Supplementary Material for Chemical Society Reviews

Cobalt-Mediated Cyclotrimerisation of Bis-Alkynes and Cyanamides

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Supporting Information

(21 Pages)

Experimental Section

Typical Procedure for Synthesis of 2-Aminopyridines. In a 100-mL round-bottom flask, equipped with a condenser and a three-way stopper connected to a balloon of argon, a mixture of diyne **1** (89 mg, 0.43 mmol) and pyrrolidino-1-carbonitrile (205 mg, 2.13 mmol, 5 mol equiv) was pumped briefly and purged twice with argon. Fifty milliliters of 1,4-dioxane was then added, followed by a 10-mL dioxane solution of $CpCo(CO)_2$ (8.1 μL, 0.064 mmol, 15 mol %), and the remaining volume of the solvent to provide a final 0.005 M concentration (relative to diyne **1**). The resulting solution was then heated at reflux for 18.5 h. The reaction mixture was then cooled to room temperature. Subsequent removal of the solvents *in vacuo*, followed by flash chromatography (SiO_2, 1:30, 1:10, 1:4, 1:2 and then 1:1 ethyl acetate in hexanes) afforded 114 mg of aminopyridine **2** (88%). For best results, newly opened bottles of anhydrous 1,4-dioxane (Sigma-Aldrich) and $CpCo(CO)_2$ (Strem Chemicals) should be used in these reactions.

The synthesis of bis-alkyne **23** was previously reported.[1]

1-Prop-2-ynyloxy-hept-2-yne (9). Bis-alkyne **9** was prepared in 98% yield from hept-2-yn-1-ol and propargyl bromide, in a similar manner as bis-alkyne **23**. ^{1}H NMR ($CDCl_3$, 300 MHz): δ 4.24 (m, 4H), 2.43 (t, J = 2.3 Hz, 1H), 2.20-2.26 (m, 2H), 1.40-1.53 (m, 4H), 0.91 (t, J = 7.2 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 88.15, 79.56, 75.26, 74.98, 57.52, 56.51, 30.99, 22.50, 18.78, 13.90.

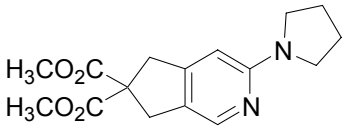
(3-Prop-2-ynyloxy-prop-1-ynyl)-benzene (11). Bis-alkyne **11** was prepared in 92% yield from 3-phenyl-prop-2-yn-1-ol and propargyl bromide, in a similar manner as bis-alkyne **23**. ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.44-7.47 (m, 2H), 7.31-7.33 (m, 3H), 4.50 (s, 2H), 4.34 (d, J = 2.4 Hz, 2H), 2.48 (t, J = 2.3 Hz, 1H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 131.79, 128.57, 128.44, 122.45, 86.86, 84.15, 79.06, 75.03, 57.79, 56.51.

1-But-2-ynyloxy-hept-2-yne (13). Bis-alkyne **13** was prepared in 88% yield from hept-2-yn-1-ol and 1-bromo-propyne, in a similar manner as bis-alkyne **23**. ^{1}H NMR ($CDCl_3$, 300 MHz): δ 4.20 (m, 4H), 2.22 (m, 2H), 1.85 (t, J = 2.3 Hz, 3H), 1.45 (m, 4H), 0.91 (t, J = 7.1 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 87.68, 83.02, 75.60, 74.93, 57.28, 56.75, 30.99, 22.24, 18.75, 13.85, 3.83. HRMS (FAB): Calcd for $C_{11}H_{16}O + H^+$: 165.127940. Found: 165.127758.

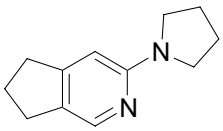
1,2-Bis-prop-2-ynyloxy-benzene (19). A suspension of benzene-1,2-diol (1.810g, 16.44 mmol) in acetone (55 mL) was added K_2CO_3 (5.468 g, 39.56 mmol, 2.41 mol equiv). After stirring the mixture at rt for 30 min, it was added with propargyl bromide (4.5 mL, 40.4 mmol, 2.46 mol equiv) and was stirred at 35 ^{o}C for 12 h. After cooling to rt, acetone was evaporated, and the residue was dissolved in EtOAc (150 mL). It was washed with brine (2 x 25 mL), dried (Na_2SO_4) and filtered. Concentration *in vacuo* and purification by flash chromatography (SiO_2, hexane, 1:30 and then 1:15 EtOAc in hexanes) afforded 2.617.g of compound **19** (85 %). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.06-7.09 (m, 2H), 6.97-7.00 (m, 2H), 4.77 (d, J = 2.4 Hz, 4H), 2.51 (t, J = 2.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 148.05, 122.58, 115.59, 79.03, 76.17, 57.31. HRMS (FAB): Calcd for $C_{12}H_{10}O_2$: 186.068080. Found: 186.068890. Anal. Calcd for $C_{12}H_{10}O_2$: C, 77.40; H, 5.41. Found: C, 77.21; H, 5.39.

1-Prop-2-ynyloxy-2-prop-2-ynyloxymethyl-benzene (20). Compound **20** was prepared in 70% yield from 2-hydroxymethyl-phenol and propargyl bromide, in a similar manner as bis-alkyne **19**. ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.27-7.34 (m, 2H), 6.98-7.03 (m, 2H), 4.76 (d, *J* = 2.4 Hz, 4H), 4.72 (d, *J* = 6.4 Hz, 2H), 2.52 (*t*, J = 2.4 Hz, 1H), 2.16 (*t*, J = 6.6 Hz, 1H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 155.71, 130.31, 130.06, 129.63, 129.55, 129.29, 129.12, 122.07, 112.29, 78.81, 76.22, 61.80, 56.42. HRMS (FAB): Calcd for $C_{13}H_{12}O_2$ + H^+: 201.091555. Found: 201.091044.

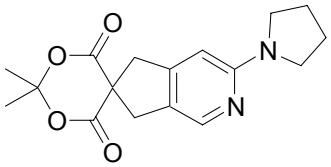
1,2-Bis-(2-prop-2-ynyloxy-ethoxy)benzene (21). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.0 (s, 4H), 4.31 (d, *J* = 2.4 Hz), 4.18-4.20 (m, 4H), 3.91-3.93 (m, 4H), 2.45 (t, *J* = 2.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 149.41, 122.19, 115.47, 80.19, 75.04, 69.25, 68.70, 58.94. IR (cm $^{-1}$): 3307, 2934, 2876, 2253, 1504, 1456, 1257, 1107, 1036, 912, 716, 651. HRMS (FAB): Calcd for $C_{13}H_{12}O_2$ + H^+: 201.091555. Found: 201.091044. Anal. Calcd for $C_{16}H_{18}O_4$: C, 70.06; H, 6.61. Found: C, 70.07; H, 6.54. HRMS (FAB): Calcd for $C_{16}H_{18}O_4$: 274.120509. Found: 274.120122.



3-Pyrrolidin-1-yl-5,7-dihydro-[2]pyrindine-6,6-dicarboxylic acid dimethyl ester (2). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.97 (s, 1H), 6.23 (s, 1H), 3.74 (s, 6H), 3.48 (s, 4H), 3.38-3.43 (m, 4H), 1.95-2.02 (m, 4H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 171.84, 156.83, 150.99, 142.97, 123.13, 101.75, 60.64, 53.01, 46.90, 40.37, 37.39, 25.54. HRMS (FAB): Calcd for $C_{16}H_{20}N_2O_4$ + H^+: 305.150132. Found: 305.149463. Anal. Calcd for $C_{16}H_{20}N_2O_4$: C, 63.14; H, 6.62; N, 9.20, O, 21.03. Found: C, 62.26; H, 6.65; N, 8.98.

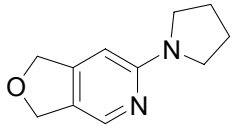


3-Pyrrolidin-1-yl-6,7-dihydro-5H-[2]pyrindine (4). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.00 (s, 1H), 6.28 (s, 1H), 3.41-3.45 (m, 4H), 2.80 (ddd, *J* = 7.0, 7.0, 7.0 Hz, 4H), 1.97-2.06 (m, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 156.51, 155.24, 142.80, 127.45, 102.08, 46.88, 32.78, 29.14, 25.57. HRMS (FAB): Calcd for $C_{12}H_{16}N_2$: 188.131349. Found: 188.130419.

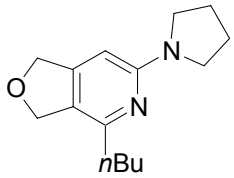


Compound 6. ^{1}H NMR ($CDCl_3$, 300 MHz): δ 8.00 (s, 1H), 6.25 (s, 1H), 3.63 (s, 2H), 3.60 (s, 2H), 3.42-3.47 (m, 4H), 1.98-2.02 (m, 4H), 1.84 (s, 3H), 1.80 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 170.52, 157.65, 151.07, 143.52, 121.97, 105.61, 101.57, 53.31, 47.30, 44.49, 43.80, 29.39, 25.92. HRMS (FAB): Calcd for $C_{17}H_{20}N_2O_4$ + H^+: 317.150132. Found: 317.149149.

