A Structural Investigation of the N-B Interaction in an *o*-(N,N-Dialkylaminomethyl)arylboronate System

*Lei Zhu, Shagufta H. Shabbir, Mark Gray, Vincent M. Lynch, Steven Sorey, and Eric V. Anslyn**

Department of Chemistry and Biochemistry, The University of Texas at Austin, Austin, TX 78712

Supporting Information

General Methods

^{1}H and ^{13}C NMR spectra were recorded on a Varian Unity Plus 300 spectrometer, and ^{11}B NMR spectra were taken on a Bruker AMX-500 (160 MHz) spectrometer using $BF_3 \bullet OEt_2$ as an external reference. High-resolution mass spectra were measured with a VG Analytical ZAB2-E spectrometer. Chemical reagents were used as purchased from various commercial sources.

Synthesis

Compound 7. Compound **4**[1] (0.5 mmol, 103 mg) and catechol (0.5 mmol, 55 mg) were dissolved in $CHCl_3$ (2.5 mL) and stirred with 1 g $MgSO_4$ suspension at room temperature for 30 min. $MgSO_4$ was removed with vacuum filtration and the filtrate was concentrated. The crude product was dissolved in $CHCl_3$ (5 mL) and concentrated again in order to azeotropically remove the condensed water. The product was purified by crystallization by diffusing pentane into its concentrated $CHCl_3$ solution. The crystallized product was found to have low solubility in CH_3OH. The filtrated, clear methanolic solution was placed in the fridge (4 ºC) where crystals were formed overnight. The crystals from $CHCl_3$ and CH_3OH solutions respectively were submitted for x-ray crystallographic analysis. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.58 (m, 1H), 7.37 (m, 2H), 7.18 (m, 1H), 6.85 (m, 2H), 6.79 (m, 2H), 4.19 (s, 2H), 3.43 (m, 2H), 2.83 (m, 2H), 1.96 (m, 4H); ^{13}C NMR (75.5 MHz, $CDCl_3$) δ 152.0, 140.3, 131.2, 128.8, 128.2, 122.7, 119.6, 109.9, 63.7, 55.4, 23.1; HRMS (FAB): calcd. $(M+H)^+$ 280.1503, found 280.1503.

Compound 8. Compound **8** was prepared with the same procedure for compound **7**. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.43 (m, 1H), 7.23 (m, 2H), 7.06 (m, 1H), 4.05 (dd, J = 13.6, 16.1 Hz, 2H), 3.35 (m, 1H), 3.13 (m, 1H), 2.98 (m, 1H), 2.73 (m, 1H), 2.02 (m, 4H), 1.53 (s, 3H), 1.46 (s, 3H); ^{13}C NMR (75.5 MHz,

[1] Zhu, L.; Anslyn, E. V. *J. Am. Chem. Soc.* **2004**, *126*, 3676.

$CDCl_3$) δ 181.5, 139.8, 130.1, 128.6, 128.1, 122.9, 76.7, 63.6, 55.1, 55.0, 28.7, 27.1, 23.2, 22.6; HRMS (FAB): calcd. $(M+H)^+$ 274.1614, found 274.1618.

X-ray crystal structure determination

Compound 5. Crystals grew as clusters of very large, colorless prisms by diffusing hexanes to a $CHCl_3$ solution of **7**. The data crystal was cut from a much larger crystal and had approximate dimensions; 0.30 × 0.23 × 0.15 mm. The data were collected on a Nonius Kappa CCD diffractometer using a graphite monochromator with MoKα radiation (λ = 0.71073Å). A total of 326 frames of data were collected using ω-scans with a scan range of 1° and a counting time of 37 seconds per frame. The data were collected at 153 K using an Oxford Cryostream low temperature device. Data reduction was performed using DENZO-SMN.[2] The structure was solved by direct methods using SIR97[3] and refined by full-matrix least-squares on F^2 with anisotropic displacement parameters for the non-H atoms using SHELXL-97.[4] The hydrogen atoms were observed in a ΔF map and refined with isotropic displacement parameters. The function, $\Sigma w(|F_o|^2 - |F_c|^2)^2$, was minimized, where $w = 1/[(\sigma(F_o))^2 + (0.0401*P)^2 + (0.1845*P)]$ and $P = (|F_o|^2 + 2|F_c|^2)/3$. $Rw(F^2)$ refined to 0.100, with R(F) equal to 0.0387 and a goodness of fit, S, = 1.03. Definitions used for calculating R(F), $Rw(F^2)$ and the goodness of fit, S, are given below.[5] The data were corrected for secondary extinction effects. The correction takes the form: $F_{corr} = kF_c/[1 + (2.2(3)x10^{-5})* F_c^2 \lambda^3/(\sin 2\theta)]^{0.25}$ where k is the overall scale factor. Neutral atom scattering factors and values used to calculate the linear absorption coefficient are from the International Tables for X-ray Crystallography (1992).[6] All the other structures (**4**, **6**, **7**, **7**•CH_3OH, and the complex between **4** and phenylpyruvic acid) were solved similarly, with all the .cif files in the supporting information.

