Supporting Information for

Catalytic Asymmetric Friedländer Condensation to Construct Cyclobutanone-Fused Quinolines with Quaternary Stereogenic Centre

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Contents

1. General Methods.

Reactions were monitored by thin layer chromatography using UV light or $KMnO_4$ to visualize the course of reaction. Purification of reaction products was carried out by flash chromatography on silica gel. Chemical yields refer to pure isolated substances. The $[\alpha]^D$ was recorded using PolAAr 3005 High Accuracy Polarimeter. ^1H, ^{13}C and ^{19}F NMR spectra were obtained using Bruker DPX-400 spectrometer. The ee values were determined by chiral HPLC analysis using Agilent Technologies 1260 Infinity series; Structural assignments were made with additional information from NOESY {^1H} NMR experiments. The HRMS spectra were measured on Bruker maXis impact spectrometer using electron spray ionization (ESI) method. Chemical shifts were reported in ppm from tetramethyl silane with the solvent resonance as the internal standard. The following abbreviations were used to designate chemical shift multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, h = heptet, m = multiplet, br = broad.

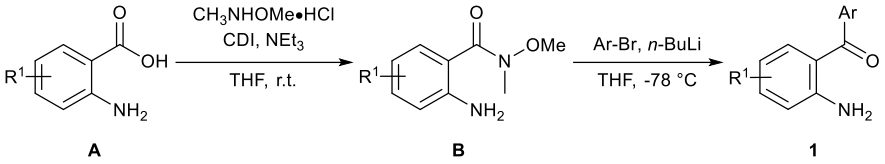
The chiral phosphoric acid catalysts **3a-3k** were prepared according to the known methods and the characterization data were in consistent with the reported data. [1] All the cyclobutane-1,3-diones were known and could be prepared according to methods reported by Brand et al and our group. [2]

[1] (a) T. Akiyama, H. Morita, J. Itoh, K. Fuchibe, *Org. Lett.,* 2005, **7**, 2583; (b) M. Hatano, T. Ikeno, T. Matsumura, S. Torii, K. Ishihara, *Adv. Synth. Catal.,* 2008, **350**, 1776; (c) F. Romanov-Michailidis, L. Guenee, A. Alexakis, *Org. Lett.,* 2013, **15**, 5890; (d) F. Romanov-Michailidis, L. Guenee, A. Alexakis, *Angew. Chem. Int. Ed.,* 2013, **52**, 9266; (e) W. W. Zi, Y. M. Wang, F. D. Toste, *J. Am. Chem. Soc.,* 2014, **136**, 12864.

[2] (a) S. Brand, B. C. de Candole, J. A. Brown, *Org. Lett.,* 2003, **5**, 2343; (b) K. G. Wen, C. Liu, D. H. Wei, Y. F. Niu, Y. Y. Peng, X. P. Zeng, *Org. Lett.,* 2021, **23**, 1118; (c) S. Zhang, R.-S. Jin, Y.-F. Niu and X.-P. Zeng, *J. Org. Chem.,* 2023, **88**, 4627; (d) C. Liu, F.-L. Zou, K.-G. Wen, Y.-Y. Peng, Q.-P. Ding and X.-P. Zeng, *Org. Lett.,* 2023, **25**, 5719.

2. Preparation of 2-aminobenzophenones

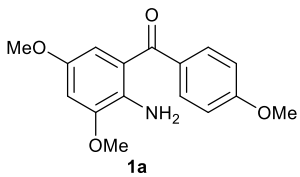
2-Aminobenzophenone **1a-1i** were prepared according to reported methods. [3]



General procedure:

Step 1: To a stirred solution of 2-aminobenzoic acid **A** (10.0 mmol) in anhydrous THF (80 mL) was added CDI (1.60 g, 10.0 mmol) at 0 °C under N_2 atmosphere. The reaction mixture was allowed to warm to r.t. and stirred for 2 h, then a suspension of *N*,*O*-dimethylhydroxylamine hydrochloride (0.97 g, 10.0 mmol) and Et_3N (1.01 g, 1.39 mL, 10.0 mmol) in THF (20 mL) was added. The reaction mixture was stirred until completion indicated by TLC analysis, the volatile solvent was removed under reduced pressure. The residue was poured into water (50 mL), adjusted to neutral with 5% NaOH solution and extracted with EtOAc (3 × 50 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, concentrated under vacuo and purified by flash column chromatography (PE/EtOAc = 10:1) to yield Weinreb amide **B**.

Step 2: Weinreb amide **B** (5.0 mmol) and Ar-Br (5.0 mmol) were dissolved in anhydrous THF (30 mL). The solution was cooled to -78 °C and *n*-BuLi (4.0 mL, 2.5 M in hexane, 10.0 mmol) was added dropwise with stirring over 1 h. After the addition completion, 1 N HCl (10 mL) was added. The mixture was extracted with EtOAc (3 × 20 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated in vacuo. The residue was purified by flash column chromatography (PE/EtOAc = 15:1) to yield the desired 2-aminoaryl ketones **1**.

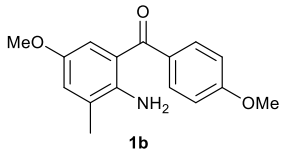


1a

Column chromatography afforded **1a** in 40% yield (574 mg) as a yellow solid. ^{1}H NMR (600 MHz, Chloroform-d) δ 7.72 (d, J = 8.5 Hz, 2H), 6.94 (d, J = 8.5 Hz, 2H), 6.60 (d, J = 2.7 Hz, 1H), 6.56 (d, J = 2.6 Hz, 1H), 5.76 (s, 2H), 3.88 (d, J = 4.6 Hz, 6H), 3.66 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 197.22, 162.36, 149.18, 148.47, 136.05, 132.35, 131.76, 117.96, 113.35,

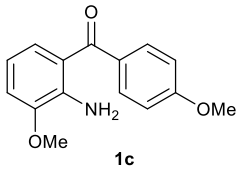
[3] a) C.-T. Wang, P.-Y. Liang, M. Li, B. Wang, Y.-Z. Wang, X.-S. Li, W.-X. Wei, X.-Y. Gou, Y.-N. Ding, Z. Zhang, Y.-K. Li, X.-Y. Liu and Y.-M. Liang, *Angew. Chem. Int. Ed.,* 2023, **62**, e202304447; b) J. Liu, Q. Li, Y. Wei and M. Shi, *Org. Lett.,* 2020, **22**, 2494; c) Y.-D. Shao, M.-M. Dong, Y.-A. Wang, P.-M. Cheng, T. Wang and D.-J. Cheng, *Org. Lett.,* 2019, **21**, 4831;

106.37, 103.74, 55.87, 55.44；HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{16}H_{17}NNaO_4$ 310.1050; Found: 310.1051.



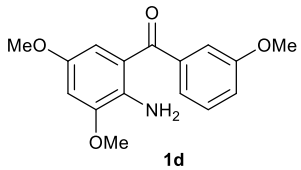
1b

Column chromatography afforded **1b** in 50% yield (677 mg) as a yellow solid. ^{1}H NMR (600 MHz, Chloroform-d) δ 7.71 (d, J = 8.4 Hz, 2H), 6.94 (d, J = 8.9 Hz, 2H), 6.91 (d, J = 3.0 Hz, 1H), 6.86 (d, J = 2.9 Hz, 1H), 5.52 (s, 2H), 3.87 (s, 3H), 3.66 (s, 3H), 2.21 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-d) δ 197.69, 162.42, 149.27, 143.08, 132.41, 131.86, 125.23, 122.97, 118.92, 114.77, 113.37, 55.92, 55.45, 17.69；HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{16}H_{17}NNaO_3$ 294.1101; Found: 294.1104.



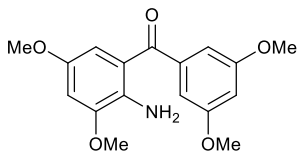
1c

Column chromatography afforded **1c** in 53% yield (681 mg) as an orange solid. ^{1}H NMR (400 MHz, Chloroform-d) δ 7.68f (t, 2H), 7.09 (dd, J = 8.2, 1.3 Hz, 1H), 6.95 – 6.93 (m, 2H), 6.87 (dd, J = 7.9, 1.3 Hz, 1H), 6.56 (t, J = 8.0 Hz, 1H), 3.88 (d, J = 11.6 Hz, 6H); ^{13}C NMR (101 MHz, Chloroform-d) δ 197.69, 162.24, 147.36, 141.45, 132.58, 131.72, 125.55, 118.38, 113.97, 113.30, 112.70, 55.80, 55.44；HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{15}H_{15}NNaO_3$ 280.0944; Found: 280.0948.



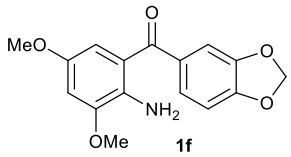
1d

Column chromatography afforded **1d** in 52% yield (746 mg) as a yellow solid. ^{1}H NMR (600 MHz, Chloroform-d) δ 7.35 (t, J = 7.8 Hz, 1H), 7.23 – 7.21 (m, 2H), 7.07 – 7.05 (m, 1H), 6.61 (d, J = 2.6 Hz, 1H), 6.55 (d, J = 2.7 Hz, 1H), 6.06 (s, 2H), 3.89 (s, 3H), 3.84 (s, 3H), 3.64 (s, 3H)；^{13}C NMR (101 MHz, Chloroform-d) δ 198.21, 159.39, 148.95, 148.37, 141.48, 137.06, 129.00, 121.68, 117.46, 116.71, 113.66, 106.33, 104.38, 55.89, 55.84, 55.43；HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{16}H_{17}NNaO_4$ 310.1050; Found: 310.1049.



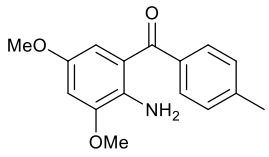
1e

Column chromatography afforded **1e** in 45% yield 713 mg) as a yellow solid. ^{1}H NMR (600 MHz, Chloroform-d) δ 6.80 (d, J = 2.3 Hz, 2H), 6.61 – 6.58 (m, 3H), 6.06 (s, 2H), 3.89 (s, 3H), 3.81 (d, J = 1.0 Hz, 6H), 3.65 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 198.03, 160.41, 148.95, 148.36, 142.10, 137.12, 116.53, 106.84, 106.23, 104.48, 103.61, 55.89, 55.87, 55.57；HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{17}H_{19}NNaO_5$ 340.1155; Found: 340.1160.



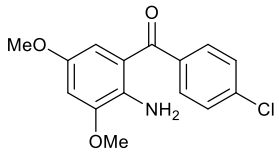
1f

Column chromatography afforded **1f** in 48% yield (722 mg) as an orange solid. ^{1}H NMR (400 MHz, Chloroform-d) δ 7.29 – 7.24 (m, 2H), 6.85 (d, J = 8.1 Hz, 1H), 6.57 (dd, J = 19.2, 2.7 Hz, 2H), 6.05 (s, 2H), 3.88 (s, 3H), 3.68 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 196.70, 150.53, 149.21, 148.47, 147.64, 136.07, 134.03, 125.41, 117.77, 109.69, 107.60, 106.30, 103.85, 101.65, 55.91, 55.88；HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{16}H_{15}NNaO_5$ 324.0842; Found: 324.0845.



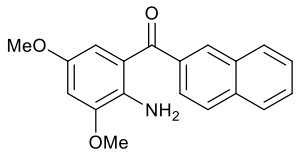
1g

Column chromatography afforded **1g** in 41% yield (555 mg) as an orange solid. ^{1}H NMR (400 MHz, Chloroform-d) δ 7.61 – 7.59 (m, 2H), 7.25 (d, J = 8.0 Hz, 2H), 6.58 (dd, J = 19.7, 2.6 Hz, 2H), 5.86 (s, 2H), 3.88 (s, 3H), 3.64 (s, 3H), 2.42 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 198.27, 149.02, 148.41, 141.75, 137.28, 136.61, 129.46, 128.74, 117.31, 106.44, 104.06, 55.88, 55.85, 21.57；HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{16}H_{17}NNaO_3$ 294.1101; Found: 294.1104.



1h

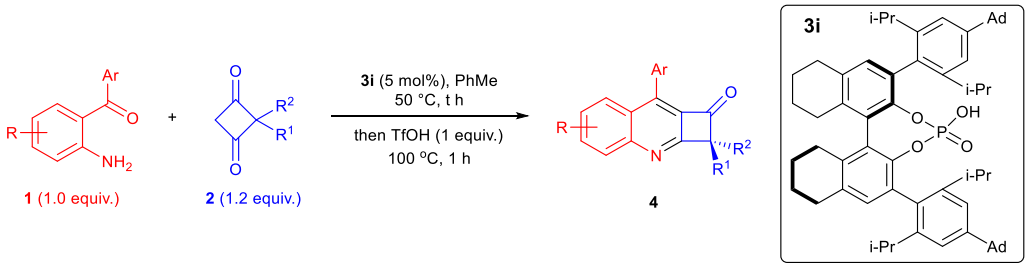
Column chromatography afforded **1h** in 40% yield (582 mg) as an orange solid. ^{1}H NMR (600 MHz, Chloroform-d) δ 7.62 (d, J = 8.4 Hz, 2H), 7.43 (d, J = 8.5 Hz, 2H), 6.61 (d, J = 2.6 Hz, 1H), 6.46 (d, J = 2.6 Hz, 1H), 3.89 (s, 3H), 3.64 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 197.07, 149.04, 148.47, 138.49, 137.34, 137.17, 130.59, 128.37, 116.35, 105.89, 104.47, 55.91, 55.83；HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{15}H_{14}ClNNaO_3$ 314.0554; Found: 314.0550.



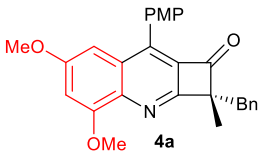
1i

Column chromatography afforded **1i** in 39% yield (599 mg) as a yellow solid. ^{1}H NMR (400 MHz, Chloroform-d) δ 8.17 (d, 1H), 7.93 – 7.89 (m, 3H), 7.80 (dd, J = 8.5, 1.7 Hz, 1H), 7.59 – 7.54 (m, 2H), 6.64 – 6.59 (m, 2H), 6.06 (s, 2H), 3.91 (s, 3H), 3.60 (d, J = 1.2 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 198.38, 149.04, 148.47, 137.41, 137.07, 134.61, 132.40, 130.08, 129.13, 127.91, 127.80, 127.73, 126.68, 125.78, 117.05, 106.34, 104.34, 55.92, 55.84; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{19}H_{17}NNaO_3$ 330.1101; Found: 330.1099.

3. General procedure for catalytic asymmetric Friedländer condensation

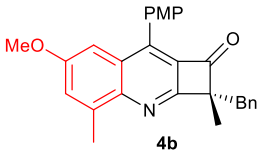


5Å MS (150 mg) was flame dried under vacuum in a 25 mL Schlenk tube. After cooling to room temperature, 2-aminobenzophenone **1** (0.25 mmol), cyclobutane-1,3-diones **2** (1.2 equiv., 0.30 mmol), **3i** (5 mol%, 0.0125 mmol, 11.8 mg), magnetic stir-ring bar and toluene (2.0 mL) were sequentially added under N_2 atmosphere. The resulting mixture was stirred at 50 °C until TLC analysis show the full consumption of 2-aminobenzophenone **1**. In the following, TfOH (0.25 mmol, 18 μL) was added and the resulting mixture was heated to 100 °C with oil bath for 1.0 h. After cooling to room temperature, 0.5 mmol K_2CO_3 and 100 μl H_2O were added and stirred for 0.5h, then silica gel column chromatography was performed directly to obtain product **4**.



4a

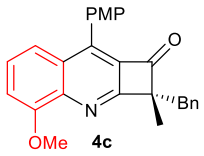
Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4a** in 92% yield (101.1 mg) as a light-yellow oil. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 20/80, 1.0 mL/min, 205 nm; t_r (major) = 15.11 min, t_r (minor) = 13.22 min) gave the isomeric composition of the product: 93% ee; $[\alpha]_D^{15.2}$ = +59.9 (c = 0.90 in $CHCl_3$); ^{1}H NMR (600 MHz, Chloroform-d) δ 7.49 (d, J = 8.7 Hz, 2H), 7.16 (d, J = 7.4 Hz, 2H), 7.11 (t, J = 7.4 Hz, 2H), 7.06 – 7.03 (m, 4H), 6.88 (d, J = 2.5 Hz, 1H), 4.12 (s, 3H), 3.88 (s, 3H), 3.80 (s, 3H), 3.41 (d, J = 13.9 Hz, 1H), 3.27 (d, J = 13.9 Hz, 1H), 1.65 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.60, 171.17, 160.98, 157.78, 156.58, 141.76, 141.72, 137.31, 135.71, 131.66, 130.09, 129.05, 127.92, 126.24, 125.57, 114.35, 103.66, 97.82, 73.14, 56.54, 55.46, 55.40, 41.86, 20.01; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{28}H_{25}NNaO_4$ 462.1676; Found: 462.1679.



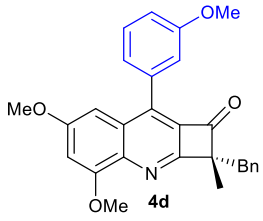
4b

Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4b** in 92% yield (97.5 mg) as a light-yellow oil. HPLC analysis (Chiralcel OD-3, ^{i}PrOH/hexane = 5/95, 1.0 mL/min, 205 nm; t_r (major) = 6.76 min, t_r (minor) = 5.84 min) gave the isomeric composition of the product: 92% ee; $[\alpha]_D^{15.4}$ =

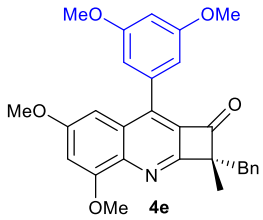
+55.5 (c = 0.98 in $CHCl_3$); ^{1}H NMR (600 MHz, Chloroform-d) δ 7.56– 7.54 (m, 2H), 7.36 – 7.34 (m, 2H), 7.26 – 7.25 (m, 2H), 7.17 – 7.14 (m, 2H), 7.12 – 7.09 (m, 1H), 7.07 – 7.05 (m, 2H), 3.89 (s, 3H), 3.80 (s, 3H), 3.28 (dd, J = 2.1 Hz, 2H), 2.86 (s, 3H), 1.59 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.82, 171.22, 160.93, 156.95, 139.44, 137.37, 134.55, 131.76, 130.15, 128.34, 127.92, 126.28, 125.80, 124.22, 114.37, 104.19, 72.54, 55.41, 55.34, 41.69, 19.85, 19.17; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{28}H_{25}NNaO_3$ 462.1727; Found: 462.1727.



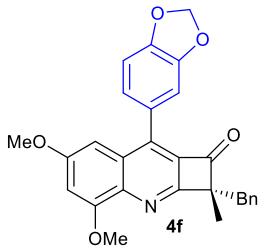
Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4c** in 96% yield (97.8 mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 20/80, 1.0 mL/min, 205 nm; t_r (major) = 11.90 min, t_r (minor) = 10.03 min) gave the isomeric composition of the product: 89% ee; $[\alpha]_D^{15.4}$ = +54.7 (c = 0.75 in $CHCl_3$); m.p. 134.5-136.4 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.76 – 7.74 (m, 1H), 7.49 (d, J = 8.7 Hz, 2H), 7.41 (t, J = 8.2 Hz, 1H), 7.23 – 7.21 (m, 1H), 7.19 – 7.16 (m, 2H), 7.13 – 7.03 (m, 5H), 4.15 (s, 3H), 3.88 (s, 3H), 3.43 (d, J = 13.8 Hz, 1H), 3.29 (d, J = 13.9 Hz, 1H), 1.67 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.58, 173.24, 161.22, 155.77, 145.00, 143.45, 137.18, 135.29, 132.21, 130.08, 128.32, 127.95, 126.30, 126.02, 125.26, 120.26, 114.30, 110.56, 73.47, 56.50, 55.42, 41.80, 19.94; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{27}H_{23}NNaO_3$ 432.1570; Found: 432.1560.



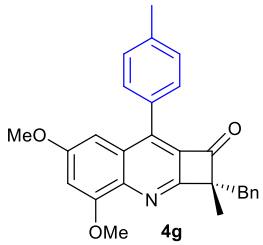
Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4d** in 92% yield (101.3 mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 20/80, 1.0 mL/min, 205 nm; t_r (major) = 8.63 min, t_r (minor) = 7.05 min) gave the isomeric composition of the product: 91% ee; $[\alpha]_D^{15.5}$ = +111.0 (c = 0.98 in $CHCl_3$); m.p. 66.7-68.2 °C; ^{1}H NMR (600 MHz, Chloroform-d) δ 7.30 (t, J = 7.9 Hz, 1H), 7.04 (d, J = 6.9 Hz, 2H), 7.00 – 6.94 (m, 6H), 6.86 (t, J = 2.0 Hz, 1H), 6.78 (d, J = 2.6 Hz, 1H), 4.01 (s, 3H), 3.73 (s, 3H), 3.66 (s, 3H), 3.31 (d, J = 13.9 Hz, 1H), 3.17 (d, J = 13.9 Hz, 1H), 1.57 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.29, 170.95, 159.80, 157.90, 156.55, 141.49, 137.25, 136.22, 134.45, 130.08, 129.76, 129.09, 127.90, 126.26, 122.09, 116.03, 114.99, 103.83, 97.66, 73.50, 56.54, 55.45, 55.42, 41.92, 20.01; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{28}H_{25}NNaO_4$ 462.1676; Found: 462.1674.



Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4e** in 91% yield (105.7 mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 15/85, 1.0 mL/min, 205 nm; t_r (major) = 10.20 min, t_r (minor) = 8.92 min) gave the isomeric composition of the product: 89% ee; $[\alpha]_D^{15.5}$ = +86.9 (c = 0.51 in $CHCl_3$); m.p. 61.3-62.7 °C; ^{1}H NMR (600 MHz, Chloroform-d) δ 7.13 (d, J = 8.0 Hz, 2H), 7.10 – 7.04 (m, 4H), 6.89 (t, J = 2.0 Hz, 1H), 6.58– 6.57 (m, 3H), 4.13 (d, J = 1.6 Hz, 3H), 3.82 – 3.80 (m, 9H), 3.41 (d, J = 13.9 Hz, 1H), 3.27 (d, J = 13.9 Hz, 1H), 1.67 (d, J = 1.5 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.18, 170.92, 160.91, 157.88, 156.56, 137.27, 136.25, 134.90, 130.10, 129.08, 127.87, 126.24, 107.80, 103.87, 102.34, 97.71, 73.57, 56.57, 55.58, 55.53, 41.96, 19.97; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{29}H_{27}NNaO_5$ 492.1781; Found: 492.1784.

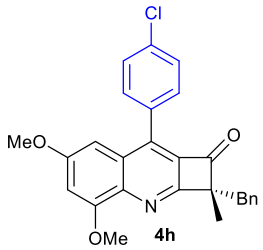


Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4f** in 88% yield (116.1 mg) as a yellow solid. HPLC analysis (Chiralcel OD-3, ^{i}PrOH/hexane = 20/80, 0.5 mL/min, 205 nm; t_r (major) = 13.18 min, t_r (minor) = 11.79 min) gave the isomeric composition of the product: 89% ee; $[\alpha]_D^{15.4}$ = +51.0 (c = 0.92 in $CHCl_3$); m.p. 67.7-68.9 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.26 (s, 1H), 7.16 – 7.03 (m, 6H), 7.01 – 6.93 (m, 2H), 6.88 (d, J = 2.5 Hz, 1H), 6.06 (t, 2H), 4.13 (s, 3H), 3.81 (s, 3H), 3.41 (d, J = 13.8 Hz, 1H), 3.27 (d, J = 13.8 Hz, 1H), 1.66 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.38, 171.03, 157.84, 156.59, 149.13, 148.16, 141.42, 137.26, 135.89, 130.07, 129.09, 129.03, 128.22, 127.92, 126.95, 126.25, 124.60, 110.14, 108.78, 103.72, 101.62, 97.71, 73.31, 56.55, 55.49, 41.88, 20.01; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{28}H_{23}NNaO_5$ 476.1468; Found: 476.1466.

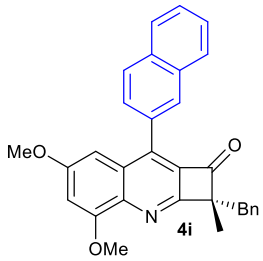


Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4g** in 85% yield (89.9 mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 15/85, 0.75 mL/min, 250 nm; t_r (major) = 10.32 min, t_r (minor) = 9.45 min) gave the isomeric composition of the product: 94% ee; $[\alpha]_D^{15.4}$ = +100.4 (c = 0.82 in $CHCl_3$); m.p. 61.4-62.9 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.39 (d, J = 7.9 Hz, 2H), 7.31 (d, J = 7.9 Hz, 2H), 7.17– 7.14 (m, 2H), 7.12 – 7.03 (m, 4H), 6.88 (d, J = 2.5 Hz, 1H), 4.12 (s, 3H), 3.77 (s, 3H), 3.41 (d, J = 13.8

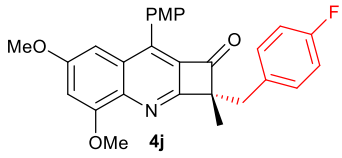
Hz, 1H), 3.27 (d, J = 13.8 Hz, 1H), 2.43 (s, 3H), 1.66 (s, 3H); ^{13} C NMR (101 MHz, Chloroform-d) δ 195.50, 171.12, 157.81, 156.54, 142.00, 141.68, 140.11, 137.28, 136.04, 130.36, 130.09, 129.90, 129.57, 129.14, 127.92, 126.24, 103.74, 97.75, 73.32, 56.55, 55.45, 41.87, 21.48, 20.03; RMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{28}H_{25}NNaO_3$ 446.1727; Found: 446.1727.



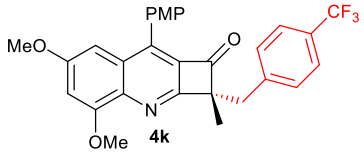
Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4h** in 90% yield (100.2mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, iPrOH/hexane = 20/80, 1.0 mL/min, 205 nm; tr (major) = 9.32 min, tr (minor) = 8.48 min) gave the isomeric composition of the product: 88% ee; $[\alpha]D^{15.4}$ = +76.7 (c = 0.78 in $CHCl_3$); m.p. 61.3-64.3 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.49 (d, J = 8.3 Hz, 2H), 7.39 (d, J = 8.3 Hz, 2H), 7.14 – 7.04 (m, 5H), 6.90 (s, 2H), 4.13 (s, 3H), 3.79 (s, 3H), 3.40 (d, J = 13.8 Hz, 1H), 3.27 (d, J = 13.8 Hz, 1H), 1.67 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 196.32, 171.77, 161.14, 157.93, 156.63, 142.03, 141.80, 141.74, 135.69, 131.92, 129.15, 129.03, 128.29, 128.25, 125.79, 125.66, 125.30, 114.46, 103.73, 97.98, 72.11, 56.52, 55.52, 55.44, 37.13, 32.17, 20.38; HRMS (ESI) m/z: [M+Na]+ Calcd for $C_{27}H_{22}ClNNaO_3$ 466.1180; Found: 466.1184.



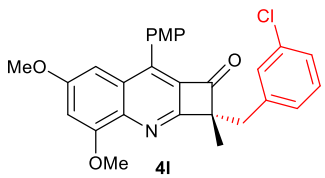
Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4i** in 89% yield (101.5 mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 20/80, 1.0 mL/min, 205 nm; t_r (major) = 13.82 min, t_r (minor) = 11.86 min) gave the isomeric composition of the product: 89% ee; $[\alpha]_D^{15.5}$ = +70.0 (c = 1.08 in $CHCl_3$); m.p. 91.2-93.6 °C; ^{1}H NMR (600 MHz, Chloroform-d) δ 7.97– 7.94 (m, 2H), 7.89 (d, J = 7.9 Hz, 2H), 7.56 – 7.54 (m, 3H), 7.18 – 7.16 (m, 2H), 7.12 (t, J = 7.5 Hz, 2H), 7.07 – 7.05 (m, 2H), 6.90 (d, J = 2.5 Hz, 1H), 4.13 (s, 3H), 3.73 (s, 3H), 3.43 (d, J = 13.9 Hz, 1H), 3.30 (d, J = 13.9 Hz, 1H), 1.69 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.36, 171.09, 158.02, 156.63, 141.72, 137.28, 136.46, 133.70, 133.15, 130.76, 130.14, 130.02, 129.31, 128.67, 128.52, 127.97, 127.82, 127.38, 126.85, 126.77, 126.30, 103.85, 97.69, 73.53, 56.59, 55.48, 41.95, 20.06; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{31}H_{25}NNaO_3$ 482.1727; Found: 482.1727.



Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4j** in 98% yield (111.5 mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 15/85, 1.0 mL/min, 205 nm; t_r (major) = 13.28 min, t_r (minor) = 10.86 min) gave the isomeric composition of the product: 87% ee; $[\alpha]_D^{15.4}$ = +55.5 (c = 0.97 in $CHCl_3$); m.p. 150.1-152.7 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.50 (d, J = 8.8 Hz, 2H), 7.12 – 7.07 (m, 2H), 7.07 – 7.04 (m, 3H), 6.89 (d, J = 2.5 Hz, 1H), 6.78 (t, J = 8.7 Hz, 2H), 4.13 (s, 3H), 3.89 (s, 3H), 3.81 (s, 3H), 3.37 (d, J = 14.0 Hz, 1H), 3.24 (d, J = 14.0 Hz, 1H), 1.64 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.46, 170.91, 162.73, 161.06, 160.31, 157.87, 156.56, 135.65, 133.02, 131.66, 131.55, 131.47, 129.07, 125.50, 114.79, 114.58, 114.39, 103.78, 97.90, 73.10, 56.54, 55.47, 55.40, 40.91, 20.03; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{28}H_{24}FNNaO_4$ 480.1582; Found: 480.1581.

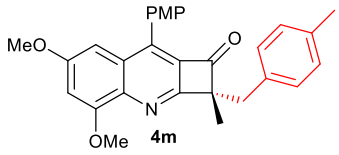


Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4k** in 88% yield (111.9 mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 20/80, 1.0 mL/min, 205 nm; t_r (major) = 16.41 min, t_r (minor) = 14.73 min) gave the isomeric composition of the product: 93% ee; $[\alpha]_D^{15.3}$ = +35.8 (c = 1.05 in $CHCl_3$); m.p. 69.3-72.1 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.51 – 7.49 (m, 2H), 7.38 (d, J = 8.0 Hz, 2H), 7.29 (d, J = 2.0 Hz, 2H), 7.07 – 7.04 (m, 3H), 6.90 (d, J = 2.5 Hz, 1H), 4.12 (s, 3H), 3.88 (s, 3H), 3.80 (s, 3H), 3.45 (d, J = 13.8 Hz, 1H), 3.32 (d, J = 13.8 Hz, 1H), 1.66 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 194.94, 170.59, 161.09, 157.95, 156.54, 142.24, 141.72, 141.48, 135.43, 131.62, 130.38, 129.13, 129.01, 128.20, 125.38, 124.86, 124.82, 124.78, 122.89, 114.38, 103.89, 97.86, 77.31, 72.61, 56.52, 55.43, 55.35, 41.43, 20.07; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{29}H_{24}F_3NNaO_4$ 530.1550; Found: 530.1541.



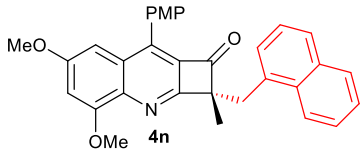
Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4l** in 94% yield (111.4mg) as a yellow solid. HPLC analysis (Chiralcel OD-3, ^{i}PrOH/hexane = 10/90, 0.5 mL/min, 205 nm; t_r (major) = 15.34 min, t_r (minor) = 12.74 min) gave the isomeric composition of the product: 90% ee; $[\alpha]_D^{15.2}$ = +52.5 (c = 0.92 in $CHCl_3$); m.p. 57.9-60.3 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.55 – 7.53 (m, 2H), 7.22 (d, J = 2.0 Hz, 1H), 7.08 – 7.02 (m, 6H), 6.89 (d, J = 2.5 Hz, 1H), 4.12 (s, 3H), 3.90 (s, 3H), 3.81 (s, 3H), 3.35 (d, J = 13.9 Hz, 1H), 3.25

(d, J = 13.9 Hz, 1H), 1.63 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.04, 170.81, 161.10, 157.93, 156.60, 139.35, 135.50, 133.74, 131.71, 130.12, 129.17, 129.11, 128.27, 126.54, 125.50, 114.42, 103.87, 97.90, 72.63, 56.59, 55.48, 55.42, 41.31, 19.89; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{28}H_{24}ClNNaO_4$ 496.1286; Found: 496.1293.



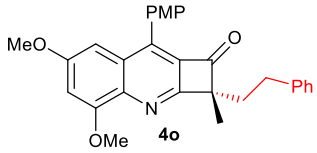
4m

Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4m** in 96% yield (108.5 mg) as a light-yellow oil. HPLC analysis (Chiralcel OD-3, ^{i}PrOH/hexane = 10/90, 0.5 mL/min, 205 nm; t_r (major) = 14.10 min, t_r (minor) = 12.32 min) gave the isomeric composition of the product: 85% ee; $[\alpha]_D^{15.3}$ = +38.3 (c = 0.91 in $CHCl_3$); ^{1}H NMR (400 MHz, Chloroform-d) δ 7.51 (d, J = 8.8 Hz, 2H), 7.08 – 7.04 (m, 5H), 6.93 – 6.88 (m, 3H), 4.12 (s, 3H), 3.89 (s, 3H), 3.81 (s, 3H), 3.37 (d, J = 13.9 Hz, 1H), 3.23 (d, J = 13.9 Hz, 1H), 2.20 (s, 3H), 1.63 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.68, 171.36, 161.00, 157.78, 156.58, 135.75, 135.65, 134.16, 131.71, 129.95, 129.06, 128.63, 125.61, 114.35, 103.63, 97.86, 73.15, 56.55, 55.46, 55.41, 41.44, 20.97, 19.96; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{29}H_{27}NNaO_4$ 476.1832; Found: 476.1835.



4n

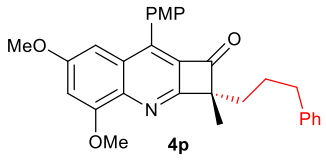
Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4n** in 89% yield (108.6 mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 20/80, 1.0 mL/min, 205 nm; t_r (major) = 15.63 min, t_r (minor) = 13.86 min) gave the isomeric composition of the product: 87% ee; $[\alpha]_D^{15.4}$ = +93.3 (c = 0.95 in $CHCl_3$); m.p. 84.3-86.0 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 8.27 (d, J = 8.5 Hz, 1H), 7.68 (d, J = 8.1 Hz, 1H),7.58 (d, J = 8.2 Hz, 1H), 7.45 – 7.41 (m, 2H), 7.38 – 7.32 (m, 3H), 7.27 – 7.24 (m, 2H), 6.99 – 6.97 (m, 3H), 6.84 (d, J = 2.5 Hz, 1H), 4.11 (s, 3H), 3.89 – 3.76 (m, 8H), 1.74 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 195.25, 171.20, 160.94, 157.74, 156.57, 141.62, 135.59, 133.73, 133.66, 132.25, 131.64, 128.95, 128.90, 128.18, 127.14, 125.51, 125.36, 125.26, 125.12, 125.07, 114.30, 103.65, 97.78, 73.32, 56.56, 55.42, 55.37, 37.78, 20.41; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{32}H_{27}NNaO_4$ 512.1832; Found: 512.1822.



4o

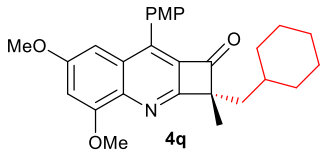
Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4o** in 97% yield (109.3 mg) as a light-yellow oil. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 20/80, 1.0 mL/min,

205 nm; t_r (major) = 14.27 min, t_r (minor) = 11.41 min) gave the isomeric composition of the product: 85% ee; $[\alpha]_D^{15.2}$ = -3.9 (c = 0.69 in $CHCl_3$); ^1H NMR (400 MHz, Chloroform-d) δ 7.72 (d, J = 8.7 Hz, 2H), 7.21 – 7.17 (m, 3H), 7.12 – 7.09 (m, 5H), 6.90 (d, J = 2.5 Hz, 1H), 4.11 (s, 3H), 3.92 (s, 3H), 3.84 (s, 3H), 2.73 – 2.60 (m, 2H), 2.41 – 2.27 (m, 2H), 1.66 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 196.32, 171.77, 161.14, 157.93, 156.63, 142.03, 141.80, 141.74, 135.69, 131.92, 129.15, 129.03, 128.29, 128.25, 125.79, 125.66, 125.30, 114.46, 103.73, 97.98, 72.11, 56.52, 55.52, 55.44, 37.13, 32.17, 20.38. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{29}H_{27}NNaO_4$ 476.1832; Found: 476.1835.



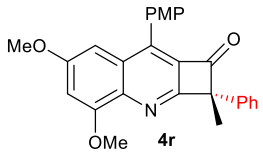
4p

Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4p** in 97% yield (113.0 mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 20/80, 1.0 mL/min, 205 nm; t_r (major) = 12.53 min, t_r (minor) = 8.68 min) gave the isomeric composition of the product: 91% ee; $[\alpha]_D^{15.3}$ = +3.8 (c = 1.08 in $CHCl_3$); m.p. 173.5-175.1 °C; ^1H NMR (400 MHz, Chloroform-d) δ 7.70 (d, J = 8.7 Hz, 2H), 7.20 (t, J = 7.4 Hz, 2H), 7.15 – 7.08 (m, 6H), 6.88 (d, J = 2.5 Hz, 1H), 4.10 (s, 3H), 3.91 (s, 3H), 3.82 (s, 3H), 2.57 (t, J = 7.8 Hz, 2H), 2.14 – 1.99 (m, 2H), 1.70 – 1.60 (m, 5H); ^{13}C NMR (101 MHz, Chloroform-d) δ 196.67, 172.06, 161.11, 157.85, 156.54, 142.02, 135.51, 131.91, 129.13, 128.44, 128.23, 125.70, 125.65, 114.42, 103.66, 97.99, 72.14, 56.53, 55.51, 55.43, 36.33, 35.31, 27.77, 20.41; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{30}H_{29}NNaO_4$ 490.1989; Found: 490.1990.



4q

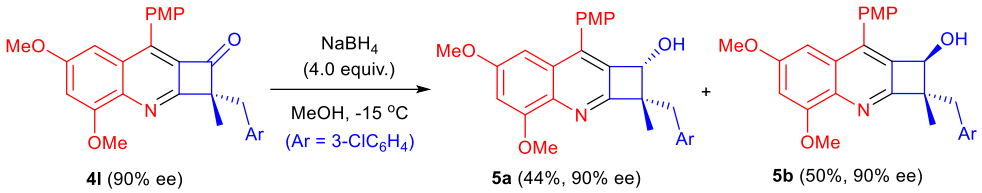
Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4q** in 97% yield (108.1 mg) as a yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 10/90, 1.0 mL/min, 205 nm; t_r (major) = 22.53 min, t_r (minor) = 20.20 min) gave the isomeric composition of the product: 89% ee; $[\alpha]_D^{15.4}$ = +16.5 (c = 0.88 in $CHCl_3$); m.p. 67.3-71 °C; ^1H NMR (400 MHz, Chloroform-d) δ 7.72 (d, J = 8.8 Hz, 2H), 7.16 (d, J = 2.5 Hz, 1H), 7.10 (d, J = 8.8 Hz, 2H), 6.88 (d, J = 2.5 Hz, 1H), 4.10 (s, 3H), 3.90 (s, 3H), 3.83 (s, 3H), 1.94 (d, J = 6.4 Hz, 2H), 1.73 – 1.51 (m, 9H), 1.17 – 1.04 (m, 3H), 0.97 – 0.84 (m, 2H); ^{13}C NMR (101 MHz, Chloroform-d) δ 196.82, 172.49, 161.05, 157.79, 156.61, 141.85, 141.70, 135.69, 131.83, 129.03, 125.69, 114.42, 103.60, 97.92, 71.84, 56.50, 55.47, 55.40, 43.11, 34.76, 34.36, 34.14, 26.21, 26.15, 26.12, 21.02; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{28}H_{31}NNaO_4$ 468.2145; Found: 468.2150.



4r

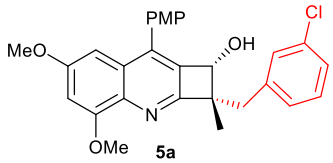
Column chromatography using DCM/EtOAc (50/1-40/1) as the eluent afforded **4r** in 84% yield (89.3 mg) as a light-yellow oil. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 20/80, 1.0 mL/min, 205 nm; t_r (major) = 18.37 min, t_r (minor) = 7.54 min) gave the isomeric composition of the product: 77% ee; $[\alpha]_D^{15.3}$ = +64.6 (c = 0.36 in $CHCl_3$); m.p. 129.4-133.2 ^{o}C; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.72 (d, J = 8.8 Hz, 2H), 7.68 – 7.66 (m, 2H), 7.33 (t, J = 7.5 Hz, 2H), 7.26 – 7.20 (m, 1H), 7.16 (d, J = 2.6 Hz, 1H), 7.10 – 7.08 (m, 2H), 6.92 (d, J = 2.5 Hz, 1H), 4.13 (s, 3H), 3.90 (s, 3H), 3.84 (s, 3H), 1.98 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 193.12, 170.40, 161.18, 158.09, 156.71, 143.05, 142.11, 140.41, 135.33, 131.93, 129.25, 128.49, 126.97, 126.24, 125.52, 114.44, 103.90, 97.89, 75.16, 56.57, 55.54, 55.45, 23.25. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{27}H_{23}NNaO_4$ 448.1519; Found: 448.1515.

4. General procedure for the reduction of 4l to 5.



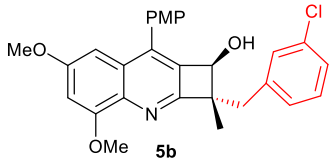
4l (90% ee) **5a** (44%, 90% ee) **5b** (50%, 90% ee)

To a flame dried 25 mL Schlenk tube was added **4l** (0.47 mmol, 223 mg), the tube was the evacuated, back filled with N_2 and added anhydrous MeOH (3 mL). The solution was cooled to -15 °C and stirred for 15 min before the slowly addition of $NaBH_4$. After additional 1.0 hour at -15 °C, the reaction was quenched by slowly addition of saturated NH_4Cl (5 mL) and diluted with EtOAc (20 mL). The biphasic solution was separated and the organic phase was dried over anhydrous $MgSO_4$. After filtration, the solvent was evaporated under vacuum and the residue was subjected to column chromatography to afford **5a** and **5b**.



5a

Column chromatography using PE/EtOAc (3/1-1/1) as the eluent afforded **5a** in 44% yield (98.6 mg) as a light-yellow soild. HPLC analysis (Chiralcel OD-H, ^{i}PrOH/hexane = 15/85, 1.0 mL/min, 205 nm; t_r (major) = 16.84 min, t_r (minor) = 13.78 min) gave the isomeric composition of the product: 90% ee; $[\alpha]_D^{32.2}$ = +16.7 (c = 0.90 in $CHCl_3$); m.p. 84.5-86.2 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.60 (d, J = 8.7 Hz, 2H), 7.48 (s, 1H), 7.26 – 7.17 (m, 3H), 7.05 (d, J = 8.7 Hz, 2H), 6.95 (d, J = 2.6 Hz, 1H), 6.75 (d, J = 2.6 Hz, 1H), 5.05 (s, 1H), 4.06 (s, 3H), 3.89 (s, 3H), 3.79 (s, 3H), 3.33 – 3.23 (m, 2H), 1.42 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 166.29, 160.05, 157.21, 156.45, 142.40, 140.56, 135.77, 134.00, 131.26, 129.88, 129.47, 128.07, 126.82, 126.50, 114.21, 100.75, 96.84, 74.85, 58.90, 56.34, 55.39, 55.35, 42.50, 18.06; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{28}H_{26}ClNNaO_4$ 498.1443; Found: 498.1444.



