

# A new synthetic approach to *N*-arylquinolino[2,3,4-*at*]porphyrins from $\beta$ -arylamino porphyrins

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## Material & Methods

<sup>1</sup>H and <sup>13</sup>C NMR spectra were recorded at 300.13 or 500.13 MHz and at 75.47 or 125.77 MHz, respectively. CDCl<sub>3</sub> was used as solvent and TMS as internal reference, the chemical shifts are expressed in δ (ppm) and the coupling constants (J) in Hertz (Hz). Unequivocal <sup>1</sup>H assignments were made using 2D COSY and NOESY experiments (mixing time of 800 ms), while <sup>13</sup>C assignments were made on the basis of 2D HSQC and HMBC experiments (delay for long-range J C/H couplings were optimized for 7 Hz). Mass spectra and HRMS were recorded using chloroform as solvent and 3-nitrobenzyl alcohol (NBA) as matrix. The UV-Vis spectra were recorded using dichloromethane as solvent. Melting points were measured using an apparatus fitted with a microscope and are uncorrected. Preparative thin-layer chromatography was carried out on 20 × 20 cm glass plates coated with silica gel (0.5 mm thick). Column chromatography was carried in silica gel (230-400 mesh). Analytical TLC was carried out on precoated sheets with silica gel (0.2 mm thick). Toluene was distilled from benzophenone and sodium metal, all other solvents and reagents were used without further purification.

2-Nitro-5,10,15,20-tetraphenylporphyrin and 2-amino-5,10,15,20-tetraphenylporphyrinato)nickel (II) were prepared according to known procedures<sup>1,2</sup> and were characterized by comparing their <sup>1</sup>H NMR spectra to the previously reported data. The 2-phenylamino-5,10,15,20-tetraphenylporphyrin **1a** is also described<sup>3</sup> and was characterized by comparing their <sup>1</sup>H and <sup>13</sup>C NMR, MS and UV-vis spectra to the previously reported data.

## Experimental procedures

**Reaction of 2-nitro-5,10,15,20-tetraphenylporphyrin with aniline.**

**Procedure i:** A mixture of 2-nitro-5,10,15,20-tetraphenylporphyrin (73.5 mg, 0.112 mmol) and aniline (7 mL) was heated at 180 °C, under a nitrogen atmosphere, until the total conversion of the starting porphyrin (*ca.* 20 hours, observed by TLC). After reaching room temperature, the reaction mixture was acidified with aqueous saturated citric acid and extracted with dichloromethane. The organic layer was washed with water, dried over sodium sulfate and evaporated to dryness under reduced pressure. The residue was taken up in dichloromethane and purified by column chromatography using a gradient of dichloromethane/light petroleum. The first fraction to be collected was identified as derivative **1a**. The second one, containing a mixture of two major compounds, was further purified by preparative TLC using dichloromethane as eluent. The compound with higher *R*<sub>f</sub> was identified as **2a** and the one with lower *R*<sub>f</sub> as **3**. The porphyrin derivatives were crystallized from dichloromethane/light petroleum as brown solids in 53% (**1a**, 41.7 mg), 6% (**2a**, 4.96 mg) and 22% (**3**, 17.8 mg) yield.

**Procedure ii:** Aniline (142 µL, 1.56 mmol, 40 equiv) was added to a solution of 2-nitro-5,10,15,20-tetraphenylporphyrin (25.4 mg, 0.039 mmol) in *o*-dichlorobenzene (2 mL). The reaction mixture was heated at reflux under a nitrogen atmosphere until the total conversion of the starting material (*ca.* 72 hours, confirmed by TLC). The reaction mixture was allowed to reach room temperature and the solvent was removed by column chromatography (silica gel) using light petroleum as the eluent. The reaction products were eluted with a 1:1 mixture of dichloromethane/light petroleum. Further purification by preparative TLC afforded compounds **1a** (5.2 mg, 19% yield), **2a** (7.1 mg, 26% yield) and **3** (vestigial amounts).

**Reaction of 2-nitro-5,10,15,20-tetraphenylporphyrin with *p*-toluidine.**

A solution of 2-nitro-5,10,15,20-tetraphenylporphyrin (25.4 mg, 0.039 mmol) and *p*-toluidine (166.5 mg, 1.55 mmol, 40 equiv) in *o*-dichlorobenzene (2 mL) was heated at reflux for 48 h under a nitrogen atmosphere, as described in **procedure ii**. Compound **1b** was obtained in 32% yield (8.8 mg) as the major product. Vestigial amounts of **2b** were also detected.

**Reaction of (2-amino-5,10,15,20-tetraphenylporphyrinato)nickel(II) with aryl bromides. General procedure.**

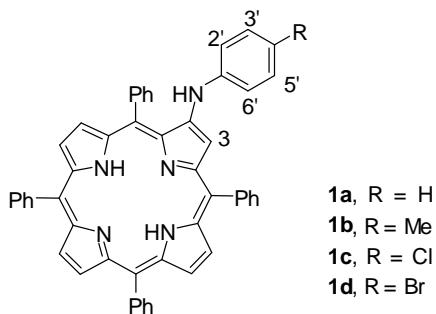
To a stirred solution of (2-amino-5,10,15,20-tetraphenylporphyrinato)nickel(II) **4** (21.9 mg, 0.032 mmol) in dry toluene (5 mL) was added the appropriate aryl bromide (2.8 equiv), palladium acetate (2.1 mg, 0.29 equiv), *rac*-BINAP (5 mg, 0.25 equiv) and KO'Bu (7.6 mg, 2.13 equiv). The mixture was heated at 100 °C, under nitrogen atmosphere, until the total conversion of the starting porphyrin (observed by TLC; 24 hours for bromobenzene and *p*-dibromobenzene, 2 hours for *p*-bromotoluene and *p*-bromochlorobenzene). The crude reaction mixture was allowed to reach room temperature and then filtered through a short column of Celite®-545, washed with water, extracted with dichloromethane and dried over sodium sulfate. The organic layer was concentrated under vacuum and the residue purified by preparative TLC using a 3.5: 6.5 mixture of light petroleum and dichloromethane as eluent.

Arylaminoporphyrin derivatives **5a-d** were crystallized from dichloromethane/light petroleum and were obtained in 69% (16.9 mg), 78% (19.3 mg), 68% (16.7 mg) and 43% (10.9 mg) yields, respectively.

### Demetallation of compounds **5**

Concentrated sulfuric acid (0.3 mL) was added dropwise to a stirred solution of porphyrin derivatives **5** (*ca.* 16 mg) in dichloromethane (3 mL) at room temperature. After 10 minutes the reaction mixture was neutralized with diluted aqueous sodium carbonate solution, washed with water, extracted with dichloromethane and dried over sodium sulfate. The solvent was removed and the residue was submitted to column chromatography (silica gel) using dichloromethane as the eluent. All compounds were crystallized from dichloromethane/light petroleum. The demetallation of **5a-d** afforded the corresponding free bases **1a-d** with 70% (10.3 mg), 72% (11.8 mg), 75% (12.0 mg) and 69% (11.0 mg) yields, respectively.

### Spectroscopic data for **1a-d**



**2-phenylamino-5,10,15,20-tetr phenylporphyrin, 1a.** Mp. 283-284 °C.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  -2.57 (s, 2H, NH), 6.61 (s, 1H, NH-Ph), 6.94 (t,  $J$  = 7.4 Hz, 1H, H-4'), 7.02 (d,  $J$  = 8.1 Hz, 2H, H-2',6'), 7.29 (dd,  $J$  = 7.4 and 8.1 Hz, 2H, H-3',5'), 7.70-7.78 (m, 9H, H-*m,p*-Ph-5,10,15), 7.84-7.87 (m, 2H, H-*m*-Ph-20), 7.89-7.93 (m, 1H, H-*p*-Ph-20), 8.18-8.21 (m, 8H, H-*o*-Ph-5,10,15,20), 8.29 (s, 1H, H-3), 8.56 (d,  $J$  = 4.7 Hz, 1H, H- $\beta$ ), 8.73 (d,  $J$  = 4.8 Hz, 1H, H- $\beta$ ), 8.77 (d,  $J$  = 4.7 Hz, 1H, H- $\beta$ ), 8.74 and 8.75 (AB,  $J$  = 4.8 Hz, 2H, H-12,13), 8.81 (d,  $J$  = 4.8 Hz, 1H, H- $\beta$ ).  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  109.1 (C-3); 113.3, 116.3; 116.8 (C-2',6'); 117.1, 117.5, 119.8; 121.1 (C-4'); 121.5, 122.3; 126.6, 126.7, 126.8, 127.6 and 127.7 (C-*m,p*-Ph-5,10,15); 128.5 (C-*m*-Ph-20); 129.1 (C-*p*-Ph-20); 129.3 (C-3',5'); 129.6, 130.1, 130.4, 130.6 and 131.6 (C- $\beta$ ); 133.1 (C-*o*-Ph-20); 134.2, 134.4 and 134.5 (C-*o*-Ph-5,10,15); 140.8, 1412.0, 142.27, 142.31, 142.8. UV-Vis ( $\text{CH}_2\text{Cl}_2$ )  $\lambda_{\text{max}}$  (log  $\epsilon$ ) 408 (5.3), 527 (4.2), 569 (4.0), 599 (3.9), 656 (3.7). MS (FAB):  $m/z$  706 ( $\text{M}+\text{H}$ )<sup>+</sup>.

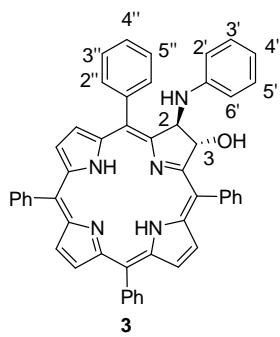
**2-*p*-methylphenylamino-5,10,15,20-tetr phenylporphyrin, 1b.** Mp. >300 °C.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  -2.57 (s, 2H, NH), 2.32 (s, 3H,  $\text{CH}_3$ ), 6.53 (s, 1H, NH-Ar), 6.95 (d,  $J$  = 8.3 Hz, 2H, H-2',6'), 7.11 (d,  $J$  = 8.3 Hz, 2H, H-3',5'), 7.72-7.90 (m, 12H, H-*m,p*-Ph-5,10,15,20), 8.16-8.22 (m, 9H, H-3 and H-*o*-Ph 5,10,15,20), 8.54 (d,  $J$  = 5.0 Hz, 1H, H- $\beta$ ), 8.70-8.80 (m, 5H, H- $\beta$ ).  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  20.7 ( $\text{CH}_3$ ); 108.2 (C-3); 116.3; 117.1 (C-2',6'); 119.6, 121.5; 126.6, 126.71, 126.74,

127.6, 127.7, 128.5 and 129.0 (C-*m,p*-Ph-5,10,15,20); 129.8 (C-3',5'); 130.7, 130.8, 131.0 and 131.2 (C- $\beta$ ); 133.1, 134.2, 134.3 and 134.5 (C-*o*-Ph-5,10,15,20); 139.8, 140.8, 142.0, 142.3, 142.8. UV-Vis ( $\text{CH}_2\text{Cl}_2$ )  $\lambda_{\max}$  ( $\log \varepsilon$ ) 409 (5.2), 527 (4.1), 602 (3.8), 658 (3.7). HRMS (ESI) calcd for  $\text{C}_{51}\text{H}_{37}\text{N}_5$  ( $\text{M}+\text{H}$ ) $^+$  720.3077, found 720.3092.

**2-*p*-chlorophenylamino-5,10,15,20-tetraphenylporphyrin, 1c.** Mp. 287-288 °C.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  -2.61 (s, 2H, NH), 6.52 (s, 1H, NH-Ar), 6.93 (d,  $J$  = 8.8 Hz, 2H, H-2',6'), 7.23 (d,  $J$  = 8.8 Hz, 2H, H-3',5'), 7.70-7.91 (m, 12H, H-*m,p*-Ph-5,10,15,20), 8.16-8.22 (m, 9H, H-3 and H-*o*-Ph-5,10,15,20), 8.57 (d,  $J$  = 4.8 Hz, 1H, H- $\beta$ ), 8.74-8.83 (m, 5H, H- $\beta$ ).  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  109.8 (C-3); 116.3; 117.7 (C-2',6'); 121.5; 126.6, 126.7, 126.8, 127.65, 127.71, 128.6 and 129.1 (1xC- $\beta$  and C-*m,p*-Ph-5,10,15,20); 129.3 (C-3',5'); 129.8, 130.1, 130.3, 131.2 and 131.9 (C- $\beta$ ); 133.1, 134.2, 134.4 and 134.5 (C-*o*-Ph-5,10,15,20); 140.8, 141.0, 141.9, 142.2, 142.7. UV-Vis ( $\text{CH}_2\text{Cl}_2$ )  $\lambda_{\max}$  ( $\log \varepsilon$ ) 409 (5.4), 433 (4.9), 526 (4.3), 568 (4.0), 599 (4.0), 655 (3.6). HRMS (ESI) calcd for  $\text{C}_{50}\text{H}_{35}\text{ClN}_5$  ( $\text{M}+\text{H}$ ) $^+$  740.2576, found 740.2561.

**2-*p*-bromophenylamino-5,10,15,20-tetraphenylporphyrin, 1d.** Mp. 293-294 °C.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  -2.61 (s, 2H, NH), 6.51 (s, 1H, NH-Ar), 6.87 (d,  $J$  = 8.7 Hz, 2H, H-2',6'), 7.37 (d,  $J$  = 8.7 Hz, 2H, H-3',5'), 7.69-7.90 (m, 12H, H-*m,p*-Ph-5,10,15,20), 8.16-8.23 (m, 9H, H-3 and H-*o*-Ph-5,10,15,20), 8.57 (d,  $J$  = 4.8 Hz, 1H, H- $\beta$ ), 8.74-8.83 (m, 5H, H- $\beta$ ).  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  110.1 (C-3); 112.7, 116.3; 117.7 (C-2',6'); 118.1, 119.9, 121.5; 126.6, 126.7, 126.8, 127.66, 127.73, 128.6 and 129.1 (C-*m,p*-Ph-5,10,15,20); 128.3, 129.7, 130.0, 130.5, 131.5 and 132.3 (C- $\beta$ ); 132.2 (C-3',5'); 133.1, 134.2, 134.4 and 134.5 (C-*o*-Ph-5,10,15,20); 140.8, 141.5, 141.9, 142.2, 142.7. UV-Vis ( $\text{CH}_2\text{Cl}_2$ )  $\lambda_{\max}$  ( $\log \varepsilon$ ) 409 (5.3), 433 (4.9) 526 (4.4), 568 (4.0), 599 (4.0), 655 (3.6). HRMS (ESI) calcd for  $\text{C}_{50}\text{H}_{35}\text{BrN}_5$  ( $\text{M}+\text{H}$ ) $^+$  786.2050, found 786.2048.

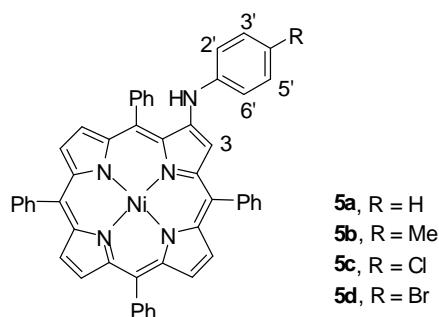
### Spectroscopic data for 3



**trans-2-hydroxy-3-phenylamino-2,3-dihydro-5,10,15,20-tetraphenylporphyrin, 3.** Mp. 197-198 °C.  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  -1.88 (s, 2H, NH), 2.46 (br s, 1H, OH), 3.90 (d,  $J$  = 4.8 Hz, 1H,  $\beta$ -NH), 5.90 (d,  $J$  = 4.8 Hz, 1H, H-2), 6.21 (s, 1H, H-3), 6.49 (d,  $J$  = 7.9 Hz, 2H, H-2',6'), 6.68 (t,  $J$  = 7.5 Hz, 1H, H-4'), 7.05 (dd,  $J$  = 7.5 and 7.9 Hz, 2H, H-3',5'), 7.45-7.47, 7.53-7.56 and 7.66-7.75 (3m, 12H,

H-*m,p*-Ph-5,10,15,20); 7.77-7.79, 7.93-7.94, 8.03-8.07, 8.10-8.12 and 8.21-8.22 (5m, 8H, H-*o*-Ph-5,10,15,20); 8.29 (d,  $J = 5.0$  Hz, 1H, H- $\beta$ ), 8.37 (d,  $J = 5.0$  Hz, 1H, H- $\beta$ ), 8.51 and 8.52 (AB,  $J = 4.5$  Hz, 2H, H-12,13), 8.67-8.68 (2m, 2H, H- $\beta$ ).  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  67.1 (C-3); 79.9 (C-2); 113.0 (C-2',6'); 113.3, 113.4; 117.7 (C-4'); 122.9 and 123.4 (C- $\beta$ ); 124.2, 124.7; 126.7 (C-*p*-Ph-5,10,15,20); 127.1; 127.4 (C-*m*-Ph-5,10,15,20); 127.6, 127.65, 127.74; 127.9 and 128.0 (C-*m*-Ph-5,10,15,20); 128.2 (C- $\beta$ ); 128.5, 128.88; 128.93 (C-3',5'); 129.0; 132.8 and 132.9 (C-12,13); 132.0, 132.5, 133.1, 133.2 and 133.96 (C-*o*-Ph-5,10,15,20); 134.0; 135.6, 135.8, 140.6 and 140.8 (C-6,9,16,19); 141.0, 141.80, 141.82; 147.1 (C-1'); 153.1 and 153.4 (C-11,14); 161.5 and 162.2 (C-1,4). UV-Vis ( $\text{CH}_2\text{Cl}_2$ )  $\lambda_{\max}$  (log  $\epsilon$ ) 415 (5.3), 516 (4.2), 544 (4.2), 590 (3.9), 642 (4.4). HRMS (ESI) calcd for  $\text{C}_{50}\text{H}_{38}\text{N}_5\text{O} (\text{M}+\text{H})^+$  724.3071, found. 724.3040

### Spectroscopic data for 5a-d



**(2-phenylamino-5,10,15,20-tetraphenylporphyrinato)nickel(II), 5a.** Mp. 290-291 °C.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  6.37 (s, 1H, NH-Ph); 6.90 (t,  $J = 7.4$  Hz, 1H, H-4'), 6.91 (d,  $J = 8.1$  Hz, 2H, H-2',6'), 7.24 (dd,  $J = 7.4$  and 8.1 Hz, 2H, H-3',5'), 7.63-7.79 (m, 12H, H-*m,p*-Ph-5,10,15,20), 7.94-7.99 (m, 8H, H-*o*-Ph-5,10,15,20), 8.25 (s, 1H, H-3), 8.54-8.72 (m, 6H, H- $\beta$ ).  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  110.7 (C-3); 115.6, 115.8; 116.3 (C-2',6'); 118.4, 120.1; 120.9 (C-4'); 126.87, 126.89, 127.0, 127.6, 127.7 and 128.5 (C-*m,p*-Ph-5,10,15,20); 128.9; 129.3 (C-3',5'); 130.6, 131.3, 131.4, 131.7, 132.0 and 132.9 (C- $\beta$ ); 133.2; 132.5, 133.45, 133.54 and 133.6 (C-*o*-Ph-5,10,15,20); 139.5, 140.69, 140.72, 140.9, 141.1, 141.4, 142.0, 142.2, 142.7, 143.0, 143.2, 143.5. UV-Vis ( $\text{CH}_2\text{Cl}_2$ )  $\lambda_{\max}$  (log  $\epsilon$ ) 414 (5.2), 541 (4.1), 580 (4.2). HRMS (ESI) calcd for  $\text{C}_{50}\text{H}_{34}\text{N}_5\text{Ni} (\text{M}+\text{H})^+$  762.2162, found 762.2175.

**(2-p-methylphenylamino-5,10,15,20-tetraphenylporphyrinato)nickel(II), 5b.** Mp. 248-249 °C.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  2.30 (s, 3H,  $\text{CH}_3$ ), 6.30 (s, 1H, NH-Ar), 6.85 (d,  $J = 8.3$  Hz, 2H, H-2',6'), 7.07 (d,  $J = 8.3$  Hz, 2H, H-3',5'), 7.61-7.78 (m, 12H, H-*m,p*-Ph-5,10,15,20), 7.93-7.99 (m, 8H, H-*o*-Ph-5,10,15,20), 8.17 (s, 1H, H-3), 8.55 (d,  $J = 4.8$  Hz, 1H, H- $\beta$ ), 8.58 (d,  $J = 4.8$  Hz, 1H, H- $\beta$ ), 8.63-8.69 (m, 4H, H- $\beta$ ).  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ , TMS):  $\delta$  20.7 ( $\text{CH}_3$ ); 109.7 (C-3); 115.6; 116.6 (C-2',6'); 118.3; 126.85, 126.88, 127.0, 127.57, 127.63, 127.7, 128.5 and 128.9 (C-*m,p*-Ph-5,10,15,20); 129.8 (C-3',5'); 130.4, 130.5, 131.2, 131.3, 131.7 and 131.9 (C- $\beta$ ); 132.5, 132.8, 133.4, 133.5 and 133.6 (C-*o*-Ph-5,10,15,20); 140.8, 141.1, 141.3, 143.0, 143.2, 143.8. UV-Vis ( $\text{CH}_2\text{Cl}_2$ )  $\lambda_{\max}$  (log  $\epsilon$ ) 413 (4.0), 583 (5.0). HRMS (ESI) calcd for  $\text{C}_{51}\text{H}_{36}\text{N}_5\text{Ni} (\text{M}+\text{H})^+$  776.2318, found 776.2317.