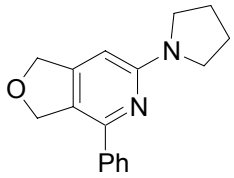
Anal. Calcd for $C_{17}H_{20}N_2O_4$: C, 64.54; H, 6.37; N, 8.86; O, 20.23. Found: C, 64.06; H, 6.64; N, 8.66.



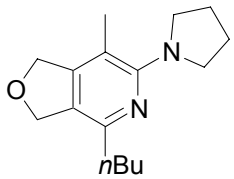
6-Pyrrolidin-1-yl-1,3-dihydro-furo[3,4-c]pyridine (8). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.97 (s, 1H), 6.16 (s, 1H), 5.00 (s, 2H), 4.90 (s, 2H), 3.36-3.39 (m, 4H), 1.91-1.98 (m, 4H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 157.05, 150.67, 140.49, 122.82, 98.34, 72.89, 71.49, 47.14, 25.70. HRMS (FAB): Calcd for $C_{11}H_{14}N_2O + H^+$: 191.118438. Found: 191.117673.



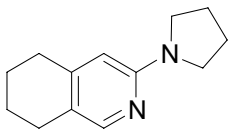
4-Butyl-6-pyrrolidin-1-yl-1,3-dihydro-furo[3,4-c]pyridine (10). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 6.04 (s, 1H), 4.99 (s, 1H), 3.42-3.46 (m, 4H), 2.52 (t, J = 7.5 Hz, 2H), 1.96-2.00 (m, 4H), 1.62-1.73 (m, 4H), 1.34-1.41 (m, 2H), 0.93 (t, J = 7.3 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 157.24, 153.31, 150.16, 120.18, 95.26, 73.18, 71.64, 46.92, 36.05, 30.55, 25.52, 22.62, 14.04.



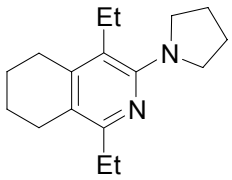
4-Phenyl-6-pyrrolidin-1-yl-1,3-dihydro-furo[3,4-c]pyridine (12). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.78-7.81 (m, 2H), 7.34-7.47 (m, 3H), 6.22 (s, 1H), 5.24 (s, 2H), 5.03 (s, 2H), 3.52-3.57 (m, 4H), 2.00-2.05 (m, 4H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 157.31, 152.14, 149.34, 140.33, 128.80, 128.74, 128.06, 120.30, 97.47, 73.11, 73.03, 47.31, 25.94.



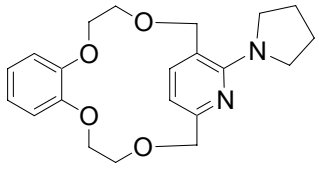
4-Butyl-7-methyl-6-pyrrolidin-1-yl-1,3-dihydro-furo[3,4-c]pyridine (14). ^{1}H NMR ($CDCl_3$, 500 MHz): δ 5.04 (s, 2H), 4.99 (s, 2H), 3.49 (m, 4H), 2.50 (t, J = 7.7 Hz, 2H), 2.14 (s, 3H), 1.90 (m, 4H), 1.66 (m, 2H), 1.36 (m, 2H), 0.92 (t, J = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 159.21, 150.14, 149.50, 123.48, 110.36, 73.42, 72.91, 50.46, 35.92, 30.81, 25.87, 22.94, 16.34, 14.40. HRMS (FAB): Calcd for $C_{16}H_{24}N_2O - H^+$: 259.181039. Found: 259.180335.



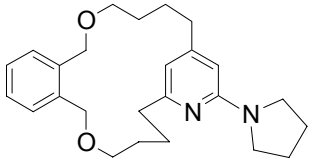
3-Pyrrolidin-1-yl-5,6,7,8-tetrahydro-isoquinoline (16). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.81 (s, 1H), 6.01 (s, 1H), 3.33-3.36 (m, 4H), 2.61 (m, 2H), 2.55 (m, 2H), 1.89-1.92 (m, 4H), 1.67-1.70 (m, 4H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 155.98, 147.91, 147.27, 120.49, 105.49, 46.76, 29.28, 25.56, 25.52, 23.40, 22.89. HRMS (FAB): Calcd for $C_{13}H_{18}N_2 + H^+$: 203.154824. Found: 203.155393.



1,4-Diethyl-3-pyrrolidin-1-yl-5,6,7,8-tetrahydro-isoquinoline (18). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 3.35-3.31 (m, 4H), 2.58-2.62 (obscured m, 4H), 2.54 (q, J = 7.4 Hz, 4H), 1.79-1.87 (m, 4H), 1.59-1.70 (m, 4H), 1.17 (t, J = 7.4 Hz, 3H), 1.07 (t, J = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 157.40, 155.60, 145.70, 123.39, 122.43, 51.32, 27.86, 27.18, 26.00, 25.78, 23.36, 23.29, 20.73, 13.99, 12.57. HRMS (FAB): Calcd for $C_{17}H_{26}N_2 + H^+$: 259.217424. Found: 259.217227.

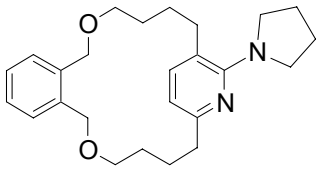


20-Pyrrolidin-1-yl-3,6,13,16-tetraoxa-19-aza-tricyclo[16.2.2.07,12]docosa-1(20),7,9,11,18,21-hexaene (22). ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.49 (d, J = 7.4 Hz, 1H), 6.73-6.84 (m, 5H), 4.89 (d, J = 13.4 Hz, 1H), 4.60 (d, J = 12.4 Hz, 1H), 4.41 (d, J = 12.4 Hz, 1H), 4.35 (d, J = 13.4 Hz, 1H), 4.10-4.15 (m, 1H), 3.94-3.99 (m, 2H), 3.62-3.86 (m, 7H), 3.26-3.30 (m, 2H), 1.88-1.93 (m, 2H), 1.73-1.85 (m, 2H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 157.32, 155.39, 148.84, 148.74, 141.09, 120.76, 120.51, 116.75, 113.27, 112.75, 112.53, 74.21, 70.87, 68.63, 68.43, 68.38, 67.48, 50.49, 49.47, 25.69, 25.59. HRMS (FAB): Calcd for $C_{21}H_{26}N_2O_4 + H^+$: 371.197083. Found: 371.198135.

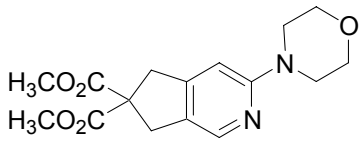


22-Pyrrolidin-1-yl-6,15-dioxa-21-aza-tricyclo[18.3.1.08,13]tetracosa 1(23),8,10,12,20(24),21-hexaene (24m). ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.34-7.37 (m, 2H), 7.24-7.27 (m, 2H), 6.30 (s,

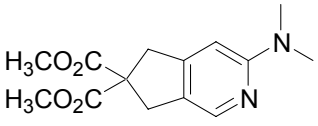
1H), 5.98 (s, 1H), 4.50 (s, 2H), 4.49 (s, 2H), 3.53 (t, J = 6.7 Hz, 2H), 3.52 (t, J = 6.7 Hz, 2H), 3.43-3.45 (m, 4H), 2.66 (t, J = 6.3 Hz, 2H), 2.54 (t, J = 6.5 Hz, 2H), 1.96-1.99 (m, 4H), 1.73-1.79 (m, 2H), 1.67-1.72 (m, 2H), 1.55-1.64 (m, 4H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 159.23, 157.36, 151.05, 136.33, 136.14, 128.18, 128.16, 127.22, 127.16, 110.87, 103.20, 70.14, 69.90, 69.64, 69.59, 46.21, 36.77, 34.23, 27.21, 27.17, 25.95, 25.04, 24.69. HRMS (FAB): Calcd for $C_{25}H_{34}N_2O_2 + H^+$: 395.269854. Found: 395.270433.



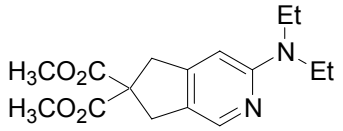
22-Pyrrolidin-1-yl-6,15-dioxa-21-aza-tricyclo[18.2.2.08,13]tetracosa-1(22),8,10,12,20,23-hexaene (24p). ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.31-7.34 (m, 2H), 7.21-7.23 (m, 2H), 7.13 (d, J = 7.3 Hz, 1H), 6.43 (d, J = 7.3 Hz, 1H), 4.31 (s, 2H), 4.28 (s, 2H), 3.39 (broad s, 4H), 3.26-3.30 (m, 4H), 2.68 (broad s, 4H), 1.86 (broad s, 4H), 1.71-1.76 (m, 2H), 1.60-1.66 (m, 2H), 1.38-1.44 (m, 2H), 1.24-1.31 (m, 2H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 157.86, 156.69, 139.56, 136.65, 136.55, 127.81, 127.76, 127.37, 127.30, 119.22, 113.14, 70.40, 70.21, 69.68, 69.58, 49.27, 36.76, 32.63, 27.74, 27.39, 25.63, 24.71, 23.49. HRMS (FAB): Calcd for $C_{25}H_{34}N_2O_2$: 395.269854. Found: 395.270433.



