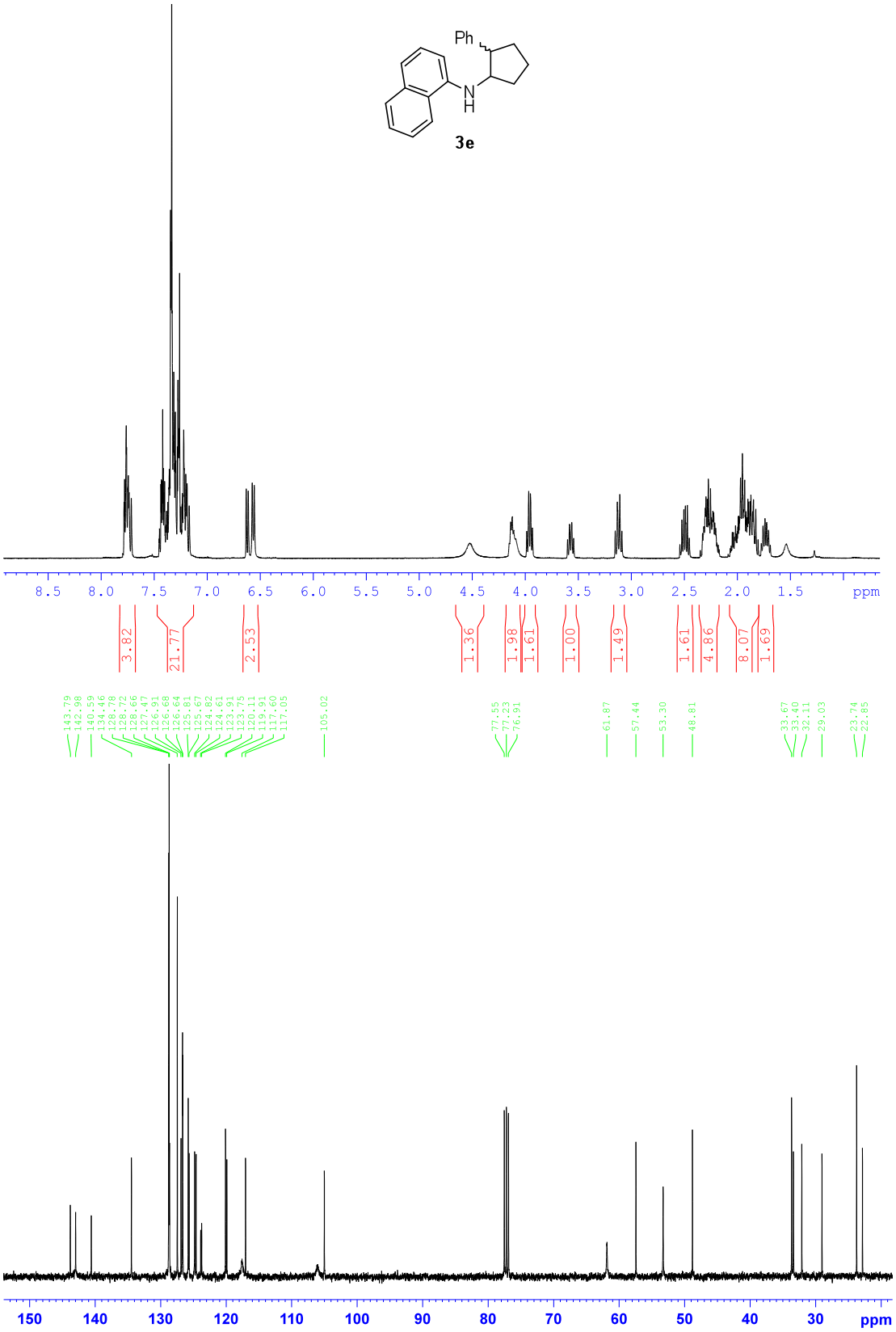
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
1.63
0.74
1.97
1.54
1.94
1.00
1.29
3.21
1.09
2.15
146.27
140.57
128.88
128.65
128.39
126.60
121.53
114.36
57.73
47.91
31.81
28.95
22.08
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

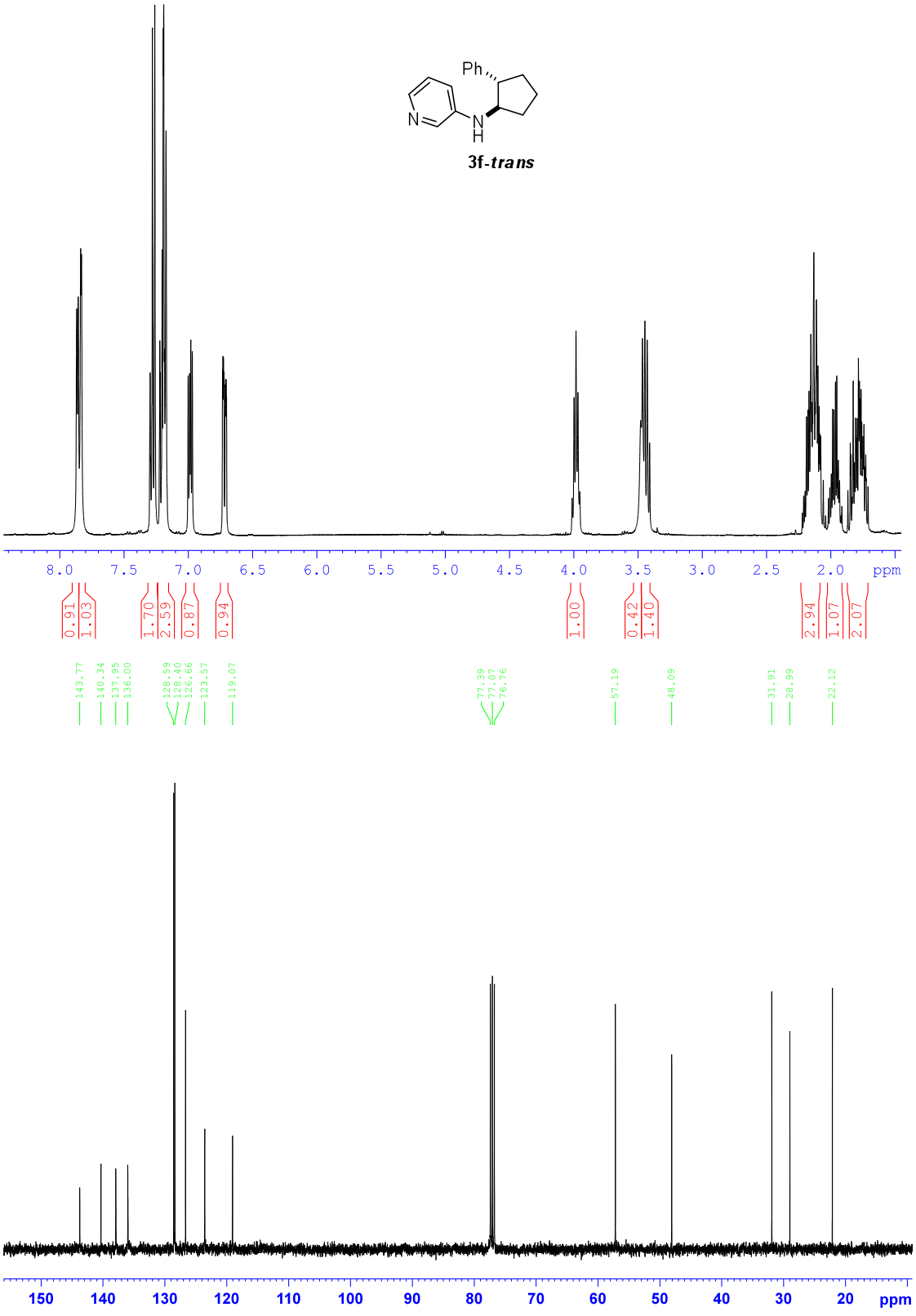

Cl
Ph
N
H
3b-cis
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
1.72
2.76
1.67
2.03
0.70
1.12
1.00
1.05
1.06
1.98
1.22
1.07
146.54
143.61
128.96
128.68
127.37
126.58
121.70
114.53
61.76
53.21
33.54
33.36
23.36
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

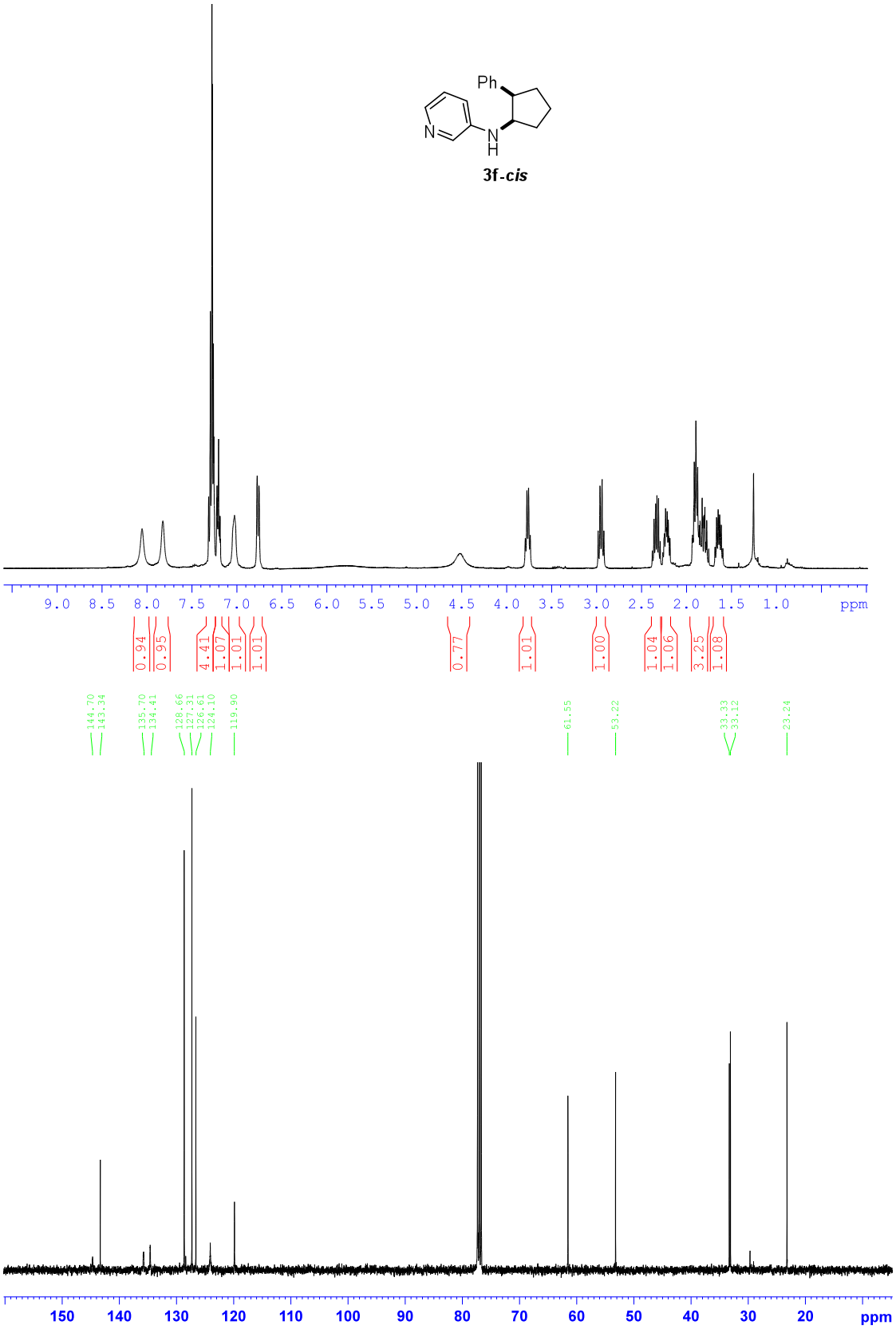

Ph
F3C
N
H
3c-trans
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
ppm
3.46
0.74
1.92
2.01
1.05
0.85
1.00
3.12
1.09
2.15
150.22
140.38
128.60
128.46
126.70
126.49
126.45
126.42
126.38
123.78
118.44
118.12
112.22
77.40
77.08
76.76
57.15
47.92
31.82
28.88
22.07
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

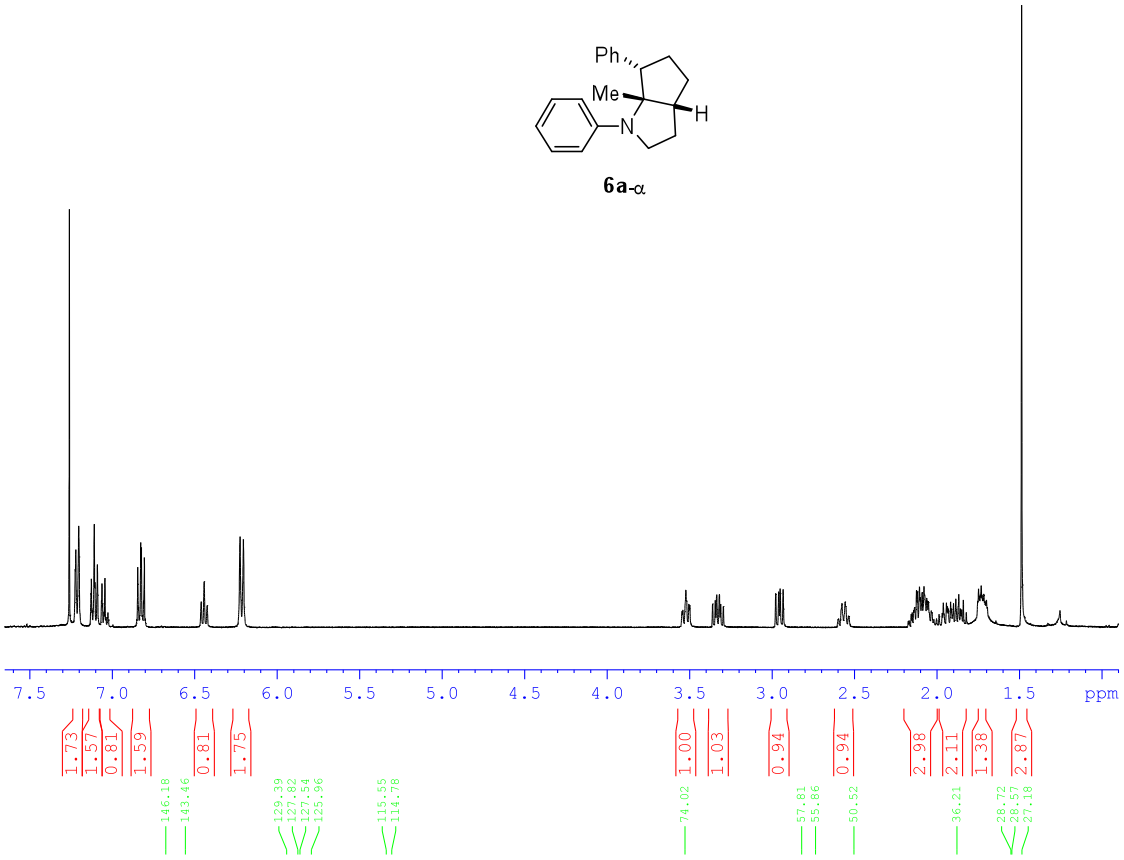

Ph
F3C
N
H
3c-cis
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
3.38
2.95
1.96
0.87
1.03
1.00
1.05
1.05
1.92
1.17
1.02
150.40
143.28
128.68
127.27
126.63
126.52
126.48
126.44
126.41
126.37
123.68
118.90
118.58
118.25
117.93
112.30
61.15
53.23
33.43
33.25
23.23
160
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm

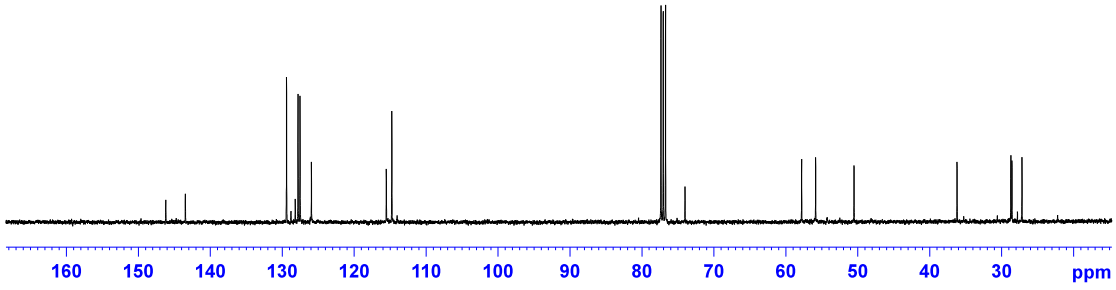

Ph
N
H
3d
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 ppm
3.65 6.62 9.01 3.11 2.47 3.27 1.74
1.42 1.33 2.65 1.00 1.67 1.86 4.06 1.17 2.04 6.43 2.61
145.06 144.49 143.52 140.56 139.52 139.29 130.19 130.15 129.41 129.07 128.89 128.69 128.66 128.55 128.51 128.41 128.40 127.69 127.63 127.46 127.13 126.73 126.52 126.35 116.68 116.24 111.34 110.41
62.48 57.64 53.15 48.44
33.52 32.60 32.21 28.75
23.23 22.37
150 140 130 120 110 100 90 80 70 60 50 40 30 ppm


Ph
N
H
3e
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
3.82
21.77
2.53
1.36
1.98
1.61
1.00
1.49
1.61
4.86
8.07
1.69
143.79
142.98
140.59
134.46
128.78
128.72
128.66
127.47
126.91
126.68
126.64
125.81
125.67
124.82
124.61
123.91
123.75
120.11
119.91
117.60
117.05
105.02
77.55
77.23
76.91
61.87
57.44
53.30
48.81
33.67
33.40
32.11
29.03
23.74
22.85
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm

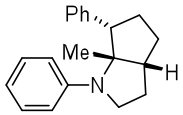

Ph
N
H
3f-*trans*
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
ppm
0.91
1.03
1.70
2.59
0.87
0.94
1.00
0.42
1.40
2.94
1.07
2.07
143.77
140.34
137.95
136.00
128.59
128.40
126.66
123.57
119.07
77.39
77.07
76.76
57.19
48.09
31.91
28.99
22.12
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm


