Supporting Information

Novel Synthesis of (*Z*)-Difluoroacrylates *via* Highly Stereoselective Addition-elimination Reaction

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Experimental section

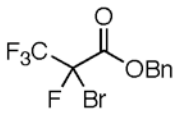
1. General Method.

All reactions were carried out in an oven-dried glassware under an atmosphere of argon, and all the reagents and anhydrous solvents were commercially available. The reagents were used without further purification or, if necessary, purified by distillation on appropriate drying agents. The isomeric mixtures of β-bromostyrene were employed in the reaction. Melting points were recorded on a Shimadzu MM-2 type instrument at atmospheric pressure. ^{1}H and ^{13}C NMR spectra were measured with a Bruker DRX-500 spectrometer operating at 500.13 MHz and 125.75 MHz, respectively. $CDCl_3$ was used as solvent in all NMR measurements and chemical shifts were recorded in ppm relative to internal tetramethylsilane. ^{19}F NMR spectra were measured for $CDCl_3$ solutions with a JEOL JNM-EX90A spectrometer operating at 84.10 MHz. All ^{19}F chemical shifts were reported in ppm relative to trichlorofluoromethane ($CFCl_3$) as an internal standard. IR spectra were determined with a Shimadzu FT-IR 8200 PC spectrophotometer. High resolution mass spectra were taken with a JEOL JMS-700 MS spectrometer. Elemental analyses were conducted with a Yanaco CHN CORDER MT-5 instrument. Column chromatography was carried out on silica gel (Wako gel C-200) and TLC analysis was performed on silica gel TLC plates (Merck, Silica gel 60 F_{254}).

2. Preparation of benzyl 2-bromo-2,3,3,3-tetrafluoropropanoate

A 50 mL-three necked round bottomed flask equipped with a magnetic stirrer bar, a thermometer, a rubber septum and an inlet tube for argon was charged with a solution of benzyl alcohol (3.244g, 30 mmol) and Et_3N (2.277 g, 22 mmol) in diethyl ether (26 mL). To this solution was slowly added 3.487 g (14 mmol) of 2-bromo-2,3,3,3-tetrafluoropropanoyl chloride in Et_2O (4 mL) *via* a syringe at 0 °C. After being stirred for 15 min. at 0 °C and then stirred for 20 h at room temperature. The reaction mixture was poured into ice-cooled water (50 mL), followed by extraction with ether (30 mL × 5). The organic layers were dried over anhydrous sodium sulfate, filtered and concentrated with a rotary evaporator. Column chromatography of the residue using hexane/benzene (2:1) yielded pure product, benzyl 2-bromo-2,3,3,3-tetrafluoropropanoate (4.233g, 94%).

2.1. Benzyl 2-bromo-2,3,3,3-tetrafluoropropanoate

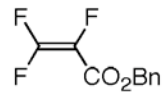


^{1}H NMR ($CDCl_3$) δ= 5.16 (s, 2H), 7.20 (s, 5H); ^{13}C NMR ($CDCl_3$) δ= 69.7, 88.8 (dq, *J* = 57.5, 272.3 Hz), 119.6 (dq, *J* = 29.5, 284.0 Hz), 128.3, 128.7, 129.0, 133.5, 160.5 (d, *J* = 26.5 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -77.99 (d, *J* = 8.8 Hz, 3F), -135.16 (q, *J* = 8.8 Hz, 1F); IR (neat) 3040 (w), 1774 (vs), 1501 (w), 1457 (w), 1304 (m), 1265 (m), 1192 (m), 1134 (s), 1018 (s), 976 (w), 918 (s) cm^{-1}; HRMS (FAB) calcd for (M+) $C_{10}H_7F_4BrO_2$: 313.9566, found 313.9573. Anal. Calcd for $C_{10}H_7F_4BrO_2$: C, 38.12; H, 2.24. Found: C, 38.02; H, 2.28.

3. Preparation of benzyl 2,3,3-trifluoroacrylate (1)

A 50 mL-three necked round bottomed flask equipped with a magnetic stirrer bar, a thermometer, a rubber septum and an inlet tube for argon was charged with a suspended solution of Zn dust (0.420 g, 11 mmol) in diethyl ether (16 mL). To this suspended solution was slowly added diethylaluminum chloride in hexane (0.95 mL, 1.0 mmol) and benzyl 2-bromo-2,3,3,3-tetrafluoropropanoate (3.139 g, 10 mmol) in Et_2O. After being stirred for 30 min. at room temperature, the reaction mixture was poured into an ice-cooled saturated aqueous ammonium chloride (50 mL). The resultant mixture was extracted with ether (30 mL × 5) and the organic layers were dried over anhydrous sodium sulfate, filtered and concentrated with a rotary evaporator under reduced pressure. Column chromatography of the residue using hexane/benzene (5:1) gave pure product, benzyl 2,3,3-trifluoroacrylate.

3.1. Benzyl 2,3,3-trifluoroacrylate (1)



^{1}H NMR ($CDCl_3$) δ= 5.29 (s, 2H), 7.32~7.38 (m, 5H); ^{13}C NMR ($CDCl_3$) δ= 67.5, 121.6 (ddd, *J* = 19.2, 38.5, 238.6 Hz), 128.3, 128.6, 128.6, 134.5, 158.0 (dt, *J* = 41.5, 300.9 Hz), 158.7 (ddd, *J* = 7.7, 7.7, 26.5 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -83.95 (dd, *J* = 19.8, 35.2 Hz, 1F), -95.28 (dd, *J* = 19.8, 112.2 Hz, 1F), -184.04 (dd, *J* = 35.2, 112.2 Hz, 1F); IR (neat) 1747 (vs), 1396 (s), 1350 (vs), 1319 (s), 1200 (vs), 1088 (vs) cm^{-1}; HRMS (EI) calcd for (M+) $C_{10}H_7F_3O_2$: 216.0398, found 216.0374. Anal. Calcd for $C_{10}H_7F_3O_2$: C, 55.56; H, 3.26. Found: C, 55.68; H, 3.34.

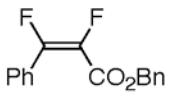
*4. Typical procedure for reaction of **1** with phenylmagnesium bromide (**3a**) in the presence of a catalytic amount of CuBr*

A 50 mL-three necked round bottomed flask equipped with a magnetic stirrer bar, a thermometer, a rubber septum and an inlet tube for argon was charged with a suspended solution of cuprous bromide (0.018 g, 0.125 mmol) in THF (0.5 mL). To this suspended solution was slowly dropwise added a solution of phenylmagnesium bromide (**a**, 1.5mmol) in THF at -78 °C. To the resulting solution was slowly added 0.108 g (0.50 mmol) of **1** in THF (1.5 mL) *via* a syringe at -78 °C. After being stirred for 1 h at -78 °C, the reaction mixture was poured into ice-cooled water (50 mL), followed by extraction with ether (30 mL × 5). The organic layers were dried over anhydrous sodium sulfate, filtered and concentrated with a rotary evaporator. Column chromatography of the residue using hexane/benzene (2:1) yielded pure product, benzyl 2,3-difluoro-3-phenylacrylate (**2a**). The stereoisomers of all compounds except for **2e**, **2j**, **2m**, and **2n** could not be separated by silica gel column chromatography.

*4.1. Benzyl 2,3-difluoro-3-phenylacrylate (**2a**)*

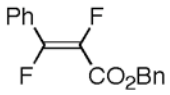
M.P. 60~61 °C; IR (KBr) 3040 (w), 1736 (vs), 1666 (vs), 1447 (s), 1393 (s), 1277 (vs), 1165 (s), 1084 (vs), 1026 (s), 968 (vs), 945 (s) cm^{-1}; HRMS (EI) calcd for (M+) $C_{16}H_{12}F_2O_2$: 274.0805, found 274.0801. Anal. Calcd for $C_{16}H_{12}F_2O_2$: C, 70.07; H, 4.41. Found: C, 69.67; H, 4.27.

Z isomer



^{1}H NMR ($CDCl_3$) δ= 5.17 (s, 2H), 7.17-7.32 (m, 5H), 7.36~7.53 (m, 5H); ^{13}C NMR ($CDCl_3$) δ= 67.2, 128.0, 128.5, 129.3 (dd, *J* = 3.3, 3.3 Hz), 314.1, 134.5, 135.1, 137.2 (dd, *J* = 21.9, 254.5 Hz), 156.3 (dd, *J* = 16.4, 267.1 Hz), 160.2 (dd, *J* = 8.0, 29.4 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -99.88 (d, *J* = 6.6 Hz, 1F), -148.73 (d, *J* = 6.6 Hz, 1F).

E isomer

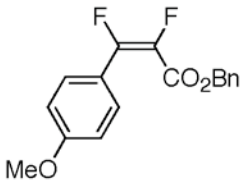


^{1}H NMR ($CDCl_3$) δ= 5.15 (s, 2H), 7.15~7.32 (m, 5H), 7.34~7.51 (m, 5H); ^{13}C NMR ($CDCl_3$) δ= 67.2, 128.0, 128.5, 129.3 (dd, *J* = 3.3, 3.3 Hz), 314.1, 134.5, 135.1, 137.2 (dd, *J* = 21.9, 254.5 Hz), 156.3 (dd, *J* = 16.4, 267.1 Hz), 160.2 (dd, *J* = 8.0, 29.4 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -133.85 (d, *J* = 127.6 Hz, 1F), -162.16 (d, *J* = 127.6 Hz, 1F).

*4.2. Benzyl 2,3-difluoro-3-(4-methoxyphenyl)acrylate (**2b**)*

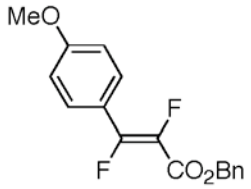
M.P. 47~49 °C; IR (KBr) 3506 (w), 1720 (vs), 1605 (vs), 1512 (s), 1462 (m), 1389 (s), 1258 (vs), 1180 (vs), 1088 (vs), 988 (m) cm^{-1}; HRMS (EI) calcd for (M+) $C_{17}H_{14}F_2O_3$: 304.0911, found 304.0909. Anal. Calcd for $C_{17}H_{14}F_2O_3$: C, 67.10; H, 4.64. Found: C, 67.37; H, 4.57.

Z isomer



^{1}H NMR ($CDCl_3$) δ= 3.79 (s, 3H), 5.17 (s, 2H), 6.83~7.47 (m, 9H); ^{13}C NMR ($CDCl_3$) δ= 55.2, 67.1, 113.4, 128.3, 128.4, 128.4, 130.9, 131.0, 134.6, 136.7 (dd, *J* = 23.0, 253.1 Hz), 156.5 (dd, *J* = 16.5, 266.5 Hz), 160.4 (dd, *J* = 8.4, 29.0 Hz), 161.8; ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -99.04 (d, *J* = 7.7 Hz, 1F), -150.075 (d, *J* = 7.7 Hz, 1F).

E isomer

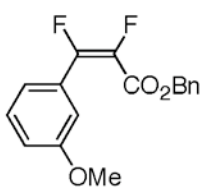


^{1}H NMR ($CDCl_3$) δ= 3.79 (s, 3H), 5.17 (s, 2H), 6.83~7.47 (m, 9H); ^{13}C NMR ($CDCl_3$) δ= 55. 2, 67.1, 113.4, 128.3, 128.4, 128.4, 130.9, 131.0, 134.6, 136.7 (dd, *J* = 23.0, 253.1 Hz), 156.5 (dd, *J* = 16.5, 266.5 Hz), 160.4 (dd, *J* = 8.4, 29.0 Hz), 161.8; ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -133.49 (d, *J* = 126.5 Hz, 1F), -164.69 (d, *J* = 126.5 Hz, 1F).

*4.3. Benzyl 2,3-difluoro-3-(3-methoxyphenyl)acrylate (**2c**)*

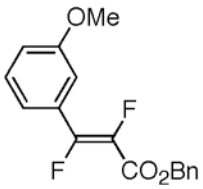
IR (KBr) 3067 (m), 2961 (m), 1732 (vs), 1686 (s), 1581 (s), 1492 (s), 1383 (s), 1294 (vs), 1165 (vs), 1095 (vs) cm^{-1}; HRMS (FAB) calcd for (M+) $C_{17}H_{14}F_2O_3$: 304.0911, found 304.0919.

Z isomer



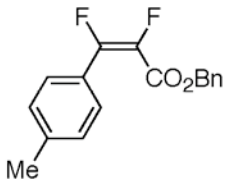
^{1}H NMR ($CDCl_3$) δ= 3.77 (s, 3H), 5.18 (s, 2H), 7.00~7.47 (m, 9H); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -99.86 (d, *J* = 8.5 Hz, 1F), -148.39 (d, *J* = 8.5 Hz, 1F).

E isomer



^{1}H NMR ($CDCl_3$) δ= 3.84 (s, 3H), 5.38 (s, 2H), 7.00~7.47 (m, 9H); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -133.32 (d, *J* = 127.1 Hz, 1F), -161.29 (d, *J* = 127.1 Hz, 1F).

*4.4. Benzyl (Z)-2,3-difluoro-3-(4-methylphenyl)acrylate (**2e**)*

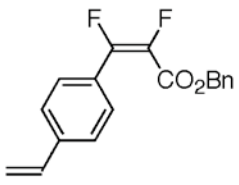


M.P. 58~59 °C; ^{1}H NMR ($CDCl_3$) δ= 2.38 (s, 3H), 5.17 (s, 2H), 7.16~7.20 (m, 4H), 7.30~7.42 (m, 5H); ^{13}C NMR ($CDCl_3$) δ= 21.5, 67.2, 125.0, 158.2, 128.3, 128.43, 128.5, 128.8, 129.2 (dd, *J* = 3.3, 3.3 Hz), 134.6, 137.0 (dd, *J* = 22.9, 254.3 Hz), 156.6 (dd, *J* = 16.3, 267.0 Hz), 160.4 (dd, *J* = 8.3, 29.0 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -99.41 (d, *J* = 6.6 Hz, 1F), -149.46 (d, *J* = 6.6 Hz, 1F); IR (neat) 2920 (w), 1724 (vs), 1682 (s), 1497 (w), 1327 (s), 1281 (s), 1169 (vs), 1092 (vs), 984 (s) cm^{-1}; HRMS (EI) calcd for (M+) $C_{17}H_{14}F_2O_2$: 288.0962, found 288.0943. Anal. Calcd for $C_{17}H_{14}F_2O_2$: C, 70.83; H, 4.89. Found: C, 71.14; H, 4.93.

*4.5. Benzyl 2,3-difluoro-3-(4-vinyllphenyl)acrylate (**2f**)*

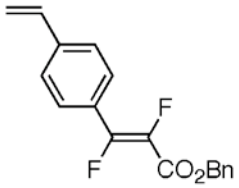
M.P. 54~55 °C; IR (KBr) 2372 (w), 1736 (vs), 1666 (s), 1454 (m), 1393 (m), 1277 (m), 1180 (m), 1084 (vs) cm^{-1}; HRMS (FAB) calcd for (M+) $C_{18}H_{14}F_2O_2$: 300.0962, found 300.0964.

Z isomer



^{1}H NMR ($CDCl_3$) δ= 5.18 (s, 2H), 5.36 (d, *J* = 8.5 Hz, 1H), 5.82 (d, *J* = 17.7 Hz, 1H), 6.71 (dd, *J* = 10.8 Hz, 17.7 Hz, 1H), 7.17~7.49 (m, 9H); ^{13}C NMR ($CDCl_3$) δ= 67.3, 116.1, 125.8, 128.3, 128.5, 129.6 (dd, *J* = 3.2, 3.2 Hz), 134.5, 135.7, 135.9, 137.2 (dd, *J* = 23.3, 255.0 Hz), 140.3, 140.4, 156.2 (dd, *J* = 16.9, 266.5 Hz), 160.2 (dd, *J* = 8.4, 29.1 Hz);^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -100.84 (d, *J* = 4.4 Hz, 1F), -148.45 (d, *J* = 4.4 Hz, 1F).

E isomer

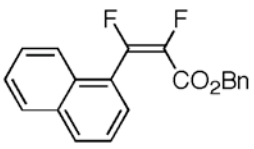


^{1}H NMR ($CDCl_3$) δ= 5.18 (s, 2H), 5.38 (d, *J* = 8.0 Hz, 1H), 5.86 (d, *J* = 17.9 Hz, 1H), 6.71 (dd, *J* = 10.8 Hz, 17.9 Hz, 1H), 7.17~7.49 (m, 9H); ^{13}C NMR ($CDCl_3$) δ= 67.2, 116.5, 126.4, 128. 3, 128.5, 129.6 (dd, *J* = 3.2, 3.2 Hz), 134.5, 135.7, 135.9, 137.2 (dd, *J* = 23.3, 255.0 Hz), 140.3, 140.4, 156.2 (dd, *J* = 16.9, 266.5 Hz), 160.2 (dd, *J* = 8.4, 29.1 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -134.51 (d, *J* = 125.4 Hz, 1F), -161.85 (d, *J* = 125.4 Hz, 1F).

*4.6. Benzyl 2,3-difluoro-3-(1-naphtyl)acrylate (**2h**)*

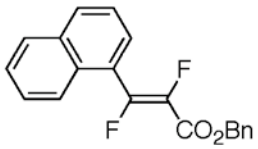
M.P. 36~38 °C; IR (KBr) 3063 (w), 2959 (w), 1732 (vs), 1686 (m), 1385 (m), 1319 (s), 1288 (m), 1169 (s), 1123 (s), 1042 (s) cm^{-1}; HRMS (FAB) calcd for (M+) $C_{20}H_{14}F_2O_2$: 324.0962, found 324.0965. Anal. Calcd for $C_{20}H_{14}F_2O_2$: C, 74.07; H, 4.35. Found: C, 73.97; H, 4.48.

Z isomer



^{1}H NMR ($CDCl_3$) δ= 4.94 (s, 2H), 6.76 (m, 2H), 7.11~7.22 (m, 3H), 7.39~7.42 (m, 1H), 7.51~7.55 (m, 3H), 7.86~7.93 (m, 3H); ^{13}C NMR ($CDCl_3$) δ= 67.2, 124.3, 124.7, 126.5, 127.4, 127.8, 128.2, 128.3, 128.5, 129.5, 131.2, 131.61, 131.64, 133.3, 134.1, 138.5 (dd, *J* = 21.6, 254.5 Hz), 155.0 (dd, *J* = 15.9, 271.3 Hz), 160.0 (dd, *J* = 8.4, 30.2 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -94.87 (d, *J* = 11.0 Hz, 1F), -147.01 (d, *J* = 11.0 Hz, 1F).

E isomer

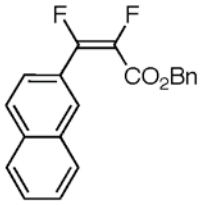


^{1}H NMR ($CDCl_3$) δ= 5.43 (s, 2H), 7.35~7.42 (m, 5H), 7.48~7.57 (m, 5H), 7.96~7.99 (m, 2H); ^{13}C NMR ($CDCl_3$) δ= 67.2, 124.4, 124.7, 126.5, 127.4, 127.8, 128.2, 128.3, 128.5, 129.5, 131.2, 131.61, 131.64, 133.3, 134.1, 138.5 (dd, *J* = 21.6, 254.5 Hz), 155.0 (dd, *J* = 15.9, 271.3 Hz), 160.0 (dd, *J* = 8.4, 30.2 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -114.56 (d, *J* = 137.6 Hz, 1F), -160.00 (d, *J* = 137.6 Hz, 1F).

*4.7. Benzyl 2,3-difluoro3-(2 -naphtyl)acrylate (**2i**)*

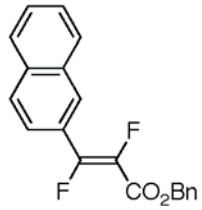
M.P. 79~80 °C; IR (KBr) 3063 (w), 1736 (s), 1678 (m), 1501 (w), 1454 (w), 1323 (m), 1231 (w), 1153 (w), 1080 (vs) cm^{-1}; HRMS (FAB) calcd for (M+) $C_{20}H_{14}F_2O_2$: 324.0962, found 324.0959. Anal. Calcd for $C_{20}H_{14}F_2O_2$: C, 74.07; H, 4.35. Found: C, 73.82; H, 4.58.