5b

Column chromatography using PE/EtOAc (3/1-1/1) as the eluent afforded **5b** in 50% yield (111.0 mg) as a light-yellow solid. HPLC analysis (Chiralcel AD-H, ^{i}PrOH/hexane = 15/85, 1.0 mL/min, 205 nm; t_r (major) = 16.70 min, t_r (minor) = 10.34 min) gave the isomeric composition of the product: 90% ee; $[\alpha]_D^{32.2}$ = +84.8 (c = 0.82 in $CHCl_3$); m.p. 91.5-92.3 °C; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.58 (d, J = 8.8 Hz, 2H), 7.25 (d, J = 10.9 Hz, 1H), 7.16 – 7.03 (m, 5H), 6.95 (d, J = 2.6 Hz,

1H), 6.76 (d, J = 2.6 Hz, 1H), 5.19 (s, 1H), 4.07 (s, 3H), 3.88 (s, 3H), 3.78 (s, 3H), 3.22 (dd, 2H), 1.45 (s, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 166.27, 160.05, 157.22, 156.44, 142.42, 140.55, 135.74, 134.00, 131.26, 129.88, 129.47, 128.07, 126.81, 126.50, 114.21, 100.75, 96.83, 74.84, 58.89, 56.33, 55.40, 55.35, 42.50, 18.06; HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{28}H_{26}ClNNaO_4$ 498.1443; Found: 498.1444.

5. Crystallographic information for product 4a

The single crystal of compound **4a** was prepared from its solution in dichloromethane/petroleum ether by slow evaporation of the solvent. The data integration and empirical absorption correction were carried out using SAINT program. Using Olex2 and SHELXTL, the structure was solved by direct method and refined matrix least-squares on F2 with anisotropic displacement. Non-hydrogen atoms were refined an isotropically, hydrogen atoms were constrained to ideal geometries. The absolute configuration was determined by single crystal X-ray diffraction analysis on Rigaku XtaLAB PRO MM003-DS dual system with a Cu micro-focus source.

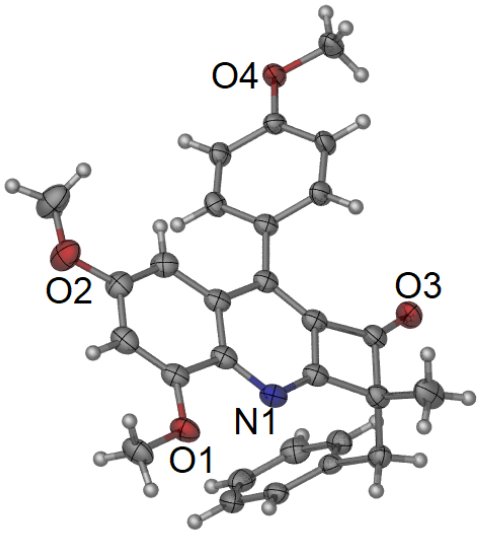


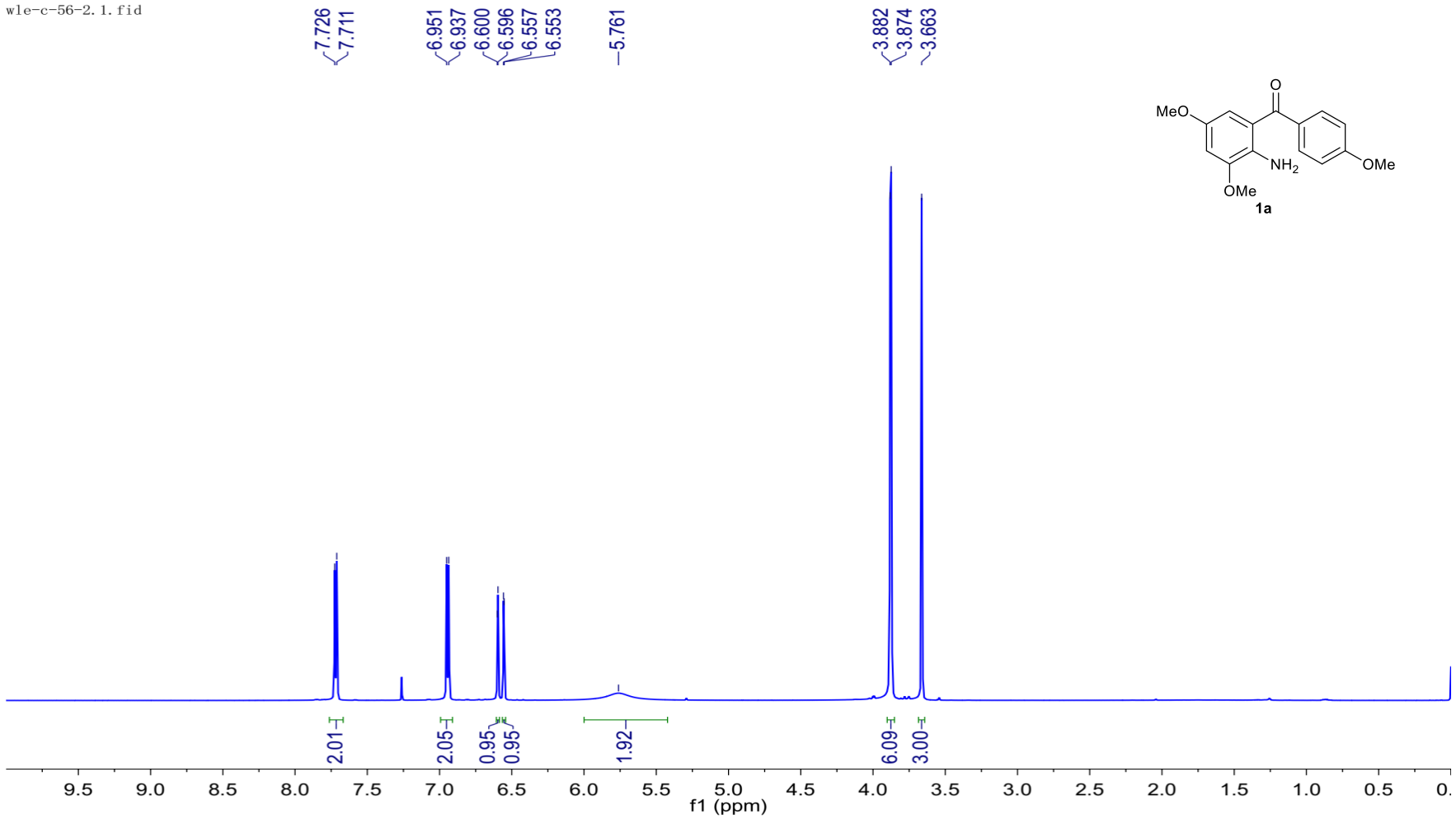
Figure S1. ORTEP of **4a** (The ellipsoid contour of probability level is 50%).

Table S1 Crystal data and structure refinement for 4a.

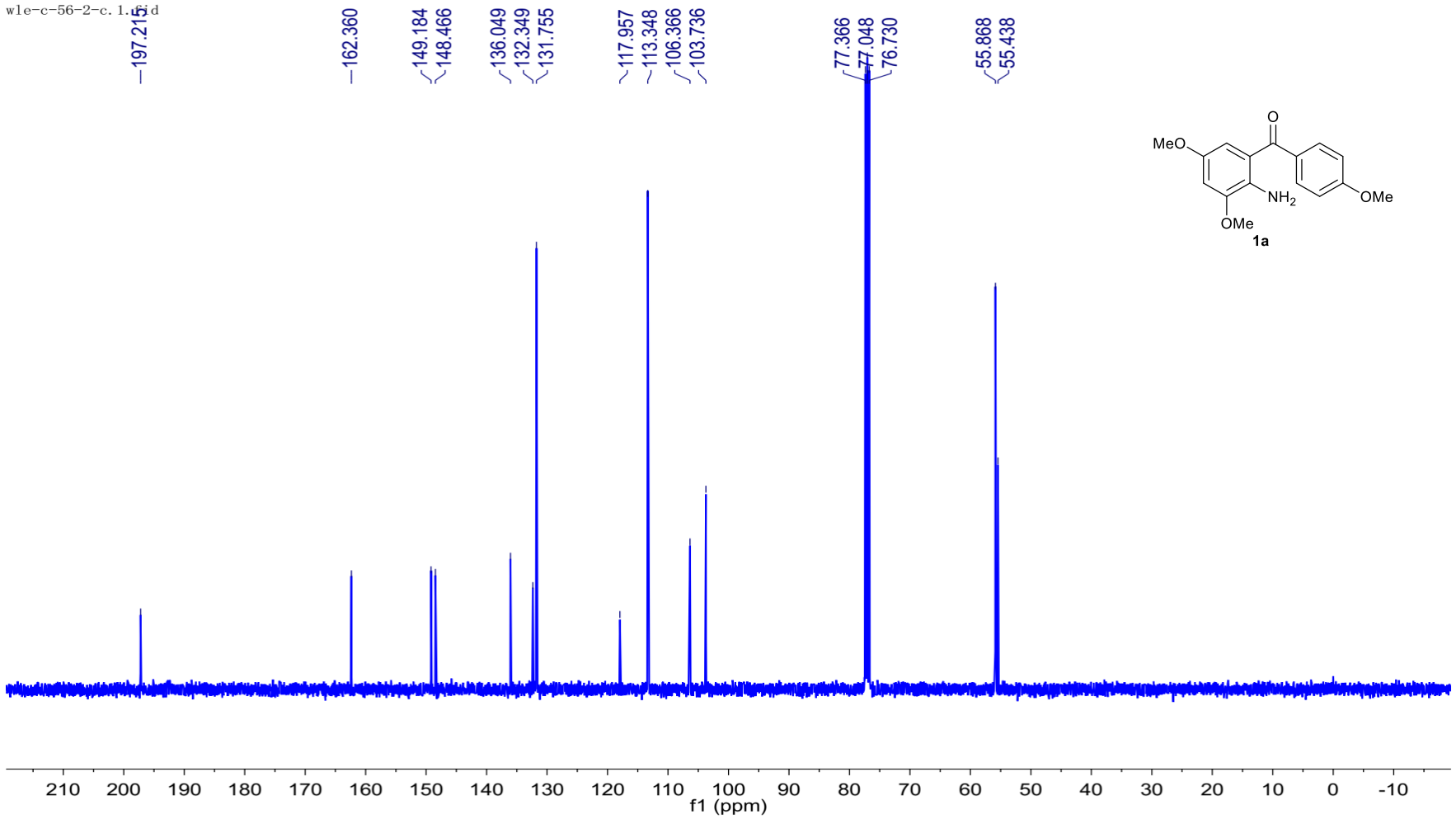
Deposition Number	2364614
Identification code	exp_3756_auto
Empirical formula	$C_{28}H_{25}NO_4$
Formula weight	439.49
Temperature/K	173.00(10)
Crystal system	orthorhombic
Space group	$P2_12_12_1$
a/Å	10.00580(10)
b/Å	16.9779(2)
c/Å	26.8076(2)
α/°	90
β/°	90
γ/°	90
Volume/Å^3	4554.01(8)
Z	8
ρ_{calc}g/cm^3	1.282

μ/mm^{-1}	0.689
F(000)	1856.0
Crystal size/mm^3	0.36 × 0.32 × 0.26
Radiation	Cu Kα (λ = 1.54184)
2Θ range for data collection/°	6.162 to 134.158
Index ranges	$-11 \leq h \leq 11$, $-20 \leq k \leq 20$, $-32 \leq l \leq 32$
Reflections collected	121861
Independent reflections	8098 [R_{int} = 0.0538, R_{sigma} = 0.0185]
Data/restraints/parameters	8098/0/603
Goodness-of-fit on F^2	1.050
Final R indexes [I>=2σ (I)]	R_1 = 0.0304, wR_2 = 0.0761
Final R indexes [all data]	R_1 = 0.0316, wR_2 = 0.0767
Largest diff. peak/hole / e $Å^{-3}$	0.52/-0.14
Flack parameter	-0.04(4)

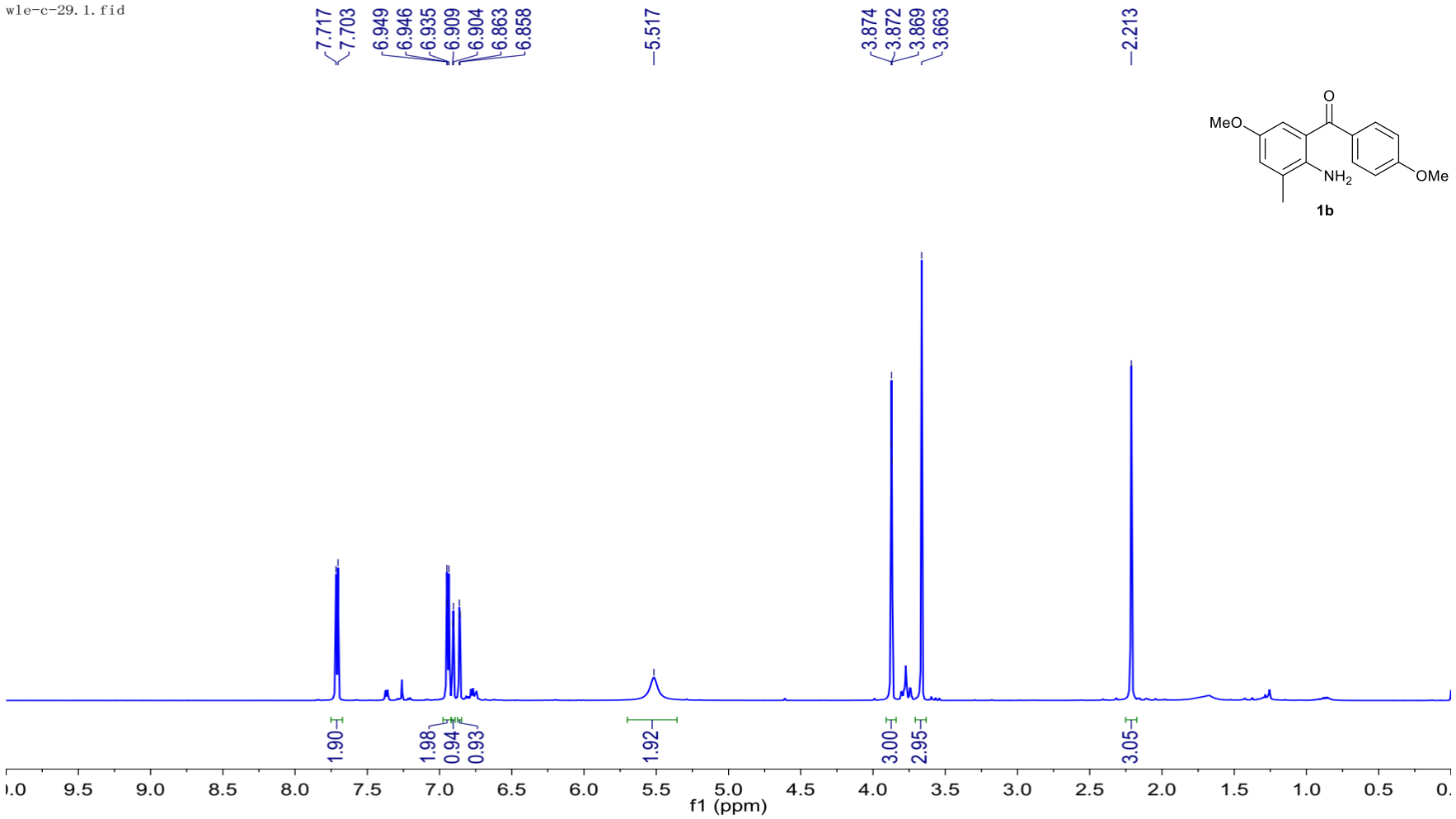
^{1}H NMR Spectrum (600 MHz, Chloroform-d) of **1a**



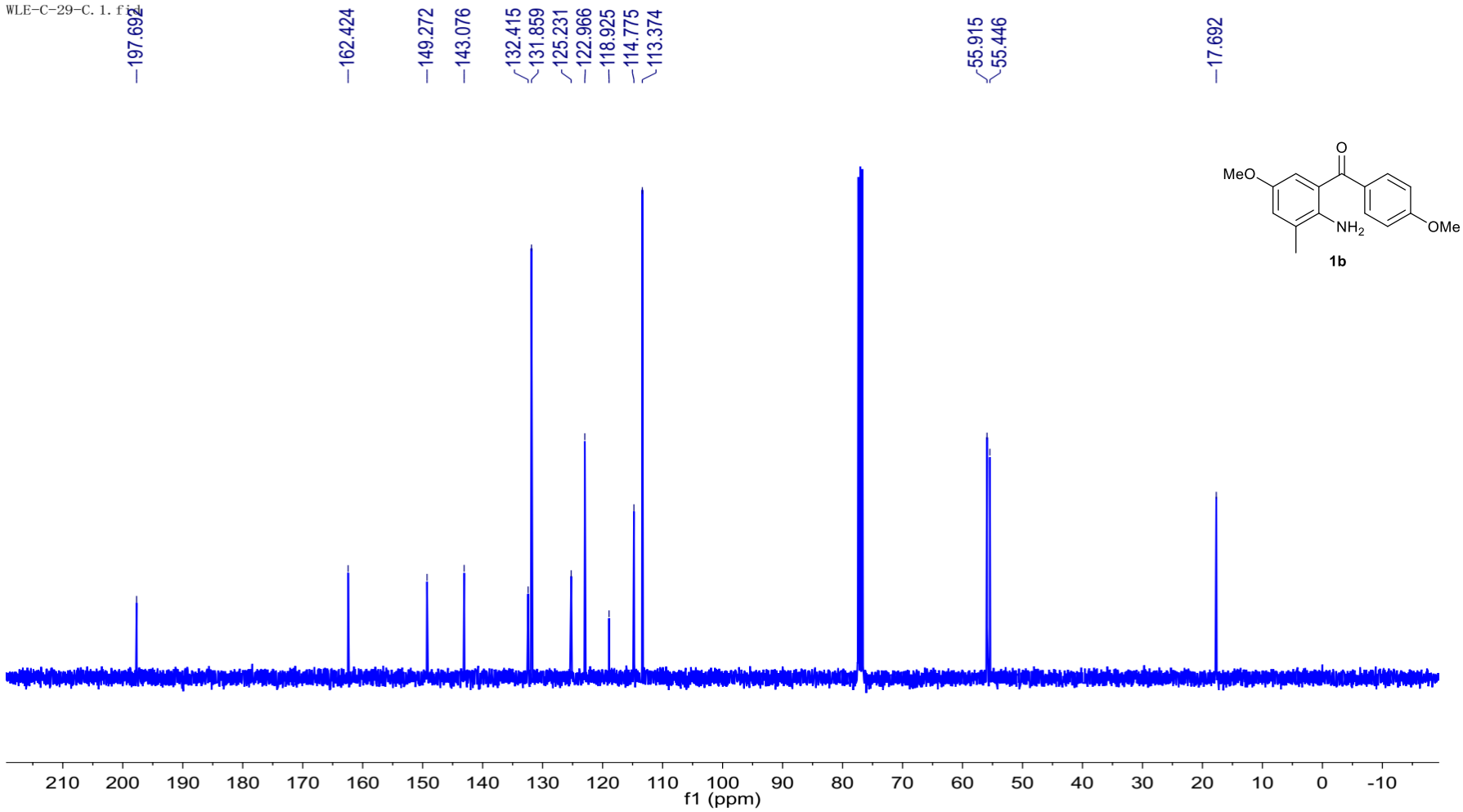
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **1a**