**(2-p-chlorophenylamino-5,10,15,20-tetraphenylporphyrinato)nickel(II), 5c.** Mp. >300 °C. <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>, TMS): δ 6.28 (s 1H, NH-Ar), 6.83 (d, J = 8.5 Hz, 2H, H-2',6'), 7.19 (d, J = 8.5 Hz, 2H, H-3',5'), 7.64-7.80 (m, 12H, H-*m,p*-Ph-5,10,15,20), 7.95-7.99 (m, 8H, H-*o*-Ph-5,10,15,20), 8.20 (s, 1H, H-3), 8.56-8.69 (m, 6H, H-β). <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>, TMS): δ 111.4 (C-3); 115.6, 116.0; 117.2 (C-2',6'); 118.5, 120.1, 125.2; 126.9, 127.0, 127.7, 128.5 and 128.9 (C-*m,p*-Ph-5,10,15,20); 129.2 (C-3',5'); 130.7, 131.47, 131.53, 131.9, 132.0 and 133.0 (C-β); 132.4, 132.9, 133.4, 133.5 and 133.6 (C-*o*-Ph-5,10,15,20); 139.5, 140.6, 140.7, 140.9, 141.0, 141.1, 141.5, 142.1, 142.8, 142.9, 142.0, 143.1, 143.37, 143.41, 145.7. UV-Vis (CH<sub>2</sub>Cl<sub>2</sub>) λ<sub>max</sub> (log ε) 416 (5.2), 541 (4.2), 579 (4.2). HRMS (ESI) calcd for C<sub>50</sub>H<sub>33</sub>ClN<sub>5</sub>Ni (M+H)<sup>+</sup> 796.1773, found 796.1777.

**(2-p-bromophenylamino-5,10,15,20-tetraphenylporphyrinato)nickel(II), 5d.** Mp. >300 °C. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>, TMS): δ 6.27 (s, 1H, NH-Ar), 6.78 (d, J = 8.7 Hz, 2H, H-2',6'), 7.32 (d, J = 8.7 Hz, 2H, H-3',5'), 7.64-7.79 (m, 12H, H-*m,p*-Ph-5,10,15,20), 7.94-8.00 (m, 8H, H-*o*-Ph-5,10,15,20), 8.21 (s, 1H, H-3), 8.55-8.69 (m, 6H, H-β). <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>, TMS): δ 111.7 (C-3); 116.1; 117.6 (C-2',6'); 120.1, 125.3; 126.9, 127.0, 127.7, 128.2 and 128.5 (C-*m,p*-Ph-5,10,15,20); 128.9, 129.0; 130.7, 131.5, 131.6, 131.9, 132.0 and 132.9 (C-β); 132.1 (C-2',5'); 132.4, 133.4, 133.5 and 133.6 (C-*o*-Ph-5,10,15,20); 139.5, 140.6, 140.9, 141.4, 141.5, 142.8, 142.9, 143.0, 143.1, 145.5. UV-Vis (CH<sub>2</sub>Cl<sub>2</sub>) λ<sub>max</sub> (log ε) 416 (5.2), 542 (4.1), 579 (4.1). HRMS (ESI) calcd for C<sub>50</sub>H<sub>32</sub>BrN<sub>5</sub>Ni (M)<sup>+</sup> 841.1169, found 841.1160.

### Single-crystal X-ray diffraction studies of 2a

A suitable single-crystal of compound **2a** was manually harvested from the crystallization vial and mounted on a Hampton Research CryoLoop using FOMBLIN Y perfluoropolyether vacuum oil (LVAC 25/6) purchased from Aldrich,<sup>4</sup> with the help of a Stemi 2000 stereomicroscope equipped with Carl Zeiss lenses. Data were collected at 150(2)K on a Bruker X8 Kappa APEX II charge-coupled device (CCD) area-detector diffractometer (Cu K<sub>α</sub> graphite-monochromated radiation, λ = 1.54178 Å) controlled by the APEX2 software package,<sup>5</sup> and equipped with an Oxford Cryosystems Series 700 cryostream monitored remotely using the software interface Cryopad.<sup>6</sup> Images were processed using the software package SAINT+,<sup>7</sup> and data were corrected for absorption by the multi-scan semi-empirical method implemented in SADABS.<sup>8</sup> The structure was solved using the direct methods implemented with SHELXS-97,<sup>9</sup> which ultimately allowed the immediate location of the majority of non-hydrogen atoms, with the remaining being directly located from difference Fourier maps calculated from successive full-matrix least squares refinement cycles on F<sup>2</sup> using SHELXL-97.<sup>10</sup> Non-hydrogen atoms were successfully refined using anisotropic displacement parameters (see Figure S17).

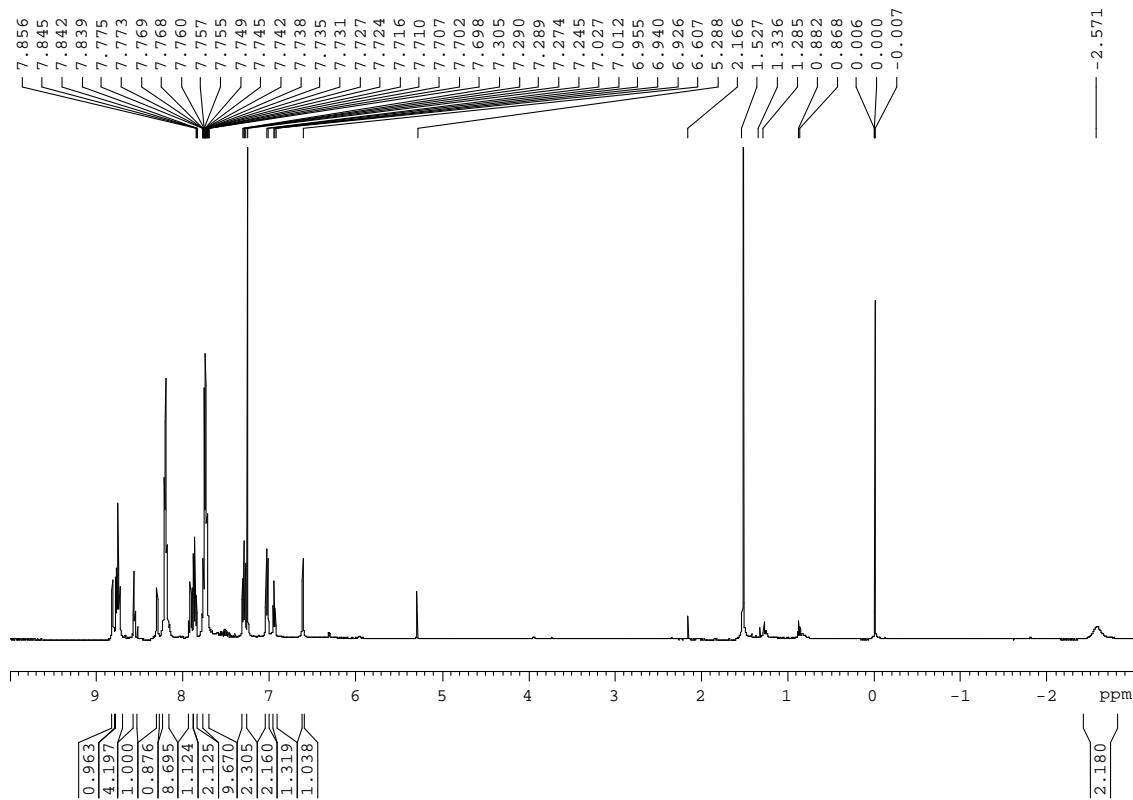
Hydrogen atoms attached to carbon were located at their idealized positions using the HFIX 43 instruction in SHELXL-97,<sup>10</sup> and included in subsequent refinement cycles in riding-motion approximation with isotropic thermal displacements parameters (*U*<sub>iso</sub>) fixed at 1.2 times *U*<sub>eq</sub> of the carbon atom to which they are attached. Hydrogen atoms associated with the internal bases of the porphyrin ring were markedly visible in difference Fourier maps and were ultimately included in the final structural model with N-H

distances restrained to 0.95(1) Å (in order to ensure chemically reasonable geometries for these moieties) and with  $U_{\text{iso}}(\text{H}) = 1.5 \times U_{\text{eq}}(\text{N})$ .

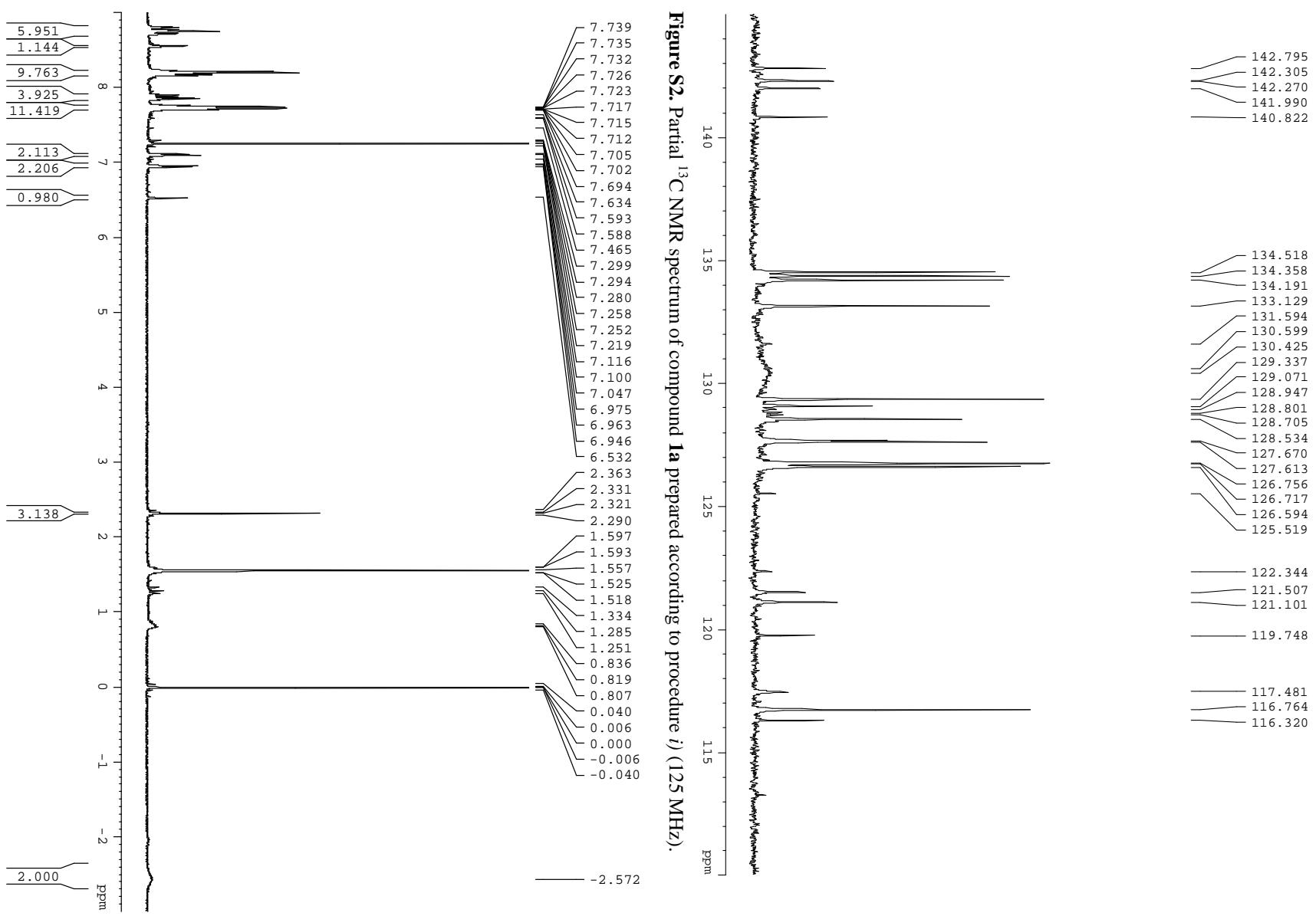
The last difference Fourier map synthesis showed the highest peak (0.272 eÅ<sup>-3</sup>) and deepest hole (-0.230 eÅ<sup>-3</sup>) located at 1.13 Å from H(35) and 0.96 Å from C(37), respectively.

Information concerning crystallographic data collection and structure refinement details is summarised in Table S1. Additional structural drawings, created with the visualization software package Crystal Diamond,<sup>11</sup> are provided as Figures S17 and S18 (see below).

Crystallographic data (excluding structure factors) for the structure reported in this paper have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. CCDC-642548. Copies of the data can be obtained free of charge on application to CCDC, 12 Union Road, Cambridge CB2 2EZ, U.K. FAX: (+44) 1223 336033. E-mail: [deposit@ccdc.cam.ac.uk](mailto:deposit@ccdc.cam.ac.uk).

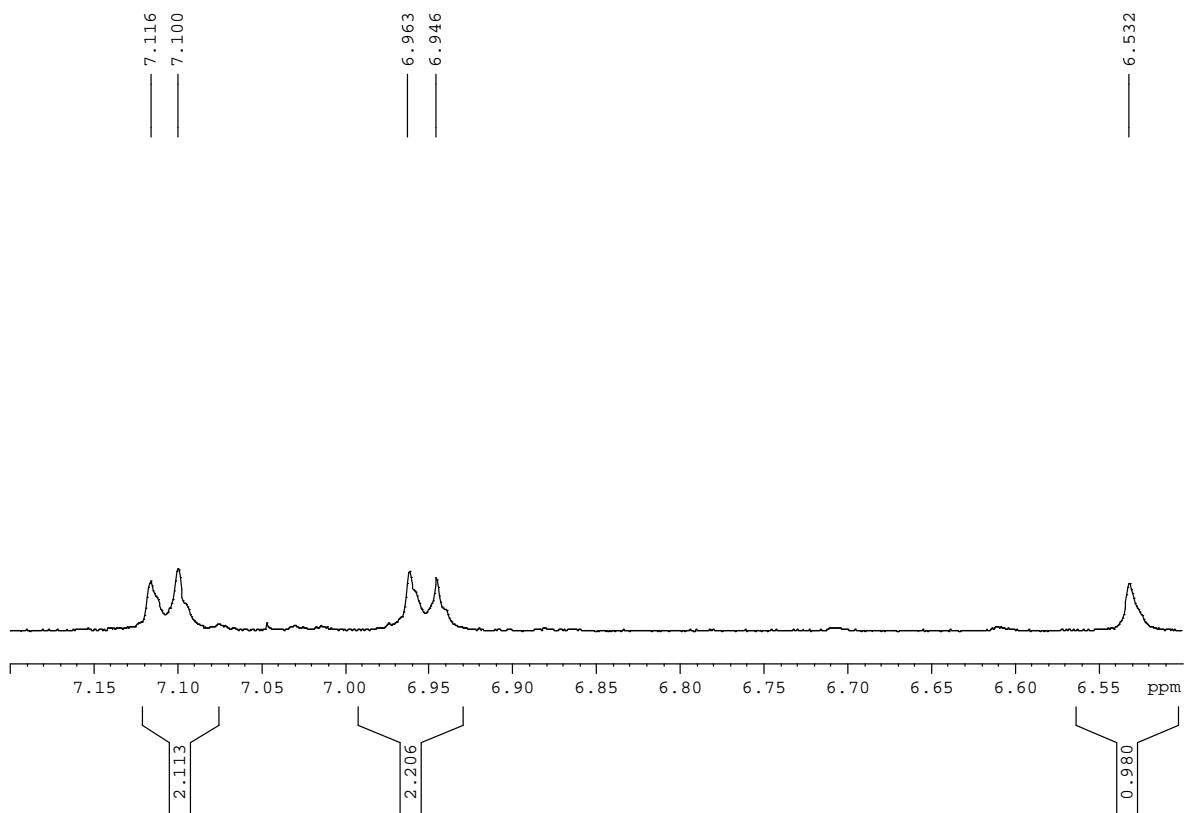


**Figure S1.**  $^1\text{H}$  NMR spectrum of compound **1a** prepared according to procedure *i*) (500 MHz).

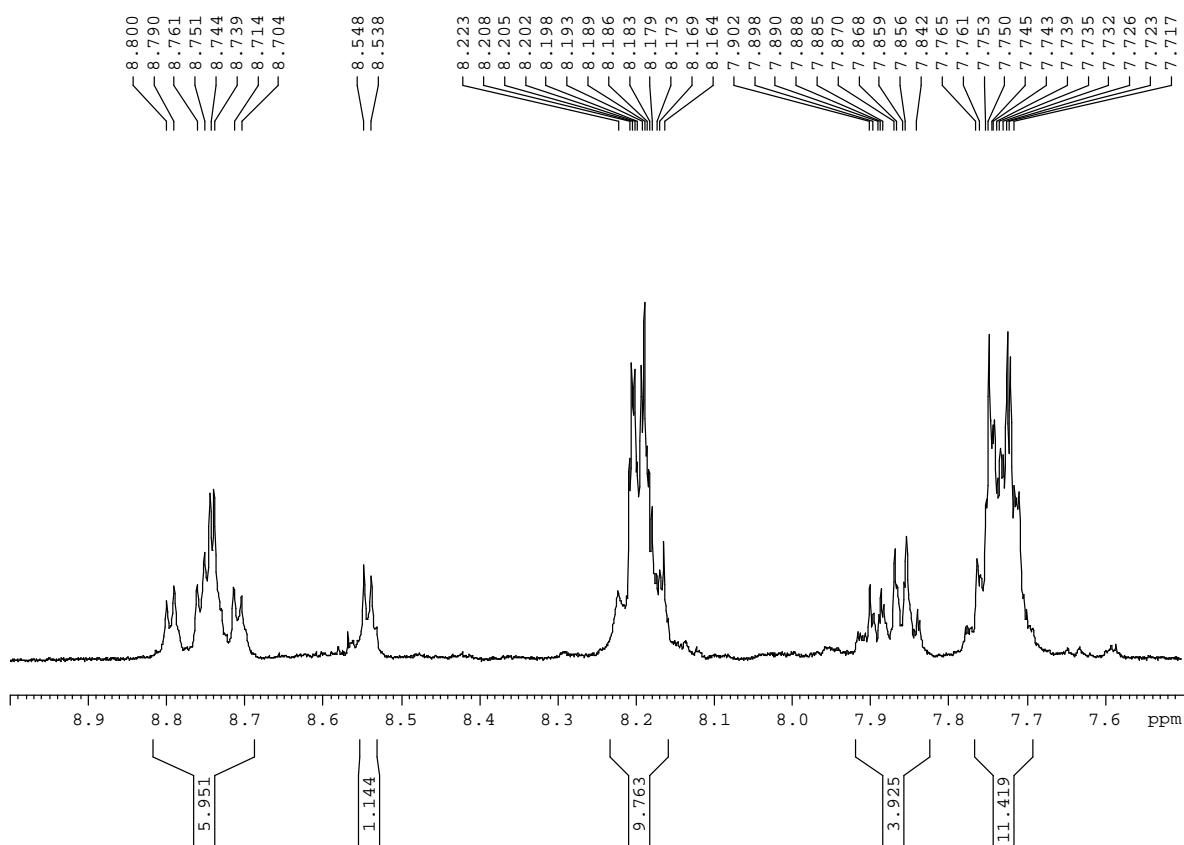


**Figure S2.** Partial <sup>13</sup>C NMR spectrum of compound **1a** prepared according to procedure *i*) (125 MHz).

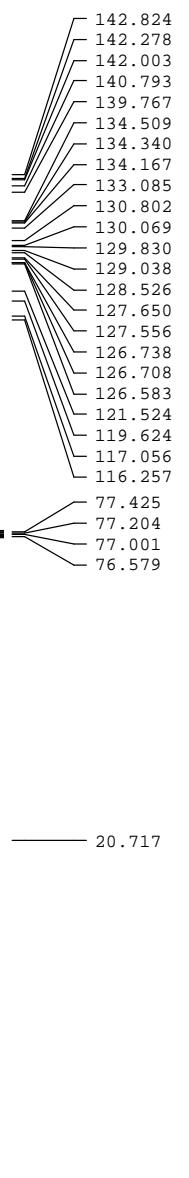
**Figure S3.** <sup>1</sup>H NMR spectrum of compound **1b** prepared according to procedure *ii*) (500 MHz).



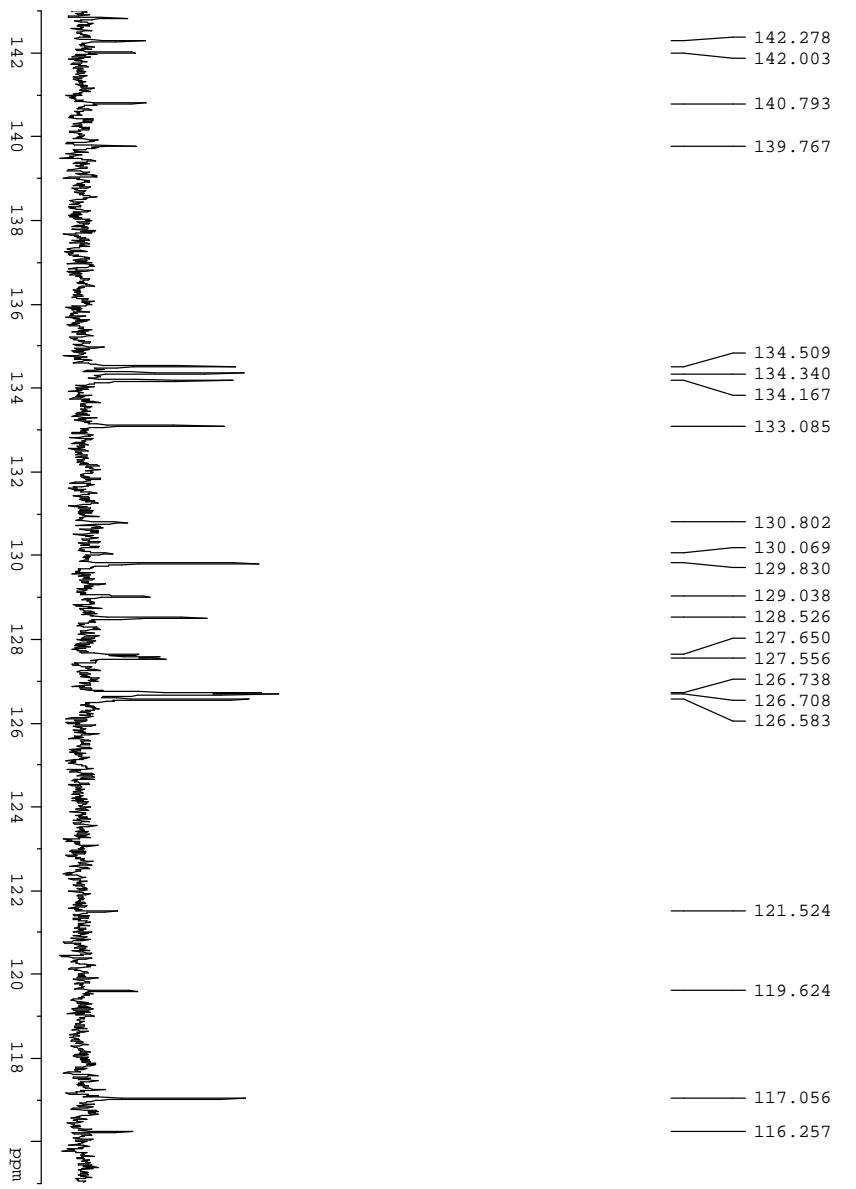
**Figure S4.** Partial <sup>1</sup>H NMR spectrum of compound **1b** prepared according to procedure *ii*) (500 MHz).