Z isomer



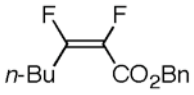
^{1}H NMR ($CDCl_3$) δ= 5.13 (s, 2H), 7.05-7.23 (m, 5H), 7.47-7.55 (m, 3H), 7.75-7.82 (m, 3H), 8.02 (s, 1H); ^{13}C NMR ($CDCl_3$) δ= 67.26, 125.21, 125.35, 125.37, 126.69, 127.69, 127.79, 127.84, 128.19, 128.37, 128.71, 130.18, 132.22, 134.27, 134.38, 137.41 (dd, *J* = 22.2 Hz, 254.6 Hz), 156.44 (dd, *J* = 16.6 Hz, 267.3 Hz), 160.24 (dd, *J* = 8.1 Hz, 29.4 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -99.67 (d, *J* = 7.8 Hz, 1F), -147.96 (d, *J* = 7.8 Hz, 1F).

E isomer



^{1}H NMR ($CDCl_3$) δ= 5.40 (s, 2H), 7.34-7.42 (m, 3H), 7.46-7.47 (m, 2H), 7.50-7.59 (m, 2H), 7.79-7.91 (m, 4H), 8.29 (s, 1H); ^{13}C NMR ($CDCl_3$) δ= 67.26, 125.21, 125.35, 125.37, 126.69, 127.69, 127.79, 127.84, 128.19, 128.37, 128.71, 130.18, 132.22, 134.27, 134.38, 137.41 (dd, *J* = 22.2 Hz, 254.6 Hz), 156.44 (dd, *J* = 16.6 Hz, 267.3 Hz), 160.24 (dd, *J* = 8.1 Hz, 29.4 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -133.51 (d, *J* = 127.7 Hz, 1F), -161.98 (d, *J* = 127.7 Hz, 1F).

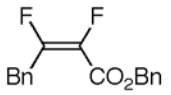
*4.8. Benzyl (Z)-3-butyl-2,3-difluoroacrylate (**2j**)*



^{1}H NMR ($CDCl_3$) δ= 0.89 (t, *J* = 7.3 Hz, 3H), 1.30-1.38 (m, 2H), 1.54~1.60 (m, 2H), 2.74 (ddt, *J* = 3.0 Hz, 8.0 Hz, 27.0 Hz, 2H), 5.26 (s, 2H), 7.32~7.39 (m, 5H); ^{13}C NMR ($CDCl_3$) δ= 13.6, 22.0, 27.9 (d, *J* = 2.7 Hz), 27.7 (dd, *J* = 2.0, 20.5 Hz), 67.1, 128.4, 128.5, 128.6, 134.9, 136.8 (dd, *J* = 19.2, 251.5 Hz), 160.4 (dd, *J* = 11.6, 272.4 Hz), 160.9 (dd, *J* = 10.1, 27.5 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -106.17 (dt, *J* = 4.4 Hz, 27.0 Hz, 1F), -155.07 (d, *J* =

4.4 Hz, 1F); IR (neat) 3036 (w), 2874 (w), 1732 (s), 1686 (m), 1501 (w), 1431 (w), 1312 (s), 1157 (m), 1022 (m) cm^{-1}; HRMS (EI) calcd for (M+) $C_{14}H_{16}F_2O_2$: 254.1118, found 254.1112. Anal. Calcd for $C_{14}H_{16}F_2O_2$: C, 66.13; H, 6.34. Found: C, 66.52; H, 6.44.

*4.9. Benzyl (Z)-3-benzyl-2,3-difluoroacrylate (**2k**)*

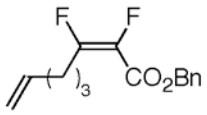


^{1}H NMR ($CDCl_3$) δ= 4.01 (dd, *J* = 2.8 Hz, 26.9 Hz, 2H), 5.24 (s, 2H), 7.16-7.33 (m, 10H); ^{13}C NMR ($CDCl_3$) δ= 34.59 (d, *J* = 20.6 Hz), 67.42, 127.35, 128.47, 128.69, 128.74, 128.83, 134.40, 134.42, 134.74, 136.92 (dd, *J* = 18.9 IIz, 254.7 IIz), 157.95 (dd, *J* = 13.0 IIz, 272.6 IIz), 160.90 (dd, *J* = 9.5 Hz, 27.7 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -105.70 (dt, *J* = 2.0 Hz, 26.9 Hz, 1F), -153.65 (d, *J* = 2.0 Hz, 1F); IR (neat) 3067 (w), 3032 (w), 1732 (vs), 1690 (vs), 1605 (w), 1497 (m), 1454 (m), 1420 (w), 1385 (s), 1312 (vs), 1258 (w), 1181 (vs), 1146 (vs), 1076 (s), 1030 (vs), 799 (w), 764 (s), 706 (vs) cm ^{1}; HRMS (EI) calcd for (M+) $C_{17}H_{14}F_2O_2$: 288.0962, found 288.0961. Anal. Calcd for $C_{17}H_{14}F_2O_2$: C, 70.83; H, 4.89. Found: C, 70.91; H, 5.07.

*4.10. Benzyl 2,3-difluoro-3-(4-pentenyl)acrylate (**2l**)*

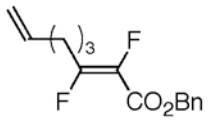
IR (neat) 3069 (vs), 2939 (vs), 1685 (vs), 1609 (m), 1499 (vs), 1383 (vs), 1147 (vs), 1028 (vs) cm^{-1}; HRMS (EI) calcd for (M+) $C_{15}H_{16}F_2O_2$: 266.1118, found 2666.1111.

Z isomer



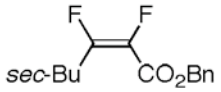
^{1}H NMR ($CDCl_3$) δ=1.72 (tt, *J* = 7.5, 7.5 Hz), 2H), 2.09 (dt, *J* = 7.5, 7.5 Hz, 2H), 2.77 (dtd, *J* = 25.4, 7.5, 2.4 Hz, 2H), 4.99 (dd, *J* = 11.3, 1.6 Hz, 1H), 5.02 (dd, *J* = 17.1, 1.6 Hz, 1H), 5.28 (s, 2H), 5.76 (dt, *J* = 11.3, 7.5 Hz, 1H), 7.33~7.45 (m, 5H); ^{13}C NMR ($CDCl_3$) δ= 15.20, 25.08, 27.93 (d, *J* = 20.3 Hz), 32.82, 65.78, 67.16, 115.43, 128.62, 129.37, 134.84, 136.85 (dd, *J* = 252.0, 19.1Hz), 137.31, 160.03 (dd, *J* = 272.2, 12.6 Hz), 160.86 (dd, *J* = 27.5, 9.5 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -106.49 (t, *J* = 25.4 Hz, 1F), -154.54 (s, 1F).

E isomer



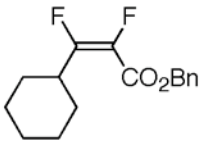
^{1}H NMR ($CDCl_3$) δ=1.70-1.80 (m, 2H), 2.15 (dt, *J* = 6.1, 6.1 Hz, 2H), 2.52 (ddt, *J* = 22.5, 6.1, 6.1 Hz, 2H), 5.00-5.10 (m, 2H), 5.31 (s, 2H), 5.72~5.85 (m, 1H), 7.33~7.45 (m, 5H); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -124.06 (dt, *J* = 129.9, 22.5 Hz, 1F), -167.08 (d, *J* = 129.9 Hz, 1F).

*4.11. Benzyl (Z)-3-sec -butyl- 2,3-difluoroacrylate (**2m**)*



^{1}H NMR ($CDCl_3$) δ= 0.82 (t, *J* = 7.5 Hz, 3H), 1.09 (d, *J* = 3.5 Hz, 3H), 1.46 (dq, *J* = 7.5 Hz, 42.5 Hz, 2H), 3.35 (dtq, *J* = 3.5 Hz, 30.8 Hz, 42.5Hz, 1H), 5.21 (d, *J* = 7.5 Hz, 2H), 7.26~7.32 (m, 5H); ^{13}C NMR ($CDCl_3$) δ= 11.6, 16.6, 26.2, 34. 1 (d, *J* = 19.8 Hz), 67.1, 128.3, 128.6, 128.7, 134.9, 136.8 (dd, *J* = 19.2, 251.5 Hz), 160.1 (dd, *J* = 11.6, 272.4 Hz), 161.3 (dd, *J* = 10.1, 27.5 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -121.14 (d, *J* = 30.8 Hz, 1F), -155.41 (s, 1F); IR (neat) 2970 (m), 2936 (w), 1732 (vs), 1682 (m), 1308 (vs), 1130 (m), 1022 (m) cm^{-1}; HRMS (FAB) calcd for (M+) $C_{14}H_{16}F_2O_2$: 254.1118, found 254.1120. Anal. Calcd for $C_{14}H_{16}F_2O_2$: C, 66.13; H, 6.34. Found: C, 65.95; H, 6.70.

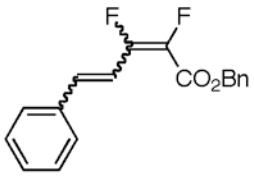
*4.12. Benzyl (Z)-3-cycrohexyl- 2,3-difluoroacrylate (**2n**)*



M.P. 60~62 °C; ^{1}H NMR ($CDCl_3$) δ= 1.13~1.31 (m, 4H), 1.46~1.54 (m, 2H), 1.67~1.80 (m, 4H), 3.33 (dtt, *J* = 12.0 Hz, 12.0 Hz, 32.7Hz, 1H), 5.27 (s, 2H), 7.34~7.39 (m, 5H); ^{13}C NMR ($CDCl_3$) δ= 25.4, 25.6, 28.5 (d, *J* = 1.7 Hz), 37.0 (dd, *J* = 1.6, 19.3 Hz), 67.1, 128.3, 128.5, 128.6, 134.9, 136.9 (dd, *J* = 19.6 Hz, 257.3 Hz), 161.0 (dd, *J* = 10.0, 27.7 Hz), 163.3 (dd, *J* = 10.7, 275.5 Hz); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -117.31 (d, *J* = 32.7 Hz, 1F), -156.80 (s, 1F); IR (neat) 2932 (vs), 2855 (m), 1728 (vs), 1674 (vs), 1454 (s), 1327 (vs), 1258 (m), 1126 (vs), 1018 (vs) cm^{-1}; HRMS (EI) calcd for (M+) $C_{16}H_{18}F_2O_2$: 280.1275, found 280.1273. Anal. Calcd for $C_{16}H_{18}F_2O_2$: C, 68.56; H, 6.47. Found: C, 68.69; H, 6.24.

*4.13. Benzyl 2,3-difluoro-3-(2-phenylethenyl)acrylate (**2o**)*

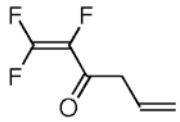
The products were obtained as an inseparable isomeric mixtures.



^{1}H NMR ($CDCl_3$) δ=5.34 (s, 3H), 5.35 (s, 3H), 5.37 (s, 3H), 6.65~6.75 (m, 4H), 6.80~7.00 (m, 4H), 7.15~7.65 (m, 40H); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ=-113.33 (dd, *J* = 14.2, 14.2 Hz, 1F), -125.70 (dd, *J* = 25.3, 25.3 Hz, 1F), -140.07 (dd, *J* = 119.9, 25.3 Hz, 1F), -147.26 (s, 1F), -149.94 (s, 1F), -162.68 (d, *J* = 119.9 Hz, 1F); IR (neat) 3029 (w), 2359 (w), 1723 (vs), 1639 (s), 1496 (m), 1384 (s), 1319 (vs), 1165 (vs), 1075 (vs) cm^{-1}; HRMS (FAB) calcd for (M+Na) $C_{18}H_{14}F_2O_2Na$: 323.0860, found 323.0863.

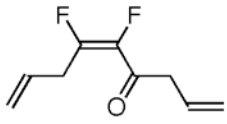
*4.14. 1,1,2-Trifluorohexa-1,5-diene-3-one (**4p**) and 5,6-Difluorononona-1,5-diene-4-one (**5p**)*

Products **4p** and **5p** could not be separated by a silica gel column chromatography as a sole product. Therefore, the chemical sifts of **4p** and **5p** are determined based on the ^{1}H and ^{19}F NMR analyses of the mixture (**4p** and **5p**).



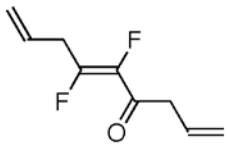
^{1}H NMR ($CDCl_3$) δ= 2.37 (dd, *J* = 8.3 Hz, 13.7 Hz, 1H), 2.55 (dd, *J* = 6.8 Hz, 13.7 Hz, 1H), 5.13-5.25 (m, 2H), 5.76-5.87 (m, 1H); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -101.11 (dd, *J* = 33.1 Hz, 83.6 Hz, 1F), -116.36 (dd, *J* = 83.6 Hz, 112.2 Hz, 1F), -178.044 (dd, *J* = 33.1 Hz, 112.2 Hz, 1F)

Z isomer



^{1}H NMR ($CDCl_3$) δ= 2.26 (dd, *J* = 8.5 Hz, 13.5 Hz, 1H), 2.37 (dd, *J* = 8.0 Hz, 13.5 Hz, 1H), 2.54 (dd, *J* = 6.5 Hz, 14.0 Hz, 1H), 2.57~2.62 (m, 1H), 3.22~3.28 (m, 1H), 5.09~5.24 (m, 2H), 5.75~5.85 (m, 1H); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -130.03 (t, *J* = 25.3 Hz, 1F), -143.27 (s, 1F).

E isomer



^{1}H NMR ($CDCl_3$) δ= 2.26 (dd, *J* = 8.5 Hz, 13.5 Hz, 1H), 2.37 (dd, *J* = 8.0 Hz, 13.5 Hz, 1H), 2.54 (dd, *J* = 6.5 Hz, 14.0 Hz, 1H), 2.57-2.62 (m, 1H), 3.06~3.13 (m, 1H), 5.09~5.24 (m, 2H), 5.75~5.85 (m, 1H); ^{19}F NMR ($CDCl_3$, $CFCl_3$) δ= -15.056 (dt, *J* = 23.1 Hz, 127.6 Hz, 1F), -158.55 (d, *J* = 127.6 Hz, 1F).

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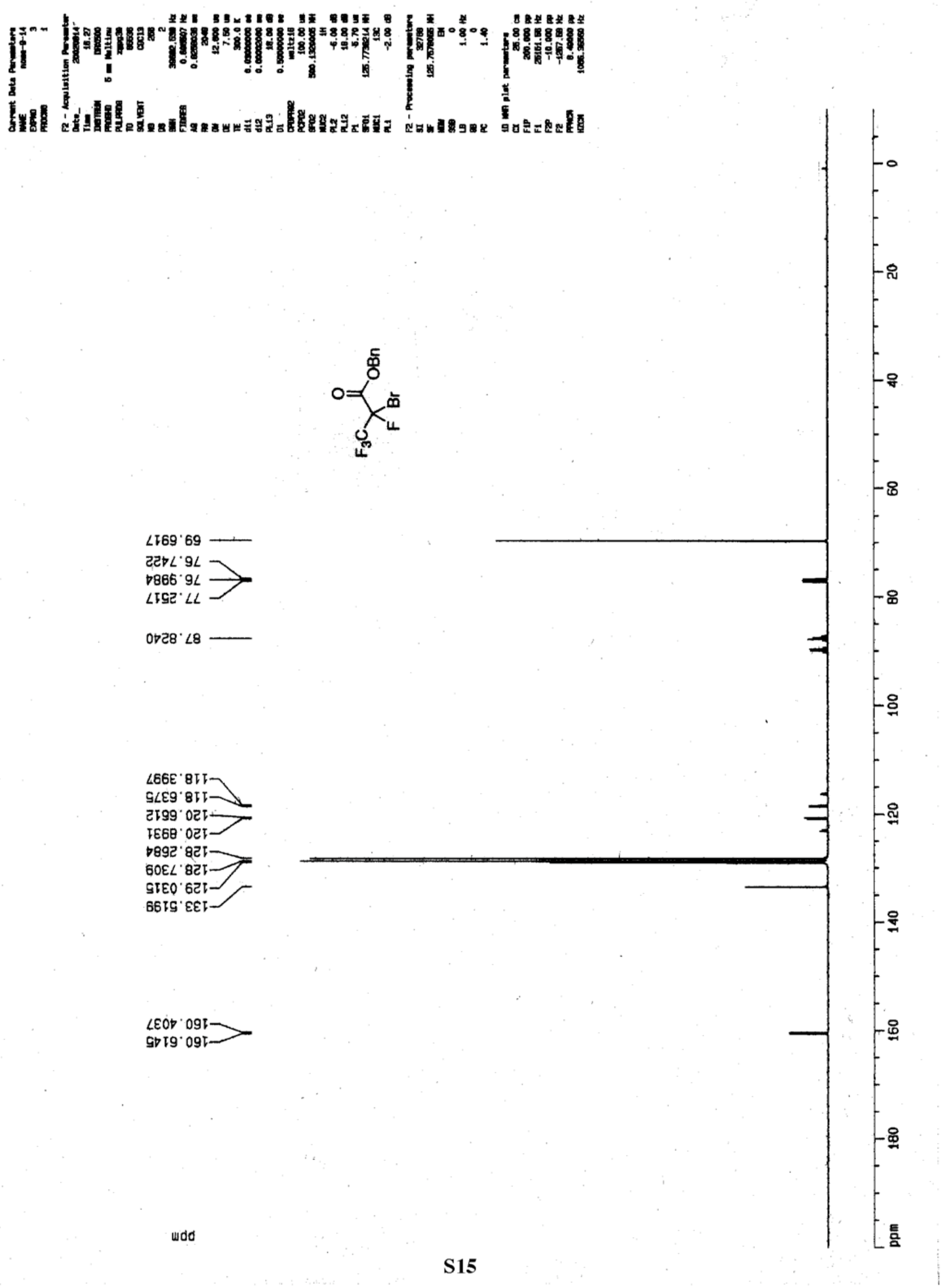
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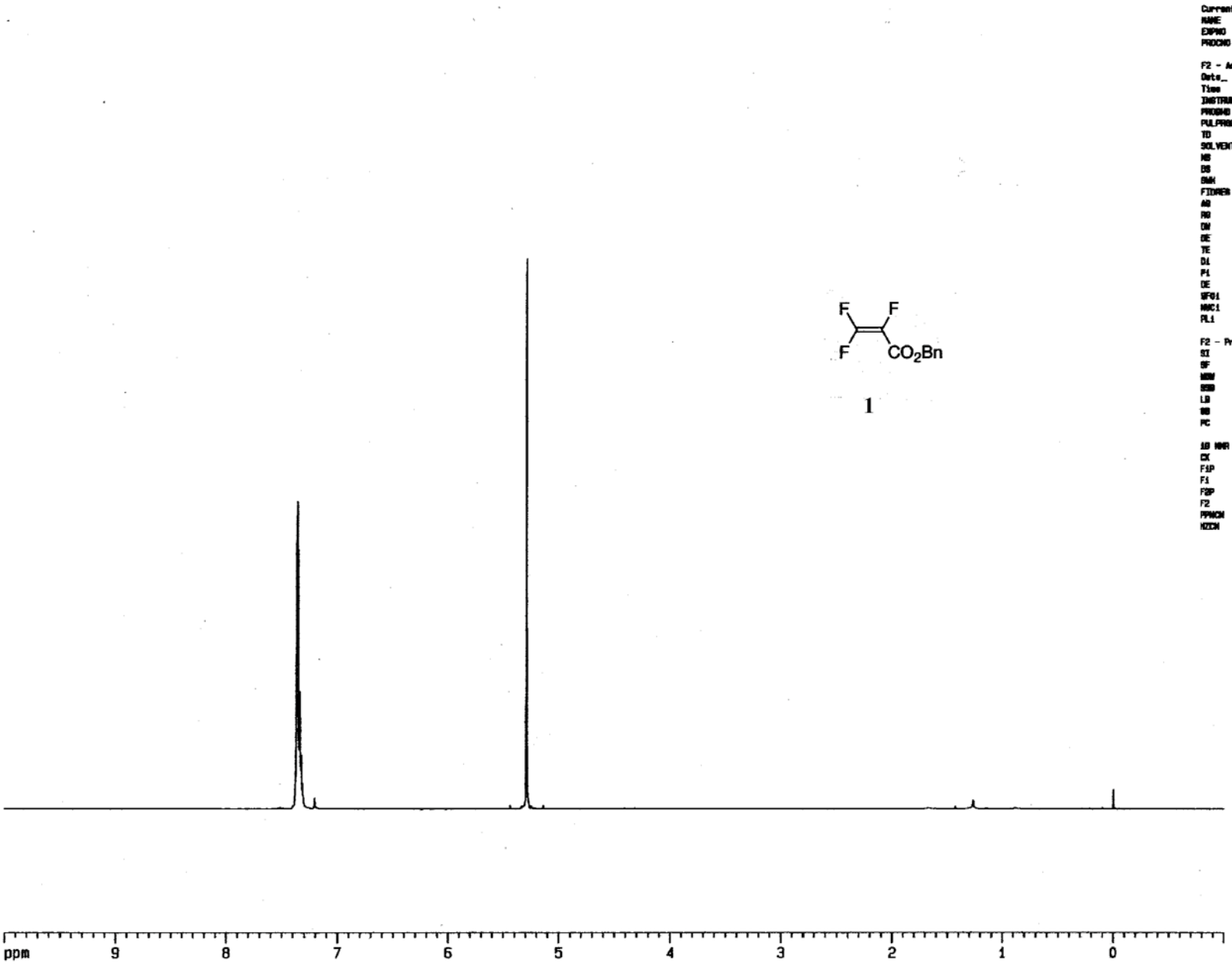


