

# Ambient Temperature Nitrogen Directed Difluoroalkynylborane Carboni-Lindsey Cycloaddition Reactions

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## General Procedures

Cycloaddition reactions were conducted in non flame-dried glassware open to air unless otherwise specified. Flash chromatography was performed on silica gel (Fluorochem Davisil silica gel 43-60 or Fischer Scientific Florisil<sup>®</sup> general purpose grade). Thin layer chromatography was performed on aluminium backed plates pre-coated with silica (0.2 mm, Merck DC-alufolien Kieselgel 60 F254) and were developed using standard visualizing agents: Ultraviolet light or potassium permanganate.

<sup>1</sup>H/<sup>13</sup>C NMR spectra were recorded on Bruker AC-250 or AV1-250 instruments or AMX-400 or AV1-400 instruments or DRX-500 instrument. <sup>1</sup>H: Chemical shifts are reported in ppm with the solvent resonance as the internal standard (CHCl<sub>3</sub>: δ 7.27 ppm). Data are reported as follows: chemical shift, multiplicity (s=singlet, d=doublet, t=triplet, q=quartet, br=broad, m=multiplet), integration, coupling constants (*J*) in Hz, and assignment. <sup>13</sup>C NMR spectra were acquired with complete proton decoupling. Chemical shifts are reported in ppm with the solvent resonance as the internal standard (CDCl<sub>3</sub>: δ 77.0 ppm). Infrared (FTIR) spectra were recorded on a Perkin Elmer Paragon 100 FTIR spectrophotometer, 1 max in cm<sup>-1</sup>. Bands are characterized as broad (br), strong (s), medium (m) and weak (w). Samples were recorded as thin films using sodium chloride plates as a DCM solution. Low resolution mass spectra were recorded on Micromass Autospec operating in E.I mode. High-resolution mass spectra (HRMS) recorded for accurate mass analysis, were performed on either a MicroMass LCT operating in Electrospray mode (TOF ES+ or ES-) or a MicroMass Autospec operating in EI (EI+) mode. Melting points were performed on recrystallised solids and recorded on a Gallenkamp melting point apparatus and are uncorrected. All solvents and reagents were purified using standard laboratory techniques according to methods published in "Purification of Laboratory Chemicals" by Perrin, Armarego, and Perrin (Pergamon Press, 1966). Potassium alkynyltrifluoroborates,<sup>1</sup> tetrazines<sup>2</sup> and triazine<sup>3</sup> were prepared according to literature procedures or were purchased from commercial sources.

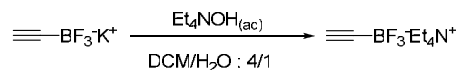
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<sup>1</sup> a) Molander, G.; Katona, B.W.; Machrouhi, F. *J. Org. Chem.* **2002**, *67*, 8416. b) Yamamoto, Y.; Hattori, K.; Ishii, J.; Nishiyama, H. *Tetrahedron*. **2006**, *62*, 4294.

<sup>2</sup> a) Boger, D.; Coleman, R.S.; Panek, J. S.; Huber, F.X.; Sauer, J. *J. Org. Chem.* **1985**, *50*, 5377. b) Coburn, M.D.; Buntain, G.A.; Harris, B.W.; Hiskey, M.A.; Lee, K.Y.; Ott, D.G., *J Heterocycl. Chem.* **1991**, *28*, 2049. c) Latosh, N.I.; Rusinov, G.L.; Ganebnykh, I.N.; Chupakhin, O.N. *Russ. J. Org. Chem.* **1999**, *35*, 1363.

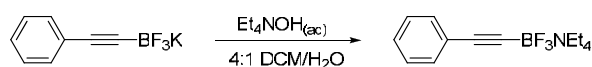
<sup>3</sup> Sauer, J.; Heldmann, D.K.; Pabst, G.R.; *Eur. J. Org. Chem.* **1999**, *1*, 313.

**General procedure for the synthesis of tetraethylammonium alkynyltrifluoroborate salts as exemplified by the synthesis of tetraethylammonium ethynyltrifluoroborate**



A 25% by volume solution of tetraethylammonium hydroxide in water (5 mL, 8.8 mmol) was added to a suspension of potassium ethynyltrifluoroborate (1.0 g, 7.6 mmol) in a 4:1 mixture of DCM and water (25 mL). The biphasic mixture was stirred for 30 minutes, by this time all of the starting material had dissolved. The organic layer was separated and the aqueous layer washed with DCM (2 x 50 mL). The combined organic fractions were dried over  $\text{MgSO}_4$  and the solvent evaporated to give tetraethylammonium ethynyltrifluoroborate (1.47 g, 86%) as a colourless solid. M.p. 211-213 °C (dec.).  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  1.32-1.39 (12H, t,  $J = 7.5$  Hz), 1.83 (1H, br s, C-H), 3.28-3.37 (8H, q,  $J = 7.5$  Hz,  $\text{CH}_2$ ).  $^{13}\text{C}$  NMR (62.9 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.5, 52.5, 77.2.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -134.8. FTIR: 3624 (w), 3260 (m), 2995 (m), 2053 (m), 1631 (w), 1487 (s), 1397 (s)  $\text{cm}^{-1}$ . HRMS (ESI) [ $M$ ] calcd for  $\text{C}_2\text{HBF}_3$ : 93.0119. Found: 93.0123.

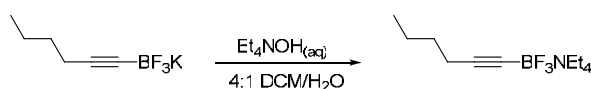
**Synthesis of tetraethylammonium (phenylethynyl)trifluoroborate.**



Following the general procedure, a 25% by volume solution of tetraethylammonium hydroxide in water (2.9 mL, 5.0 mmol) was added to a suspension of potassium (phenylethynyl)trifluoroborate (1.0 g, 4.8 mmol) in a 4:1 mixture of DCM and water (25 mL). Tetraethylammonium (phenylethynyl)trifluoroborate (1.41 g, 98%) was isolated as colourless solid. M.p. 123-124 °C.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  1.25 (12H, t,  $J = 7.5$  Hz,  $\text{CH}_3$ ), 3.25 (8H, q,  $J = 7.5$  Hz,  $\text{CH}_2$ ), 7.16-7.24 (3H, m, CH), 7.32-7.40 (2H, m, CH).  $^{13}\text{C}$  NMR (62.8 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.4, 52.4, 90.4 (br), 125.5, 127.1, 128.2, 131.5.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -133.8. FTIR: 2984 (w), 2939 (w),

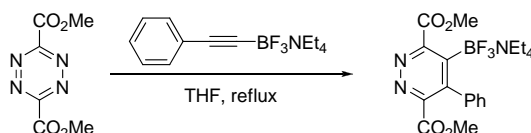
1489 (m), 1442 (w), 1396 (m), 1371 (w), 1225 (m), 1176 (m), 1009 (s), 988 (s)  $\text{cm}^{-1}$ .  
 HRMS (ESI)  $[M^+]$  calcd for  $\text{C}_8\text{H}_5\text{BF}_3$ : 169.0436. Found: 169.0432.

### Synthesis of tetraethylammonium (hex-1-ynyl)trifluoroborate.



Following the general procedure, a 25% by volume solution of tetraethylammonium hydroxide in water (3.2 mL, 5.7 mmol) was added to a suspension of potassium (1-hexyn-1-yl)trifluoroborate (1.0 g, 5.3 mmol) in a 4:1 mixture of DCM and water (25 mL). Tetraethylammonium trifluoro(hex-1-ynyl)borate (1.4 g, 88%) was isolated as a low melting colourless solid.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  0.88 (3H, t,  $J = 7.0$  Hz,  $\text{CH}_3$ ), 1.30-1.54 (16H, m,  $\text{CH}_3$ ,  $\text{CH}_2$ ), 2.13 (2H, t,  $J = 7.0$  Hz,  $\text{CH}_2$ ), 3.34 (8H, q,  $J = 7.0$  Hz,  $\text{CH}_2$ ).  $^{13}\text{C}$  NMR (62.9 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.4, 13.7, 19.3, 22.1, 31.7, 52.4, 90.5 (br).  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -133.0. FTIR: 3601 (w), 2956 (m), 2932 (m), 2360 (w), 1485 (m), 1460 (m), 1365 (m), 1174 (w), 1092 (s), 998 (s)  $\text{cm}^{-1}$ . HRMS (ESI)  $[M^+]$  calcd for  $\text{C}_6\text{H}_9\text{BF}_3$ : 149.0751. Found: 149.0749.

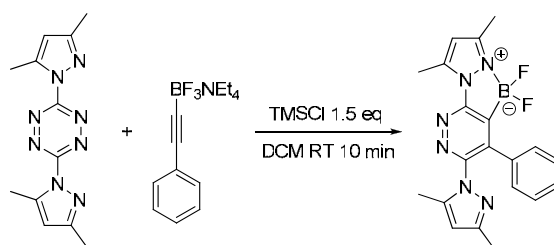
### Synthesis of tetraethylammonium dimethyl 4-(trifluoroborate)-5-phenylpyridazine-3,6-dicarboxylate.



A solution of dimethyl 1,2,4,5-tetrazine-3,6-dicarboxylate (50 mg, 0.25 mmol) and tetraethylammonium (phenylethynyl)trifluoroborate (75 mg, 0.25 mmol) in THF (2 mL) was heated at reflux for 1 hour. The volatiles were removed in vacuo to give the title product tetraethylammonium dimethyl 4-(trifluoroborate)-5-phenylpyridazine-3,6-dicarboxylate (117 mg, 99%) as a yellow oil. Due to the unstable nature of the

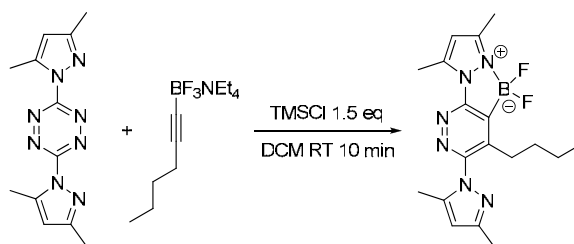
product to column chromatography no further purification was attempted.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  1.07 (12H, t,  $J = 7.5$  Hz), 3.00 (8H, q,  $J = 7.5$  Hz,  $\text{CH}_2$ ), 3.55 (3H, s,  $\text{CH}_3$ ), 3.89 (3H, s,  $\text{CH}_3$ ), 7.29 (5H, br, CH).  $^{13}\text{C}$  NMR (62.9 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.2, 52.2, 52.4, 52.5, 127.3, 127.7, 128.8, 137.5, 143.9, 154.3, 159.8, 167.1, 169.0.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -134.0. FTIR: 2997 (w), 2951 (w), 1740 (s), 1536 (w), 1489 (m), 1444 (m), 1397 (m), 1356 (m), 1307 (w), 1205 (m), 1174 (m), 1104 (m), 1052 (s)  $\text{cm}^{-1}$ . HRMS (ESI)  $[\text{M}]^-$  calcd for  $\text{C}_{14}\text{H}_{11}\text{BN}_2\text{O}_4\text{F}_3$ : 339.0764. Found: 339.0748.

**General procedure for TMSCl-promoted cycloadditions as exemplified by the synthesis of 13.**



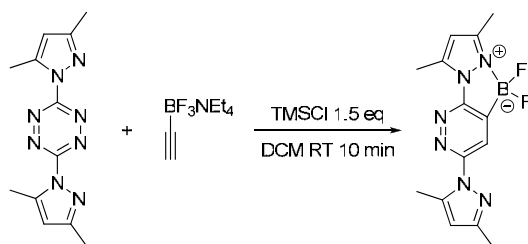
To a solution of 3,6-bis(3,5-dimethyl-1*H*-pyrazol-1-yl)-1,2,4,5-tetrazine (50 mg, 0.185 mmol) and tetraethylammonium (phenylethynyl)trifluoroborate (83 mg, 0.277 mmol) in DCM (1 mL) was added dropwise distilled TMSCl (35  $\mu\text{L}$ , 0.277 mmol). A vigorous reaction took place with production of nitrogen. The reaction was stirred at room temperature until the red colour of the tetrazine had faded (~10 min). The solvent was then evaporated and the residue dry loaded and purified chromatographically over silica gel (gradient; starting with petroleum ether, ending with 50% ethyl acetate in petroleum ether). Compound **13** was isolated as a colourless solid (73 mg, 99%). M.p: 161.0-161.8  $^{\circ}\text{C}$ .  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  2.01 (3H, s,  $\text{CH}_3$ ), 2.20 (3H, s,  $\text{CH}_3$ ), 2.53 (3H, s,  $\text{CH}_3$ ), 2.96 (3H, s,  $\text{CH}_3$ ), 5.90 (1H, s, CH), 6.31 (1H, s, CH), 7.34 (5H, s, Ar).  $^{13}\text{C}$  NMR (62.9 MHz,  $\text{CDCl}_3$ ):  $\delta$  11.2, 11.3, 12.8, 13.5, 107.0, 112.3, 128.4, 128.5, 129.3, 133.8, 141.2, 142.4, 143.9, 148.5, 150.2, 153.6, 158.1.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -150.8. FTIR: 2928 (w), 1575 (m), 1560 (m), 1498 (m), 1474 (m), 1420 (s), 1263 (w), 1114 (s)  $\text{cm}^{-1}$ . HRMS: (ESI)  $[\text{MH}^+]$  calcd for  $\text{C}_{20}\text{H}_{20}\text{BN}_6\text{F}_2$ : 393.1811, found 393.1826.

## Synthesis of 12.



Following the general procedure, a solution of 3,6-bis(3,5-dimethyl-1*H*-pyrazol-1-yl)-1,2,4,5-tetrazine (50 mg, 0.185 mmol) and tetraethylammonium (hex-1-ynyl)trifluoroborate (77 mg, 0.277 mmol) in DCM (1 mL) was treated with TMSCl (35  $\mu$ L, 0.277 mmol). Chromatographic purification over silica gel (gradient; starting with petroleum ether, ending with 50% ethyl acetate in petroleum ether). Compound **12** was isolated as a colourless solid (62 mg, 89%). M.p: 118.0-118.6  $^{\circ}$ C.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  0.82 (3H, t,  $J$  = 7.0 Hz,  $\text{CH}_3$ ), 1.19-1.34 (2H, m,  $\text{CH}_2$ ), 1.34-1.49 (2H, m,  $\text{CH}_2$ ), 2.30 (3H, s,  $\text{CH}_3$ ), 2.32 (3H, s,  $\text{CH}_3$ ), 2.54 (3H, s,  $\text{CH}_3$ ), 2.82-2.93 (5H, m,  $\text{CH}_3$  +  $\text{CH}_2$ ), 6.05 (1H, s, CH), 6.27 (1H, s, CH).  $^{13}\text{C}$  NMR (62.9 MHz,  $\text{CDCl}_3$ ):  $\delta$  11.2, 11.8, 12.7, 13.5, 13.6, 22.6, 30.4, 31.2, 106.8, 112.0, 141.5, 142.2, 147.2, 148.3, 150.1, 155.1, 157.5.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -154.2. FTIR: 2959 (m), 2931 (m), 2872 (w), 2562 (w), 1474 (m), 1418 (s), 1110 (s)  $\text{cm}^{-1}$ . HRMS: (ESI)  $[\text{MH}^+]$  calcd for  $\text{C}_{18}\text{H}_{24}\text{BN}_6\text{F}_2$ : 373.2124, found 373.2105.

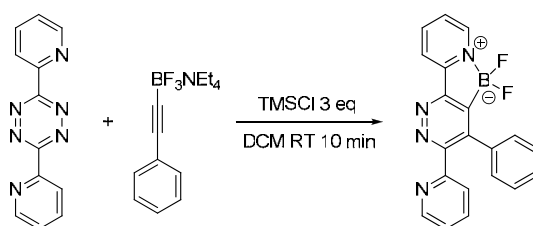
## Synthesis of 14



Following the general procedure, a solution of 3,6-bis(3,5-dimethyl-1*H*-pyrazol-1-yl)-1,2,4,5-tetrazine (50 mg, 0.185 mmol) and tetraethylammonium ethynyltrifluoroborate (62 mg, 0.277 mmol) in DCM (1 mL) was treated with TMSCl (35  $\mu$ L, 0.277 mmol). Chromatographic purification over silica gel (gradient; starting with petroleum ether, ending with ethyl acetate). Compound **14** was isolated as a

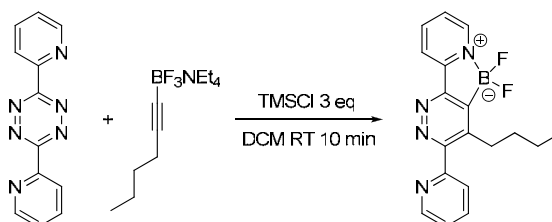
colourless solid (44 mg, 75 %). M.p: 213.0-214.0 °C.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  2.32 (3H, s,  $\text{CH}_3$ ), 2.53 (3H, s,  $\text{CH}_3$ ), 2.72 (3H, s,  $\text{CH}_3$ ), 2.92 (3H, s,  $\text{CH}_3$ ), 6.07 (1H, s, CH), 6.27 (1H, s, CH), 8.42 (1H, s, CH)  $^{13}\text{C}$  NMR (62.9 MHz,  $\text{CDCl}_3$ ):  $\delta$  11.2, 12.7, 13.6, 14.8, 110.1, 112.0, 125.4, 141.8, 142.2, 148.1, 151.3, 155.9, 156.6.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -154.8. FTIR: 2360 (s), 2341 (m), 1577 (m), 1425(s), 1291 (m), 1103 (s)  $\text{cm}^{-1}$ . HRMS: (EI)  $[\text{MH}^+]$  calcd for  $\text{C}_{14}\text{H}_{15}\text{BN}_6\text{F}_2$ : 316.1419, found 316.1419.

### Synthesis of 16.



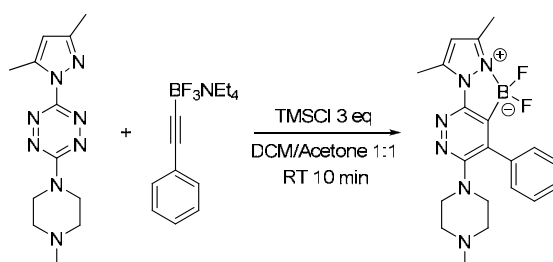
Following the general procedure, a solution of 3,6-di-2-pyridyl-1,2,4,5-tetrazine (43 mg, 0.185 mmol) and tetraethylammonium (phenylethynyl)trifluoroborate (83mg, 0.277 mmol) in DCM (1 mL) was treated with TMSCl (70  $\mu\text{L}$ , 0.554 mmol). The solvent was evaporated and the residue filtered over a small pad of florisil (eluant: ethyl acetate). Compound **16** was isolated as a colourless solid (57 mg, 85 %). M.p: 216.0-217.0 °C.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.22-7.45 (6H, m, Ar), 7.68-7.82 (3H, m, Ar), 8.36 (1H, dt,  $J$  = 8.0 Hz, 1.0 Hz, Ar), 8.51 (1H, d,  $J$  = 5.0 Hz, Ar), 8.67 (1H, d,  $J$  = 5.0 Hz, Ar), 8.72 (1H, d,  $J$  = 8.0 Hz, Ar).  $^{13}\text{C}$  NMR (62.9 MHz,  $\text{CDCl}_3$ )  $\delta$  120.3, 123.3, 125.2, 126.7, 128.2, 128.3, 129.4, 136.4, 136.5, 142.0, 143.2, 144.7, 149.1, 152.5, 156.3, 157.9, 159.7.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -154.0. FTIR: 3060 (m), 2360 (w), 2227 (w), 1627 (s), 1587 (m), 1492 (s), 1382 (s), 1159 (s), 1092 (s)  $\text{cm}^{-1}$ . HRMS: (ESI)  $[\text{MH}^+]$  calcd for  $\text{C}_{20}\text{H}_{14}\text{BN}_4\text{F}_2$ : 359.1280, found 359.1274.