Ph
N
N
H
3f-cis
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 ppm
0.94 0.95 4.41 1.07 1.01 1.01 0.77 1.01 1.00 1.04 1.06 3.25 1.08
144.70 143.34 135.70 134.41 128.66 127.31 126.61 124.10 119.90 61.55 53.22 33.33 33.12 23.24
150 140 130 120 110 100 90 80 70 60 50 40 30 20 ppm

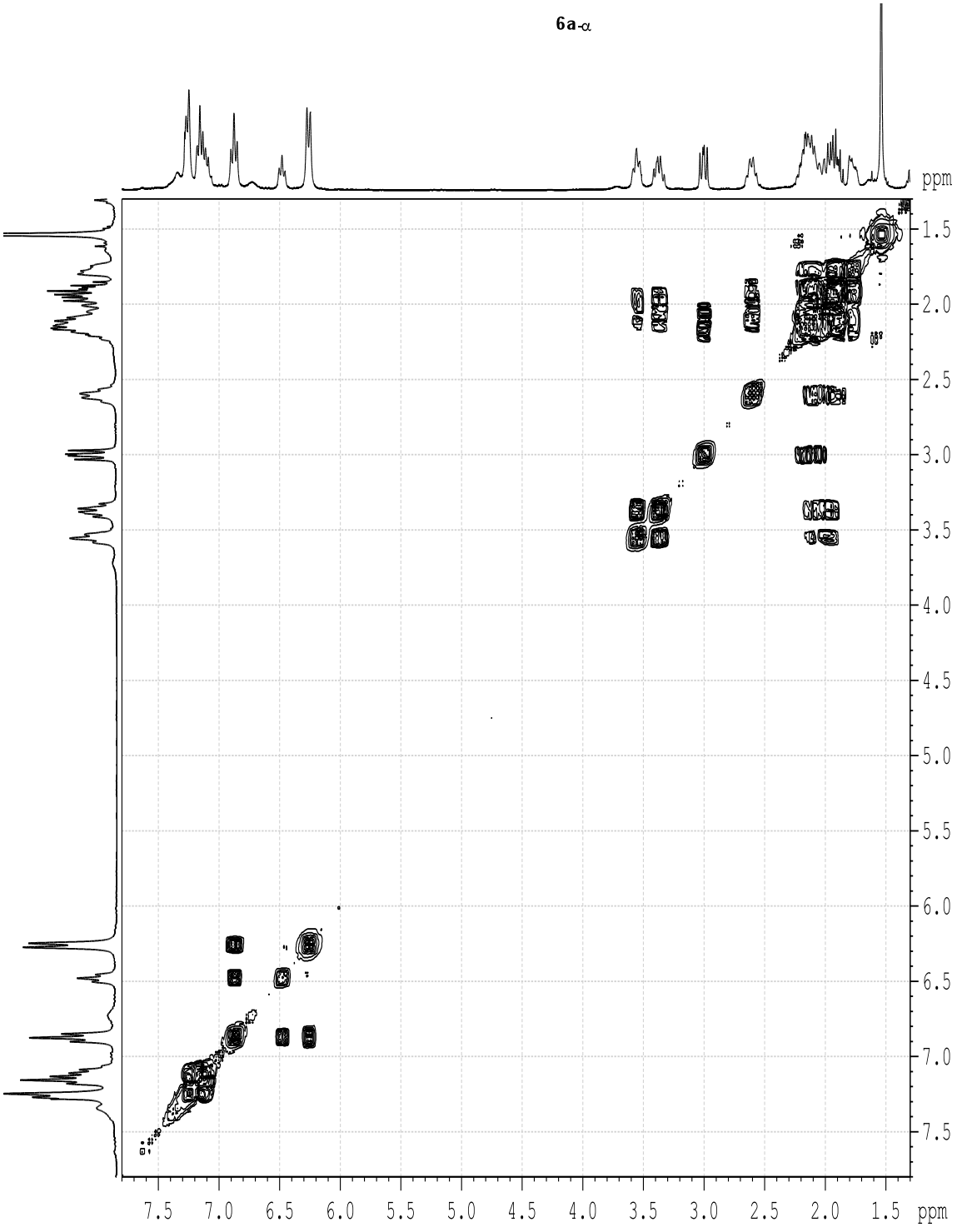

Ph
Me
N
H
6a-α
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
1.73
1.57
0.81
1.59
0.81
1.75
1.00
1.03
0.94
0.94
2.98
2.11
1.38
2.87
146.18
143.46
129.39
127.82
127.54
125.96
115.55
114.78
74.02
57.81
55.86
50.52
36.21
28.72
28.57
27.18