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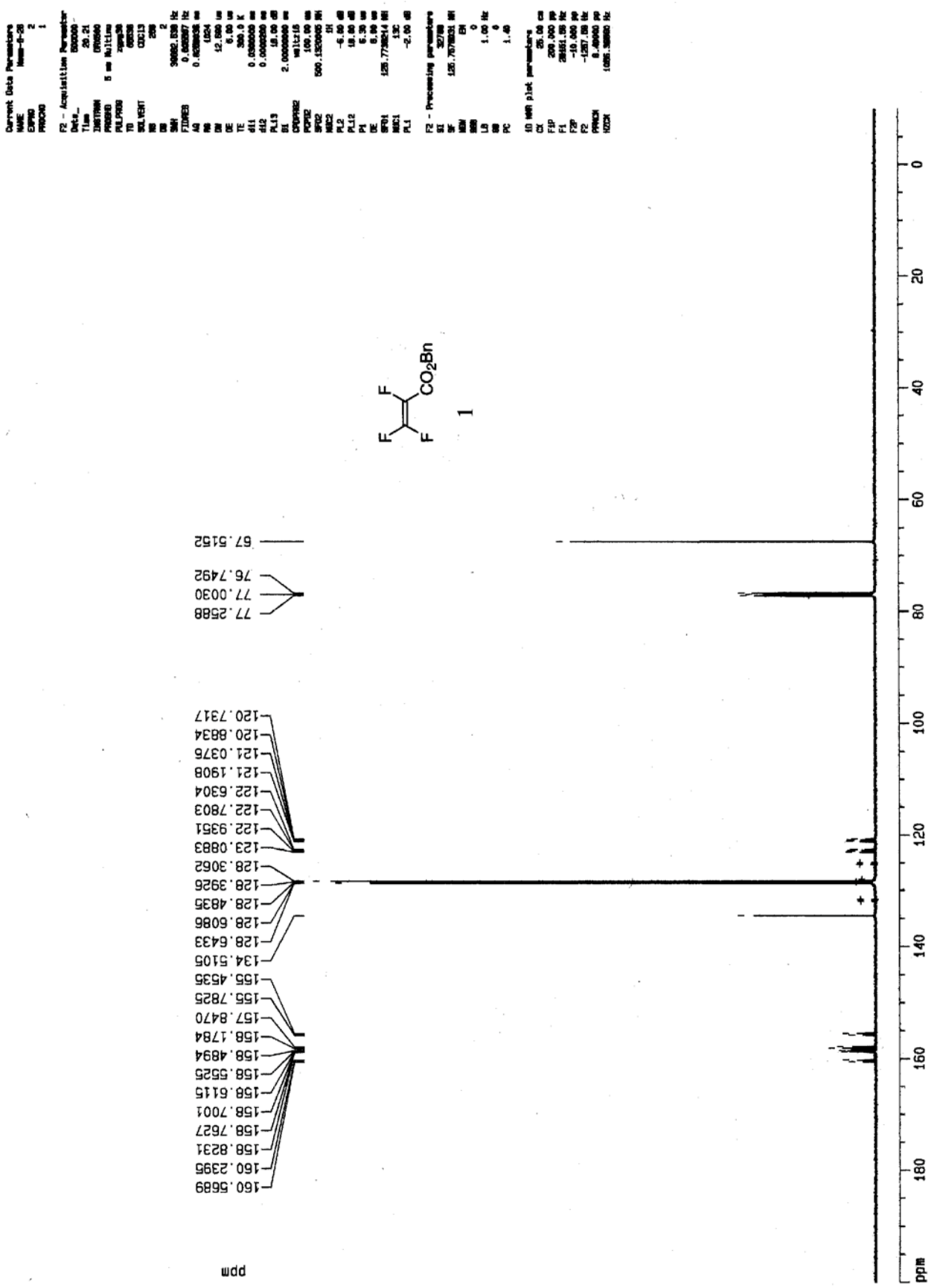
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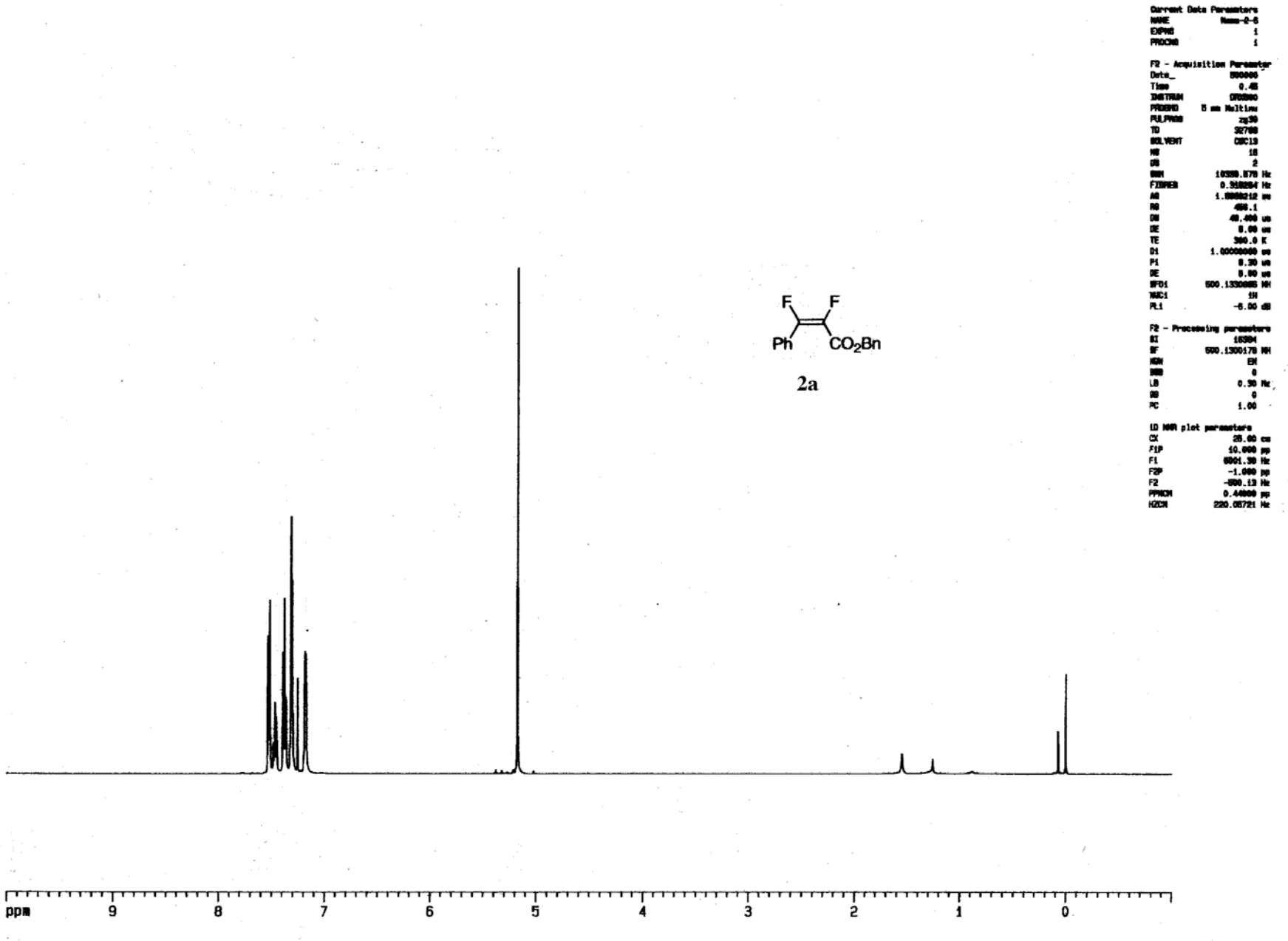
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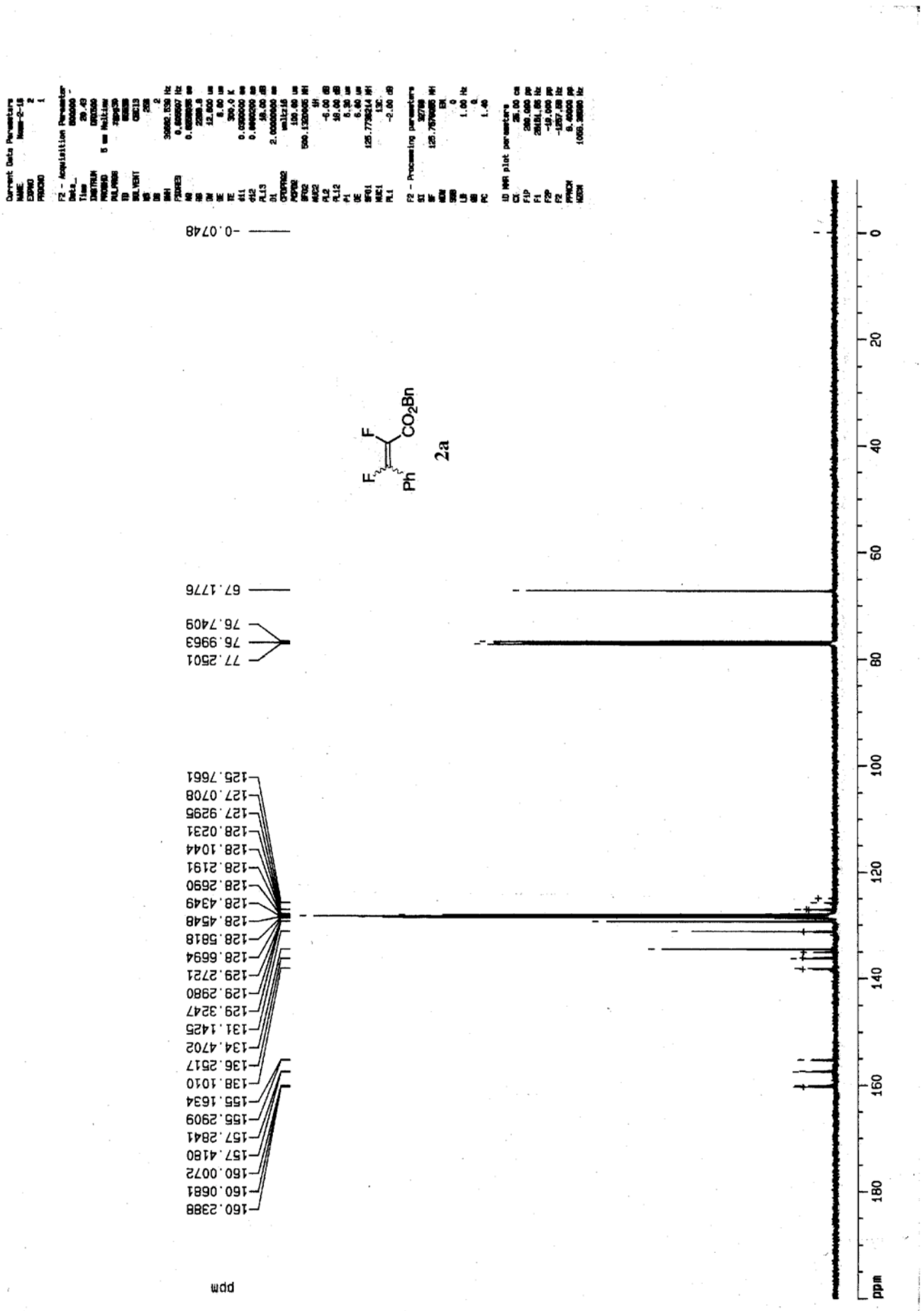
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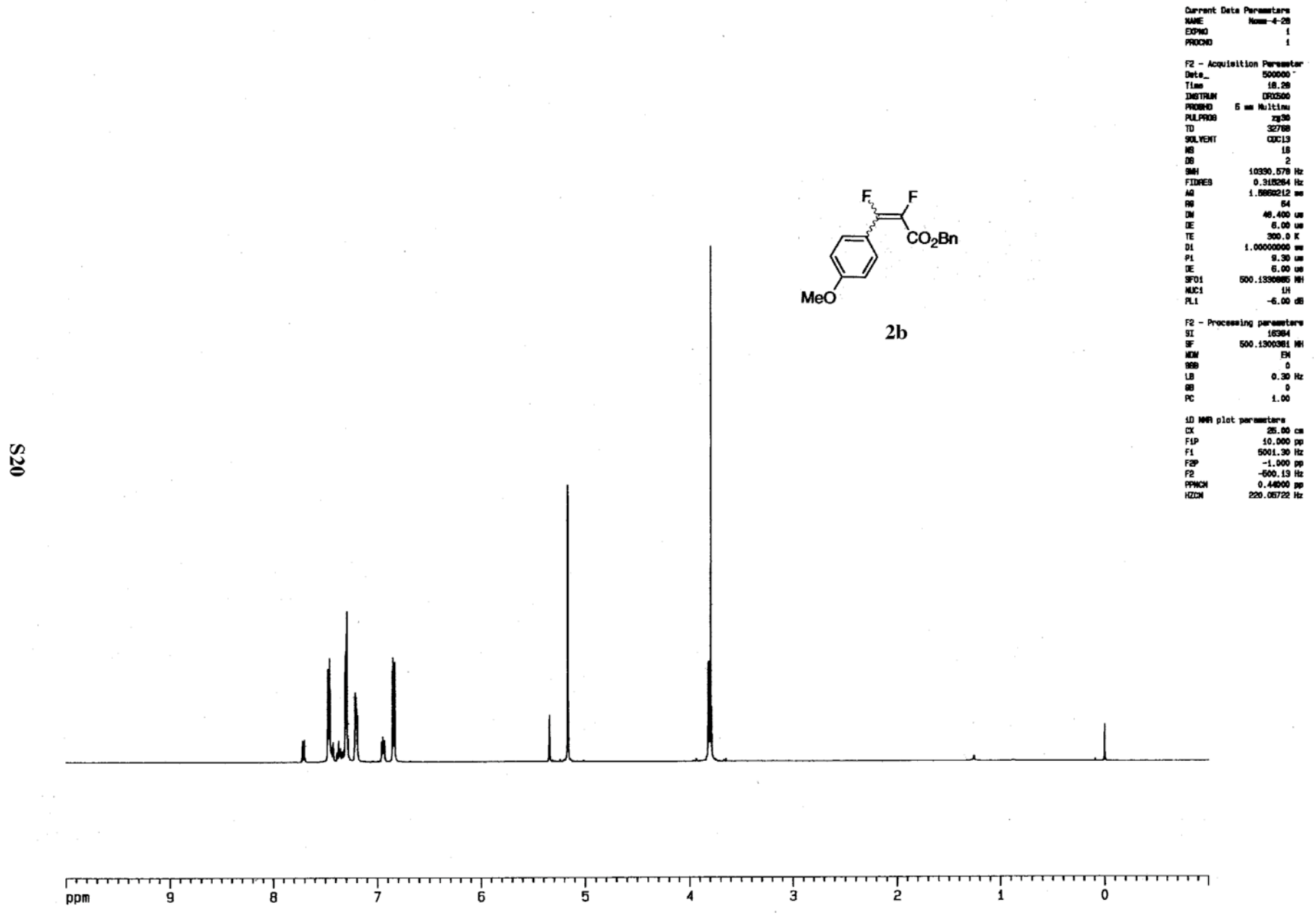