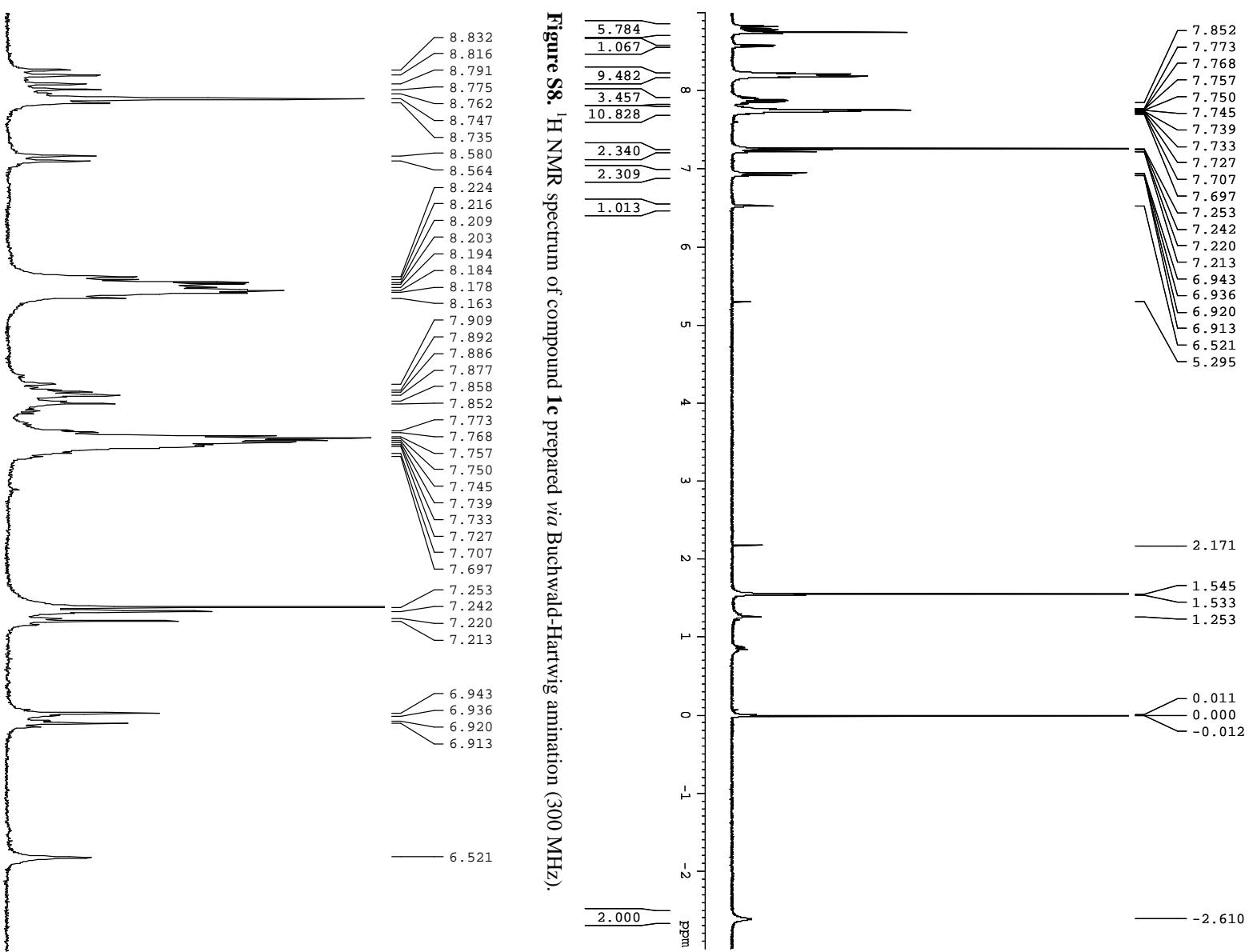
**Figure S5.** Partial <sup>1</sup>H NMR spectrum of compound **1b** prepared according to procedure *ii*) (500 MHz).



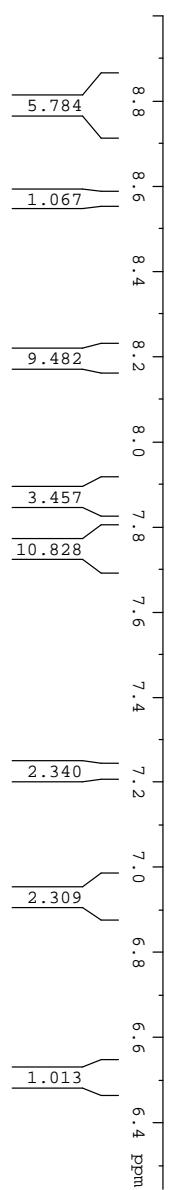
**Figure S6.**  $^{13}\text{C}$  NMR spectrum of compound **1b** prepared according to procedure *ii*) (125 MHz).



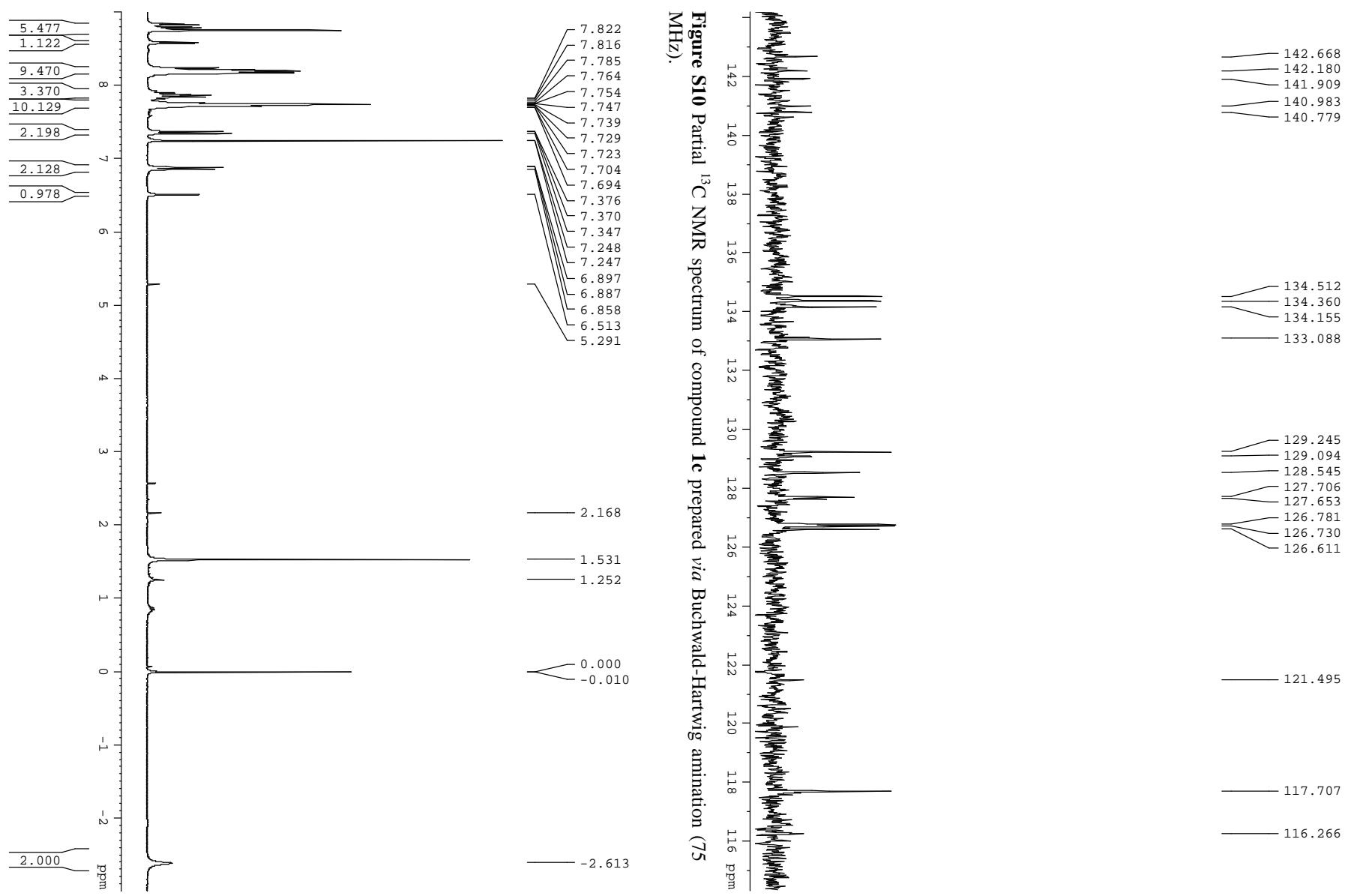
**Figure S7.** Partial  $^{13}\text{C}$  NMR spectrum of compound **1b** prepared according to procedure *ii*) (125 MHz).



**Figure S8.** <sup>1</sup>H NMR spectrum of compound **1c** prepared via Buchwald-Hartwig amination (300 MHz).

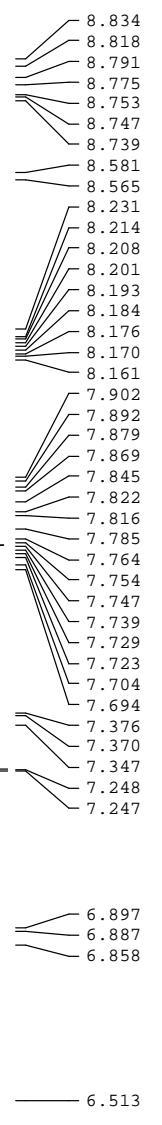


**Figure S9** Partial <sup>1</sup>H NMR spectrum of compound **1c** prepared via Buchwald-Hartwig amination (300 MHz).

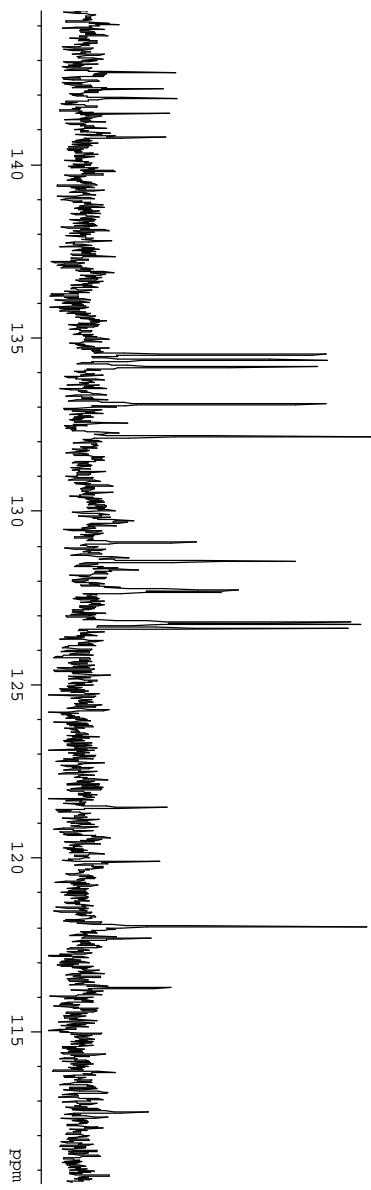
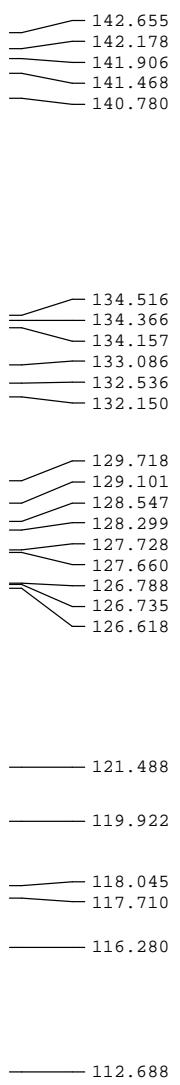


**Figure S10** Partial  $^{13}\text{C}$  NMR spectrum of compound **1c** prepared via Buchwald-Hartwig amination (75 MHz).

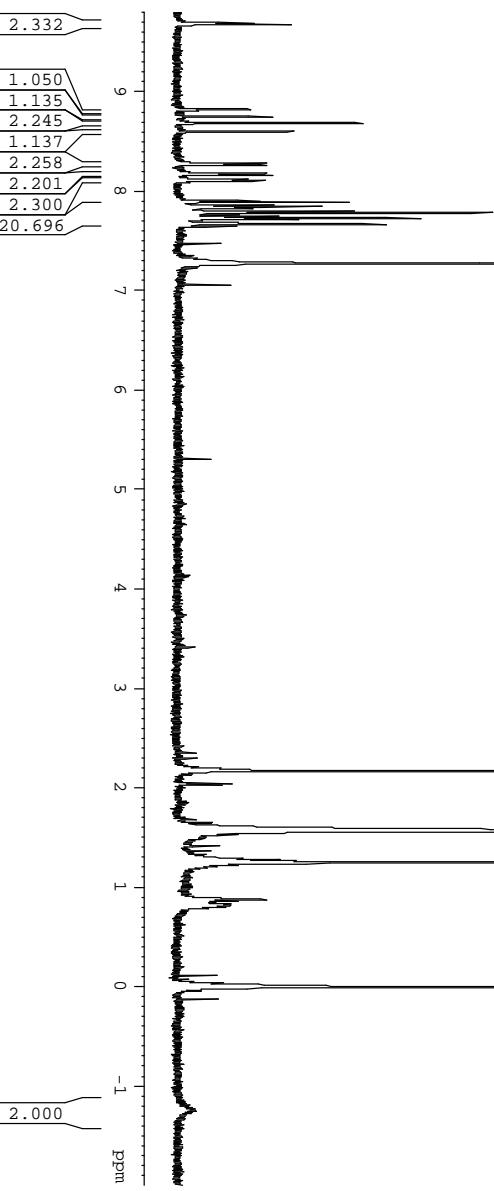
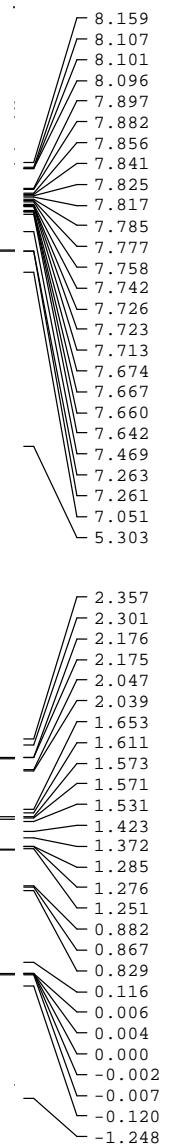
**Figure S11.**  $^1\text{H}$  NMR spectrum of compound **1d** prepared via Buchwald-Hartwig amination (300 MHz).



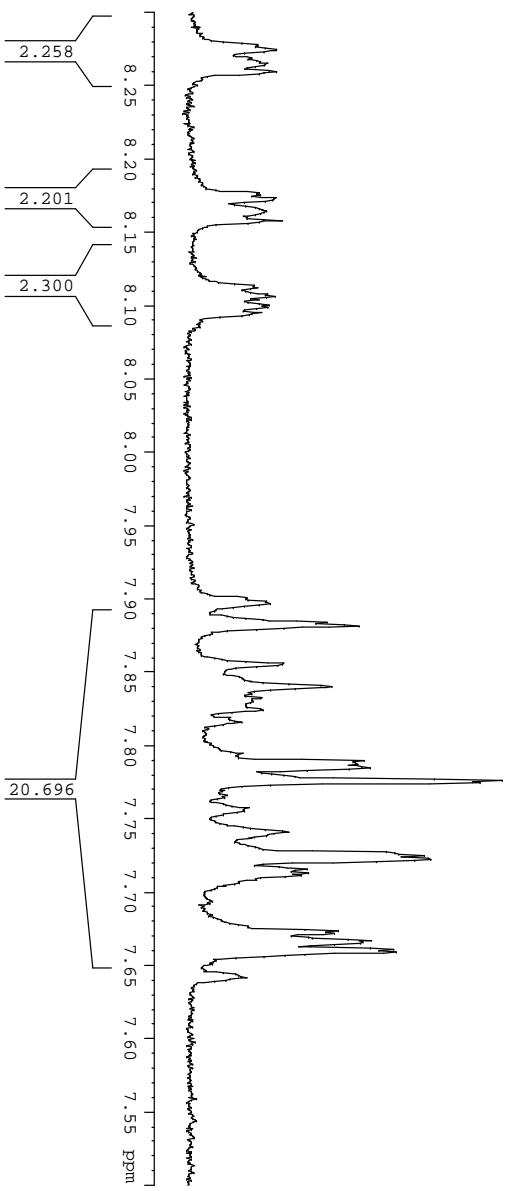
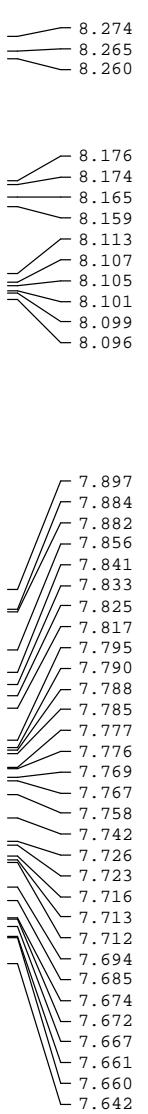
**Figure S12.** Partial  $^1\text{H}$  NMR spectrum of compound **1d** prepared *via* Buchwald-Hartwig amination (300 MHz).



**Figure S13.** Partial  $^{13}\text{C}$  NMR spectrum of compound **1d** prepared *via* Buchwald-Hartwig amination (75 MHz).



**Figure S14.**  $^1\text{H}$  NMR spectrum of compound **2a** prepared according to procedure *i*) (500 MHz).



**Figure S15.** Partial  $^1\text{H}$  NMR spectrum of compound **2a** prepared according to procedure *i*) (500 MHz).



Figure S16. Partial <sup>1</sup>H NMR spectrum of compound **2a** prepared according to procedure *i*) (500 MHz).