---

[2] DENZO-SMN. (1997). Z. Otwinowski and W. Minor, Methods in Enzymology, 276: Macromolecular Crytallography, part A, 307-326, C. W. Carter, Jr. and R. M. Sweets, Editors, Academic Press.

[3] Sir 97. (1999). A program for crystal structure solution. Altomare A., Burla M. C., Camalli M., Cascarano G. L., Giacovazzo C., Guagliardi, A., Moliterni A. G. G., Polidori G., Spagna R. J. Appl. Cryst. 32, 115-119.

[4] Sheldrick, G. M. (1994). SHELXL97. Program for the Refinement of Crystal Structures. University of Gottingen, Germany.

[5] $Rw(F^2) = \{\Sigma w(|F_o|^2 - |F_c|^2)^2/\Sigma w(|F_o|)^4\}^{1/2}$ where w is the weight given each reflection.
$R(F) = \Sigma(|F_o| - |F_c|)/\Sigma|F_o|\}$ for reflections with $F_o > 4(\sigma(F_o))$.
$S = [\Sigma w(|F_o|^2 - |F_c|^2)^2/(n - p)]^{1/2}$, where n is the number of reflections and p is the number of refined parameters.

[6] International Tables for X-ray Crystallography (1992). Vol. C, Tables 4.2.6.8 and 6.1.1.4, A. J. C. Wilson, editor, Boston: Kluwer Academic Press.

General procedure for ^{11}B NMR titrations

All the ^{11}B NMR experiments were done with quartz NMR tubes (Wilmad). Stock solutions of compound **6** (0.1 M) and catechol (0.1 M) in CD_3OD (or $CDCl_3$) were prepared. Each of the eight NMR tubes was loaded with 100 μL of solution **6** (0.1 M) first, followed with 0, 25 μL, 50 μL, 75 μL, 100 μL, 200 μL, 600 μL, and 800 μL of catechol solution (0.1 M) respectively. CD_3OD (or $CDCl_3$) was then added to take the total volume to 1.0 mL. Therefore, each tube contained 10 mM of **6**, with 0, 2.5 mM, 5 mM, 7.5 mM, 10 mM, 20 mM, 60 mM, and 80 mM of catechol respectively. Boron NMR were collected on Varian INOVA 500 with a sweep width of 51000 Hz, 131k of data points, a 90º pulse width and a 1.2 second recycle time. Each spectrum was processed with 10 Hz line broadening, and a second order polynomial fitting routine was used to remove ^{11}B background. The temperature was regulated at 27ºC.

General procedure for ^{11}B NMR – pH profiles

Solutions of compound **6** (0.6 mL, 0.1 M in CH_3OH), HEPES (0.75 mL, 0.1 M in D_2O), and catechol (0.6 mL, 0.1 M in CH_3OH) were added in 16 vials and their pH values were adjusted with NaOH (2 M) or $HClO_4$ (2 M) in a range from 3 – 12. The total volume of the samples was adjusted to 3.0 mL. The final concentrations for **6**, HEPES, and catechol were 20 mM, 25 mM, and 20 mM, respectively.