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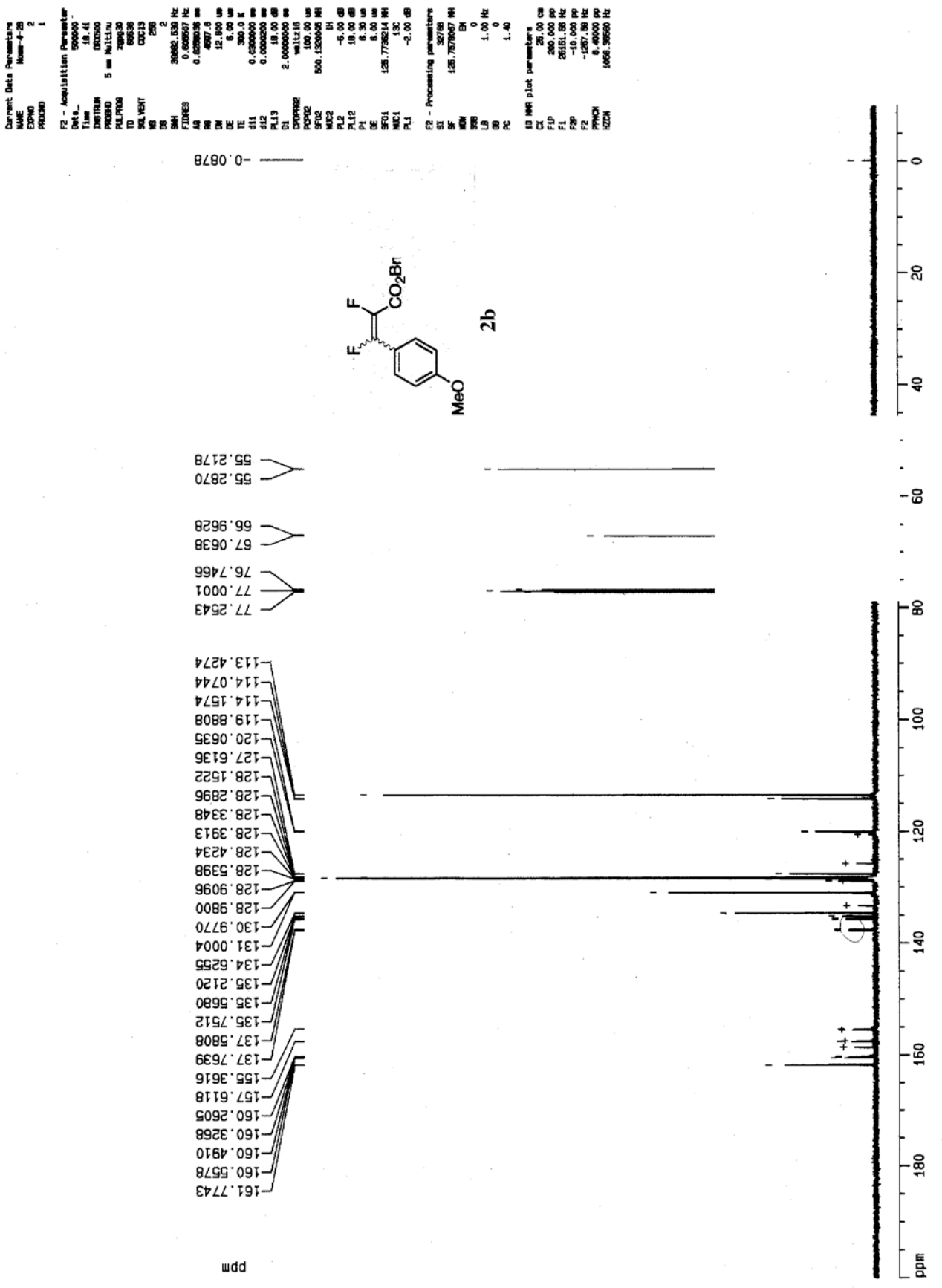
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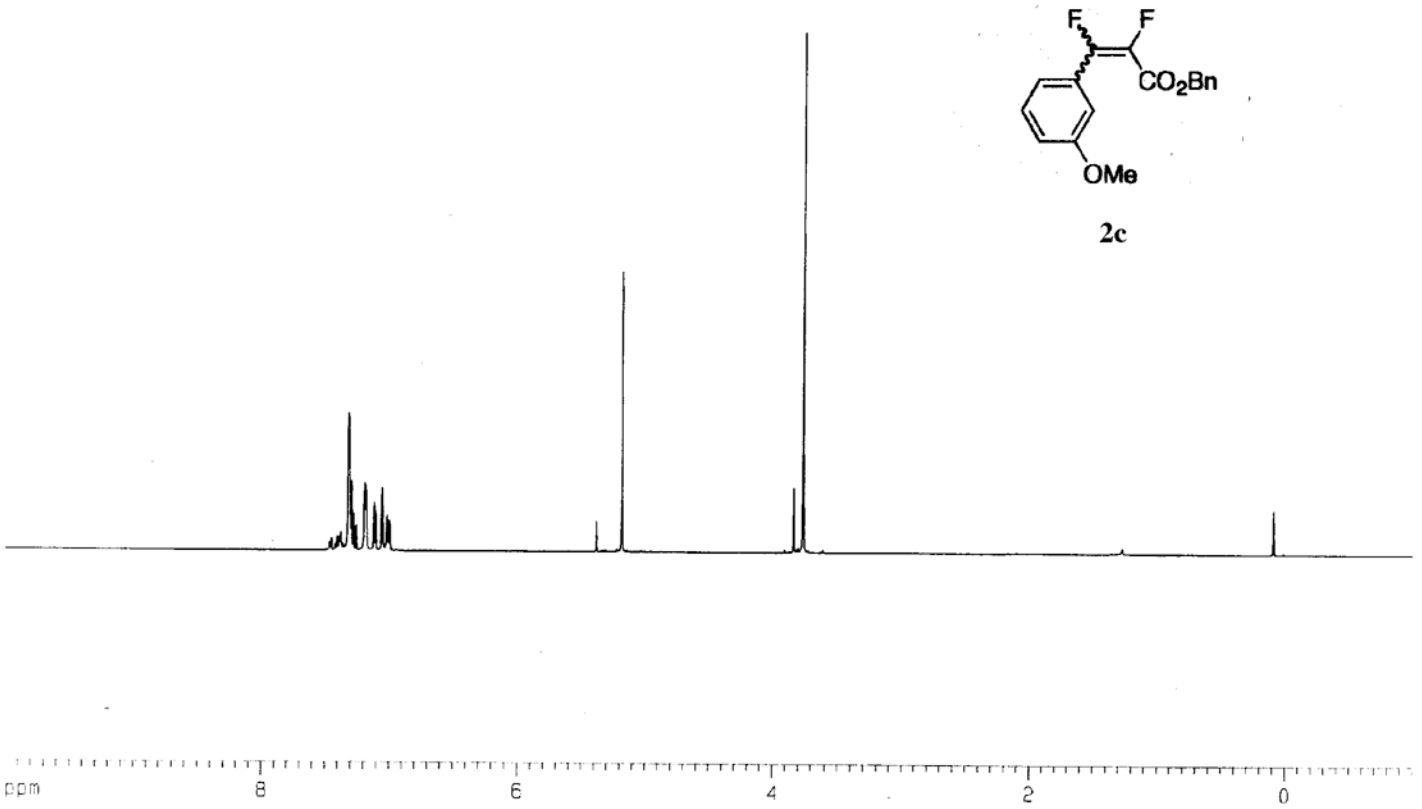

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HZCM           275.07150 Hz/cm
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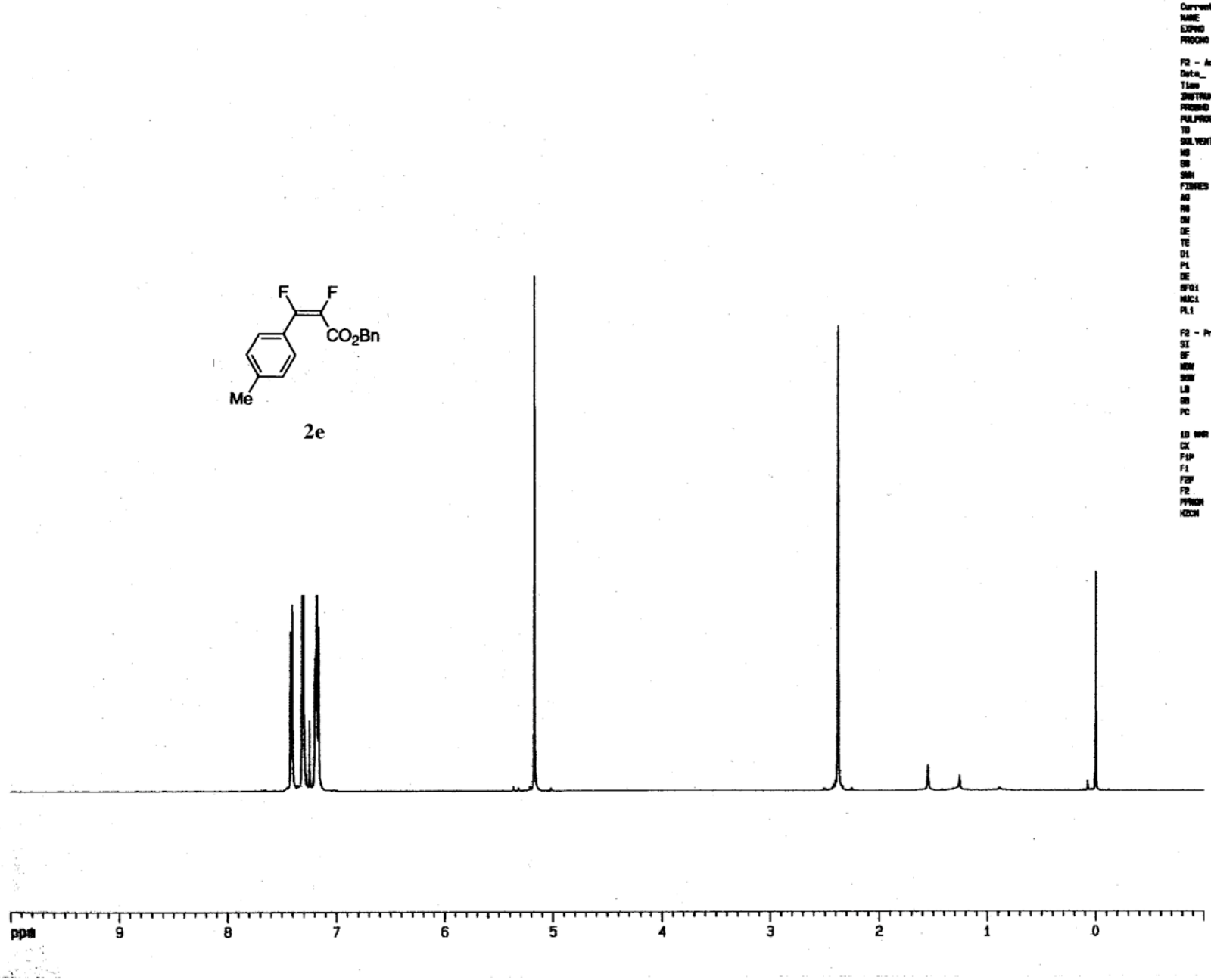
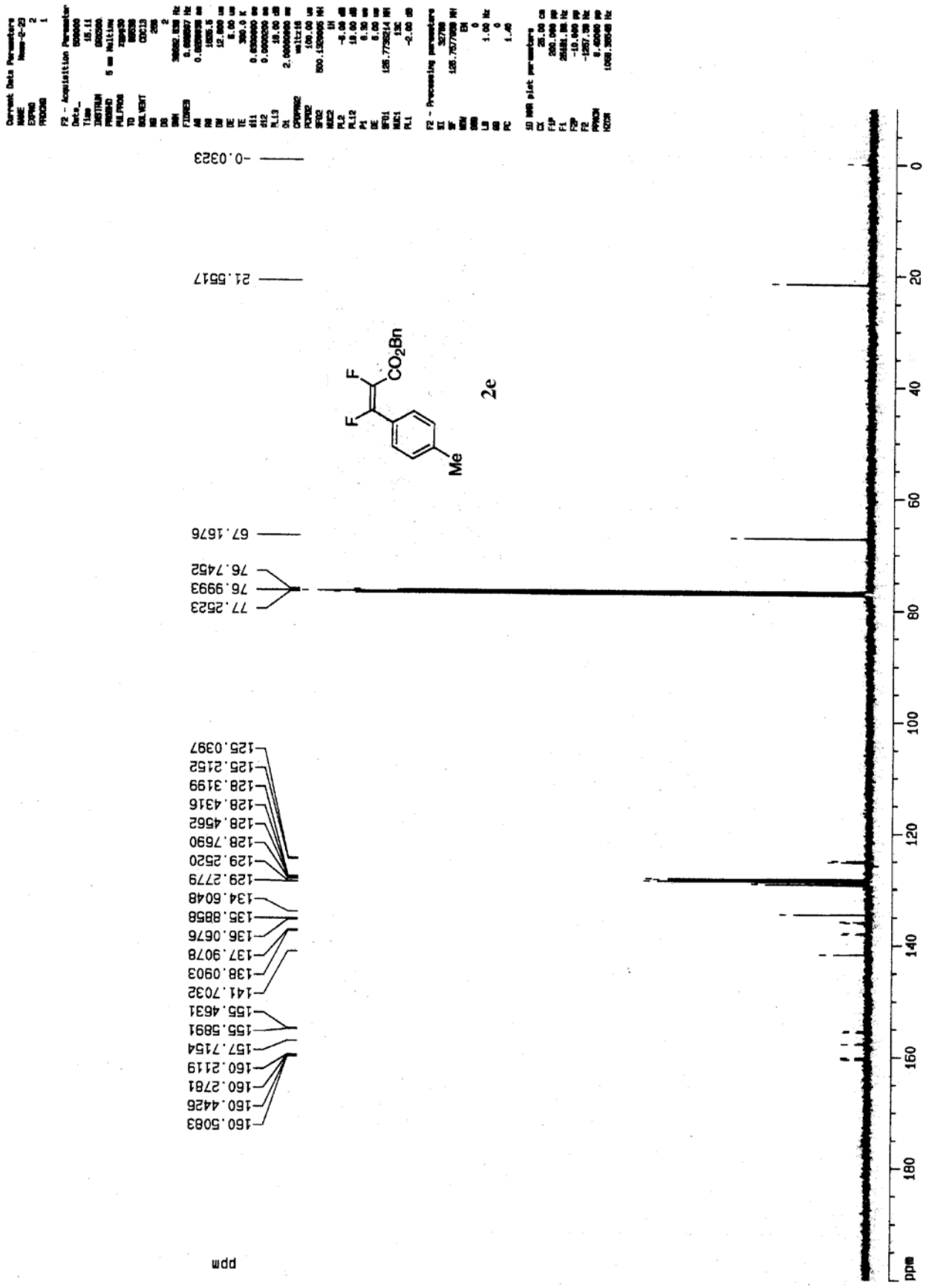
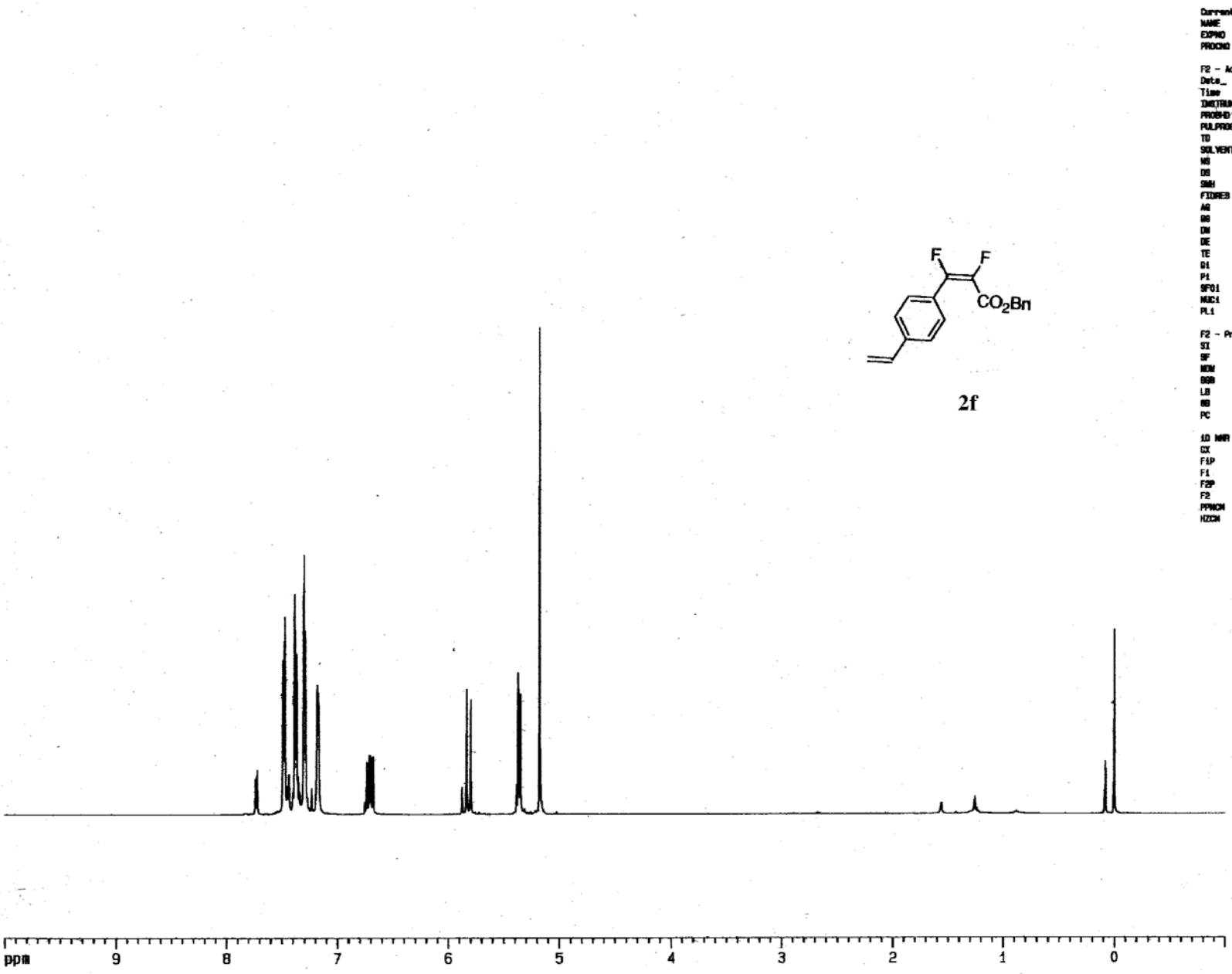
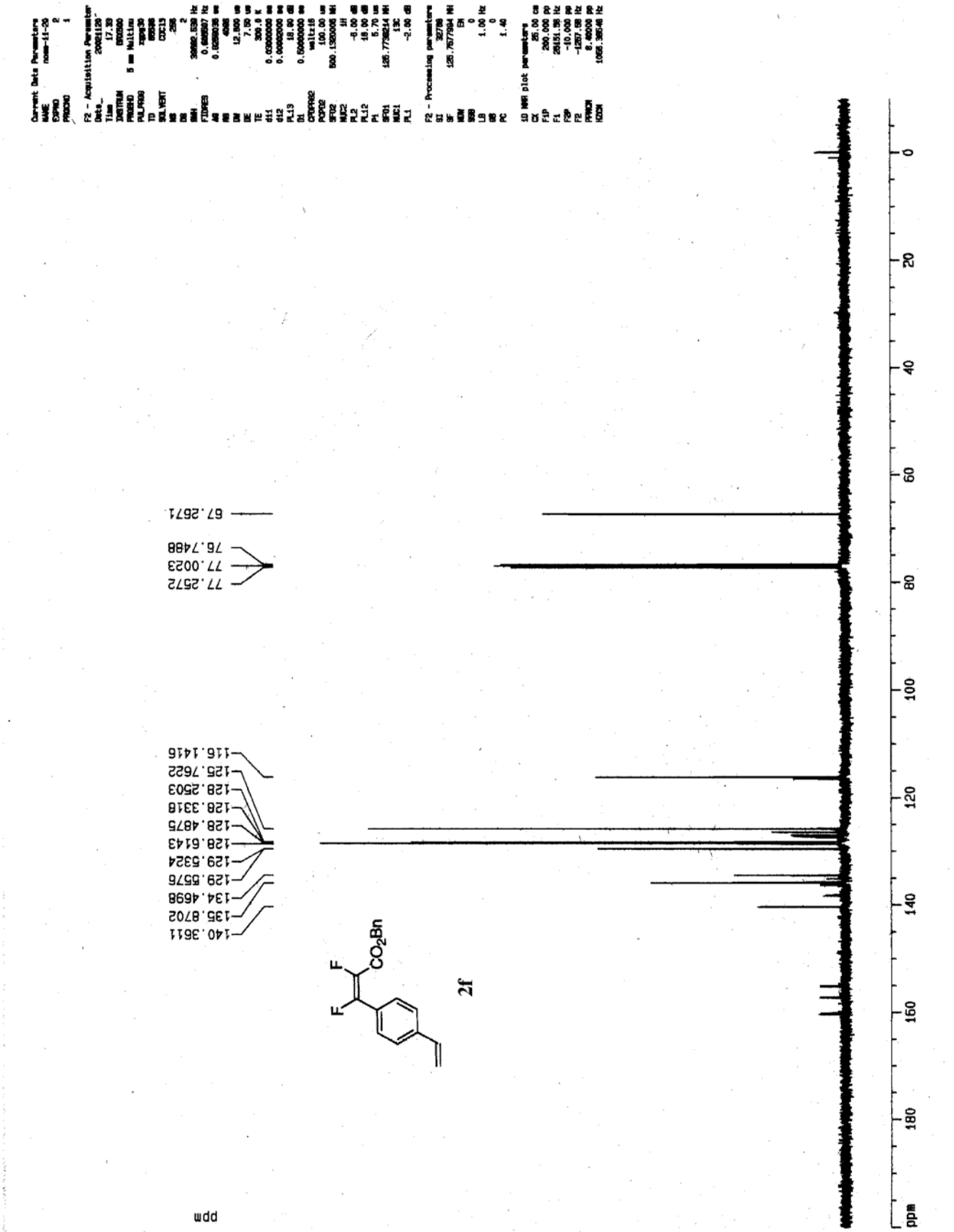