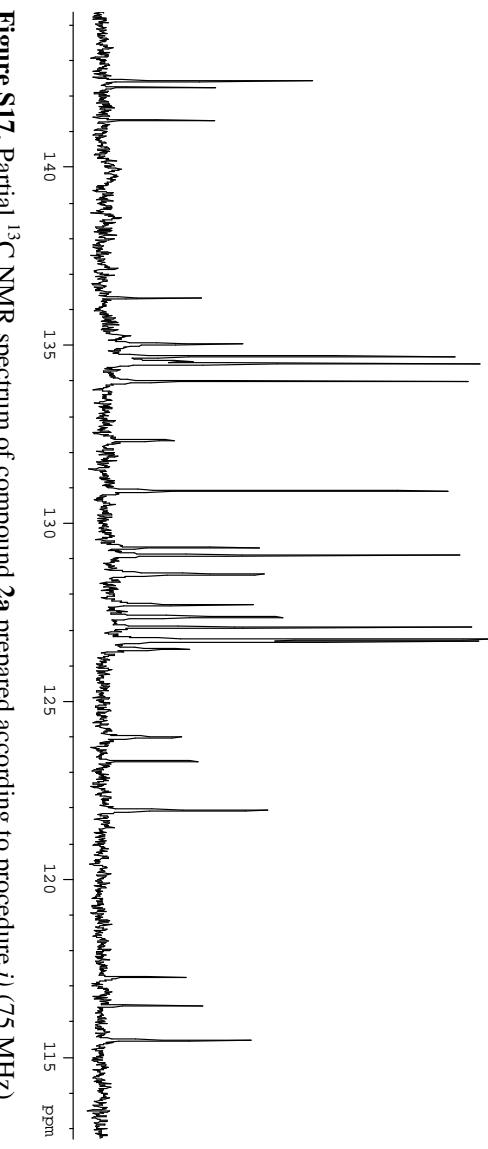
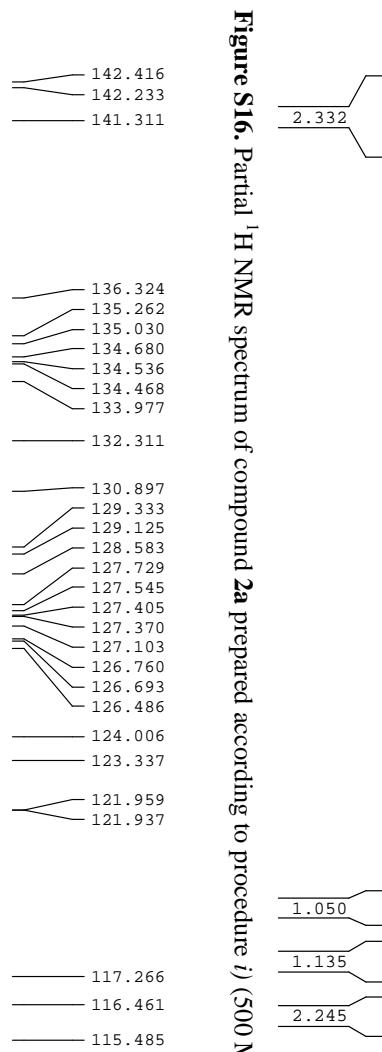
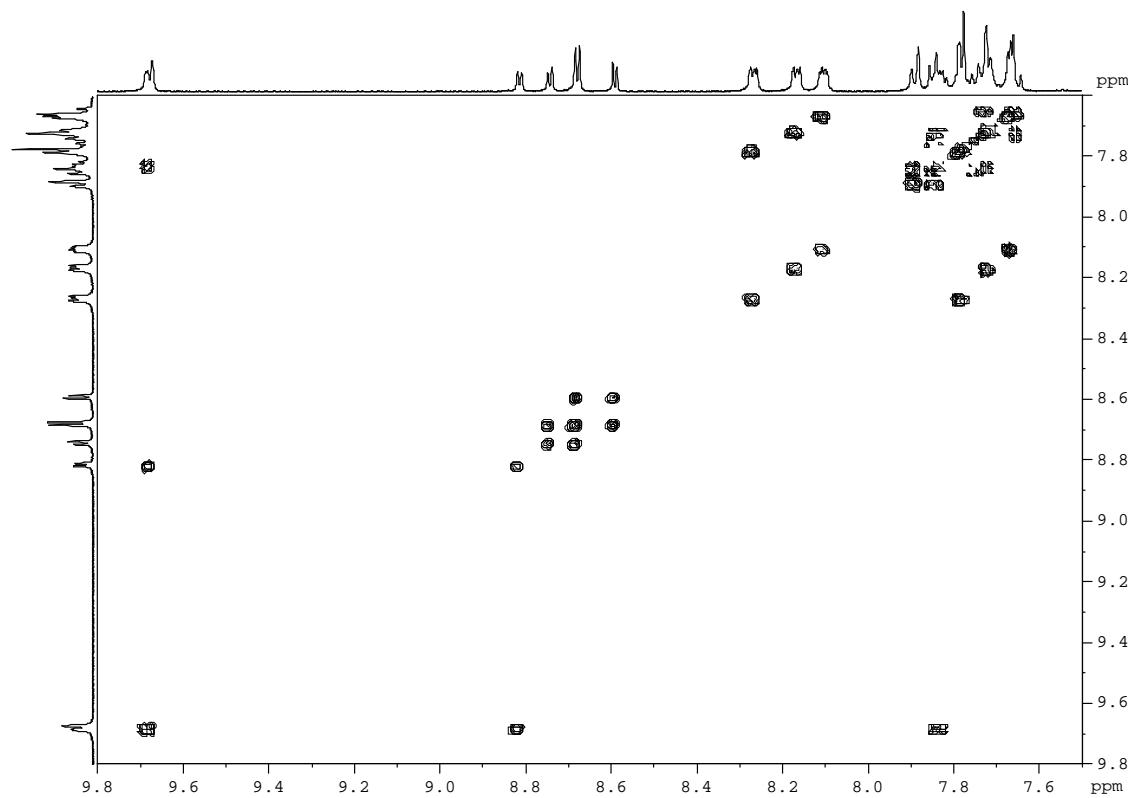
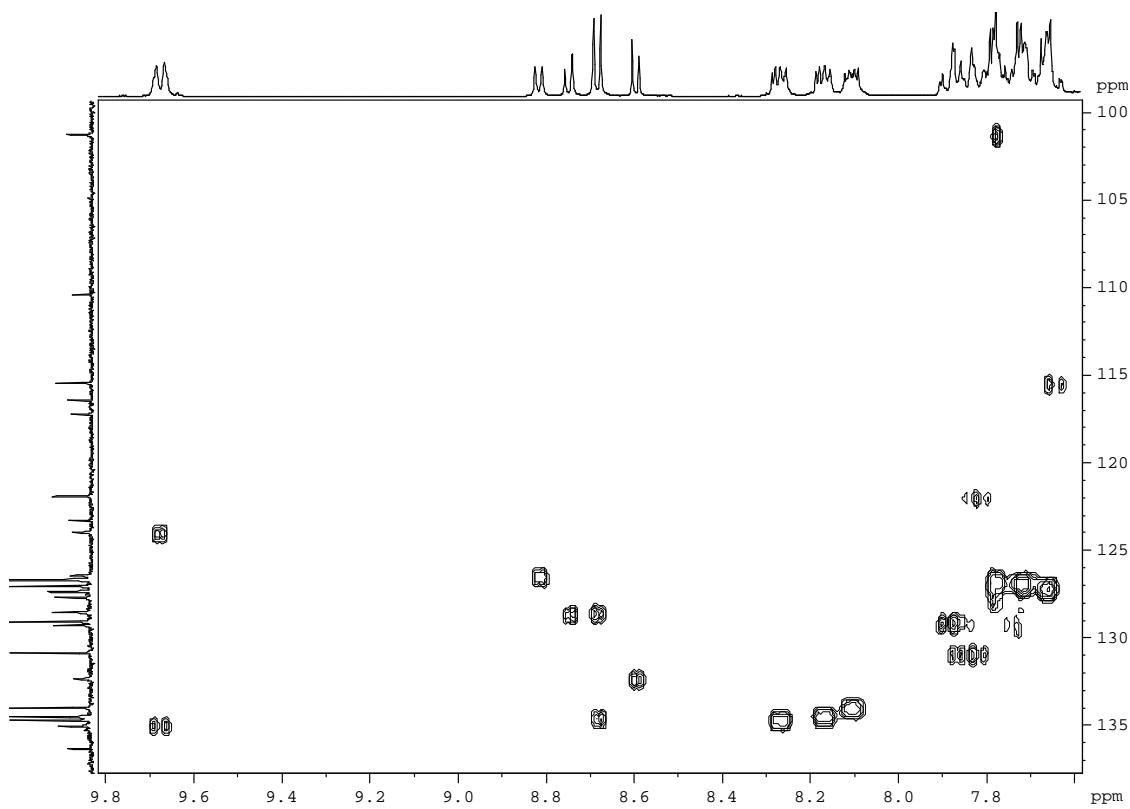


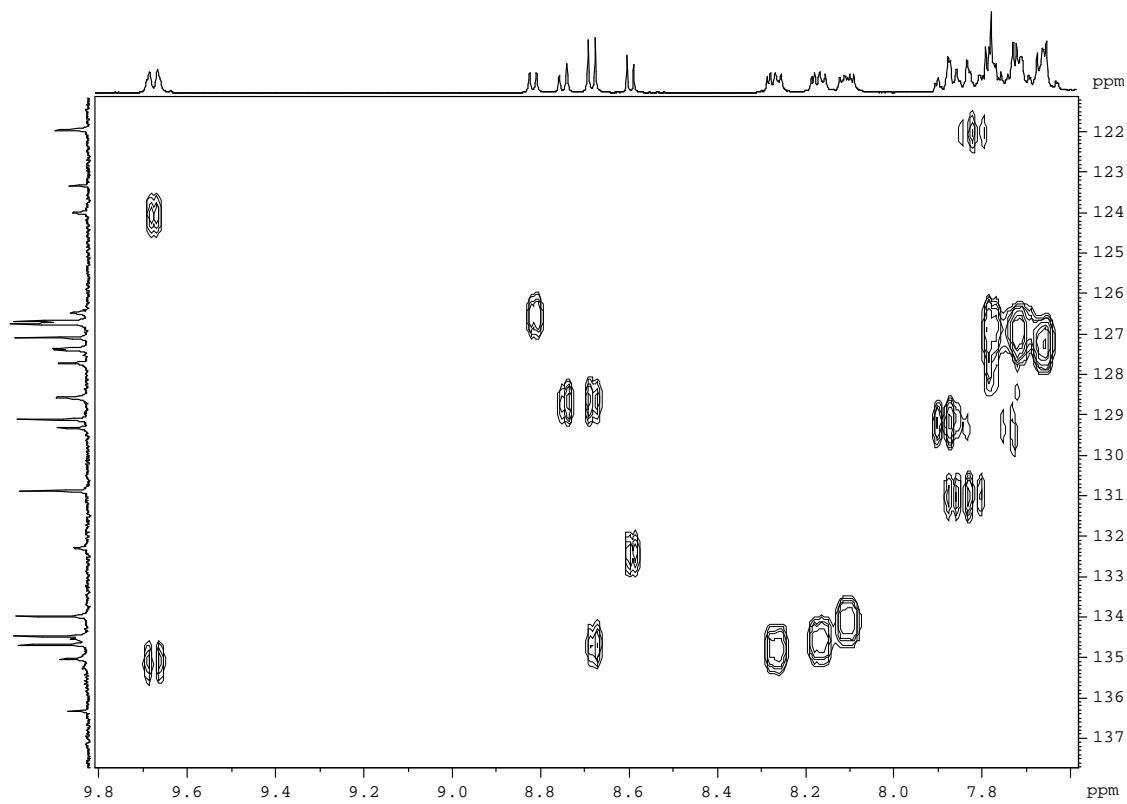
Figure S17. Partial <sup>13</sup>C NMR spectrum of compound **2a** prepared according to procedure *i*) (75 MHz).



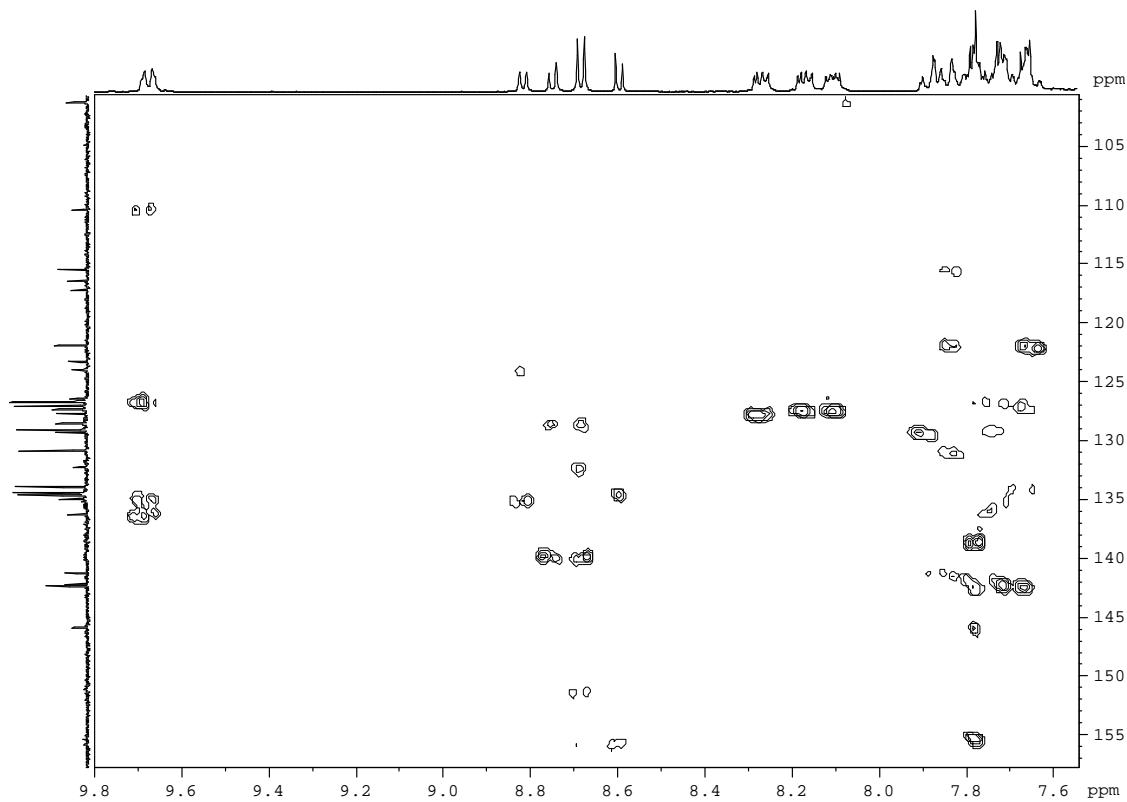
**Figure S18.** Partial COSY spectrum of compound **2a** prepared according to procedure *i*) (500 MHz).



**Figure S19.** Partial HSQC spectrum of compound **2a** prepared according to procedure *i*) (300 MHz).



**Figure S20.** Partial HSQC spectrum of compound **2a** prepared according to procedure *i*) (300 MHz).



**Figure S21.** Partial HMBC spectrum of compound **2a** prepared according to procedure *i*) (300 MHz).

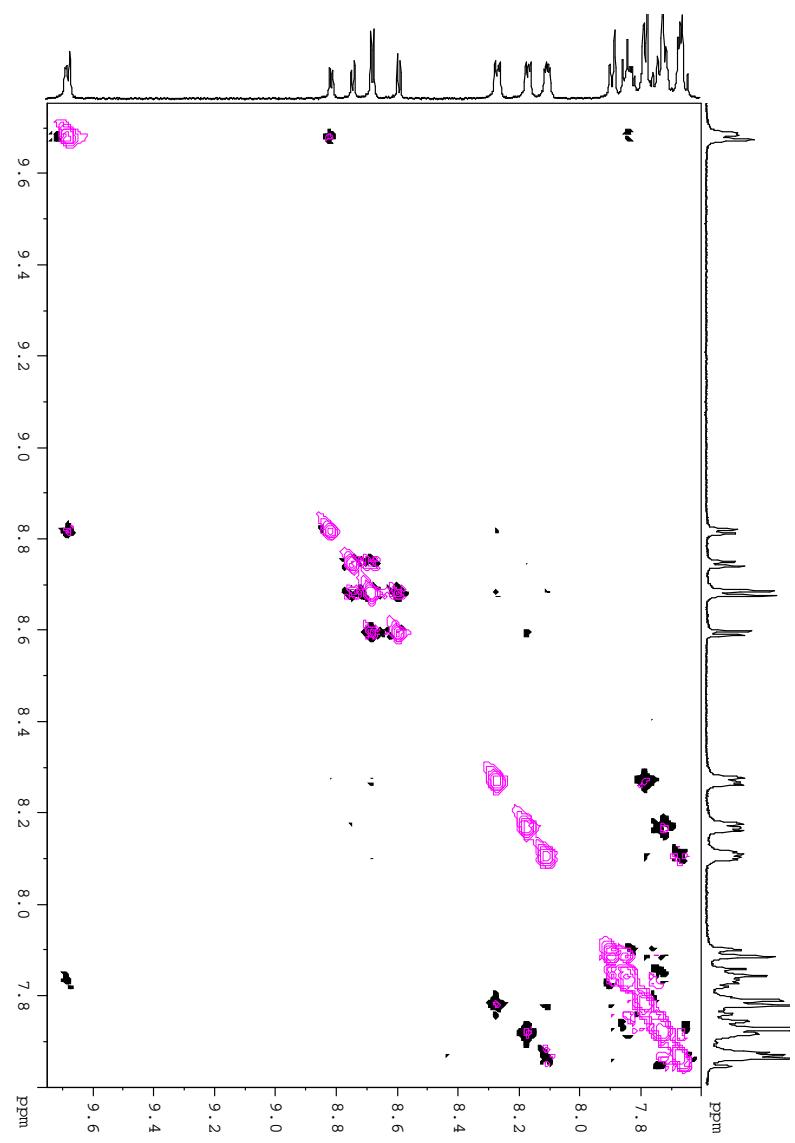


Figure S22. NOESY spectrum of compound **2a** prepared according to procedure *i*) (500 MHz).

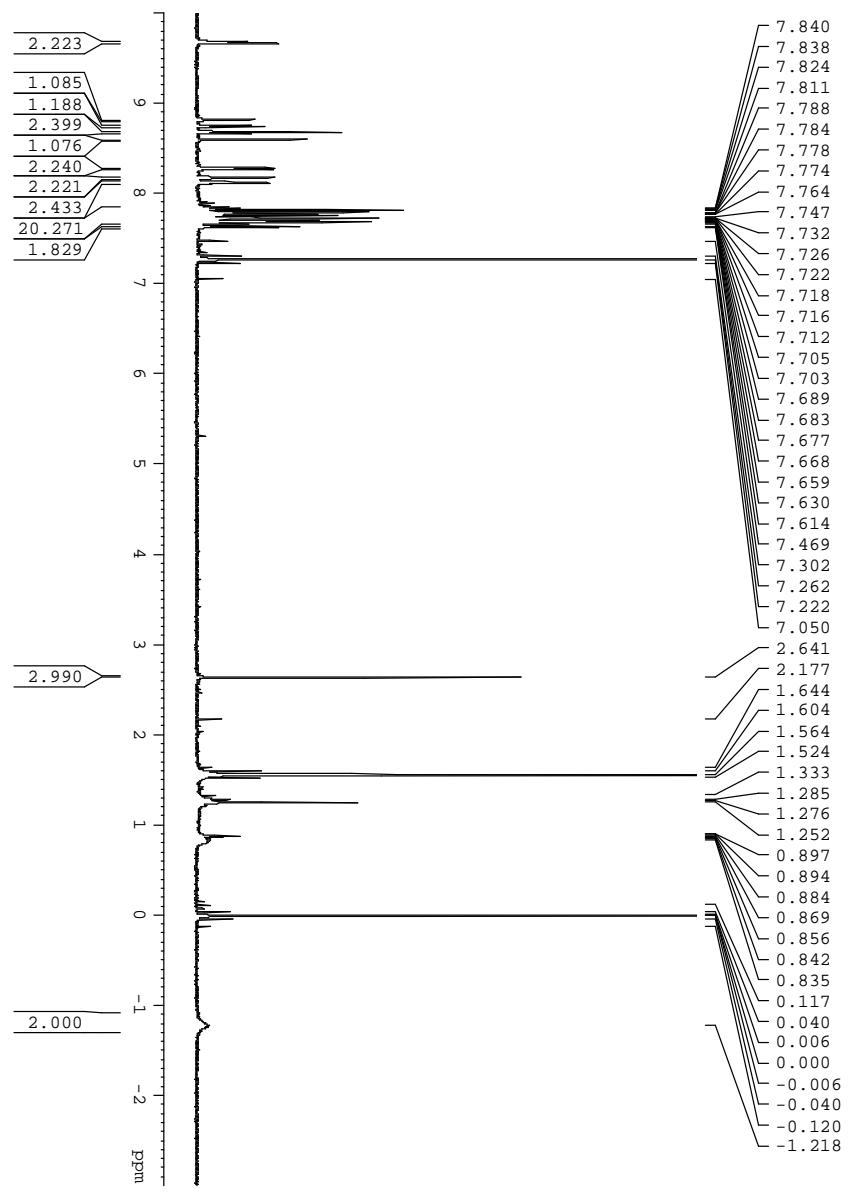
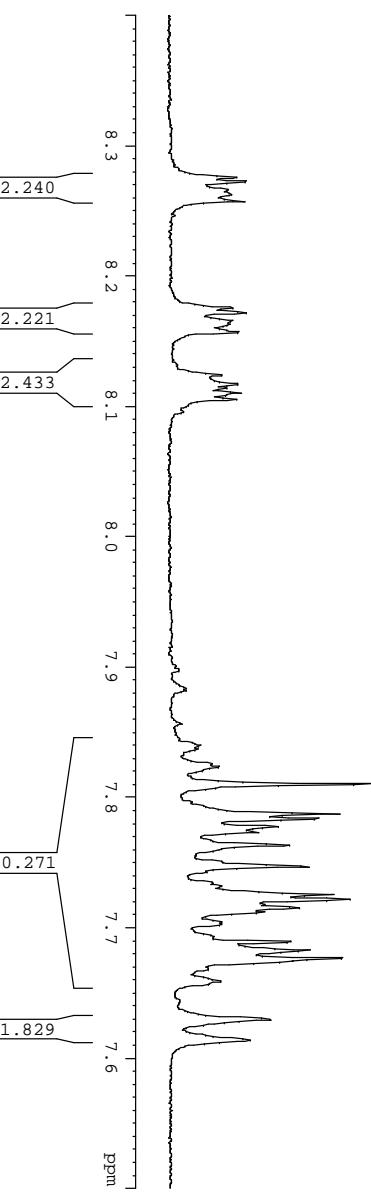
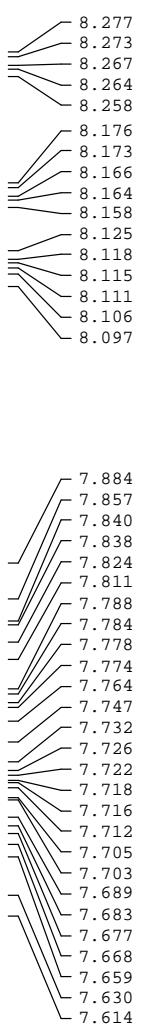
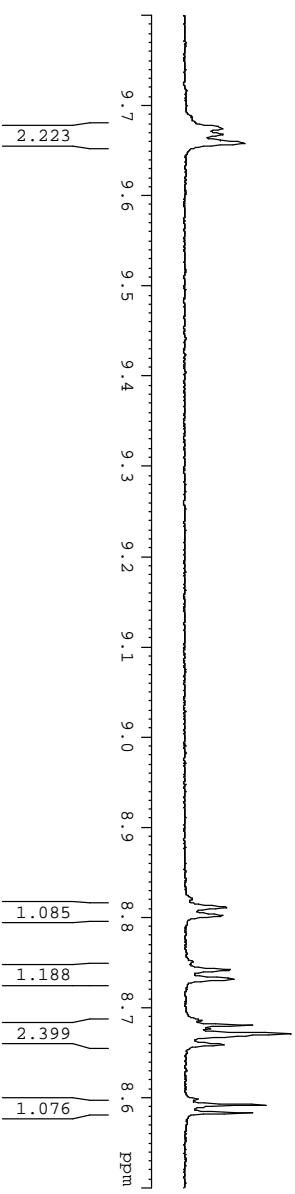


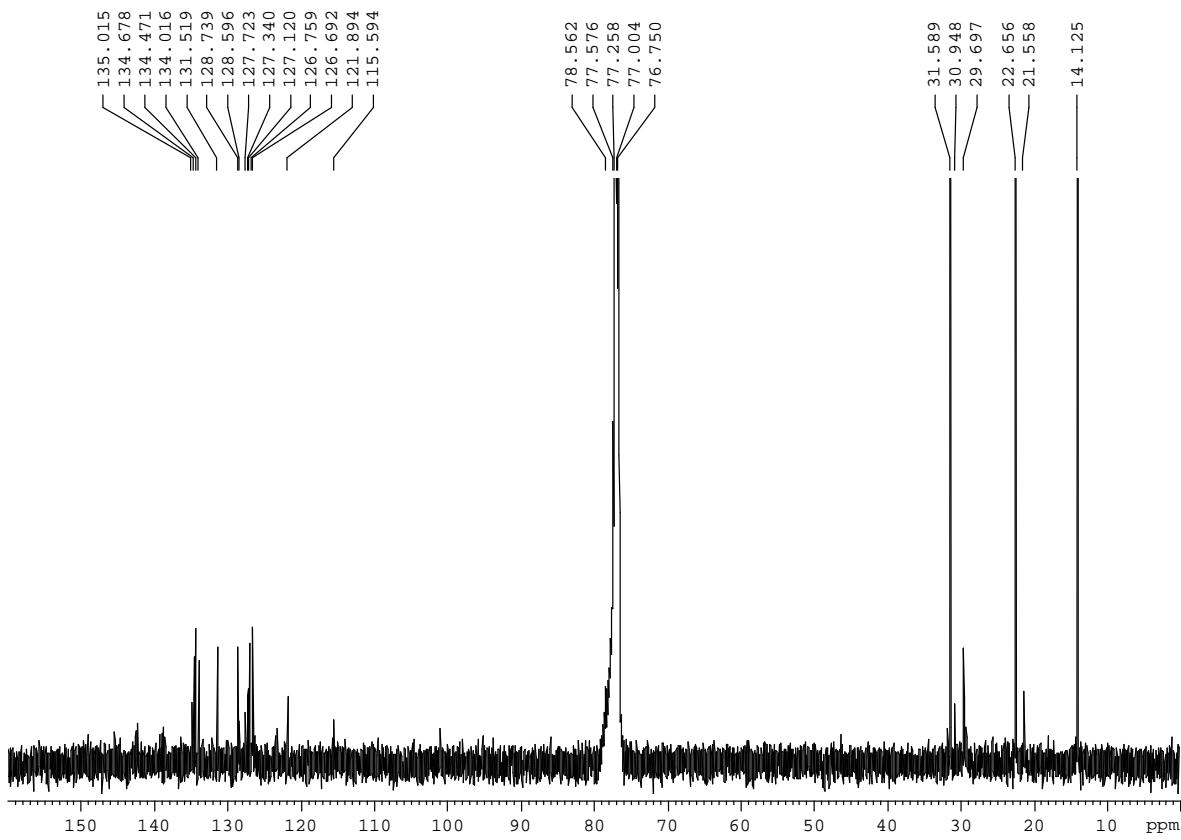
Figure S23.  $^1\text{H}$  NMR spectrum of compound **2b** prepared *via* thermal oxidative cyclization (500 MHz).