Computational Analysis

Geometry optimizations were performed on all structures in the gas phase using the Gaussian suite of programs at the B3LYP/6-31+G(d,p) level of theory.[7] Frequency calculations were ran on these structures to ensure that they were minima and to obtain zero-point energies and thermal enthalpic

[7] Gaussian 03W, Revision B.05, Frisch, M. J.; Trucks, G. W.; Schlegel, H. B.; Scuseria, G. E.; Robb, M. A.; Cheeseman, J. R.; Montgomery, Jr., J. A.; Vreven, T.; Kudin, K. N.; Burant, J. C.; Millam, J. M.; Iyengar, S. S.; Tomasi, J.; Barone, V.; Mennucci, B.; Cossi, M.; Scalmani, G.; Rega, N.; Petersson, G. A.; Nakatsuji, H.; Hada, M.; Ehara, M.; Toyota, K.; Fukuda, R.; Hasegawa, J.; Ishida, M.; Nakajima, T.; Honda, Y.; Kitao, O.; Nakai, H.; Klene, M.; Li, X.; Knox, J. E.; Hratchian, H. P.; Cross, J. B.; Bakken, V.; Adamo, C.; Jaramillo, J.; Gomperts, R.; Stratmann, R. E.; Yazyev, O.; Austin, A. J.; Cammi, R.; Pomelli, C.; Ochterski, J. W.; Ayala, P. Y.; Morokuma, K.; Voth, G. A.; Salvador, P.; Dannenberg, J. J.; Zakrzewski, V. G.; Dapprich, S.; Daniels, A. D.; Strain, M. C.; Farkas, O.; Malick, D. K.; Rabuck, A. D.; Raghavachari, K.; Foresman, J. B.; Ortiz, J. V.; Cui, Q.; Baboul, A. G.; Clifford, S.; Cioslowski, J.; Stefanov, B. B.; Liu, G.; Liashenko, A.; Piskorz, P.; Komaromi, I.; Martin, R. L.; Fox, D. J.; Keith, T.; Al-Laham, M. A.; Peng, C. Y.; Nanayakkara, A.; Challacombe, M.; Gill, P. M. W.; Johnson, B.; Chen, W.; Wong, M. W.; Gonzalez, C.; and Pople, J. A.; Gaussian, Inc., Wallingford CT, 2004.

corrections at 298K. Subsequently, single point energies were obtained in a water solvent using the Polarizable Continuum Model (PCM).[8]

[8] Miertus, S.; Tomasi, *J. Chem. Phys.* **1982**, *65*, 239.