### Synthesis of 17.



Following the general procedure, a solution of 3,6-di-2-pyridyl-1,2,4,5-tetrazine (43 mg, 0.185 mmol) and tetraethylammonium (hex-1-ynyl)trifluoroborate (77 mg, 0.277 mmol) in DCM (1 mL) was treated with TMSCl (70  $\mu$ L, 0.554 mmol). The solvent was evaporated and the residue filtered over a small pad of florisil (eluant: ethyl acetate). Compound **17** was isolated as a colourless solid (52 mg, 84 %). M.p: 120.7-121.5  $^{\circ}$ C.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  0.83 (3H, t,  $J$  = 7.0 Hz,  $\text{CH}_3$ ), 1.22-1.40 (2H, m,  $\text{CH}_2$ ), 1.50-1.63 (2H, m,  $\text{CH}_2$ ), 3.08-3.20 (2H, m,  $\text{CH}_2$ ), 7.42 (1H, td,  $J$  = 6.5, 1.5 Hz, Ar), 7.80 (1H, t,  $J$  = 6.5 Hz, Ar), 7.85- 8.02 (2H, m, Ar), 8.37 (1H, td,  $J$  = 8.0, 1.5 Hz, Ar), 8.60-8.80 (3H, m Ar).  $^{13}\text{C}$  NMR (62.9 MHz,  $\text{CDCl}_3$ ):  $\delta$  13.6, 22.8, 31.5, 32.4, 120.1, 123.5, 124.9, 126.3, 136.8, 141.9, 144.4, 146.1, 148.6, 152.9, 156.7, 157.4, 160.5.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -157.0. FTIR: 2958 (m), 2870 (w), 2360 (s), 2341 (m), 1628 (m), 1490 (s), 1388 (s), 1114 (s)  $\text{cm}^{-1}$ . HRMS: (ESI)  $[\text{MH}^+]$  calcd for  $\text{C}_{18}\text{H}_{18}\text{BN}_4\text{F}_2$ : 339.1593, found 339.1591.

### Synthesis of 19.

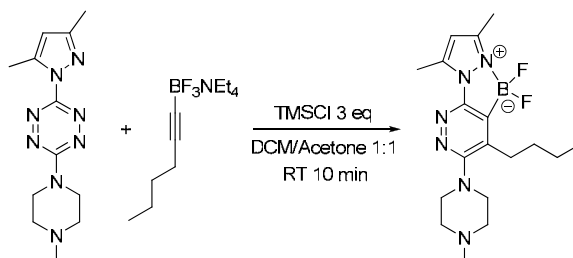


Following the general procedure, a solution of 3-(3,5-dimethyl-1H-pyrazol-1-yl)-6-(4-methyl-1-piperazinyl)-1,2,4,5-tetrazine (51 mg, 0.185 mmol) and tetraethylammonium (phenylethynyl)trifluoroborate (83 mg, 0.277 mmol) in a 1:1 mixture of DCM/acetone (2 mL) was added TMSCl (70  $\mu$ L, 0.554 mmol). Chromatographic purification over silica gel (gradient; starting with acetone, ending acetone/ $\text{Et}_3\text{N}$  95:5). Compound **19** was isolated as a colourless solid (67 mg, 91 %). M.p: 213.4-214.2  $^{\circ}$ C (dec.).  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  2.29 (3H, s,  $\text{CH}_3$ ), 3.35-2.42 (4H, m,  $\text{CH}_2$ ), 2.47 (3H, s,  $\text{CH}_3$ ), 2.89 (3H, s,  $\text{CH}_3$ ), 3.19-3.30 (4H, m,  $\text{CH}_2$ ), 6.21 (1H, s,  $\text{CH}_3$ ), 7.42 (1H, t,  $J$  = 7.5 Hz), 7.49 (2H, t,  $J$  = 7.5 Hz), 7.78 (2H, d,  $J$  = 7.5 Hz).  $^{13}\text{C}$  NMR (100.6 MHz,  $\text{CDCl}_3$ ):  $\delta$  11.0, 12.6, 46.0, 48.9, 54.6, 111.4, 127.9, 128.7, 128.9, 136.2, 138.1, 141.0, 146.8, 155.3, 160.5.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -151.0. FTIR: 2938 (m),



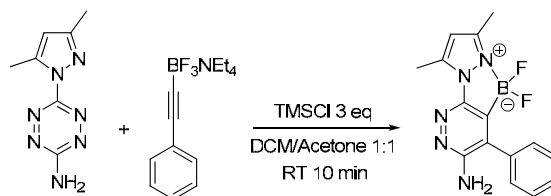
2845 (m), 2799 (m), 2360 (m), 1573 (m), 1416 (s), 1261 (s), 1117 (s), 1007 (m)  $\text{cm}^{-1}$ .  
 HRMS: (ESI)  $[\text{MH}^+]$  calcd for  $\text{C}_{20}\text{H}_{24}\text{BN}_6\text{F}_2$ : 397.2124, found 397.2118.

### Synthesis of 20.



Following the general procedure, a solution of 3-(3,5-dimethyl-1*H*-pyrazol-1-yl)-6-(4-methyl-1-piperazinyl)-1,2,4,5-tetrazine (51 mg, 0.185 mmol) and tetraethylammonium (hex-1-ynyl)trifluoroborate (77 mg, 0.277 mmol) in a 1:1 mixture of DCM/acetone (2 mL) was added TMSCl (70  $\mu\text{L}$ , 0.554 mmol). Chromatographic purification over silica gel (gradient; starting with acetone, ending acetone/ $\text{Et}_3\text{N}$  95:5). Compound **20** was isolated as a colourless solid (54 mg, 80 %). M.p: 80.8-82.2  $^{\circ}\text{C}$ .  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  0.98 (3H, t,  $J = 7.0$  Hz,  $\text{CH}_3$ ), 1.35-1.53 (2H, m,  $\text{CH}_2$ ), 1.68-1.84 (2H, m,  $\text{CH}_2$ ), 2.40 (3H, s,  $\text{CH}_3$ ), 2.51 (3H, s,  $\text{CH}_3$ ), 2.60-2.70 (4H, m,  $\text{CH}_2$ ), 2.72-2.82 (2H, m,  $\text{CH}_2$ ), 2.87 (3H, s,  $\text{CH}_3$ ), 3.28-3.38 (4H, m,  $\text{CH}_2$ ), 6.20 (1H, s, CH).  $^{13}\text{C}$  NMR (62.9 MHz,  $\text{CDCl}_3$ ):  $\delta$  11.0, 12.6, 13.8, 23.1, 30.5, 31.5, 46.0, 50.6, 55.0, 111.4, 141.2, 143.3, 146.9, 155.5, 163.2.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -153.8. FTIR: 2959 (m), 2934 (m), 2846 (w), 2793 (w), 2360 (m), 2341 (w), 1568 (w), 1411 (s), 1108 (m)  $\text{cm}^{-1}$ . HRMS: (ESI)  $[\text{MH}^+]$  calcd for  $\text{C}_{18}\text{H}_{28}\text{BN}_6\text{F}_2$ : 377.2437, found 377.2425.

### Synthesis of 22.



Following the general procedure, a solution of 3-amino-6-(3,5-dimethylpyrazol-1-yl)-1,2,4,5-tetrazine (37 mg, 0.185 mmol) and tetraethylammonium

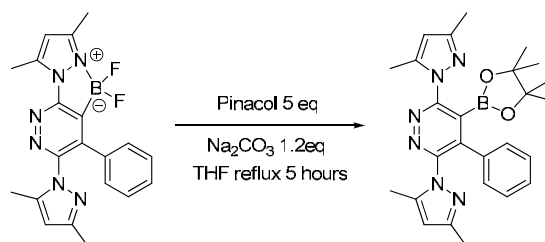
(phenylethynyl)trifluoroborate (83 mg, 0.277 mmol) in a 1:1 mixture of DCM/acetone (2 mL) was added TMSCl (70  $\mu$ L, 0.554 mmol). Chromatographic purification over florisil (gradient; starting with petroleum ether, ending with ethyl acetate). Compound **22** was isolated as a colourless solid (40 mg, 69 %). M.p: 201.8-202.6  $^{\circ}$ C.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  2.47 (3H, s,  $\text{CH}_3$ ), 2.87 (3H, s,  $\text{CH}_3$ ), 5.06 (2H, br s,  $\text{NH}_2$ ), 6.21 (1H, s, CH), 7.43-7.60 (3H, m, Ar), 7.61-7.70 (2H, m, Ar).  $^{13}\text{C}$  NMR (125.8 MHz,  $\text{CDCl}_3$ ):  $\delta$  11.0, 12.5, 111.2, 128.5, 129.2, 129.3, 133.2, 133.9, 140.7, 146.4, 153.7, 157.1.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -151.8. FTIR: 3480 (w), 3385 (w), 2360 (m), 1592 (m), 1427 (s), 1113 (s)  $\text{cm}^{-1}$ . HRMS: (ESI)  $[\text{MH}^+]$  calcd for  $\text{C}_{15}\text{H}_{15}\text{BN}_5\text{F}_2$ : 314.1389, found 314.1394.

### Synthesis of **24**.



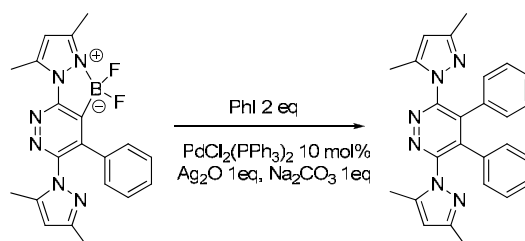
A flame dried flask fitted with a reflux condenser was charged with 3-(2-pyridyl)-1,2,4-triazine (30 mg, 0.185 mmol) and tetraethylammonium (hex-1-ynyl)trifluoroborate (258 mg, 0.925 mmol). The mixture was dissolved in dry DCM (2 mL) and to this was added dropwise distilled TMSCl (106  $\mu$ L, 0.832 mmol). The mixture was stirred at room temperature for 10 minutes and then heated to reflux for 10 minutes. Chromatographic purification over silica gel (gradient; starting with petroleum ether, ending with ethyl acetate). Product **24** was isolated as a yellow oil (28 mg, 67 %).  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ):  $\delta$  0.97 (3H, t,  $J = 7.5$  Hz,  $\text{CH}_3$ ), 1.35-1.53 (2H, m,  $\text{CH}_2$ ), 1.65-1.82 (2H, m,  $\text{CH}_2$ ), 2.84 (2H, t,  $J = 7.5$  Hz,  $\text{CH}_2$ ), 7.18 (1H, d,  $J = 5.5$  Hz, Ar), 7.59-7.68 (1H, m, Ar), 8.24 (1H, td,  $J = 7.5, 1.5$  Hz, Ar), 8.33 (1H, d,  $J = 8.0$  Hz, Ar), 8.49 (1H, d,  $J = 5.0$  Hz, Ar), 8.60 (1H, d,  $J = 5.0$  Hz, Ar).  $^{13}\text{C}$  NMR (125.8 MHz,  $\text{CDCl}_3$ ):  $\delta$  13.9, 22.5, 32.5, 34.7, 119.1, 125.0, 126.1, 141.3, 144.1, 149.9, 154.9, 155.2, 156.3.  $^{19}\text{F}$  NMR (235.1 MHz,  $\text{CDCl}_3$ ):  $\delta$  -159.1. FTIR: 3055 (w), 2957 (s), 2931 (s), 2863 (m), 1628 (s), 1583 (s), 1571 (s), 1491 (s), 1476 (s), 1380 (m), 1260 (m), 1099 (s), 1000(s)  $\text{cm}^{-1}$ . HRMS: (ESI)  $[\text{MH}^+]$  calcd for  $\text{C}_{14}\text{H}_{16}\text{BN}_2\text{F}_2$ : 261.1372, found 261.1375.

## Synthesis of 25.



A flame dried flask fitted with a reflux condenser was charged with **13** (100 mg, 0.25 mmol), pinacol (150 mg, 1.27 mol) and  $\text{Na}_2\text{CO}_3$  (32mg, 0.30 mmol) in dry THF (1 mL). The mixture heated at reflux for 5 hours. The solvent was evaporated and the excess pinacol removed by kugelrohr distillation. The residue was purified by chromatographic purification over florisil (gradient; starting with petroleum ether, ending with petroleum ether/ethyl acetate 1:1). Product **25** was isolated as a colourless solid (82 mg, 68 %) and showed satisfactory spectroscopic and analytical data.<sup>4</sup>

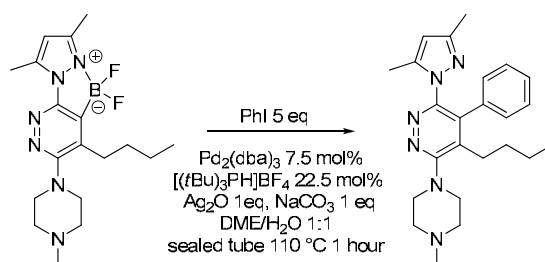
## Synthesis of 26.



A flask fitted with a refluxed condenser was charged with **13** (39 mg, 0.1 mmol),  $\text{PdCl}_2(\text{PPh}_3)_2$  (7 mg, 0.01 mmol),  $\text{Ag}_2\text{O}$  (23mg, 0.1 mmol),  $\text{Na}_2\text{CO}_3$  (11mg, 0.1 mmol) and iodobenzene (40 mg, 0.2 mmol) in a 1:1 mixture of DME/ $\text{H}_2\text{O}$  (1 mL). The reaction was heated to 80 °C for 4 hours, cooled to room temperature and dry loaded onto silica gel. Chromatographic purification (gradient; starting with petroleum ether, ending with petrol/ethyl acetate 1/1). Product **26** was isolated as a yellow solid (25 mg, 60 %) and showed satisfactory spectroscopic and analytical data.<sup>4</sup>

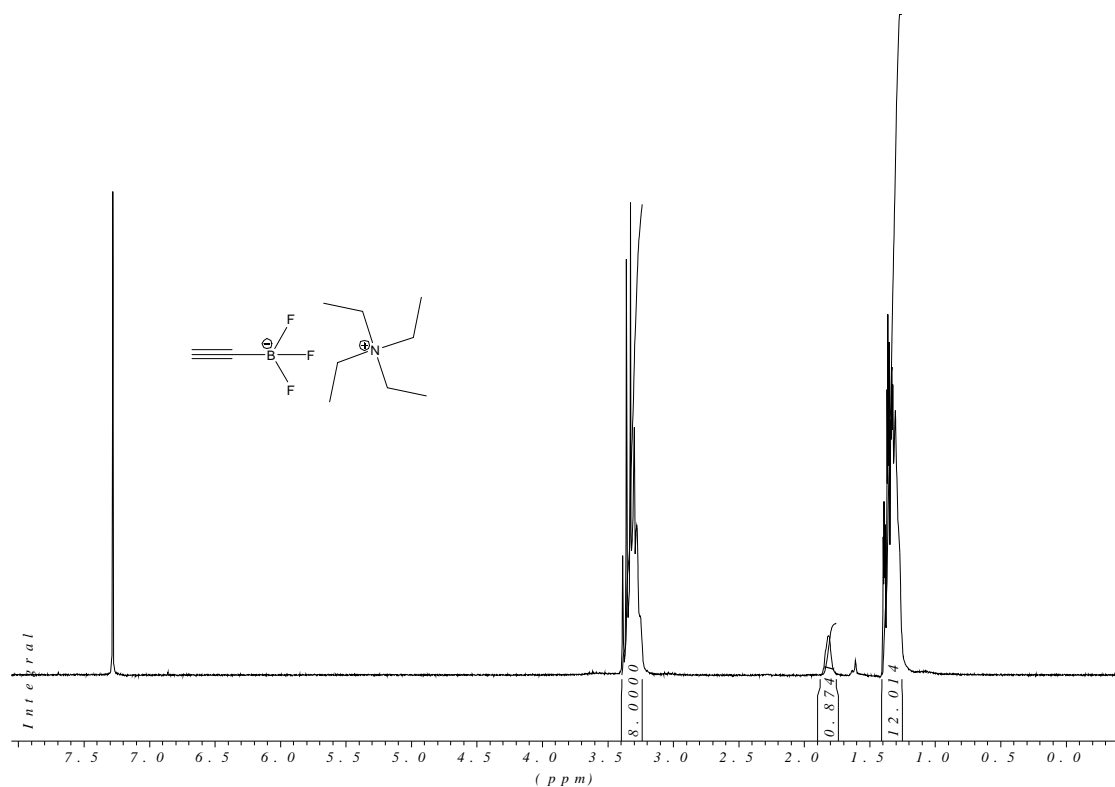
<sup>4</sup> Helm, M. D.; Moore, J. E.; Plant, A.; Harrity, J. P. A. *Angew. Chem. Int. Ed.* **2005**, *44*, 3889.

## Synthesis of 27.

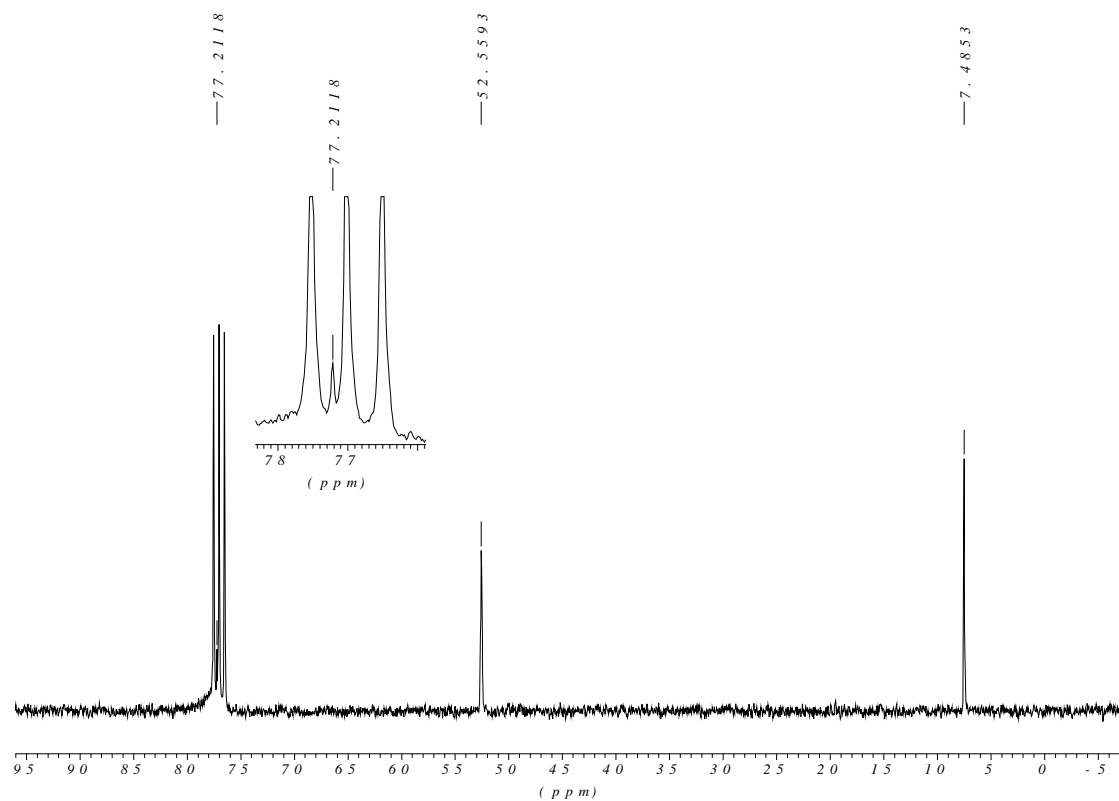


A microwave vial was charged with **20** (19 mg, 0.05 mmol),  $\text{Pd}_2(\text{dba})_3$  (7 mg, 7.5  $\mu\text{mol}$ ),  $\text{Ag}_2\text{O}$  (12 mg, 0.05 mmol),  $\text{Na}_2\text{CO}_3$  (6mg, 0.05 mmol) and iodobenzene (50 mg, 0.245 mmol) in a 1:1 mixture of DME/ $\text{H}_2\text{O}$  (1 mL). The vial was flushed with argon,  $t\text{-Bu}_3\text{P.HBF}_4$  (5 mg, 0.018 mmol) was added before the flask was sealed and introduced into a preheated silicon oil bath at 110  $^{\circ}\text{C}$ . After one hour at this temperature the reaction was allowed to cool to room temperature and was dry loaded onto silica gel. Chromatographic purification (gradient; starting with petroleum ether, ending with ethyl acetate/ $\text{Et}_3\text{N}$  95/5). Product **27** was isolated as a colourless solid (14 mg, 68 %). M.p: 212-213  $^{\circ}\text{C}$ .  $^1\text{H}$  NMR (250 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$  0.75 (3H, t,  $J = 7.0$  Hz,  $\text{CH}_3$ ), 1.07-1.24 (2H, m,  $\text{CH}_2$ ), 1.26-1.42 (2H, m,  $\text{CH}_2$ ), 2.06 (3H, s,  $\text{CH}_3$ ), 2.08 (3H, s,  $\text{CH}_3$ ), 2.44 (3H, s,  $\text{CH}_3$ ), 2.68-2.80 (6H, m,  $\text{CH}_2$ ), 3.43-3.51 (4H, m,  $\text{CH}_2$ ), 5.85 (1H, s, CH), 7.13-7.23 (2H, m, Ar), 7.30-7.40 (3H, m, Ar).  $^{13}\text{C}$  NMR (62.9 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$  9.8, 11.5, 12.3, 22.2, 27.7, 30.0, 44.7, 50.1, 54.5, 105.5, 127.8, 128.2, 128.5, 132.5, 137.9, 141.3, 141.8, 149.4, 150.9, 164.5. FTIR: 2931 (m), 2845 (w), 2792 (m), 2361 (m), 2342 (m), 1459 (m), 1406 (s), 1366 (m), 1287 (w), 1254 (w)  $\text{cm}^{-1}$ . HRMS: (ESI)  $[\text{MH}^+]$  calcd for  $\text{C}_{24}\text{H}_{33}\text{N}_6$ : 405.2767, found 405.2762.