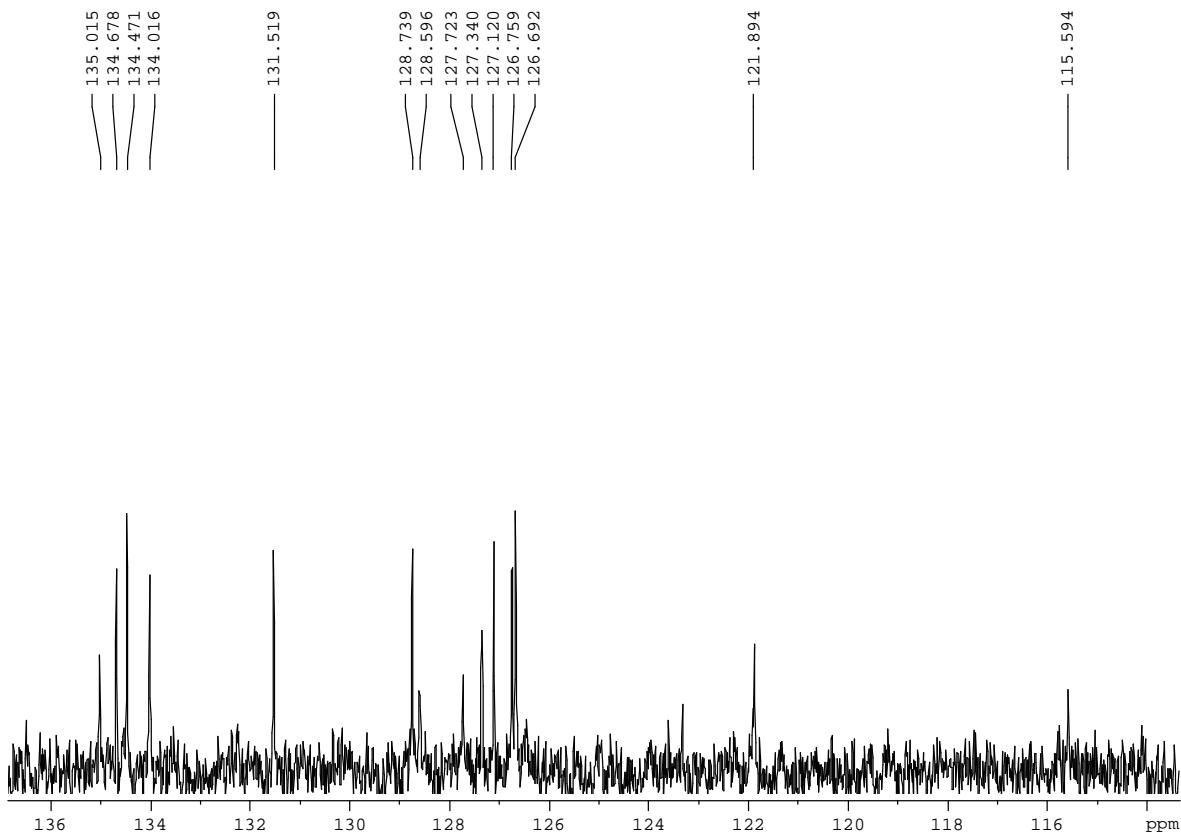
**Figure S24.** Partial  $^1\text{H}$  NMR spectrum of compound **2b** prepared *via* thermal oxidative cyclization (500 MHz).



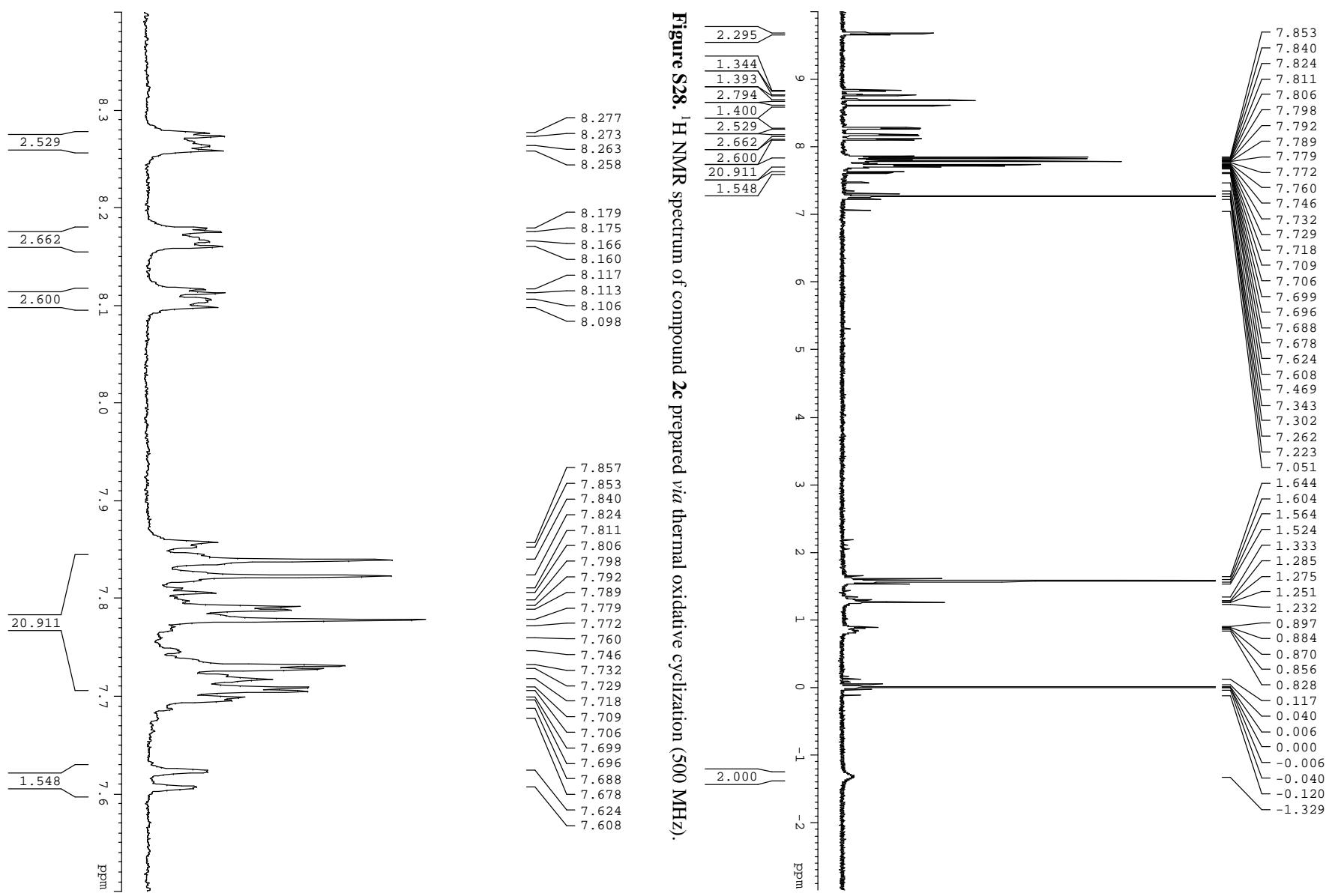
**Figure S25.** Partial  $^1\text{H}$  NMR spectrum of compound **2b** prepared *via* thermal oxidative cyclization (500 MHz).



**Figure S26.** <sup>13</sup>C NMR spectrum of compound **2b** prepared *via* thermal oxidative cyclization (125 MHz).

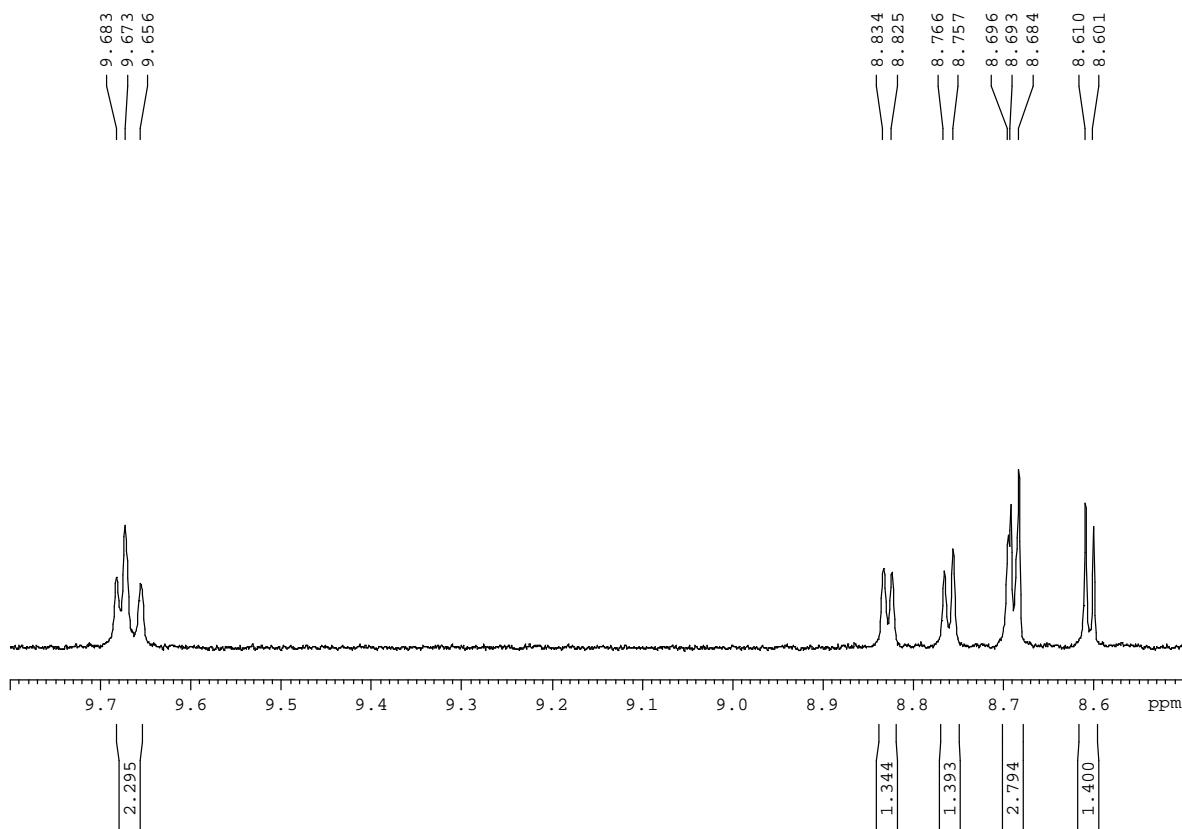


**Figure S27.** Partial <sup>13</sup>C NMR spectrum of compound **2b** prepared *via* thermal oxidative cyclization (125 MHz).

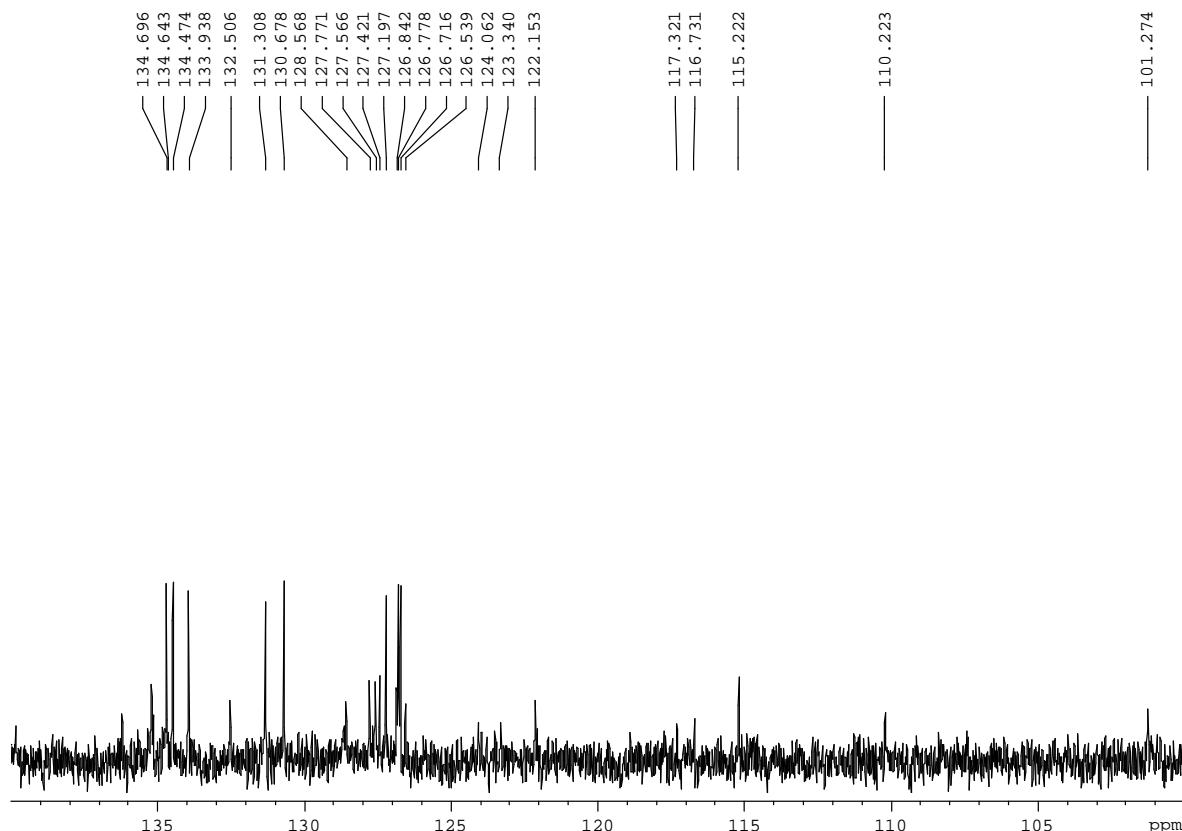


**Figure S28.** <sup>1</sup>H NMR spectrum of compound **2c** prepared via thermal oxidative cyclization (500 MHz).

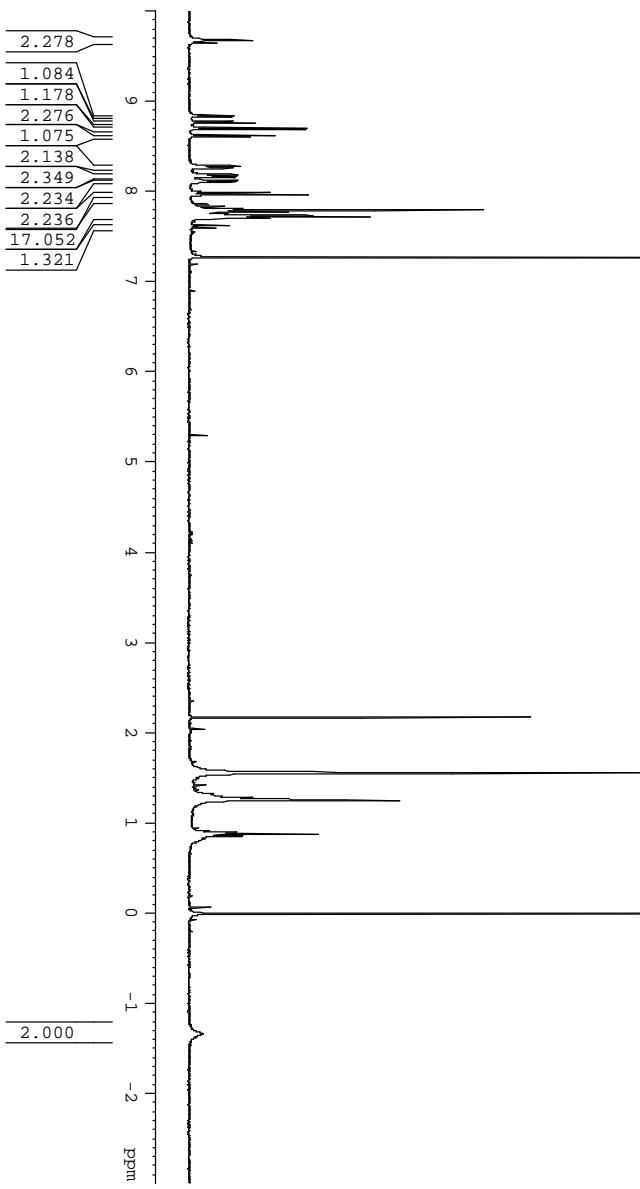
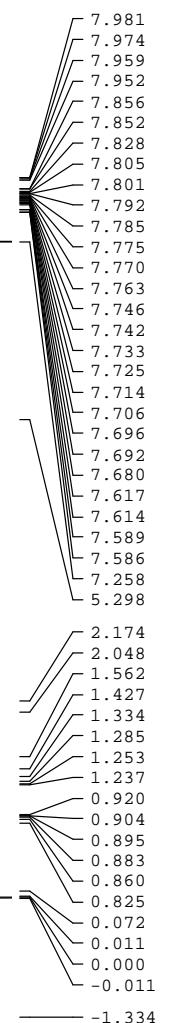
**Figure S29.** Partial <sup>1</sup>H NMR spectrum of compound **2c** prepared via thermal oxidative cyclization (500 MHz).



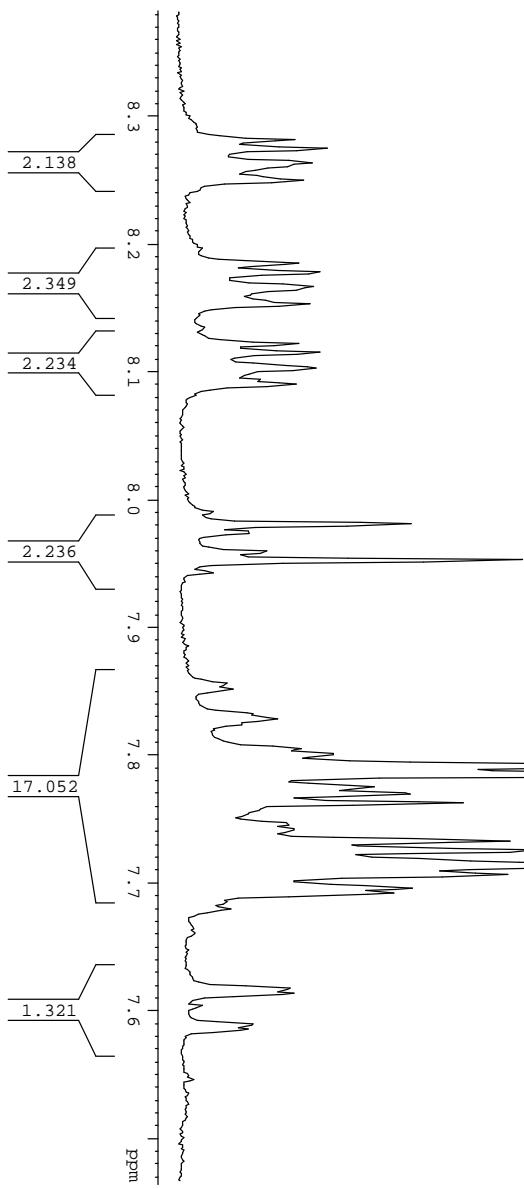
**Figure S30.** Partial  $^1\text{H}$  NMR spectrum of compound **2c** prepared *via* thermal oxidative cyclization (500 MHz).



**Figure S31.** Partial  $^{13}\text{C}$  NMR spectrum of compound **2c** prepared *via* thermal oxidative cyclization (125 MHz).