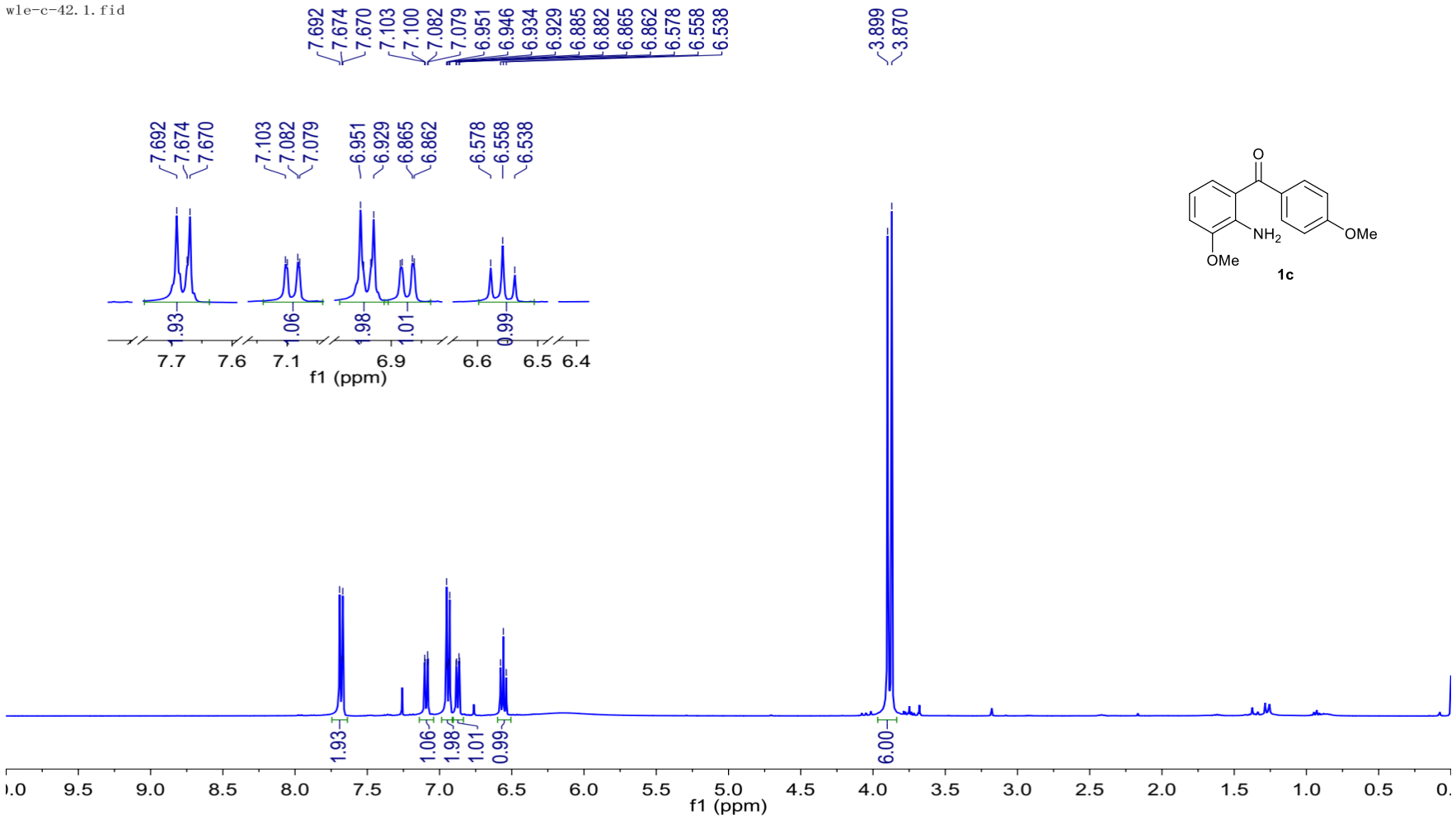
[1]H NMR Spectrum (600 MHz, Chloroform-d) of **1b**



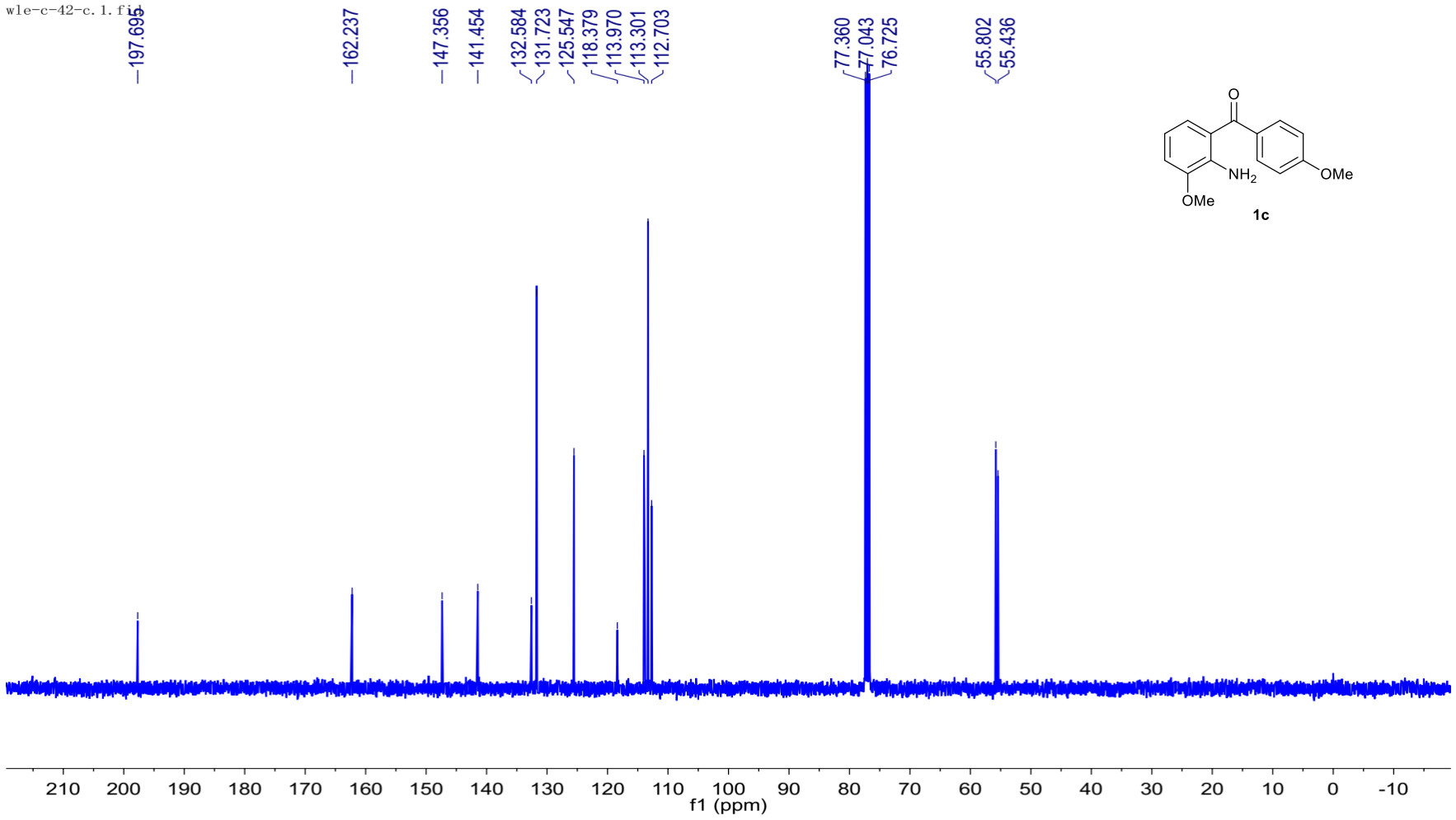
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **1b**



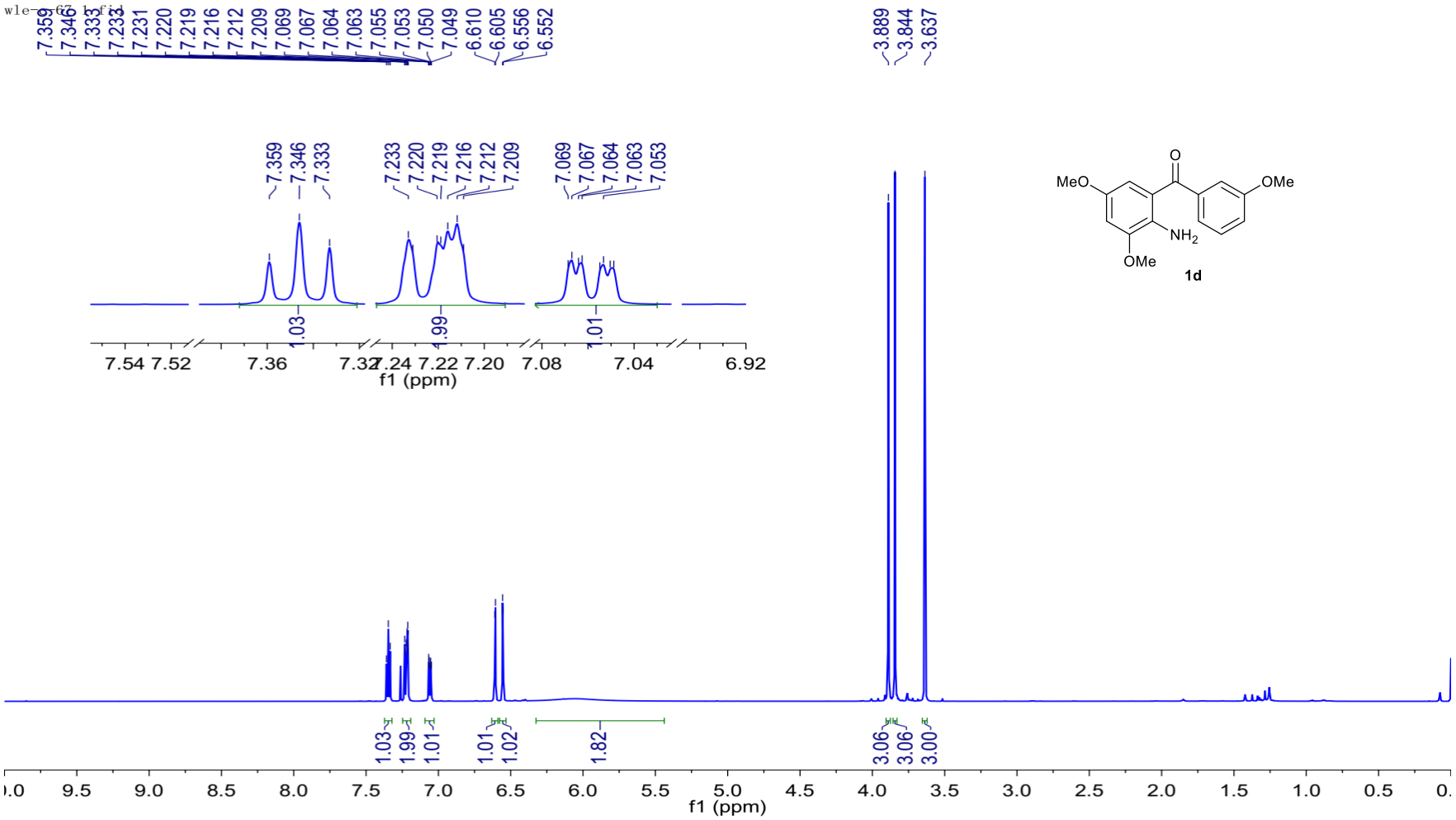
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **1c**



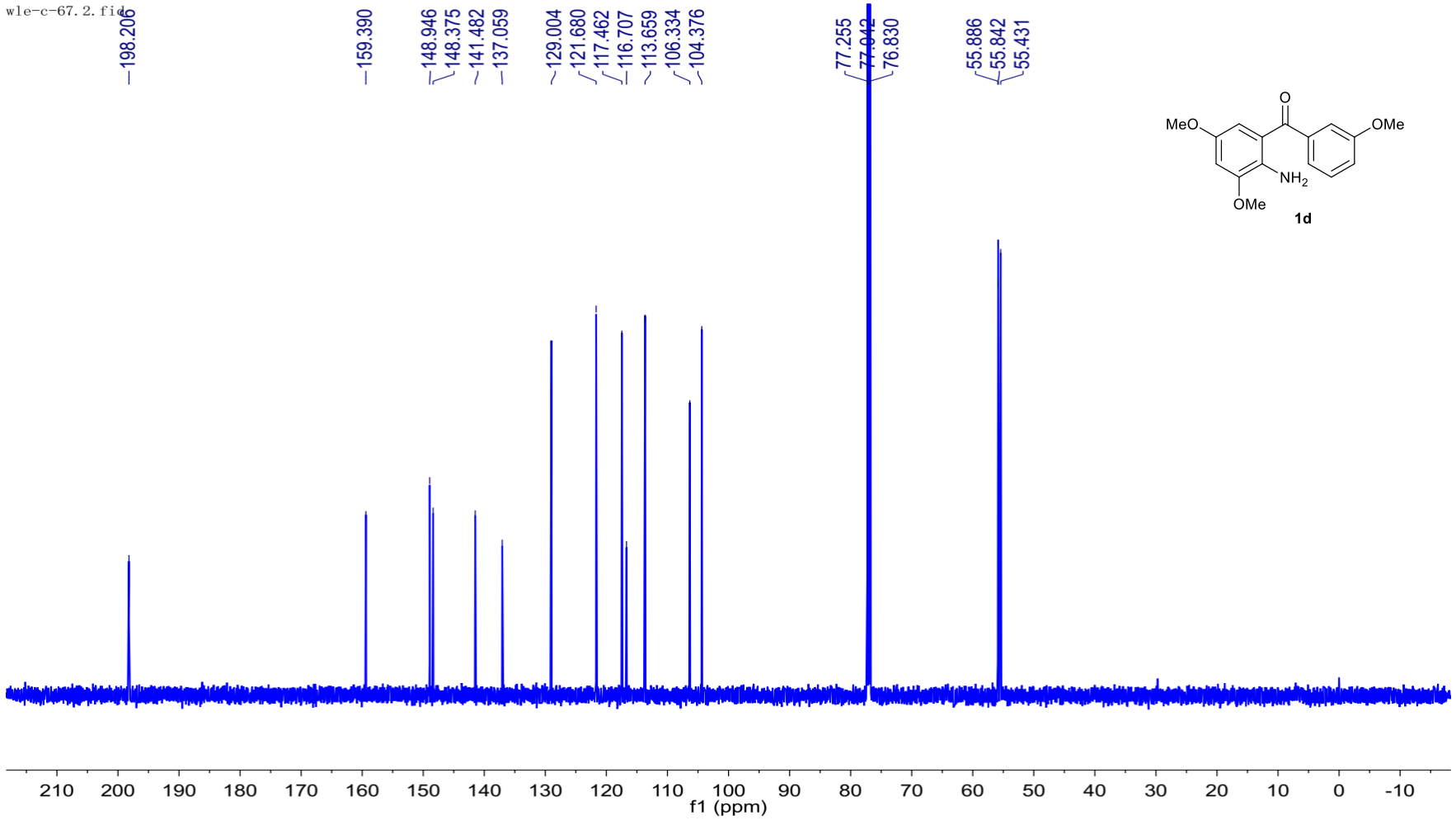
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **1c**



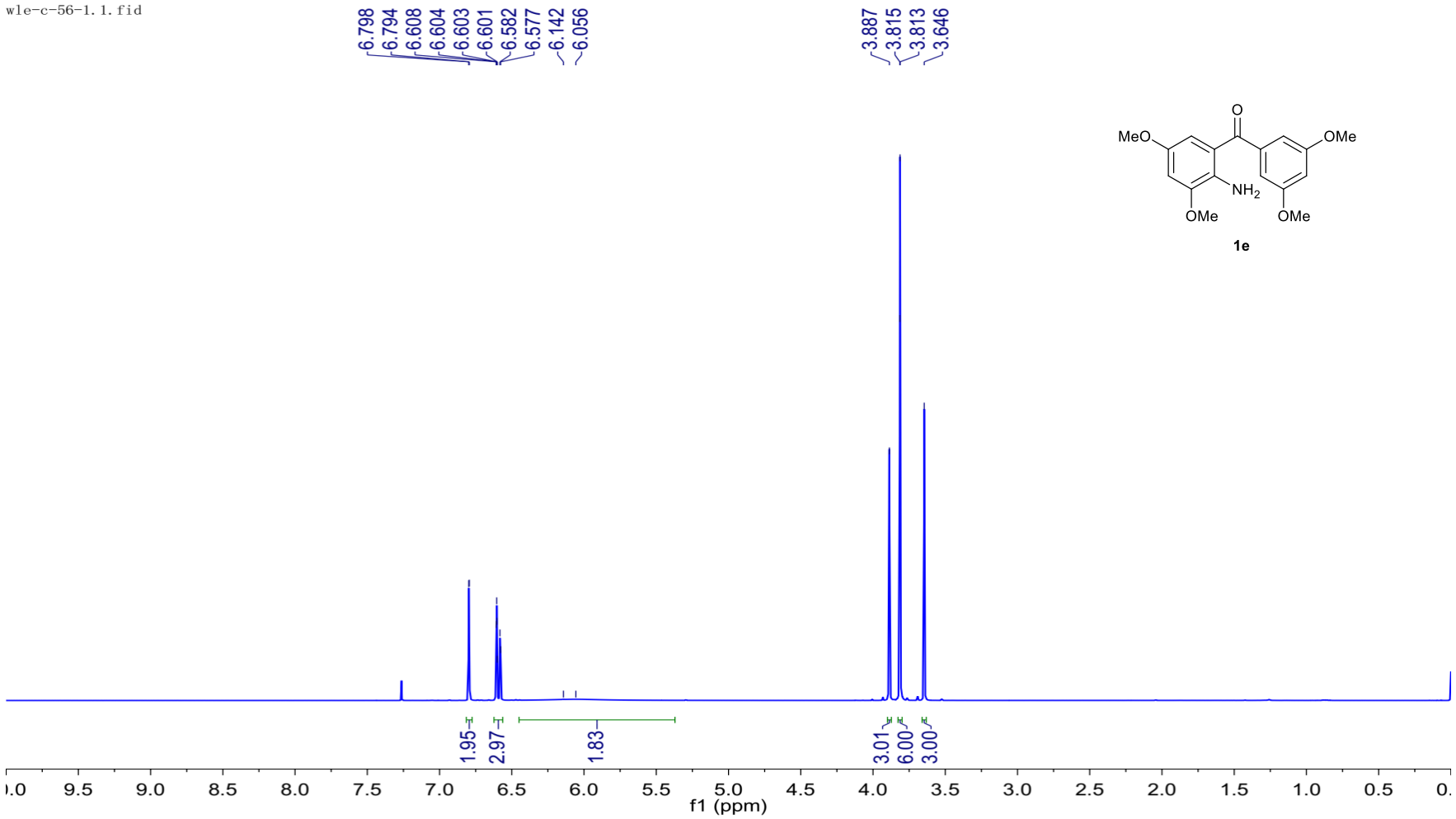
^{1}H NMR Spectrum (600 MHz, Chloroform-d) of **1d**



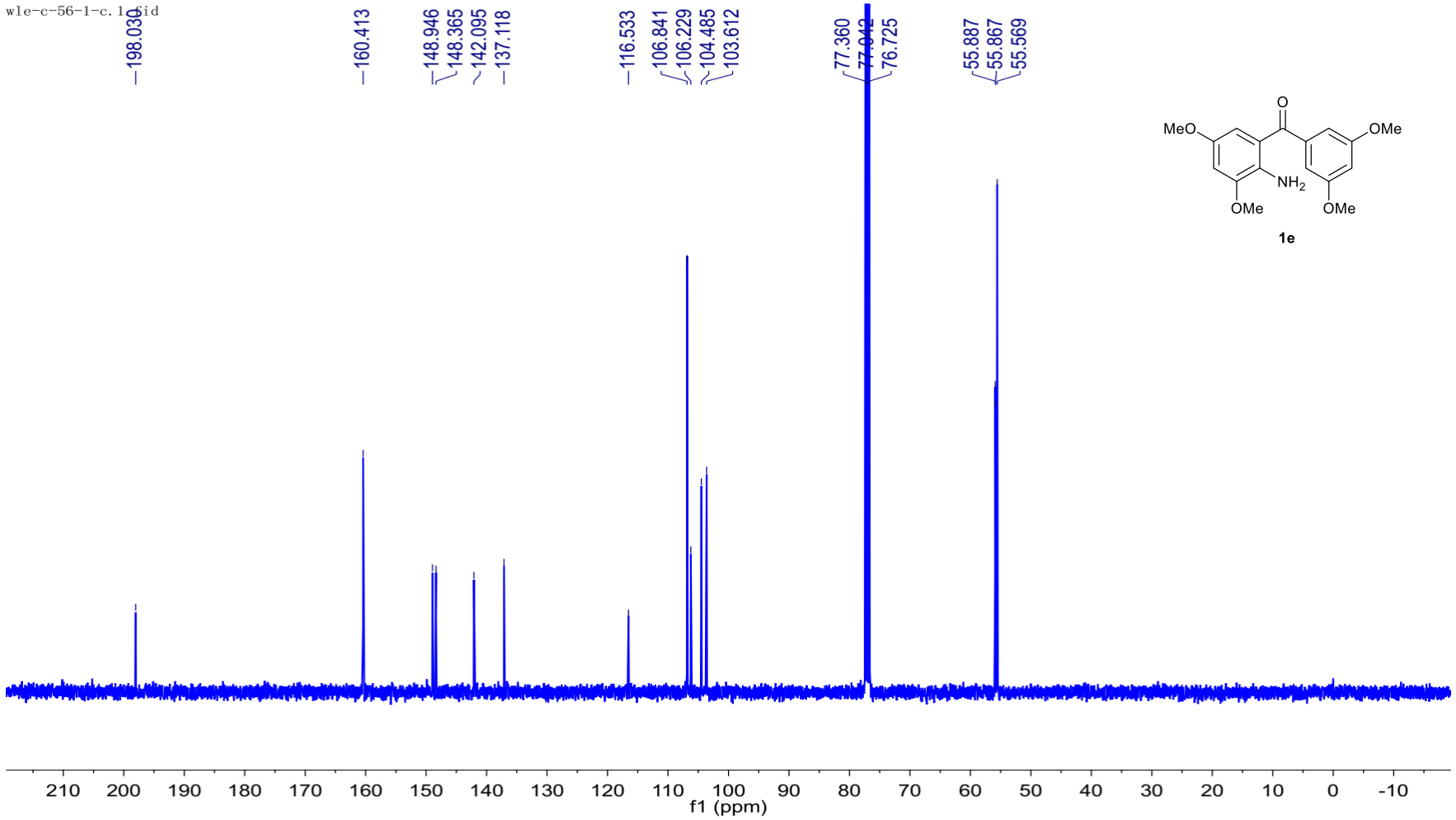
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **1d**