^{11}B NMR spectra of several compounds

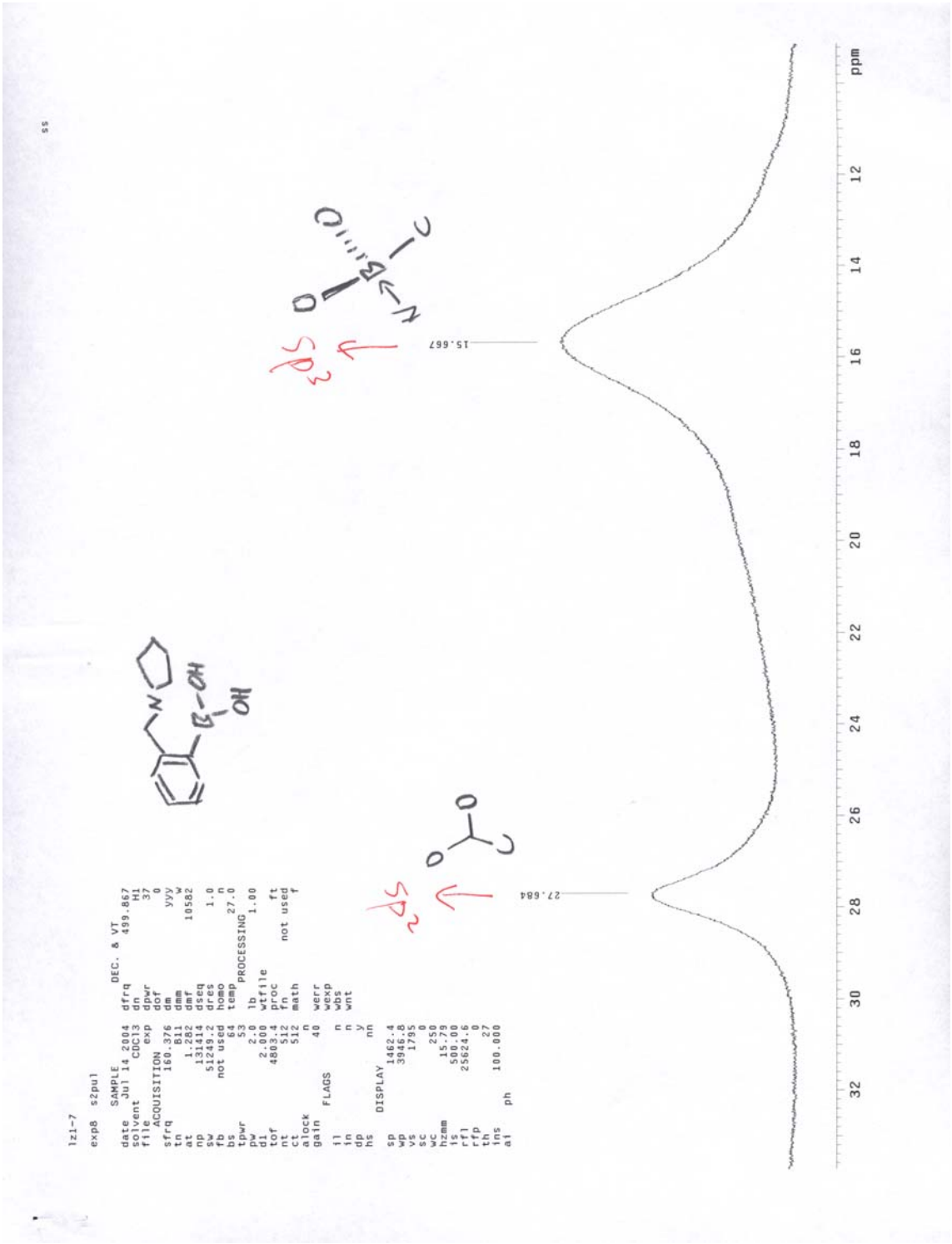

Figure S1. ^{11}B NMR ($CDCl_3$, 160 MHz) of compound **4**.