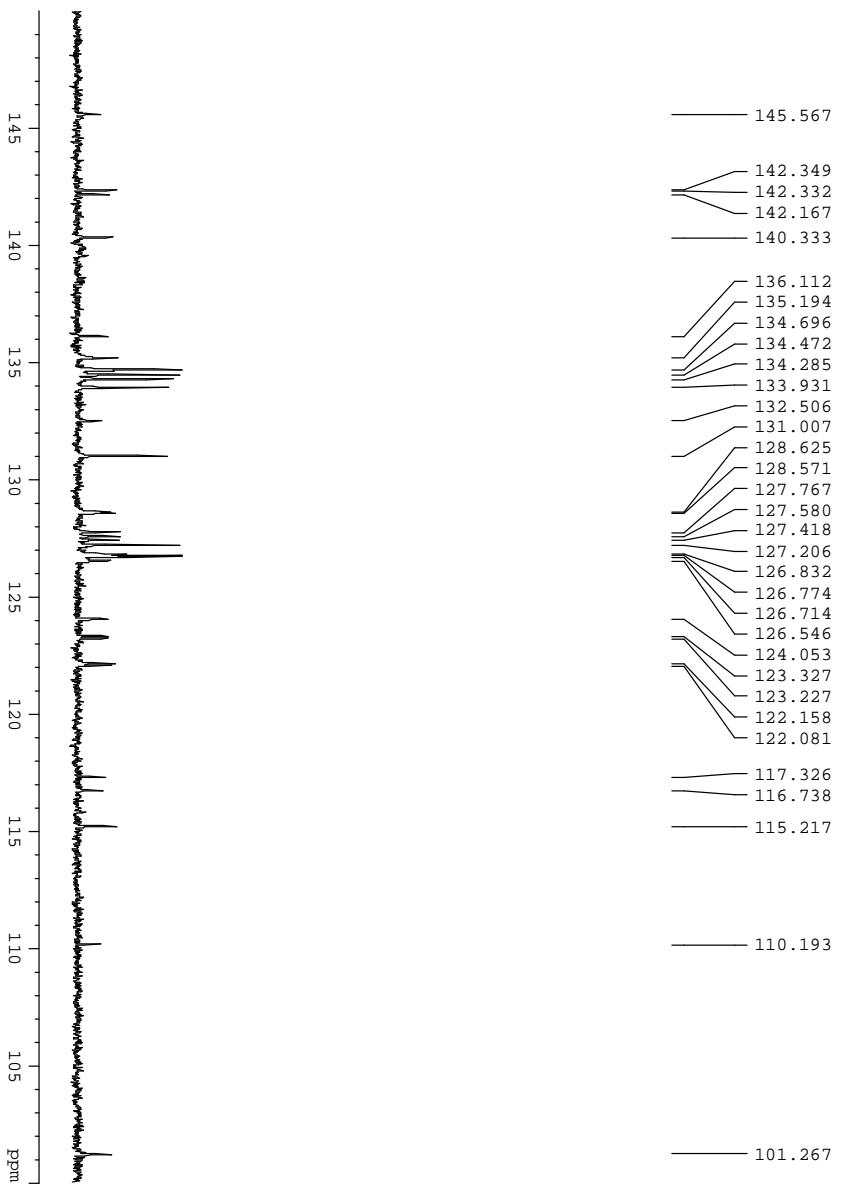
**Figure S32.**  $^1\text{H}$  NMR spectrum of compound **2d** prepared *via* thermal oxidative cyclization (300 MHz).



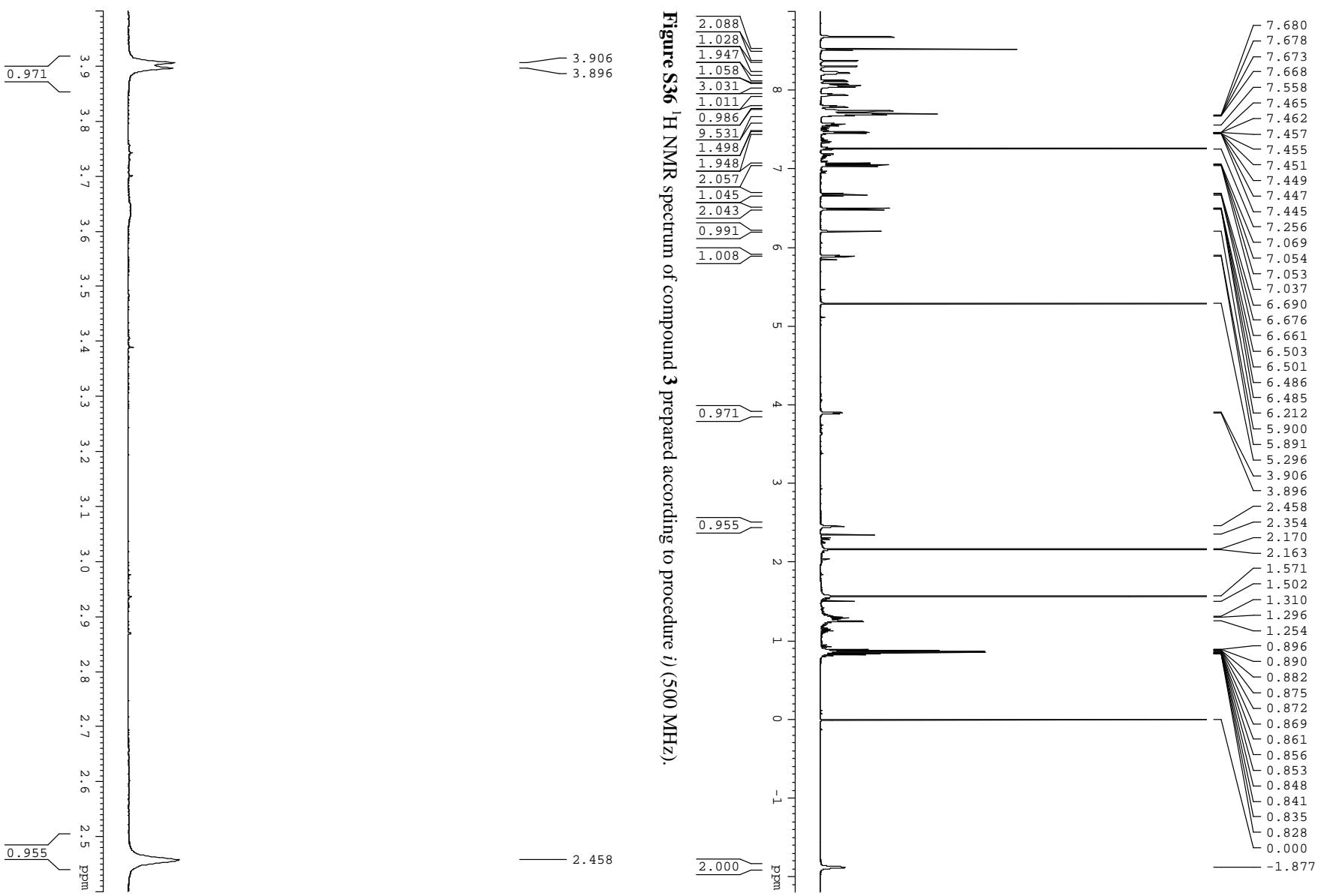
**Figure S33.** Partial  $^1\text{H}$  NMR spectrum of compound **2d** prepared *via* thermal oxidative cyclization (300 MHz).



**Figure S34.** Partial <sup>1</sup>H NMR spectrum of compound 2d prepared *via* thermal oxidative cyclization (300 MHz).

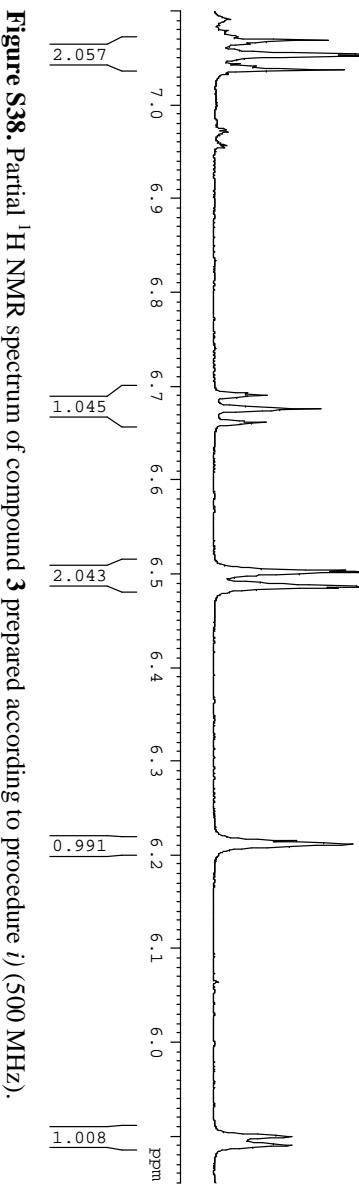
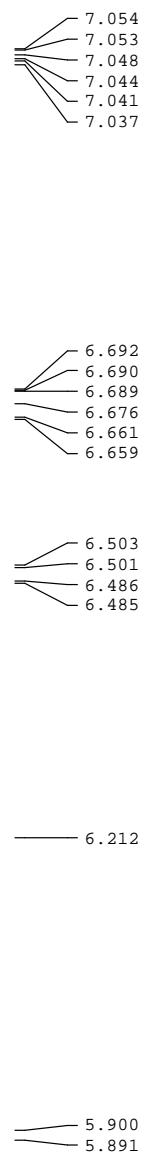


**Figure S35.** Partial <sup>13</sup>C NMR spectrum of compound 2d prepared *via* thermal oxidative cyclization (75 MHz).

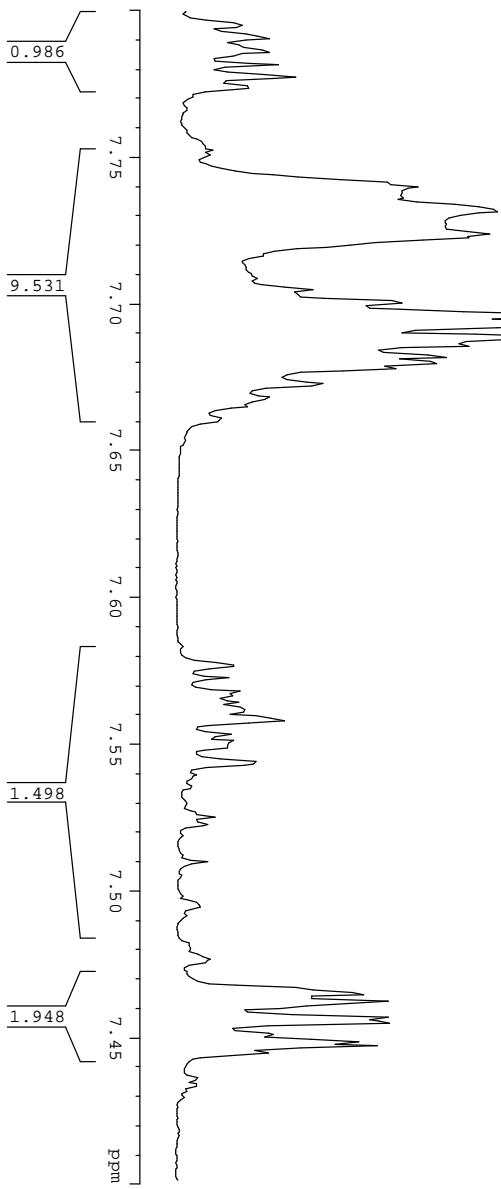


**Figure S36**  $^1\text{H}$  NMR spectrum of compound **3** prepared according to procedure *i*) (500 MHz).

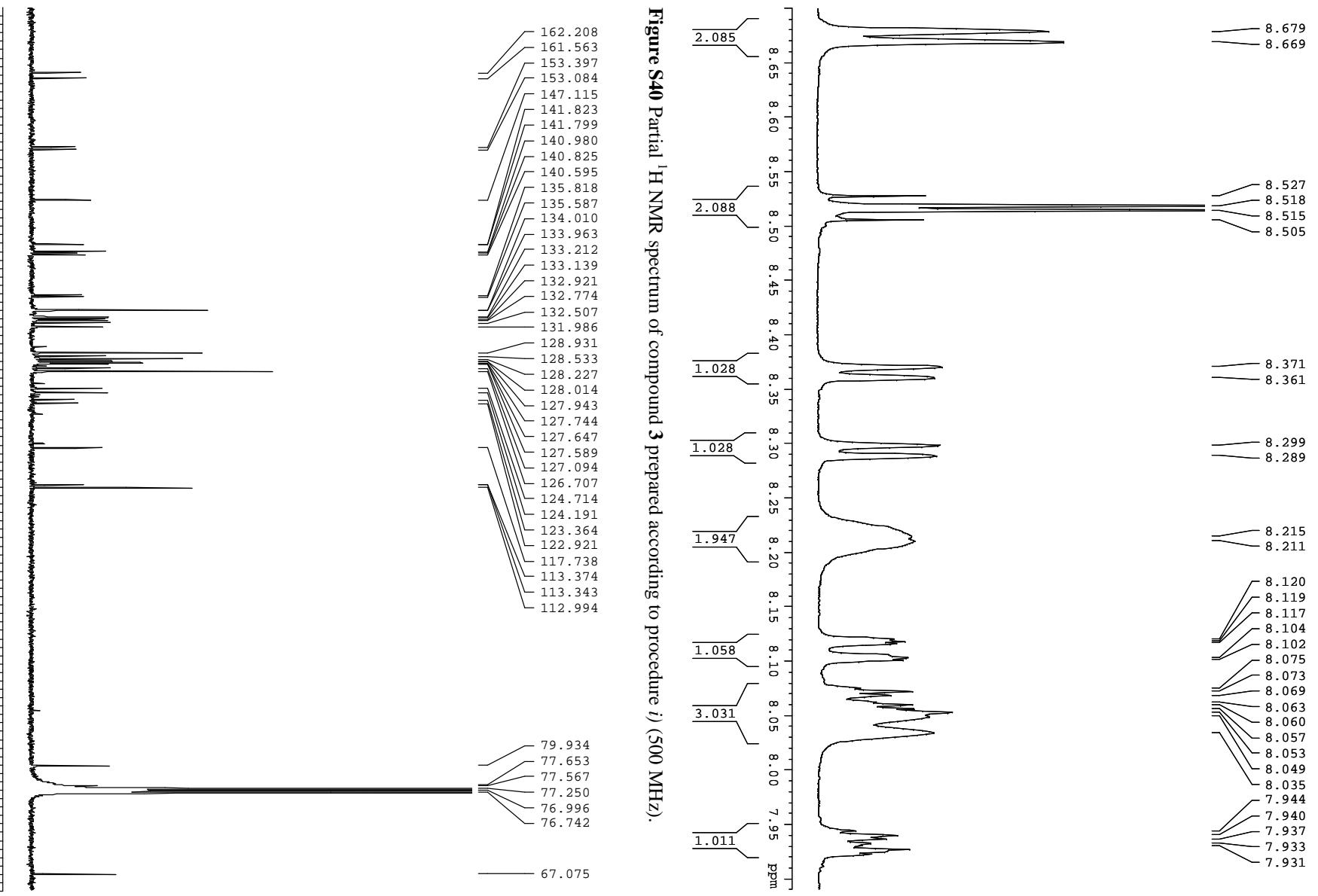
**Figure S37.** Partial  $^1\text{H}$  NMR spectrum of compound **3** prepared according to procedure *i*) (500 MHz).



**Figure S38.** Partial  $^1\text{H}$  NMR spectrum of compound 3 prepared according to procedure *i*) (500 MHz).

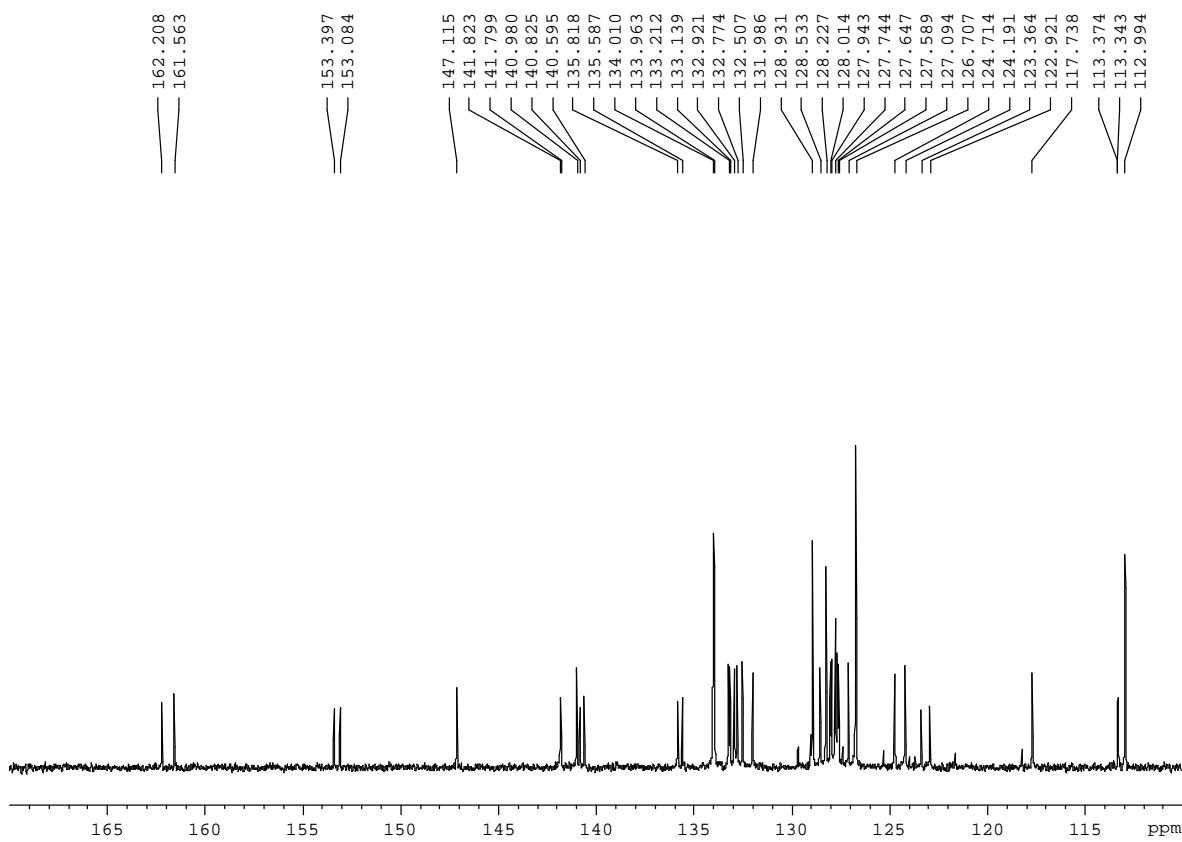


**Figure S39.** Partial  $^1\text{H}$  NMR spectrum of compound 3 prepared according to procedure *i*) (500 MHz).

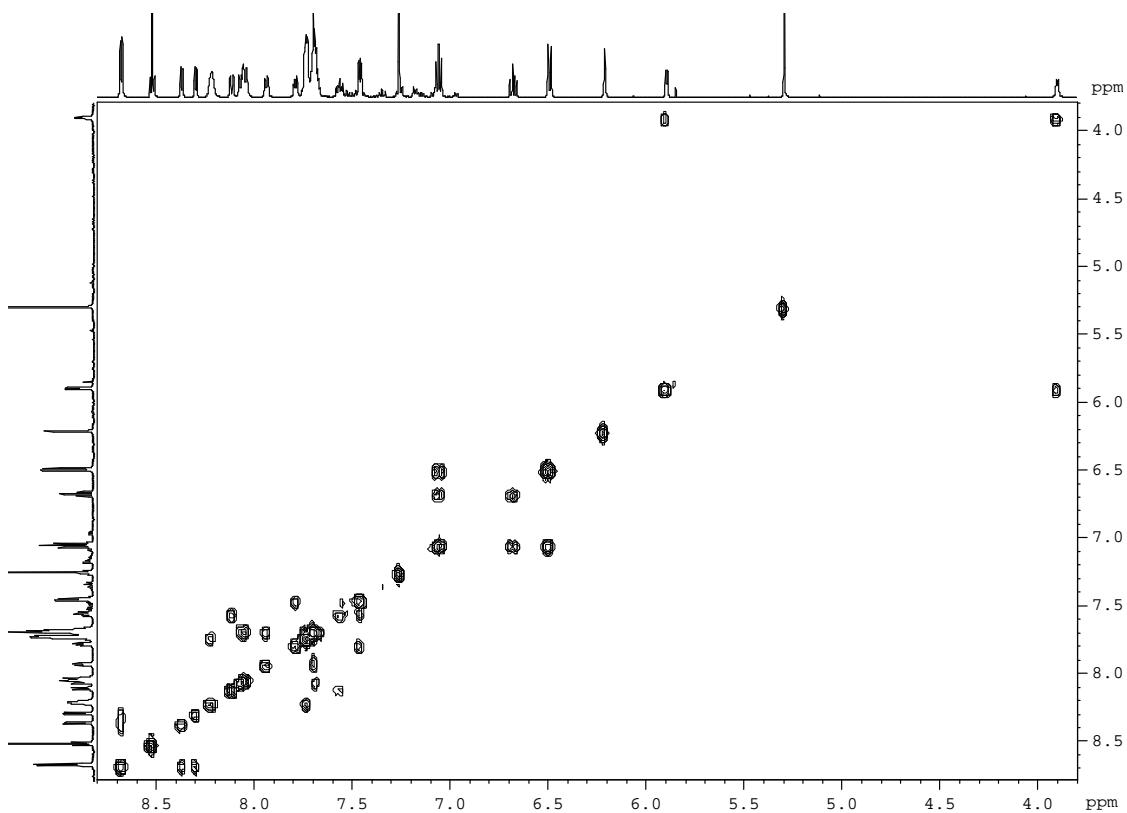


**Figure S40** Partial  $^1\text{H}$  NMR spectrum of compound 3 prepared according to procedure *i*) (500 MHz).

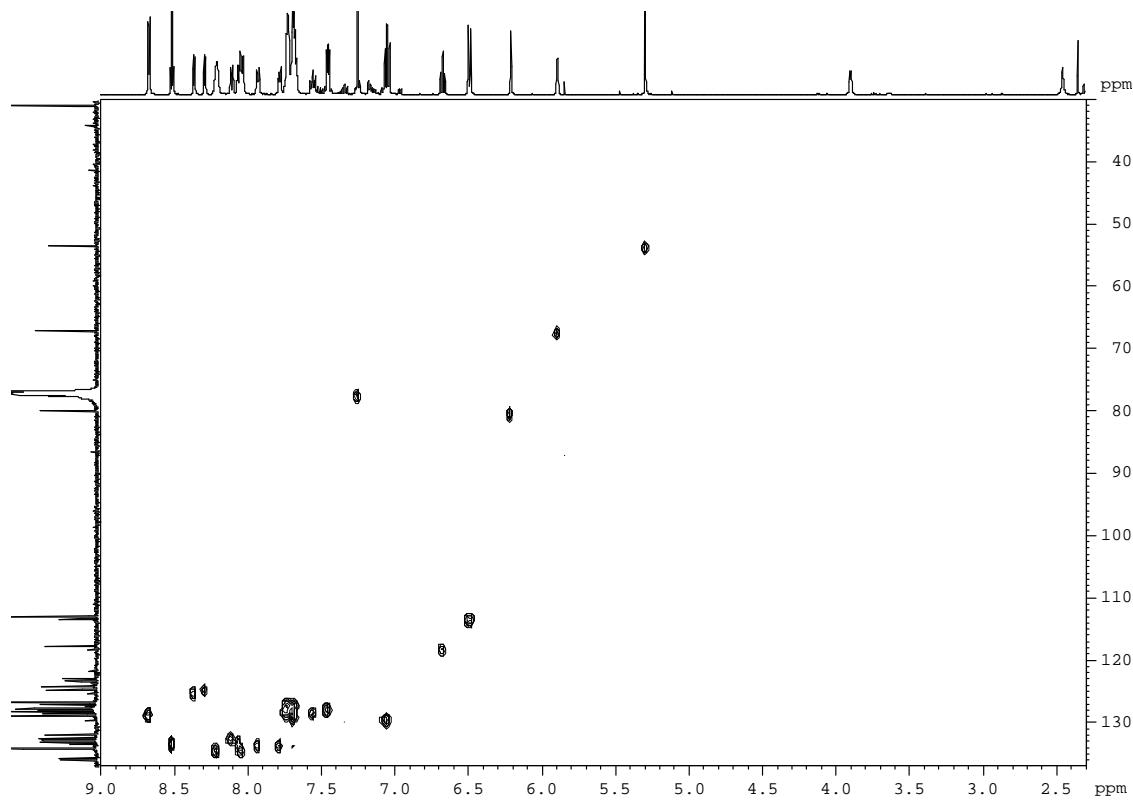
**Figure S41.**  $^{13}\text{C}$  NMR spectrum of compound 3 prepared according to procedure *i*) (125 MHz).