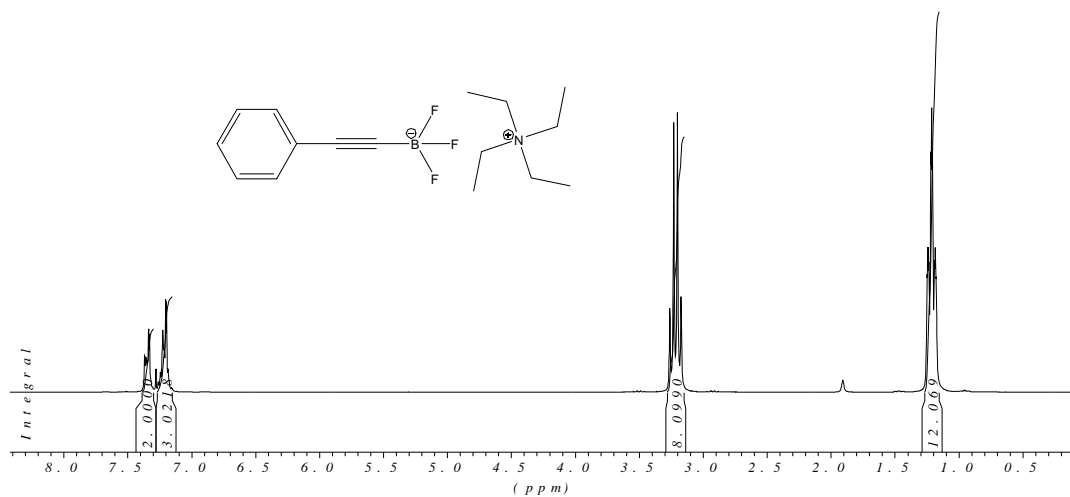
$^1\text{H}$  NMR spectrum of tetraethylammonium ethynyltrifluoroborate



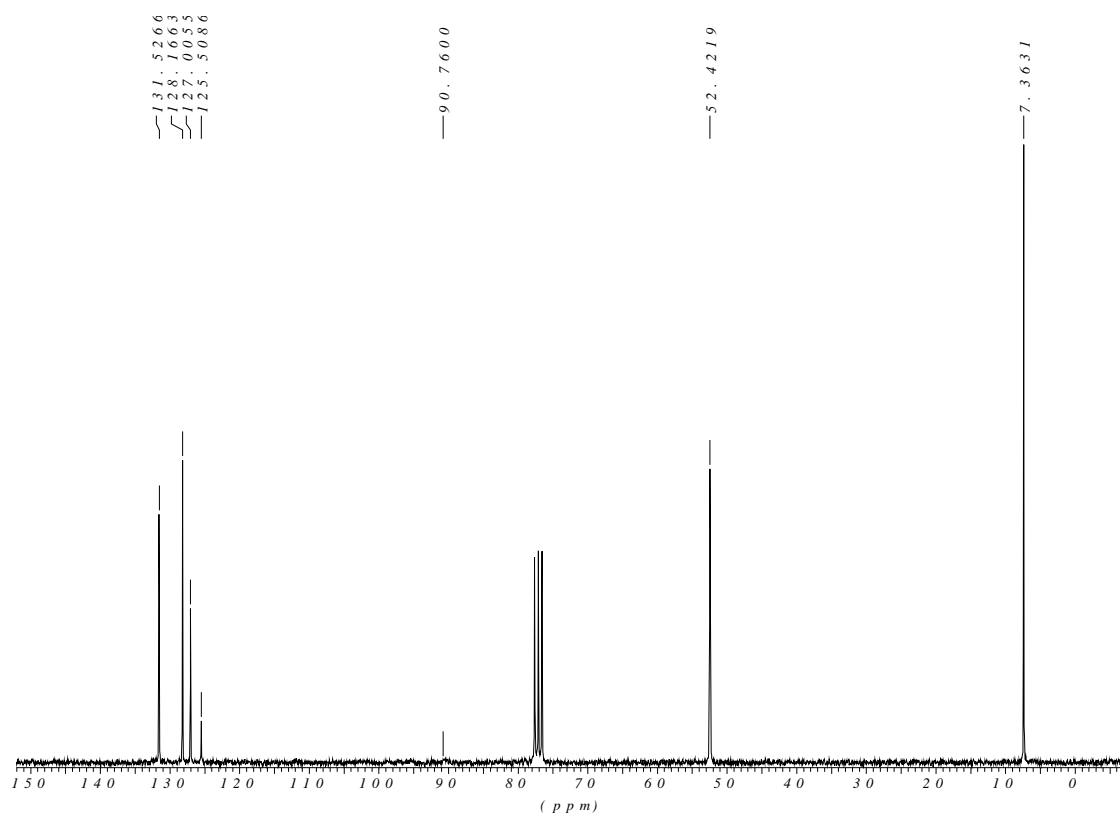
$^{13}\text{C}$  NMR spectrum of tetraethylammonium ethynyltrifluoroborate



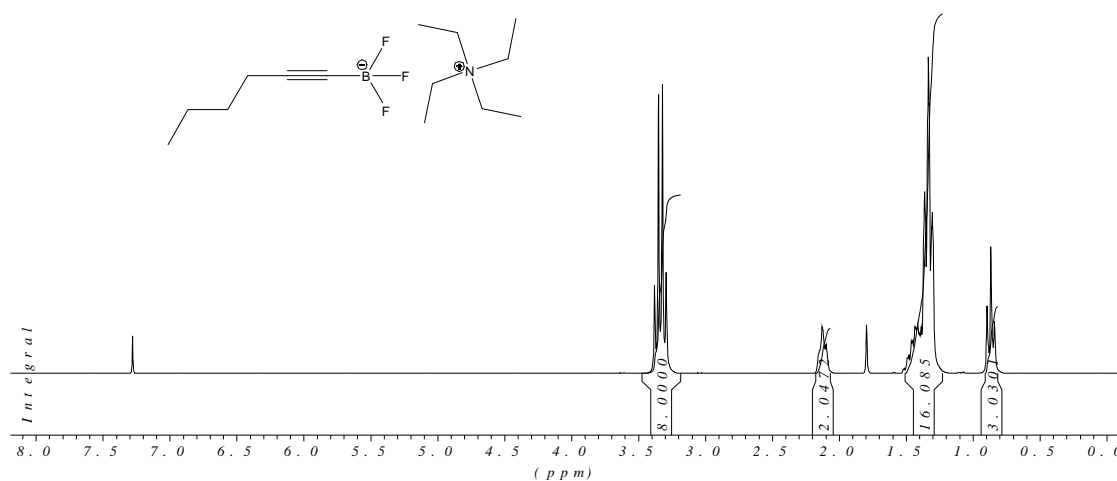
$^1\text{H}$  NMR spectrum of tetraethylammonium (phenylethynyl)trifluoroborate



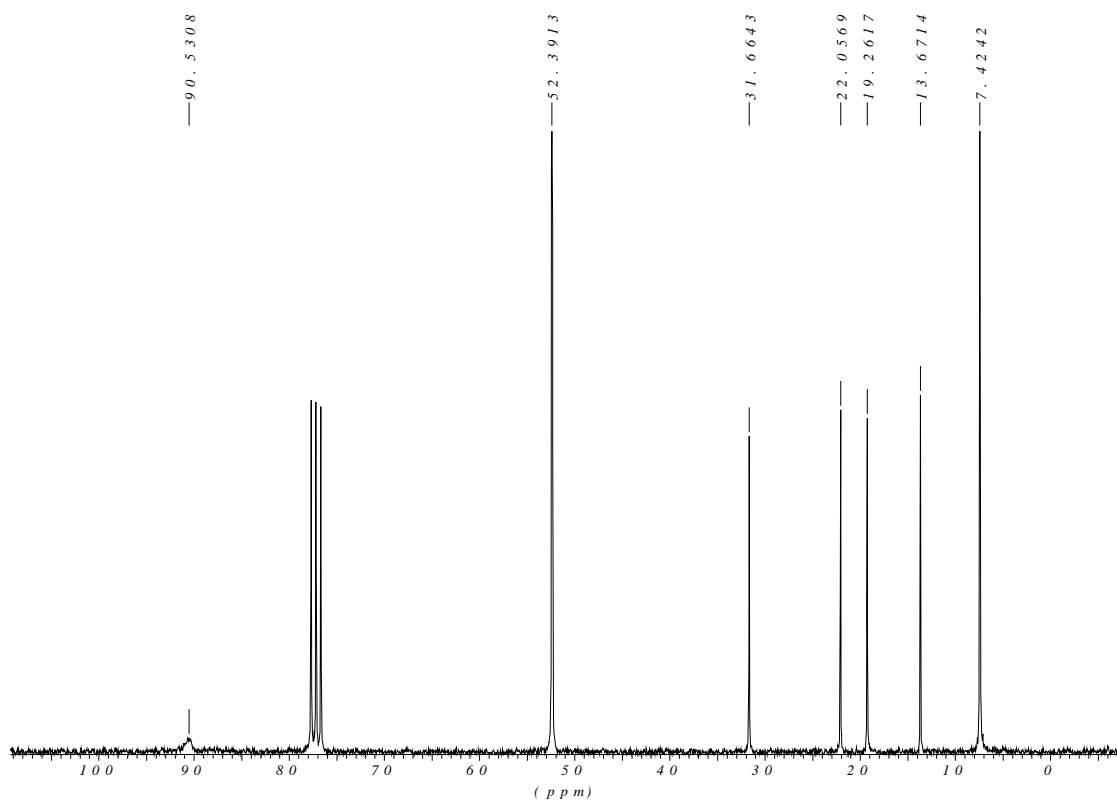
$^{13}\text{C}$  NMR spectrum of tetraethylammonium (phenylethynyl)trifluoroborate



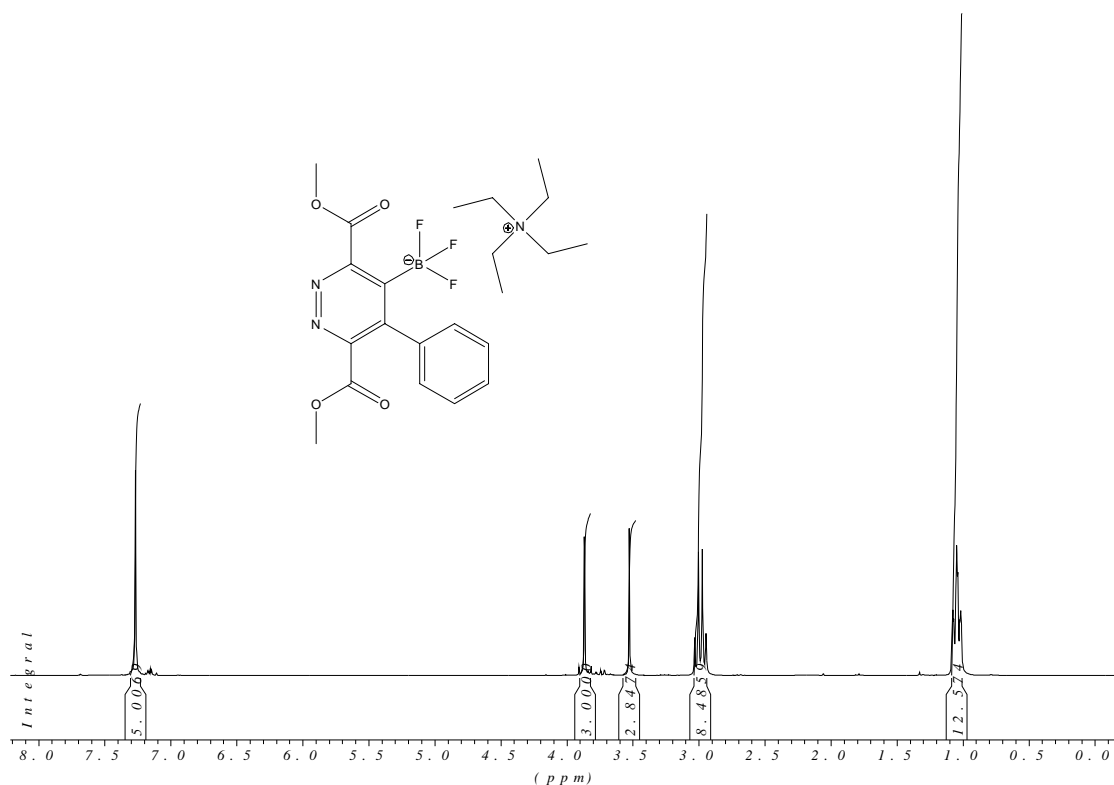
$^1\text{H}$  NMR spectrum of tetraethylammonium (hex-1-ynyl)trifluoroborate



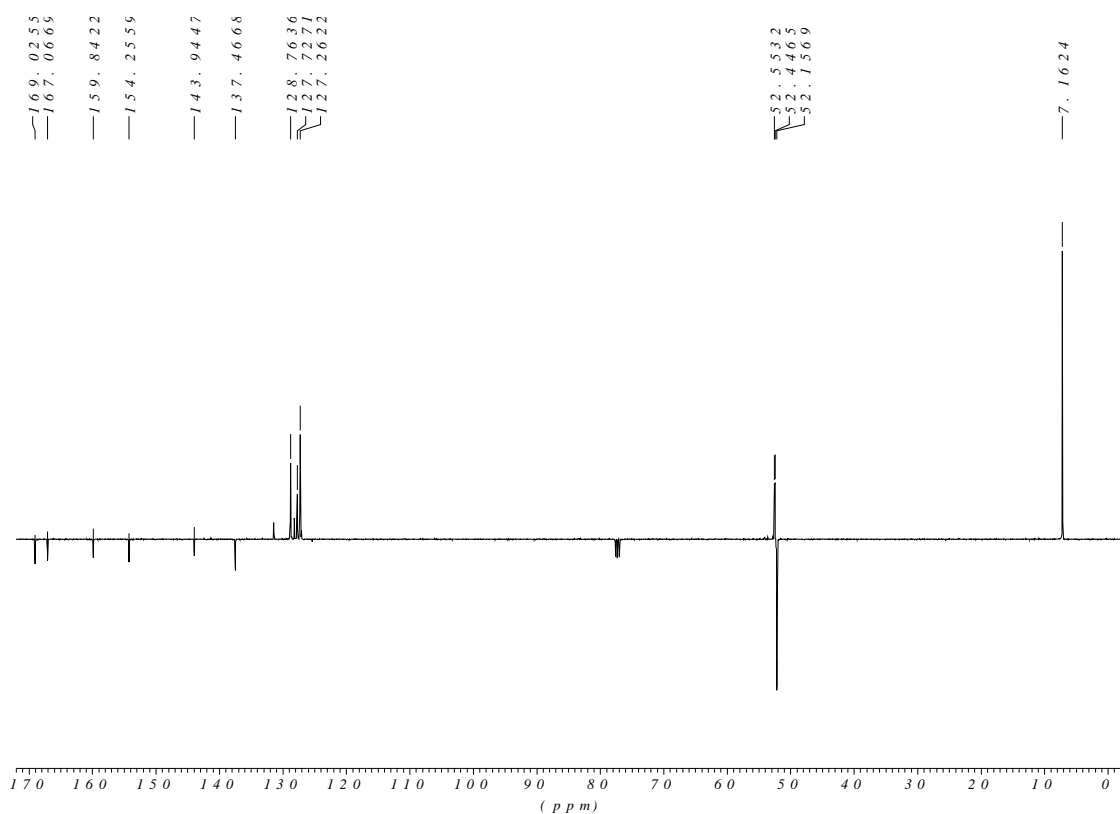
$^{13}\text{C}$  NMR spectrum of tetraethylammonium (hex-1-ynyl)trifluoroborate



$^1\text{H}$  NMR spectrum of tetraethylammonium dimethyl 4-(trifluoroborate)-5-phenylpyridazine-3,6-dicarboxylate

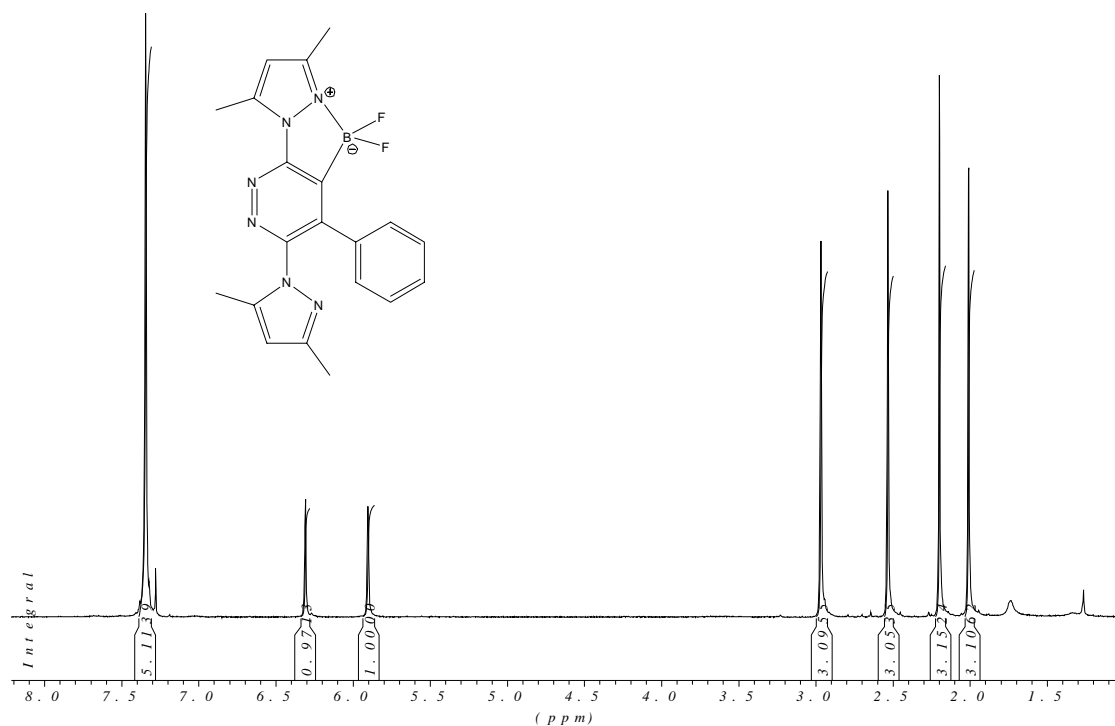


$^{13}\text{C}$  NMR spectrum of tetraethylammonium dimethyl 4-(trifluoroborate)-5-phenylpyridazine-3,6-dicarboxylate