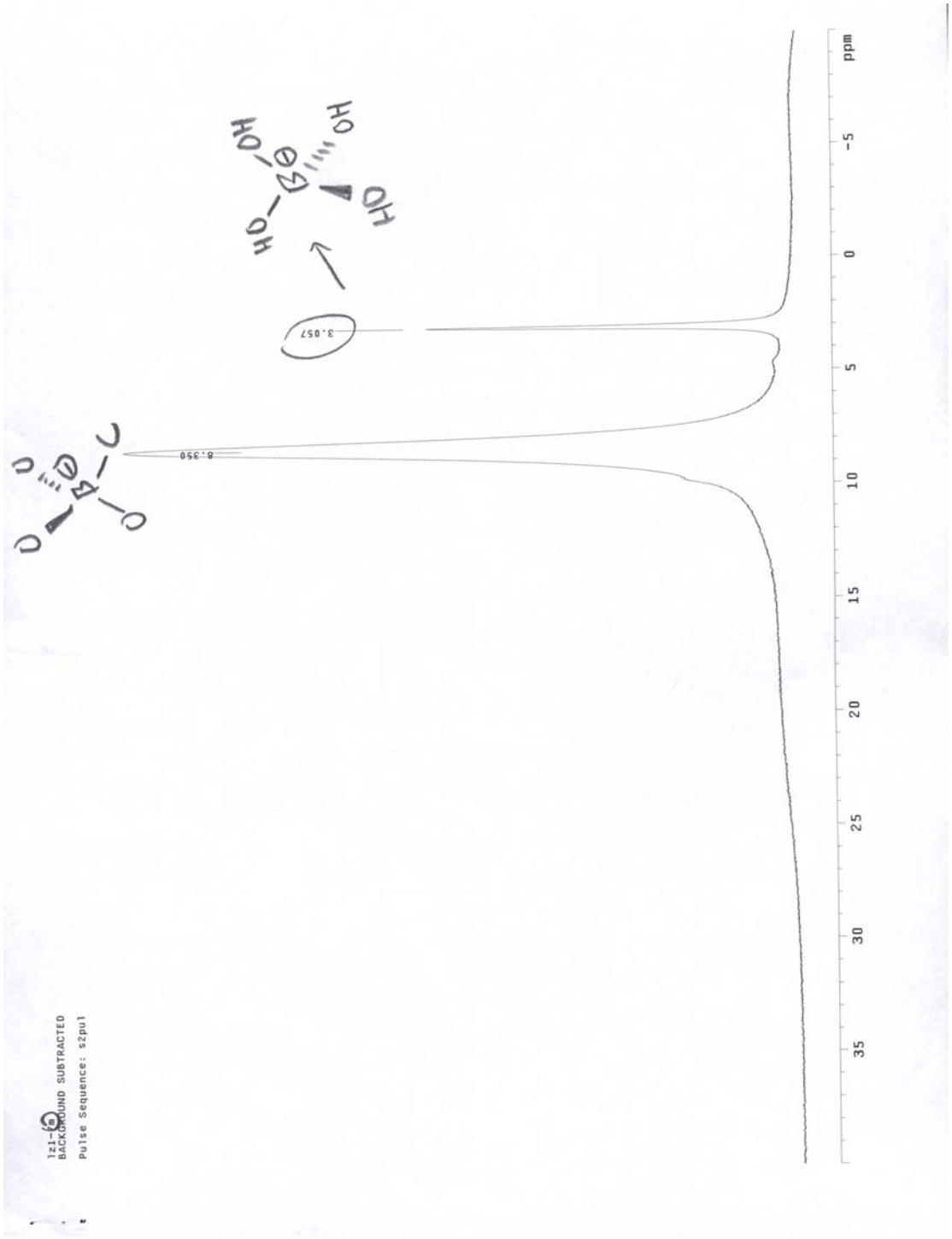

Figure S2. ^{11}B NMR (CD_3OD, 160 MHz) of compound **4**.