F
F
CO2Bn
Me
2e
Current Data Parameters
NAME Nsms-2-23
EXPNO 1
PROCNO 1
F2 - Acquisition Parameter
Data_ 800000
Time 14.00
INSTRUM DRX800
PROBHD 5 mm Multinu
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 16
DS 2
SWH 10330.578 Hz
FIDRES 0.315284 Hz
AQ 1.5800212 se
RG 181
DW 48.400 us
DE 6.00 us
TE 300.0 K
D1 1.00000000 se
P1 8.30 us
DE 8.00 us
SFO1 500.1300005 MH
NUC1 1H
PL1 -6.00 dB
F2 - Processing parameters
SI 16384
SF 500.1300204 MH
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1H NMR plot parameters
CX 25.00 cm
F1P 10.000 pp
F1 5001.30 Hz
F2P -1.000 pp
F2 -500.13 Hz
PPMCM 0.44000 pp
HZCM 220.06722 Hz
ppm
9
8
7
6
5
4
3
2
1
0

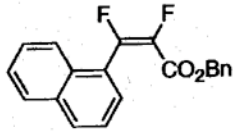

-0.0323
21.5517
67.1676
76.7452
76.9993
77.2523
125.0397
125.2152
128.3199
128.4316
128.4562
128.7690
129.2520
129.2779
134.6048
135.8858
136.0676
137.9078
138.0903
141.7032
155.4631
155.5891
157.7154
160.2119
160.2781
160.4426
160.5083
F
F
CO2Bn
Me
2e
ppm
0
20
40
60
80
100
120
140
160
180



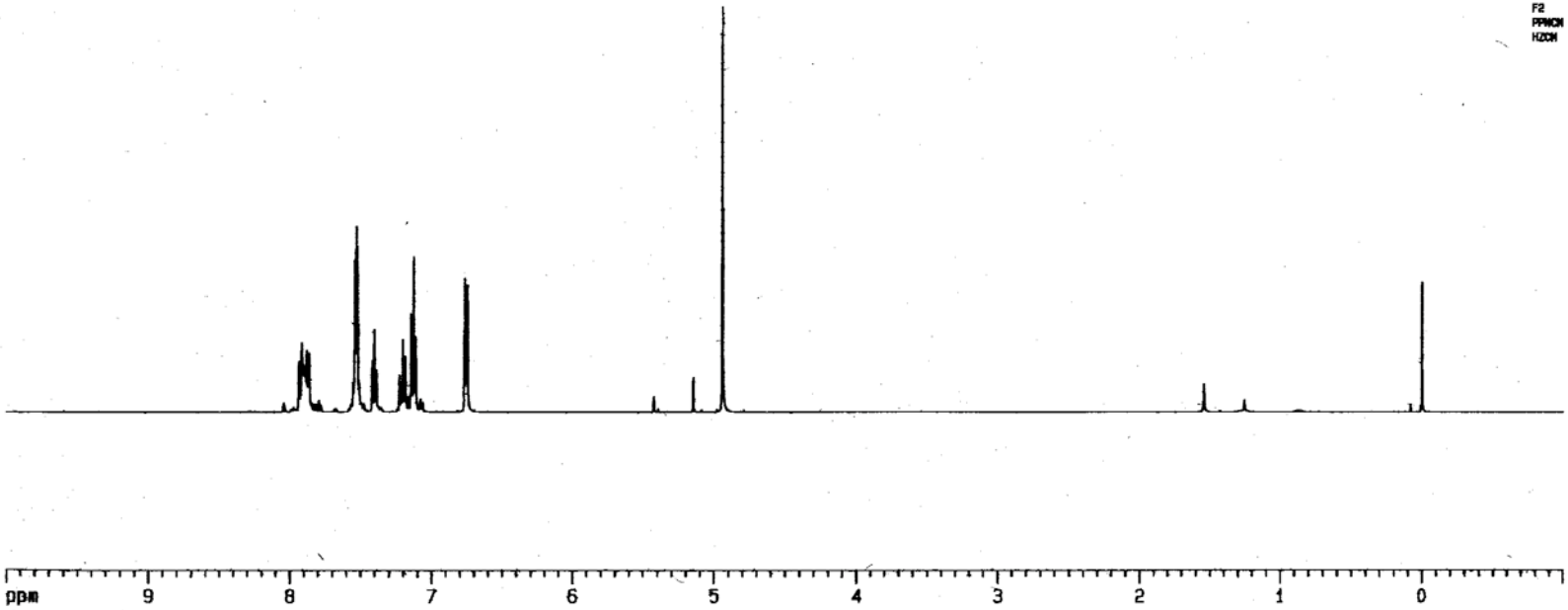
2f

```
Current Data Parameters
NAME            noes-11-20
EXPNO                    1
PROCNO                   1

F2 - Acquisition Parameter
Date_          20021120
Time               17.22
INSTRUM          DRX500
PROBHD     5 mm Multinu
PULPROG            zg30
TD                32768
SOLVENT           CDCl3
NS                   16
DS                    2
SWH           10330.578 Hz
FIDRES        0.315264 Hz
AQ            1.5869312 sec
RG                 203.2
DW                48.400 usec
DE                 6.00 usec
TE                300.0 K
D1            1.00000000 sec
P1                 9.30 usec
SFO1          500.1330885 MHz
NUC1                1H
PL1               -6.00 dB

F2 - Processing parameters
SI                16384
SF          500.1300280 MHz
WDW                 EM
SSB                  0
LB                0.30 Hz
GB                   0
PC                1.00

1D NMR plot parameters
CX                25.00 cm
F1P               10.000 ppm
F1              5001.30 Hz
F2P               -1.000 ppm
F2              -500.13 Hz
PPMCM             0.44000 ppm
HZCM            220.05722 Hz
```

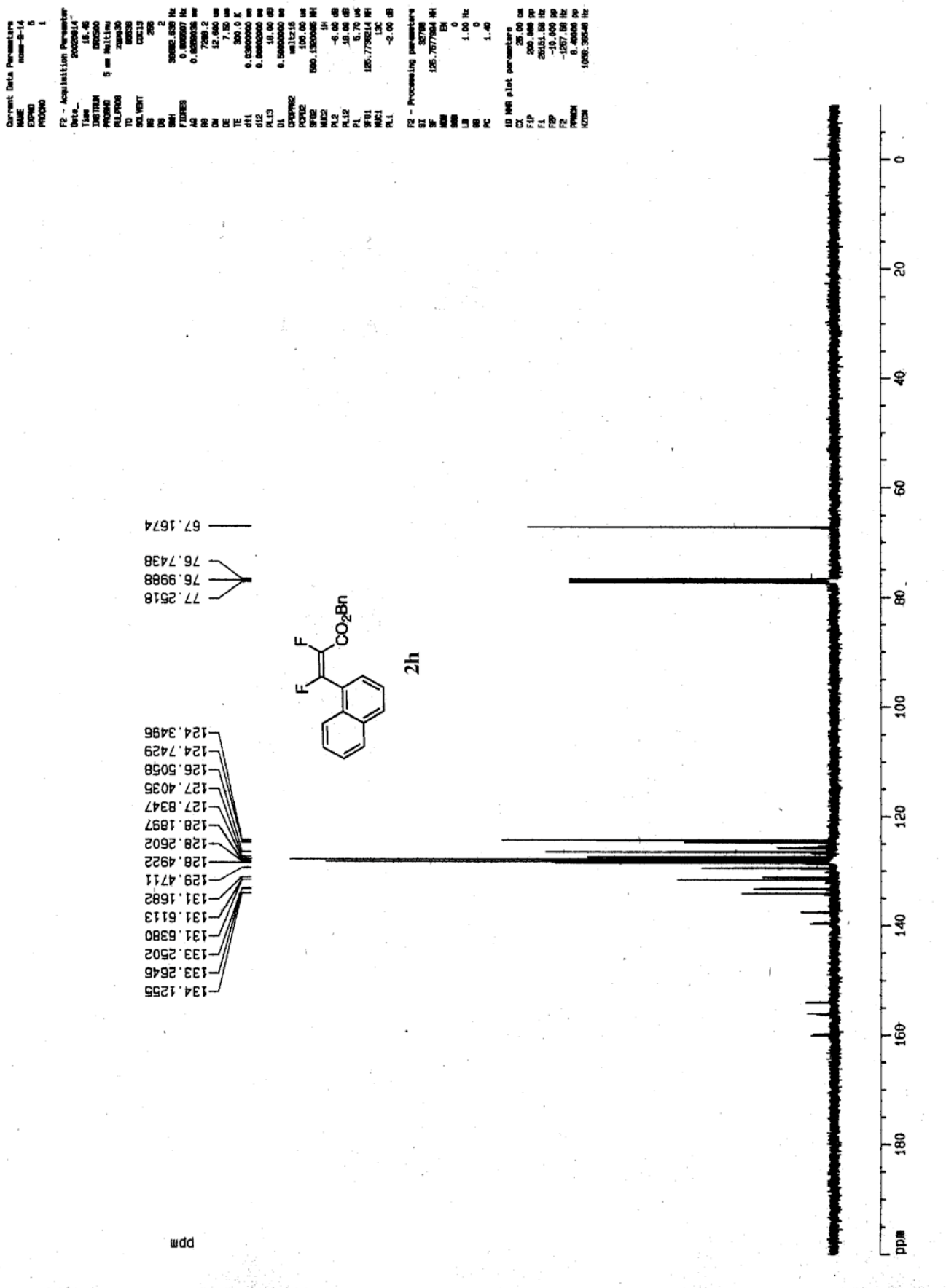

67.2671
76.7488
77.0023
77.2572
116.1416
125.7622
128.2503
128.3318
128.4875
128.6143
129.5324
129.8576
134.4698
135.8702
140.3611
F
F
CO2Bn
2f
ppm

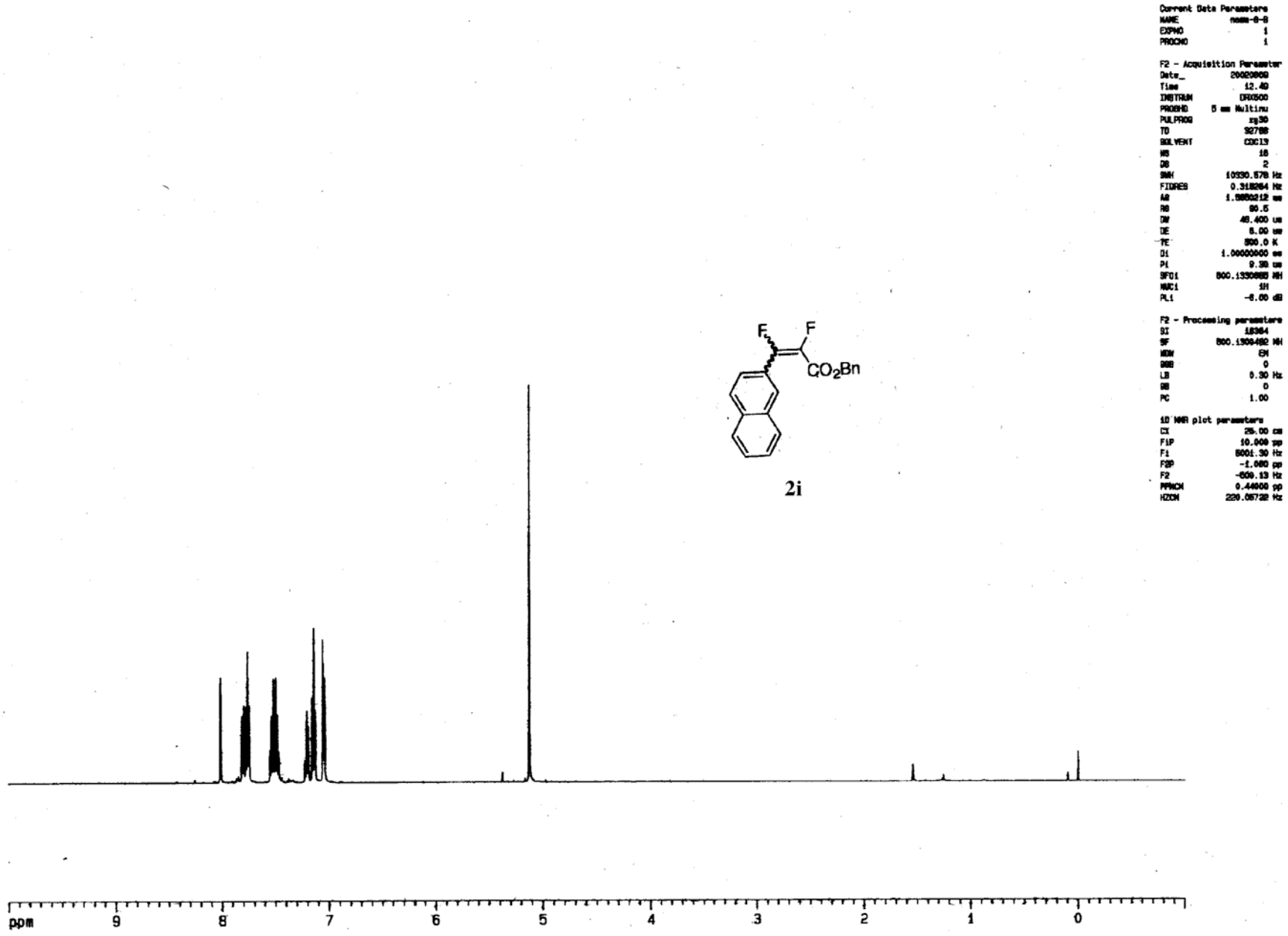


2h



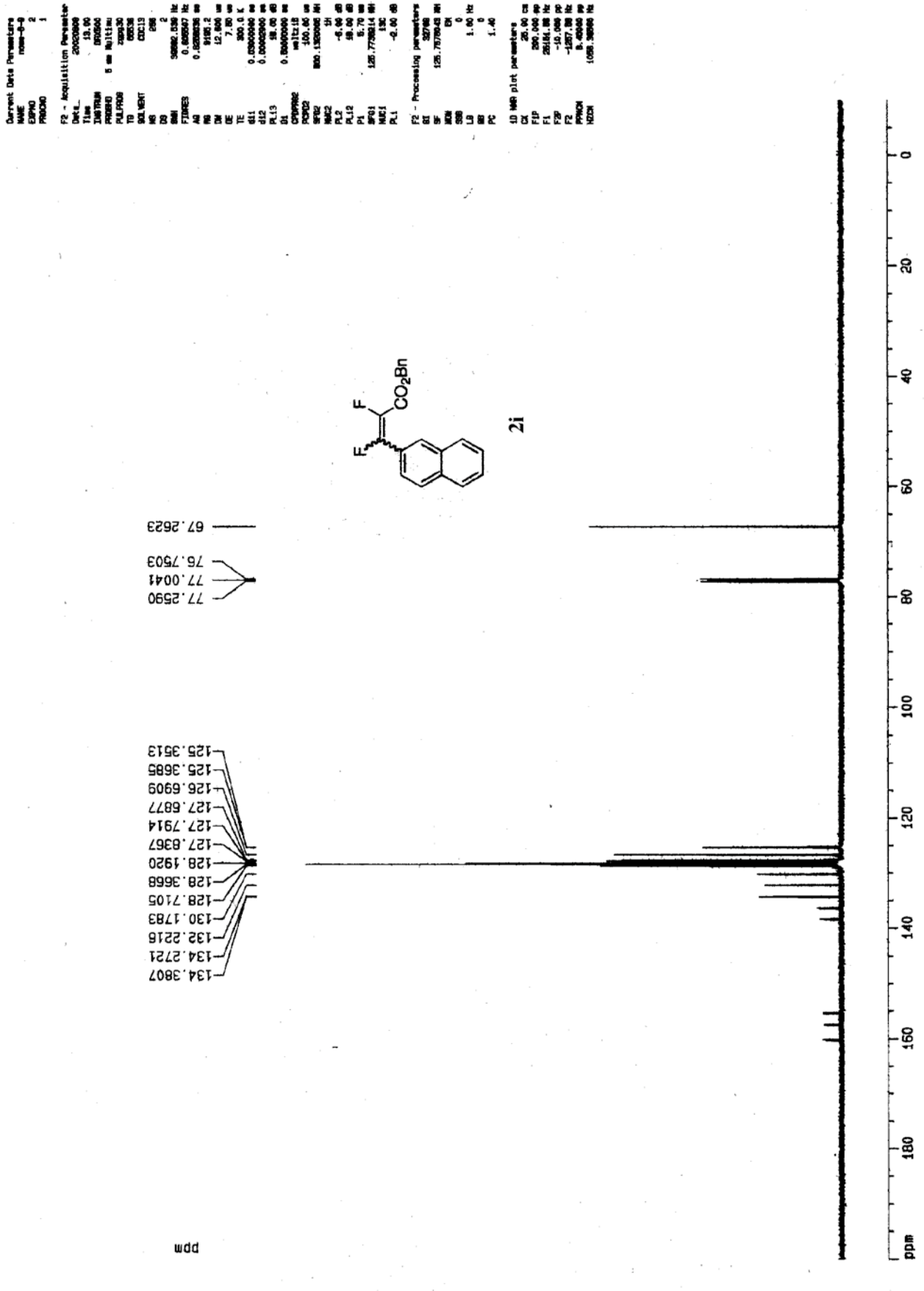

```
Current Data Parameters
NAME            nose-9-14
EXPNO                   4
PROCNO                  1

F2 - Acquisition Parameter
Date_          20020814
Time                16.28
INSTRUM             DRX500
PROBHD     5 mm Multinu
PULPROG             zg30
TD                 32768
SOLVENT            CDCl3
NS                    16
DS                     2
SWH            10330.578 Hz
FIDRES         0.315264 Hz
AQ             1.5860212 sec
RG                 203.2
DW                40.400 usec
DE                 6.00 usec
TE                300.0 K
D1             1.00000000 sec
P1                 9.30 usec
SFO1          500.1330885 MHz
NUC1                   1H
PL1                -6.00 dB

F2 - Processing parameters
SI                 16384
SF            500.1300289 MHz
WDW                    EM
SSB                    0
LB                 0.30 Hz
GB                     0
PC                 1.00

1D NMR plot parameters
CX                 25.00 cm
F1P               10.000 ppm
F1                5001.30 Hz
F2P               -1.000 ppm
F2                -500.13 Hz
PPMCM              0.44000 ppm
HZCM             220.05722 Hz
```