160
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm

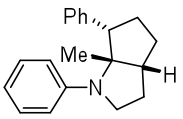
^{1}H-^{1}H COSY of 6a-α



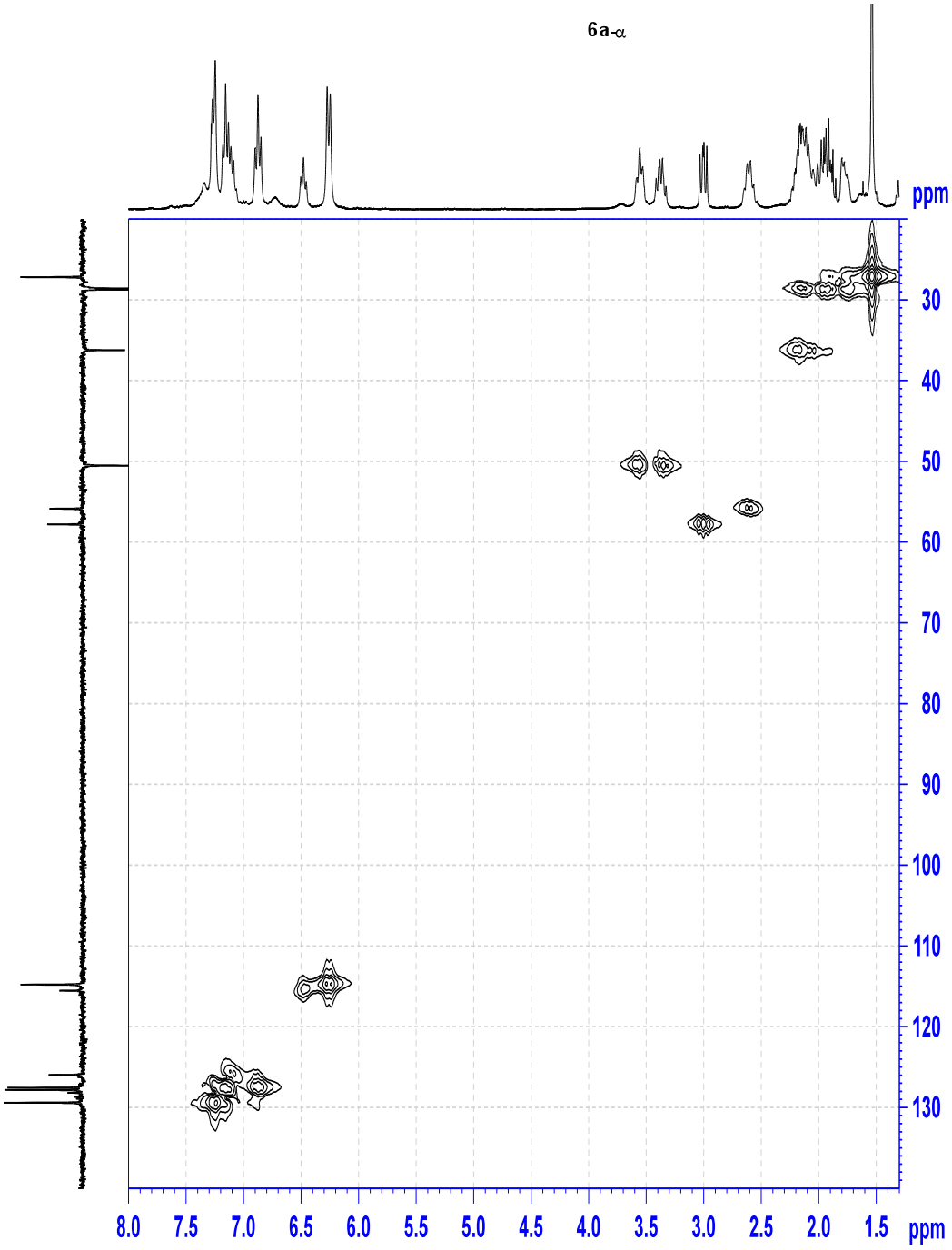
6a-α



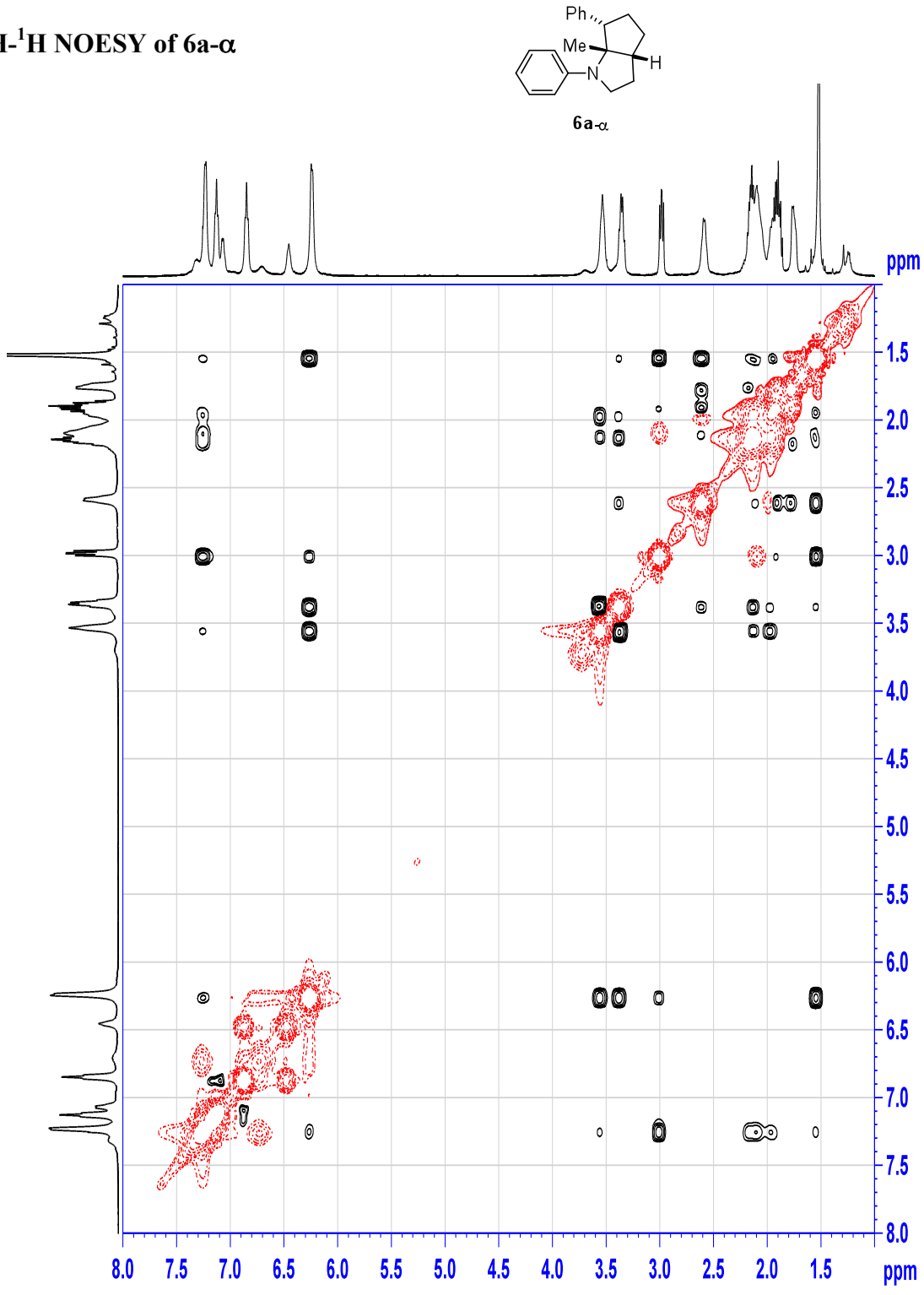
^{1}H-^{13}C HMQC of 6a-α

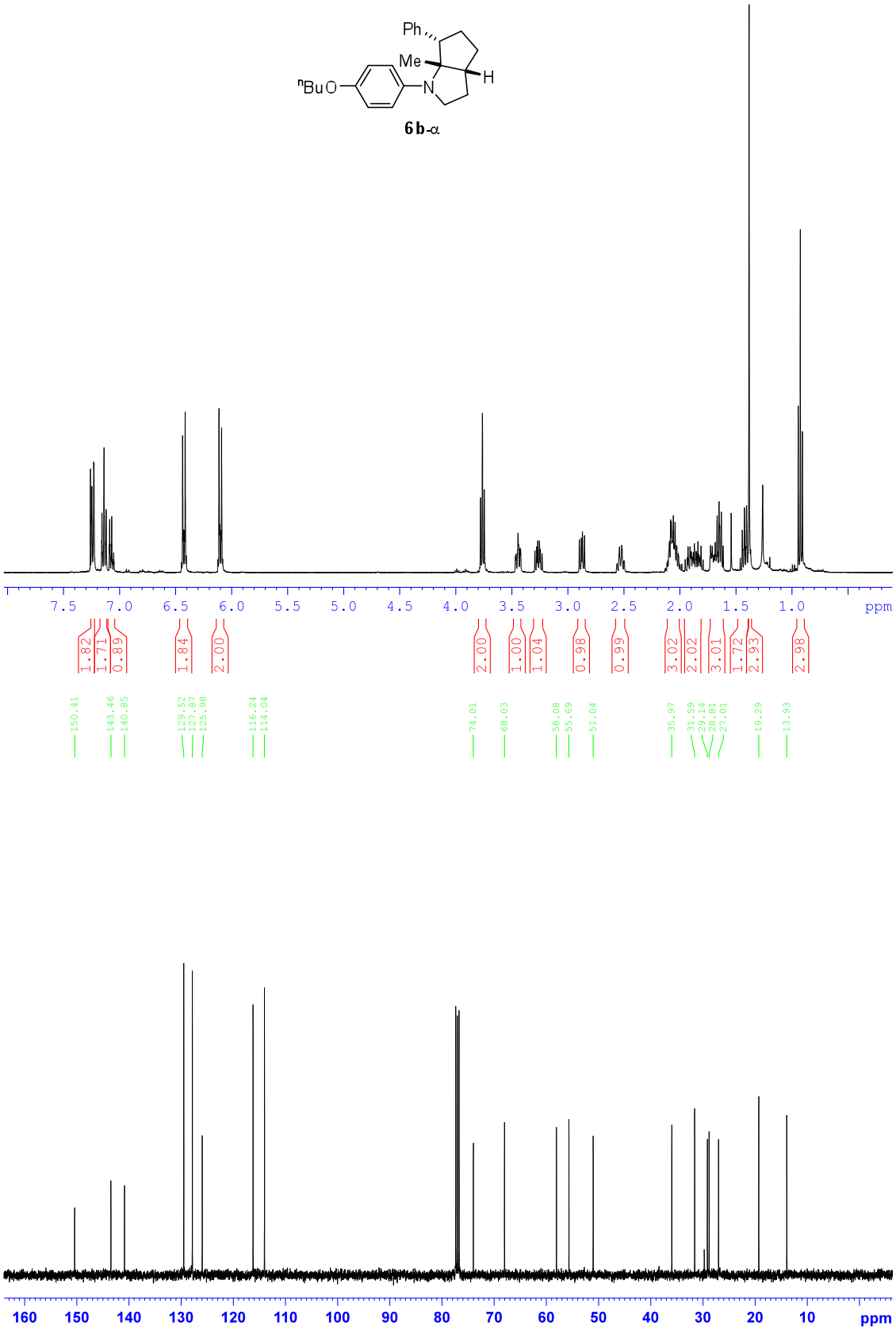


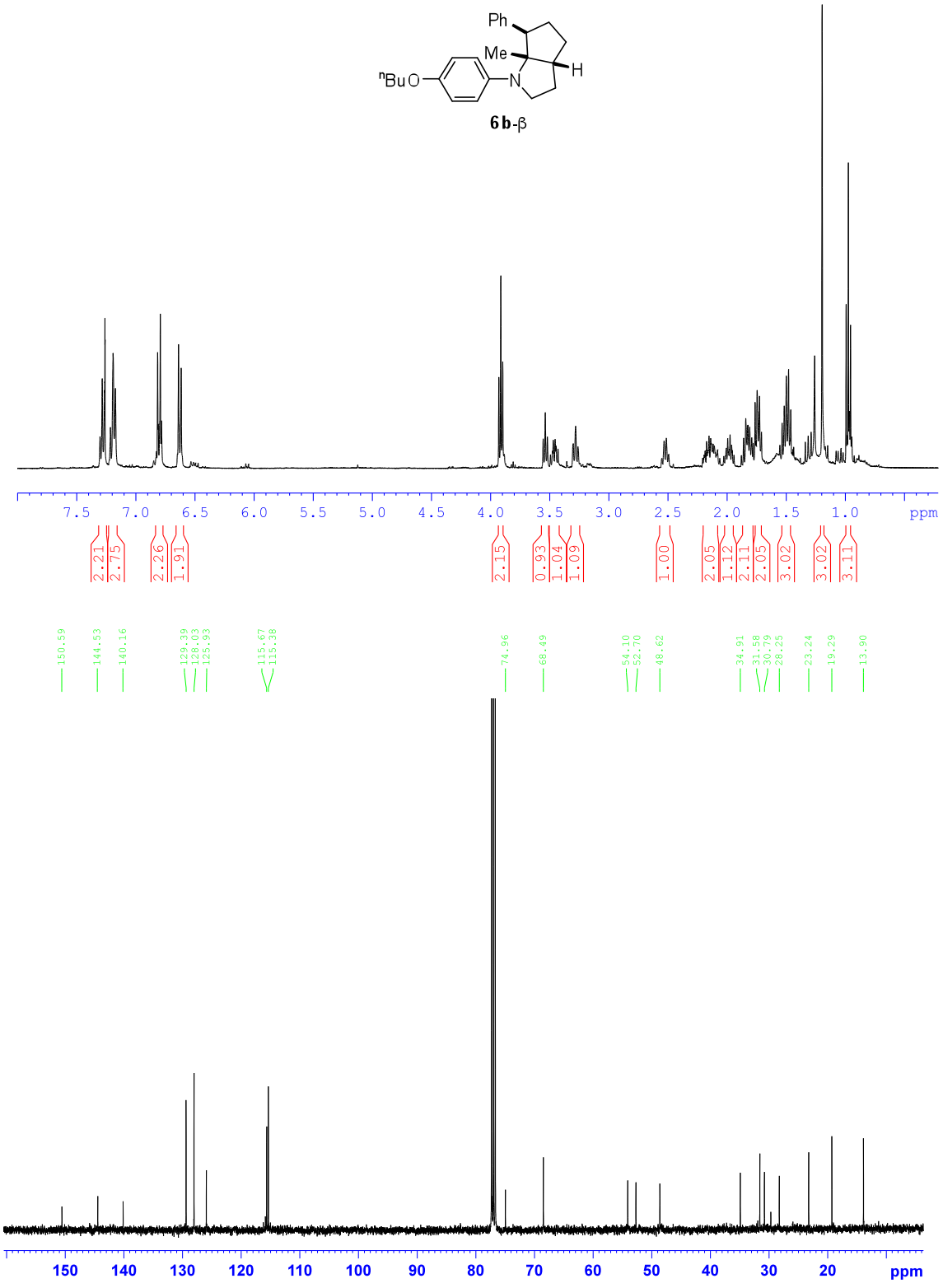
6a-α

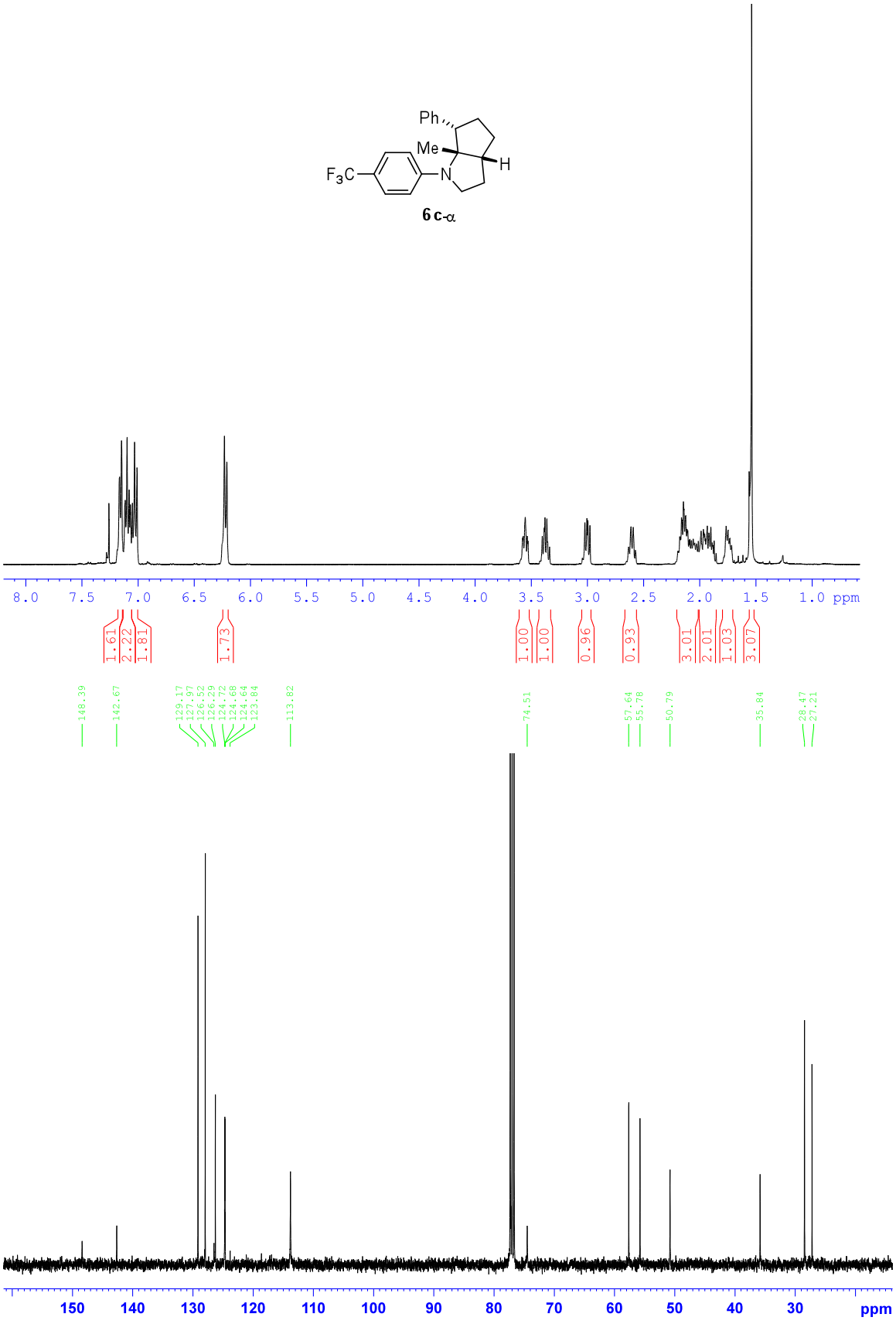


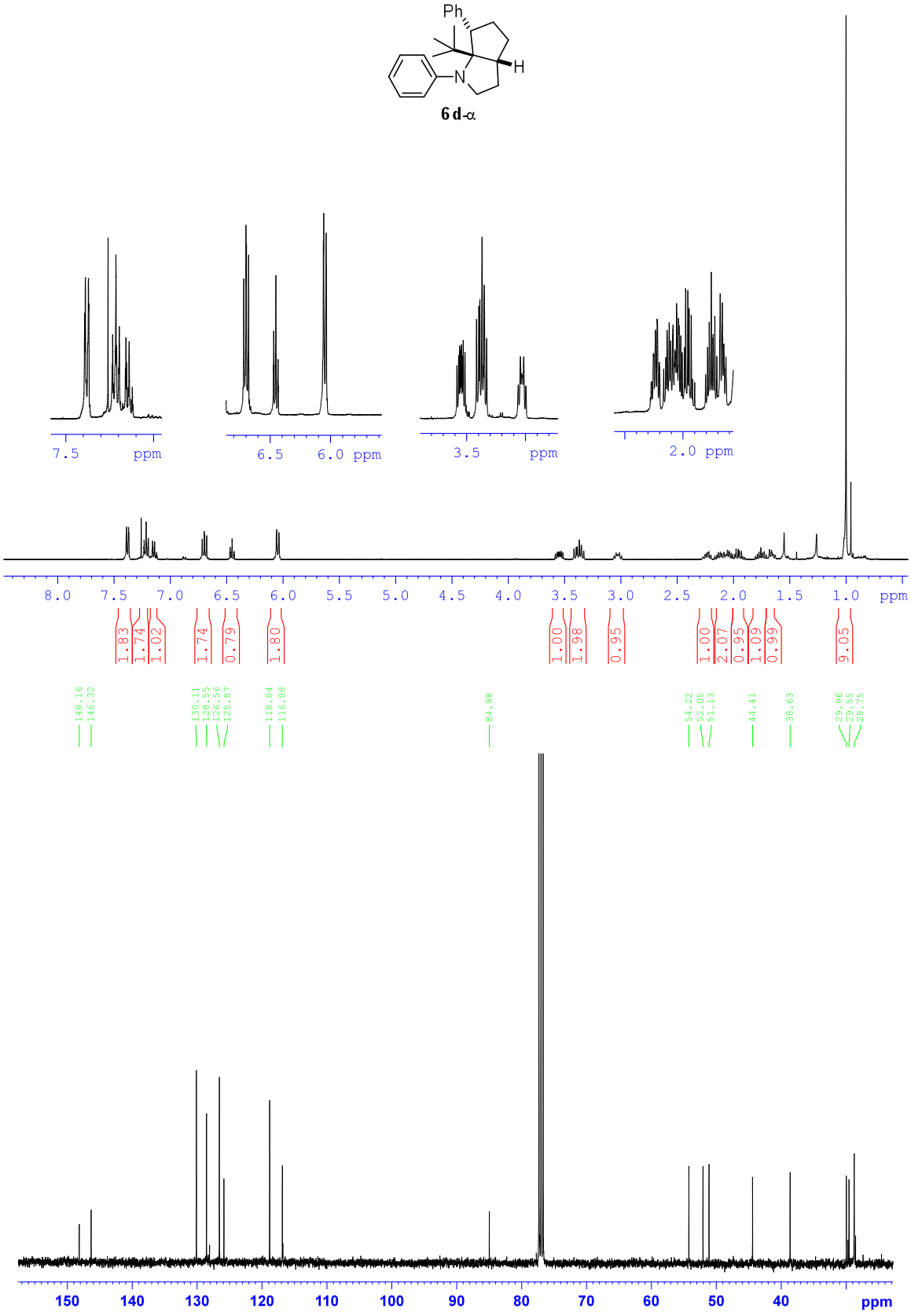
^{1}H-^{1}H NOESY of 6a-α

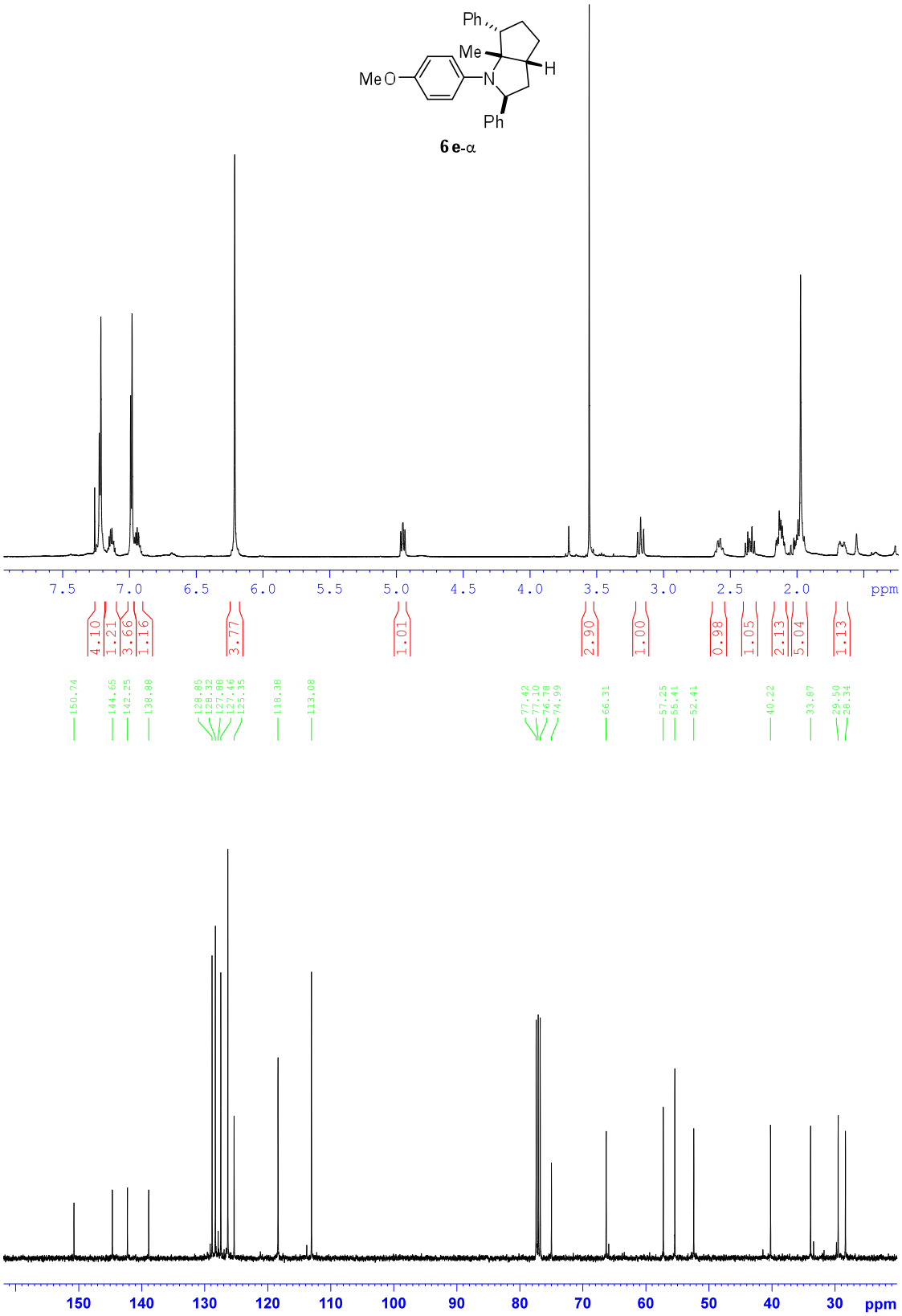



Ph
Me
nBuO
N
H
6b-α
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
1.82
1.71
0.89
1.84
2.00
2.00
1.00
1.04
0.98
0.99
3.02
2.02
3.01
1.72
2.93
2.98
150.41
143.46
140.85
129.52
127.87
125.98
116.24
114.04
74.01
68.03
58.08
55.69
51.04
35.97
31.59
29.14
28.81
27.01
19.29
13.93
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

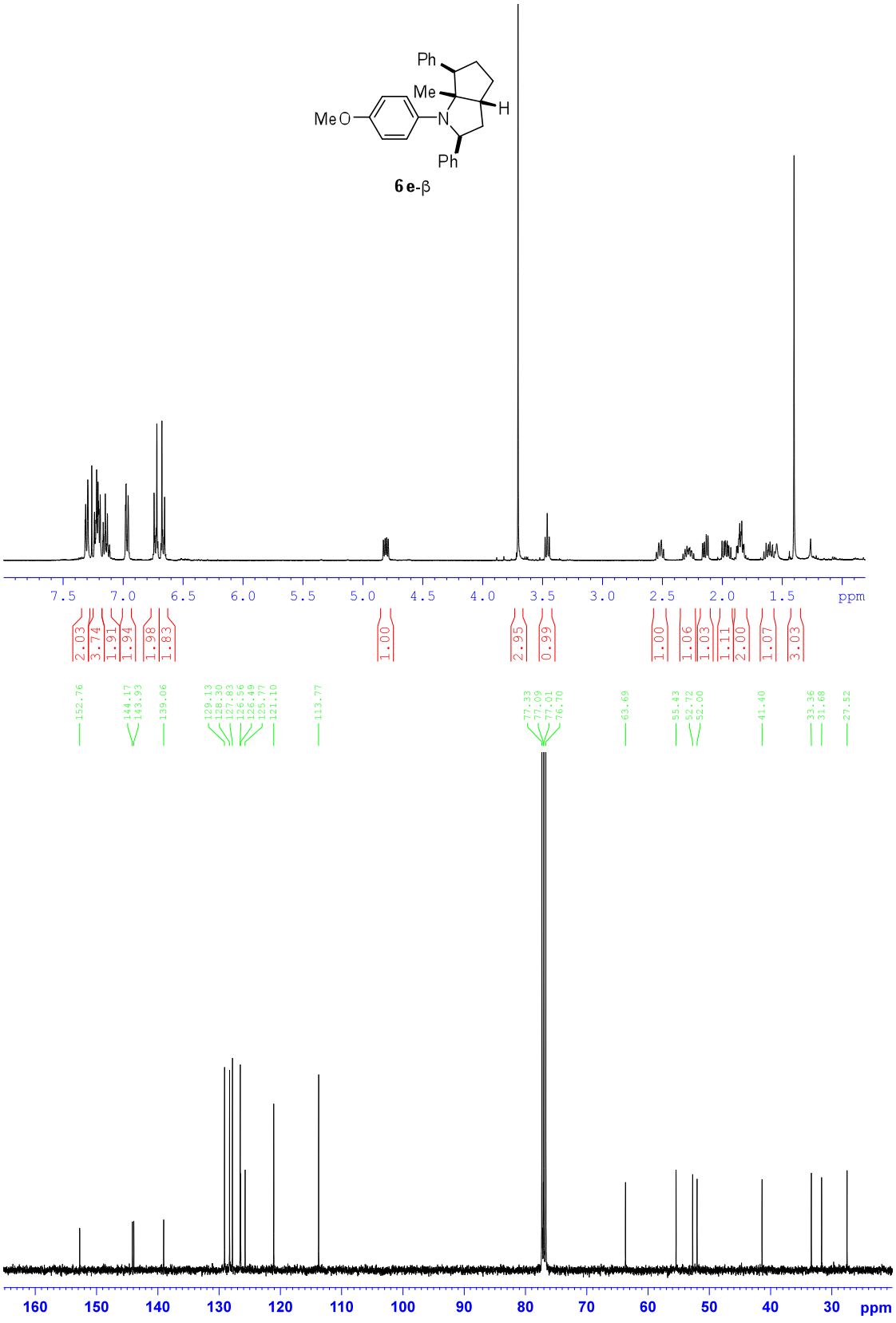

Ph
Me
H
nBuO
N
6b-β
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
2.21
2.75
2.26
1.91
2.15
0.93
1.04
1.09
1.00
2.05
1.12
2.11
2.05
3.02
3.02
3.11
150.59
144.53
140.16
129.39
128.03
125.93
115.67
115.38
74.96
68.49
54.10
52.70
48.62
34.91
31.58
30.79
28.25
23.24
19.29
13.90
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