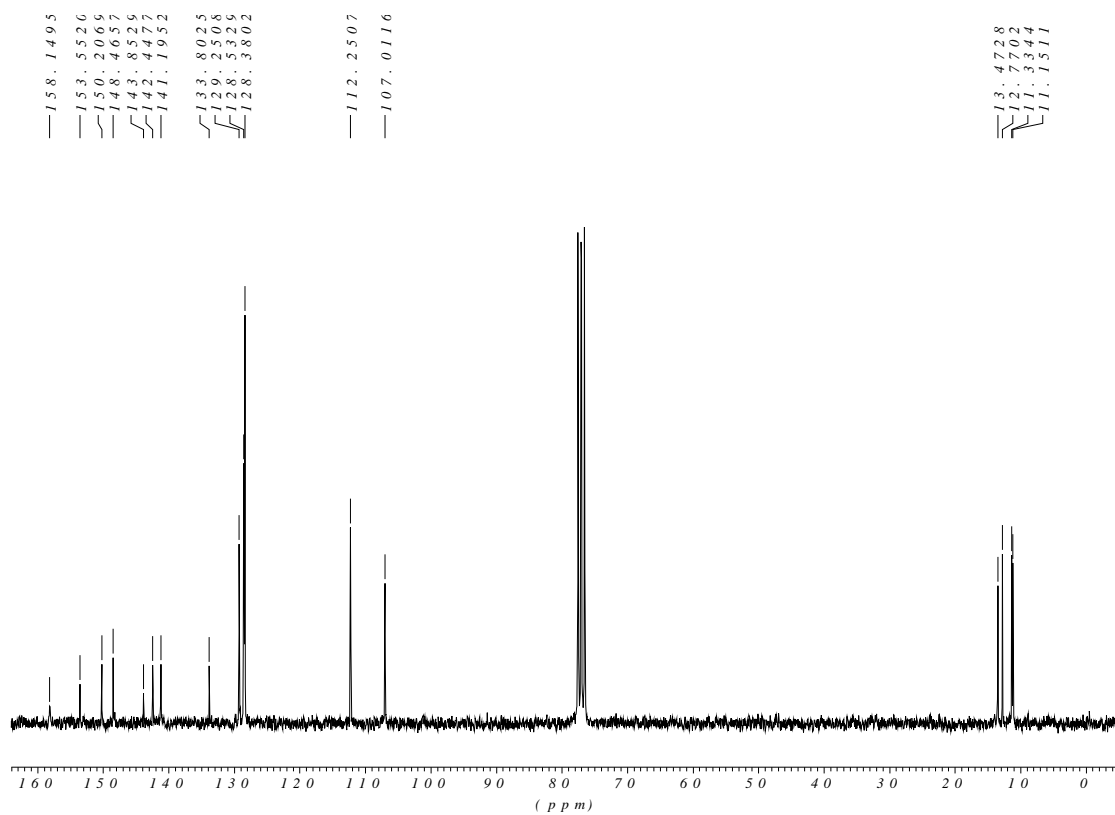




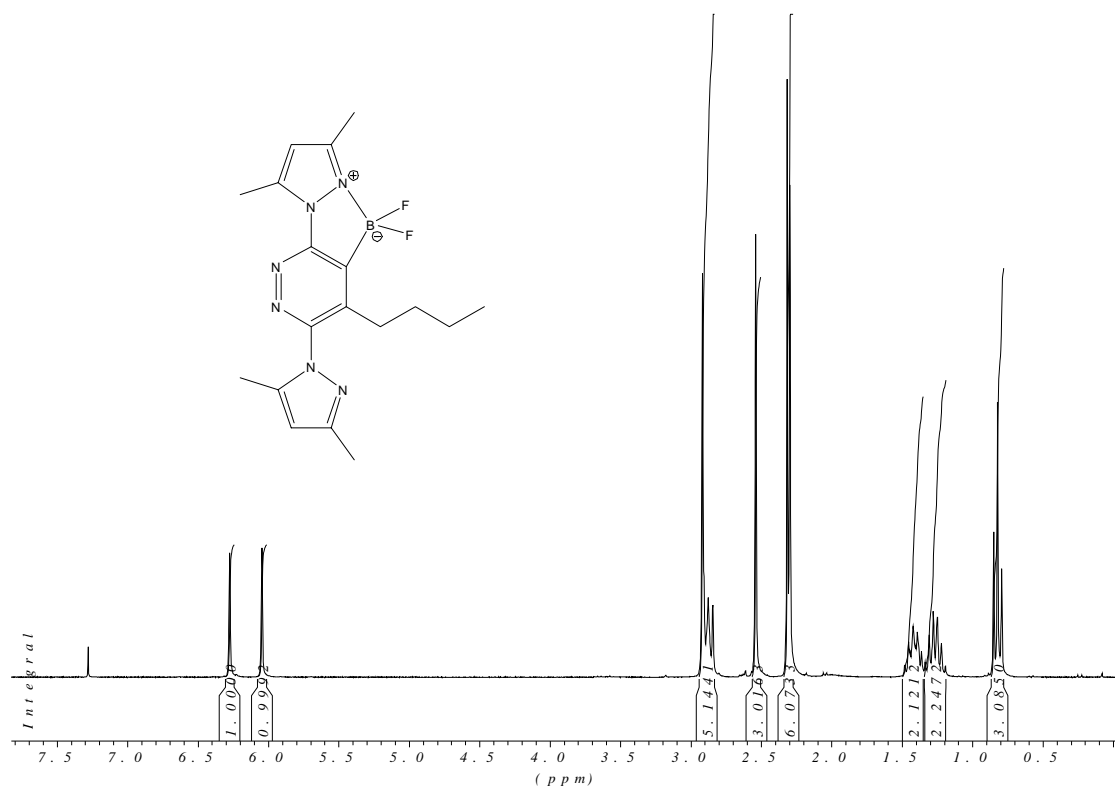
$^1\text{H}$  NMR spectrum of **13**



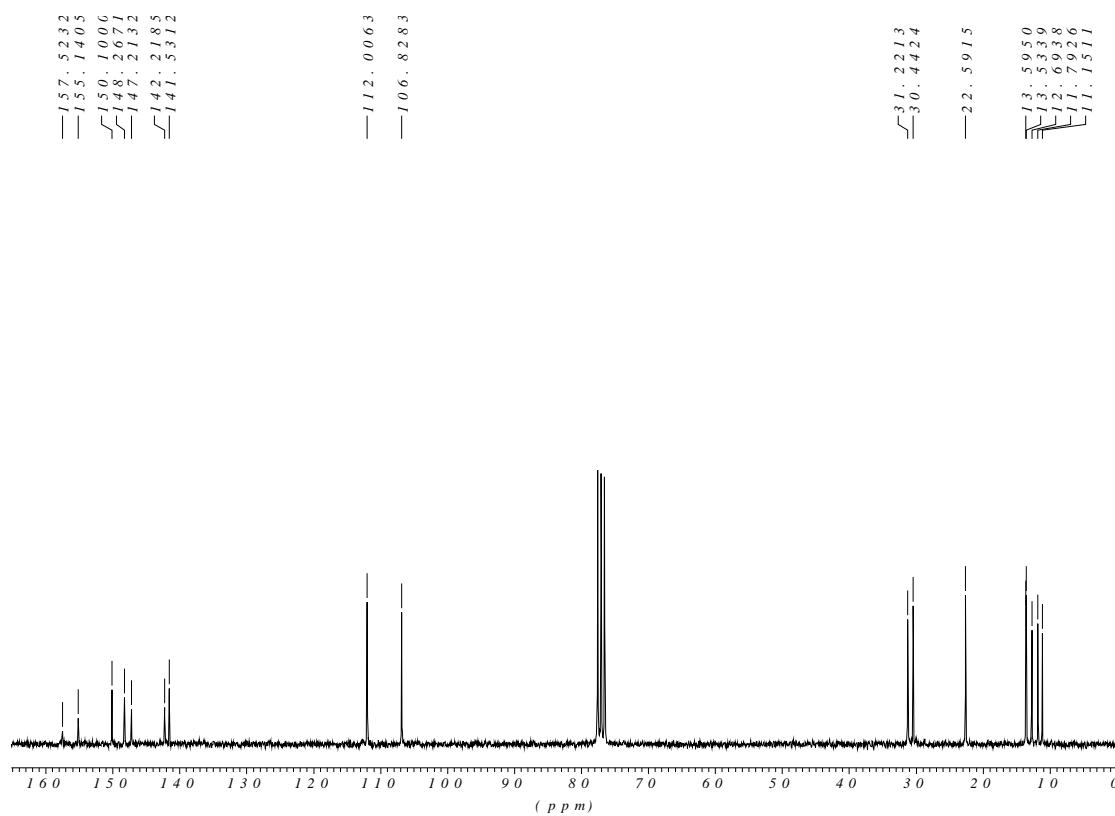
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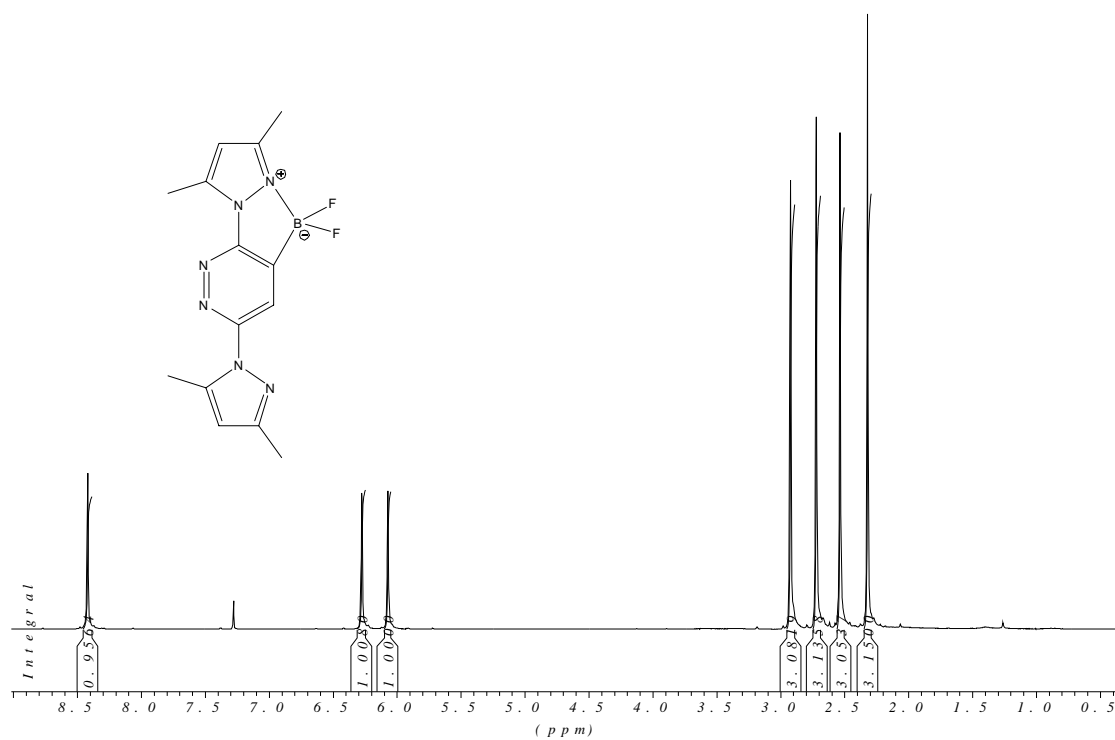
$^1\text{H}$  NMR spectrum of **12**