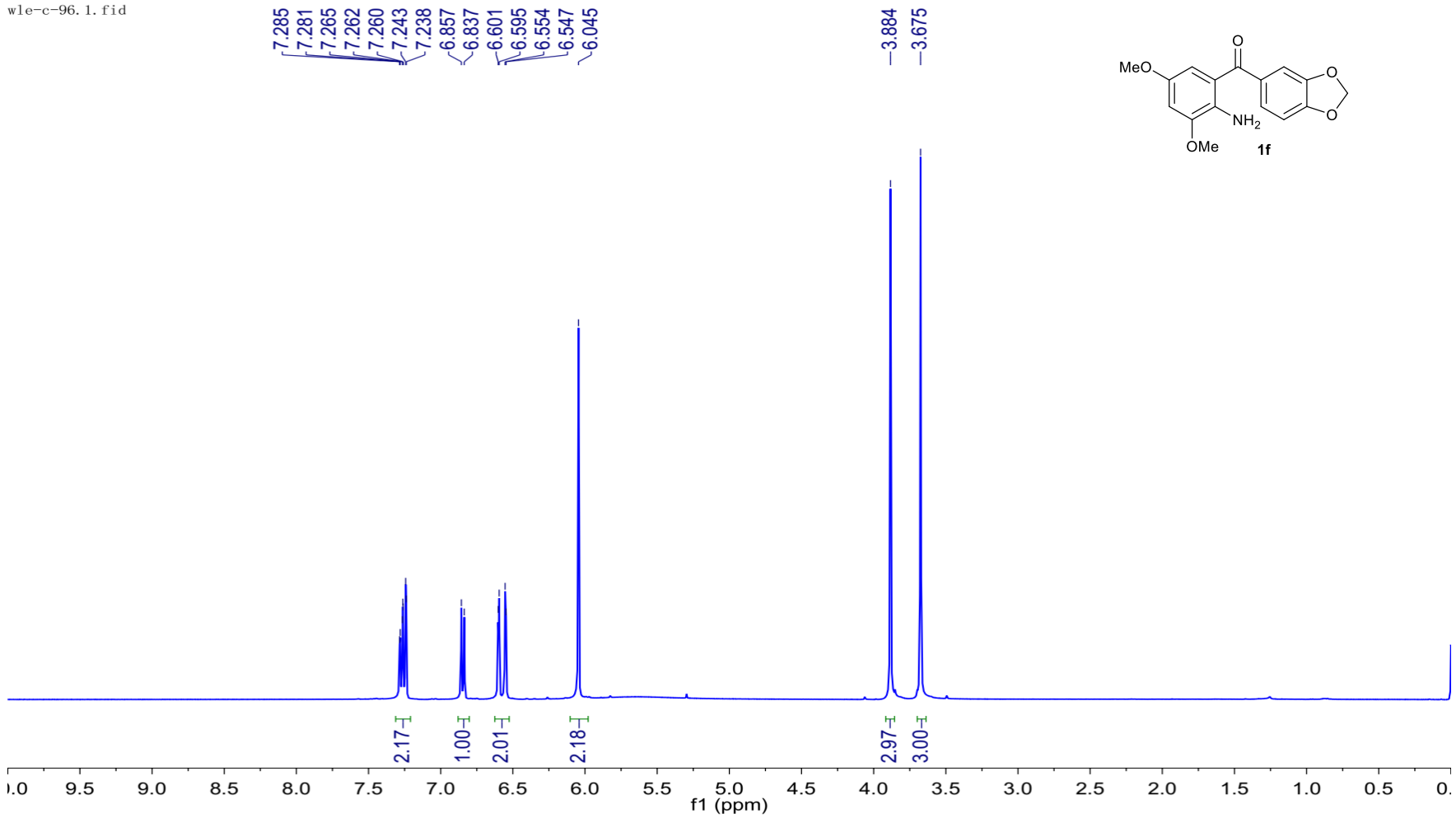
[1]H NMR Spectrum (600 MHz, Chloroform-d) of **1e**



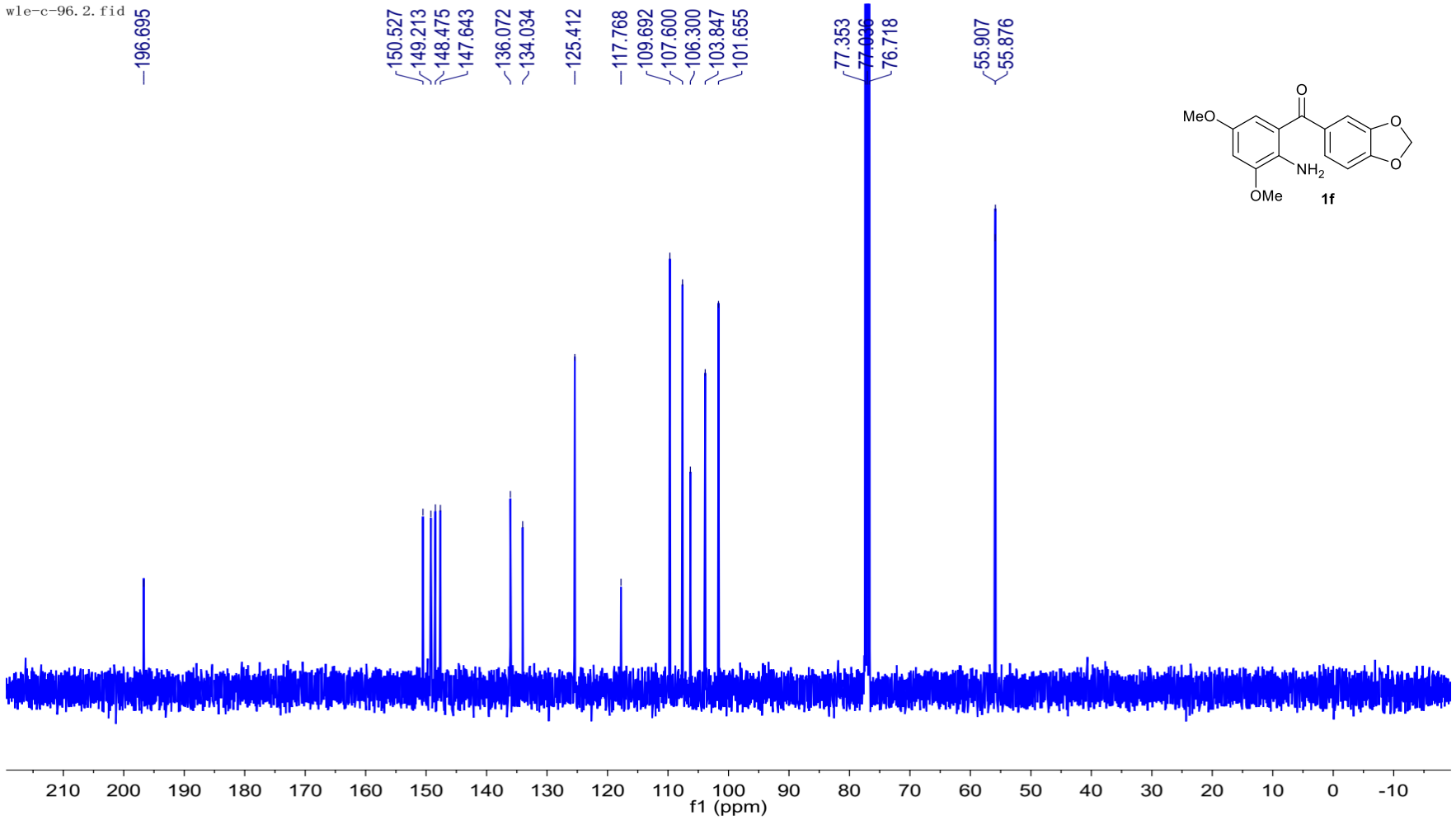
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **1e**



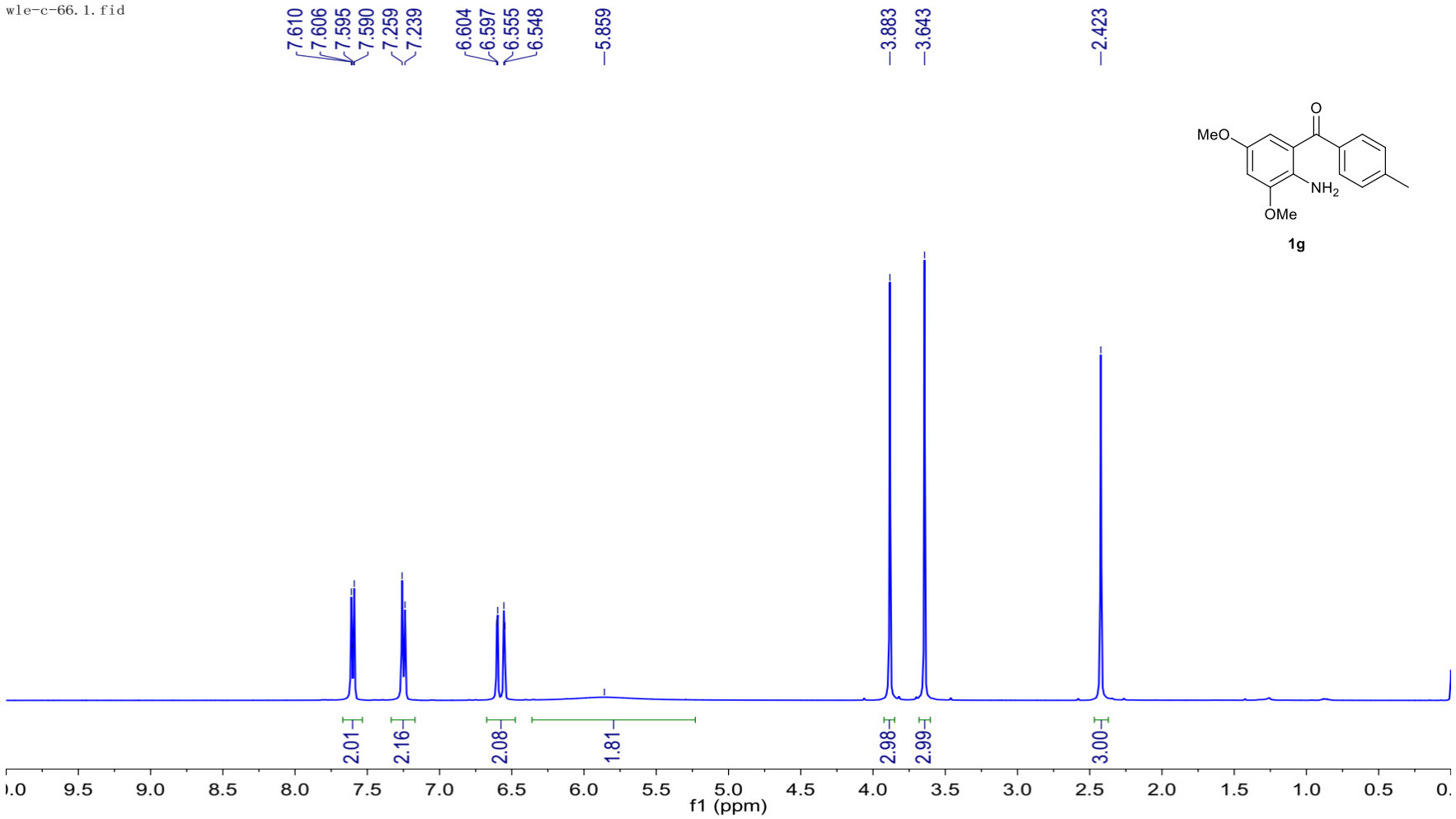
^{1}H NMR Spectrum (400 MHz, Chloroform-d) of **1f**



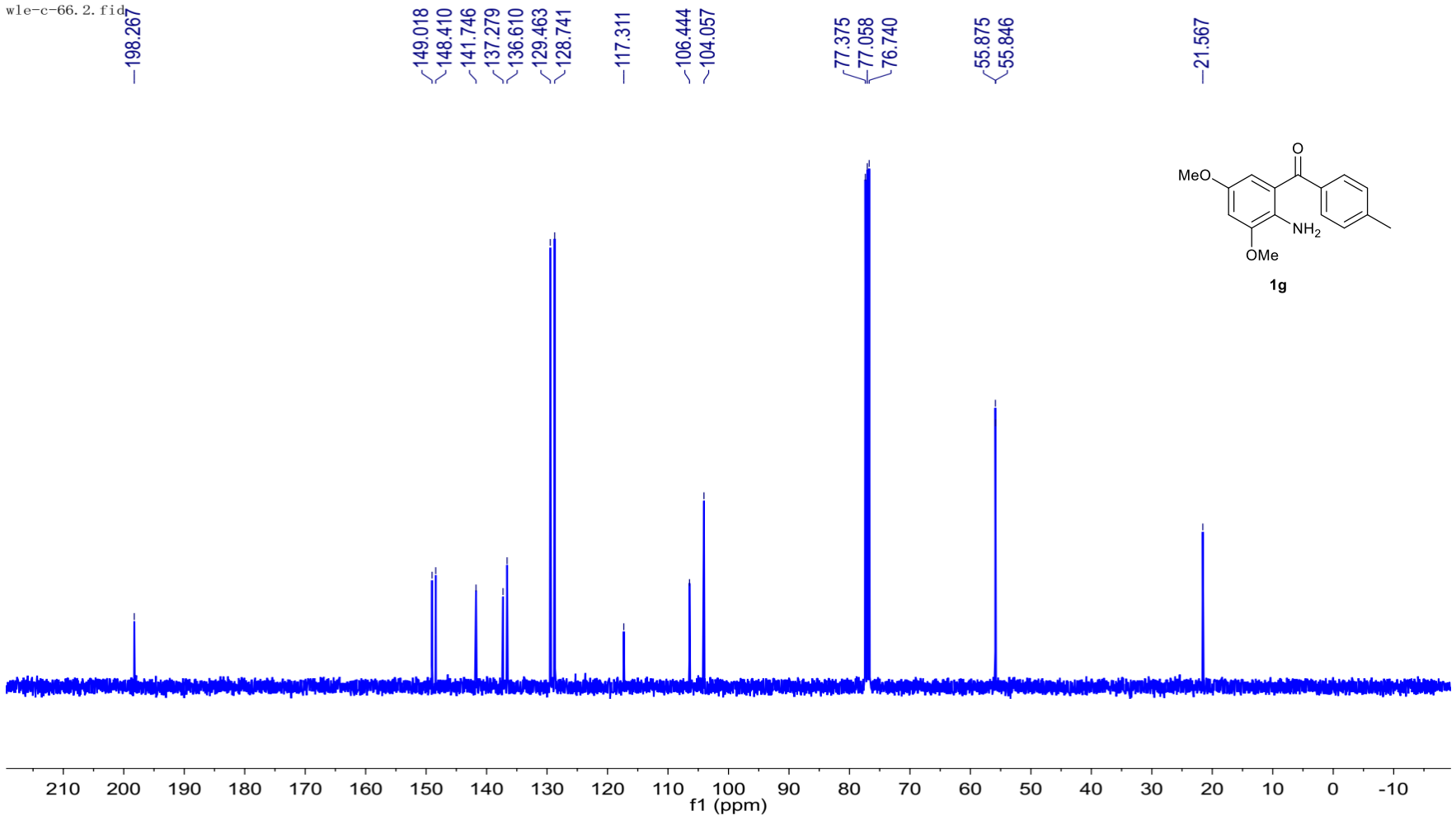
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **1f**



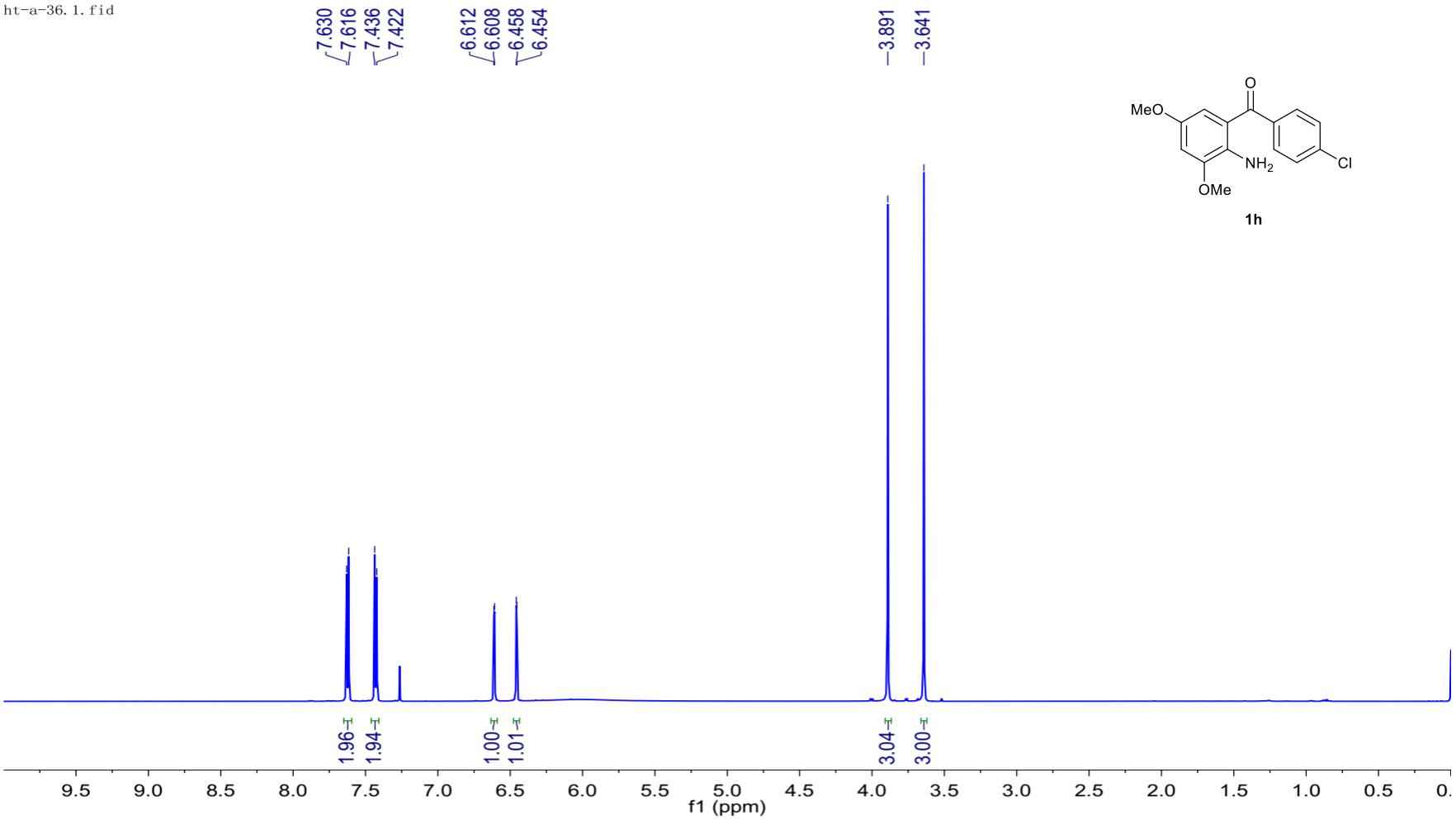
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **1g**



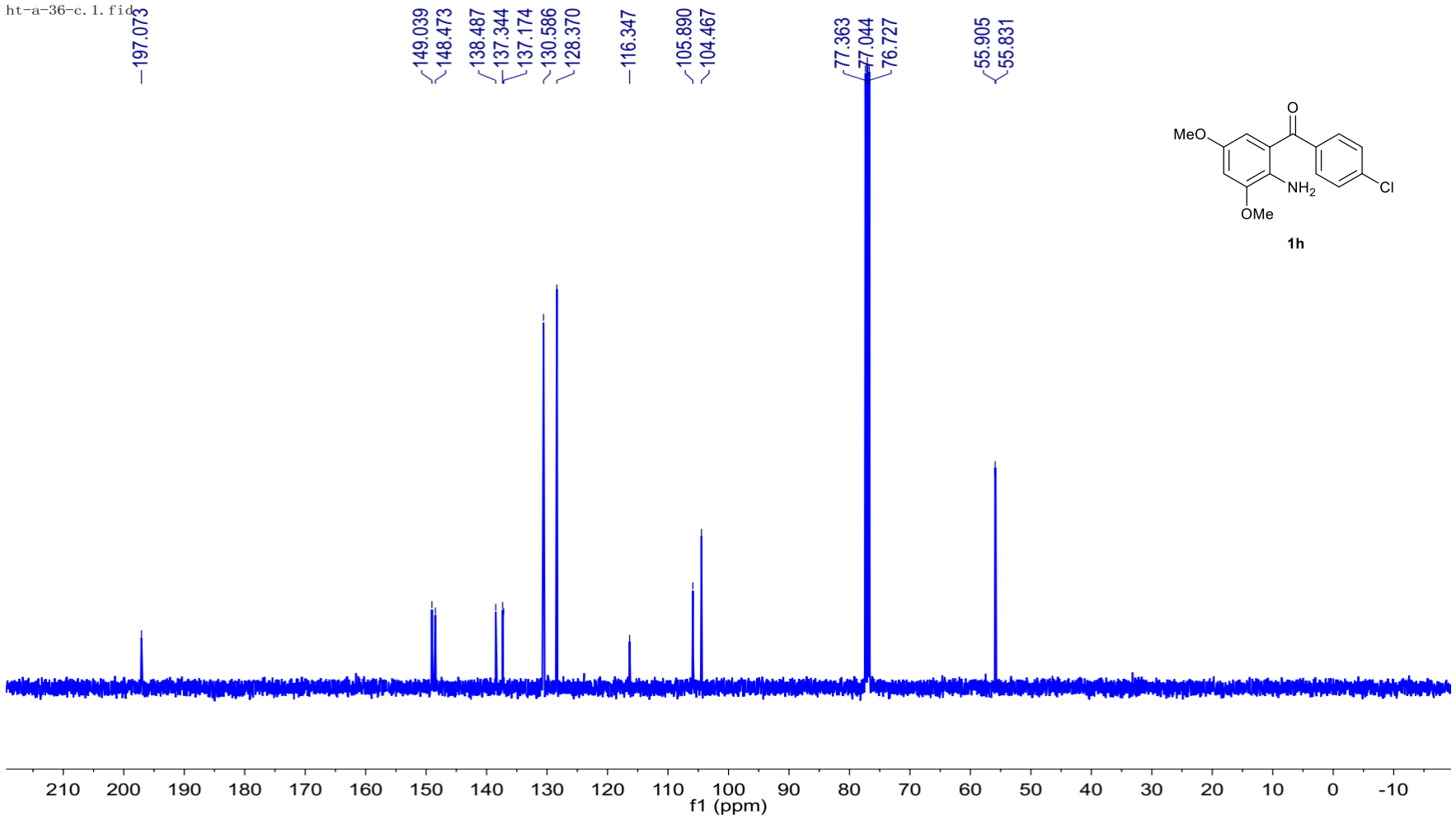
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **1g**