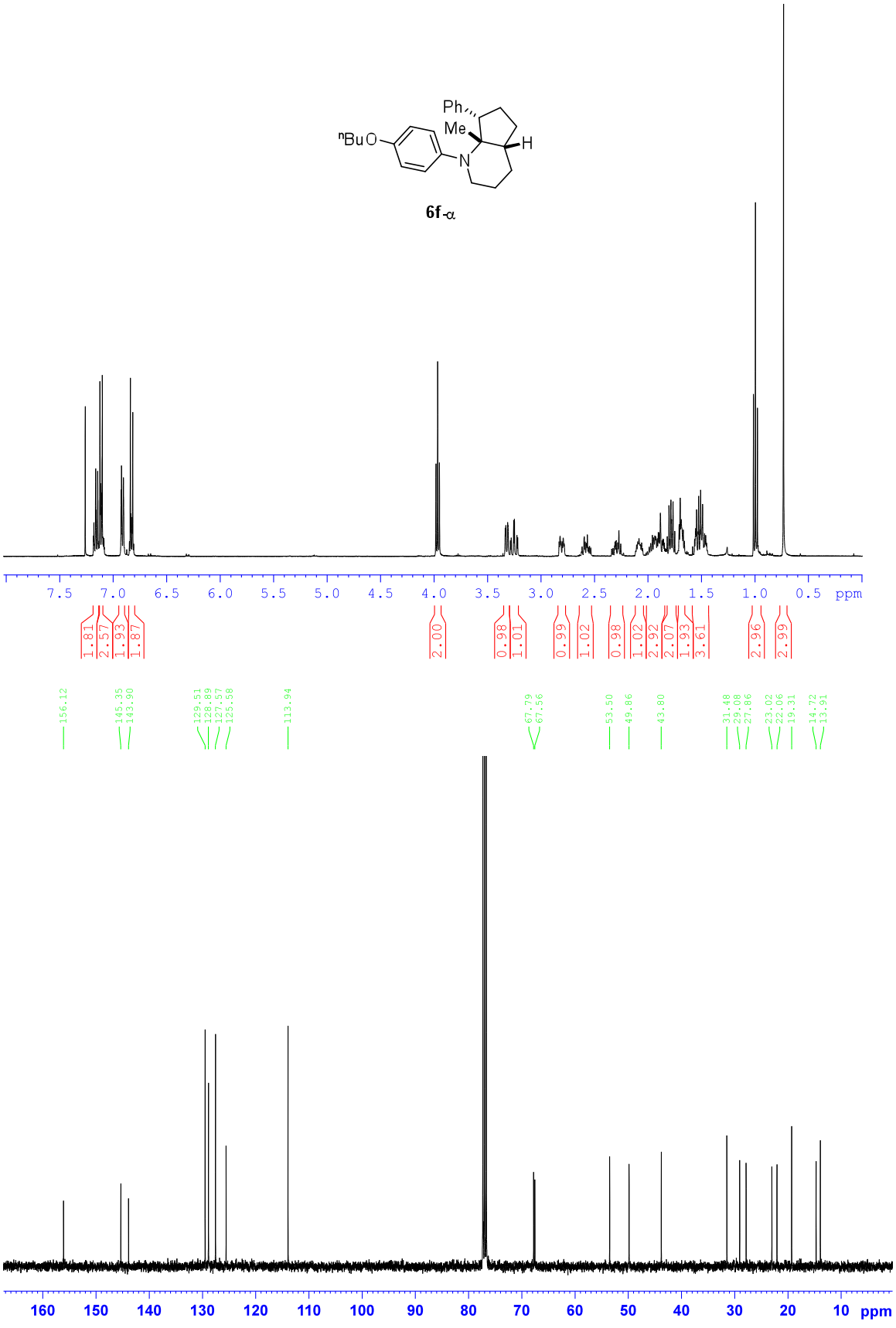

Ph
Me
F3C
N
H
6 c-α
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 ppm
1.61 2.22 1.81 1.73 1.00 1.00 0.96 0.93 3.01 2.01 1.03 3.07
148.39 142.67 129.17 127.97 126.52 126.29 124.72 124.68 124.64 123.84 113.82 74.51 57.64 55.78 50.79 35.84 28.47 27.21
150 140 130 120 110 100 90 80 70 60 50 40 30 ppm


Ph
H
N
6d-α
7.5
ppm
6.5
6.0 ppm
3.5
ppm
2.0 ppm
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
1.83
1.74
1.02
1.74
0.79
1.80
1.00
1.98
0.95
1.00
2.07
0.95
1.09
0.99
9.05
148.16
146.32
130.11
128.55
126.56
125.87
118.84
116.88
84.98
54.22
52.05
51.13
44.41
38.63
29.96
29.55
28.75
150
140
130
120
110
100
90
80
70
60
50
40
ppm

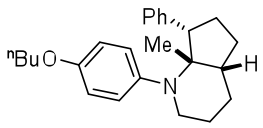

Ph
Me
MeO
N
H
Ph
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
ppm
4.10
1.21
3.66
1.16
3.77
1.01
2.90
1.00
0.98
1.05
2.13
5.04
1.13
150.74
144.65
142.25
138.88
128.85
128.32
127.88
127.46
125.35
118.38
113.08
77.42
77.10
76.78
74.99
66.31
57.25
55.41
52.41
40.22
33.87
29.50
28.34
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm

6e-α

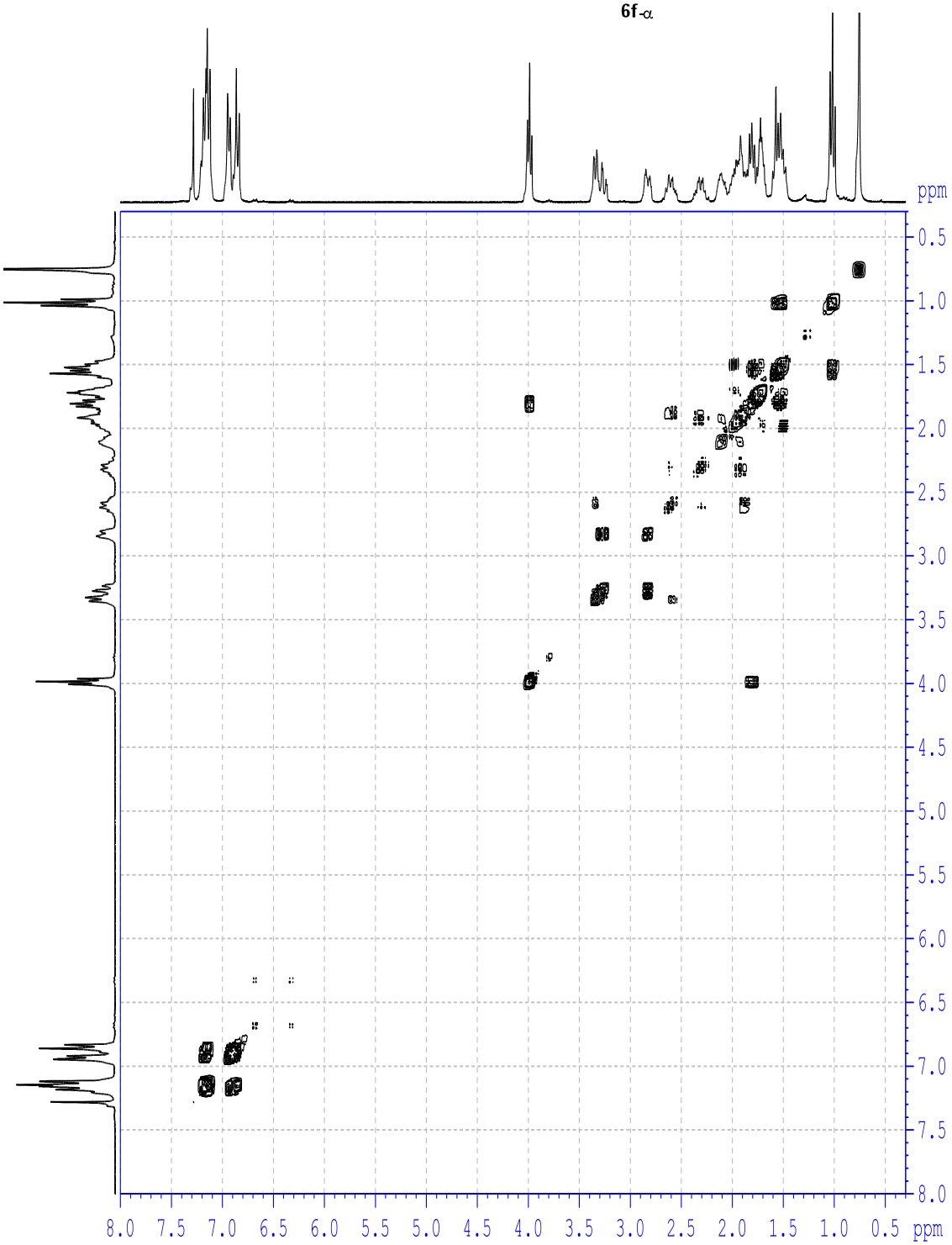

Ph
Me
MeO
N
H
Ph
6e-β
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
2.03
3.74
1.91
1.94
1.98
1.83
1.00
2.95
0.99
1.00
1.06
1.03
1.11
2.00
1.07
3.03
152.76
144.17
143.93
139.06
129.13
128.30
127.83
126.56
126.49
125.77
121.10
113.77
77.33
77.09
77.01
76.70
63.69
55.43
52.72
52.00
41.40
33.36
31.68
27.52
160
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm


Ph
Me
nBuO
N
H
6f-α
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.81 2.57 1.93 1.87 2.00 0.98 1.01 0.99 1.02 0.98 1.02 2.92 2.07 1.93 3.61 2.96 2.99
156.12 145.35 143.90 129.51 128.89 127.57 125.58 113.94 67.79 67.56 53.50 49.86 43.80 31.48 29.08 27.86 23.02 22.06 19.31 14.72 13.91
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