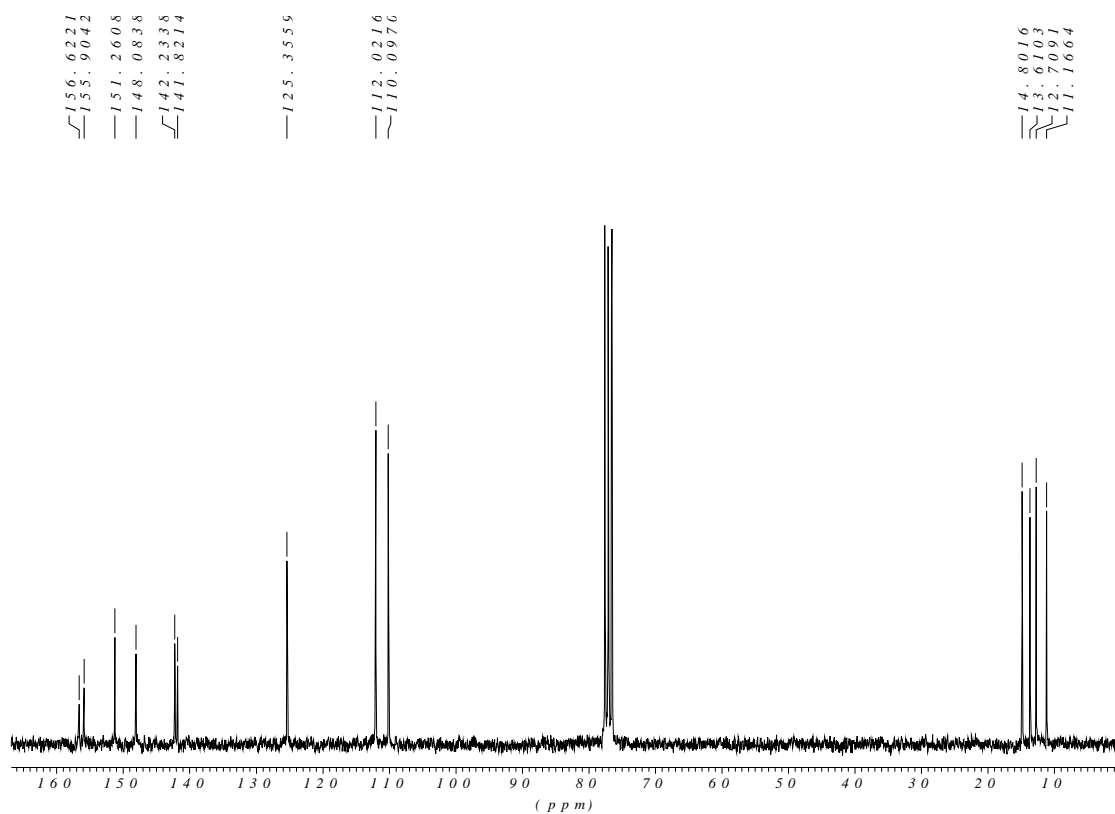
$^{13}\text{C}$  NMR spectrum of **12**



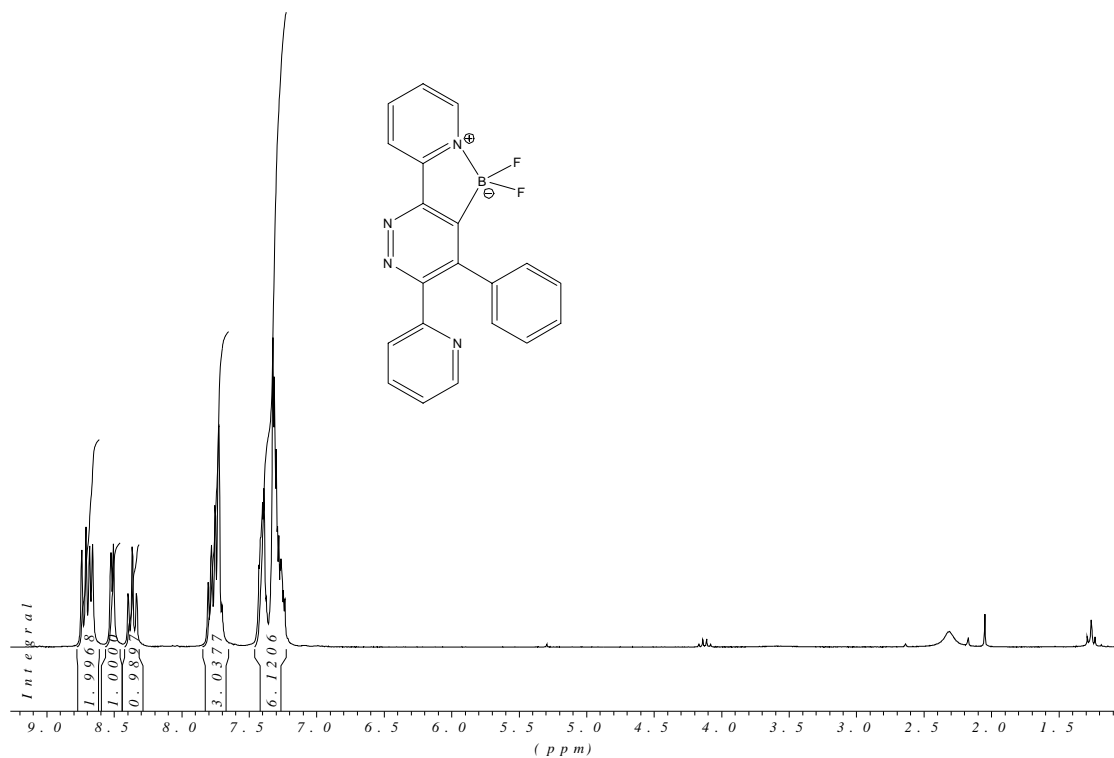
$^1\text{H}$  NMR spectrum of **14**



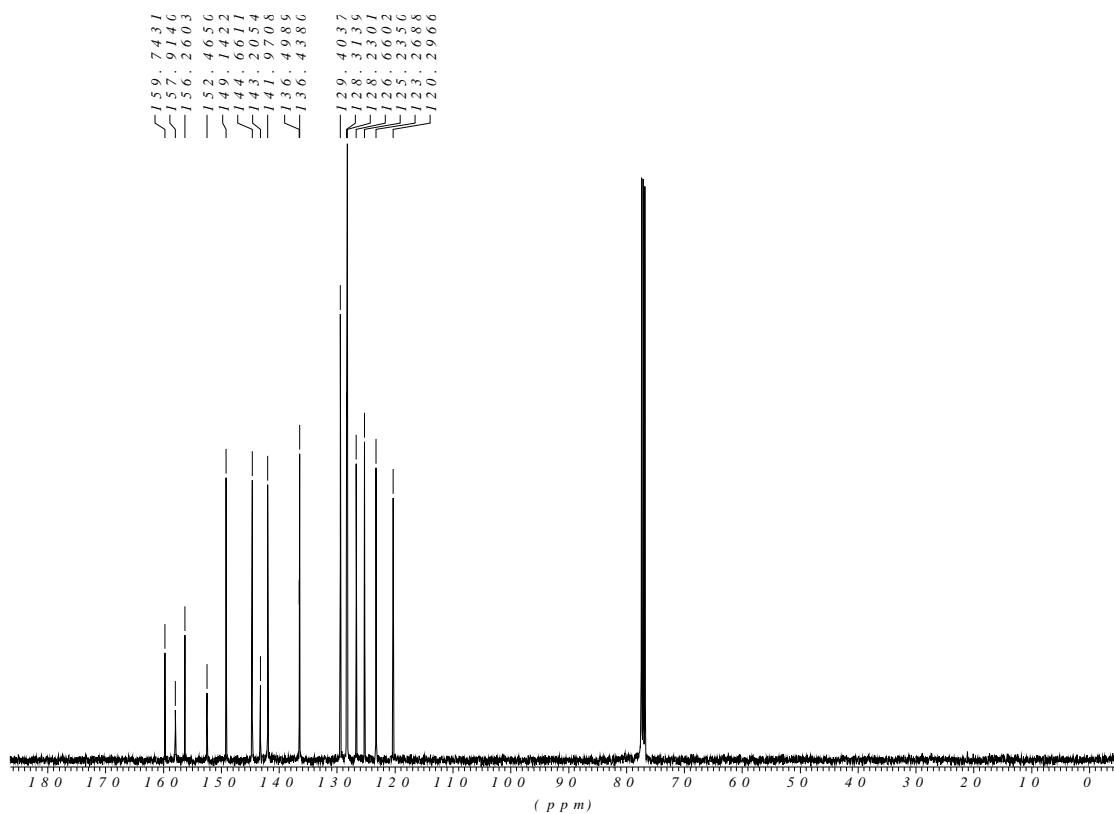
$^{13}\text{C}$  NMR spectrum of **14**



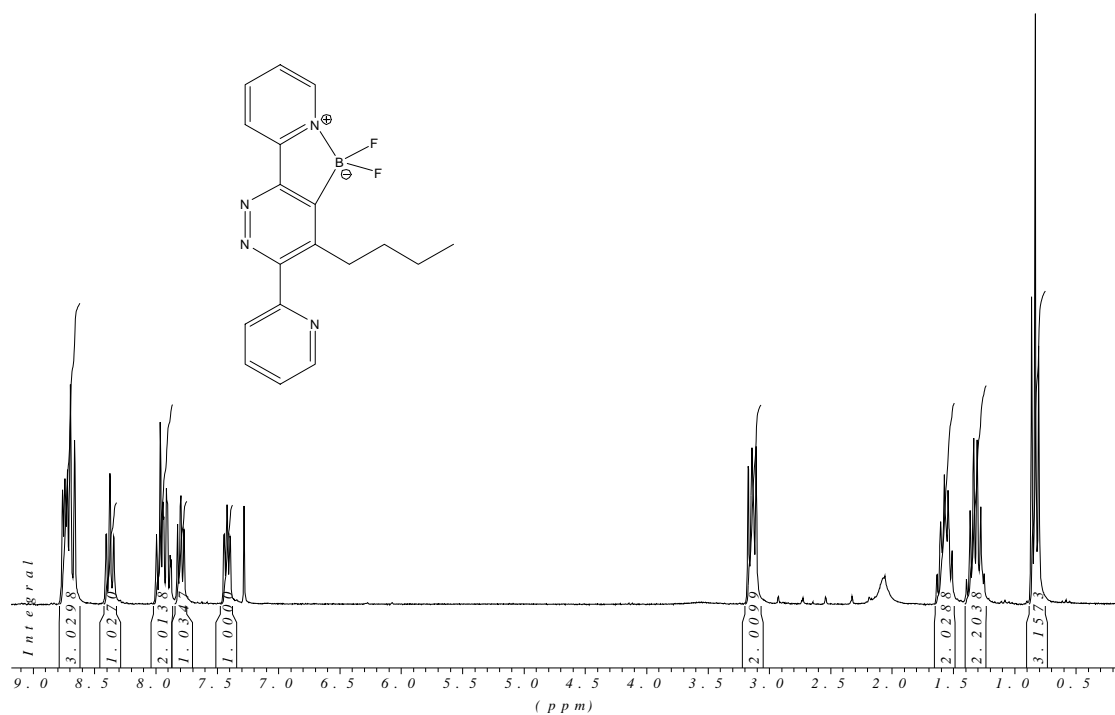
$^1\text{H}$  NMR spectrum of **16**



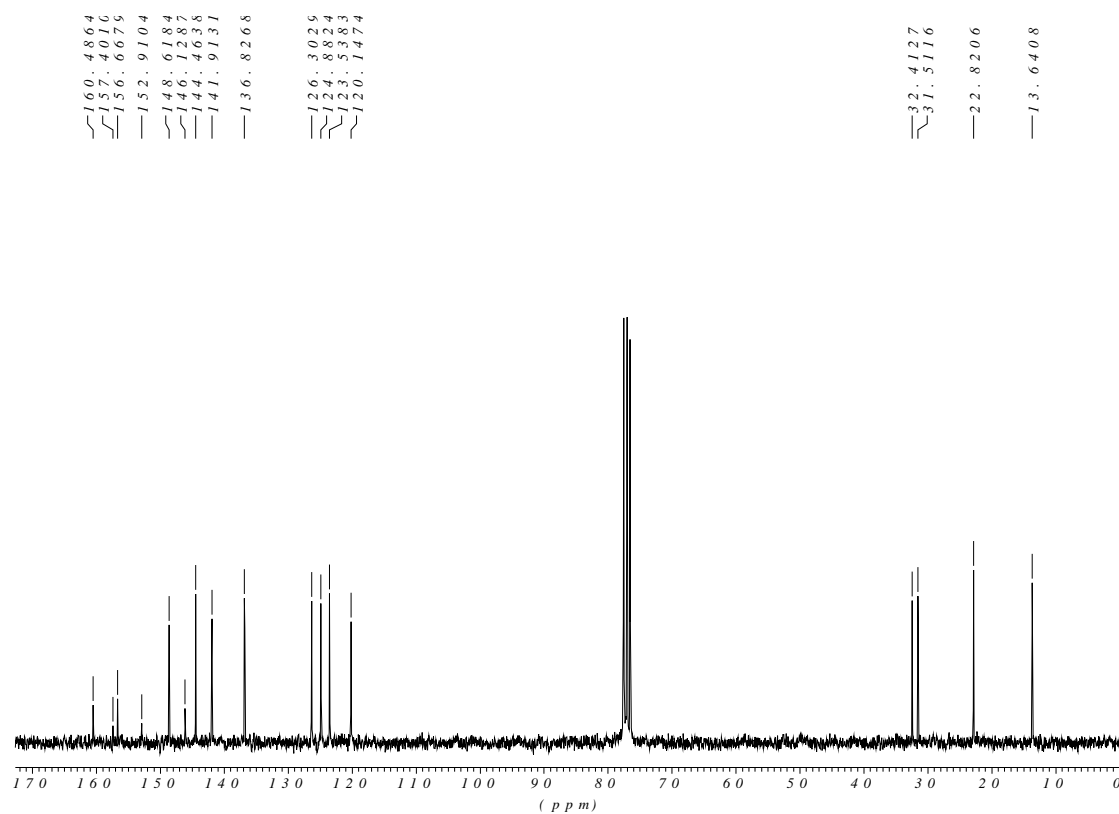
$^{13}\text{C}$  NMR spectrum of **16**



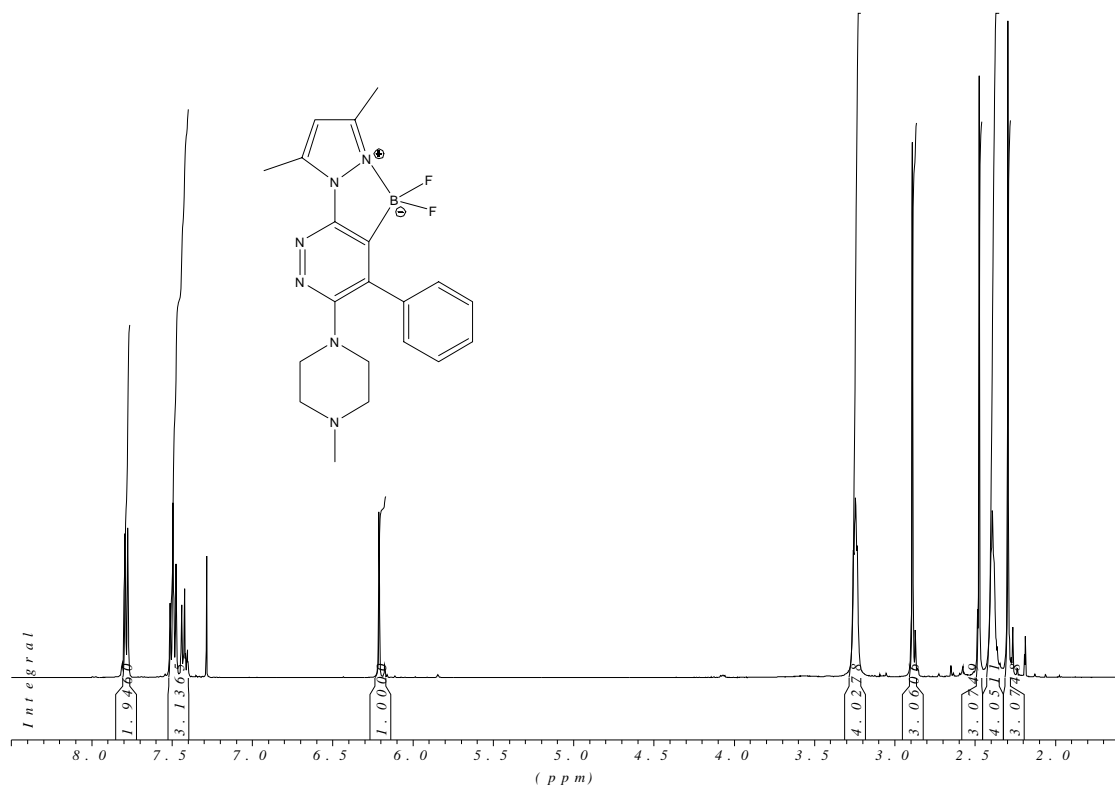
$^1\text{H}$  NMR spectrum of **17**



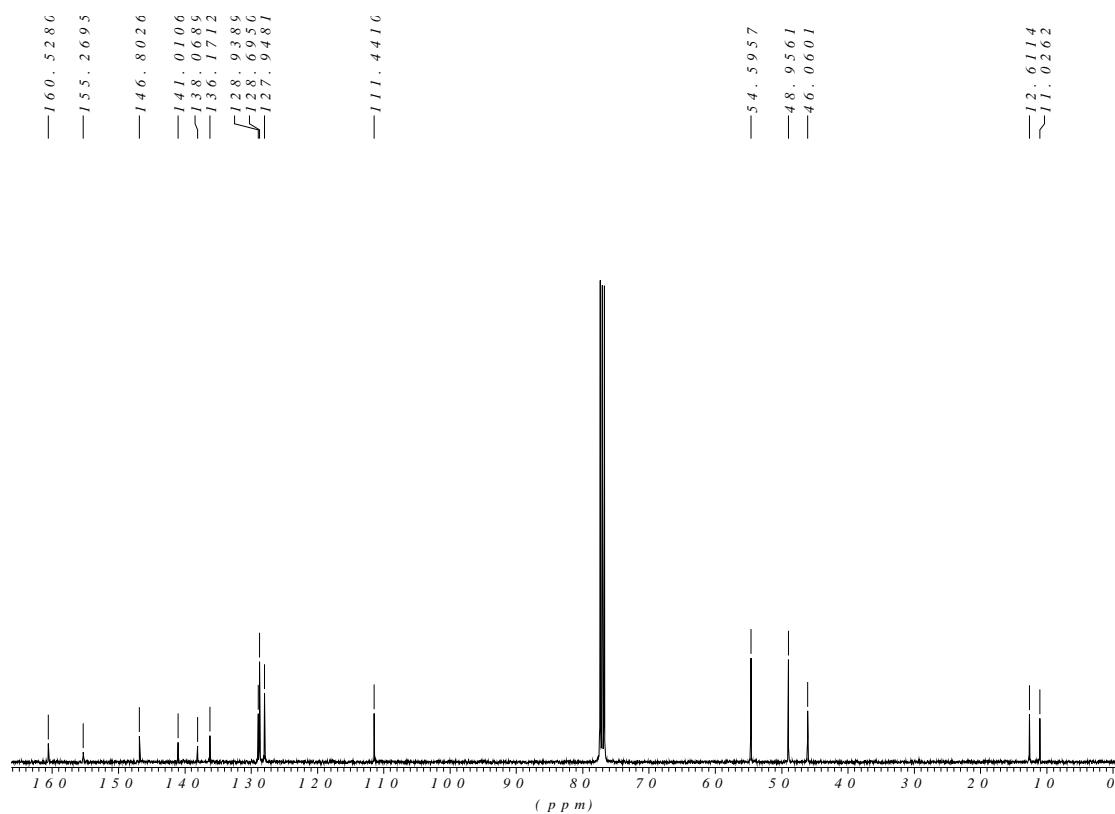
$^{13}\text{C}$  NMR spectrum of **17**



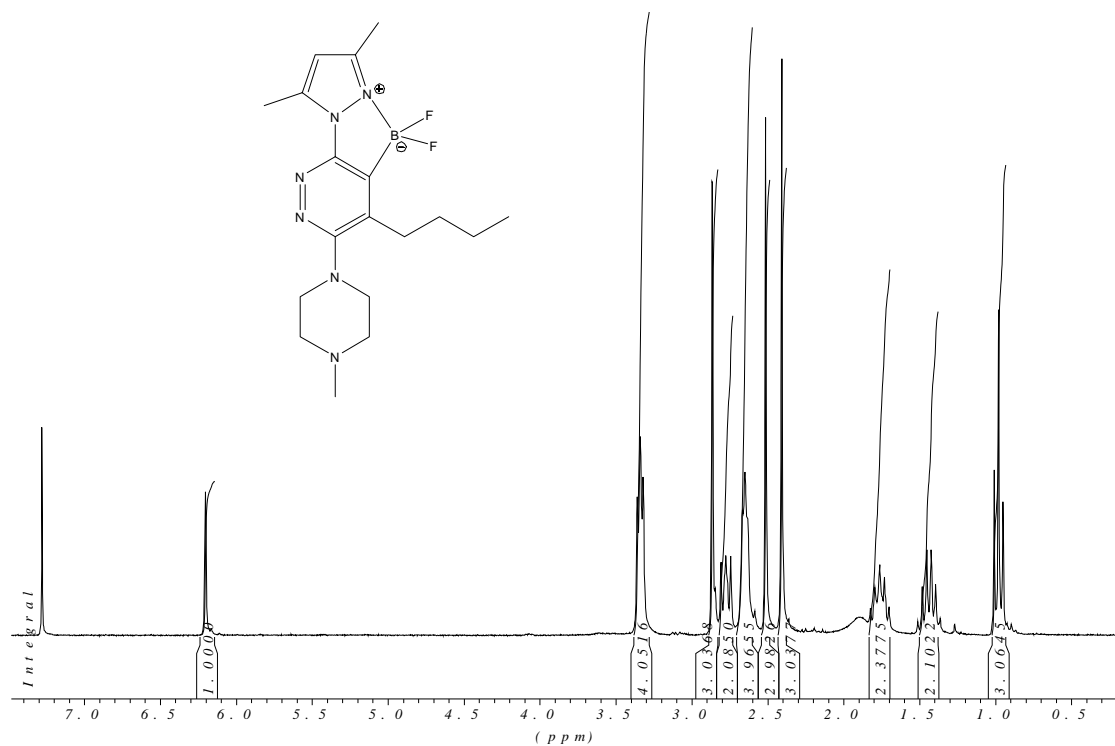
$^1\text{H}$  NMR spectrum of **19**



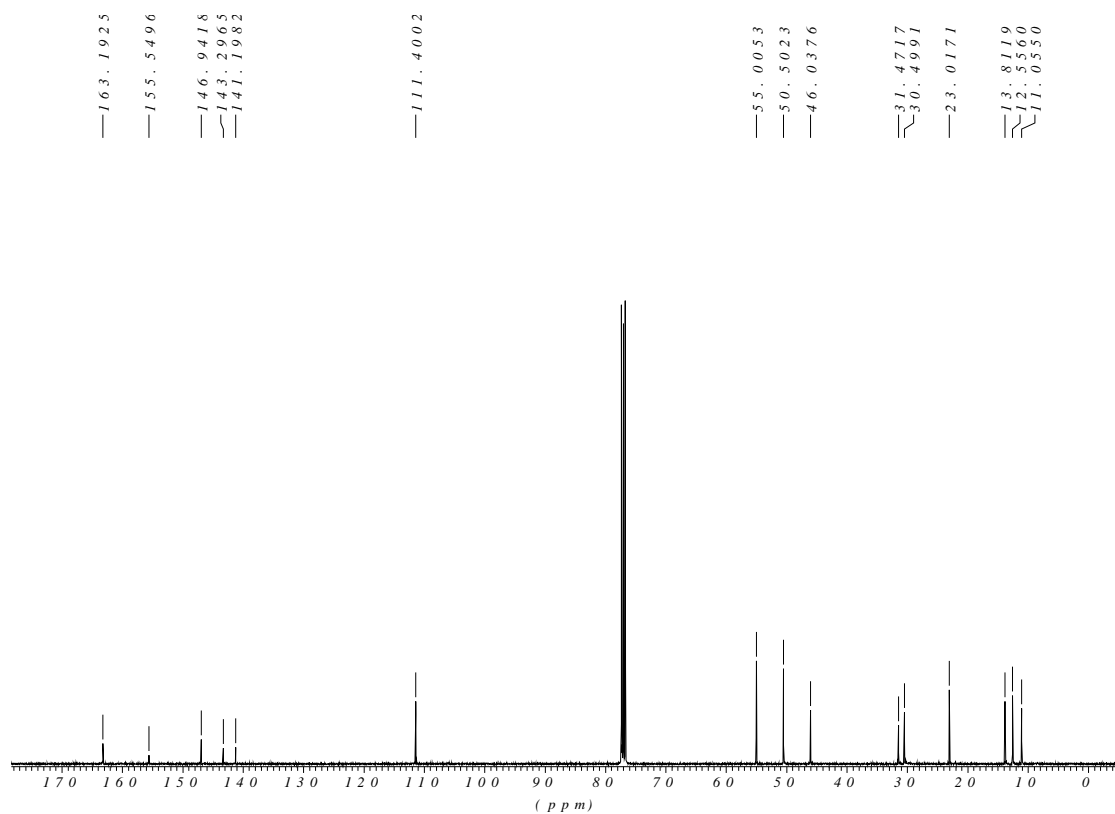
$^{13}\text{C}$  NMR spectrum of **19**



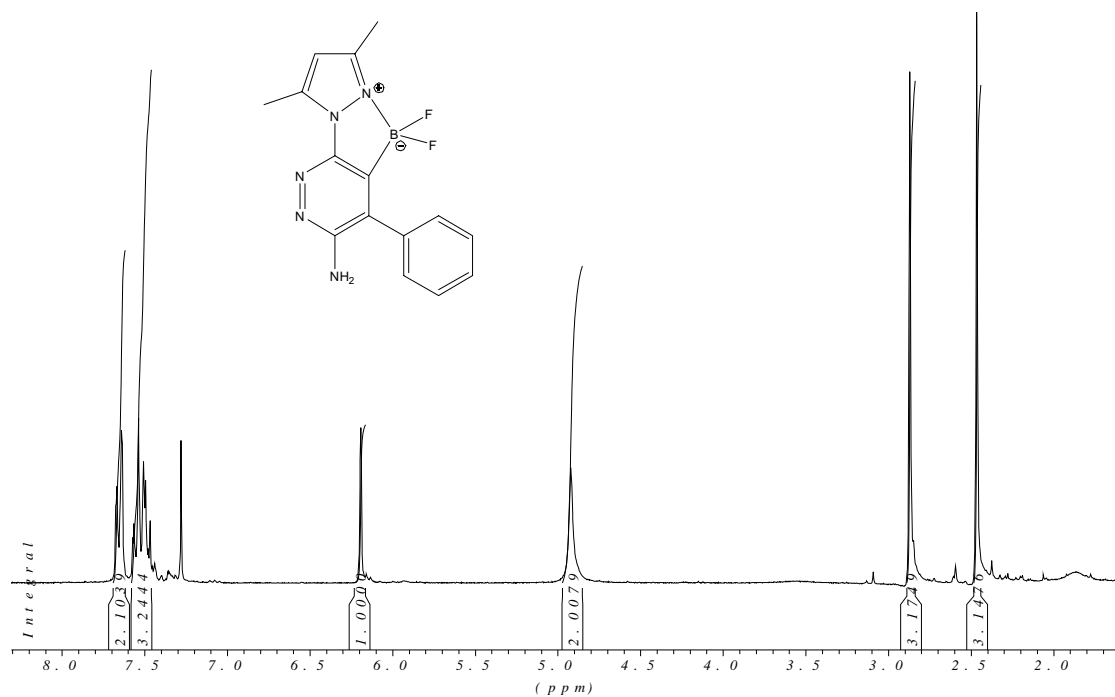
$^1\text{H}$  NMR spectrum of **20**



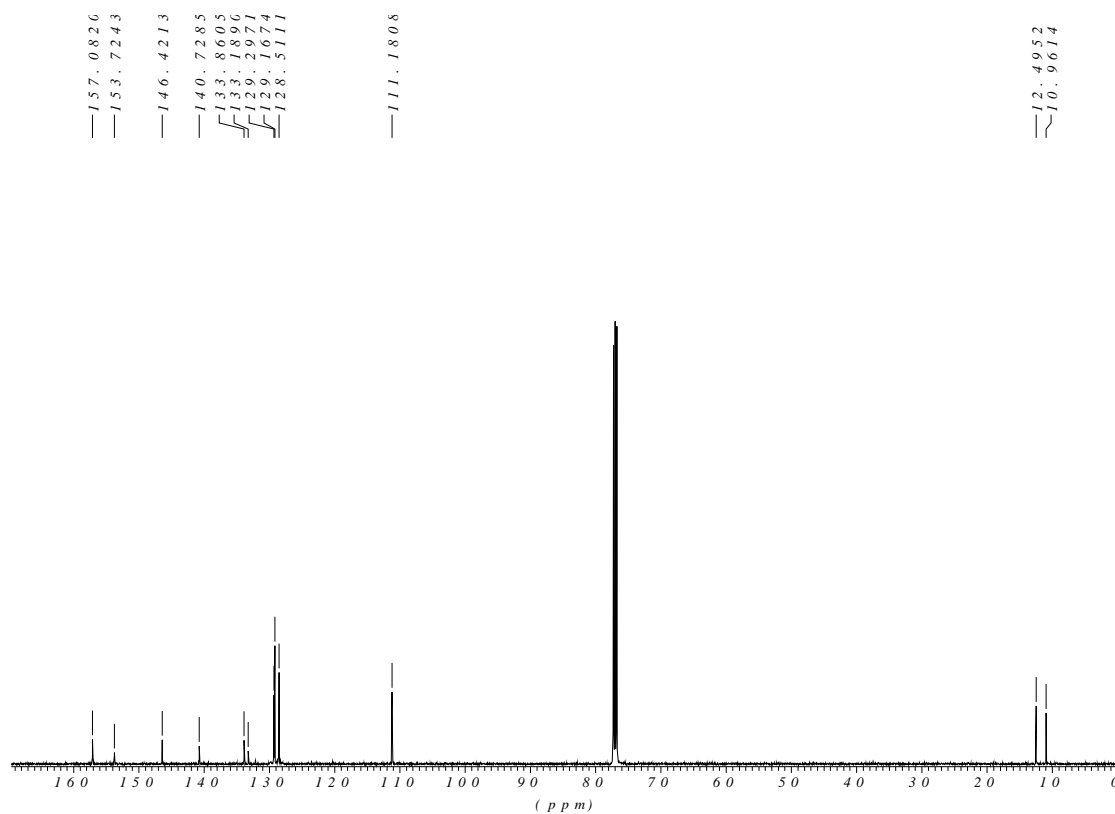
$^{13}\text{C}$  NMR spectrum of **20**



$^1\text{H}$  NMR spectrum of **22**