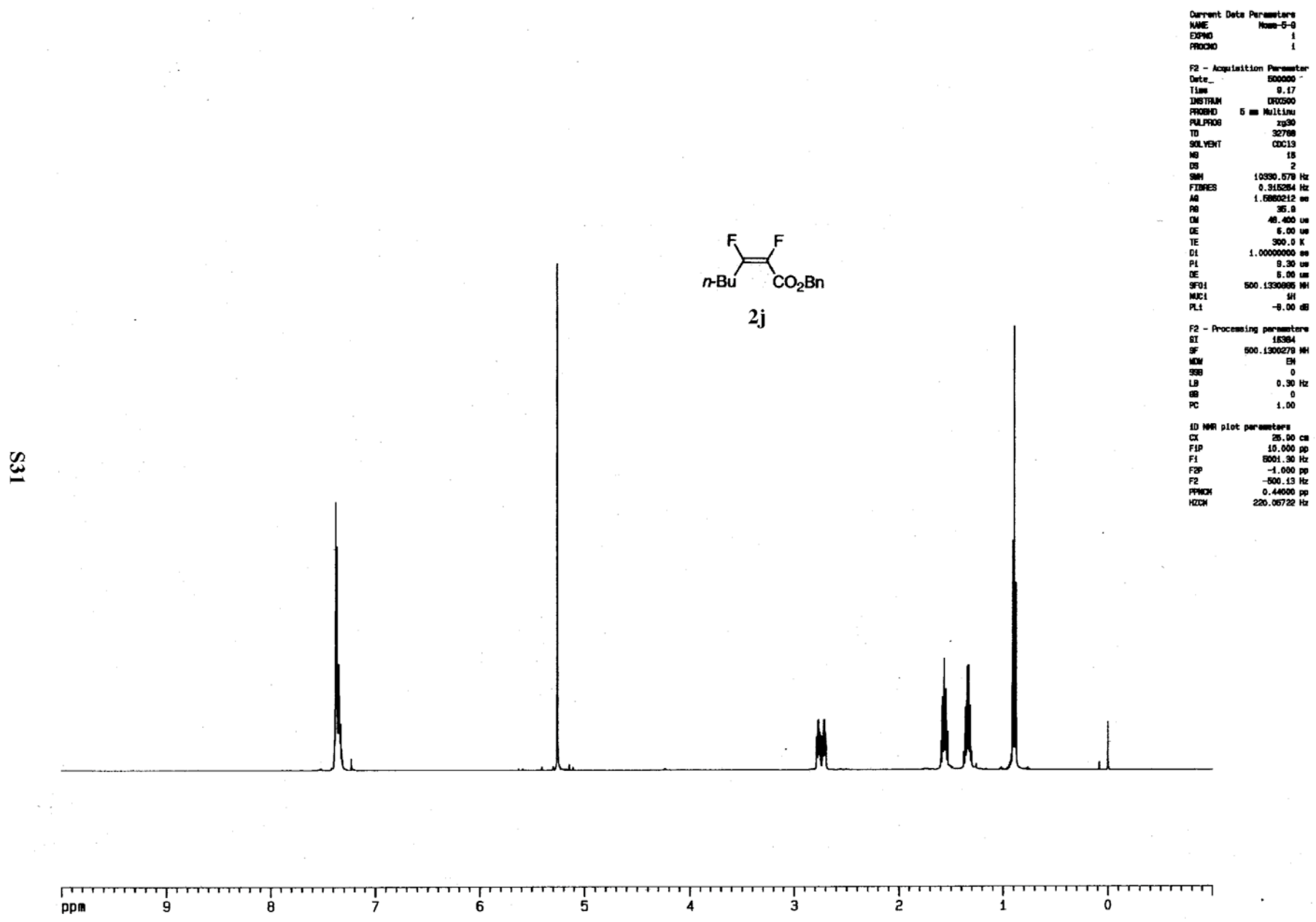

2h
F
F
CO2Bn
67.1674
76.7438
76.9988
77.2518
124.3496
124.7429
126.5058
127.4035
127.8347
128.1897
128.2602
128.4922
129.4711
131.1682
131.6113
131.6380
133.2502
133.2646
134.1255
ppm

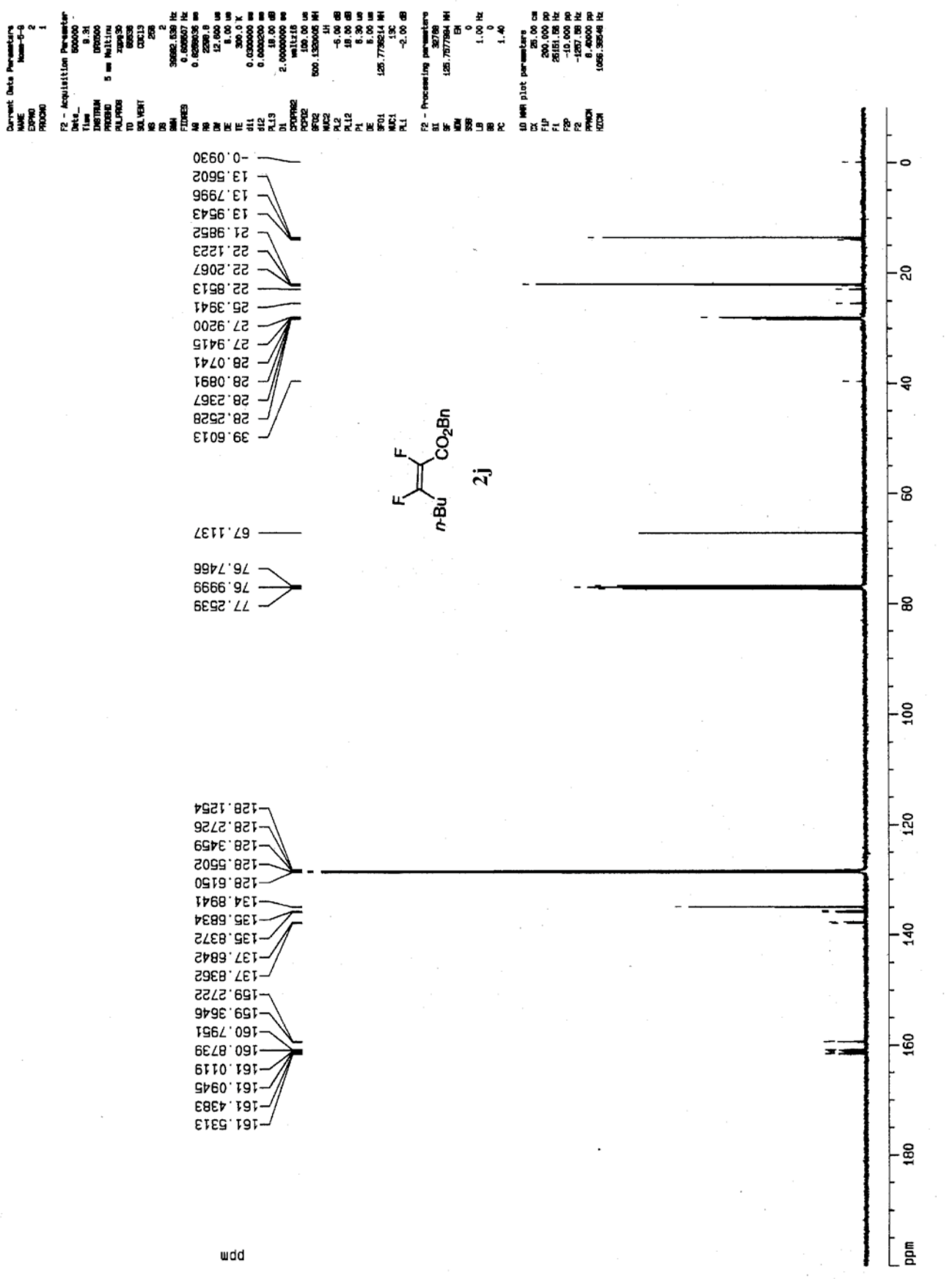


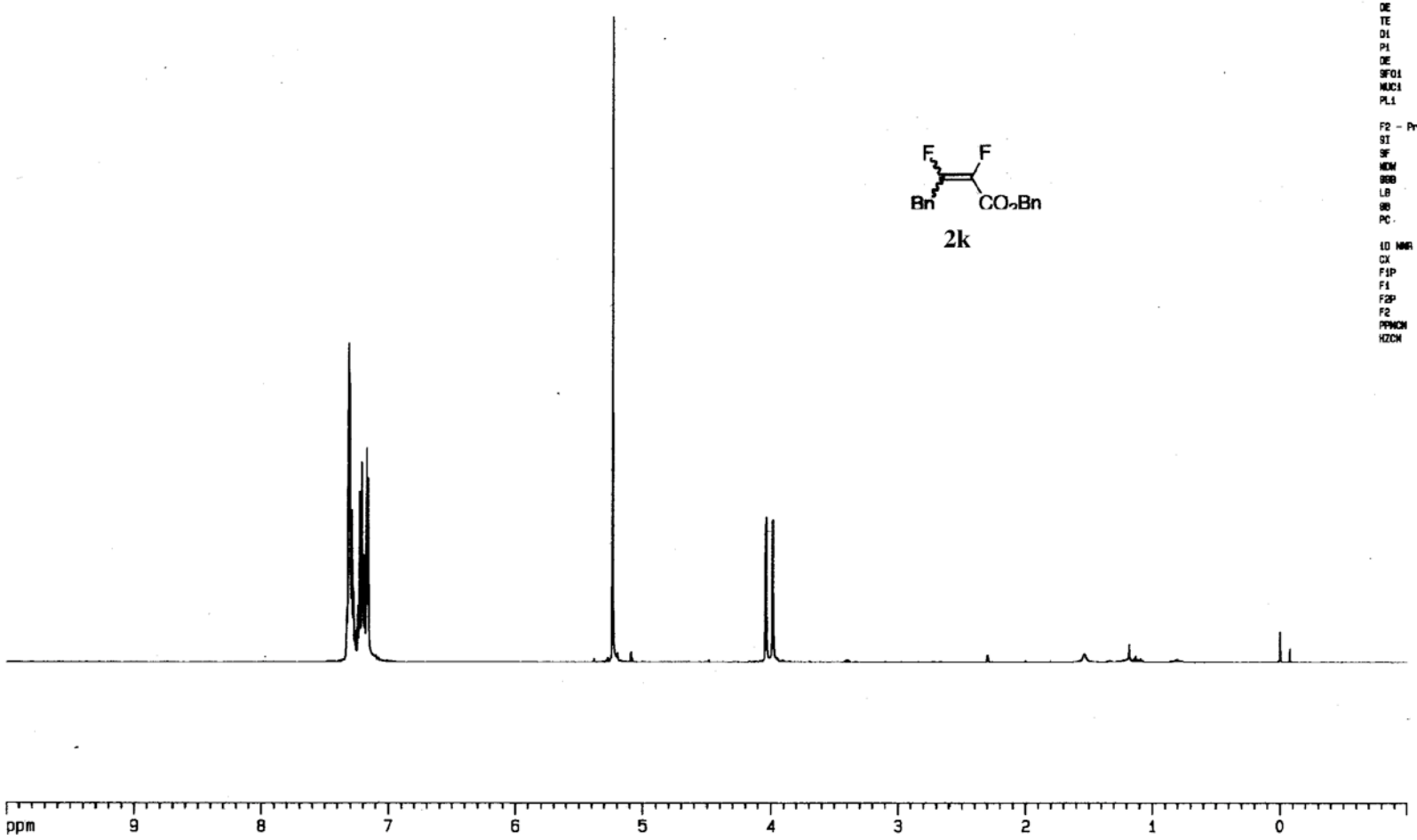
2i

```
Current Data Parameters
NAME                  nasa-8-8
EXPNO                        1
PROCNO                       1

F2 - Acquisition Parameter
Date_              20020809
Time                    12.49
INSTRUM                 DRX500
PROBHD     5 mm Multinu
PULPROG                 zg30
TD                     32768
SOLVENT                 CDCl3
NS                          16
DS                           2
SWH                10330.578 Hz
FIDRES              0.315264 Hz
AQ                  1.5880212 sec
RG                       90.5
DW                     48.400 usec
DE                      6.00 usec
TE                     300.0 K
D1                  1.00000000 sec
P1                      9.38 usec
SFO1               600.1330885 MHz
NUC1                        1H
PL1                     -6.00 dB

F2 - Processing parameters
SI                       16384
SF                 600.1300482 MHz
WDW                         EM
SSB                          0
LB                        0.30 Hz
GB                           0
PC                        1.00

1D NMR plot parameters
CX                       25.00 cm
F1P                      10.000 ppm
F1                     6001.30 Hz
F2P                     -1.000 ppm
F2                     -600.13 Hz
PPMCM                  0.44000 ppm
HZCM                 220.05722 Hz
```


F
CO2Bn
F
2i
67.2623
76.7503
77.0041
77.2590
125.3513
125.3685
126.6909
127.6877
127.7914
127.8367
128.1920
128.3668
128.7105
130.1783
132.2216
134.2721
134.3807
ppm

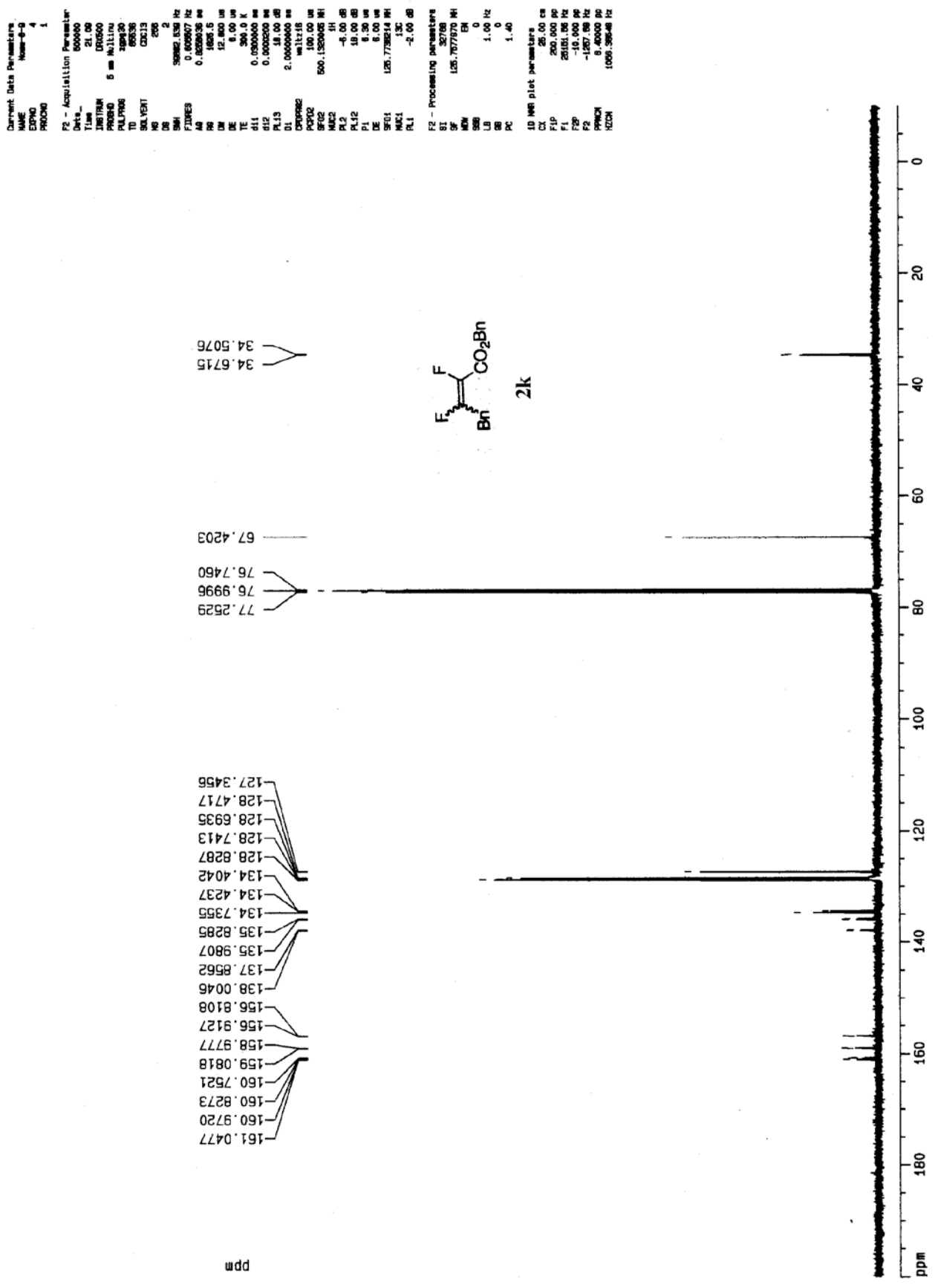

F
F
n-Bu
CO2Bn
2j
Current Data Parameters
NAME Nowe-5-8
EXPNO 1
PROCNO 1
F2 - Acquisition Parameter
Date_ 500000
Time 9.17
INSTRUM DRX500
PROBHD 5 mm Multinu
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 16
DS 2
SWH 10330.578 Hz
FIDRES 0.315254 Hz
AQ 1.5860212 se
RG 35.8
DW 48.400 us
DE 6.00 us
TE 300.0 K
D1 1.00000000 se
P1 9.30 us
DE 6.00 us
SFO1 500.1330885 MH
NUC1 1H
PL1 -0.00 dB
F2 - Processing parameters
SI 16384
SF 500.1300278 MH
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 25.00 cm
F1P 10.000 pp
F1 5001.30 Hz
F2P -1.000 pp
F2 -500.13 Hz
PPMCM 0.44000 pp
HZCM 220.05722 Hz
ppm
9
8
7
6
5
4
3
2
1
0

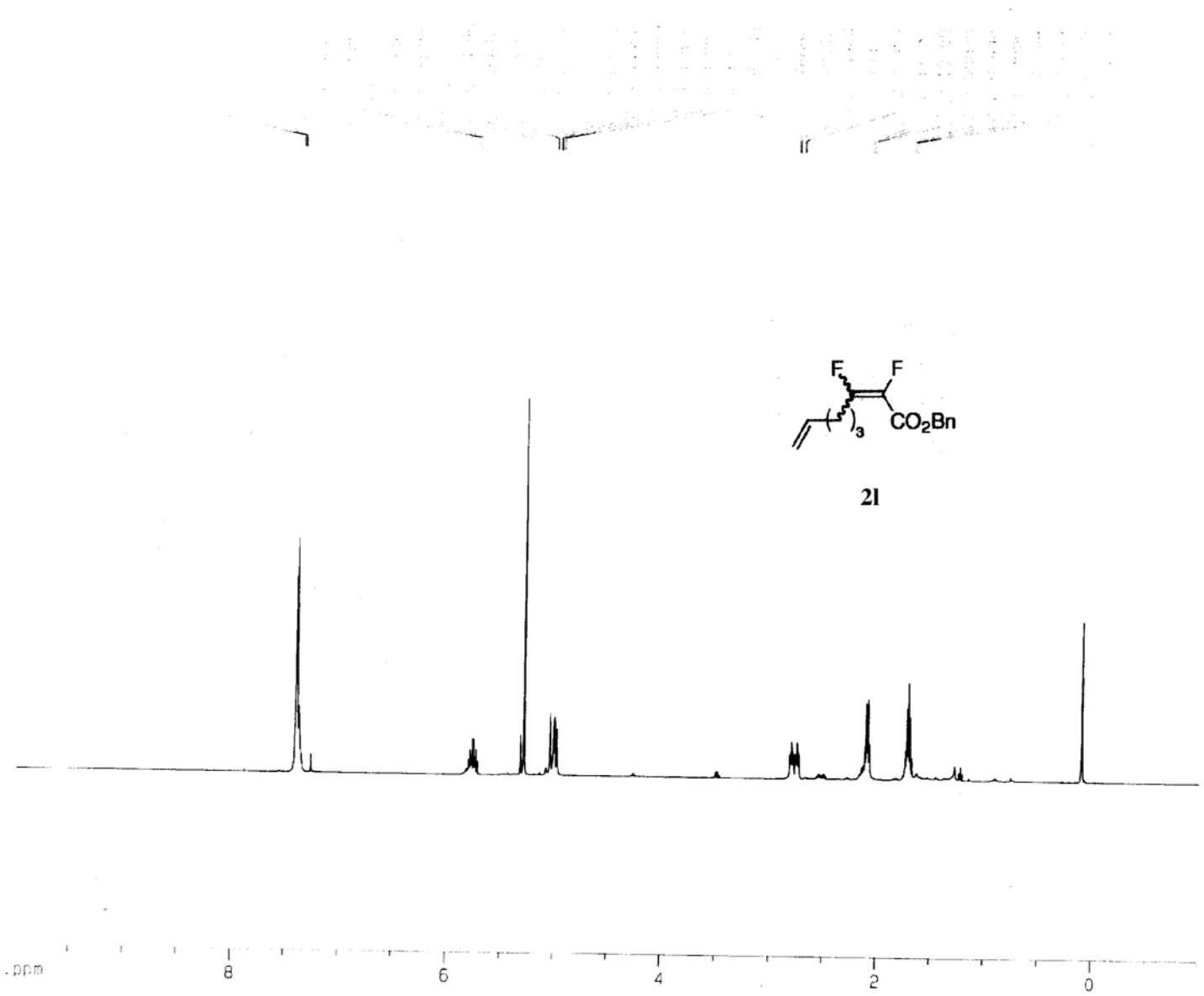

2j
F
F
CO2Bn
n-Bu
-0.0930
13.5602
13.7996
13.9543
21.9852
22.1223
22.2067
22.8513
25.3941
27.9200
27.9415
28.0741
28.0891
28.2367
28.2528
39.6013
67.1137
76.7466
76.9999
77.2539
128.1254
128.2726
128.3459
128.5502
128.6150
134.8941
135.6834
135.8372
137.6842
137.8362
159.2722
159.3646
160.7951
160.8739
161.0119
161.0945
161.4383
161.5313
ppm