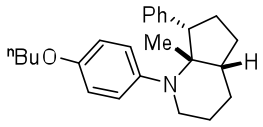
^{1}H-^{1}H COSY of 6f-α



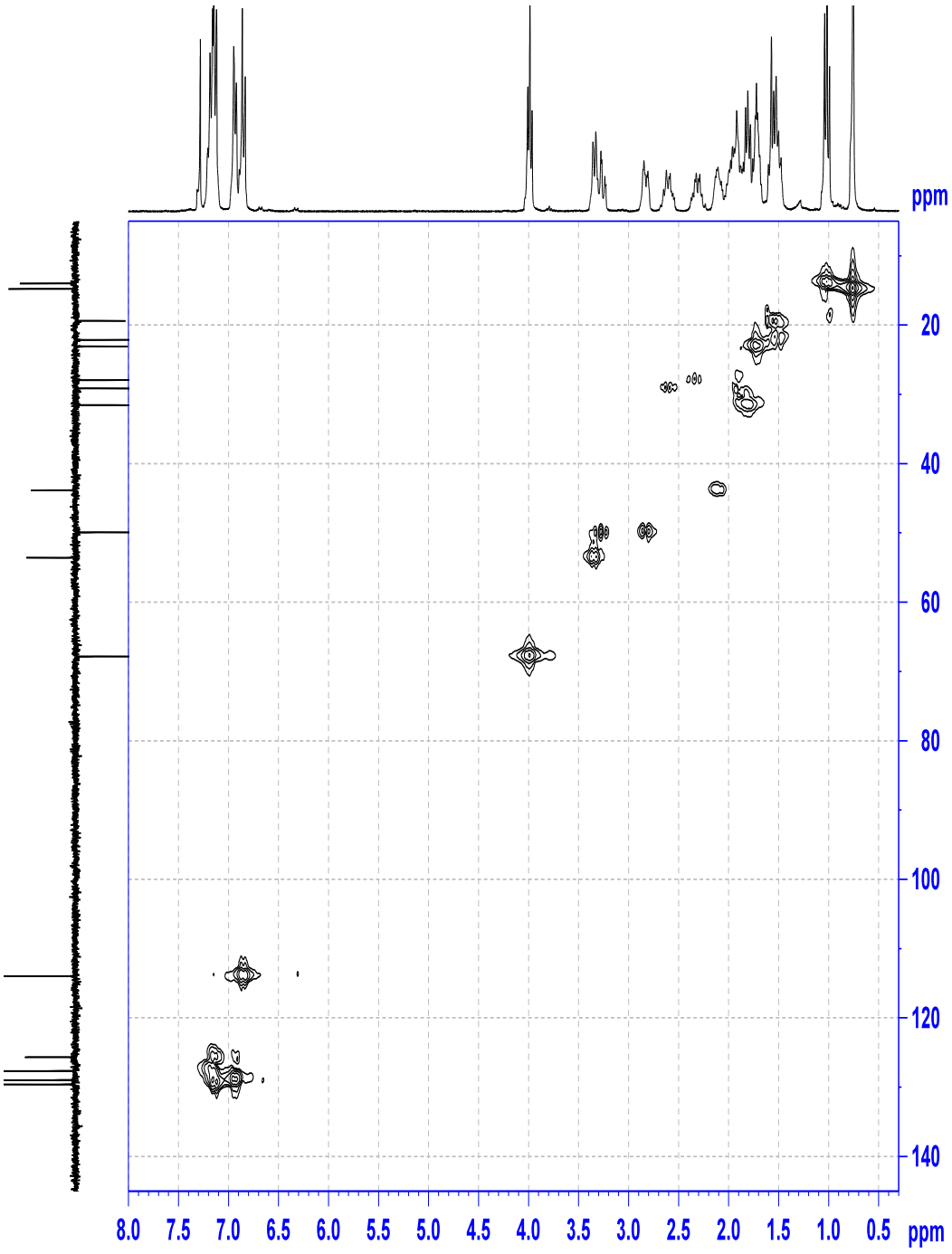
6f-α



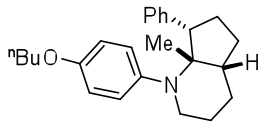
^{1}H-^{13}C HMQC of 6f-α



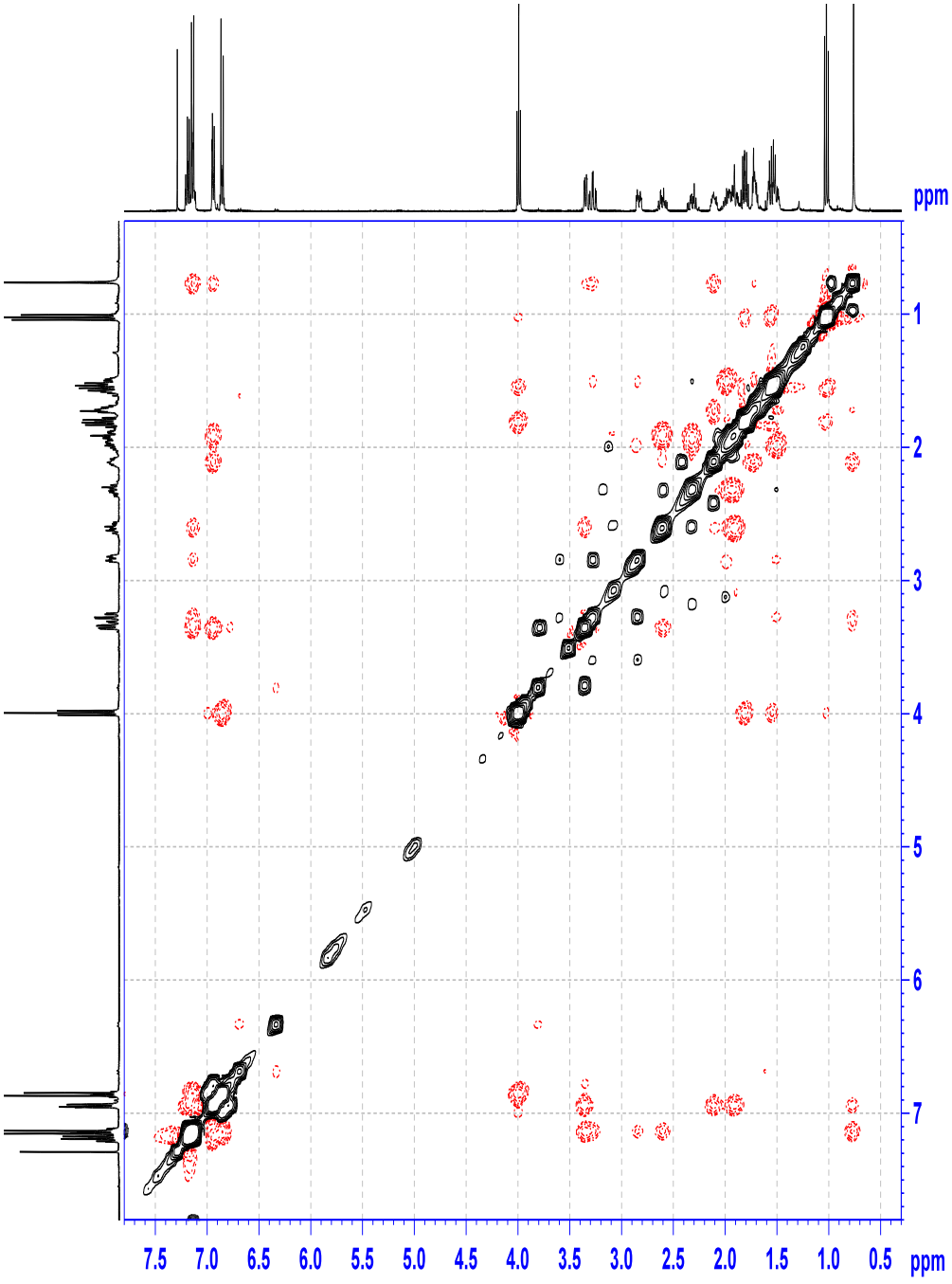
6f-α

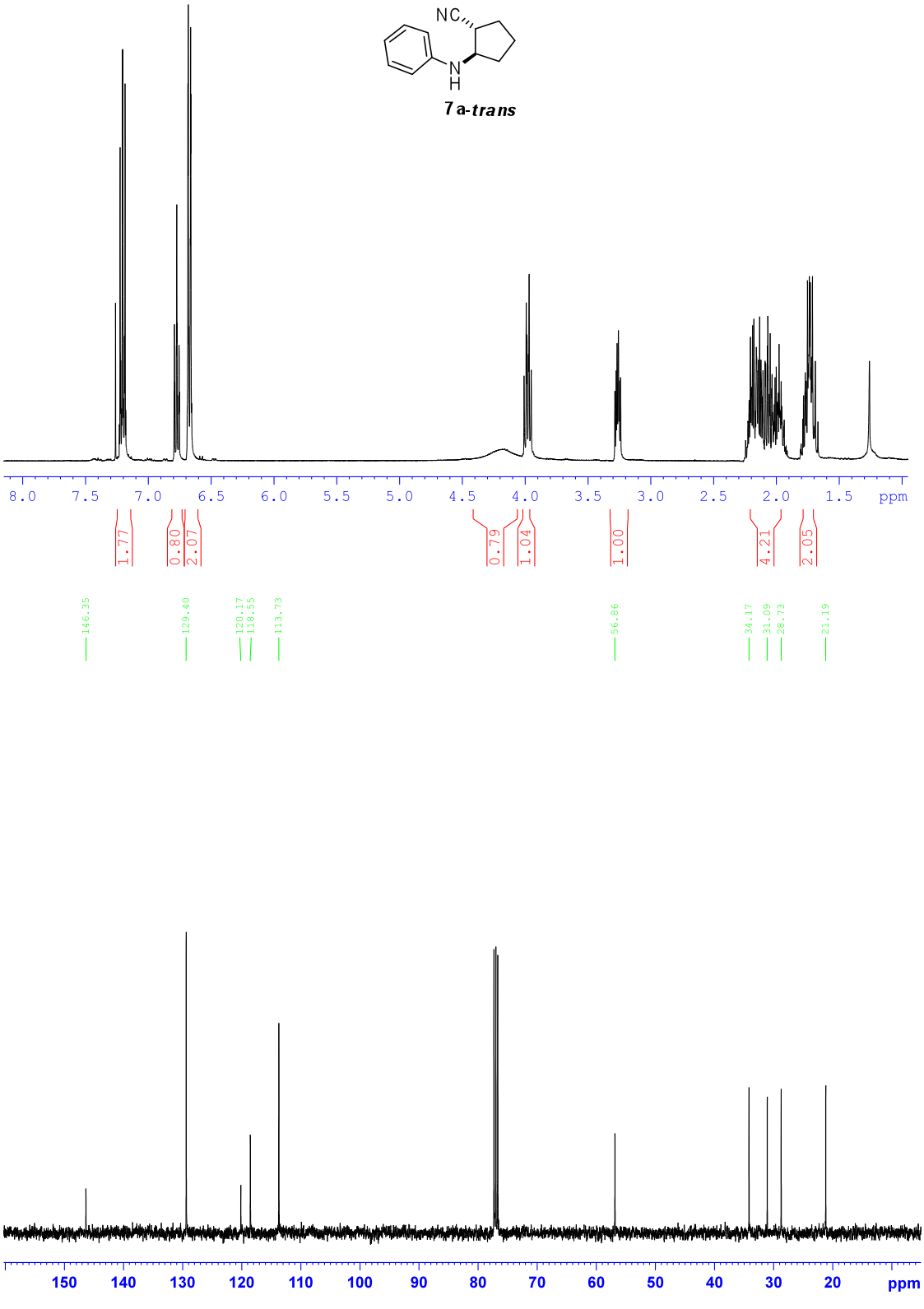


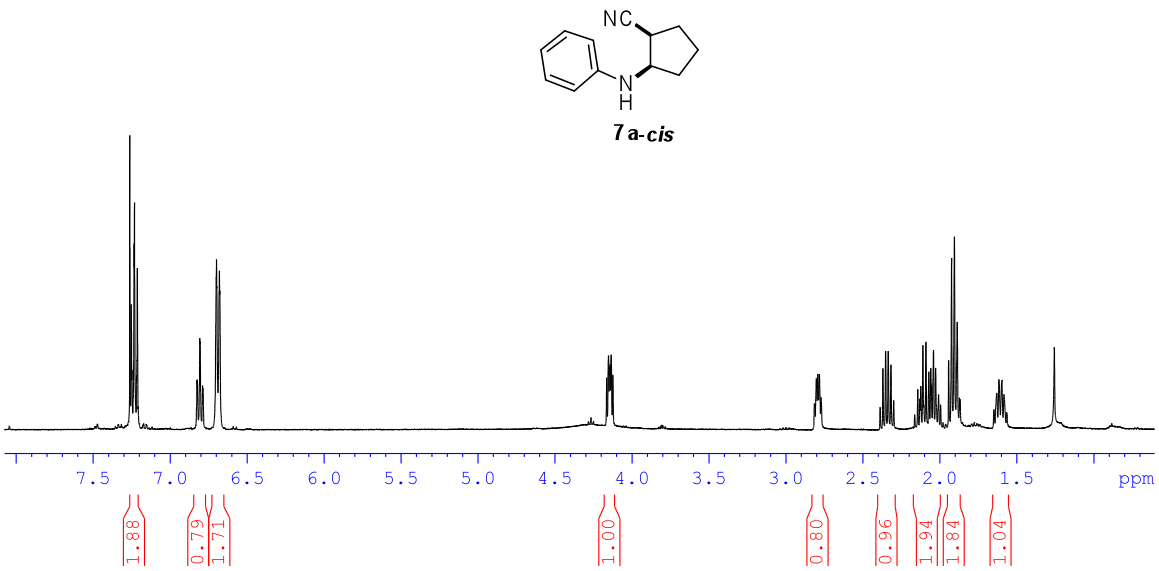
^{1}H-^{1}H NOESY of 6f-α

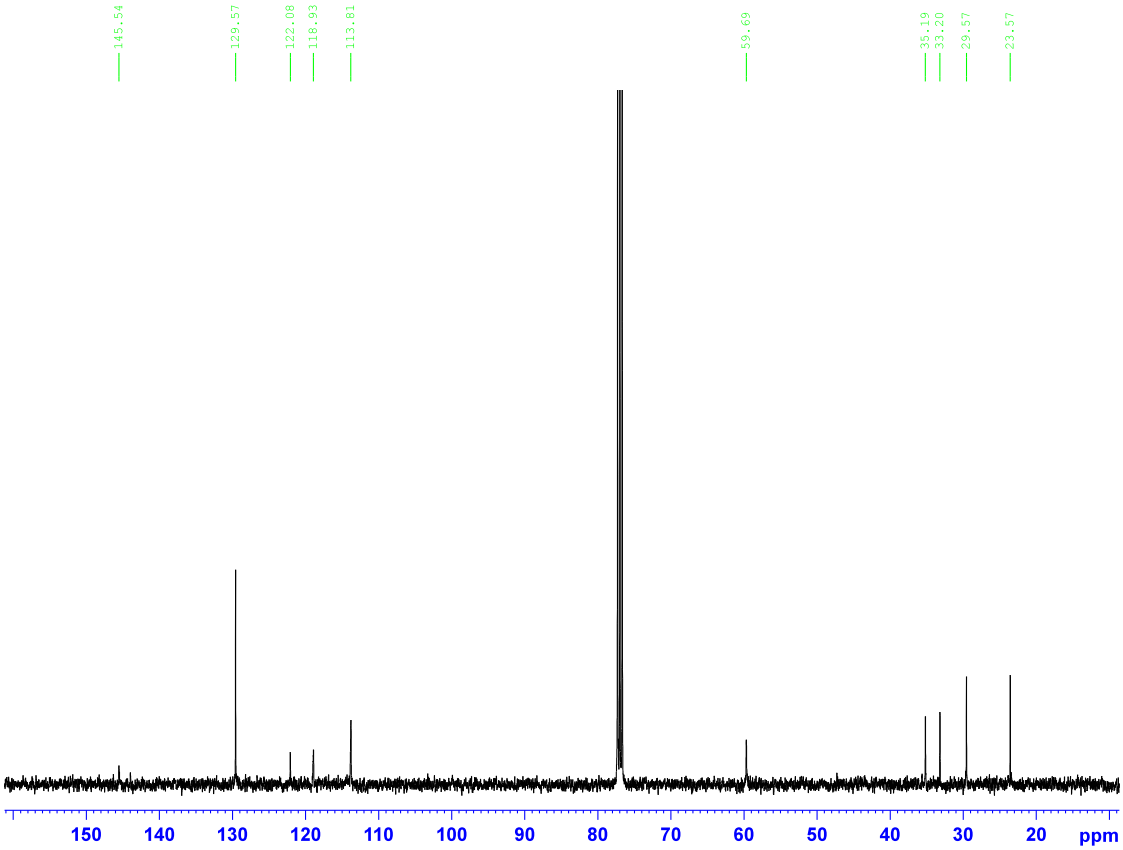


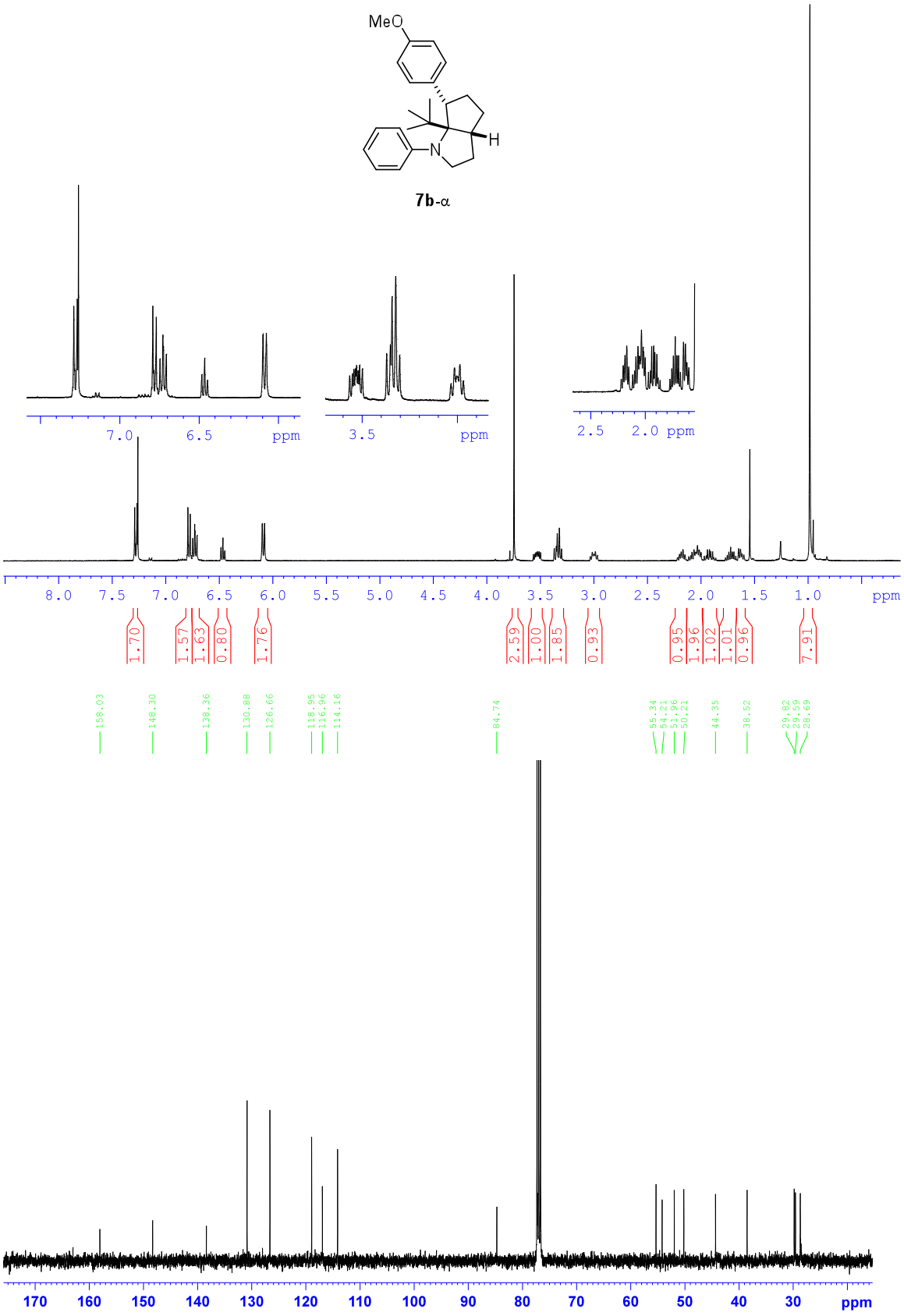
6f-α

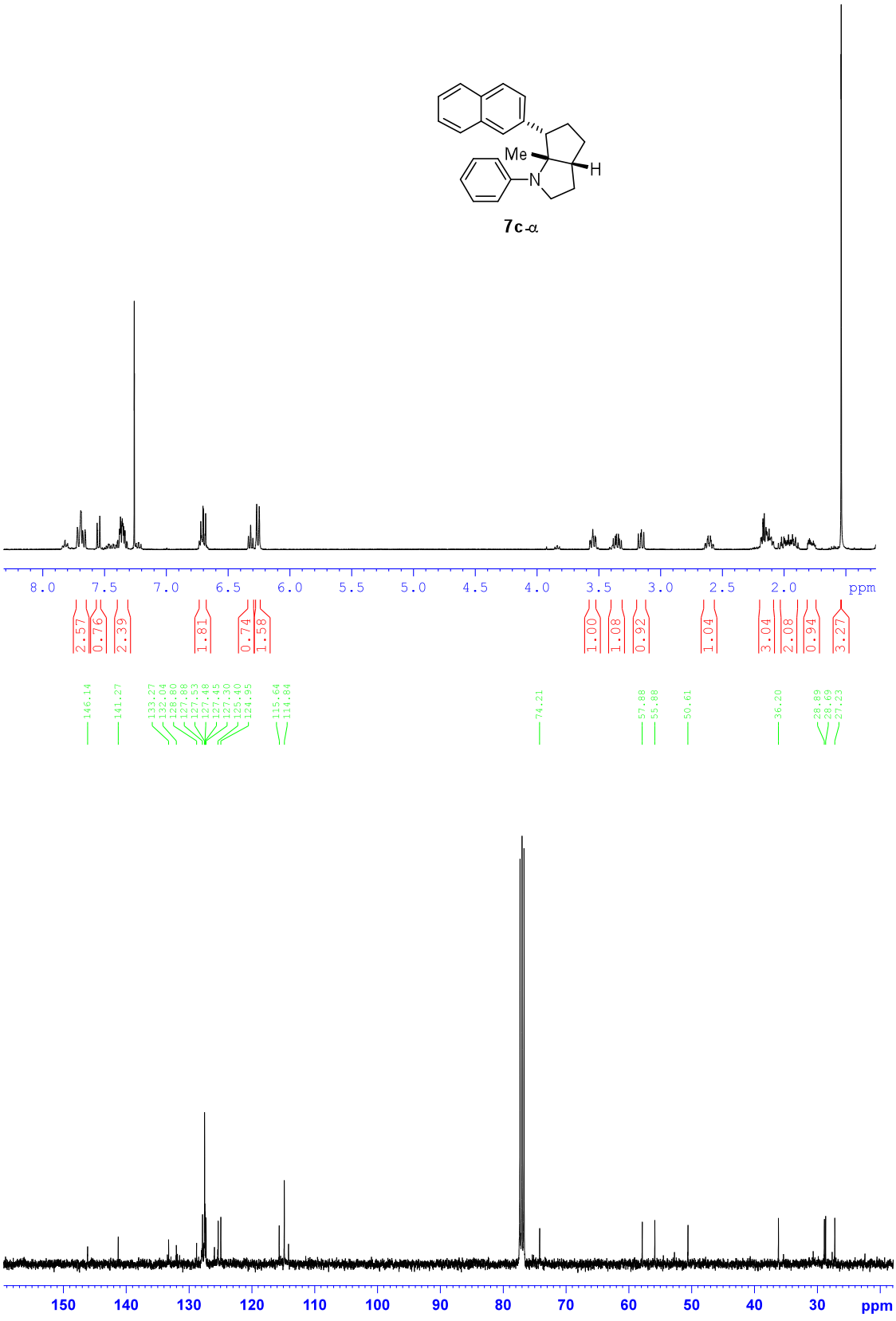


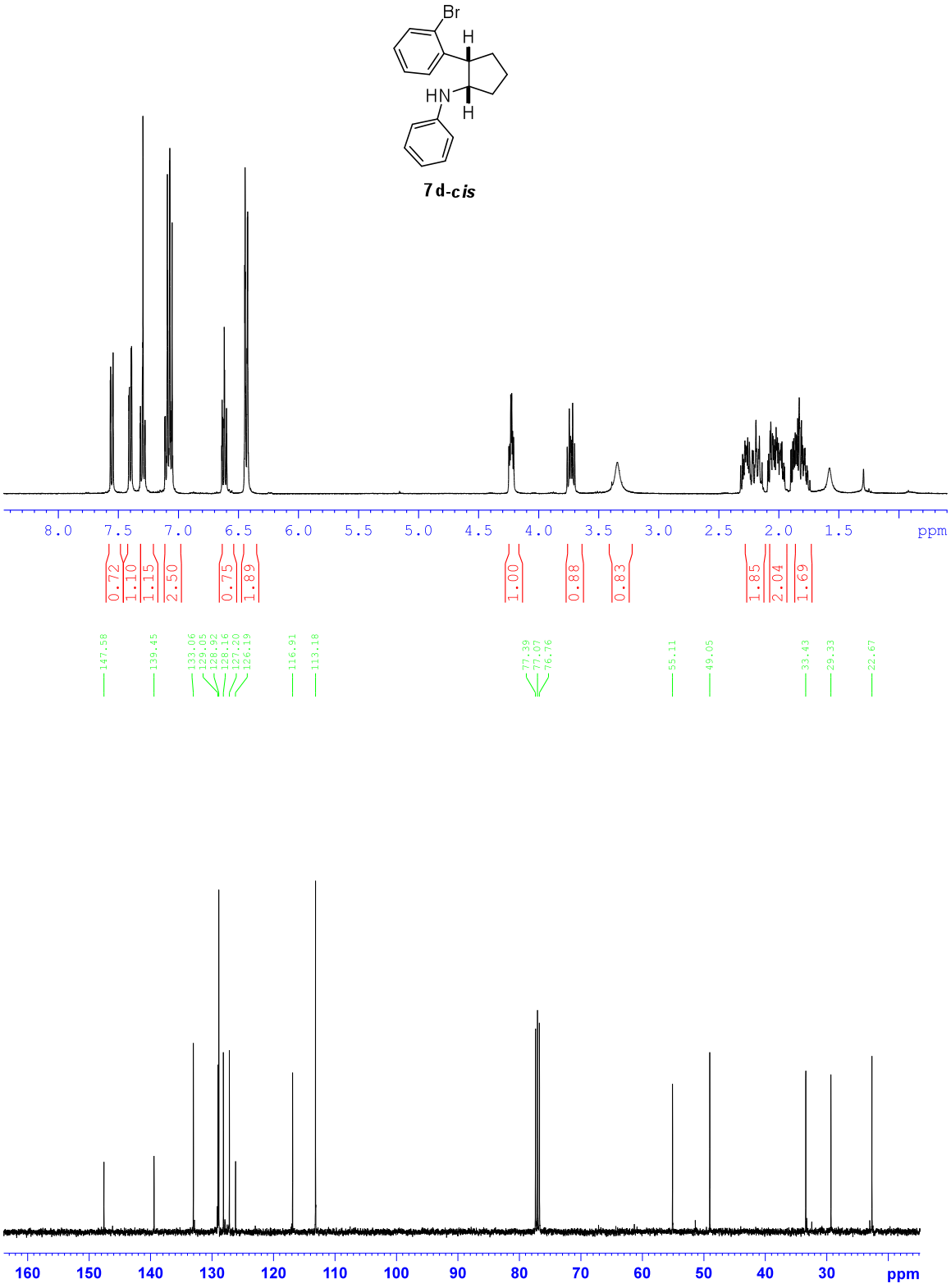

NC
N
H
7a-trans
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
1.77
0.80
2.07
0.79
1.04
1.00
4.21
2.05
146.35
129.40
120.17
118.55
113.73
56.86
34.17
31.09
28.73
21.19
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