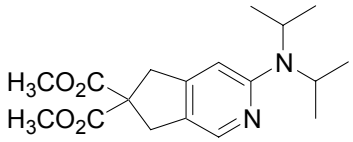
3-Morpholin-4-yl-5,7-dihydro-[2]pyrindine-6,6-dicarboxylic Acid Dimethyl Ester (25). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.96 (s, 1H), 6.46 (s, 1H), 3.68-3.76 (m, 4H), 3.63 (s, 6H), 3.54 (s, 4H), 3.37-3.43 (m, 4H). HRMS (FAB): Calcd for $C_{16}H_{20}N_2O_5 + H^+$: 321.145047. Found: 321.143969. Anal. Calcd for $C_{16}H_{20}N_2O_5$: C, 59.99; H, 6.29; N, 8.74, O, 24.97. Found: C, 58.91; H, 6.28; N, 8.86.



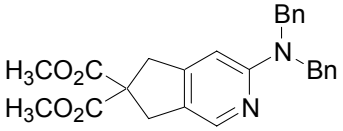
3-Dimethylamino-5,7-dihydro-[2]pyrindine-6,6-dicarboxylic Acid Dimethyl Ester (26). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.92 (s, 1H), 6.33 (s, 1H), 3.68 (s, 6H), 3.41 (m, 4H), 3.00 (s, 6H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 172.14, 159.22, 151.75, 142.86, 124.03, 101.72, 61.00, 53.36, 40.82, 38.89, 37.73. HRMS (FAB): Calcd for $C_{14}H_{18}N_2O_4 + H^+$: 279.134482. Found: 279.134093. Anal. Calcd for $C_{14}H_{18}N_2O_4$: C, 60.42; H, 6.52; N, 10.07, O, 23.00. Found: C, 59.61; H, 7.33; N, 9.64.



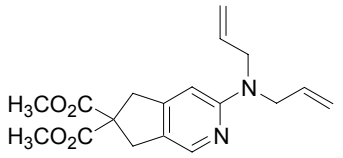
3-Diethylamino-5,7-dihydro-[2]pyrindine-6,6-dicarboxylic Acid Dimethyl Ester (27). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.96 (s, 1H), 6.32 (s, 1H), 3.75 (s, 6H), 3.44-3.51 (m, 8H), 1.15 (t, *J* = 7.0 Hz, 6H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 172.27, 157.52, 151.36, 143.43, 123.26, 101.02, 60.96, 53.33, 43.01, 40.86, 37.78, 13.33. HRMS (FAB): Calcd for $C_{16}H_{22}N_2O_4$ + H^+: 307.165782. Found: 307.165589. Anal. Calcd for $C_{16}H_{22}N_2O_4$: C, 62.73; H, 7.24; N, 9.14, O, 20.89. Found: C, 62.64; H, 7.25; N, 9.11.



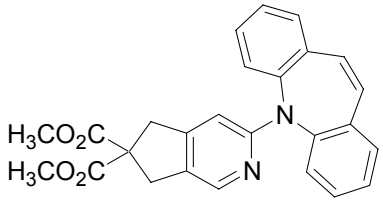
3-Diisopropylamino-5,7-dihydro-[2]pyrindine-6,6-dicarboxylic Acid Dimethyl Ester (28). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.96 (s, 1H), 6.39 (s, 1H), 4.20 (septet, *J* = 6.9 Hz, 2H), 3.75 (s, 6H), 3.47 (s, 4H), 1.28 (d, *J* = 6.8 Hz, 12H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 171.98, 157.38, 150.08, 142.74, 122.96, 103.56, 60.56, 52.97, 45.78, 40.58, 37.47, 20.82.



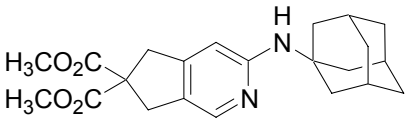
3-Dibenzylamino-5,7-dihydro-[2]pyrindine-6,6-dicarboxylic Acid Dimethyl Ester (29). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.01 (s, 1H), 7.20-7.32 (m, 10H), 6.33 (s, 1H), 4.76 (s, 4H), 3.74 (s, 6H), 3.49 (s, 2H), 3.42 (s, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 172.28, 158.69, 151.87, 143.39, 138.96, 129.01, 127.43, 124.85, 101.42, 60.85, 53.48, 53.41, 51.52, 40.84, 37.85. HRMS (FAB): Calcd for $C_{26}H_{26}N_2O_4$ + H^+: 431.197083. Found: 431.196255.



3-Diallylamino-5,7-dihydro-[2]pyrindine-6,6-dicarboxylic Acid Dimethyl Ester (30). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.97 (s, 1H), 6.33 (s, 1H), 5.78-5.91 (m, 2H), 5.11-5.16 (m, 4H), 4.07 (m, 4H), 3.75 (s, 6H), 3.47 (s, 4H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 172.24, 157.91, 151.73, 143.04, 134.40, 124.38, 116.39, 101.79, 60.93, 53.47, 50.80, 40.86, 37.79.

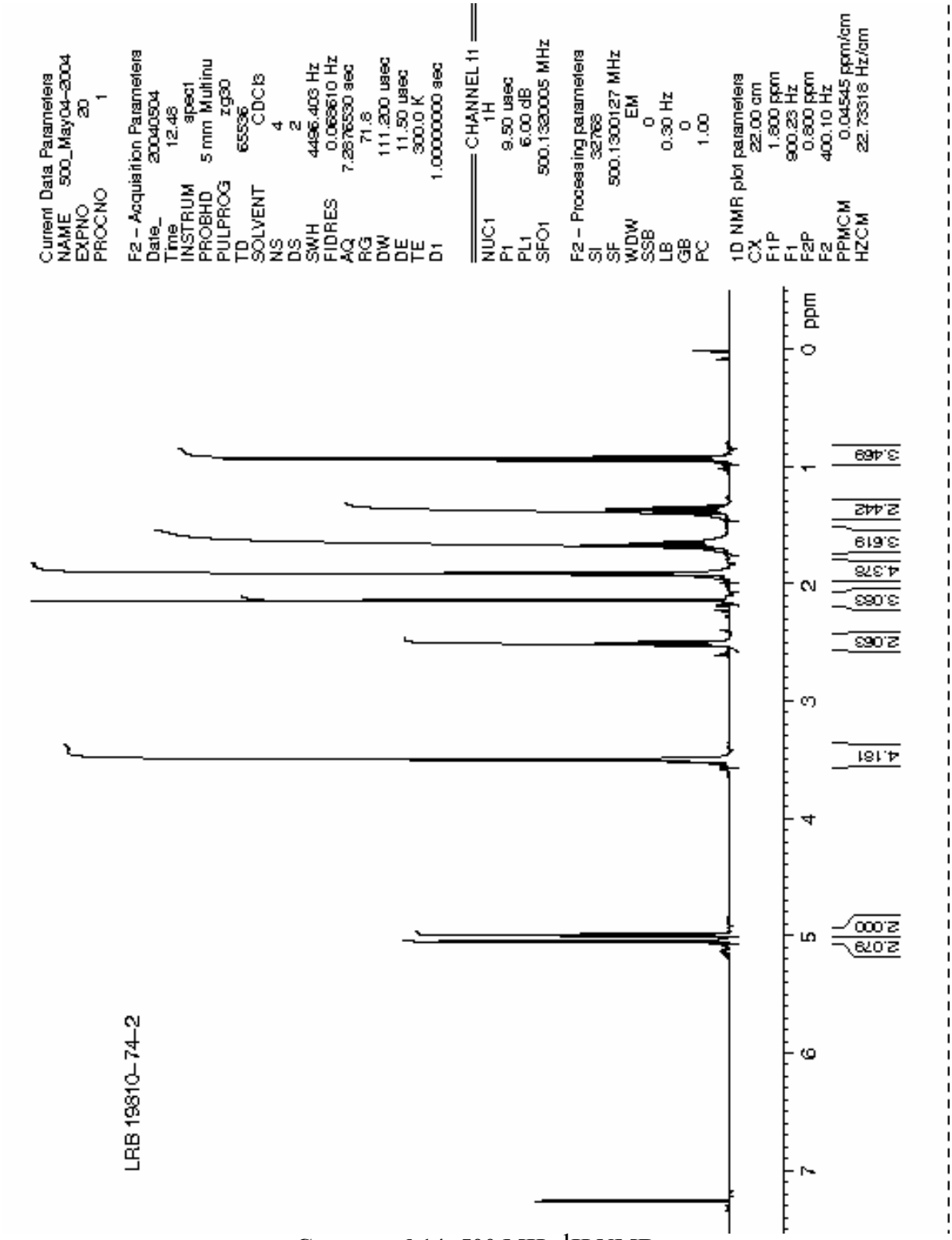


3-Dibenzo[b,f]azepin-5-yl-5,7-dihydro-[2]pyrindine-6,6-dicarboxylic Acid Dimethyl Ester (31). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.82 (s, 1H), 7.30-7.48 (m, 8H), 6.85 (s, 2H), 5.97 (s, 1H), 3.71 (s, 6H), 3.42 (s, 2H), 3.32 (s, 2H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ 171.74, 158.12, 150.72, 142.67, 142.51, 135.72, 130.53, 130.15, 129.89, 129.48, 127.01, 126.15, 101.80, 60.36, 52.98, 40.28, 37.42. HRMS (FAB): Calcd for $C_{26}H_{22}N_2O_4 + H^+$: 427.165782. Found: 427.164460.