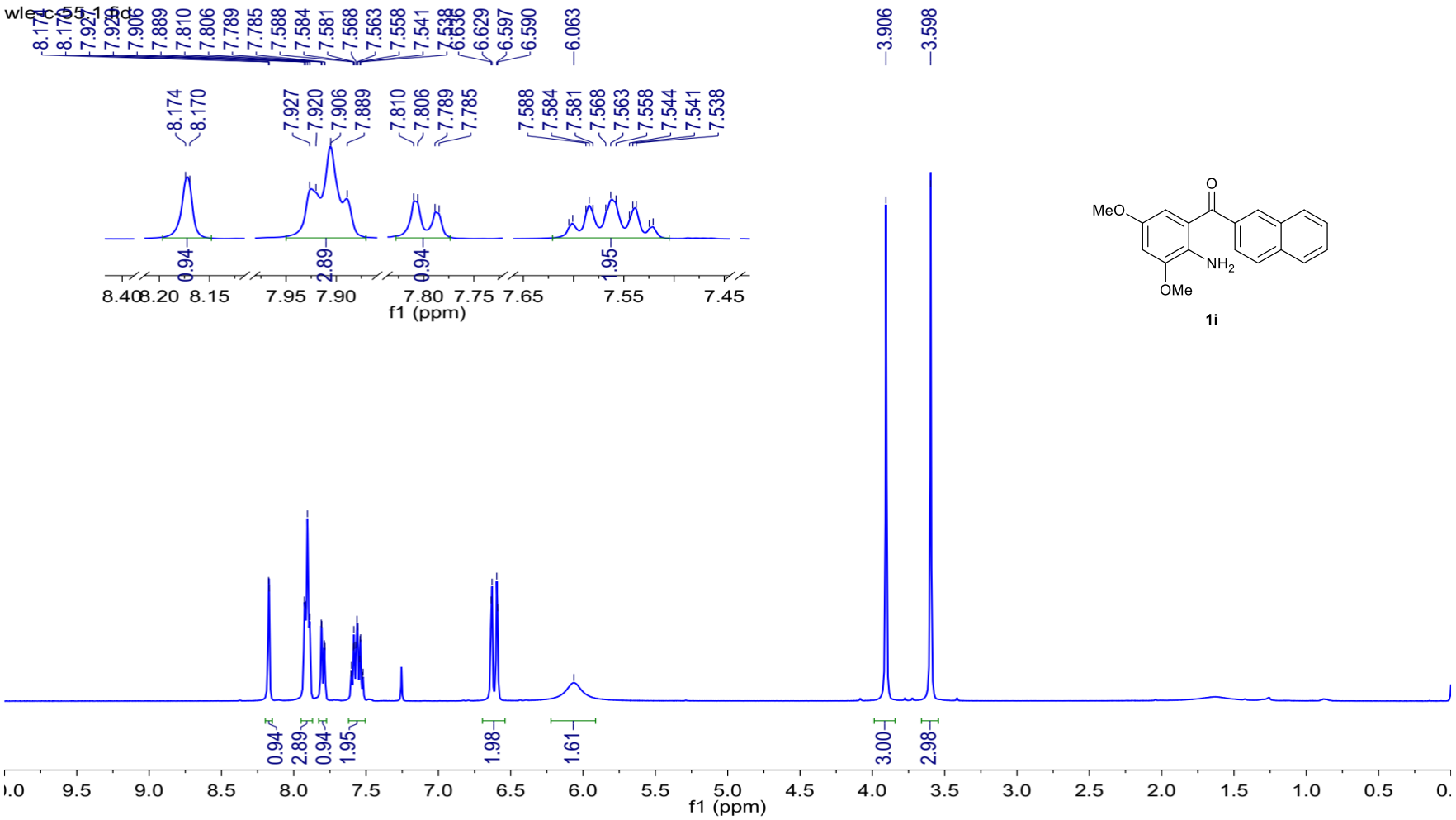
[1]H NMR Spectrum (600 MHz, Chloroform-d) of **1h**



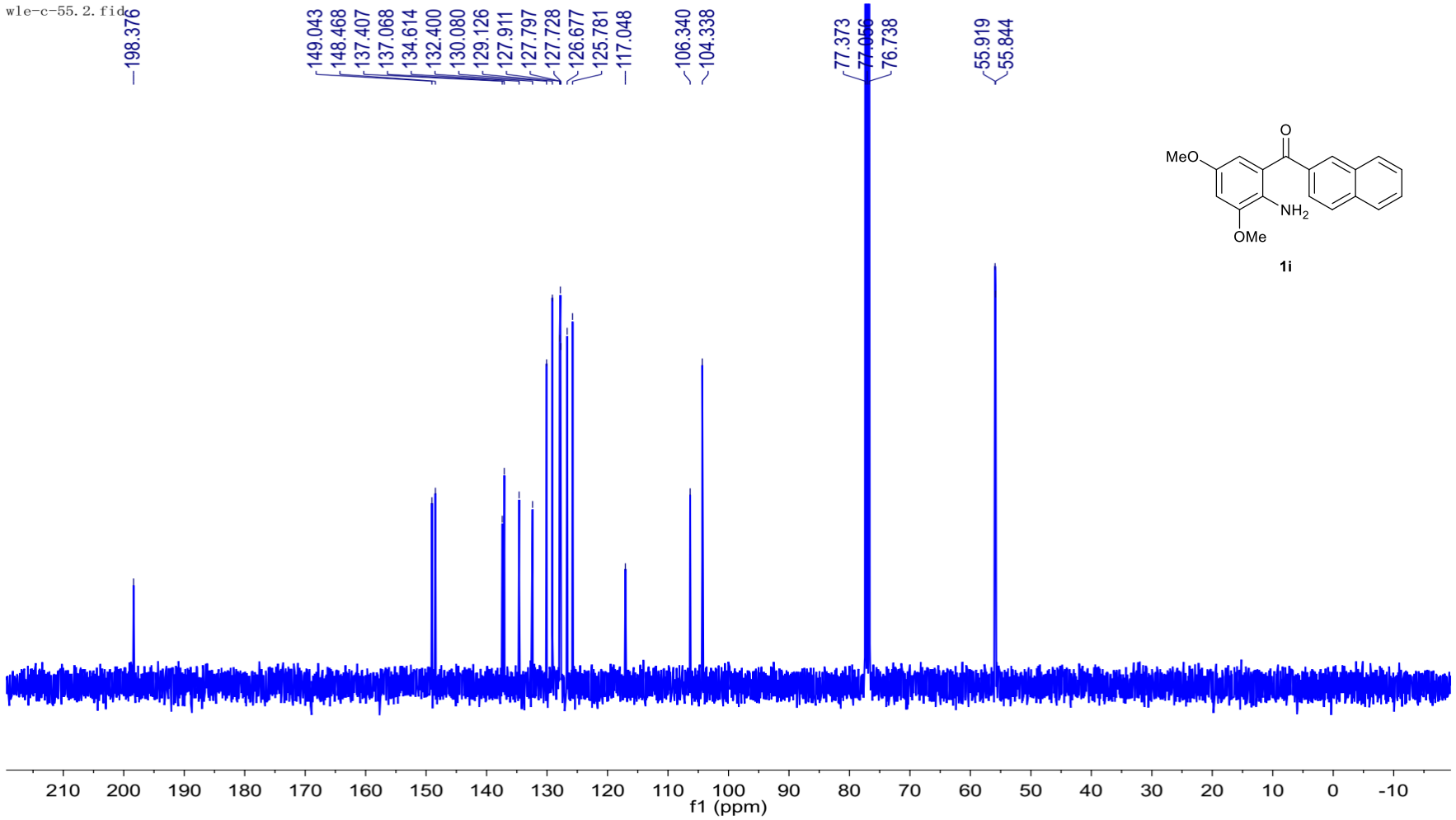
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **1h**



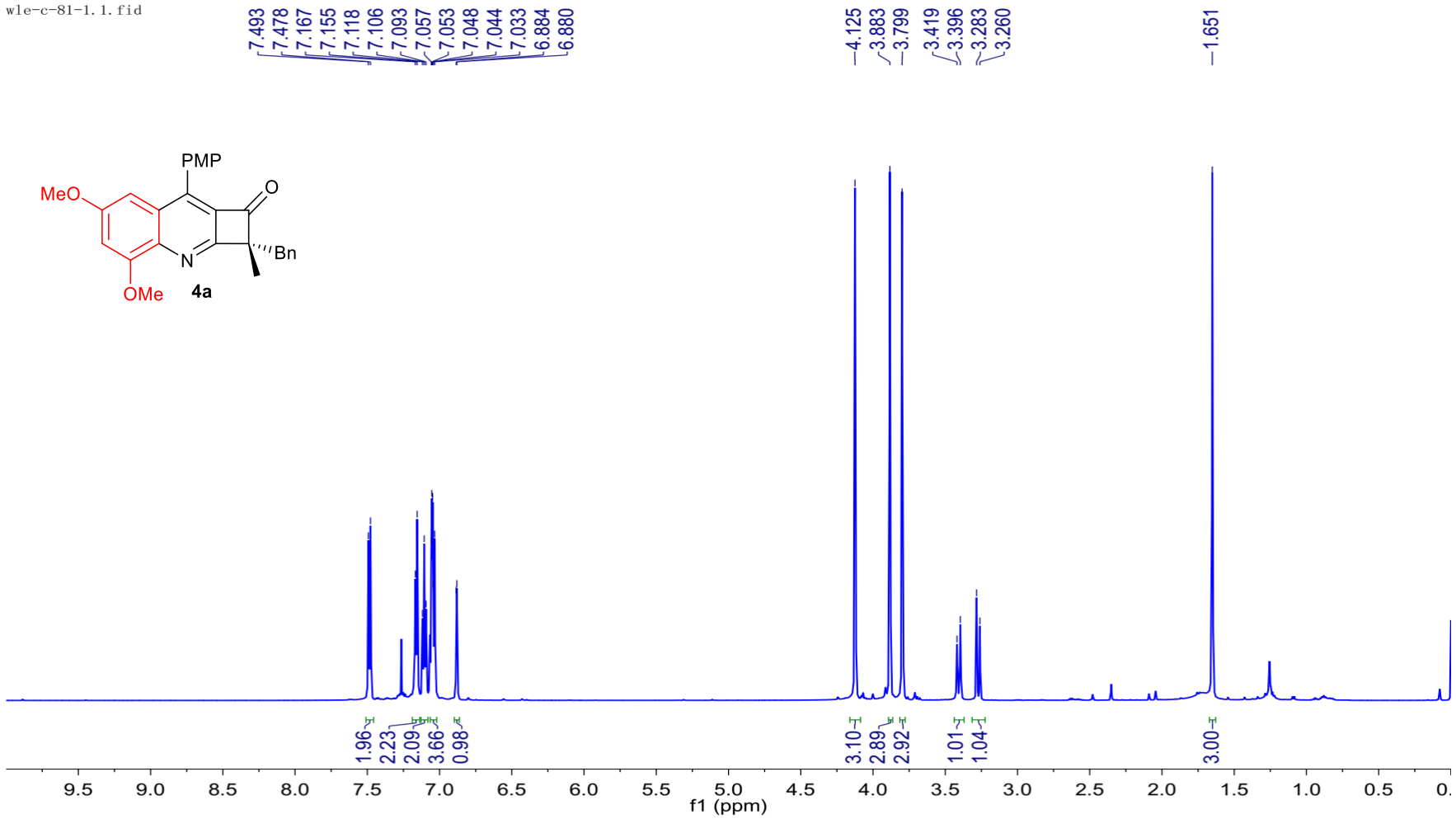
^{1}H NMR Spectrum (400 MHz, Chloroform-d) of **1i**



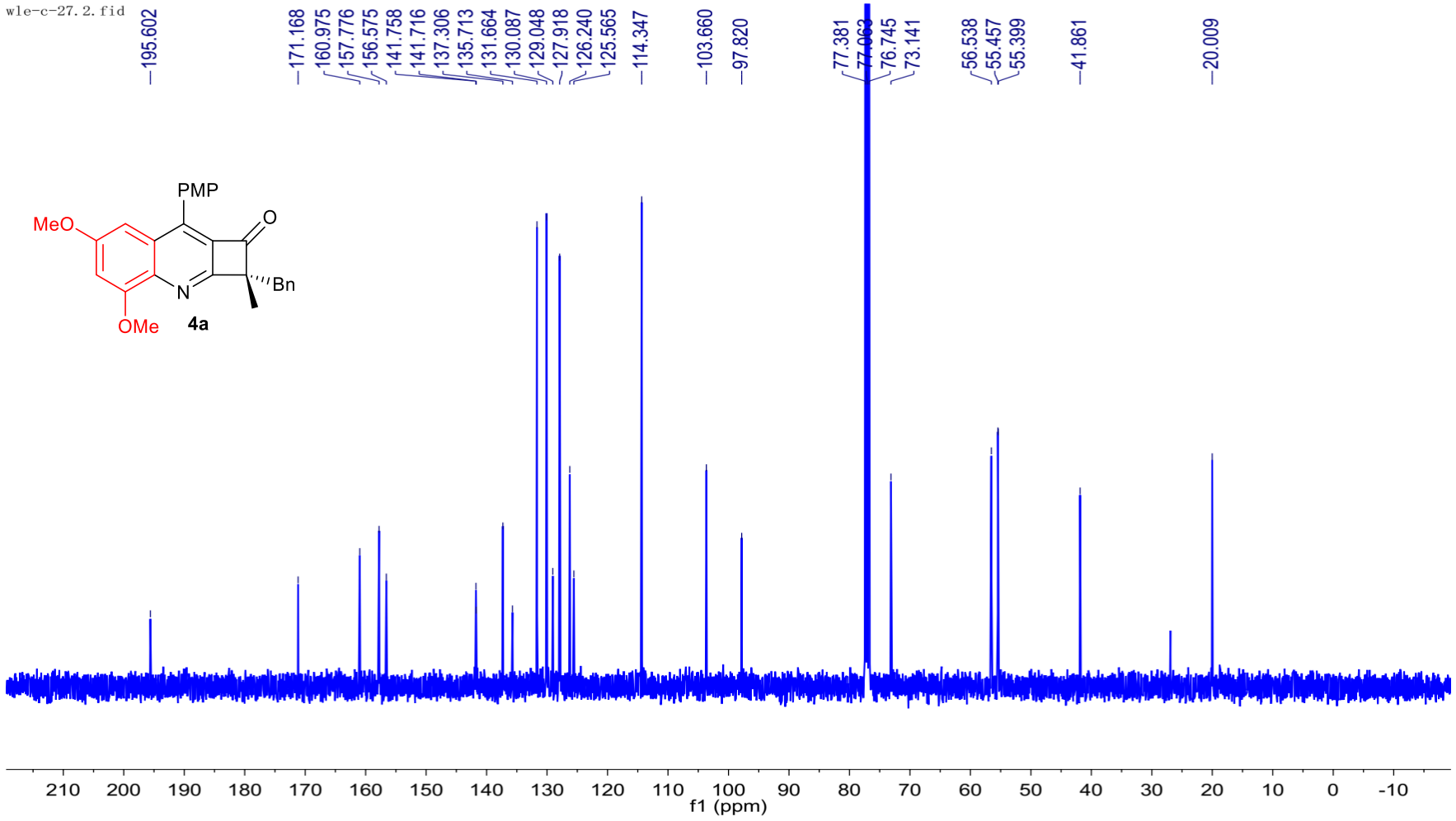
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **1i**



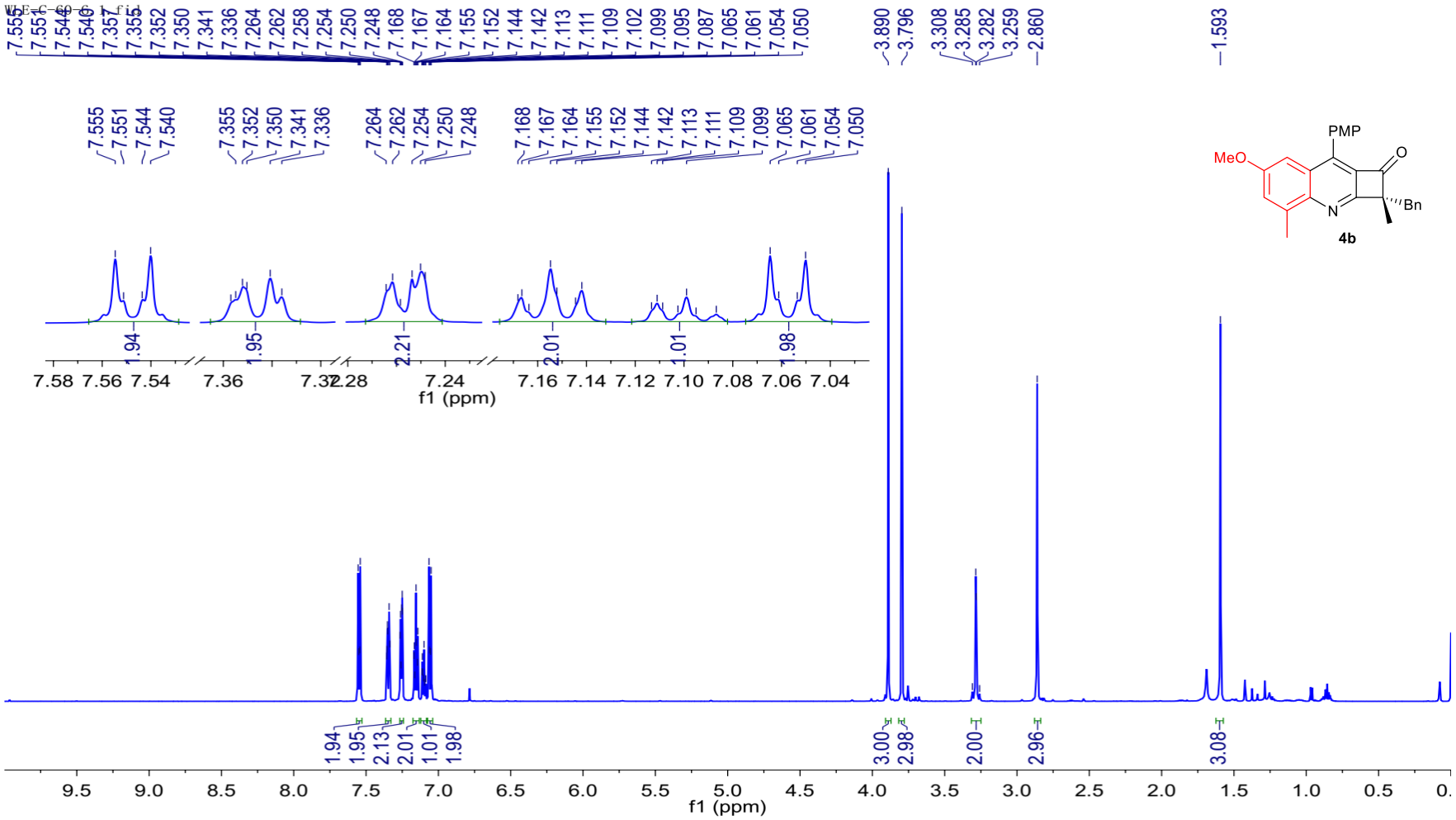
1H NMR Spectrum (600 MHz, Chloroform-d) of **4a**



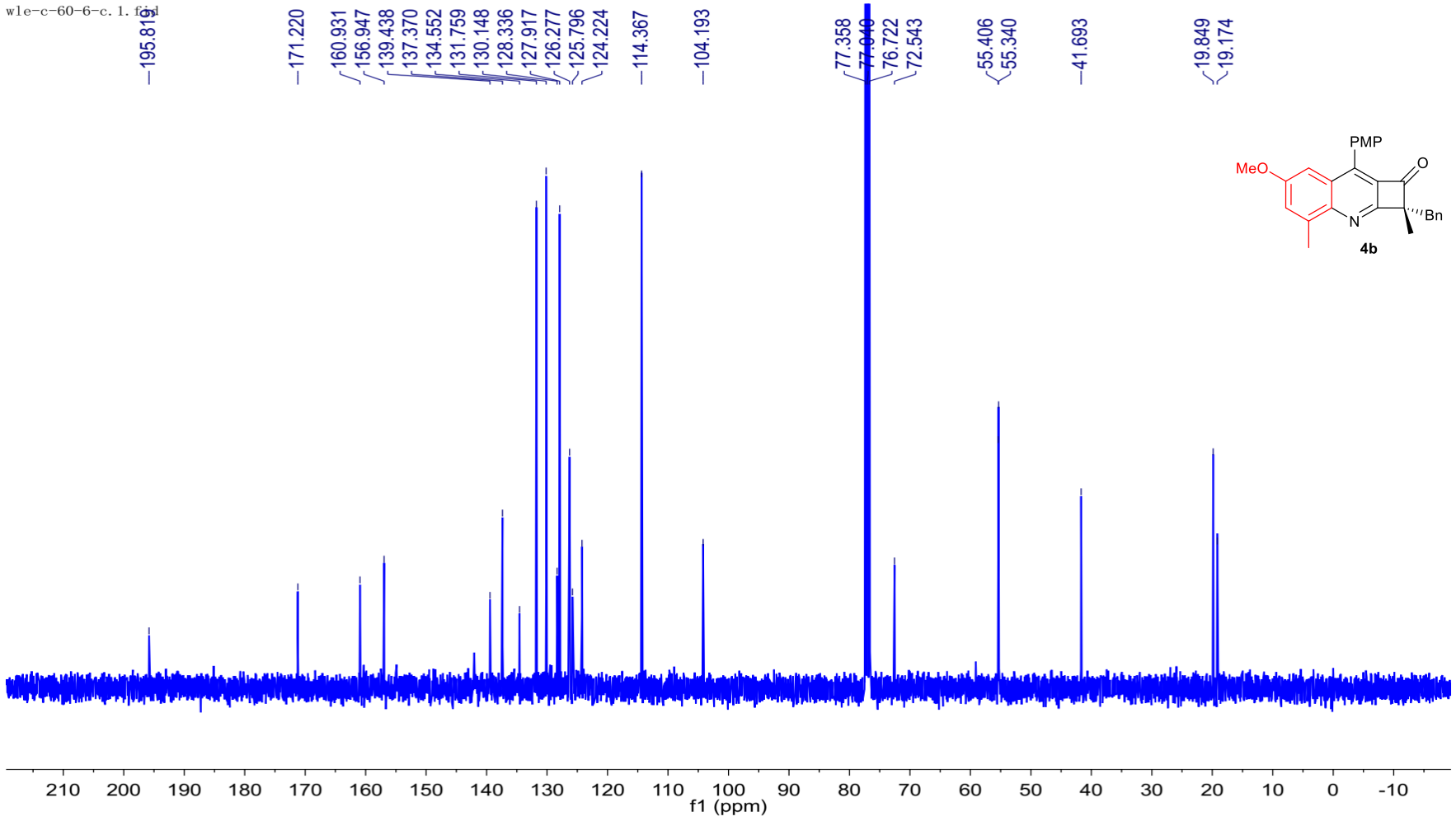
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4a**