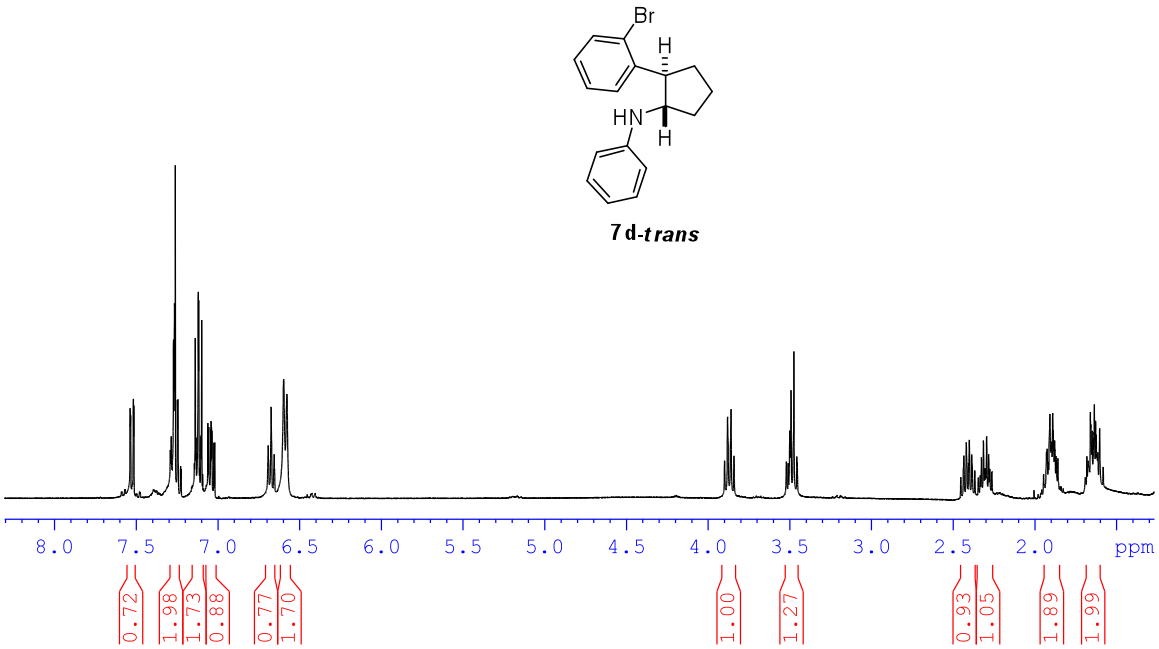

NC
N
H
7a-cis
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
1.88
0.79
1.71
1.00
0.80
0.96
1.94
1.84
1.04


145.54
129.57
122.08
118.93
113.81
59.69
35.19
33.20
29.57
23.57
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

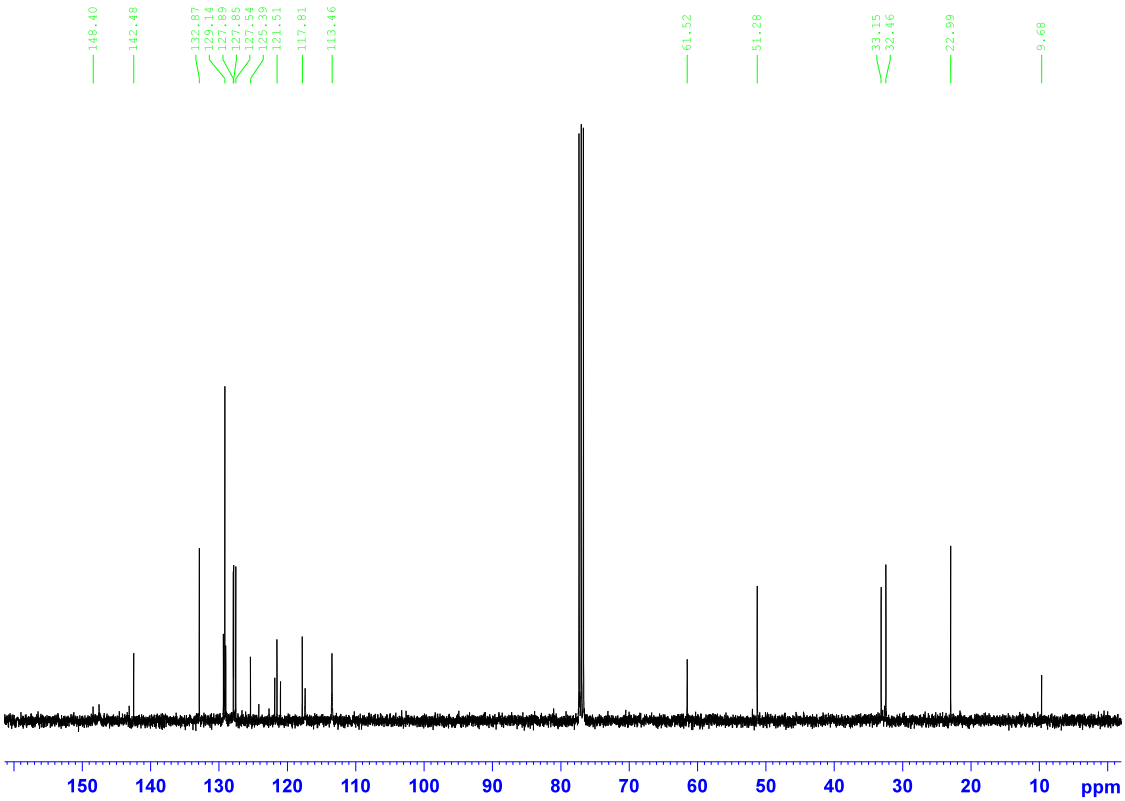

MeO
H
N
7b-α
7.0
6.5
ppm
3.5
ppm
2.5
2.0 ppm
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
1.70
1.57
1.63
0.80
1.76
2.59
1.00
1.85
0.93
0.95
1.96
1.02
1.01
0.96
7.91
158.03
148.30
138.36
130.88
126.66
118.95
116.96
114.16
84.74
55.34
54.21
51.96
50.21
44.35
38.52
29.82
29.59
28.69
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm

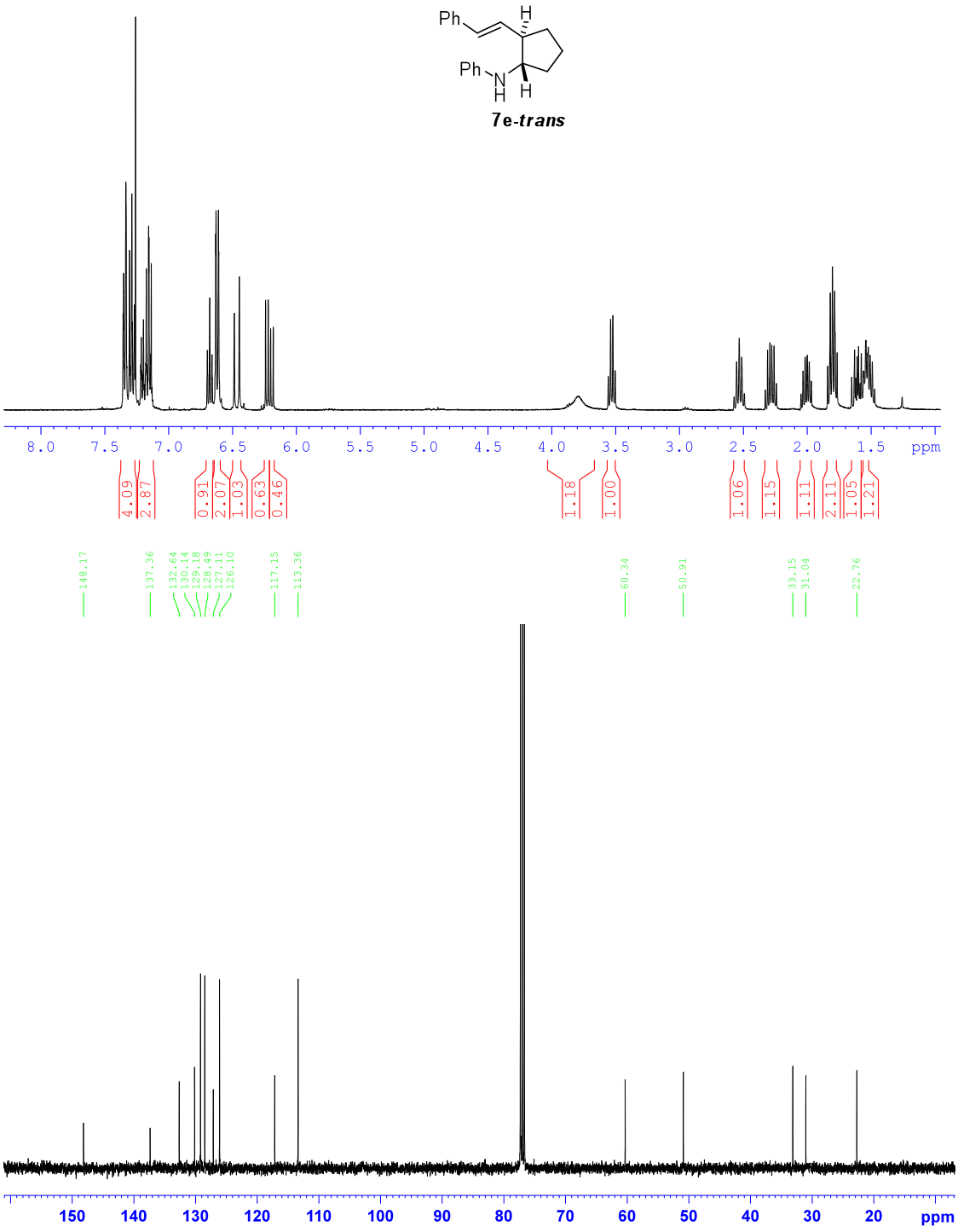

Me
H
N
7c-α
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
ppm
2.57
0.76
2.39
1.81
0.74
1.58
1.00
1.08
0.92
1.04
3.04
2.08
0.94
3.27
146.14
141.27
133.27
132.04
128.80
127.88
127.53
127.48
127.45
127.30
125.40
124.95
115.64
114.84
74.21
57.88
55.88
50.61
36.20
28.89
28.69
27.23
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm

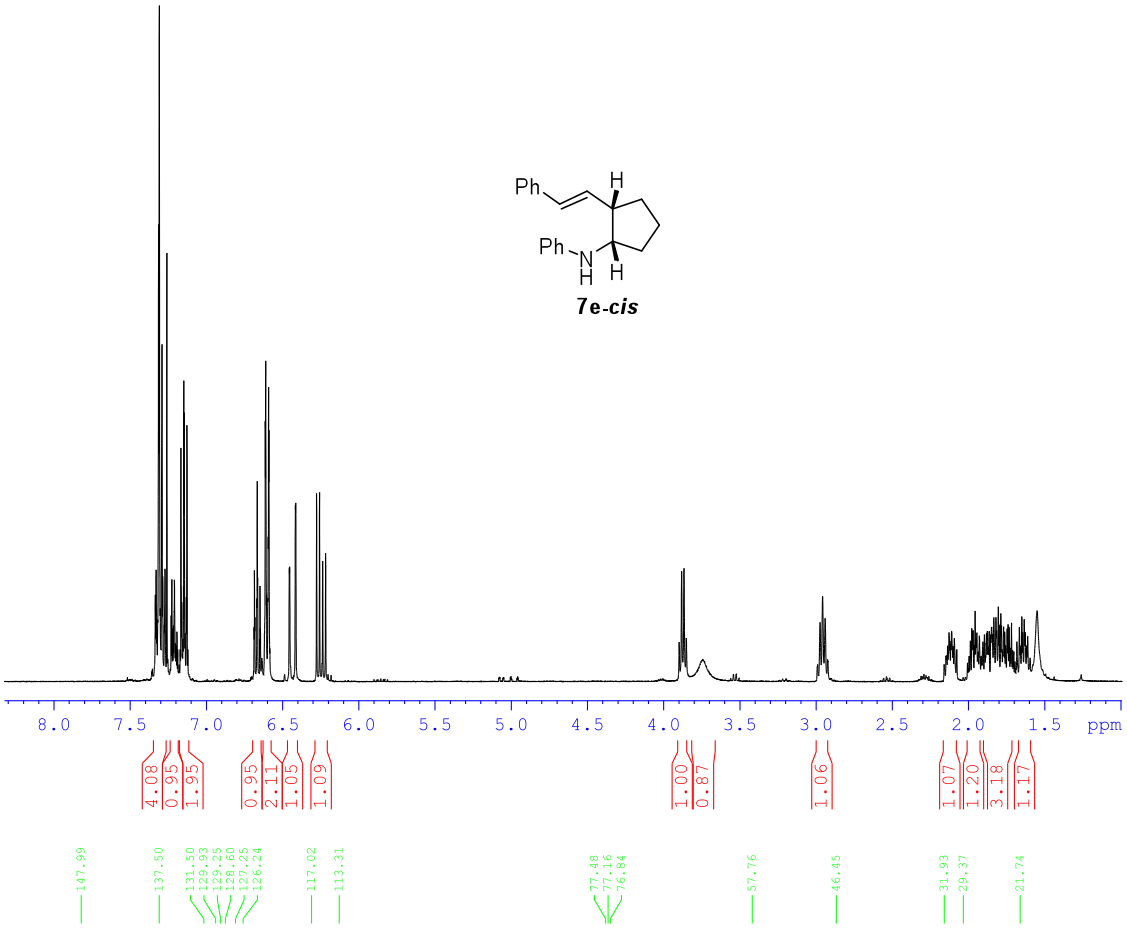

Br
H
HN
H
7d-cis
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
0.72
1.10
1.15
2.50
0.75
1.89
1.00
0.88
0.83
1.85
2.04
1.69
147.58
139.45
133.06
129.05
128.92
128.16
127.20
126.19
116.91
113.18
77.39
77.07
76.76
55.11
49.05
33.43
29.33
22.67
160
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm


Br
H
HN
H
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
ppm
0.72
1.98
1.73
0.88
0.77
1.70
1.00
1.27
0.93
1.05
1.89
1.99

7d-*trans*


148.40
142.48
132.87
129.14
127.89
127.85
127.54
125.39
121.51
117.81
113.46
61.52
51.28
33.15
32.46
22.99
9.68
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


Ph
H
Ph
N
H
H
7e-trans
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
4.09
2.87
0.91
2.07
1.03
0.63
0.46
1.18
1.00
1.06
1.15
1.11
2.11
1.05
1.21
148.17
137.36
132.64
130.14
129.18
128.49
127.11
126.10
117.15
113.36
60.34
50.91
33.15
31.04
22.76
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm


Ph
H
Ph
N
H
H
7e-cis
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
4.08
0.95
1.95
0.95
2.11
1.05
1.09
1.00
0.87
1.06
1.07
1.20
3.18
1.17
147.99
137.50
131.50
129.93
129.25
128.60
127.25
126.24
117.02
113.31
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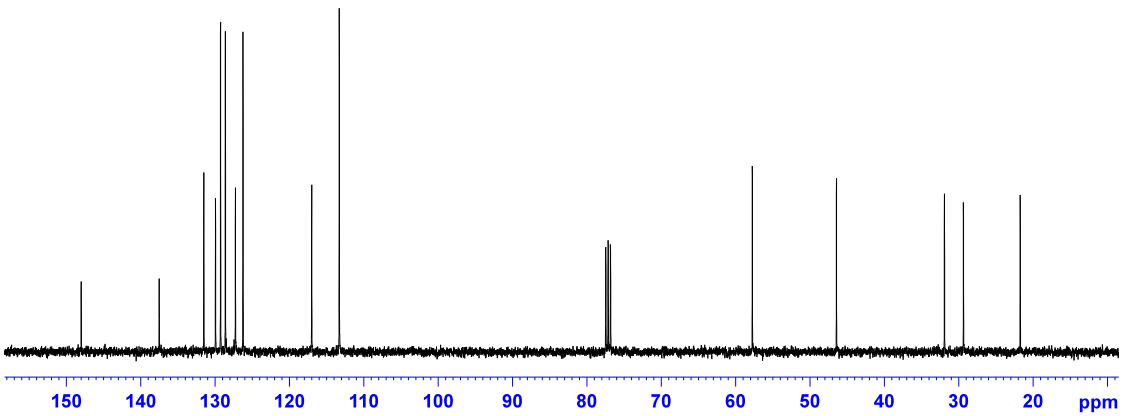
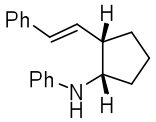
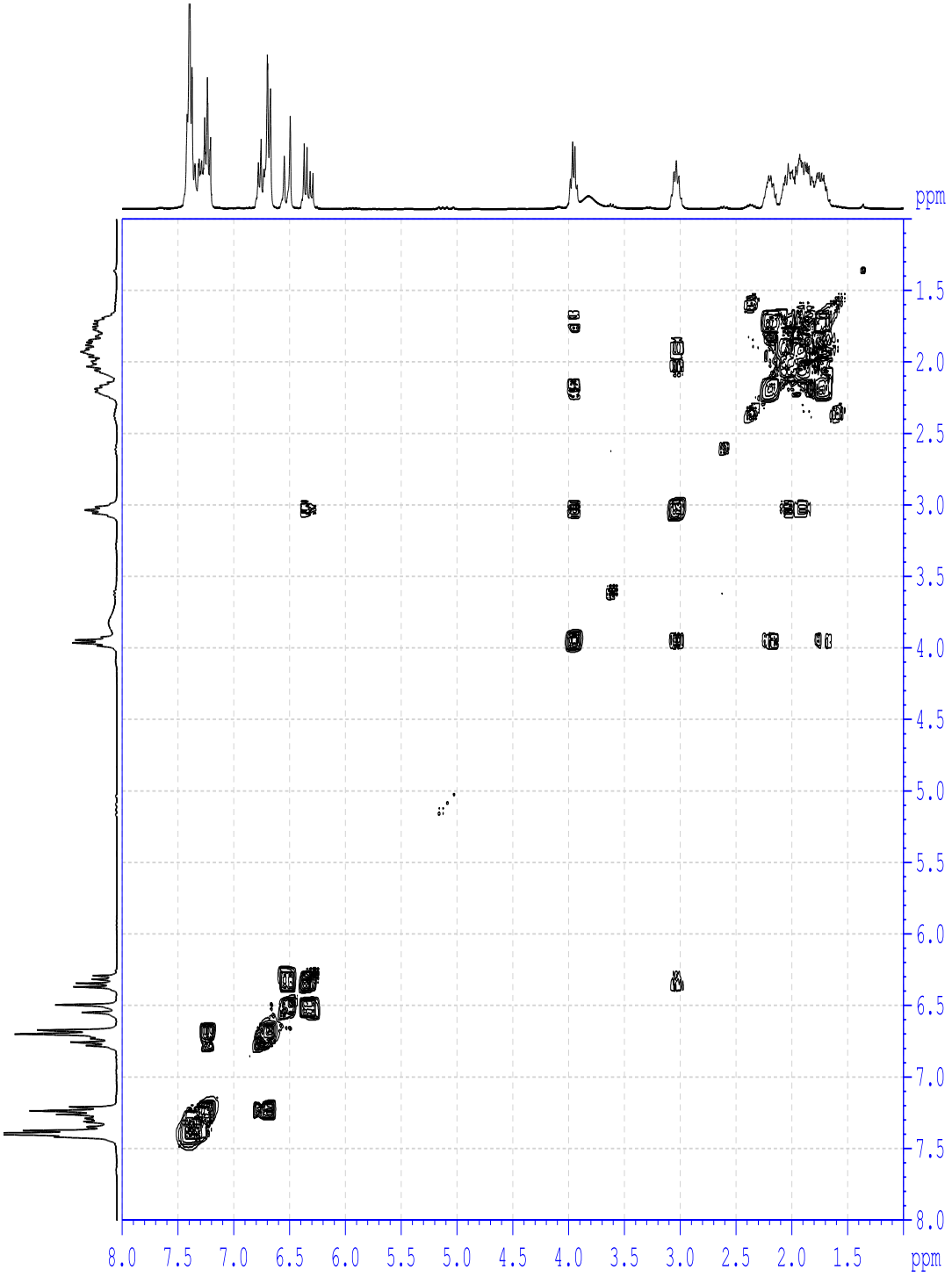
77.16
76.84
57.76
46.45
31.93
29.37
21.74