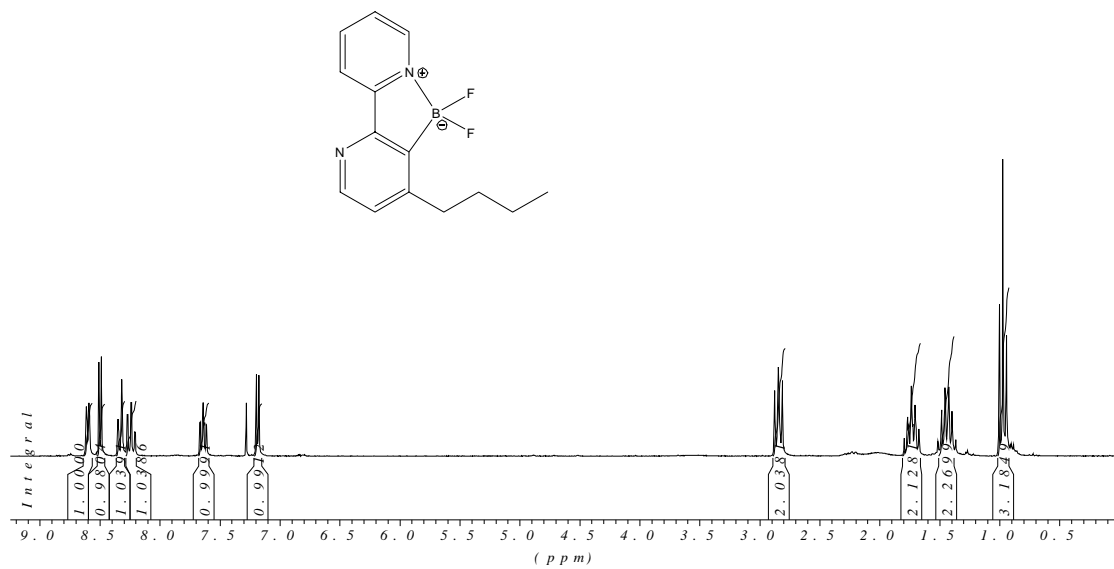


$^{13}\text{C}$  NMR spectrum of **22**

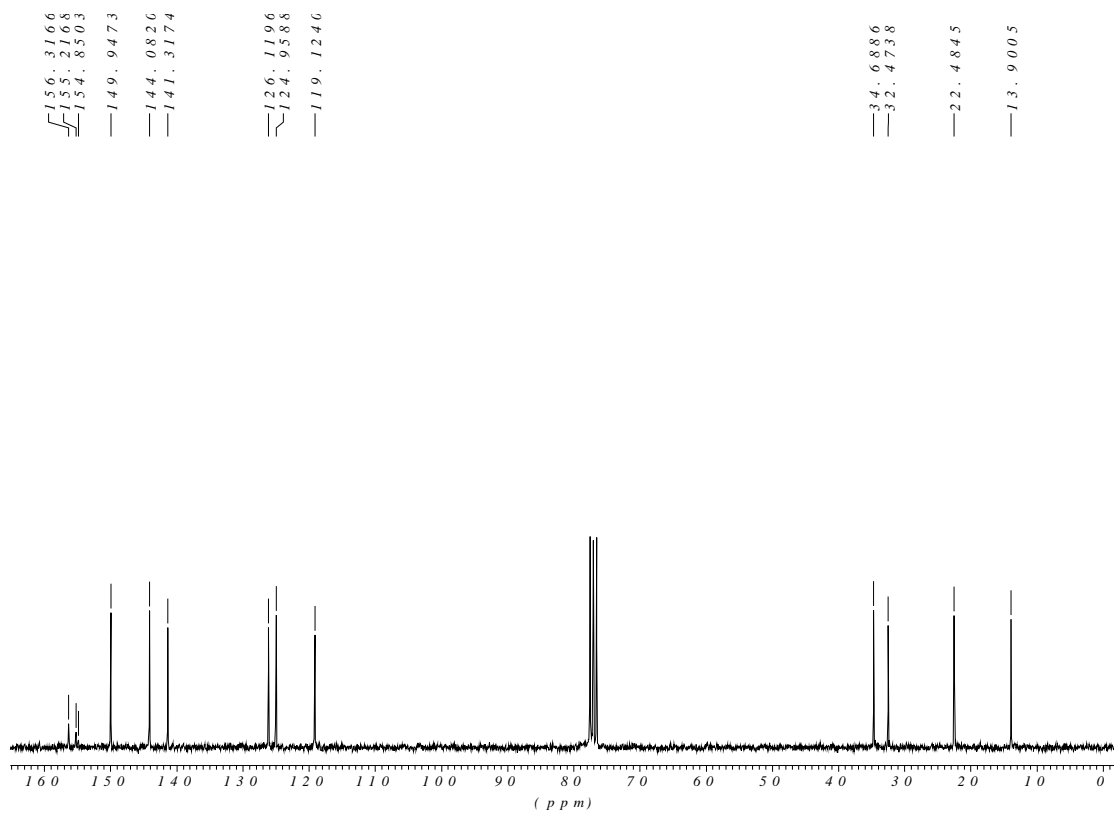




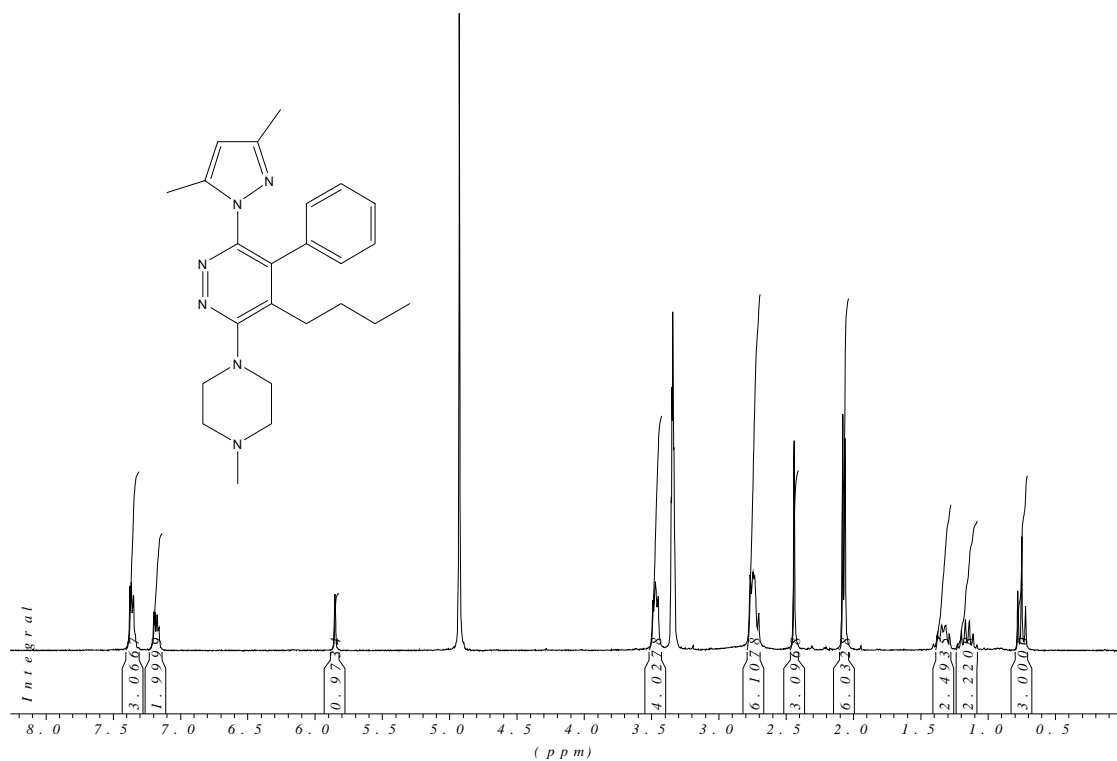
$^1\text{H}$  NMR spectrum of **24**



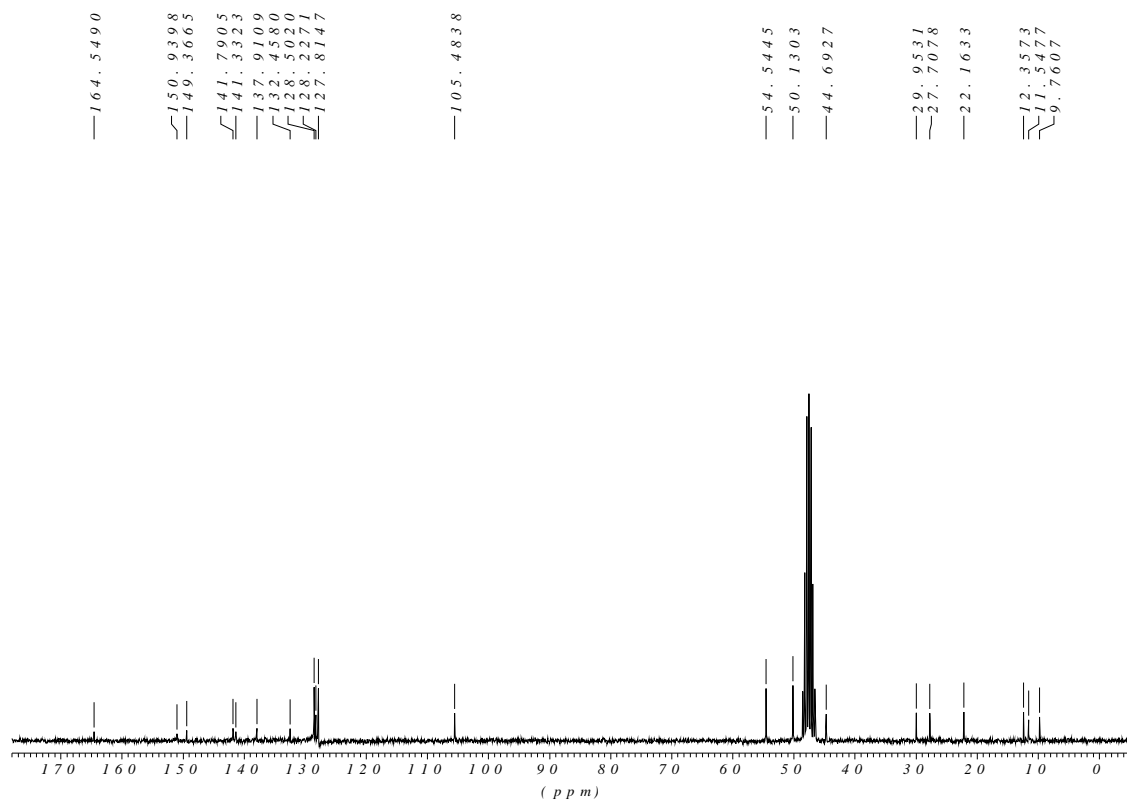
$^{13}\text{C}$  NMR spectrum of **24**



$^1\text{H}$  NMR spectrum of **27**



$^{13}\text{C}$  NMR spectrum of **27**

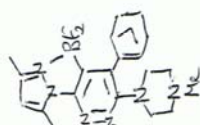


## Regiochemistry Assignments

The regiochemistry of compounds **19** and **24** were assigned by nOe spectroscopy (see below). The regiochemistry of compound **22** was assigned by X-ray crystallography. CCDC-750154 contains the supplementary crystallographic data for compound **22**. These data can be obtained free of charge from the Cambridge Crystallographic Data Centre via [www.ccdc.cam.ac.uk/data\\_request/cif](http://www.ccdc.cam.ac.uk/data_request/cif). The regiochemistry of compound **20** has been assigned by inference.