2k

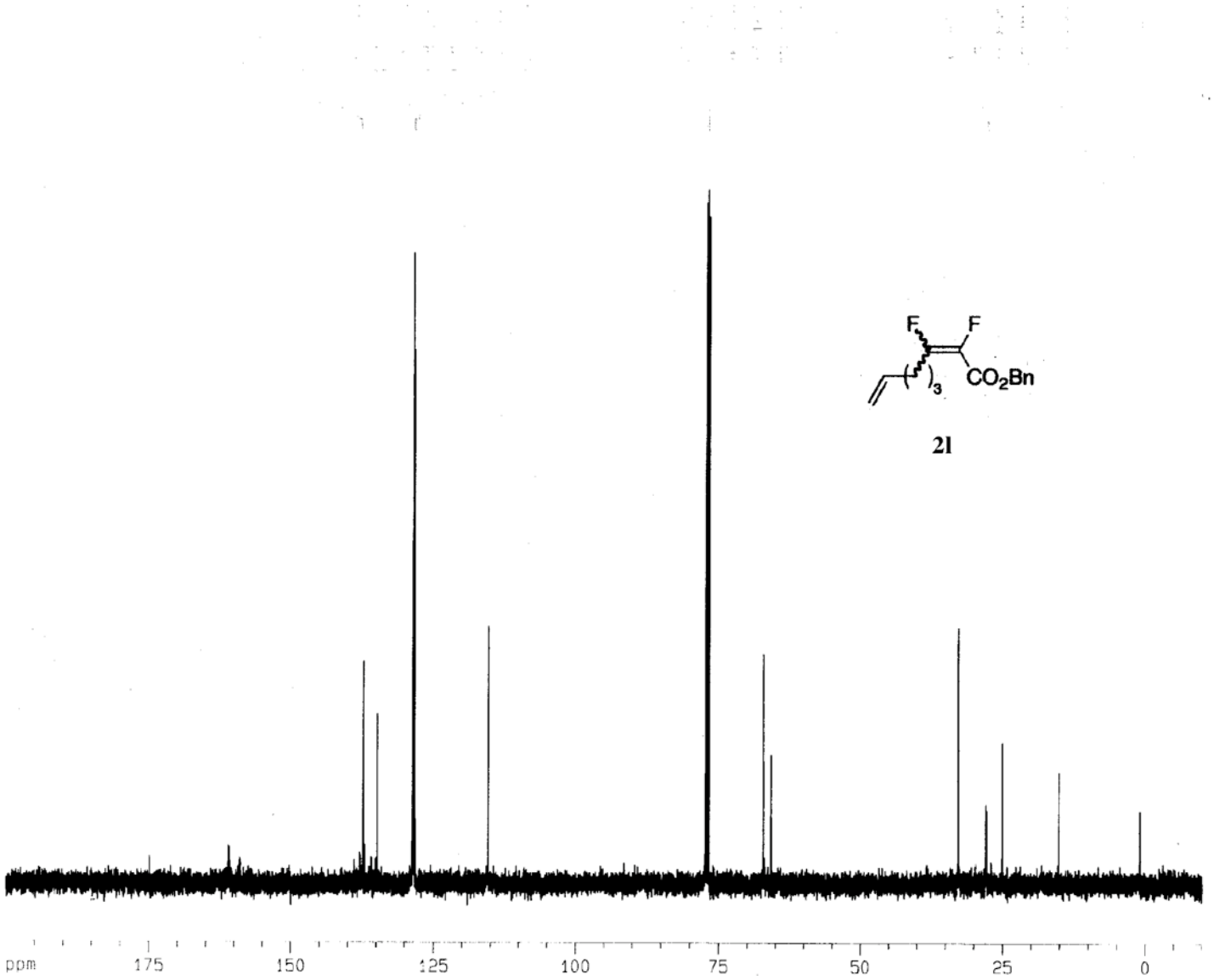
```
Current Data Parameters
NAME                  Moss-6-9
EXPNO                        3
PROCNO                       1

F2 - Acquisition Parameter
Date_                  500900
Time                    20.56
INSTRUM                 DRX500
PROBHD     5 mm Multinu
PULPROG                 zg30
TD                      32768
SOLVENT                 CDCl3
NS                         16
DS                          2
SWH                10330.578 Hz
FIDRES              0.315264 Hz
AQ                  1.5860212 se
RG                        181
DW                     48.400 us
DE                      6.00 us
TE                     300.0 K
D1                  1.00000000 se
P1                      9.30 us
DE                      6.00 us
SFO1           500.1330885 MH
NUC1                      1H
PL1                    -6.00 dB

F2 - Processing parameters
SI                      16384
SF             500.1300839 MH
WDW                        EM
SSB                         0
LB                   0.30 Hz
GB                          0
PC                    1.00

1D NMR plot parameters
CX                     25.00 cm
F1P                    10.000 pp
F1                   5001.30 Hz
F2P                   -1.000 pp
F2                    -500.15 Hz
PPMCM                 0.44000 pp
HZCM                220.05724 Hz
```


34.5076
34.6715
67.4203
76.7460
76.9996
77.2529
127.3456
128.4717
128.6935
128.7413
128.8287
134.4042
134.4237
134.7355
135.8285
135.9807
137.8562
138.0046
156.8108
156.9127
158.9777
159.0818
160.7521
160.8273
160.9720
161.0477
2k
F
CO2Bn
F
Bn
ppm



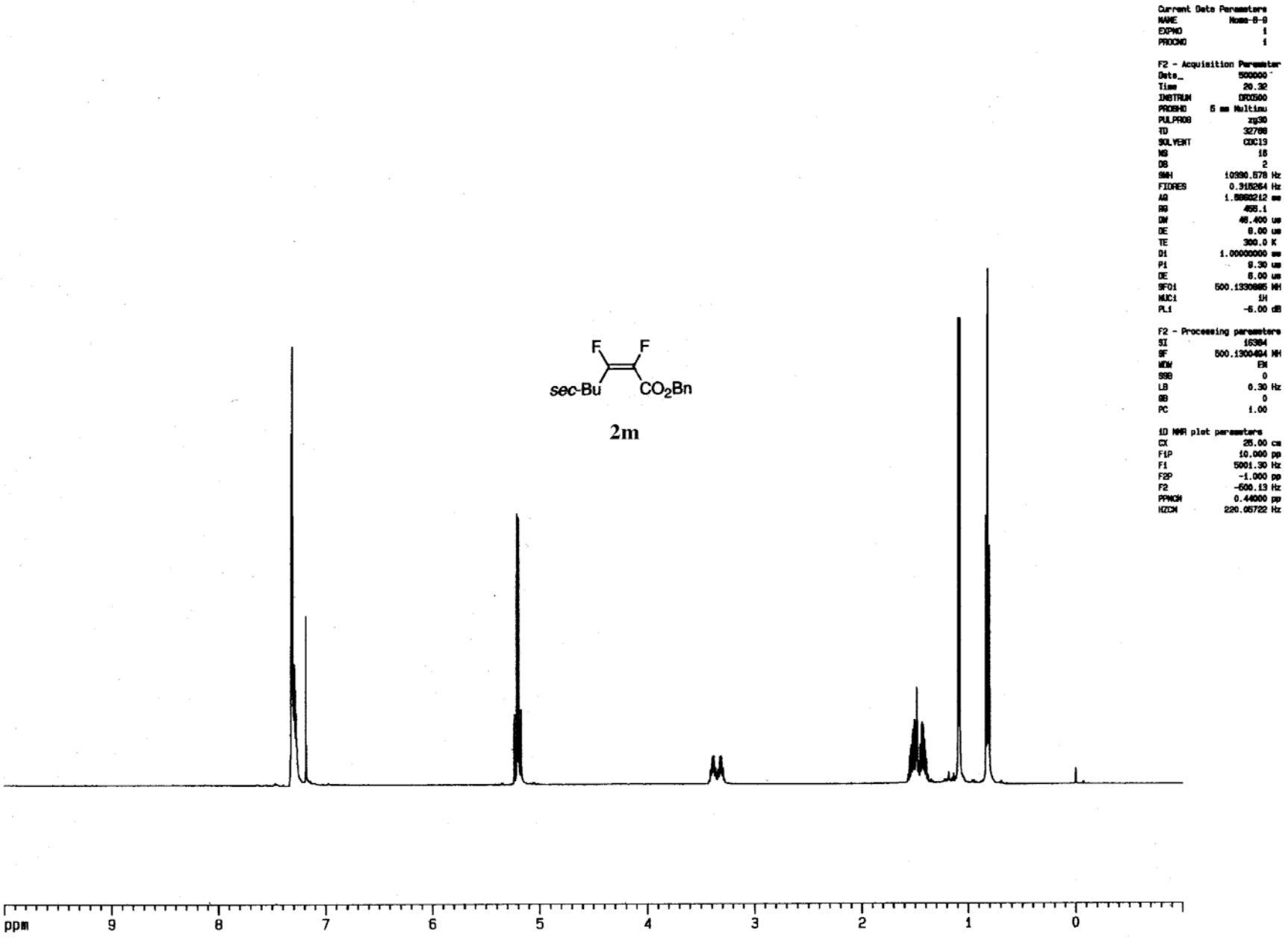
2l

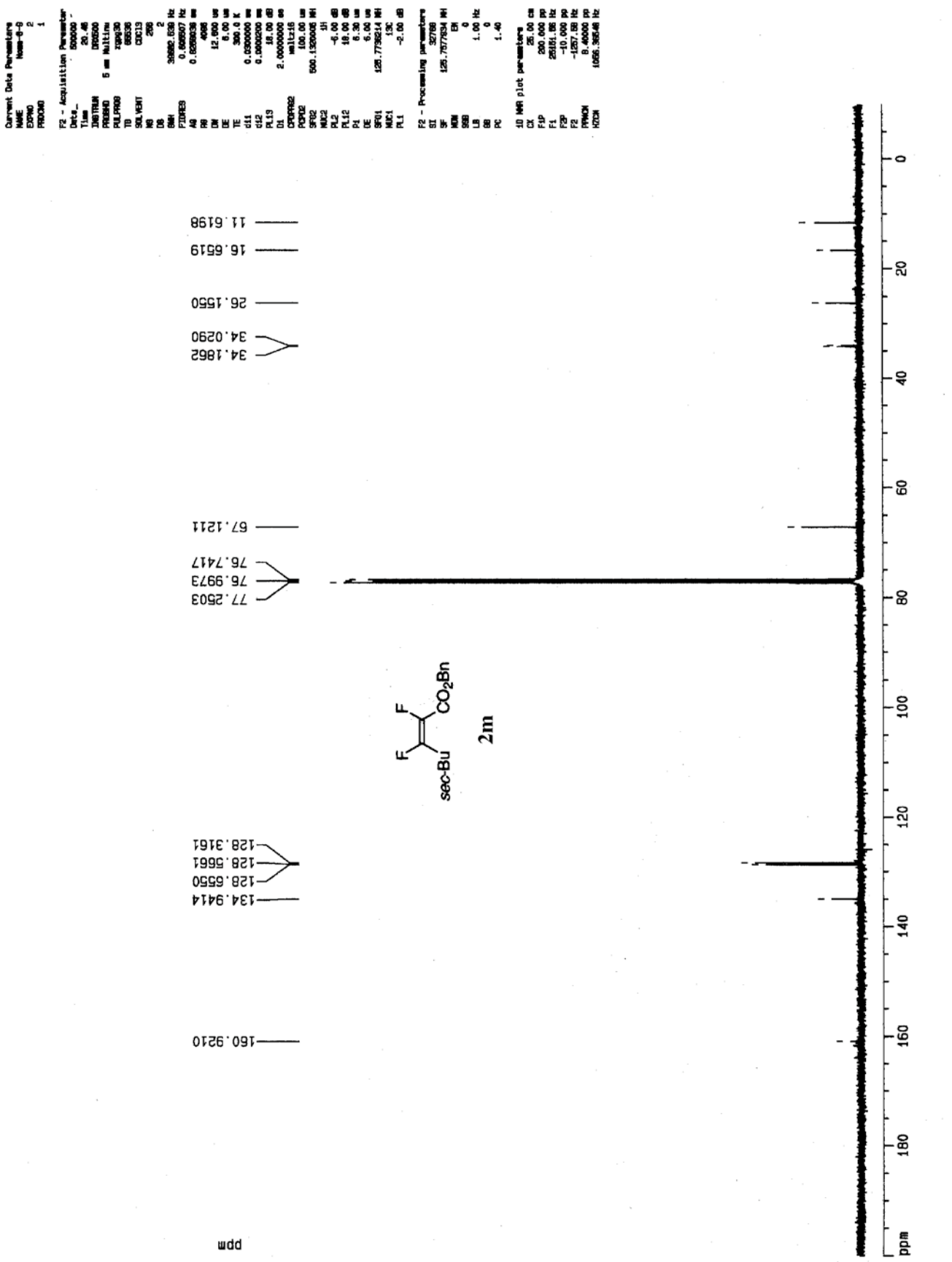
```
Current Data Parameters
NAME        yamada-05.11.10
EXPNO                     1
PROCNO                    1

F2 - Acquisition Parameters
Date_              20051110
Time                  15.20
INSTRUM             drx500
PROBHD   5 mm Multinucl
PULPROG               zg30
TD                   65536
SOLVENT              CDCl3
NS                      16
DS                       2
SWH           10330.578 Hz
FIDRES        0.157632 Hz
AQ            3.1719923 sec
RG                      57
DW              48.400 usec
DE               6.00 usec
TE               296.8 K
D1            1.00000000 sec
MCREST        0.00000000 sec
MCWRK         0.01500000 sec

======== CHANNEL f1 ========
NUC1                    1H
P1                10.30 usec
PL1               -6.00 dB
SFO1          500.1330885 MHz

F2 - Processing parameters
SI                   32768
SF            500.1300131 MHz
WDW                     EM
SSB                      0
LB                0.30 Hz
GB                       0
PC                    1.00

1D NMR plot parameters
CX                20.00 cm
CY                 6.33 cm
F1P              10.000 ppm
F1               5001.30 Hz
F2P              -1.000 ppm
F2               -500.13 Hz
PPMCM          0.55000 ppm/cm
HZCM          275.07150 Hz/cm
```