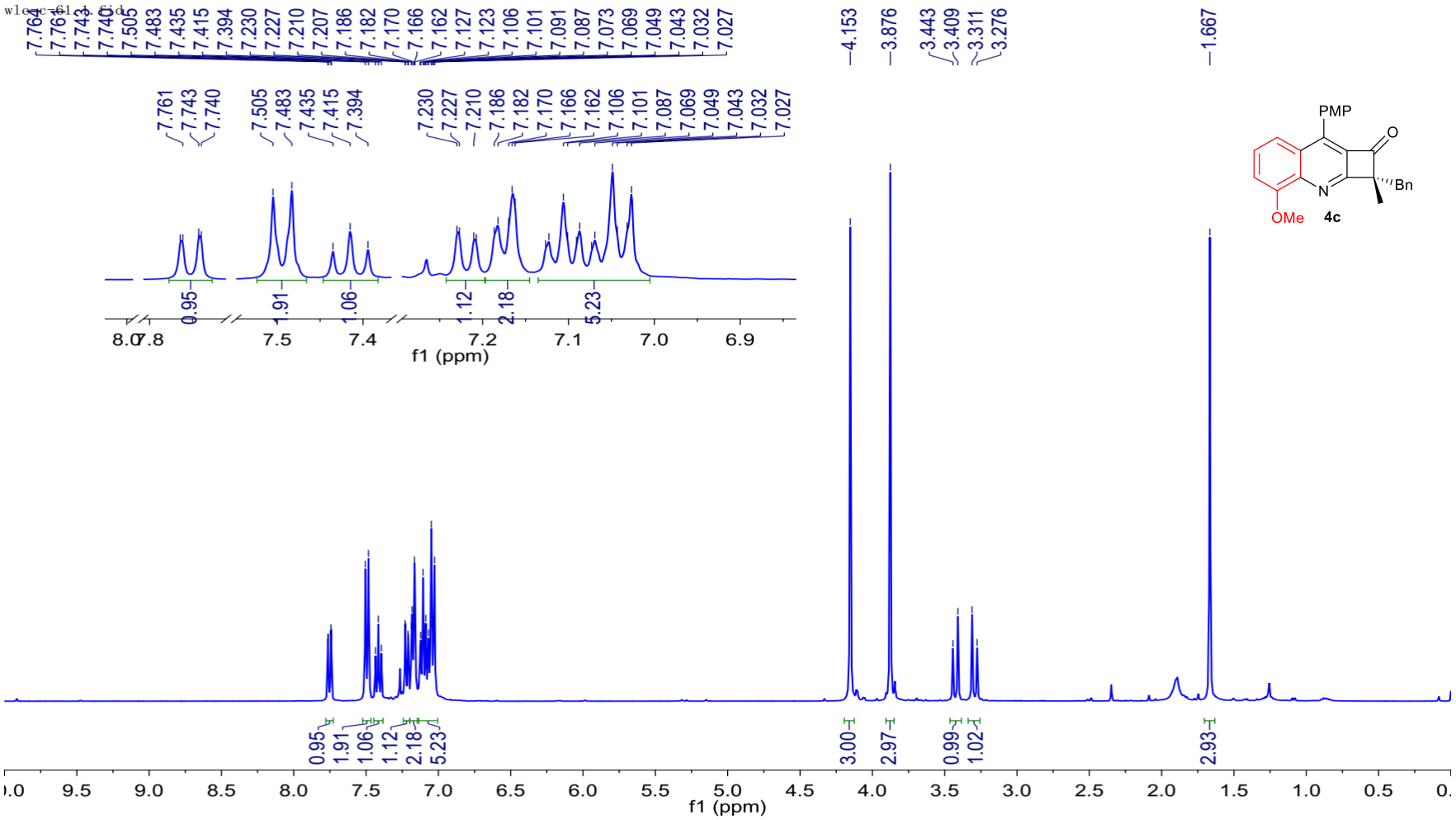
[1]H NMR Spectrum (600 MHz, Chloroform-d) of **4b**



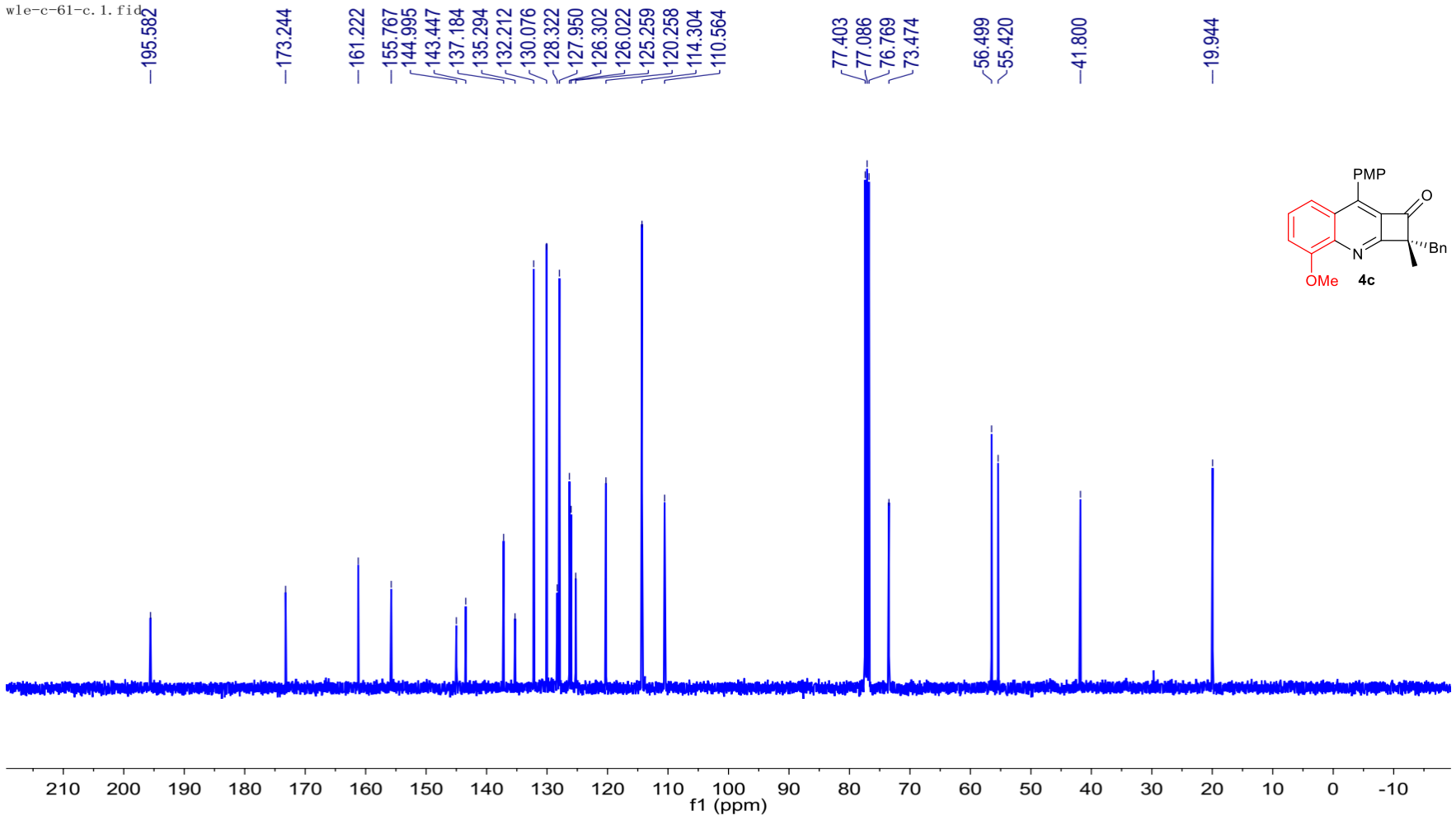
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4b**



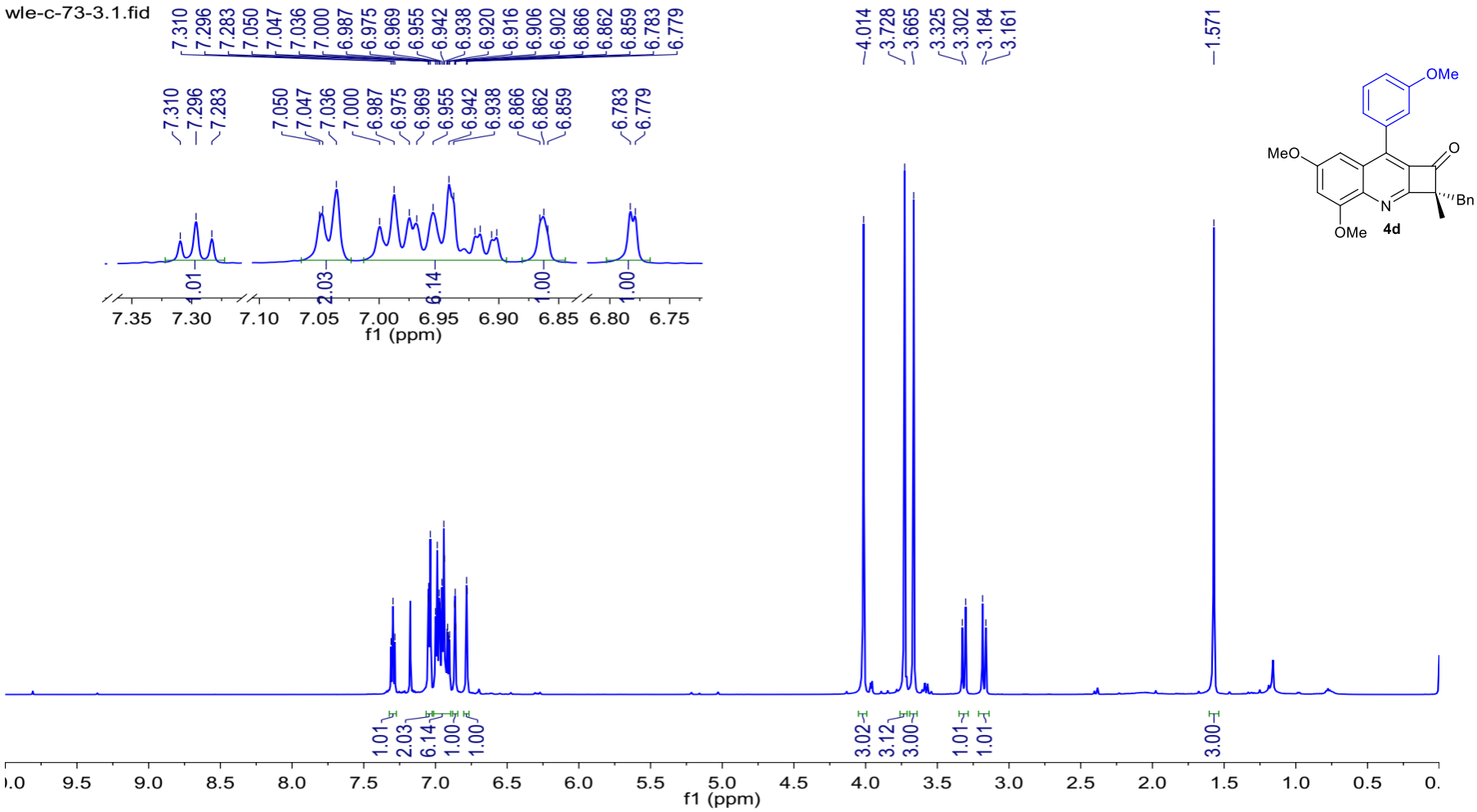
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **4c**



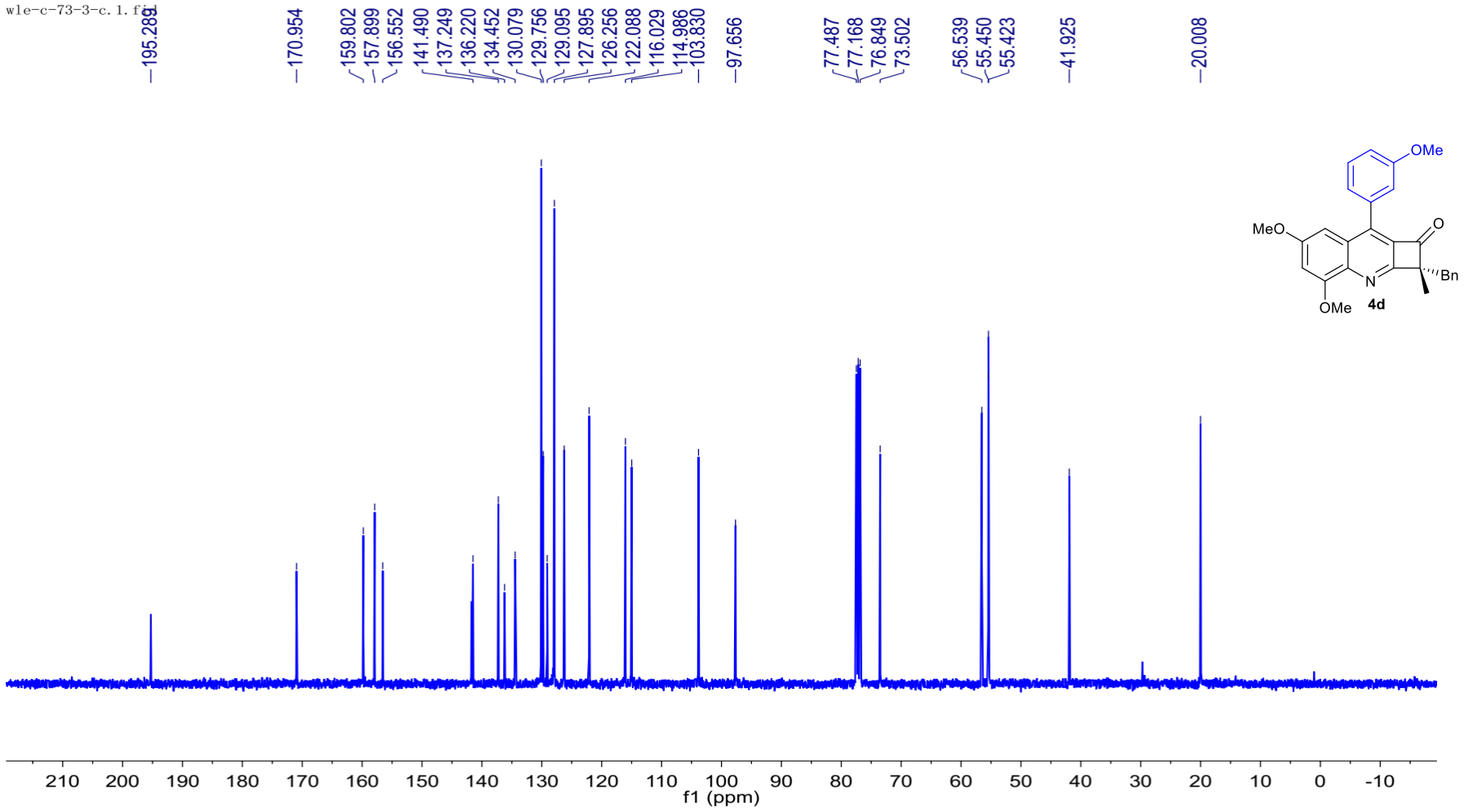
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4c**



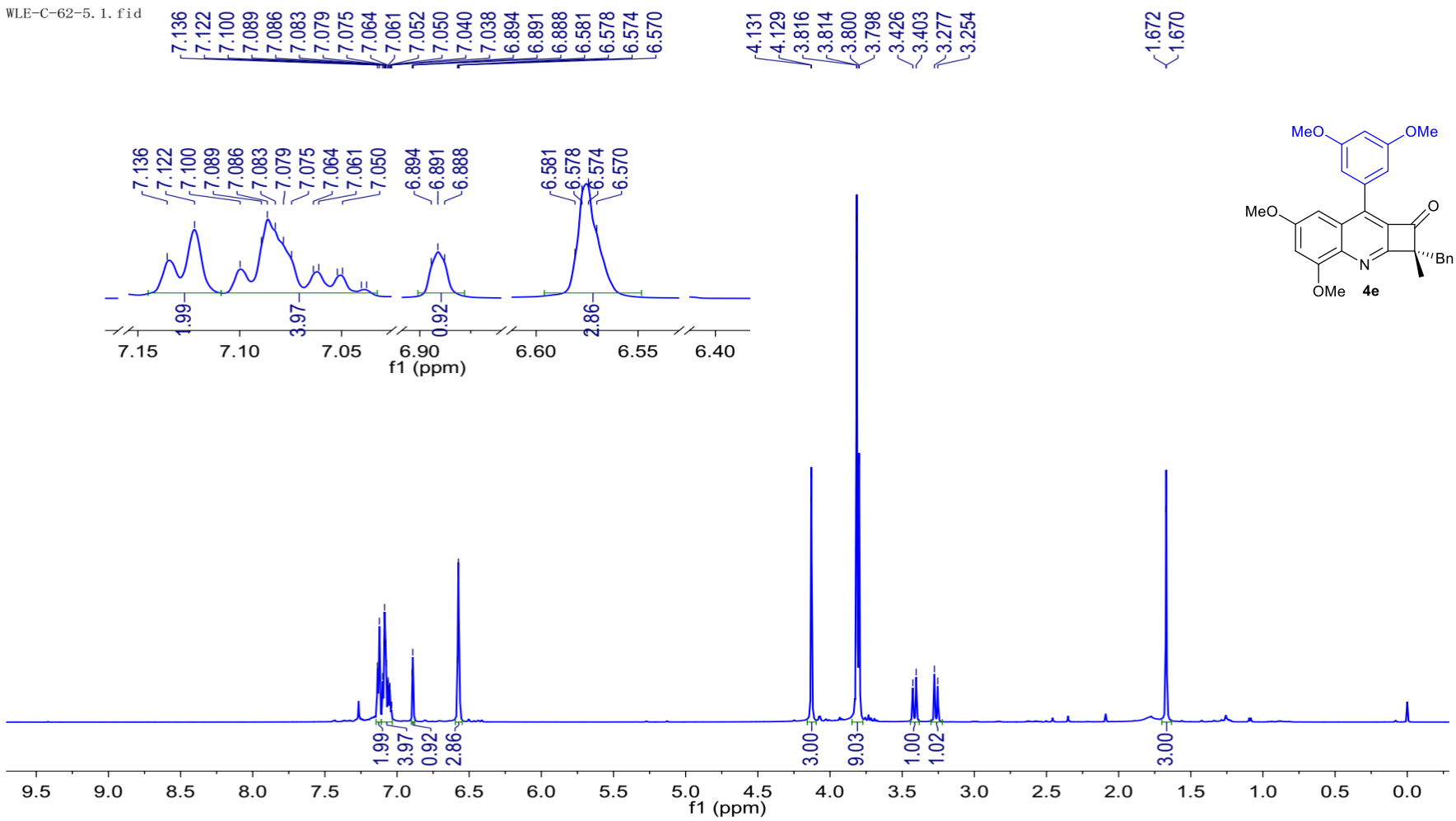
[1]H NMR Spectrum (600 MHz, Chloroform-d) of **4d**