# <sup>1</sup>H NMR spectrum of **19**

J. Vivat E27 Sample ref. JFV 401-1 in CDCl<sub>3</sub>



The University of Sheffield

Current Data Parameters

NAME Juv01

EXPNO 1

PROCNO 1

F2 - Acquisition Parameters

Date\_ 20090401

Time 11.22

PROBHD 5 mm BBI 1H/1H

PULPROG zgpg30

TD 65536

SOLVENT DMSO

NS 12

DS 4

SWH 5995.204 Hz

FIDRES 0.182559 Hz

AQ 2.7329211 sec

RG 320

DM 83.400 usec

DE 2.00 usec

TE 296.0 usec

D1 2.00000000 sec

TD0 1

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P1 7.10 usec

PL1 -3.00 dB

SFO1 500.135000 MHz

F2 - Processing parameters

SI 16384

WDW EM

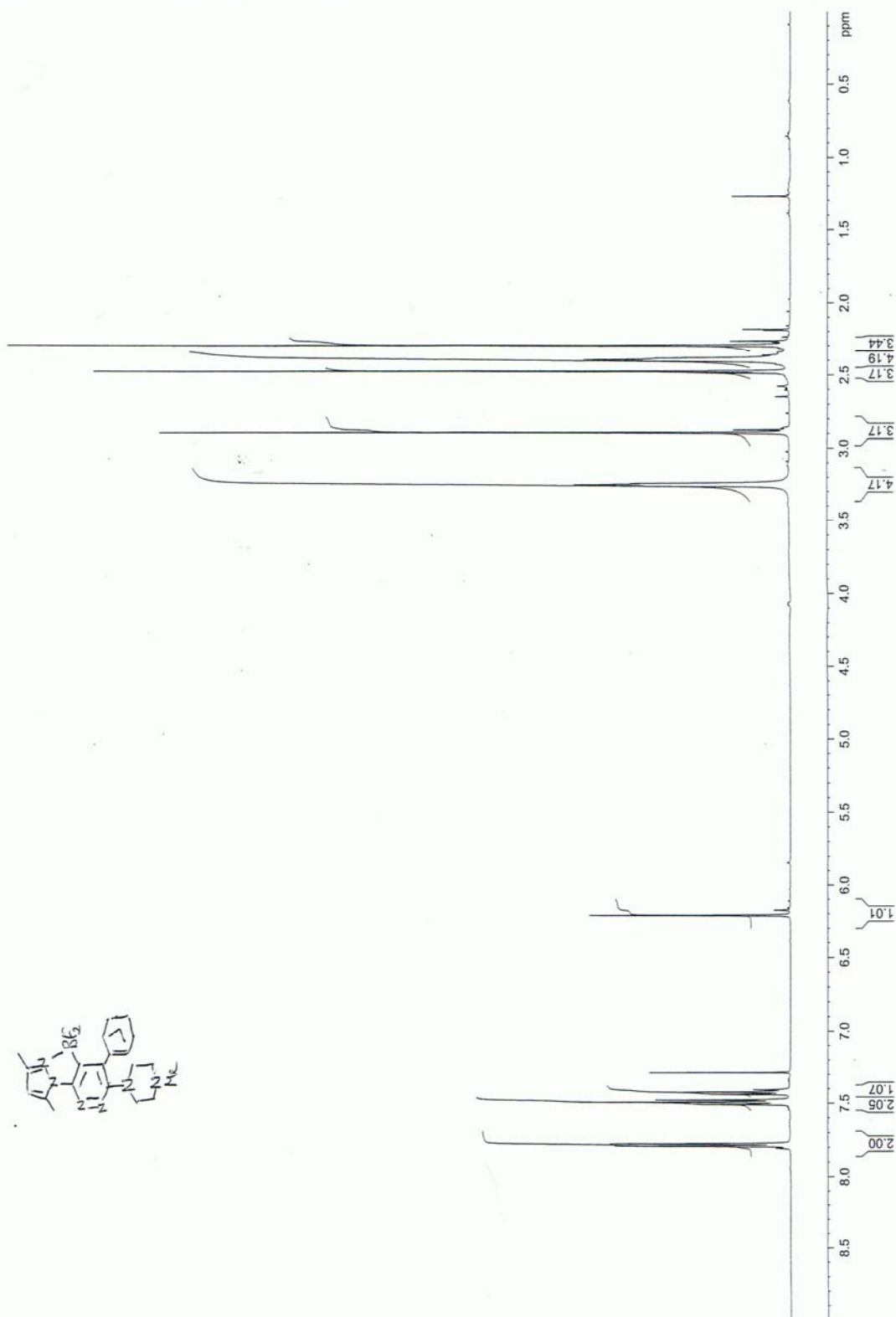
SF 500.135000 MHz

GB 0

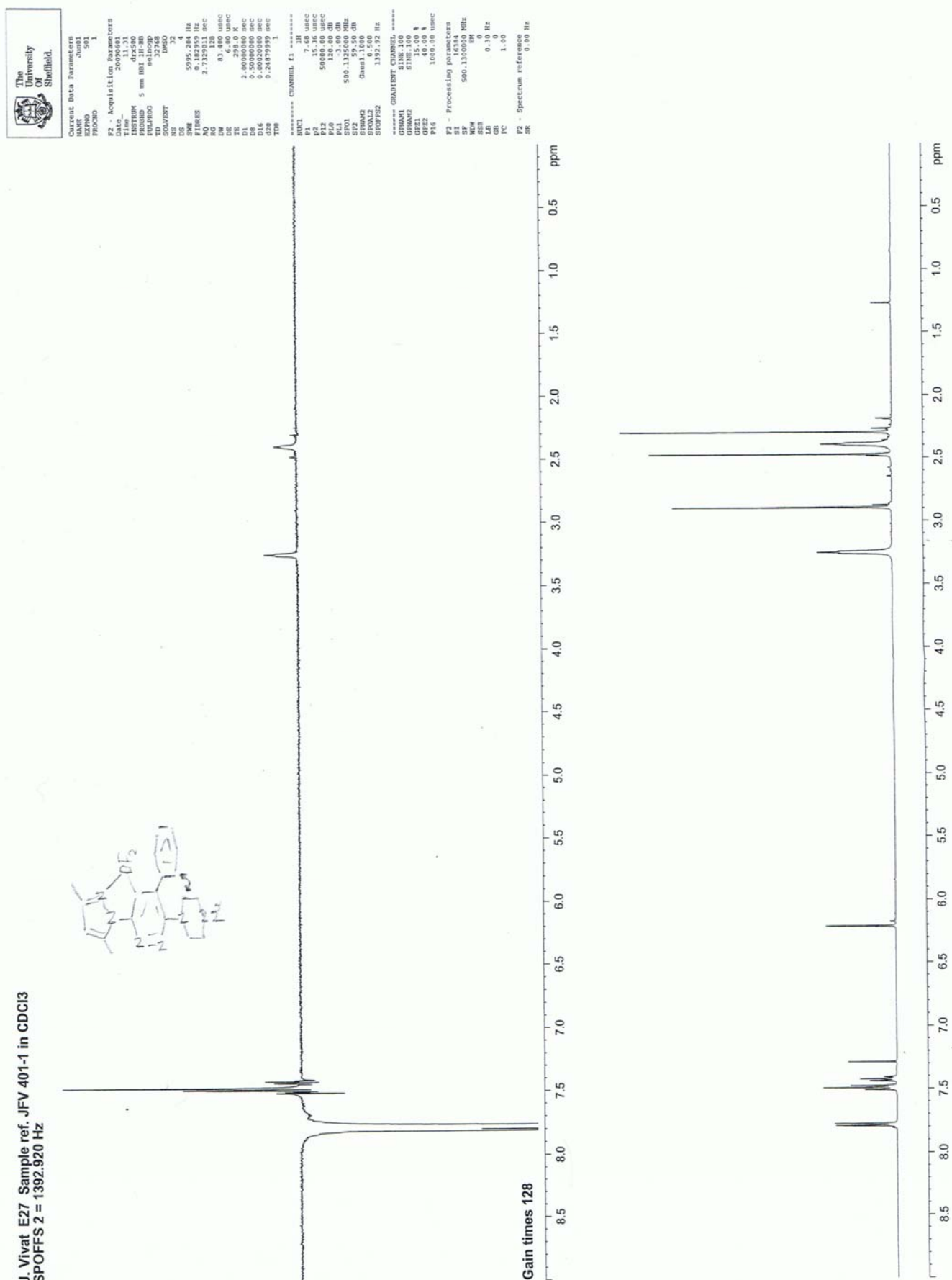
PC 1.00

F2 - Spectrum reference

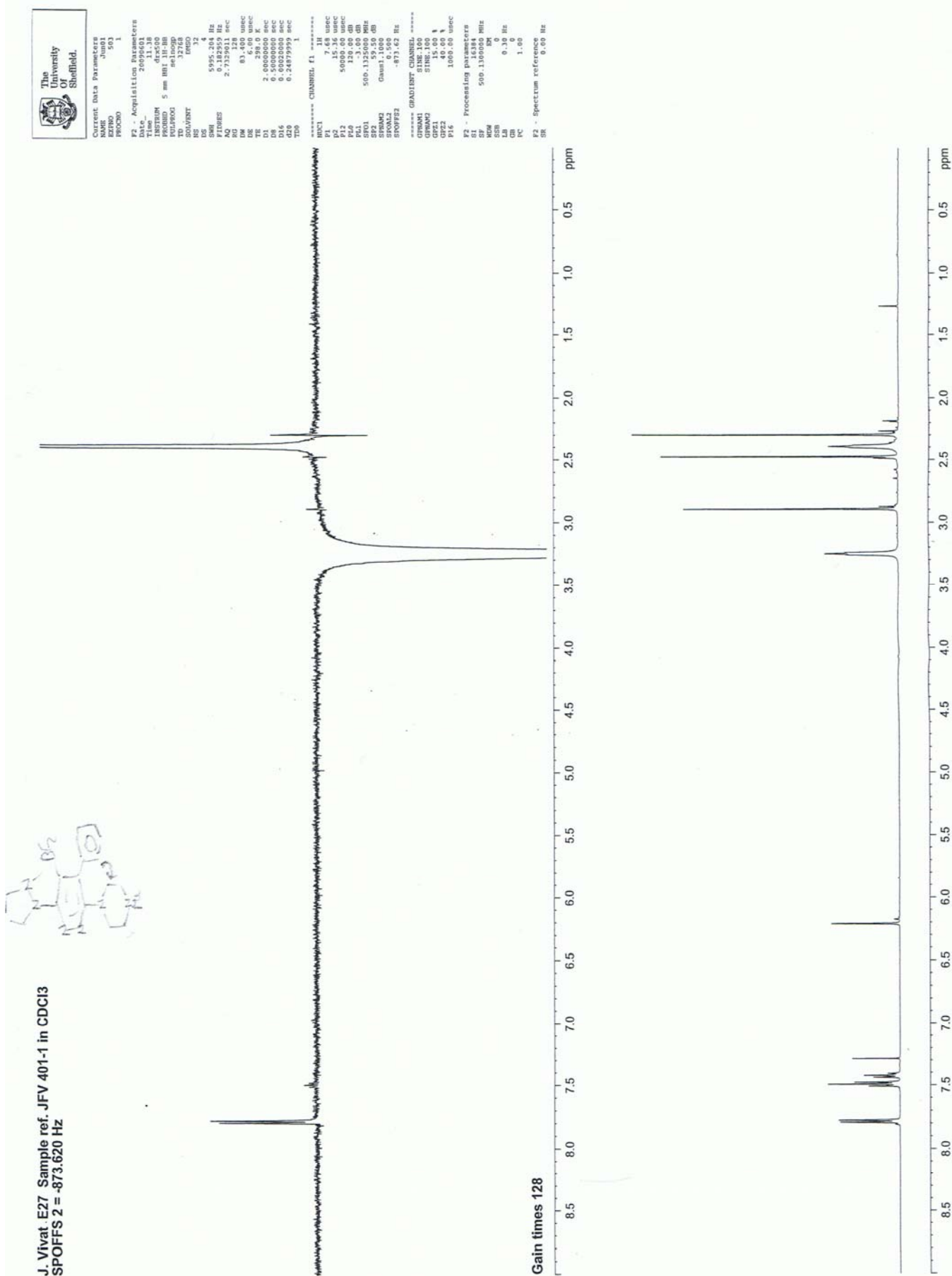
SR 0.00 Hz



J. Vivat E27 Sample ref. JFV 401-1 in CDCI3  
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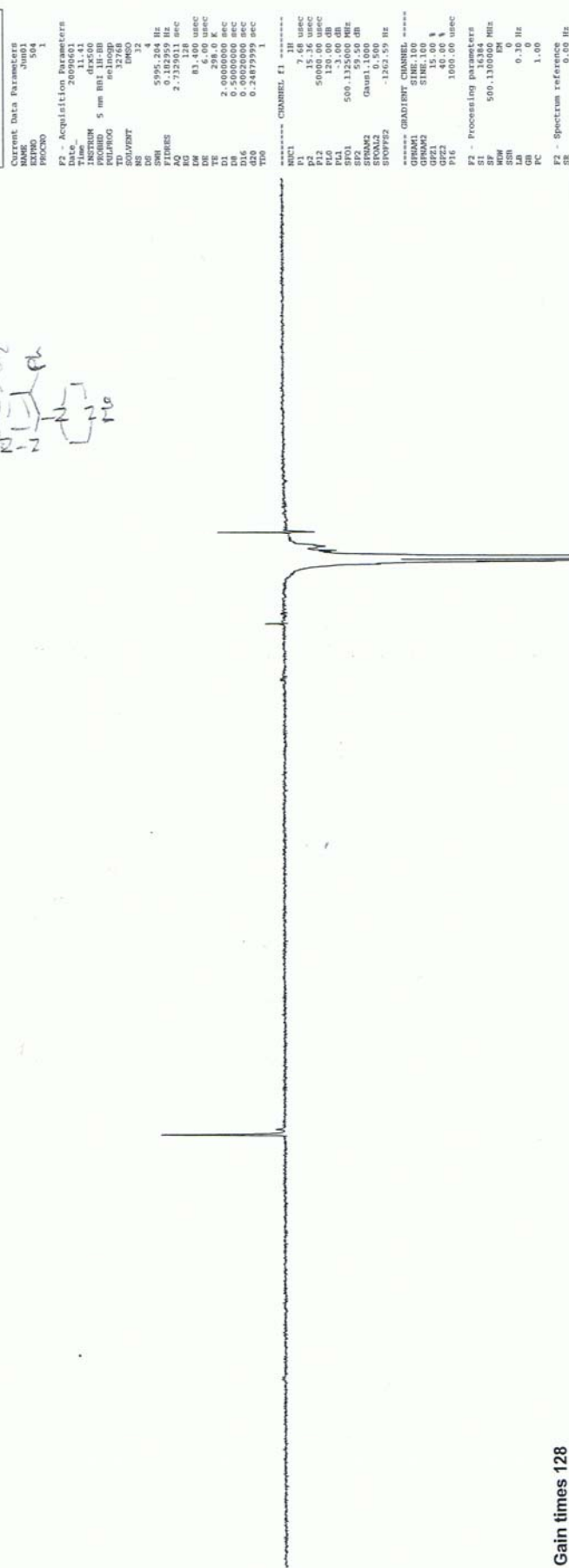
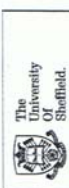
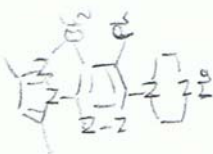


# nOe spectrum of 19



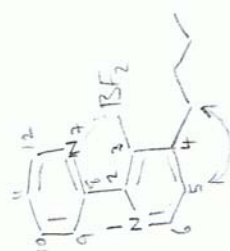
# nOe spectrum of **19**

J. Vivat E27 Sample ref. JFV 401-1 in CDCl<sub>3</sub>  
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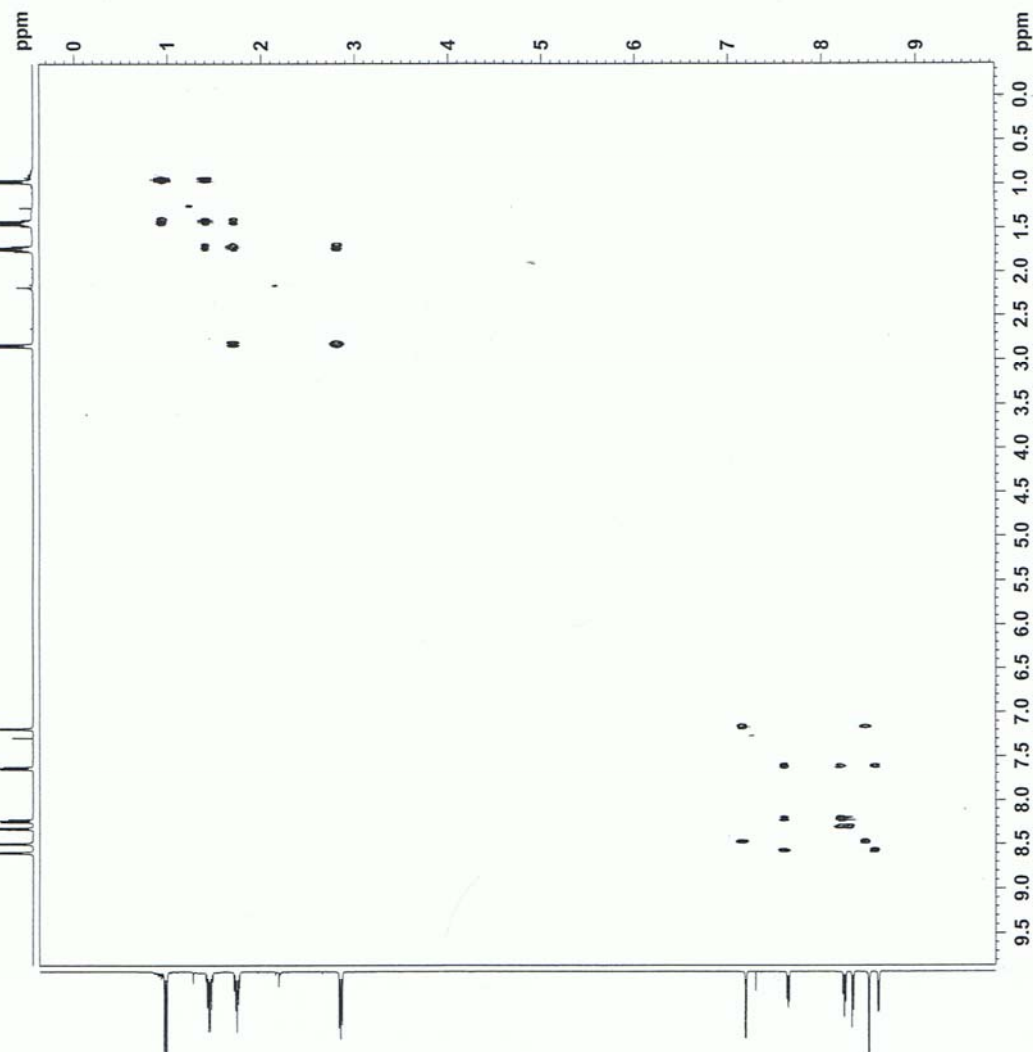


# COSY spectrum of **24**

J. Vivat E22 Sample ref. JFV 499 in CDCl<sub>3</sub>



<sup>1</sup>H-<sup>1</sup>H COSY

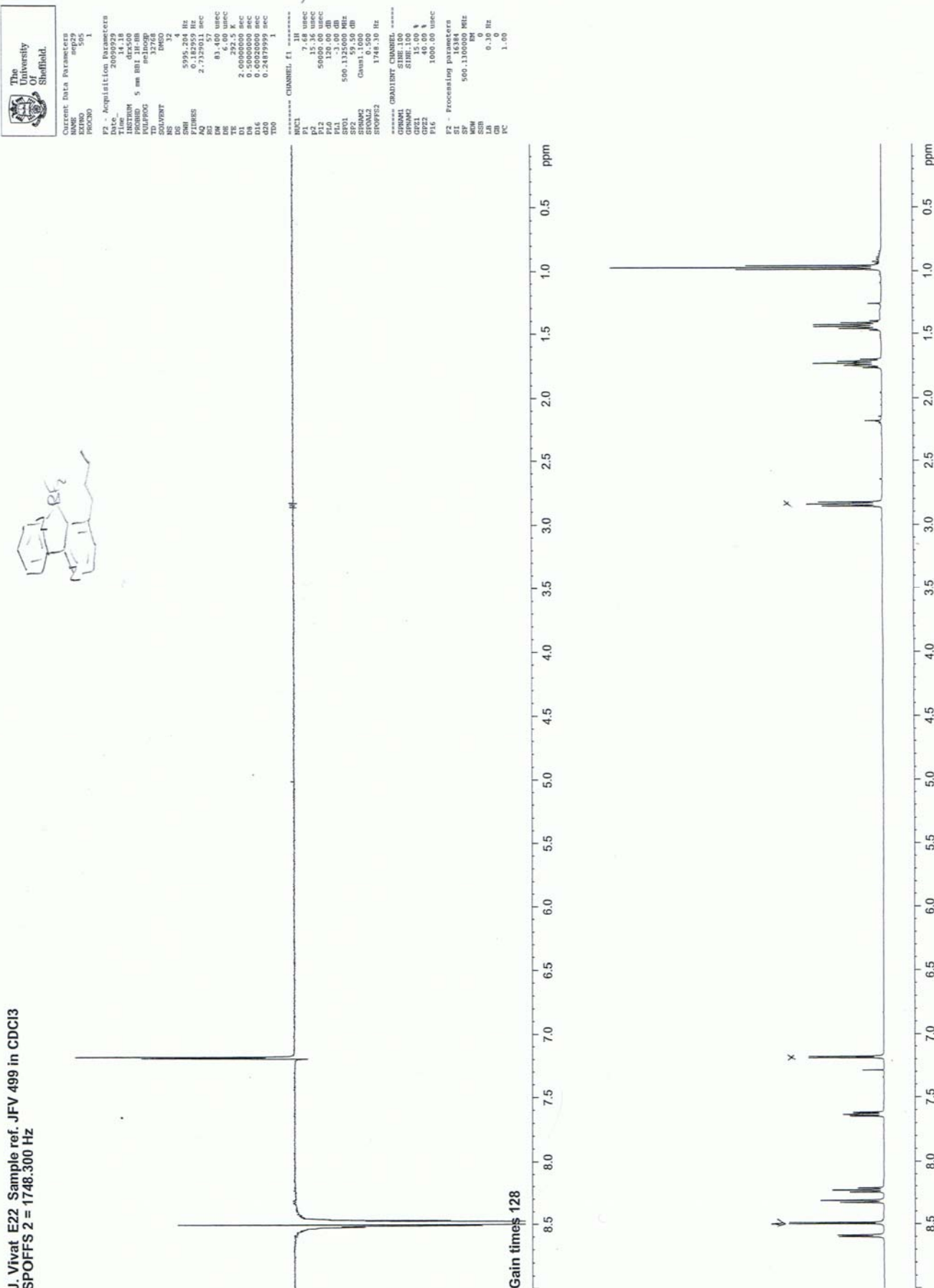


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PROCNO 1  
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PULPROG zgpg30  
TD 2048  
SOLVENT CDCl<sub>3</sub>  
DS 8  
GB 512.475 Hz  
FIDRES 2.705225 Hz  
AQ 0.200144 sec  
RG 25.4  
DM 97.000 usec  
DE 6.00 usec  
TE 292.6 K  
DO 0.0000300 sec  
D1 1.4000000 sec  
D1.1 0.0000000 sec  
D1.6 0.0002000 sec  
IN0 0.0019560 sec  
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P0 7.68 usec  
PL1 0.00 dB  
PL2 -1.00 dB  
SFO1 500.132866 MHz  
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GUNIT1 SINE.100  
GUC1 10.00 V  
P16 1000.00 usec  
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NUC1 1H  
P0 7.68 usec  
PL1 0.00 dB  
PL2 -1.00 dB  
SFO1 500.132866 MHz  
FIDRES 2.705225 Hz  
AQ 0.200144 sec  
RG 25.4  
DM 97.000 usec  
DE 6.00 usec  
TE 292.6 K  
DO 0.0000300 sec  
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D1.1 0.0000000 sec  
D1.6 0.0002000 sec  
IN0 0.0019560 sec  
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P0 7.68 usec  
PL1 0.00 dB  
PL2 -1.00 dB  
SFO2 125.761150 MHz  
F2 - Processing parameters  
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SF 500.1300113 MHz  
WDW HANN  
SSB 0  
GB 0  
PC 1.40  
F1 - Processing parameters  
SI 1024  
SF 500.1300113 MHz  
WDW HANN  
SSB 0  
GB 0  
PC 1.40



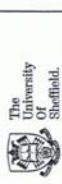
J. Vivat E22 Sample ref. JFV 499 in CDCI3  
SPOFFS 2 = -1079.510 Hz



nOe spectrum of **24**

# nOe spectrum of 24

J. Vivat E22 Sample ref. JFV 499 in CDCl<sub>3</sub>  
SPOFFS 2 = 1317.200 Hz

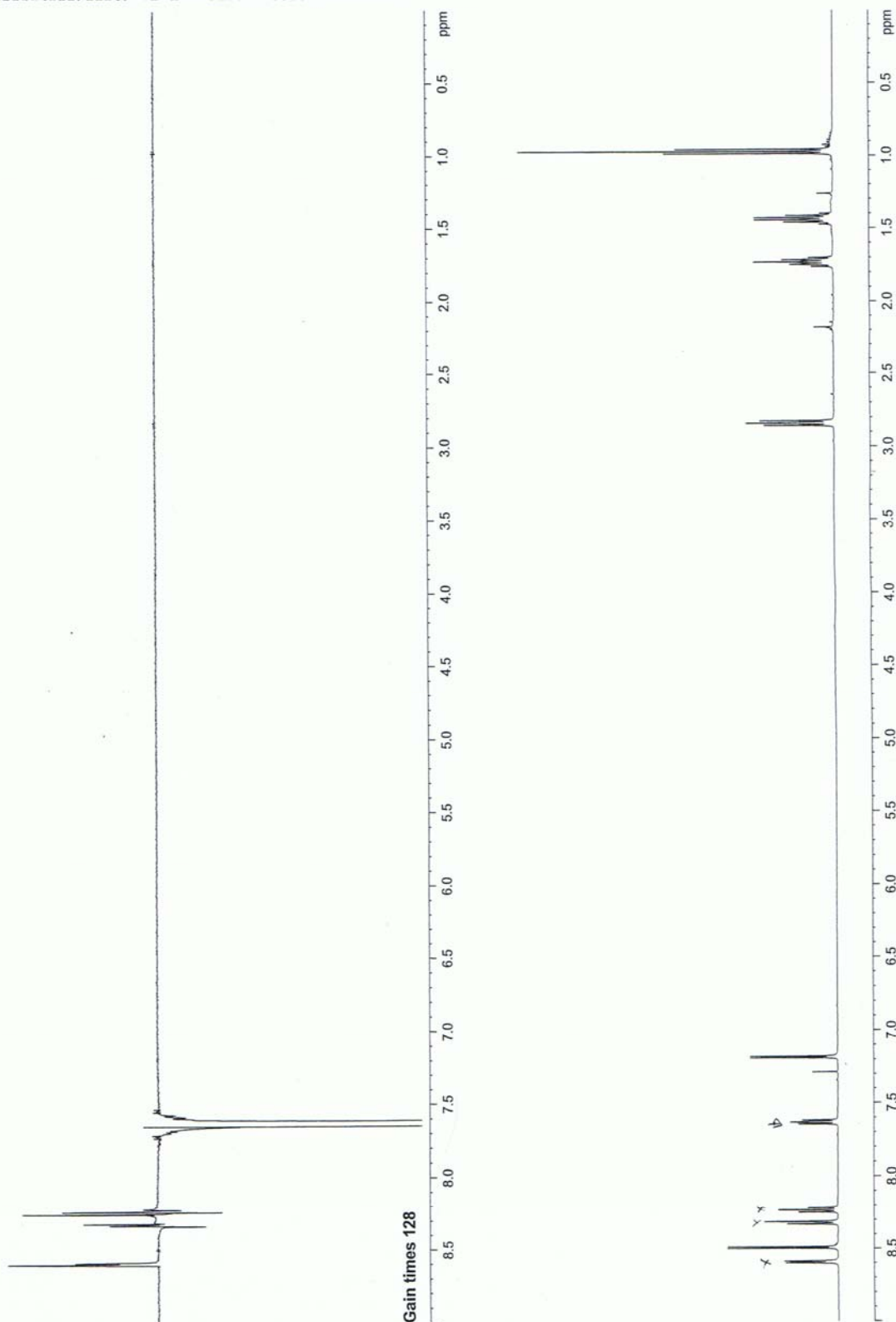


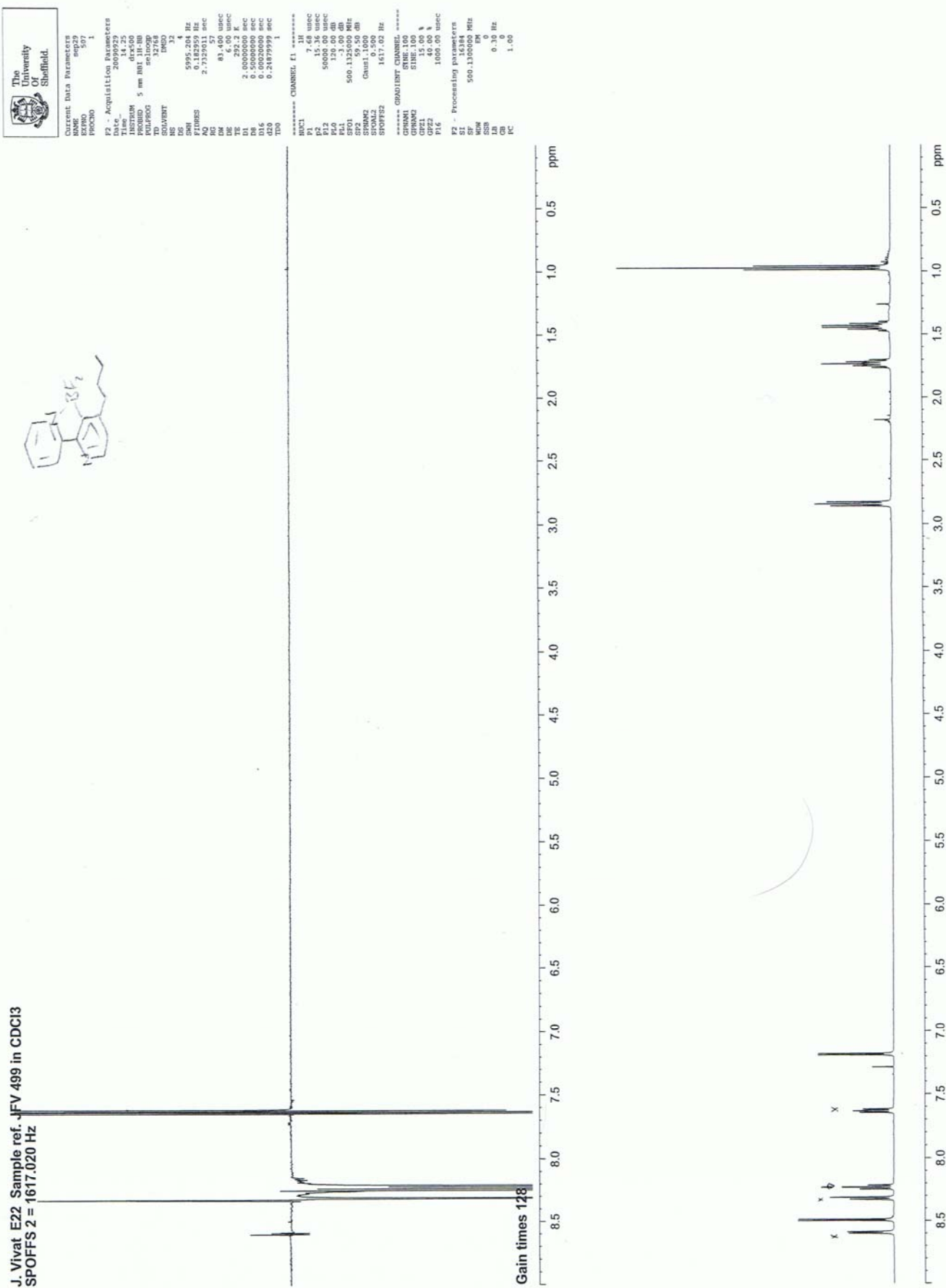
Current Data Parameters  
NAME: jfv499  
EXPNO: 500  
PROCNO: 1  
F2 - Acquisition Parameters  
Date\_ : 20070728  
Time: 14.28  
INSTRUM: drx500  
PROBHD: 5 mm HNP-100  
PULPROG: zgpg30  
TD: 32768  
SOLVENT: DMSO  
DS: 4  
SS: 5995.204 Hz  
NUC1: 13C  
NUC2: 1H  
AQ: 2.7129011 sec  
RG: 57  
RG2: 83.00 usec  
RM: 6.00 usec  
TE: 292.4 K  
D1: 2.00000000 sec  
D16: 0.00020000 sec  
D20: 0.00020000 sec  
D20: 0.24879999 sec  
TD0: 1