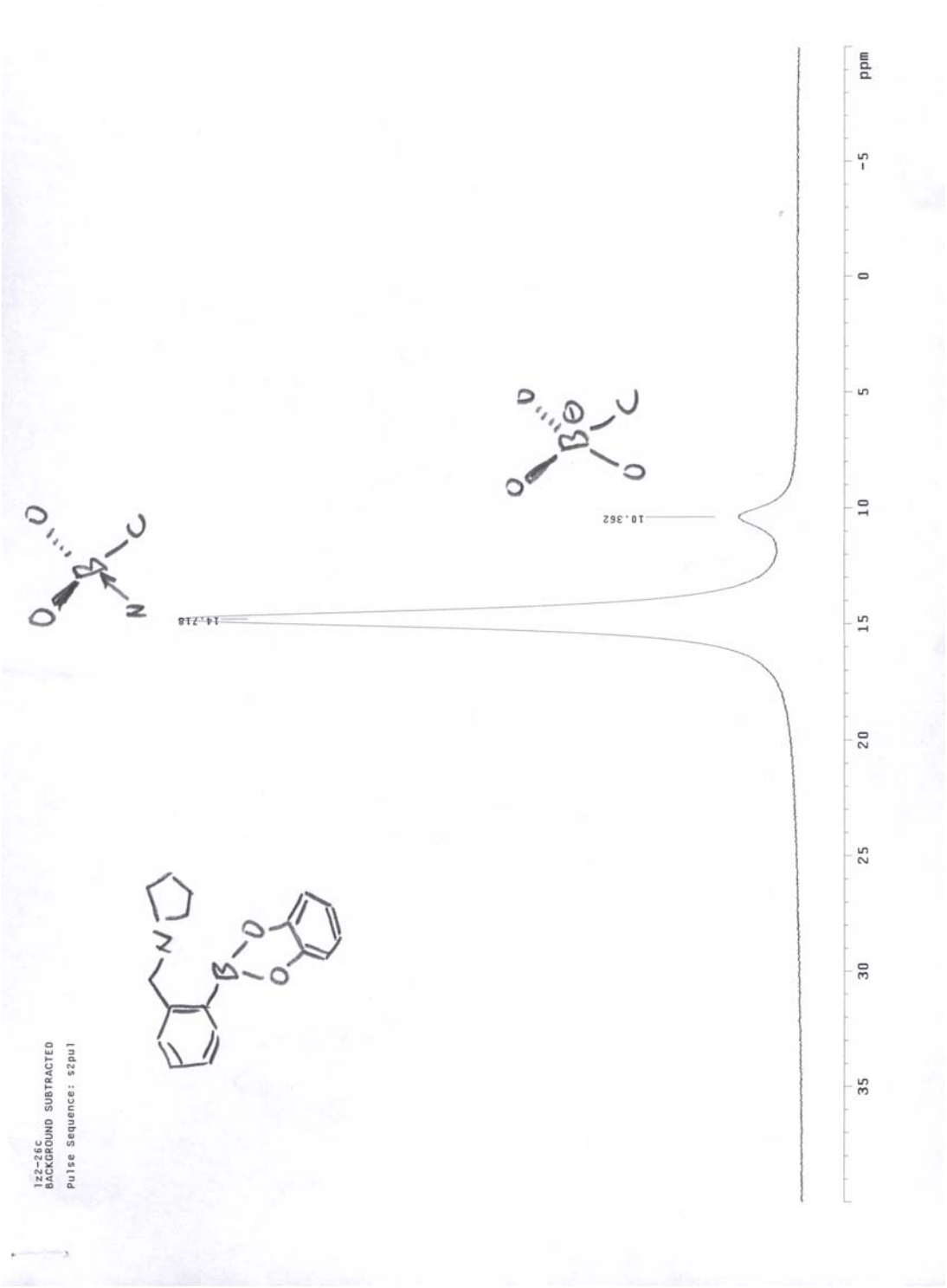

Figure S3. ^{11}B NMR ($CDCl_3$, 160 MHz) of compound **7**.