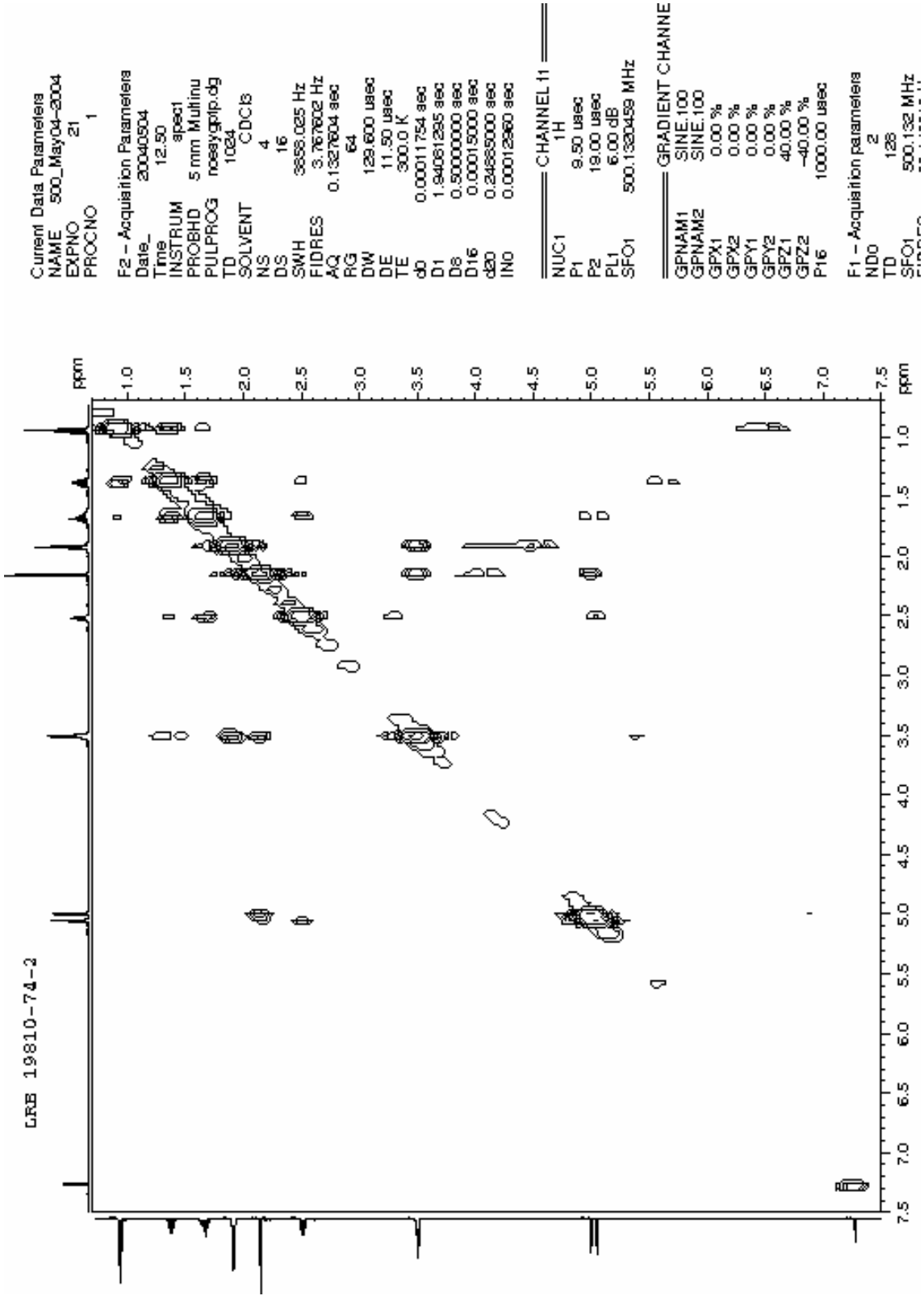


3-(Adamantan-1-ylamino)-5,7-dihydro-[2]pyrindine-6,6-dicarboxylic Acid Dimethyl Ester (32). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.87 (s, 1H), 6.36 (s, 1H), 3.75 (s, 6H), 3.46 (obscured s, 2H), 3.45 (obscured s, 2H), 2.00 (broad s, 3H), 1.99 (broad s, 3H), 1.71 (broad s, 7H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 172.19, 157.81, 151.07, 143.44, 124.97, 104.78, 60.88, 53.37, 51.68, 43.00, 40.73, 37.83, 36.90, 30.03. HRMS (FAB): Calcd for $C_{22}H_{28}N_2O_4 + H^+$: 385.212733. Found: 385.213540.

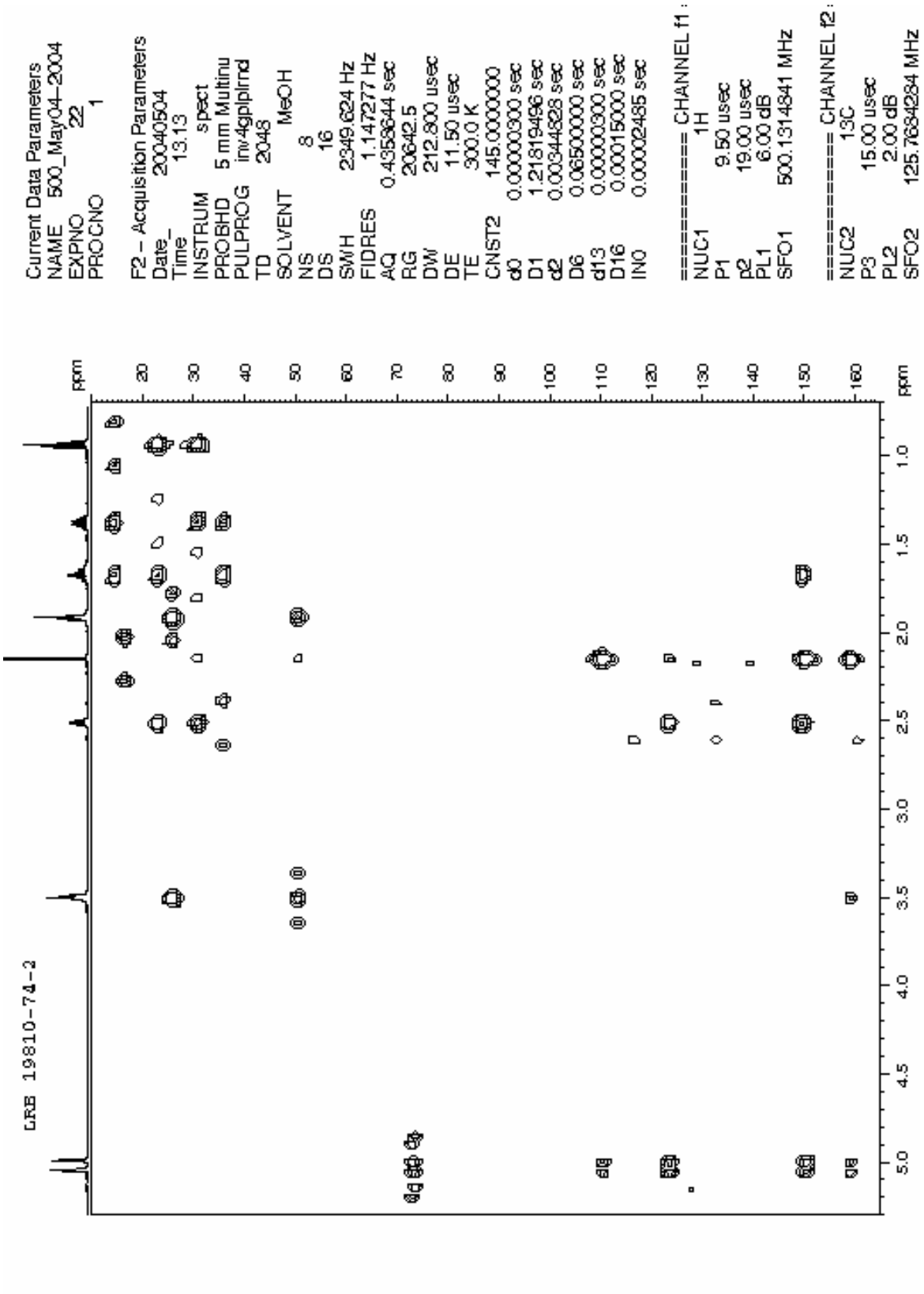
[1] A. F. Moretto, H.-C. Zhang and B. E. Maryanoff, *J. Am. Chem. Soc.,* 2001, **123**, 3157–3158.