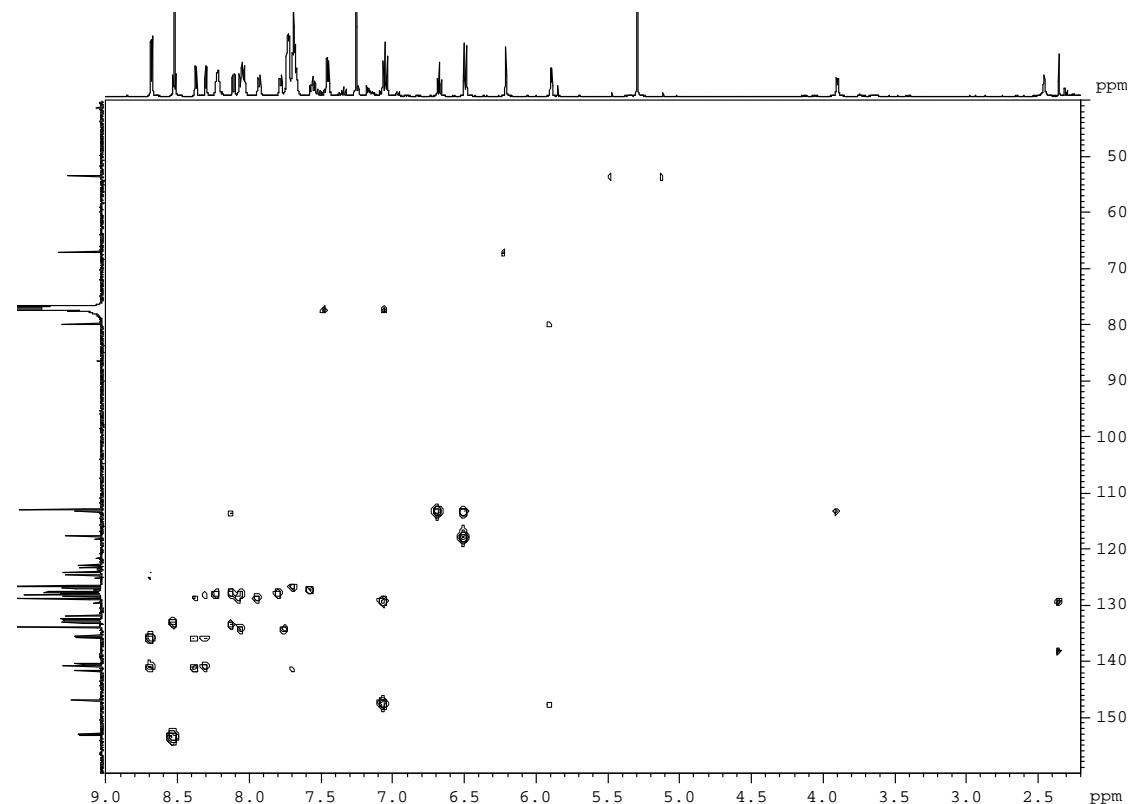
**Figure S42.** Partial  $^{13}\text{C}$  NMR spectrum of compound **3** prepared according to procedure *i*) (125 MHz).



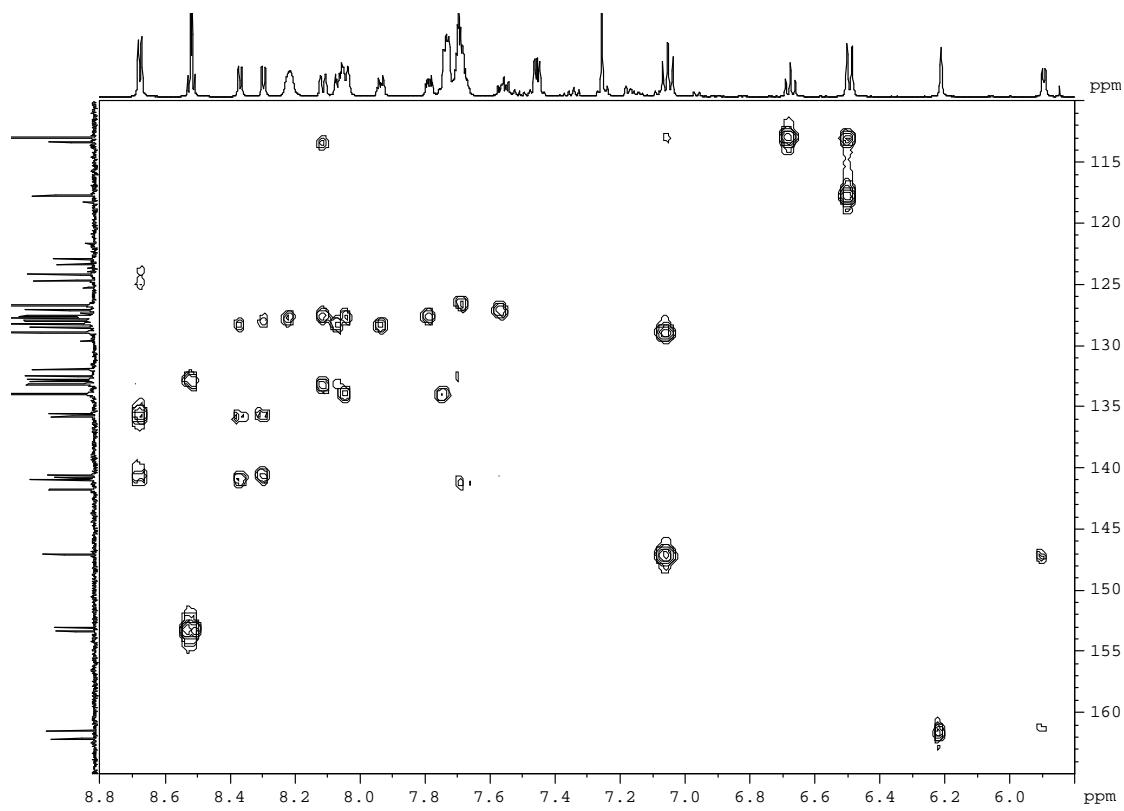
**Figure S43.** Partial COSY spectrum of compound **3** prepared according to procedure *i*) (500 MHz).



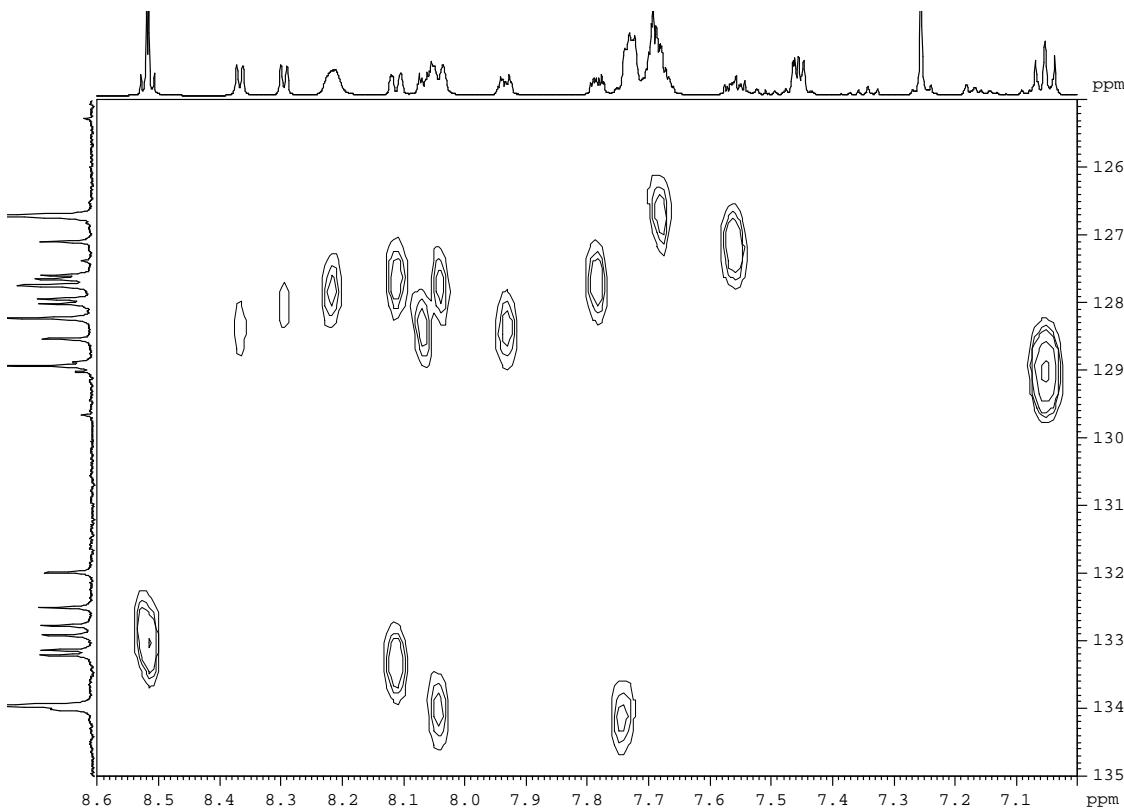
**Figure S44.** Partial HSQC spectrum of compound 3 prepared according to procedure *i*) (500 MHz).



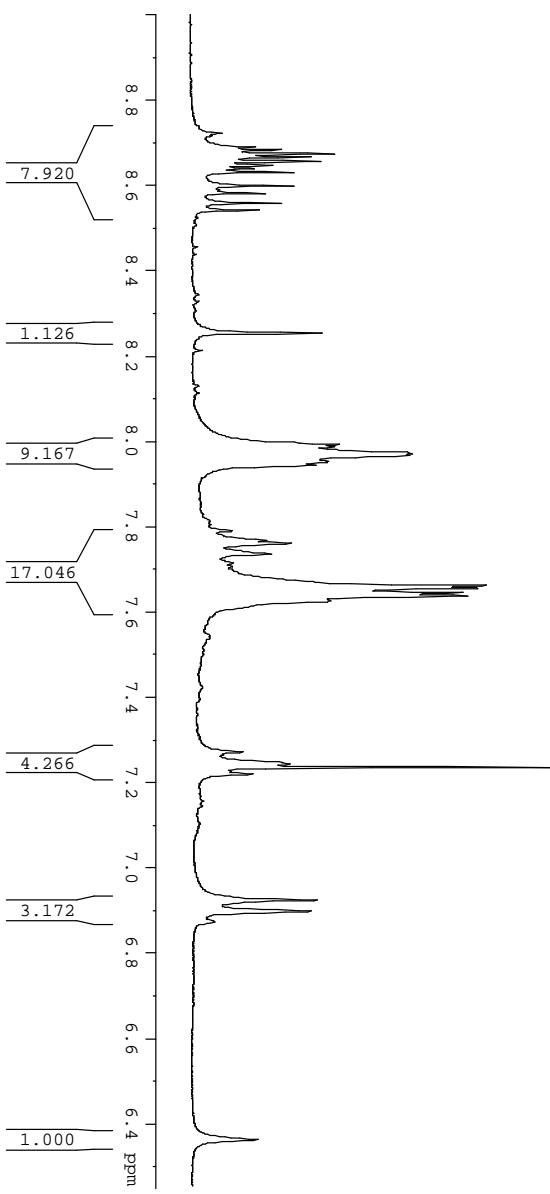
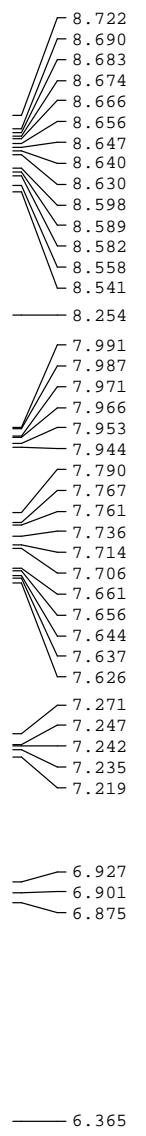
**Figure S45.** Partial HMBC spectrum of compound 3 prepared according to procedure *i*) (500 MHz).



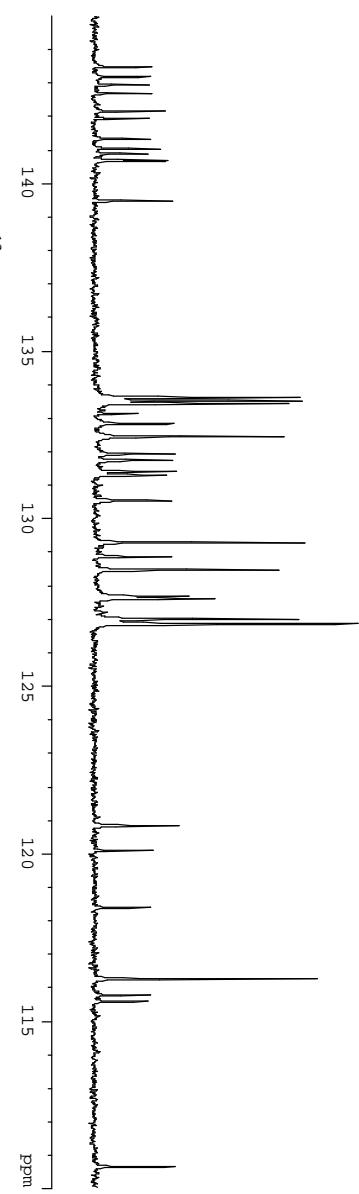
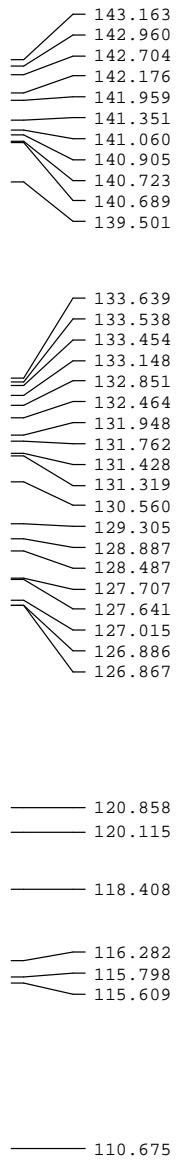
**Figure S46.** Partial HMBC spectrum of compound 3 prepared according to procedure *i*) (500 MHz).



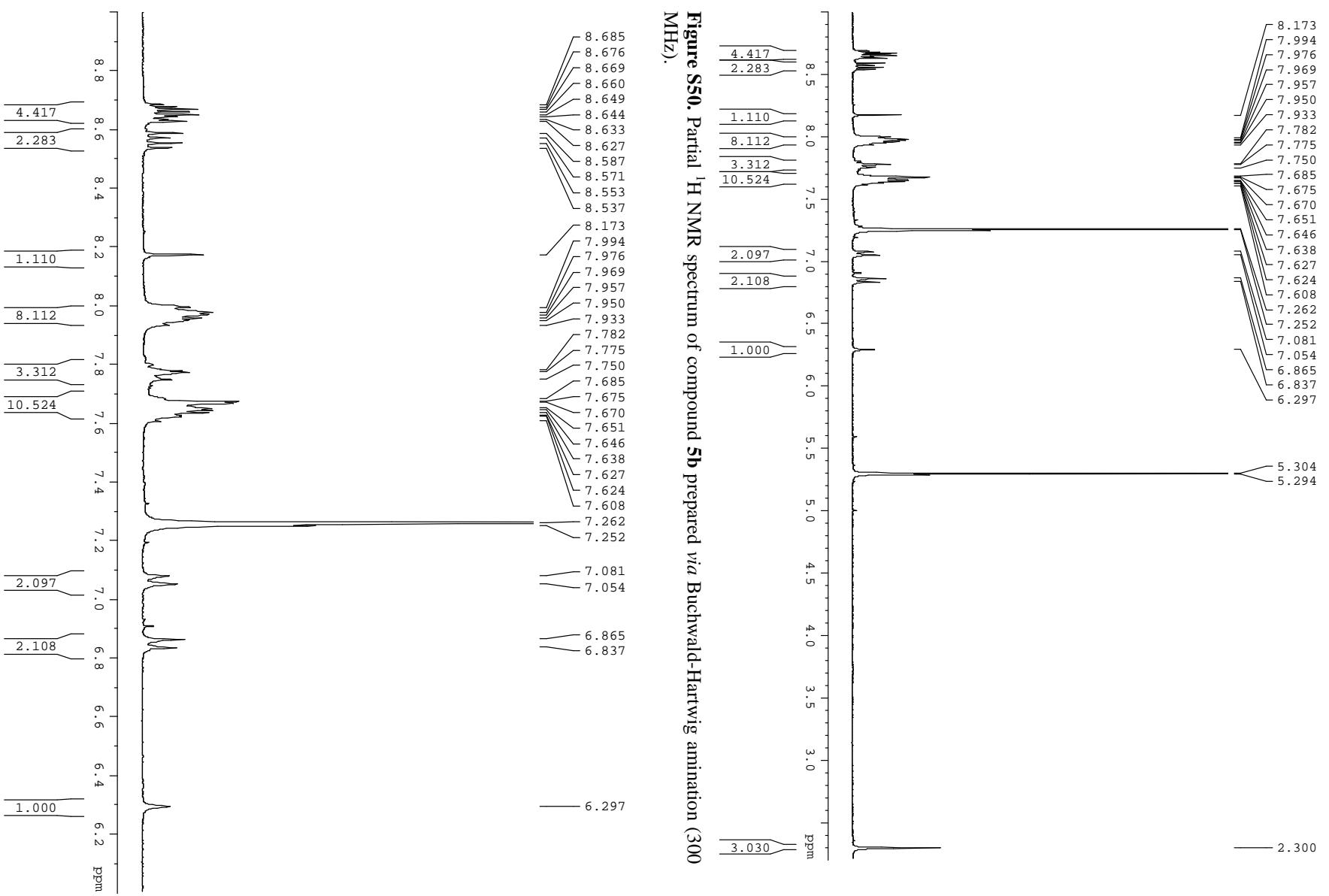
**Figure S47.** Partial HMBC spectrum of compound 3 prepared according to procedure *i*) (500 MHz).



**Figure S48** Partial <sup>1</sup>H NMR spectrum of compound **5a** prepared *via* Buchwald-Hartwig amination (300 MHz).

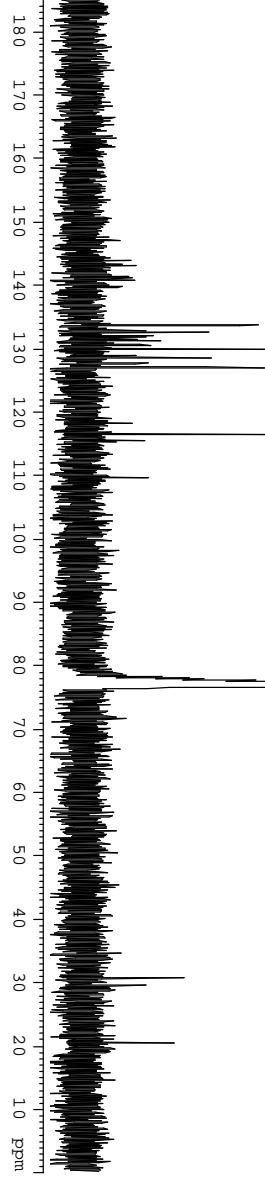
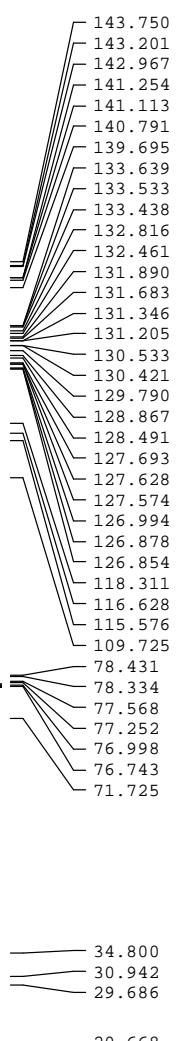


**Figure S49.** Partial <sup>13</sup>C NMR spectrum of compound **5a** prepared *via* Buchwald-Hartwig amination (75 MHz).