===== CHANNEL f1 =====  
NUC1: 13C  
P1: 7.48 usec  
P2: 15.36 usec  
P12: 50000.00 usec  
PL1: -1.50 dB  
PL2: -3.00 dB  
SFO1: 500.1325000 MHz  
SFO2: 500.1325000 MHz  
SFO12: 500.1325000 MHz  
GAM1: 1000  
SFOF12: 0.500  
1317.20 Hz

===== GRABUNT CHANNEL =====  
CHRM1: 100  
CHRM2: 100  
CP1: 15.00 V  
CP2: 40.00 V  
P16: 1000.00 usec

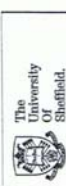
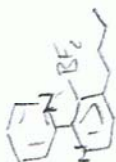
F2 - Processing parameters  
SI: 32768  
SF: 500.1325000 MHz  
WDW: EM  
SSB: 0  
GB: 0  
PC: 1.00



nOe spectrum of **24**

# nOe spectrum of 24

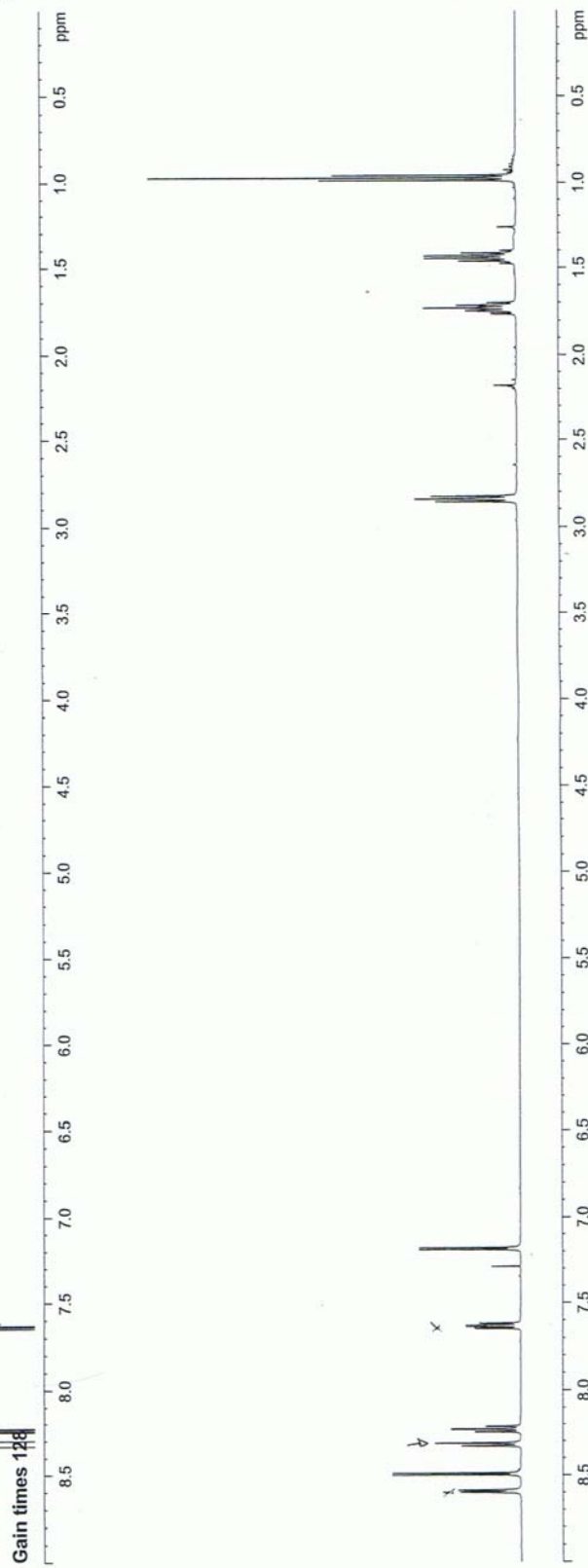
J. Vivat E22 Sample ref. JFV 499 in CDCl<sub>3</sub>  
SPOFFS 2 = 1662.440 Hz



Current Data Parameters  
NAME JFV499  
EXPNO 500  
PROCNO 1

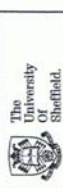
F2 - Acquisition Parameters  
Date\_ 20090922  
Time 14.22  
INSTRUM spect  
PROBHD 5 mm WB1  
PULPROG zgpg30  
TD 32768  
FIDRES 0.000100  
AQ 0.000100  
RG 32  
RG2 32  
RG3 32  
RG4 32  
RG5 32  
RG6 32  
RG7 32  
RG8 32  
RG9 32  
RG10 32  
RG11 32  
RG12 32  
RG13 32  
RG14 32  
RG15 32  
RG16 32  
RG17 32  
RG18 32  
RG19 32  
RG20 32  
RG21 32  
RG22 32  
RG23 32  
RG24 32  
RG25 32  
RG26 32  
RG27 32  
RG28 32  
RG29 32  
RG30 32  
RG31 32  
RG32 32  
RG33 32  
RG34 32  
RG35 32  
RG36 32  
RG37 32  
RG38 32  
RG39 32  
RG40 32  
RG41 32  
RG42 32  
RG43 32  
RG44 32  
RG45 32  
RG46 32  
RG47 32  
RG48 32  
RG49 32  
RG50 32  
RG51 32  
RG52 32  
RG53 32  
RG54 32  
RG55 32  
RG56 32  
RG57 32  
RG58 32  
RG59 32  
RG60 32  
RG61 32  
RG62 32  
RG63 32  
RG64 32  
RG65 32  
RG66 32  
RG67 32  
RG68 32  
RG69 32  
RG70 32  
RG71 32  
RG72 32  
RG73 32  
RG74 32  
RG75 32  
RG76 32  
RG77 32  
RG78 32  
RG79 32  
RG80 32  
RG81 32  
RG82 32  
RG83 32  
RG84 32  
RG85 32  
RG86 32  
RG87 32  
RG88 32  
RG89 32  
RG90 32  
RG91 32  
RG92 32  
RG93 32  
RG94 32  
RG95 32  
RG96 32  
RG97 32  
RG98 32  
RG99 32  
RG100 32

===== CHANNEL f1 =====  
NUC1 13C  
P1 14.00 usec  
PL1 0.00 dB  
PR1 1.00  
NUC2 1H  
P2 13.36 usec  
PL2 0.00 dB  
PR2 1.00  
NUC3 13C  
P3 14.00 usec  
PL3 0.00 dB  
PR3 1.00  
NUC4 1H  
P4 13.36 usec  
PL4 0.00 dB  
PR4 1.00  
NUC5 13C  
P5 14.00 usec  
PL5 0.00 dB  
PR5 1.00  
NUC6 1H  
P6 13.36 usec  
PL6 0.00 dB  
PR6 1.00  
NUC7 13C  
P7 14.00 usec  
PL7 0.00 dB  
PR7 1.00  
NUC8 1H  
P8 13.36 usec  
PL8 0.00 dB  
PR8 1.00  
NUC9 13C  
P9 14.00 usec  
PL9 0.00 dB  
PR9 1.00  
NUC10 1H  
P10 13.36 usec  
PL10 0.00 dB  
PR10 1.00  
NUC11 13C  
P11 14.00 usec  
PL11 0.00 dB  
PR11 1.00  
NUC12 1H  
P12 13.36 usec  
PL12 0.00 dB  
PR12 1.00  
NUC13 13C  
P13 14.00 usec  
PL13 0.00 dB  
PR13 1.00  
NUC14 1H  
P14 13.36 usec  
PL14 0.00 dB  
PR14 1.00  
NUC15 13C  
P15 14.00 usec  
PL15 0.00 dB  
PR15 1.00  
NUC16 1H  
P16 13.36 usec  
PL16 0.00 dB  
PR16 1.00  
NUC17 13C  
P17 14.00 usec  
PL17 0.00 dB  
PR17 1.00  
NUC18 1H  
P18 13.36 usec  
PL18 0.00 dB  
PR18 1.00  
NUC19 13C  
P19 14.00 usec  
PL19 0.00 dB  
PR19 1.00  
NUC20 1H  
P20 13.36 usec  
PL20 0.00 dB  
PR20 1.00  
NUC21 13C  
P21 14.00 usec  
PL21 0.00 dB  
PR21 1.00  
NUC22 1H  
P22 13.36 usec  
PL22 0.00 dB  
PR22 1.00  
NUC23 13C  
P23 14.00 usec  
PL23 0.00 dB  
PR23 1.00  
NUC24 1H  
P24 13.36 usec  
PL24 0.00 dB  
PR24 1.00  
NUC25 13C  
P25 14.00 usec  
PL25 0.00 dB  
PR25 1.00  
NUC26 1H  
P26 13.36 usec  
PL26 0.00 dB  
PR26 1.00  
NUC27 13C  
P27 14.00 usec  
PL27 0.00 dB  
PR27 1.00  
NUC28 1H  
P28 13.36 usec  
PL28 0.00 dB  
PR28 1.00  
NUC29 13C  
P29 14.00 usec  
PL29 0.00 dB  
PR29 1.00  
NUC30 1H  
P30 13.36 usec  
PL30 0.00 dB  
PR30 1.00  
NUC31 13C  
P31 14.00 usec  
PL31 0.00 dB  
PR31 1.00  
NUC32 1H  
P32 13.36 usec  
PL32 0.00 dB  
PR32 1.00  
NUC33 13C  
P33 14.00 usec  
PL33 0.00 dB  
PR33 1.00  
NUC34 1H  
P34 13.36 usec  
PL34 0.00 dB  
PR34 1.00  
NUC35 13C  
P35 14.00 usec  
PL35 0.00 dB  
PR35 1.00  
NUC36 1H  
P36 13.36 usec  
PL36 0.00 dB  
PR36 1.00  
NUC37 13C  
P37 14.00 usec  
PL37 0.00 dB  
PR37 1.00  
NUC38 1H  
P38 13.36 usec  
PL38 0.00 dB  
PR38 1.00  
NUC39 13C  
P39 14.00 usec  
PL39 0.00 dB  
PR39 1.00  
NUC40 1H  
P40 13.36 usec  
PL40 0.00 dB  
PR40 1.00  
NUC41 13C  
P41 14.00 usec  
PL41 0.00 dB  
PR41 1.00  
NUC42 1H  
P42 13.36 usec  
PL42 0.00 dB  
PR42 1.00  
NUC43 13C  
P43 14.00 usec  
PL43 0.00 dB  
PR43 1.00  
NUC44 1H  
P44 13.36 usec  
PL44 0.00 dB  
PR44 1.00  
NUC45 13C  
P45 14.00 usec  
PL45 0.00 dB  
PR45 1.00  
NUC46 1H  
P46 13.36 usec  
PL46 0.00 dB  
PR46 1.00  
NUC47 13C  
P47 14.00 usec  
PL47 0.00 dB  
PR47 1.00  
NUC48 1H  
P48 13.36 usec  
PL48 0.00 dB  
PR48 1.00  
NUC49 13C  
P49 14.00 usec  
PL49 0.00 dB  
PR49 1.00  
NUC50 1H  
P50 13.36 usec  
PL50 0.00 dB  
PR50 1.00  
NUC51 13C  
P51 14.00 usec  
PL51 0.00 dB  
PR51 1.00  
NUC52 1H  
P52 13.36 usec  
PL52 0.00 dB  
PR52 1.00  
NUC53 13C  
P53 14.00 usec  
PL53 0.00 dB  
PR53 1.00  
NUC54 1H  
P54 13.36 usec  
PL54 0.00 dB  
PR54 1.00  
NUC55 13C  
P55 14.00 usec  
PL55 0.00 dB  
PR55 1.00  
NUC56 1H  
P56 13.36 usec  
PL56 0.00 dB  
PR56 1.00  
NUC57 13C  
P57 14.00 usec  
PL57 0.00 dB  
PR57 1.00  
NUC58 1H  
P58 13.36 usec  
PL58 0.00 dB  
PR58 1.00  
NUC59 13C  
P59 14.00 usec  
PL59 0.00 dB  
PR59 1.00  
NUC60 1H  
P60 13.36 usec  
PL60 0.00 dB  
PR60 1.00  
NUC61 13C  
P61 14.00 usec  
PL61 0.00 dB  
PR61 1.00  
NUC62 1H  
P62 13.36 usec  
PL62 0.00 dB  
PR62 1.00  
NUC63 13C  
P63 14.00 usec  
PL63 0.00 dB  
PR63 1.00  
NUC64 1H  
P64 13.36 usec  
PL64 0.00 dB  
PR64 1.00  
NUC65 13C  
P65 14.00 usec  
PL65 0.00 dB  
PR65 1.00  
NUC66 1H  
P66 13.36 usec  
PL66 0.00 dB  
PR66 1.00  
NUC67 13C  
P67 14.00 usec  
PL67 0.00 dB  
PR67 1.00  
NUC68 1H  
P68 13.36 usec  
PL68 0.00 dB  
PR68 1.00  
NUC69 13C  
P69 14.00 usec  
PL69 0.00 dB  
PR69 1.00  
NUC70 1H  
P70 13.36 usec  
PL70 0.00 dB  
PR70 1.00  
NUC71 13C  
P71 14.00 usec  
PL71 0.00 dB  
PR71 1.00  
NUC72 1H  
P72 13.36 usec  
PL72 0.00 dB  
PR72 1.00  
NUC73 13C  
P73 14.00 usec  
PL73 0.00 dB  
PR73 1.00  
NUC74 1H  
P74 13.36 usec  
PL74 0.00 dB  
PR74 1.00  
NUC75 13C  
P75 14.00 usec  
PL75 0.00 dB  
PR75 1.00  
NUC76 1H  
P76 13.36 usec  
PL76 0.00 dB  
PR76 1.00  
NUC77 13C  
P77 14.00 usec  
PL77 0.00 dB  
PR77 1.00  
NUC78 1H  
P78 13.36 usec  
PL78 0.00 dB  
PR78 1.00  
NUC79 13C  
P79 14.00 usec  
PL79 0.00 dB  
PR79 1.00  
NUC80 1H  
P80 13.36 usec  
PL80 0.00 dB  
PR80 1.00  
NUC81 13C  
P81 14.00 usec  
PL81 0.00 dB  
PR81 1.00  
NUC82 1H  
P82 13.36 usec  
PL82 0.00 dB  
PR82 1.00  
NUC83 13C  
P83 14.00 usec  
PL83 0.00 dB  
PR83 1.00  
NUC84 1H  
P84 13.36 usec  
PL84 0.00 dB  
PR84 1.00  
NUC85 13C  
P85 14.00 usec  
PL85 0.00 dB  
PR85 1.00  
NUC86 1H  
P86 13.36 usec  
PL86 0.00 dB  
PR86 1.00  
NUC87 13C  
P87 14.00 usec  
PL87 0.00 dB  
PR87 1.00  
NUC88 1H  
P88 13.36 usec  
PL88 0.00 dB  
PR88 1.00  
NUC89 13C  
P89 14.00 usec  
PL89 0.00 dB  
PR89 1.00  
NUC90 1H  
P90 13.36 usec  
PL90 0.00 dB  
PR90 1.00  
NUC91 13C  
P91 14.00 usec  
PL91 0.00 dB  
PR91 1.00  
NUC92 1H  
P92 13.36 usec  
PL92 0.00 dB  
PR92 1.00  
NUC93 13C  
P93 14.00 usec  
PL93 0.00 dB  
PR93 1.00  
NUC94 1H  
P94 13.36 usec  
PL94 0.00 dB  
PR94 1.00  
NUC95 13C  
P95 14.00 usec  
PL95 0.00 dB  
PR95 1.00  
NUC96 1H  
P96 13.36 usec  
PL96 0.00 dB  
PR96 1.00  
NUC97 13C  
P97 14.00 usec  
PL97 0.00 dB  
PR97 1.00  
NUC98 1H  
P98 13.36 usec  
PL98 0.00 dB  
PR98 1.00  
NUC99 13C  
P99 14.00 usec  
PL99 0.00 dB  
PR99 1.00  
NUC100 1H  
P100 13.36 usec  
PL100 0.00 dB  
PR100 1.00



# nOe spectrum of 24

J. Vivat E22 Sample ref. JFV 499 in CDCl<sub>3</sub>  
SPOFFS 2 = 1798.270 Hz



Current Data Parameters  
NAME JFV499  
EXPNO 304  
PROCNO 1

F2 - Acquisition Parameters  
Date\_ 20090925  
Time 14.15  
INSTRUM spect  
PROBHD 5 mm BBI-500  
PULPROG zgpg30  
TD 32768  
SOLVENT cdcl3  
NS 32  
DS 4  
SWH 5995.26 Hz  
FIDRES 0.18259 Hz  
AQ 2.7225011 sec  
RG 63.57  
UR 6.00 usec  
TE 292.7 K  
NUC1 13C  
NUC2 1H  
D1 0.00020000 sec  
D16 0.00020000 sec  
D20 0.2487599 sec  
D30 1

===== CHANNEL f1 =====  
NUC1 13C  
P1 7.48 usec  
PL1 0 dB  
RG 15.36 usec  
SFO 125.760 MHz  
WDW EM  
SSB 0  
GB 0  
PC 1.00

===== GRADIENT CHANNEL =====  
GPNP1 100  
GPNP2 100  
GPNP3 100  
GPNP4 100  
GPNP5 100  
GPNP6 100  
GPNP7 100  
GPNP8 100  
GPNP9 100  
GPNP10 100  
GPNP11 100  
GPNP12 100  
GPNP13 100  
GPNP14 100  
GPNP15 100  
GPNP16 100  
GPNP17 100  
GPNP18 100  
GPNP19 100  
GPNP20 100  
GPNP21 100  
GPNP22 100  
GPNP23 100  
GPNP24 100  
GPNP25 100  
GPNP26 100  
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GPNP89 100  
GPNP90 100  
GPNP91 100  
GPNP92 100  
GPNP93 100  
GPNP94 100  
GPNP95 100  
GPNP96 100  
GPNP97 100  
GPNP98 100  
GPNP99 100  
GPNP100 100

F2 - Processing parameters  
SI 32768  
SF 500.130000 MHz  
WDW EM  
SSB 0  
GB 0  
PC 1.00