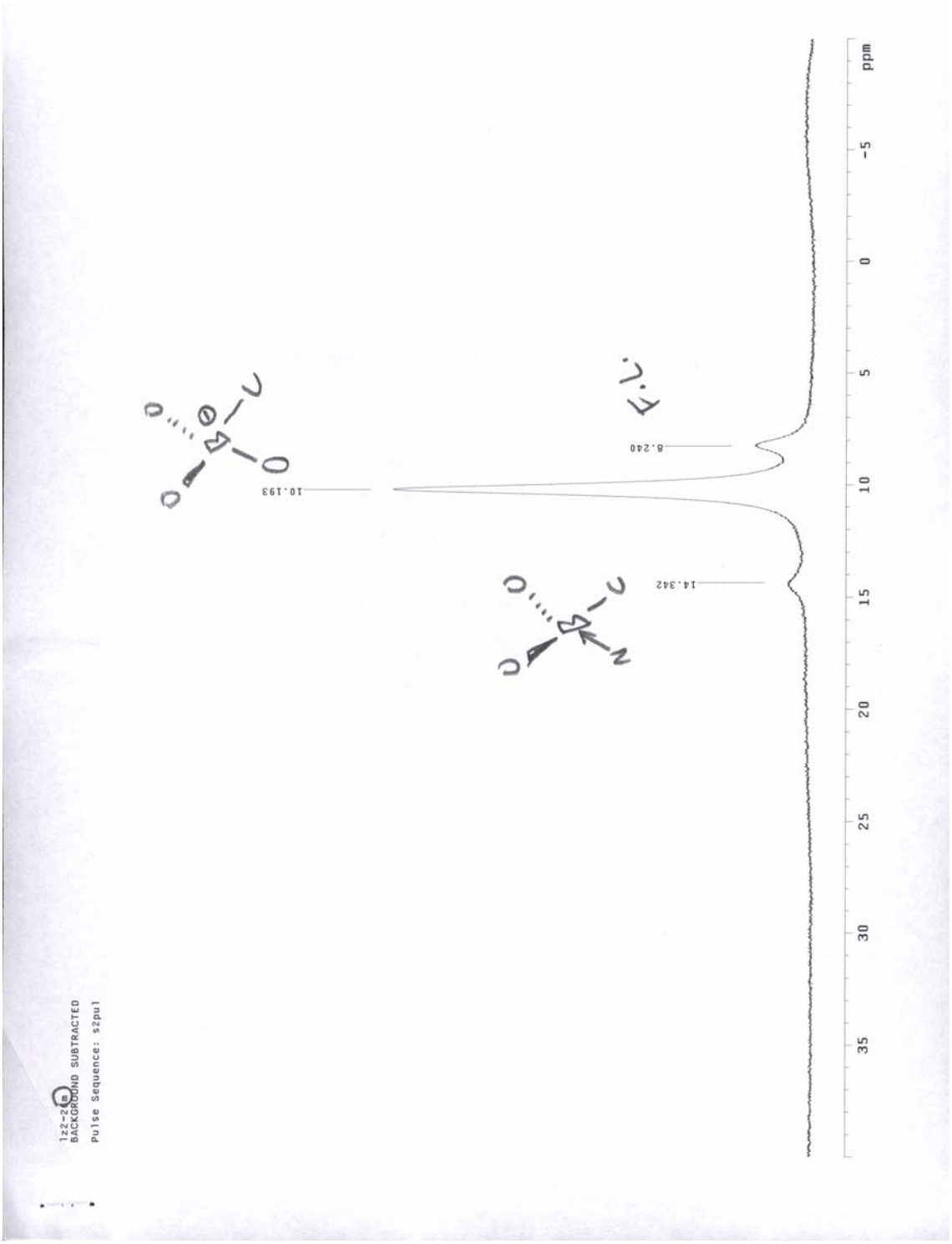

Figure S4. ^{11}B NMR (CD_3OD, 160 MHz) of compound **7**.

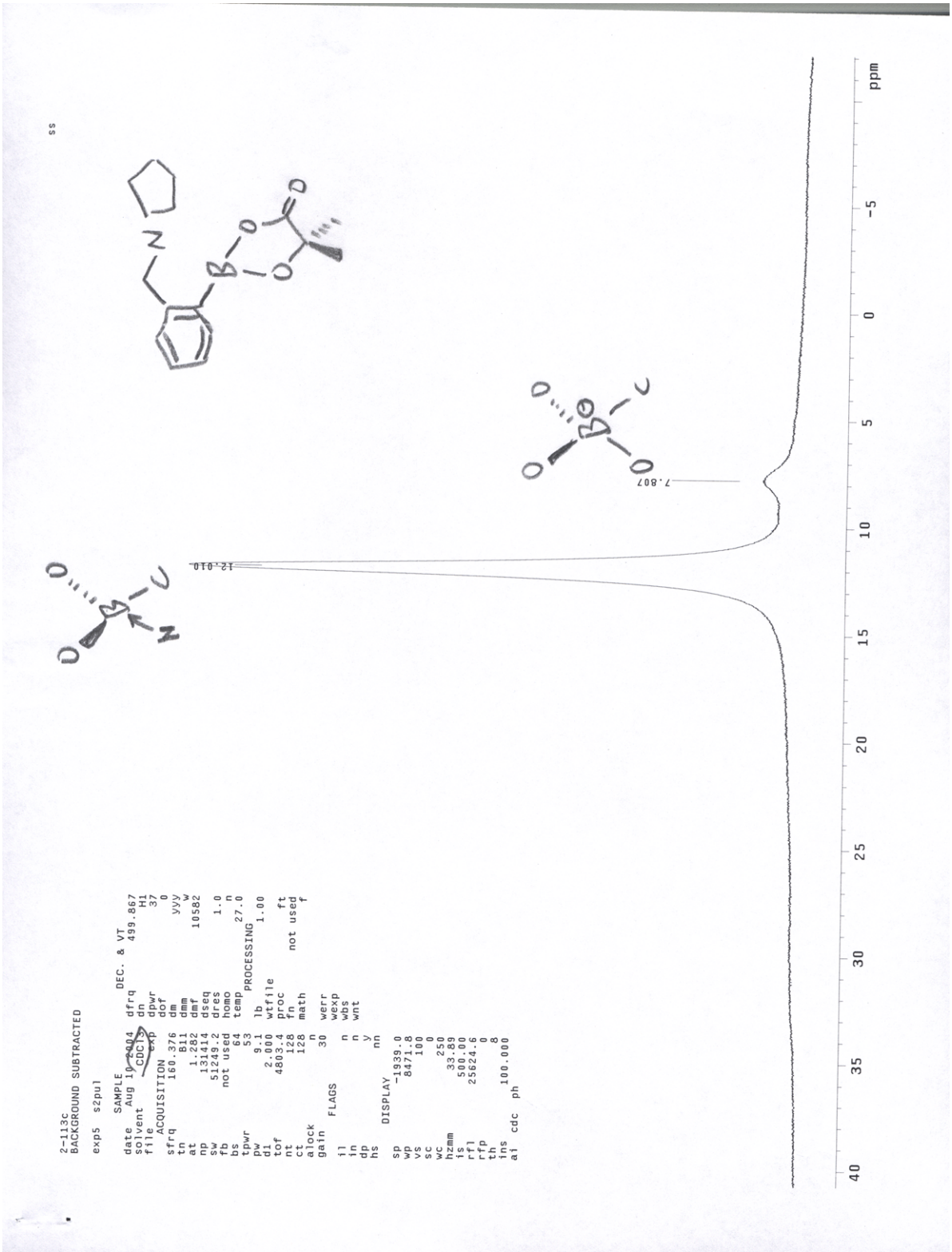

Figure S5. ^{11}B NMR ($CDCl_3$, 160 MHz) of compound **8**.