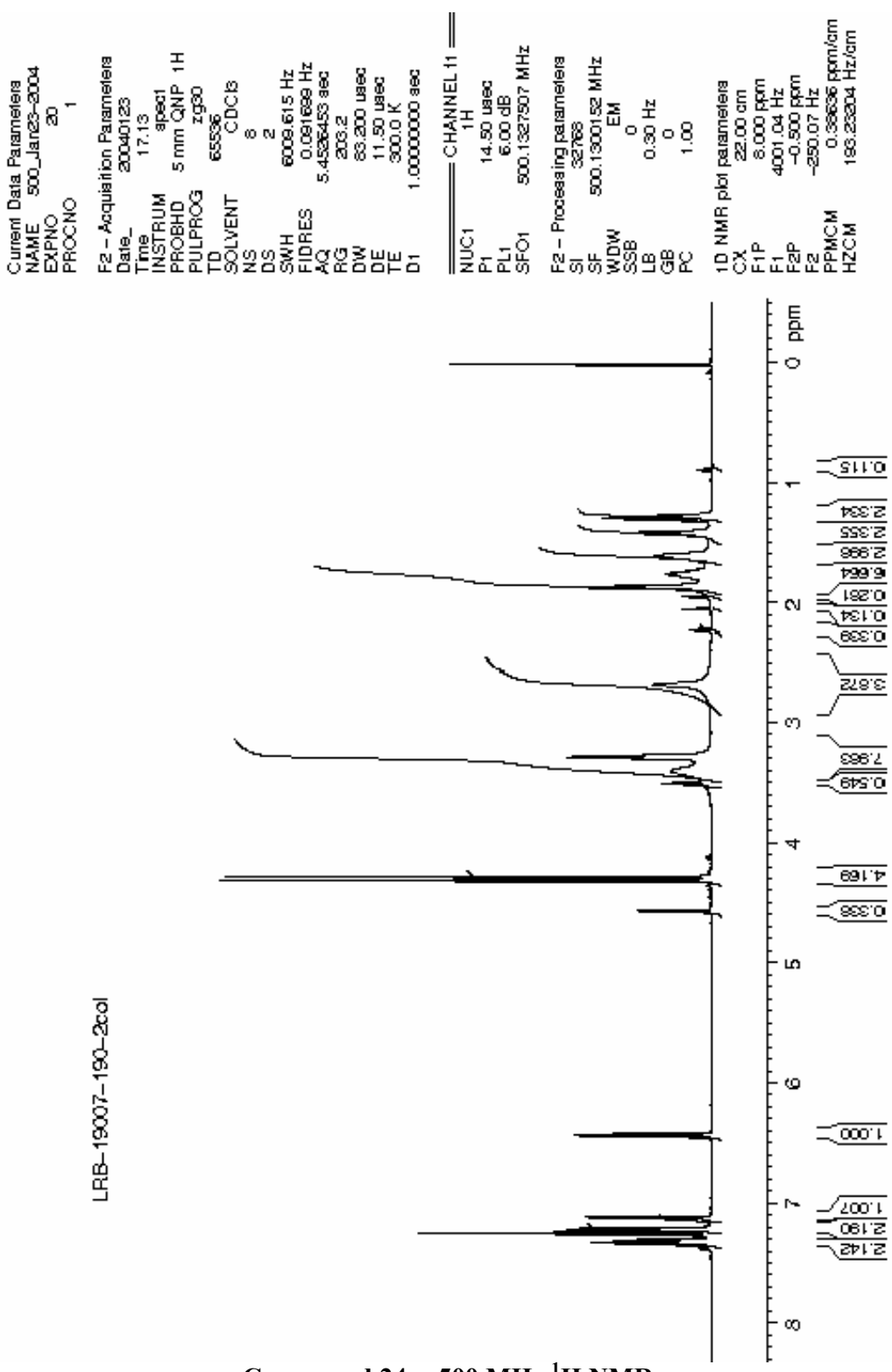
Compound 14: 500 MHz ^{1}H NMR



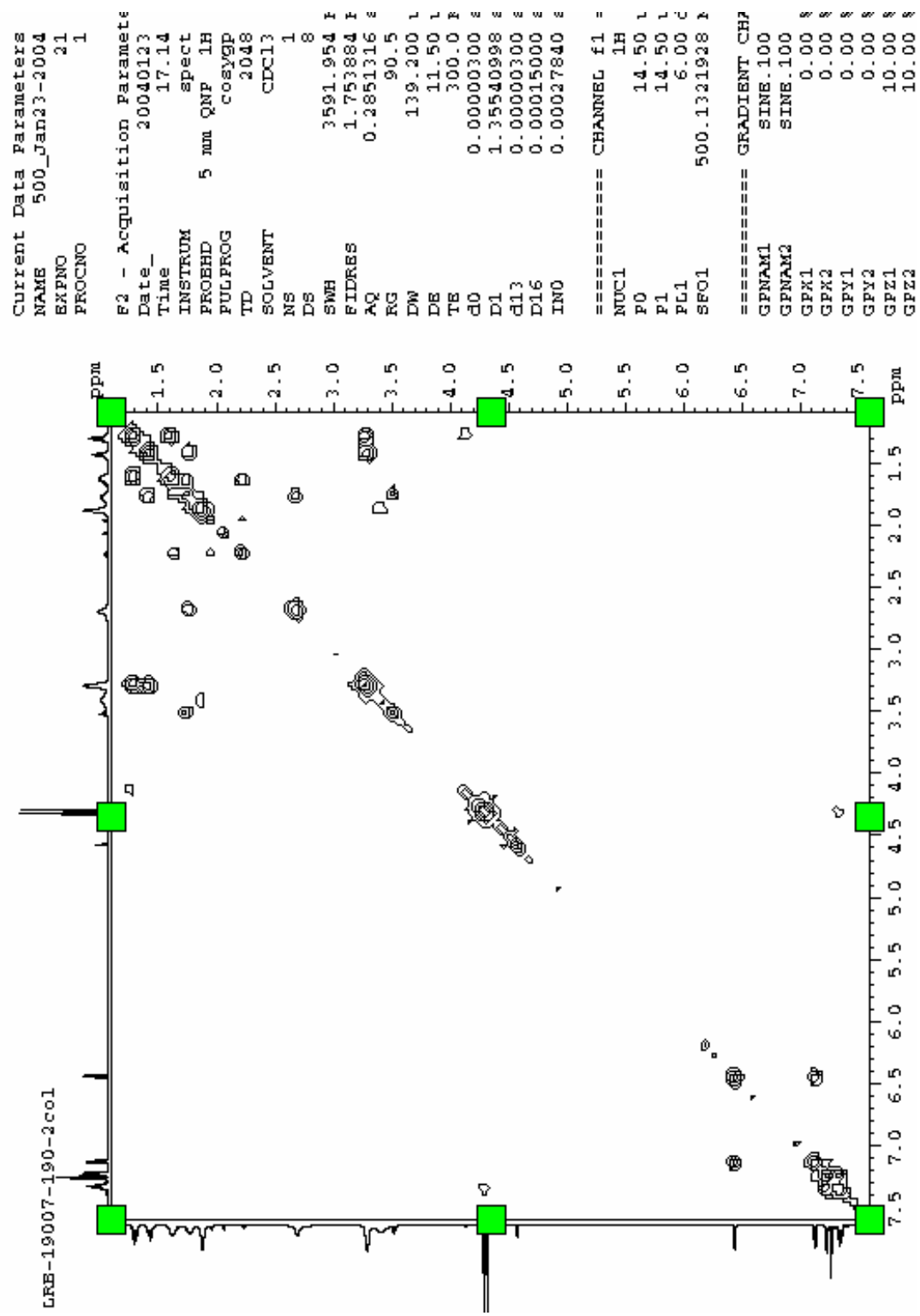
Compound 14: NOESY



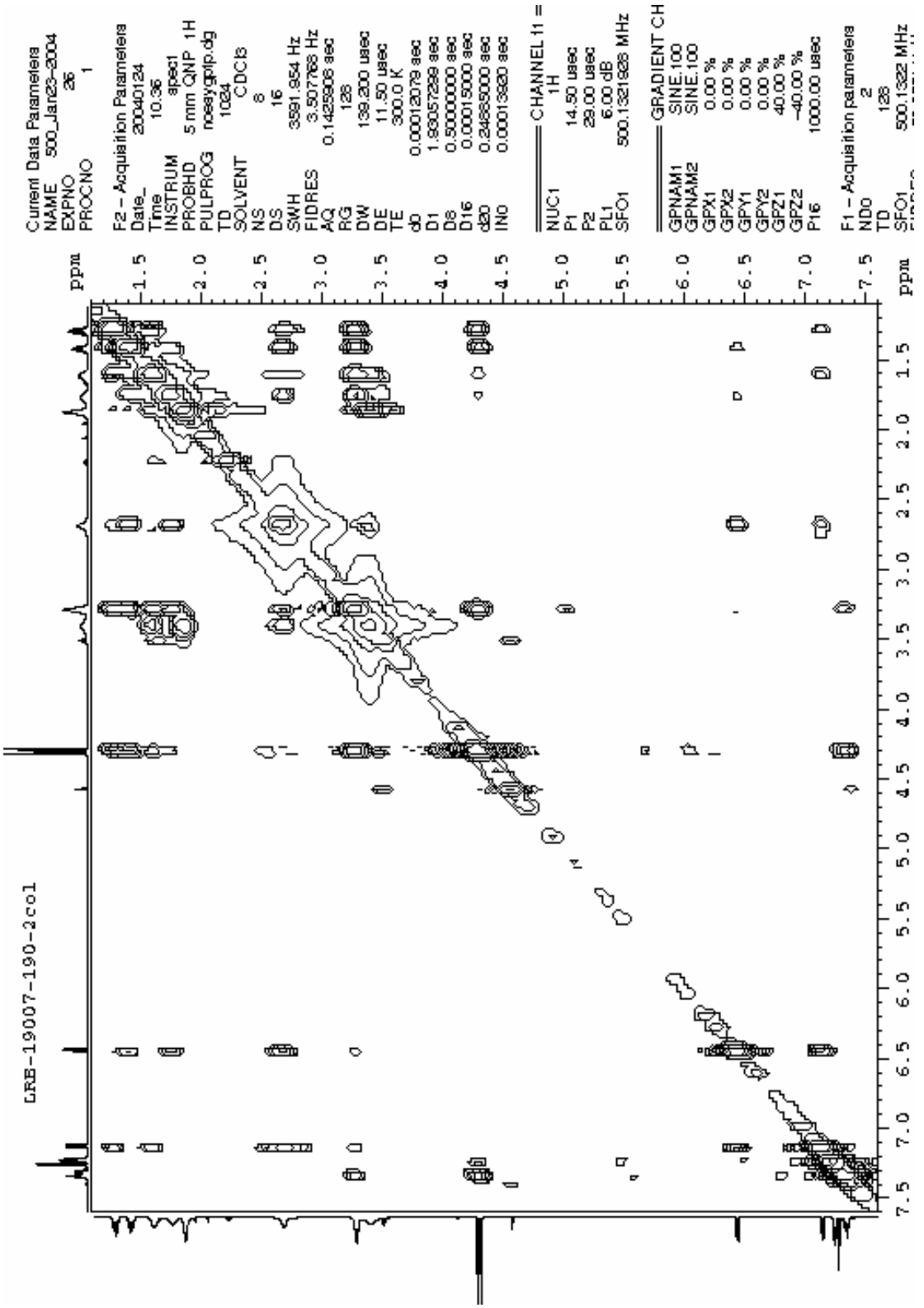