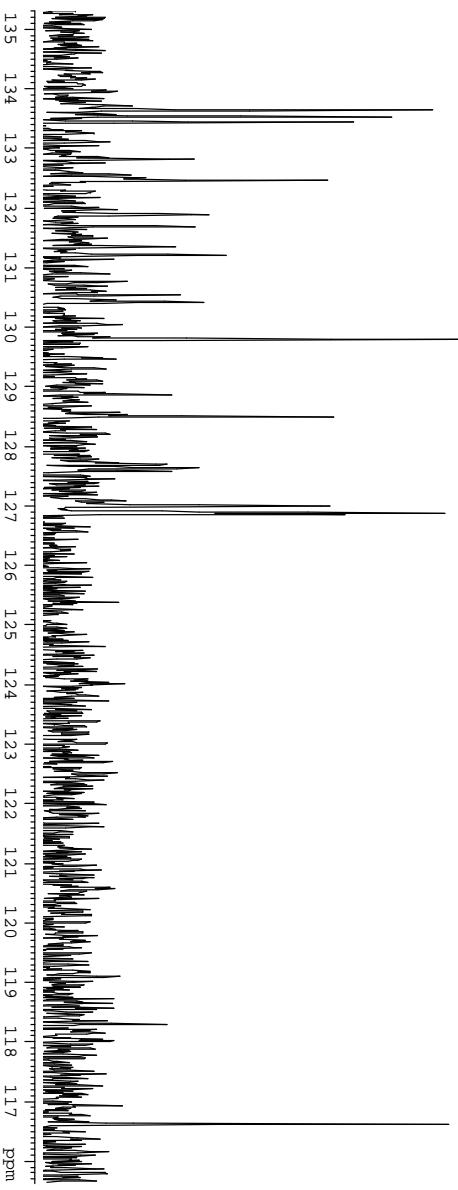
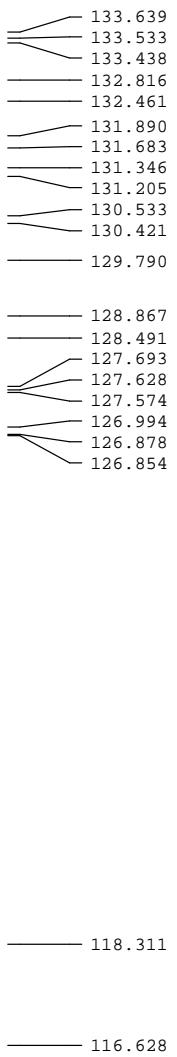


**Figure S50.** Partial  $^1\text{H}$  NMR spectrum of compound **5b** prepared *via* Buchwald-Hartwig amination (300 MHz).

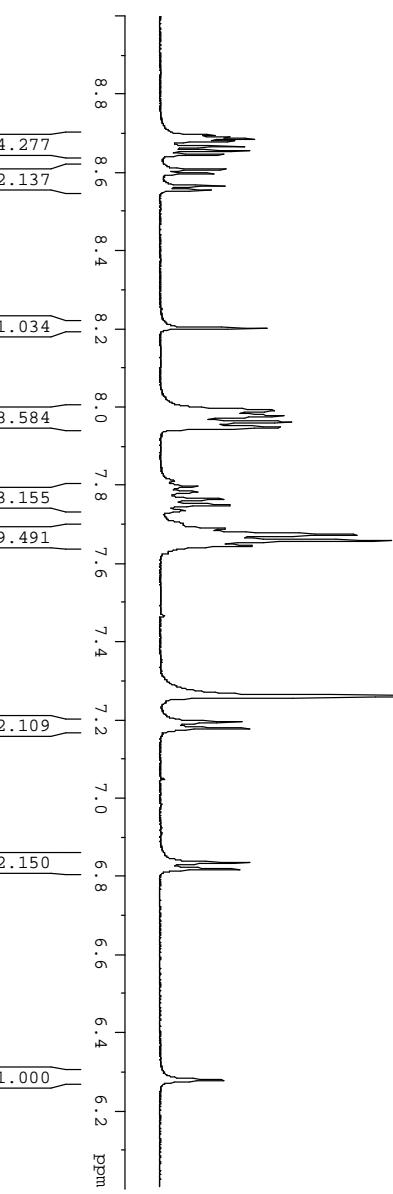
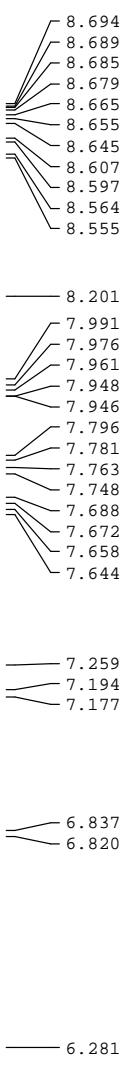
**Figure S51.** Partial  $^1\text{H}$  NMR spectrum of compound **5b** prepared *via* Buchwald-Hartwig amination (300 MHz).



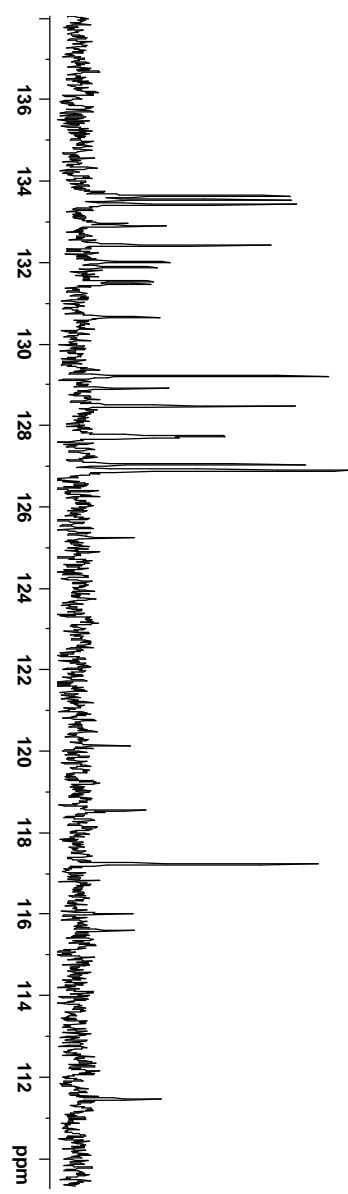
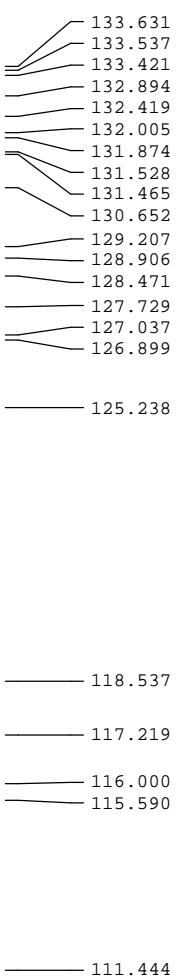
**Figure S52.** <sup>13</sup>C NMR spectrum of compound **5b** prepared via Buchwald-Hartwig amination (75 MHz).



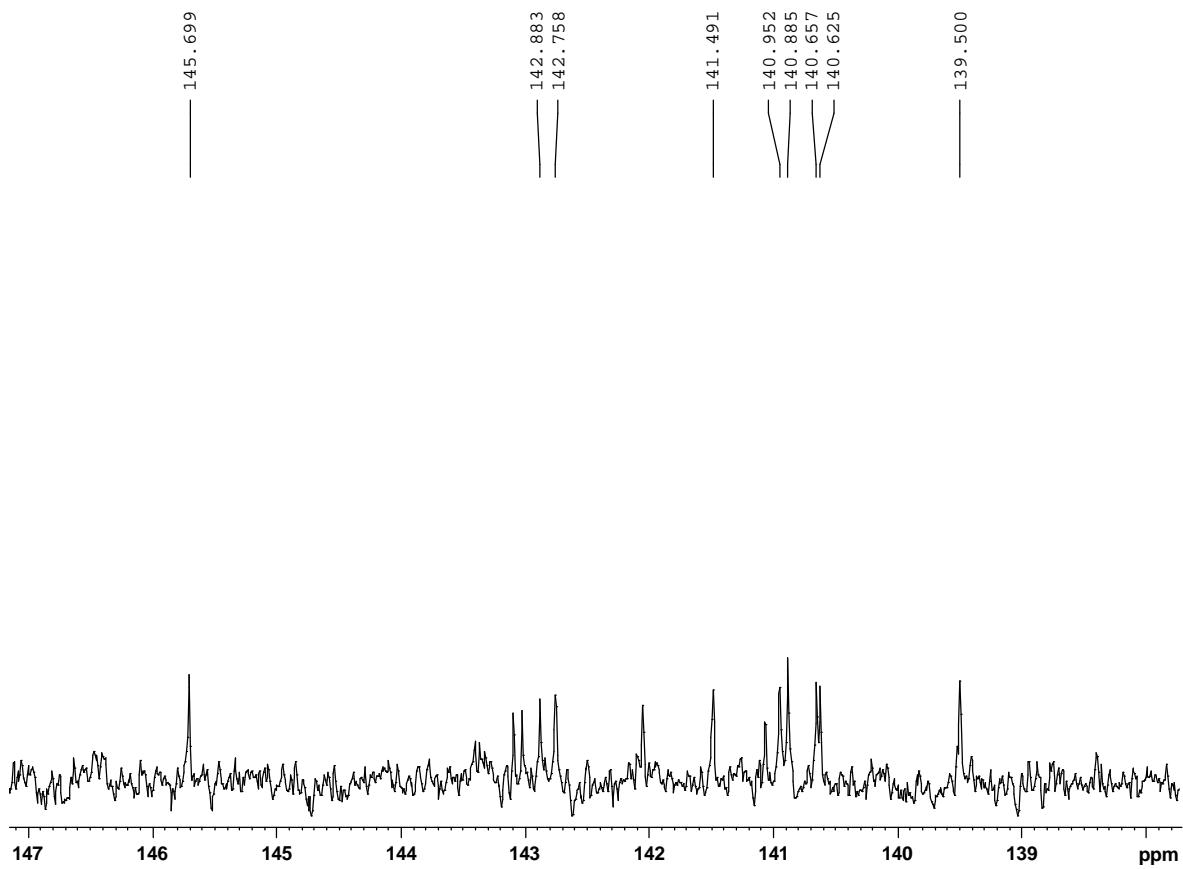
**Figure S53.** Partial <sup>13</sup>C NMR spectrum of compound **5b** prepared via Buchwald-Hartwig amination (75 MHz).



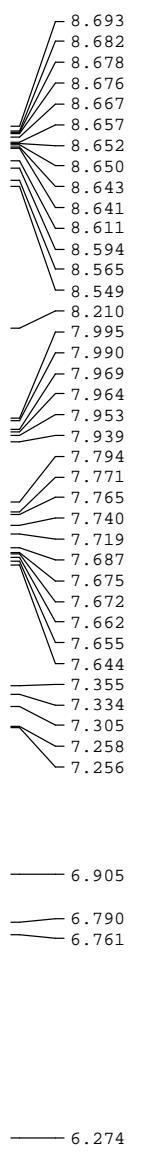
**Figure S54.** Partial <sup>1</sup>H NMR spectrum of compound 5c prepared via Buchwald-Hartwig amination (500 MHz).



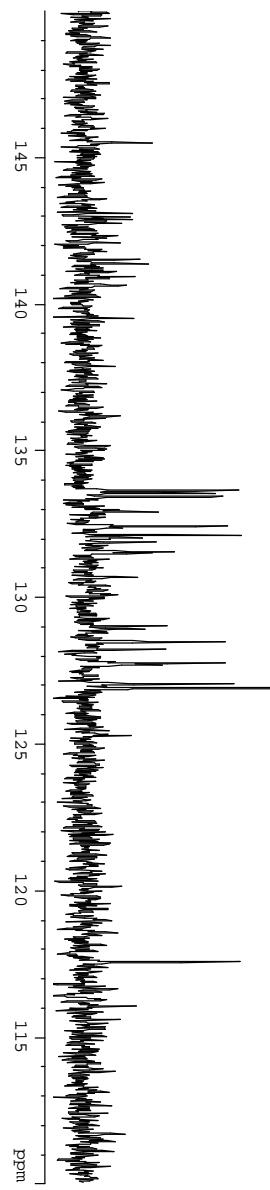
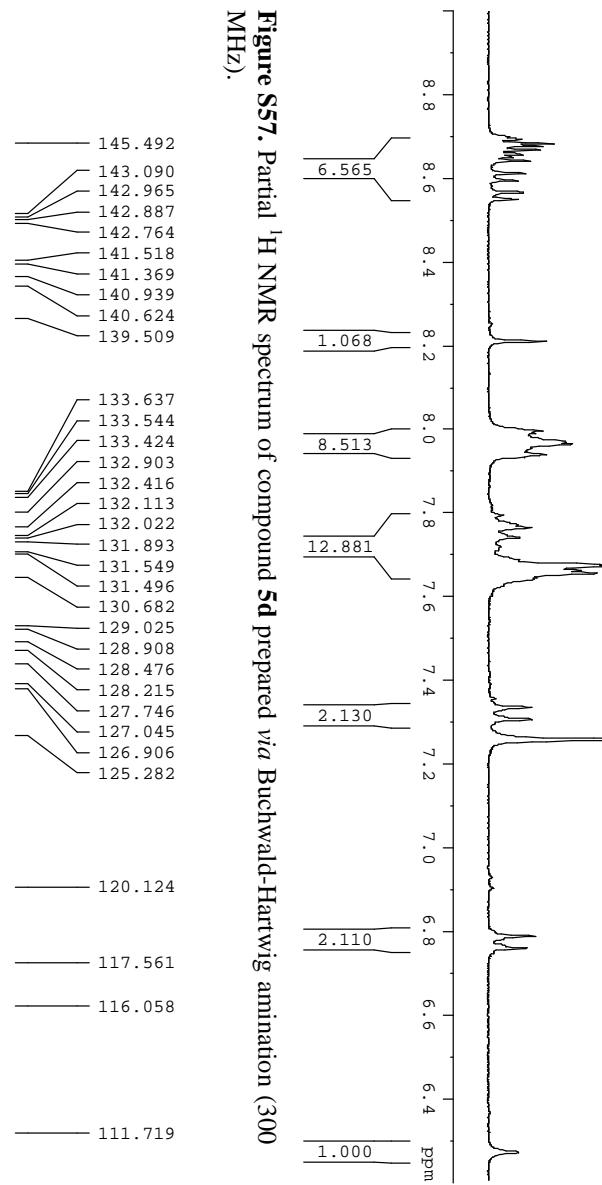
**Figure S55.** Partial <sup>13</sup>C NMR spectrum of compound 5c prepared via Buchwald-Hartwig amination (125 MHz).



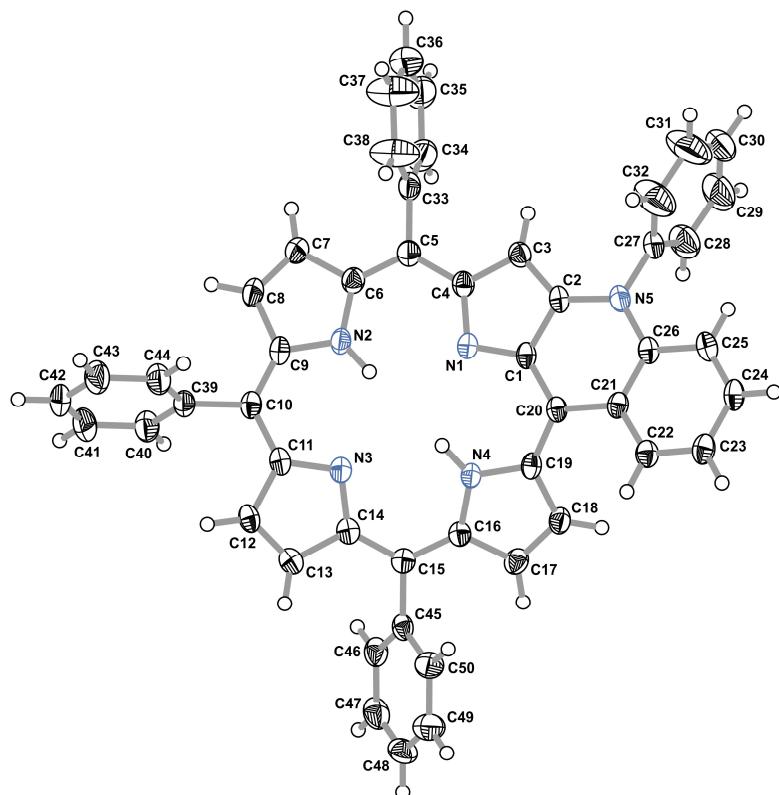
**Figure S56.** Partial <sup>13</sup>C NMR spectrum of compound **5c** prepared via Buchwald-Hartwig amination (125 MHz).



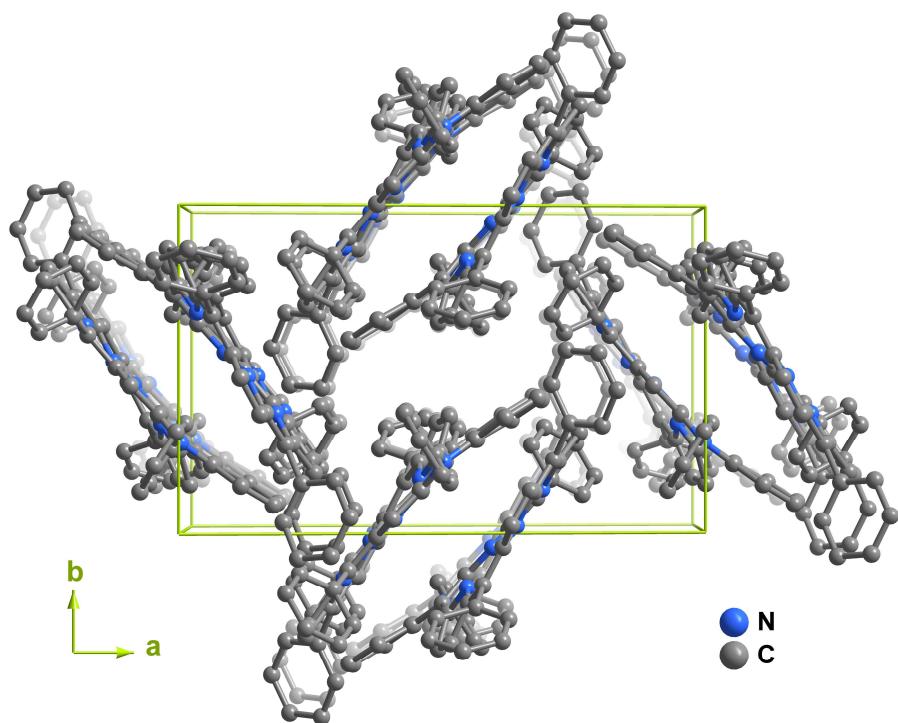
**Figure S57.** Partial <sup>1</sup>H NMR spectrum of compound **5d** prepared via Buchwald-Hartwig amination (300 MHz).



**Figure S58.** Partial <sup>13</sup>C NMR spectrum of compound **5d** prepared via Buchwald-Hartwig amination (75 MHz).



**Figure S59.** Schematic representation of the molecular unit of compound **2a** showing the labelling scheme for all non-hydrogen atoms. Thermal ellipsoids are drawn at the 50% probability level and hydrogen atoms are represented as small spheres with arbitrary radii.



**Figure S60.** Crystal packing of compound **2a** viewed in perspective along the [001] crystallographic direction. Hydrogen atoms have been omitted for the sake of clarity.

**Table S1.** Crystal and structure refinement data for compound **2a**.

Formula	C <sub>50</sub> H <sub>33</sub> N <sub>5</sub>
Formula weight	703.81
Crystal system	Monoclinic
Space group	P2 <sub>1</sub> /n
a/Å	17.7092(7)
b/Å	10.6971(3)
c/Å	19.5954(7)
β/°	104.6350(10)
Volume/Å <sup>3</sup>	3591.7(2)
Z	4
D <sub>c</sub> /g cm <sup>-3</sup>	1.302
μ(Mo-Kα)/mm <sup>-1</sup>	0.077
F(000)	1472
Crystal size/mm	0.20×0.08×0.04
Crystal type	Brown prisms
θ range	3.59 to 24.71
Index ranges	-20 ≤ h ≤ 20 -12 ≤ k ≤ 11 -22 ≤ l ≤ 22
Reflections collected	77784
Independent reflections	6113 ( <i>R</i> <sub>int</sub> = 0.0819)
Completeness to θ = 24.71°	99.7%
Final <i>R</i> indices [I>2σ(I)] <sup>a,b</sup>	<i>R</i> 1 = 0.0455 <i>wR</i> 2 = 0.0966
Final <i>R</i> indices (all data) <sup>a,b</sup>	<i>R</i> 1 = 0.0867 <i>wR</i> 2 = 0.1151
Weighting scheme <sup>c</sup>	<i>m</i> = 0.0459 <i>n</i> = 1.6643
Largest diff. peak and hole	0.272 and -0.230 eÅ <sup>-3</sup>

$$^a R1 = \sum |F_o| - |F_c| / \sum |F_o|; ^b wR2 = \sqrt{\sum [w(F_o^2 - F_c^2)^2] / \sum [w(F_o^2)^2]}$$

$$^c w = 1 / [\sigma^2(F_o^2) + (mP)^2 + nP] \text{ where } P = (F_o^2 + 2F_c^2)/3$$

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