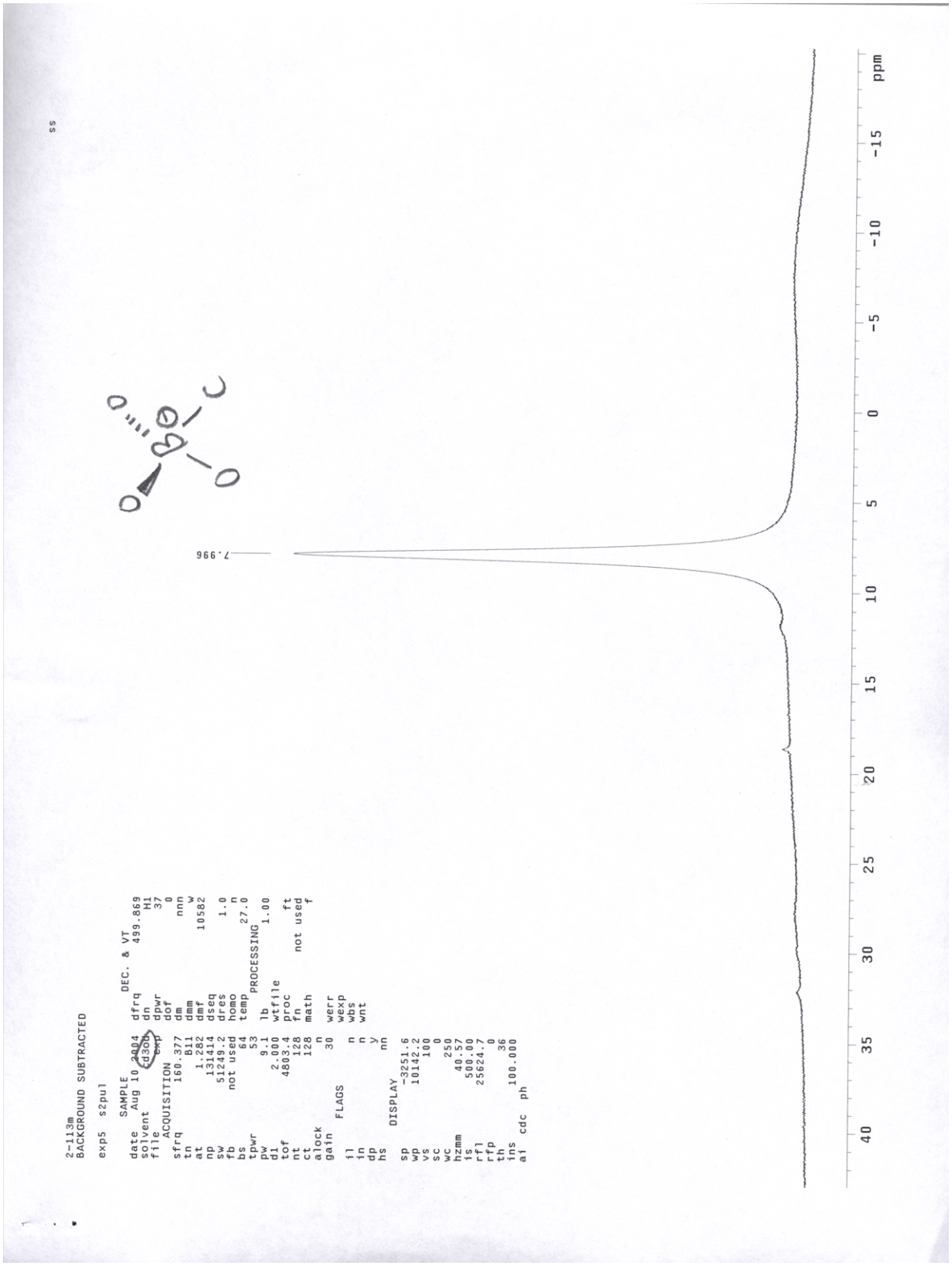

Figure S6. ^{11}B NMR (CD_3OD, 160 MHz) of compound **8**.