Compound 14: HMBC



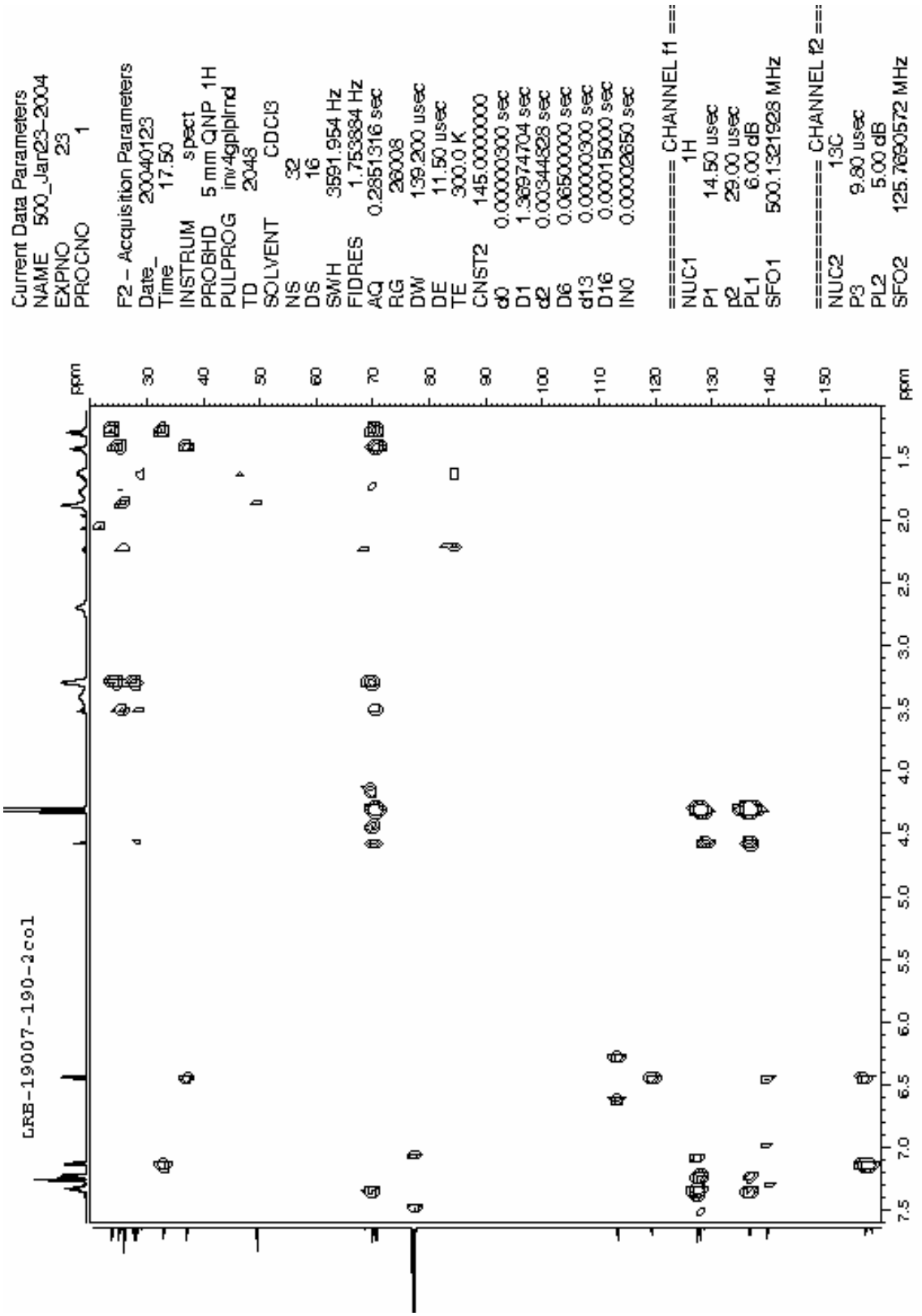
Compound 24p: 500 MHz ^{1}H NMR



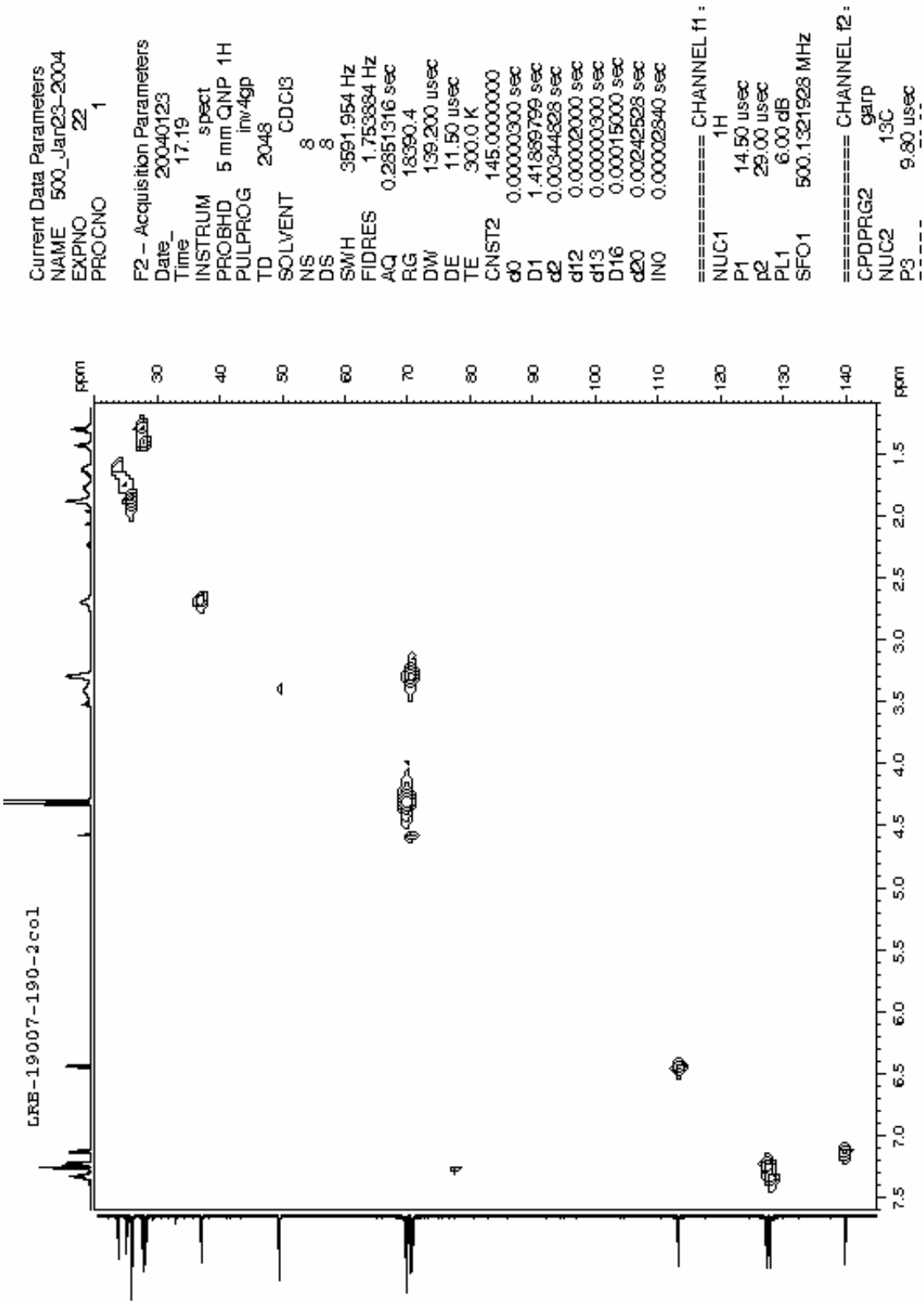
Compound 24p: COSY