150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

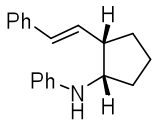
^{1}H-^{1}H COSY of 7e-*cis*



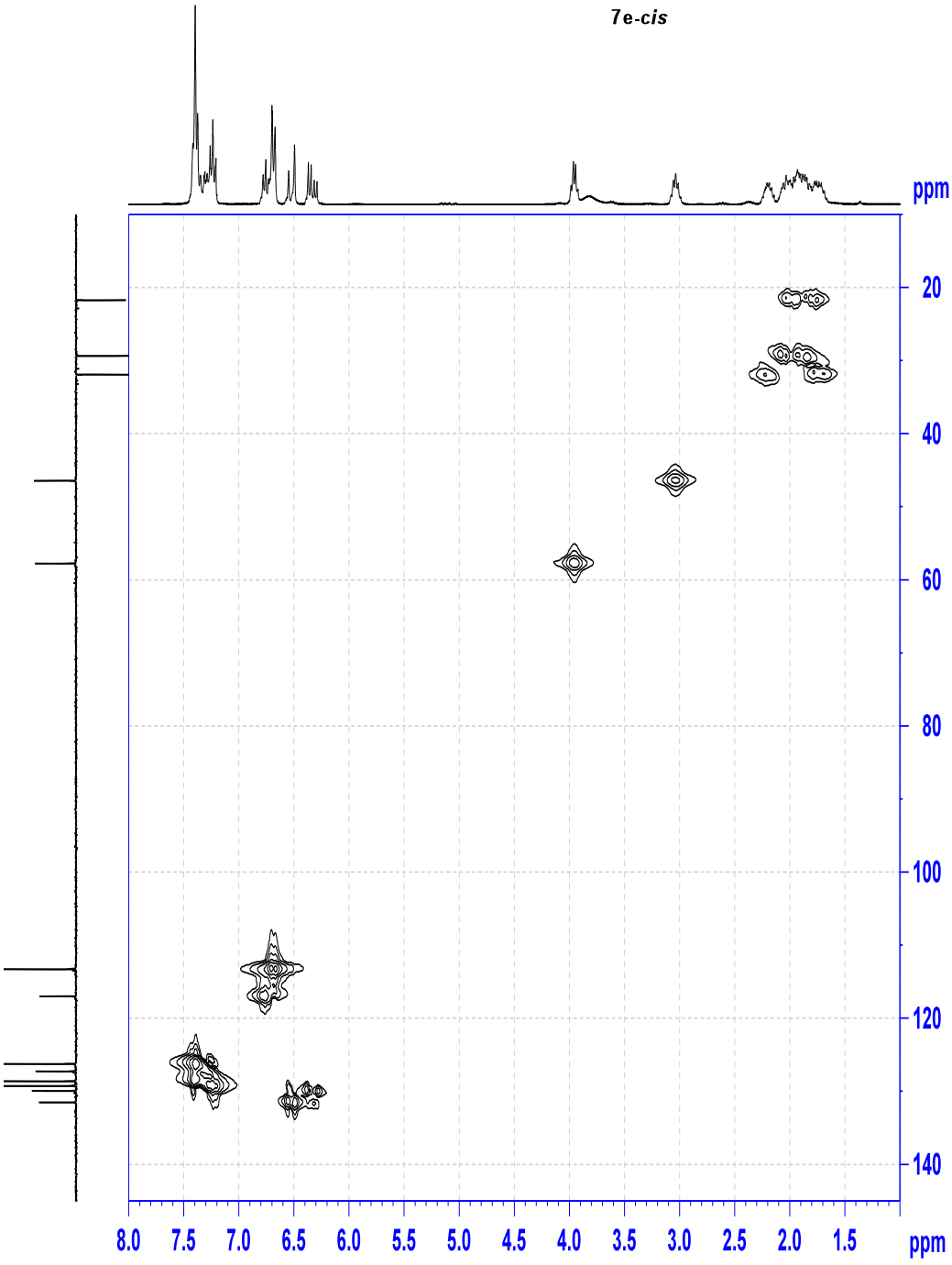
7e-cis



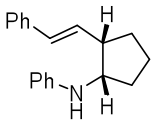
^{1}H-^{13}C HMQC of 7e-*cis*



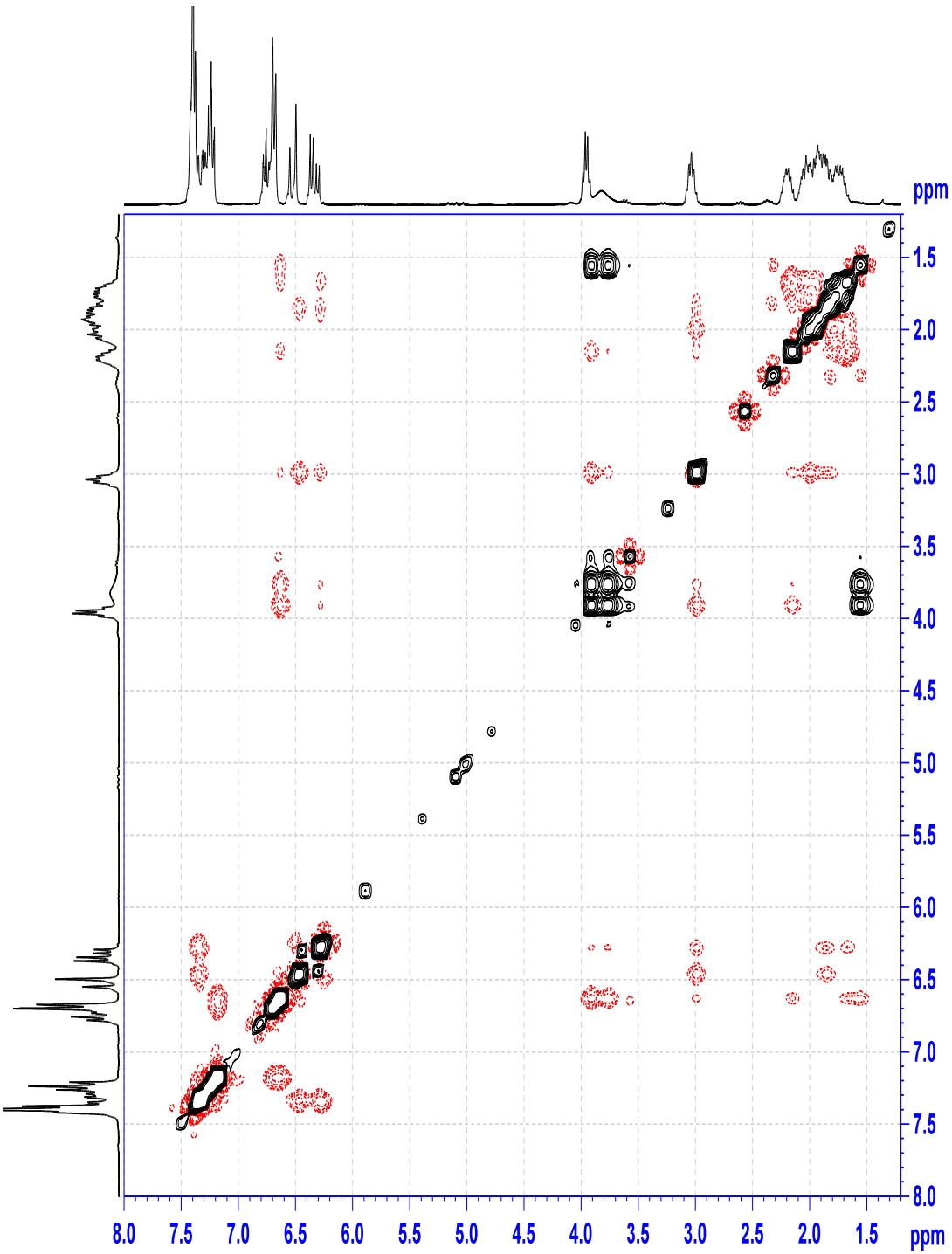
7e-cis

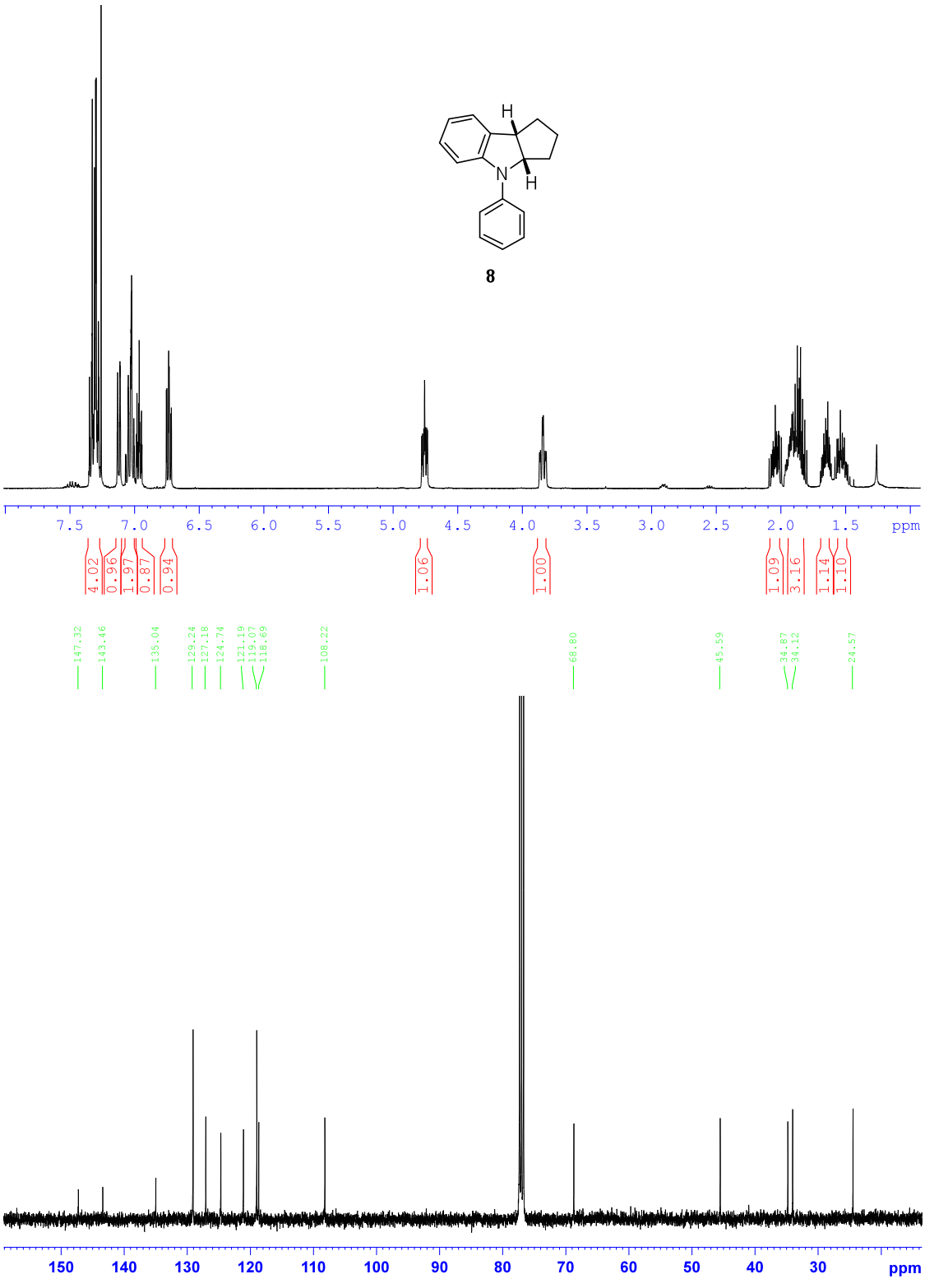


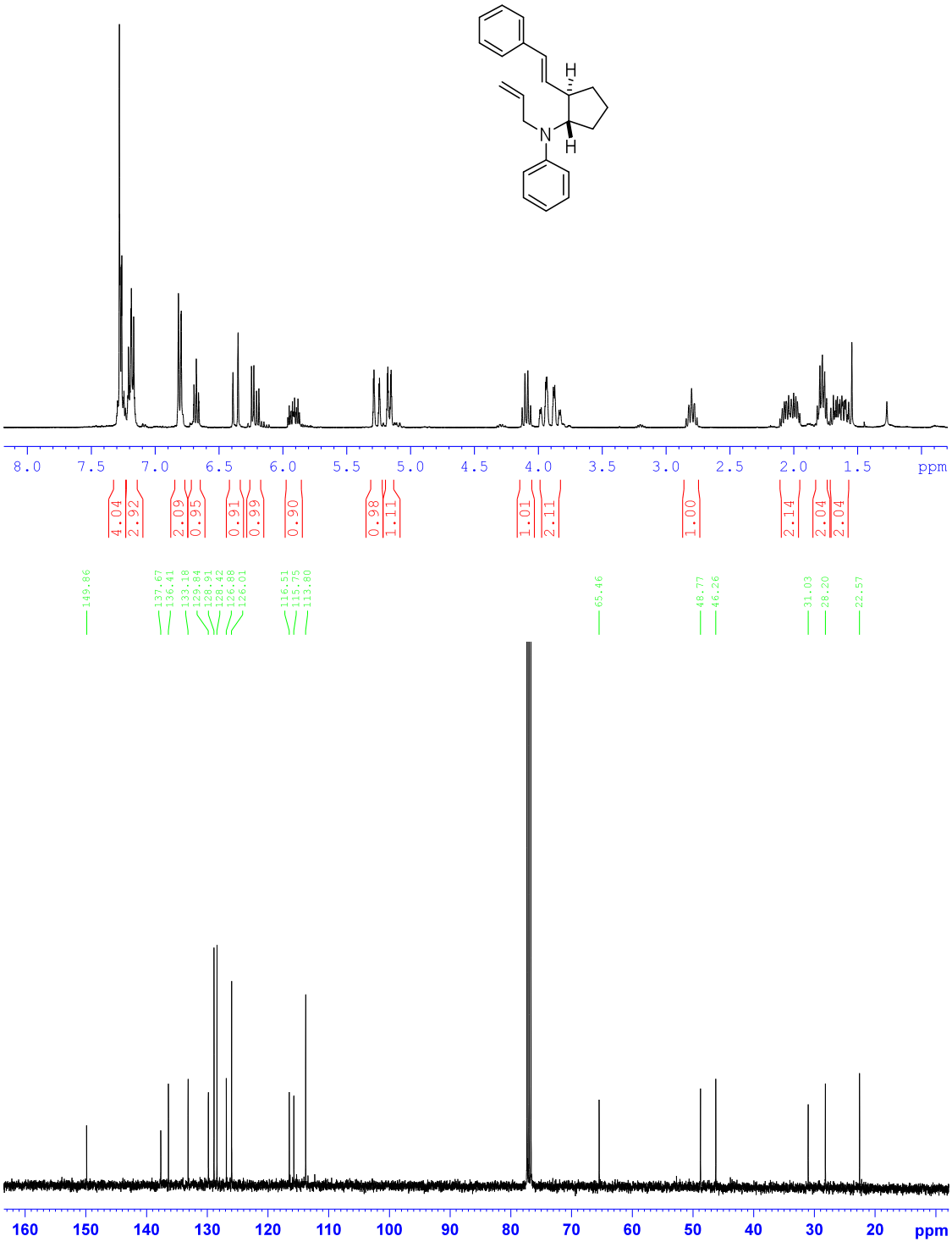
^{1}H-^{1}H NOESY of 7e-*cis*

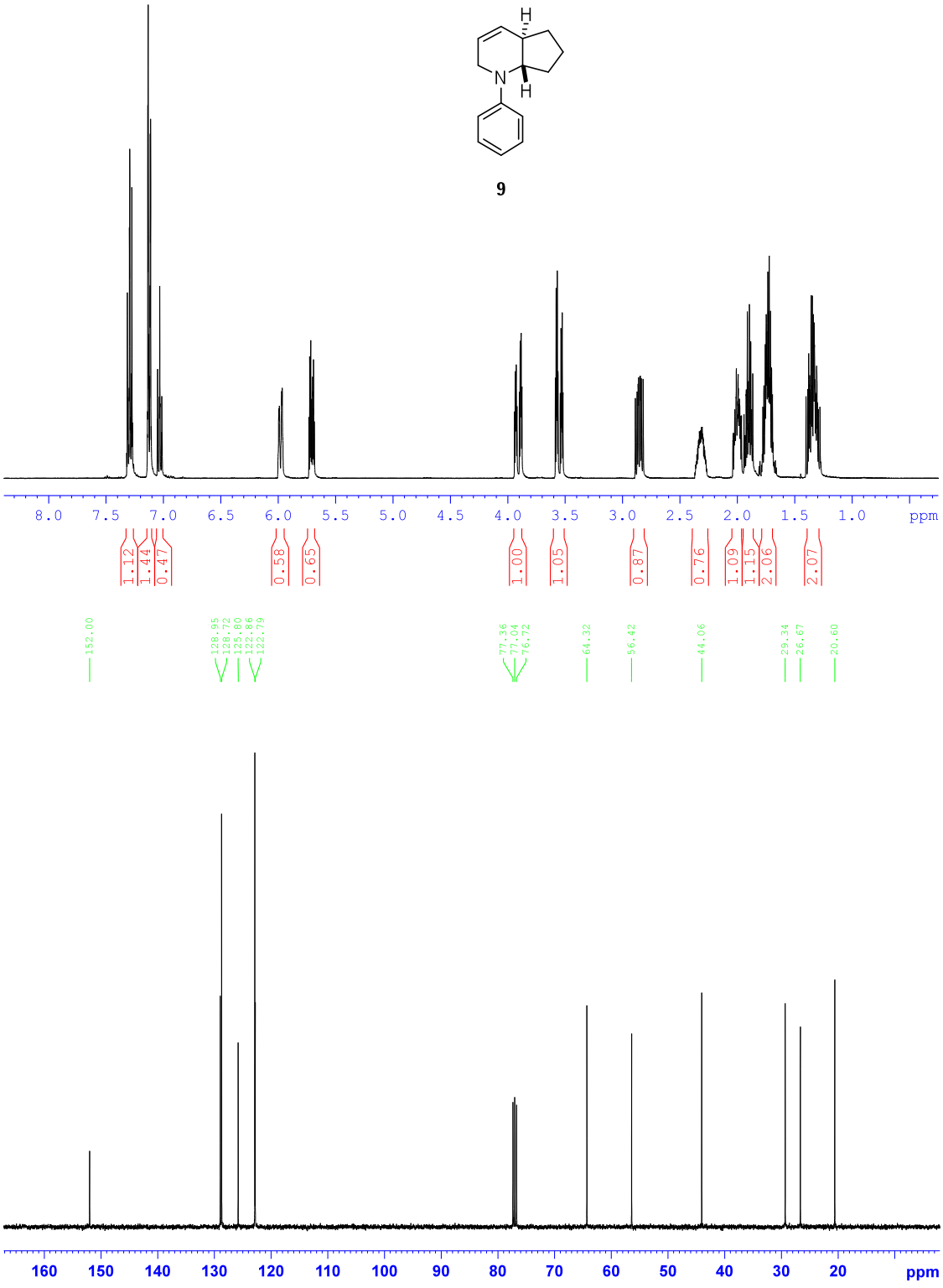


7e-*cis*

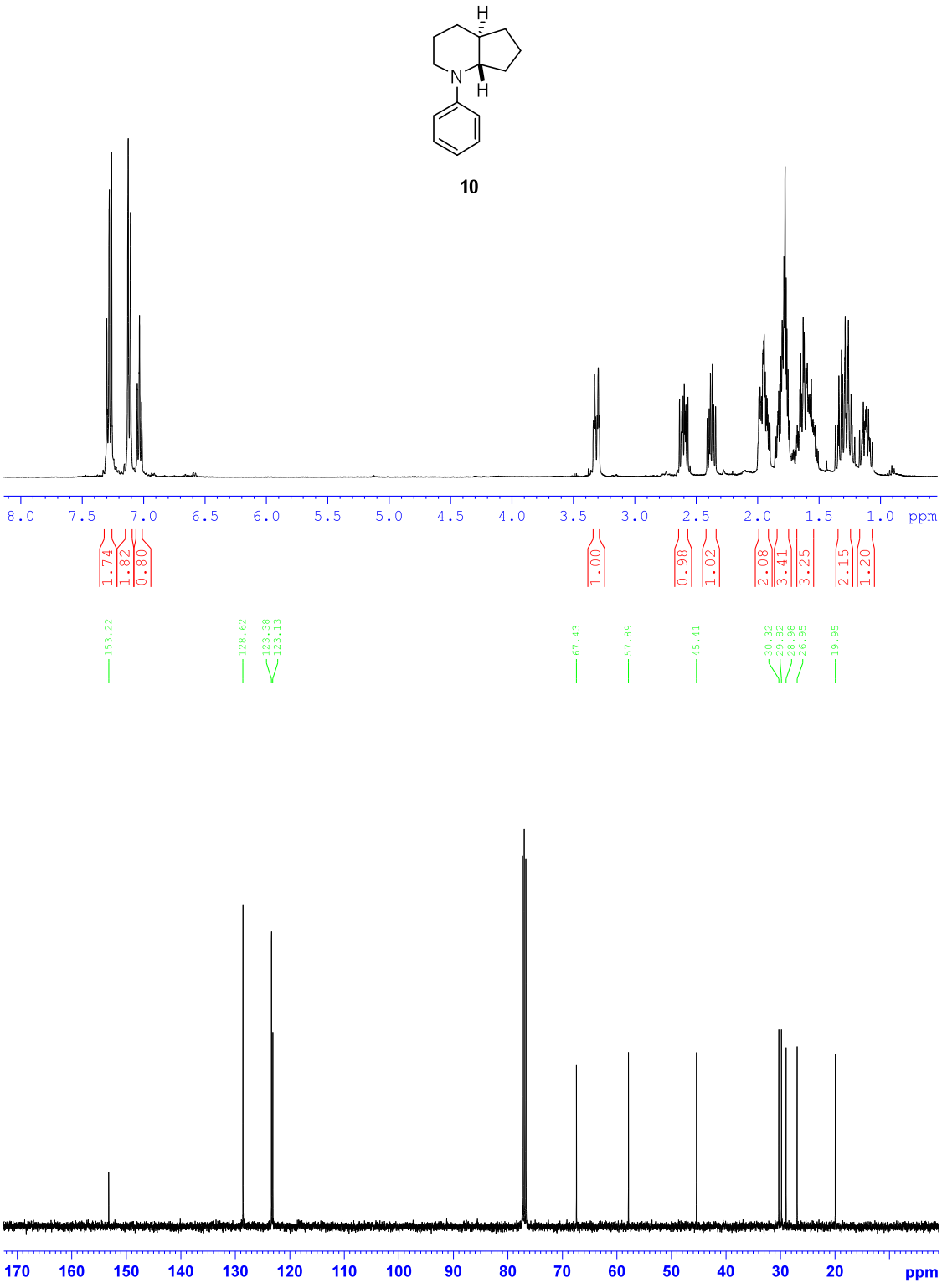


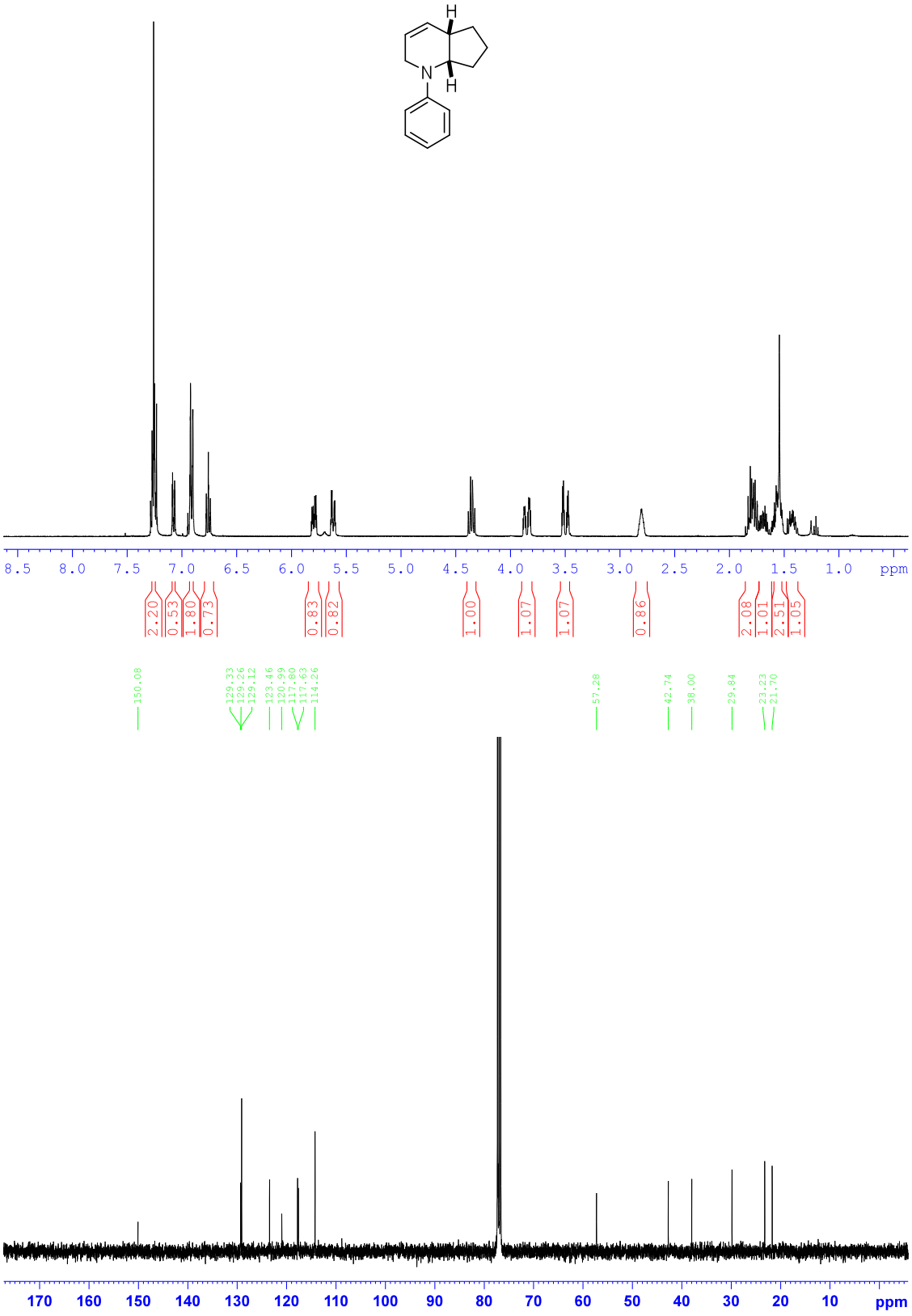

H
N
H
8
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
4.02
0.96
1.97
0.87
0.94
1.06
1.00
1.09
3.16
1.14
1.10
147.32
143.46
135.04
129.24
127.18
124.74
121.19
119.07
118.69
108.22
68.80
45.59
34.87
34.12
24.57
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm


H
N
H
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
4.04
2.92
2.09
0.95
0.91
0.99
0.90
0.98
1.11
1.01
2.11
1.00
2.14
2.04
2.04
149.86
137.67
136.41
133.18
129.84
128.91
128.42
126.88
126.01
116.51
115.75
113.80
65.46
48.77
46.26
31.03
28.20
22.57
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

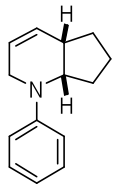

H
N
H
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
1.12
1.44
0.47
0.58
0.65
1.00
1.05
0.87
0.76
1.09
1.15
2.06
2.07
152.00
128.95
128.72
125.80
122.96
122.79
77.36
77.04
76.72
64.32
56.42
44.06
29.34
26.67
20.60
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

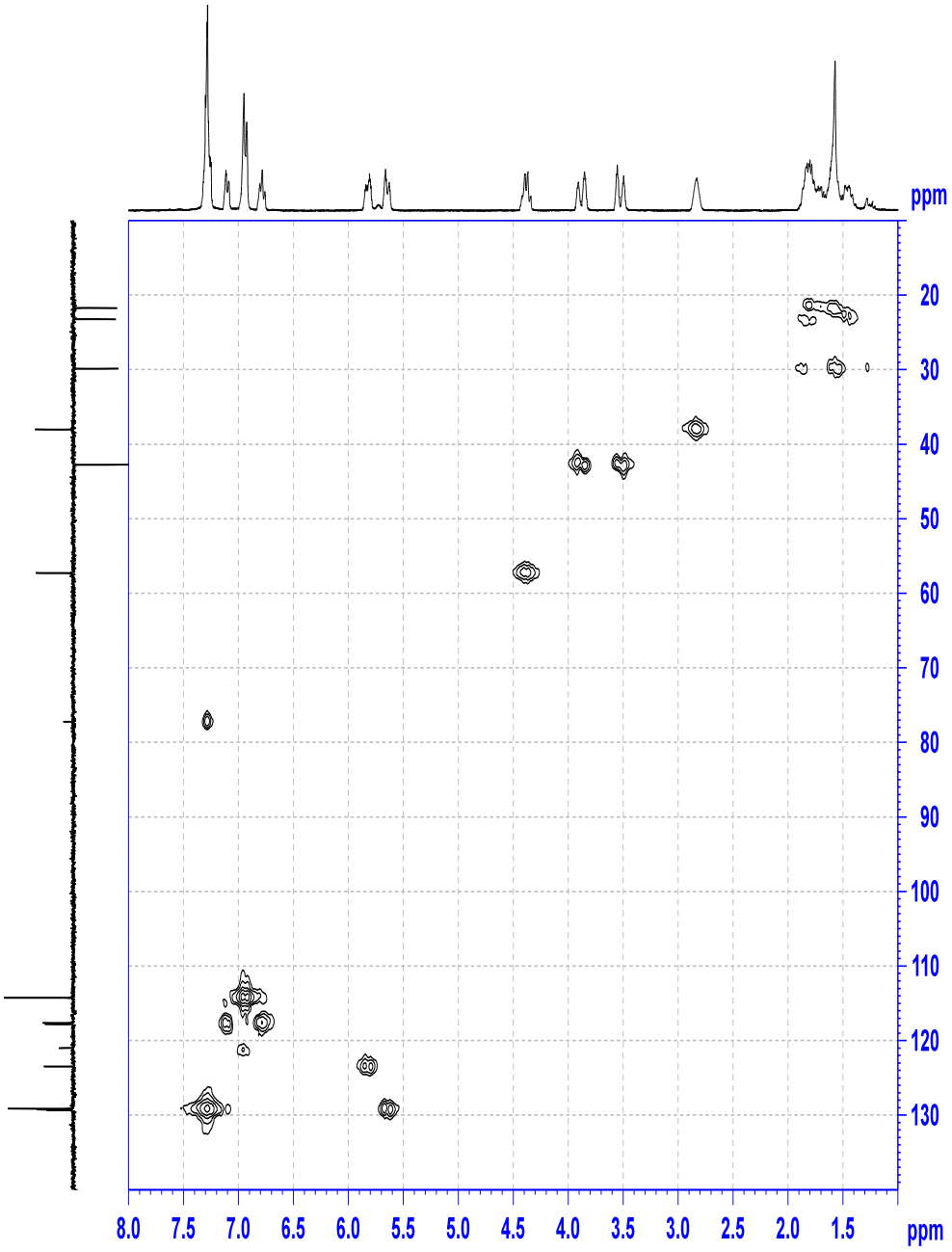
9


H
N
H
10
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 ppm
1.74
1.82
0.80
1.00
0.98
1.02
2.08
3.41
3.25
2.15
1.20
153.22
128.62
123.38
123.13
67.43
57.89
45.41
30.32
29.82
28.98
26.95
19.95
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 ppm


H
N
H
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 ppm
2.20 0.53 1.80 0.73 0.83 0.82 1.00 1.07 1.07 0.86 2.08 1.01 2.51 1.05
150.08 129.33 129.26 129.12 123.46 120.99 117.80 117.63 114.26 57.28 42.74 38.00 29.84 23.23 21.70
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

^{1}H-^{13}C HMQC


H
N
H


ppm
20
30
40
50
60
70
80
90
100
110
120
130
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm

^{1}H-^{1}H NOESY