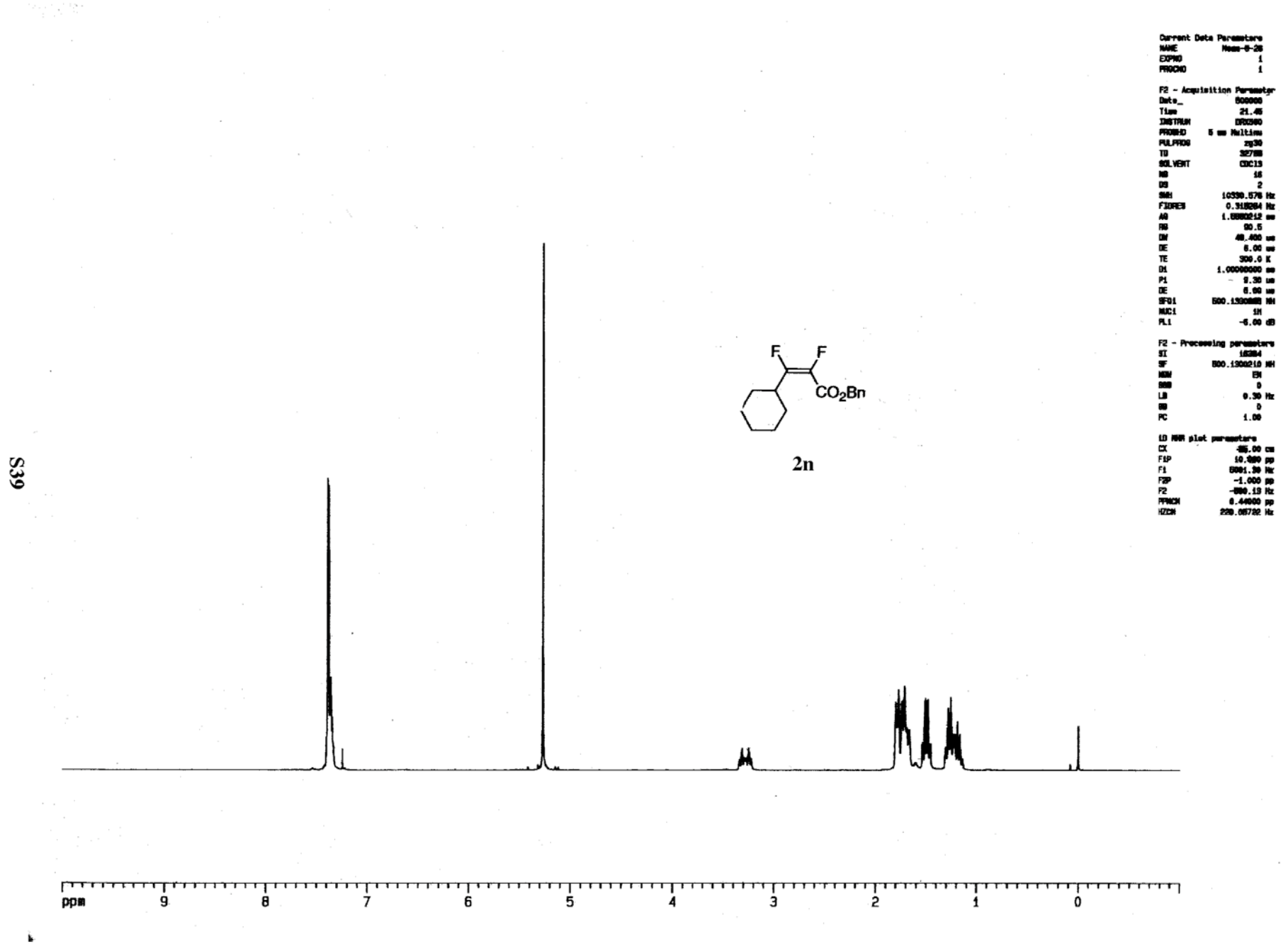


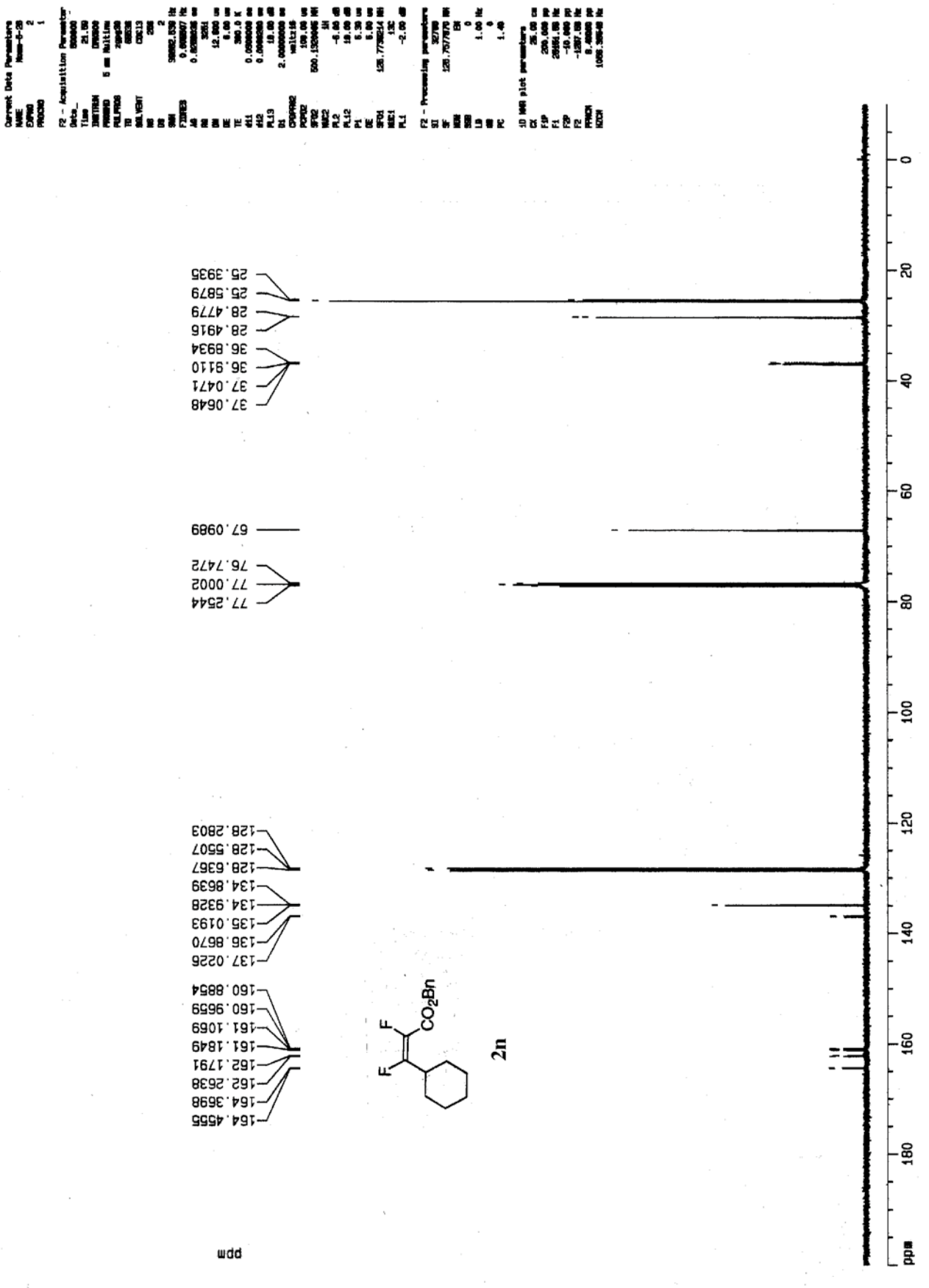
2l

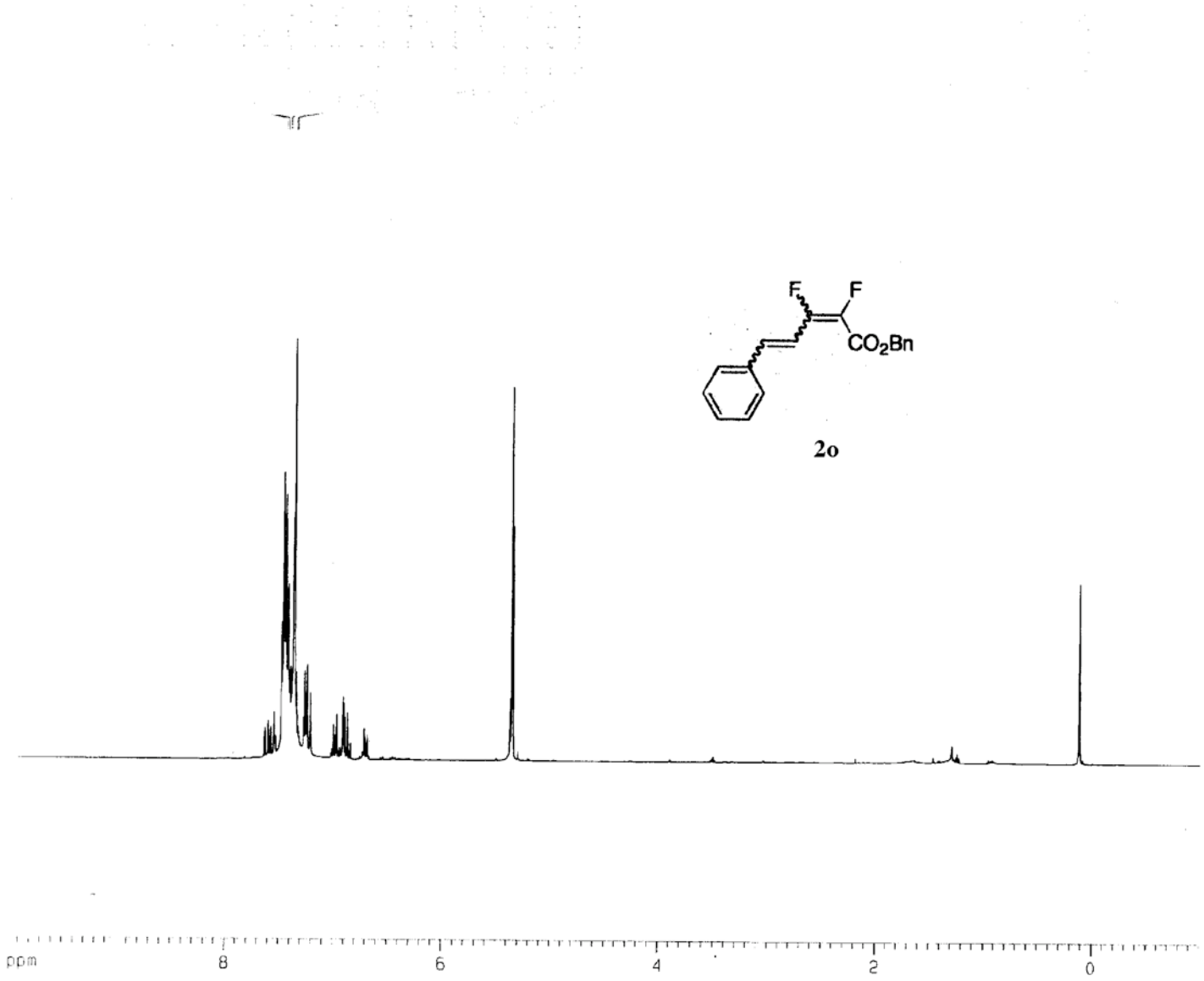
```
Current Data Parameters
NAME      yamada-05.11.15
EXPNO                   1
PROCNO                  1

F2 - Acquisition Parameters
Date_            20051115
Time                21.33
INSTRUM           drx500
PROBHD   5 mm Multinucl
PULPROG           zgpg30
TD                 65536
SOLVENT            CDCl3
NS                   256
DS                     2
SWH            30030.029 Hz
FIDRES         0.458222 Hz
AQ             1.0912244 sec
RG                9195.2
DW                16.650 usec
DE                 6.00 usec
TE                297.2 K
D1             0.50000000 sec
d11            0.03000000 sec
MCREST         0.00000000 sec
MCWRK          0.01500000 sec

======== CHANNEL f1 ========
NUC1                  13C
P1                   5.70 usec
PL1                 -2.00 dB
SFO1         125.7703643 MHz

======== CHANNEL f2 ========
CPDPRG2           waltz16
NUC2                  1H
PCPD2              100.00 usec
PL2                 -6.00 dB
PL12                13.74 dB
PL13                13.74 dB
SFO2         500.1320005 MHz

F2 - Processing parameters
SI                   32768
SF           125.7577987 MHz
WDW                     EM
SSB                      0
LB                    1.00 Hz
GB                       0
PC                    1.40

1D NMR plot parameters
CX                   20.00 cm
CY                   11.54 cm
F1P                200.000 ppm
F1                25151.56 Hz
F2P                -10.000 ppm
F2                -1257.58 Hz
PPMCM             10.50000 ppm/cm
HZCM           1320.45679 Hz/cm
```


Current Data Parameters
NAME Nome-8-8
EXPNO 1
PROCNO 1
F2 - Acquisition Parameter
Date_ 500000
Time 20.32
INSTRUM DRX500
PROBHD 5 mm Multinu
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 16
DS 2
SWH 10990.678 Hz
FIDRES 0.335264 Hz
AQ 1.4860212 sec
RG 456.1
DW 46.400 usec
DE 6.00 usec
TE 300.0 K
D1 1.00000000 sec
P1 9.30 usec
DE 6.00 usec
SFO1 500.1330885 MHz
NUC1 1H
PL1 -6.00 dB
F2 - Processing parameters
SI 16384
SF 500.1300024 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 25.00 cm
F1P 10.000 ppm
F1 5001.30 Hz
F2P -1.000 ppm
F2 -500.13 Hz
PPMCM 0.40000 ppm
HZCM 220.05722 Hz
F
F
sec-Bu
CO2Bn
2m
ppm
9
8
7
6
5
4
3
2
1
0


11.6198
16.6519
26.1550
34.0290
34.1862
67.1211
76.7417
76.9973
77.2503
128.3161
128.5661
128.6550
134.9414
160.9210
F
CO2Bn
F
sec-Bu
2m
ppm

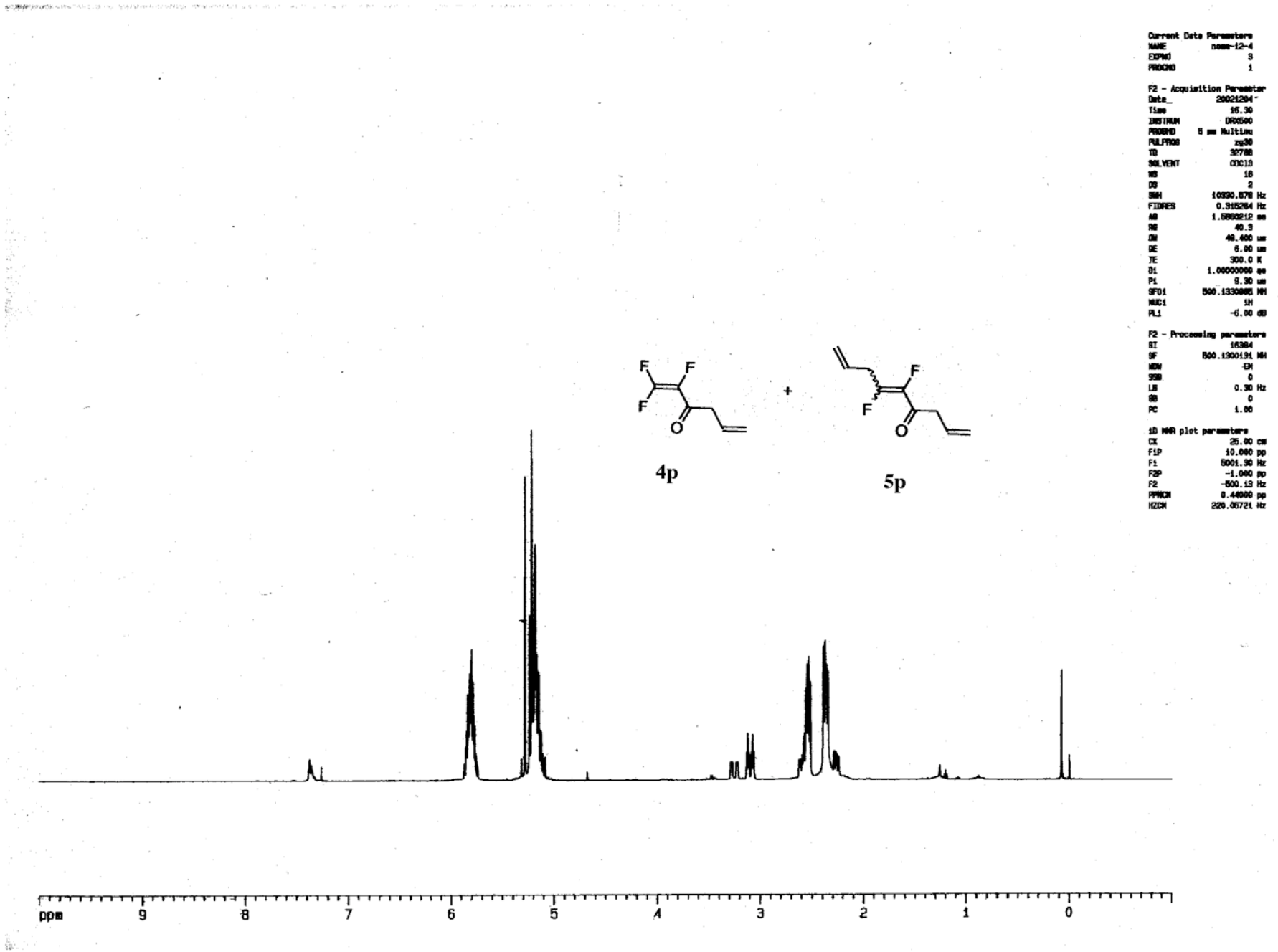

Current Data Parameters
NAME Hsss-6-26
EXPNO 1
PROCNO 1
F2 - Acquisition Parameter
Date_ 500000
Time 21.46
INSTRUM DRX500
PROBHD 5 mm Multinu
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 16
DS 2
SWH 10330.578 Hz
FIDRES 0.315284 Hz
AQ 1.5880212 sec
RG 90.5
DW 48.400 usec
DE 6.00 usec
TE 300.0 K
D1 1.00000000 sec
P1 8.30 usec
DE 6.00 usec
SFO1 500.1300000 MHz
NUC1 1H
PL1 -6.00 dB
F2 - Processing parameters
SI 16384
SF 500.1300210 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 25.00 cm
F1P 10.000 ppm
F1 5001.30 Hz
F2P -1.000 ppm
F2 -500.13 Hz
PPMCM 0.44000 ppm/cm
HZCM 220.05732 Hz
F
F
CO2Bn
2n
ppm
9
8
7
6
5
4
3
2
1
0

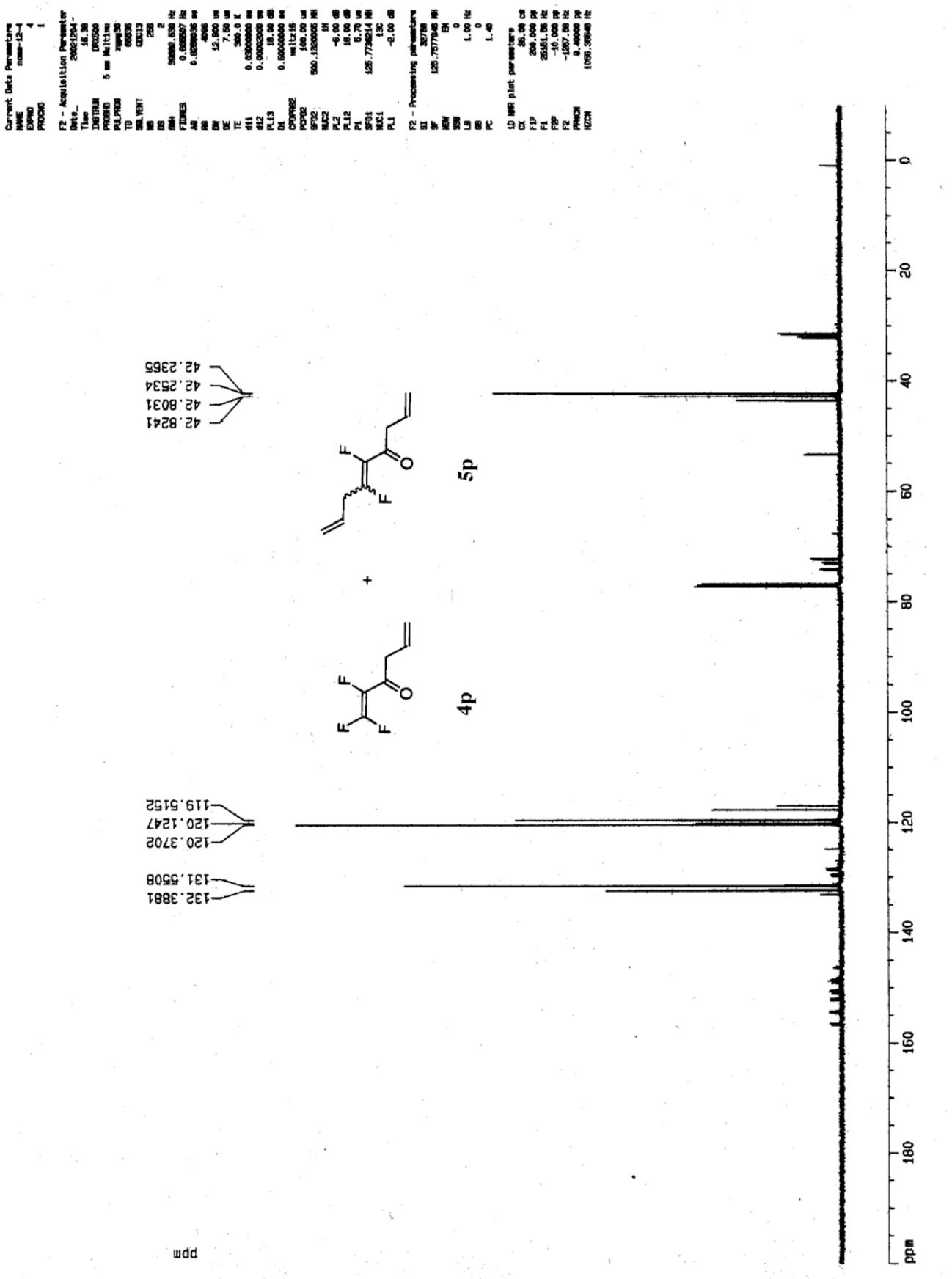

25.3935
25.5879
28.4779
28.4916
36.8934
36.9110
37.0471
37.0648
67.0989
76.7472
77.0002
77.2544
128.2803
128.5507
128.6367
134.8639
134.9328
135.0193
136.8670
137.0225
160.8854
160.9659
161.1069
161.1849
162.1791
162.2638
164.3698
164.4555
F
F
CO2Bn
2n
ppm



2o

```
Current Data Parameters
NAME      yamada-05.11.11
EXPNO                   1
PROCNO                  1

F2 - Acquisition Parameters
Date_           20051111
Time               20.56
INSTRUM          drx500
PROBHD   5 mm Multinucl
PULPROG            zg30
TD                65536
SOLVENT           CDCl3
NS                   16
DS                    2
SWH          10330.578 Hz
FIDRES        0.157632 Hz
AQ           3.1719923 sec
RG                  128
DW               48.400 usec
DE                6.00 usec
TE               297.2 K
D1           1.00000000 sec
MCREST       0.00000000 sec
MCWRK        0.01500000 sec

======== CHANNEL f1 ========
NUC1                   1H
P1                10.30 usec
PL1               -6.00 dB
SFO1        500.1330885 MHz

F2 - Processing parameters
SI                 32768
SF          500.1300131 MHz
WDW                   EM
SSB                    0
LB                0.30 Hz
GB                     0
PC                1.00

1D NMR plot parameters
CX                20.00 cm
CY                 7.03 cm
F1P               10.000 ppm
F1              5001.30 Hz
F2P               -1.000 ppm
F2              -500.13 Hz
PPMCM          0.55000 ppm/cm
HZCM          275.07150 Hz/cm
```


Current Data Parameters
NAME nmm-12-4
EXPNO 3
PROCNO 1
F2 - Acquisition Parameter
Date_ 20221204
Time 16.30
INSTRUM DRX500
PROBHD 5 mm Multinu
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 16
DS 2
SWH 10330.578 Hz
FIDRES 0.315264 Hz
AQ 1.5860212 se
RG 40.3
DW 48.400 us
DE 6.00 us
TE 300.0 K
D1 1.00000000 se
P1 8.30 us
SFO1 500.1330885 MH
NUC1 1H
PL1 -6.00 dB
F2 - Processing parameters
SI 16384
SF 500.1300191 MH
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 25.00 cm
F1P 10.000 pp
F1 5001.90 Hz
F2P -1.000 pp
F2 -500.13 Hz
PPMCM 0.44000 pp
HZCM 220.05721 Hz
F
F
F
O
+
F
F
O
4p
5p
ppm
9
8
7
6
5
4
3
2
1
0


42.2365
42.2534
42.8031
42.8241
119.5152
120.1247
120.3702
131.5508
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5p
4p
+
ppm