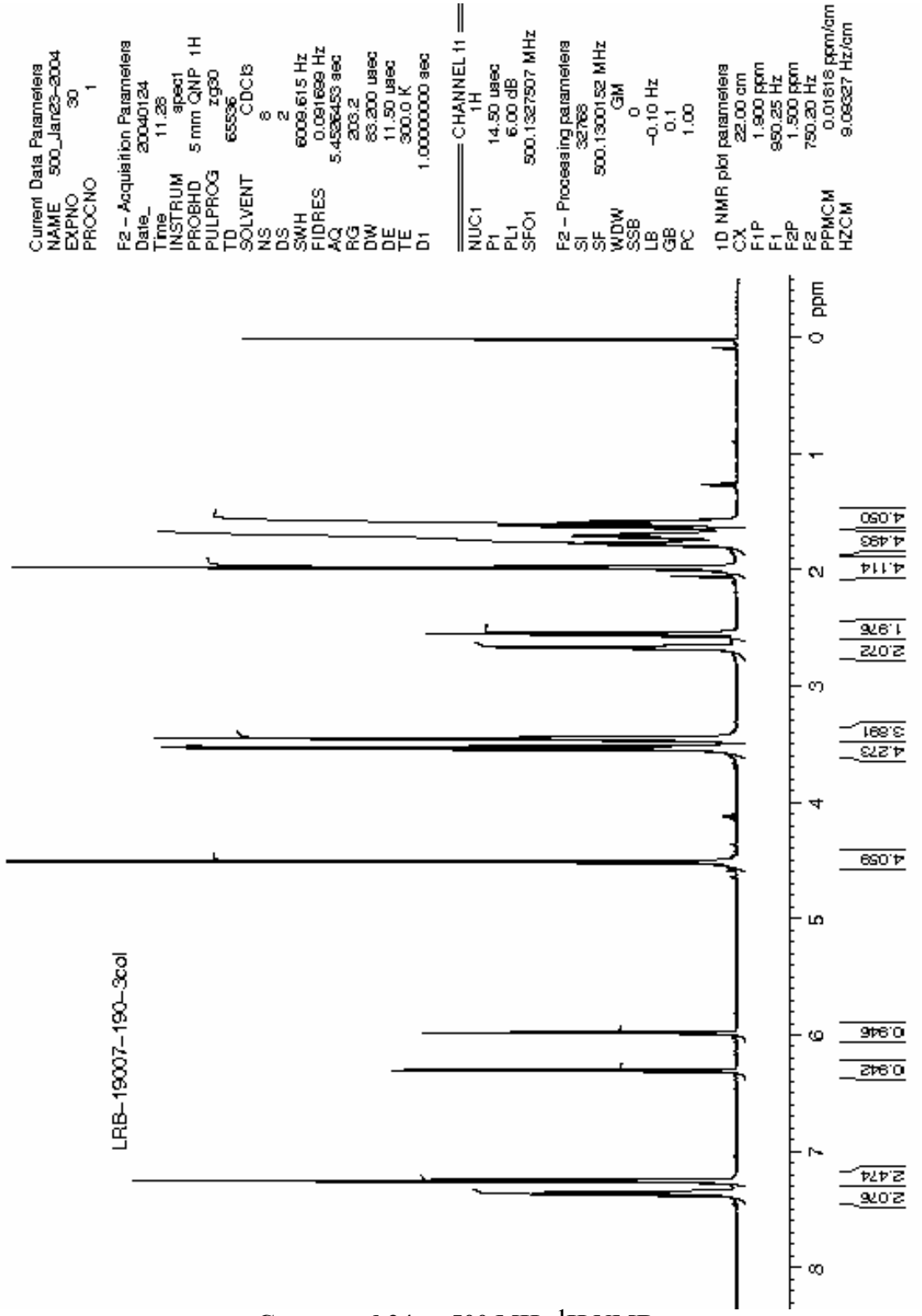
Compound 24p: NOESY



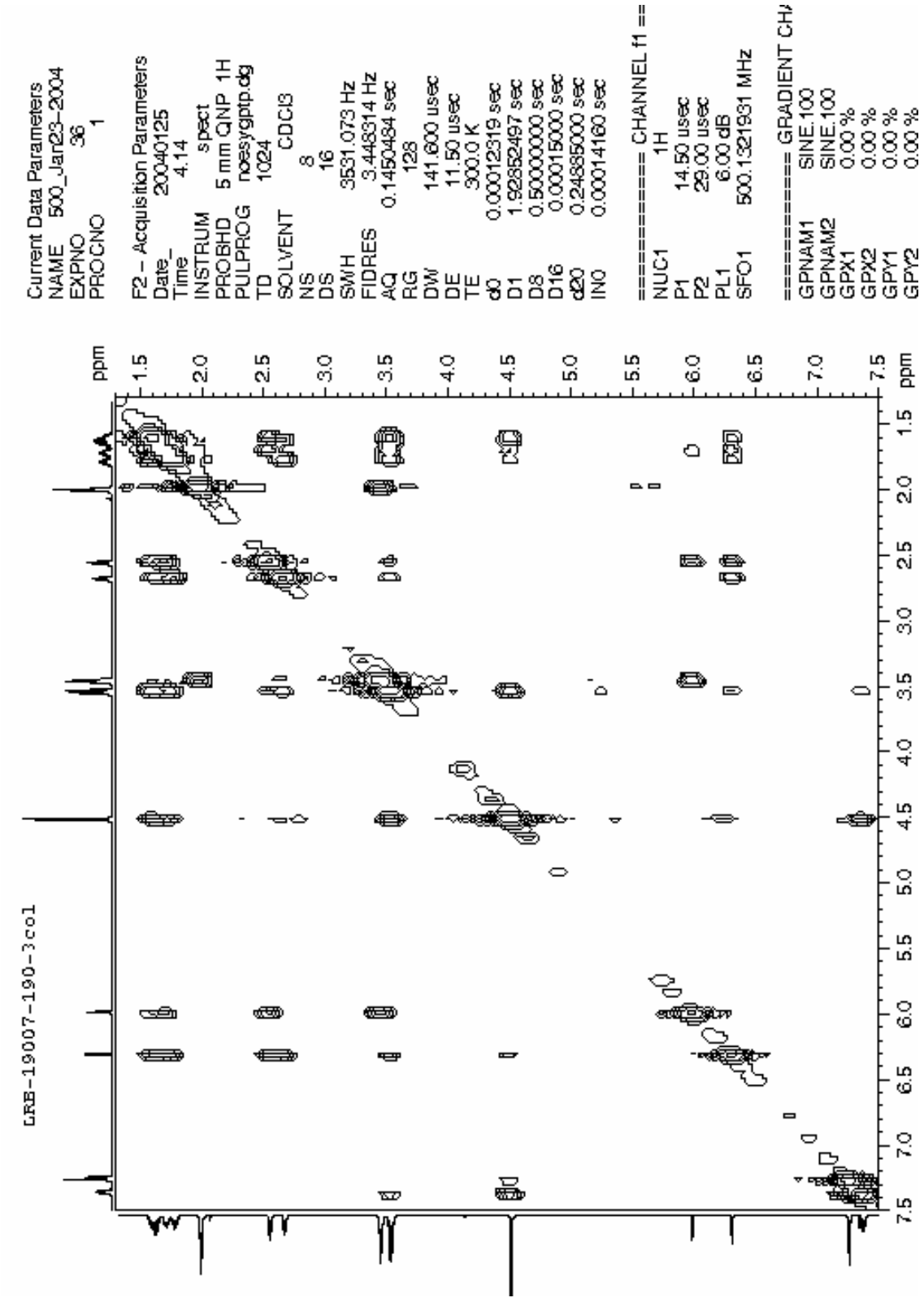
Compound 24p: HMBC



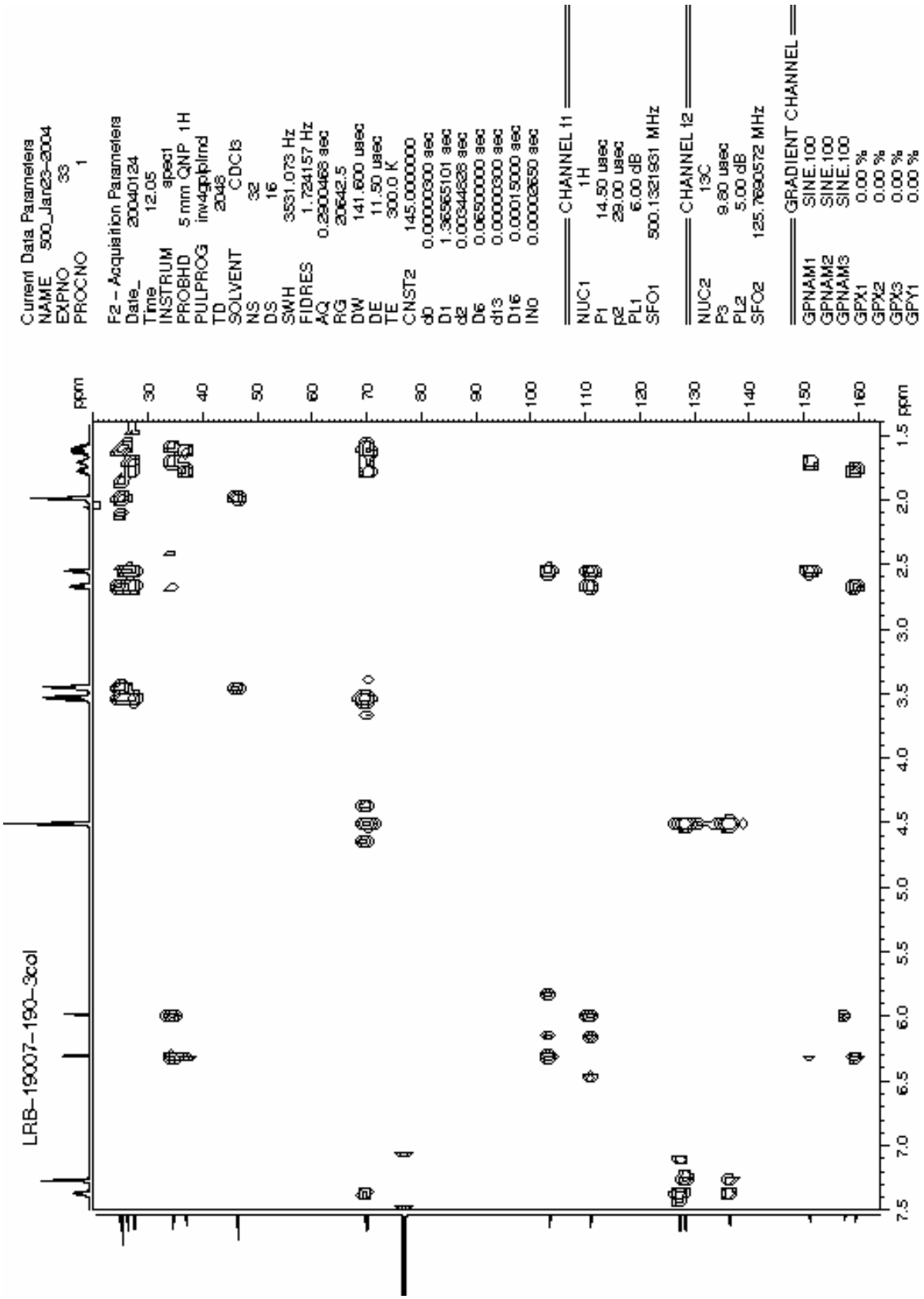
Compound 24p: HETCOR



Compound 24m: 500 MHz ^{1}H NMR

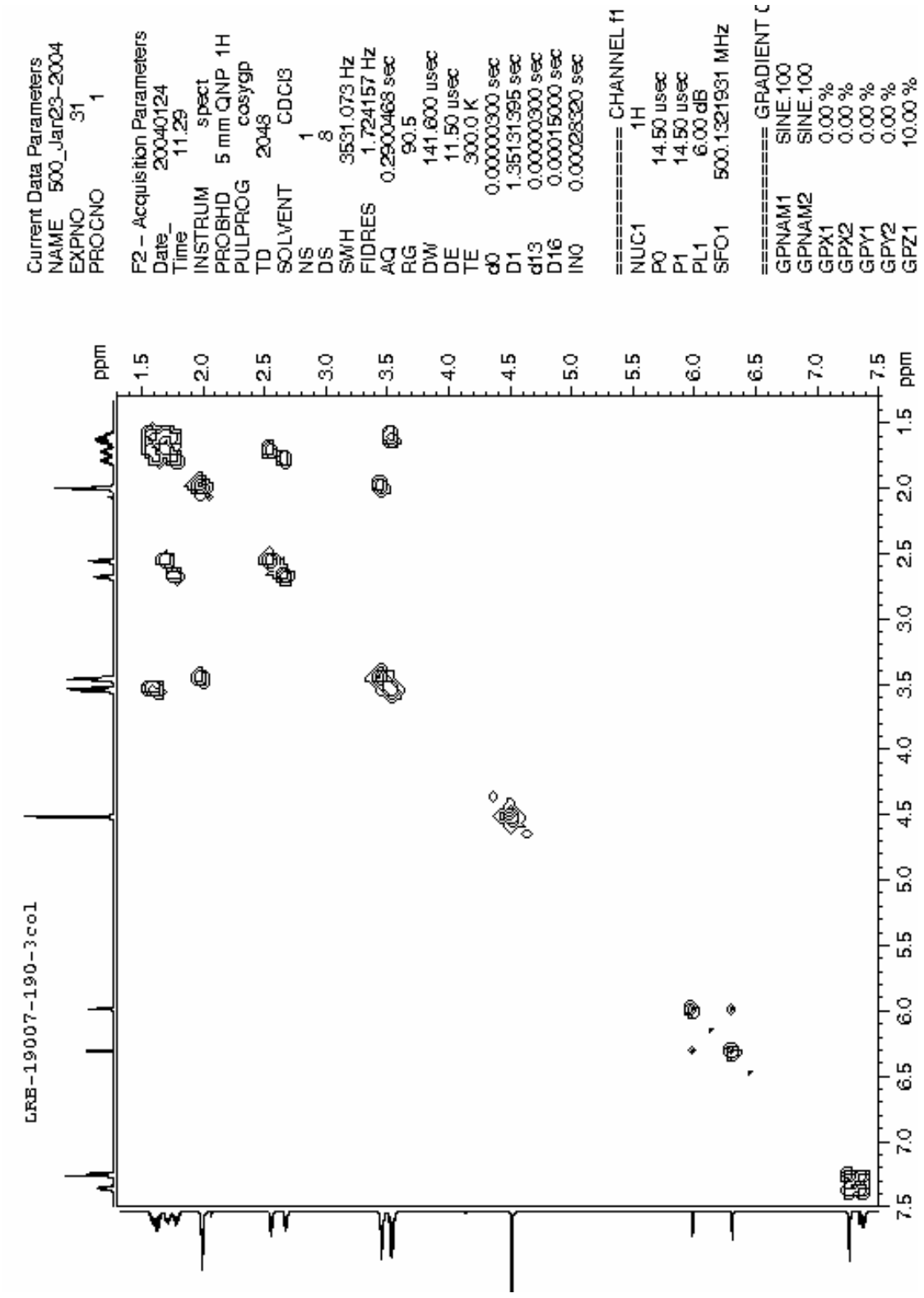


Compound 24m: NOESY



Compound 24m: HMBC

Compound 24m: HETCOR



Compound 24m: COSY