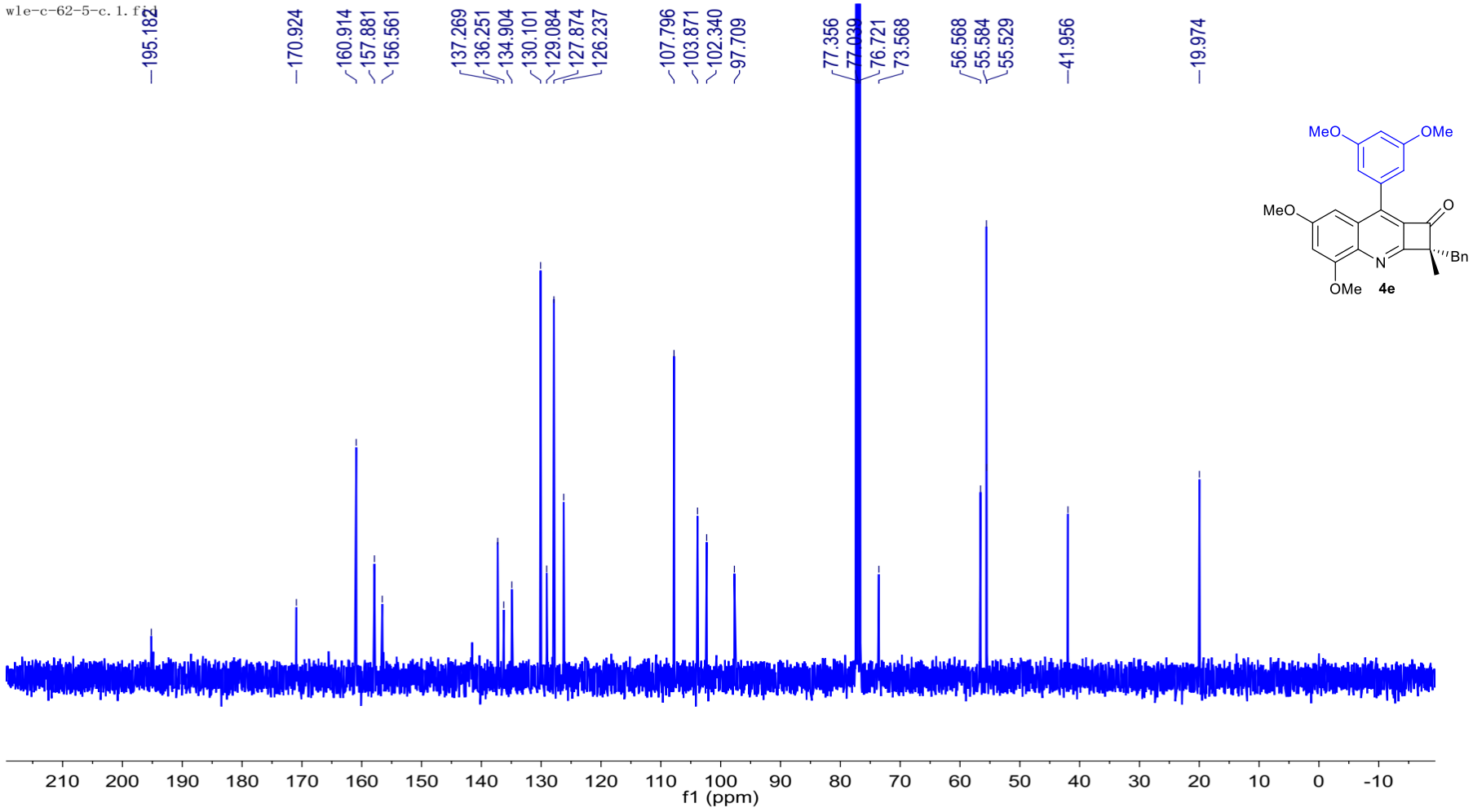
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4d**



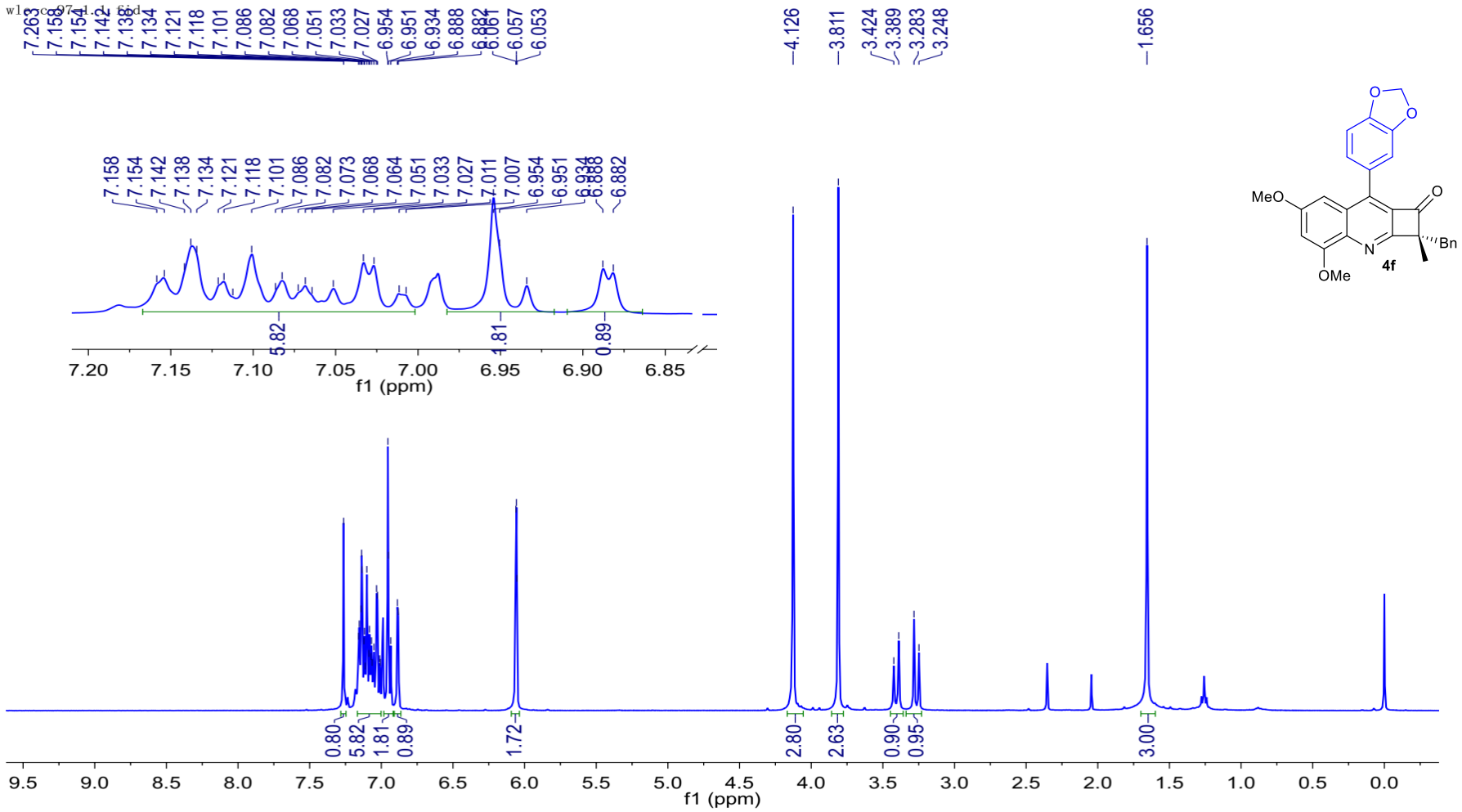
^{1}H NMR Spectrum (600 MHz, Chloroform-d) of **4e**



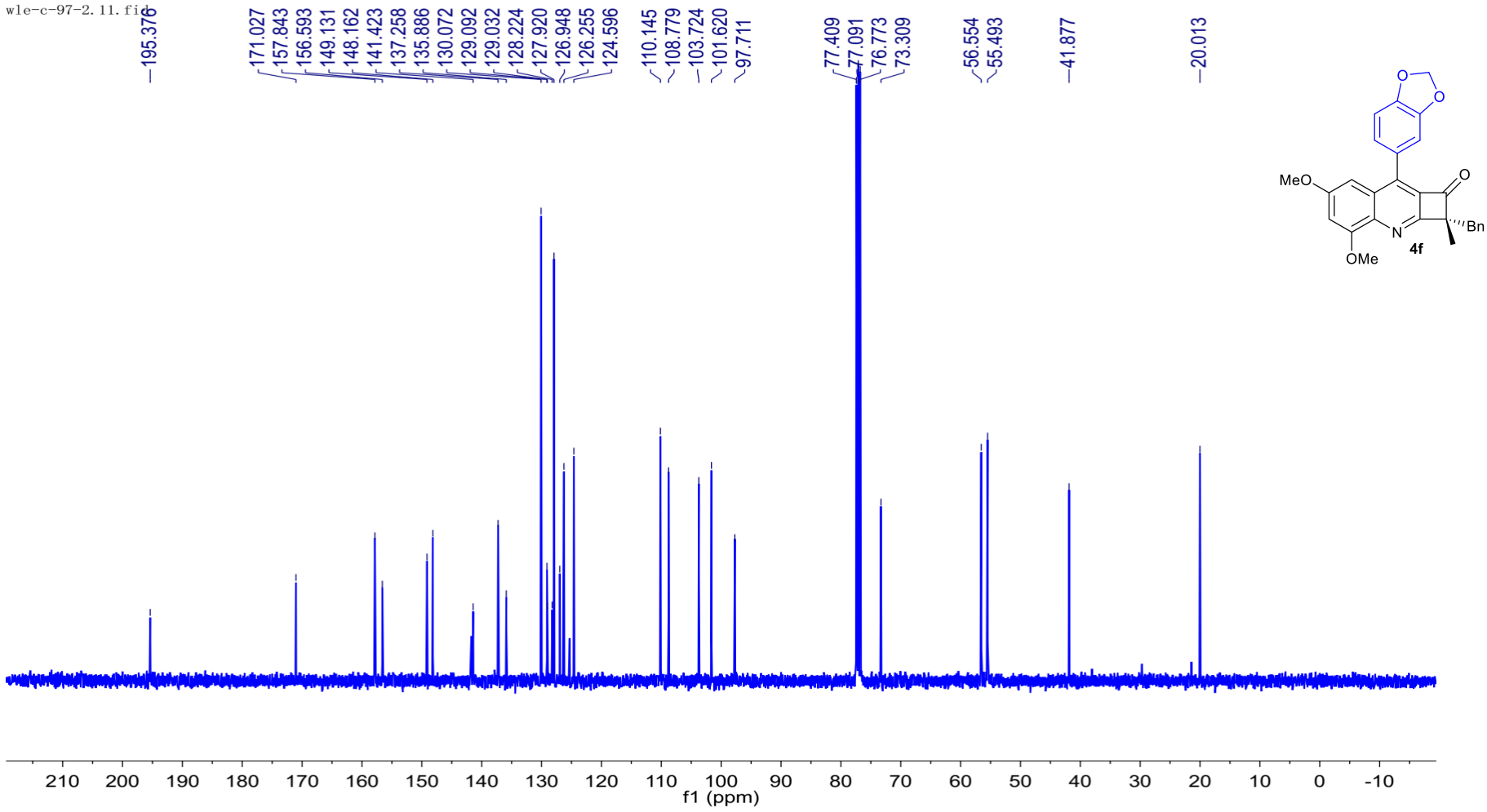
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4e**



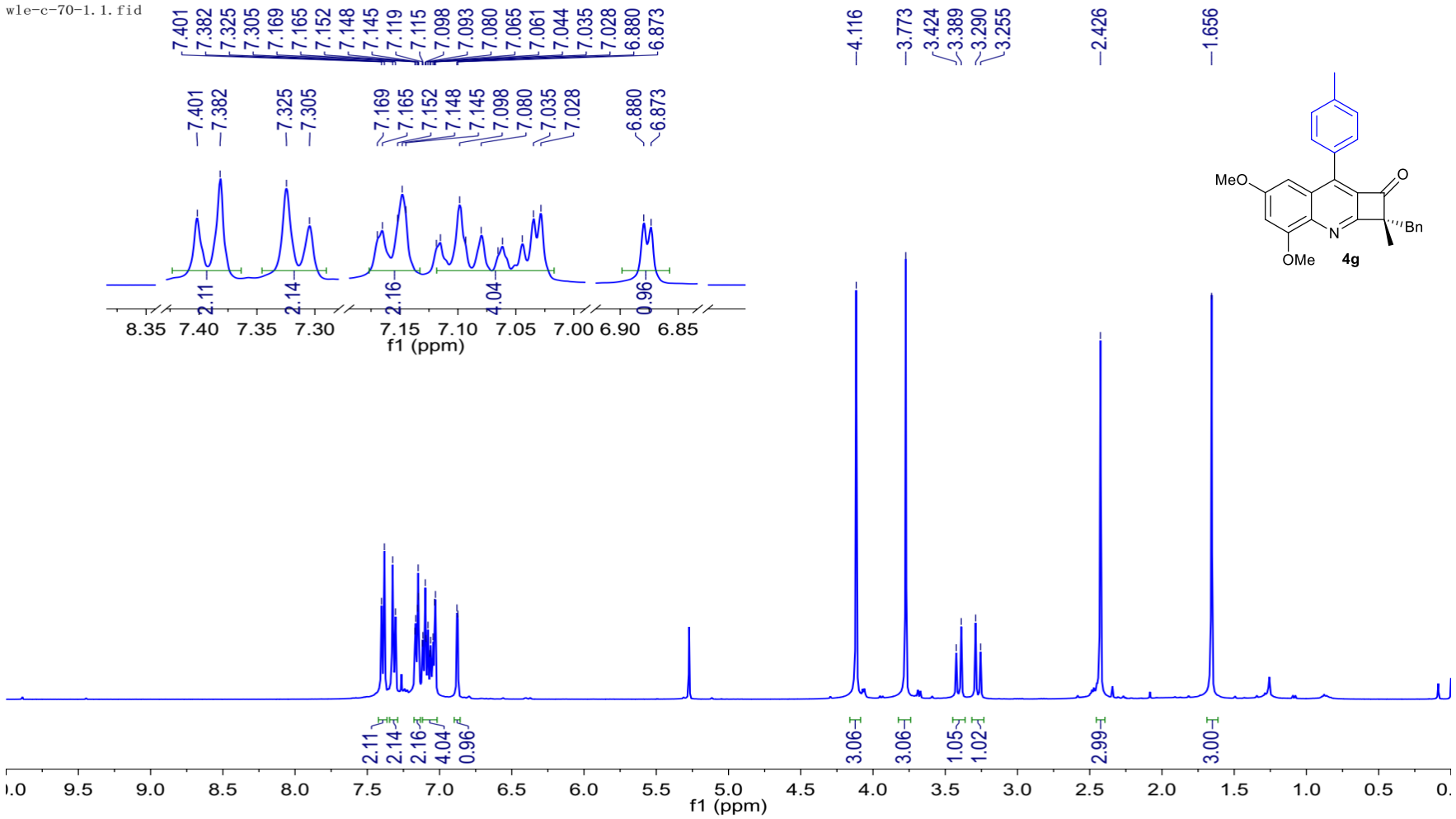
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **4f**



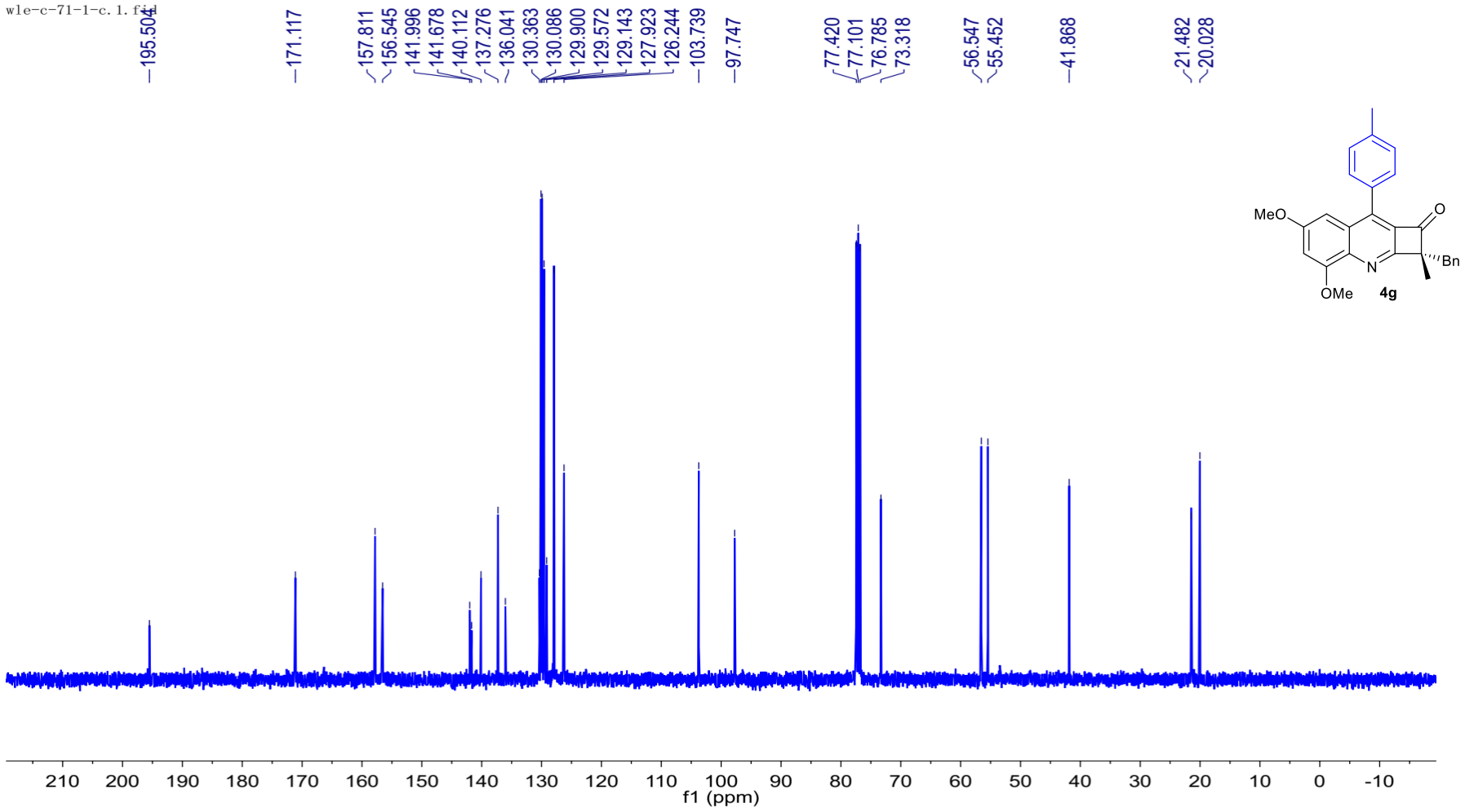
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4f**



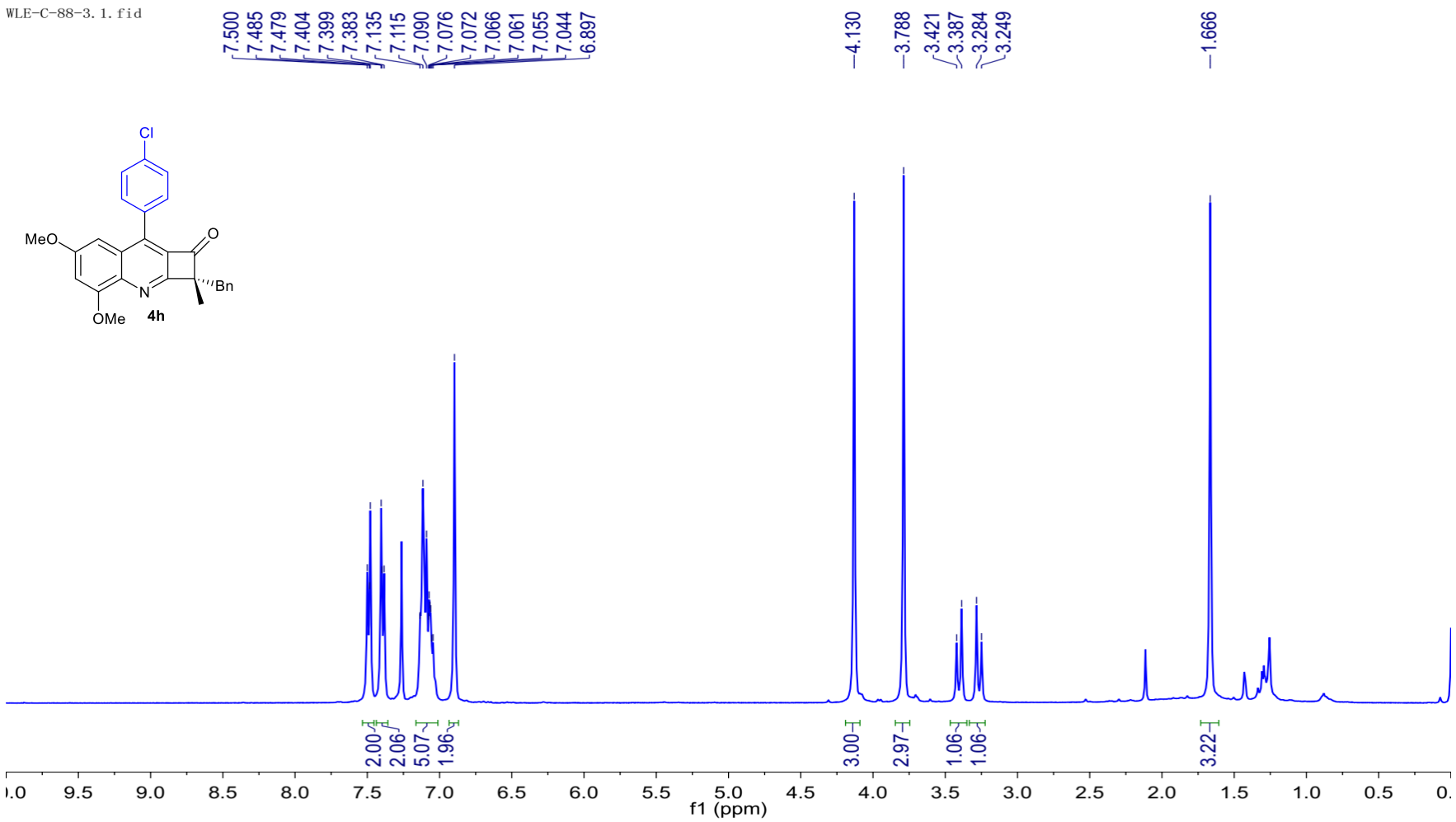
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **4g**



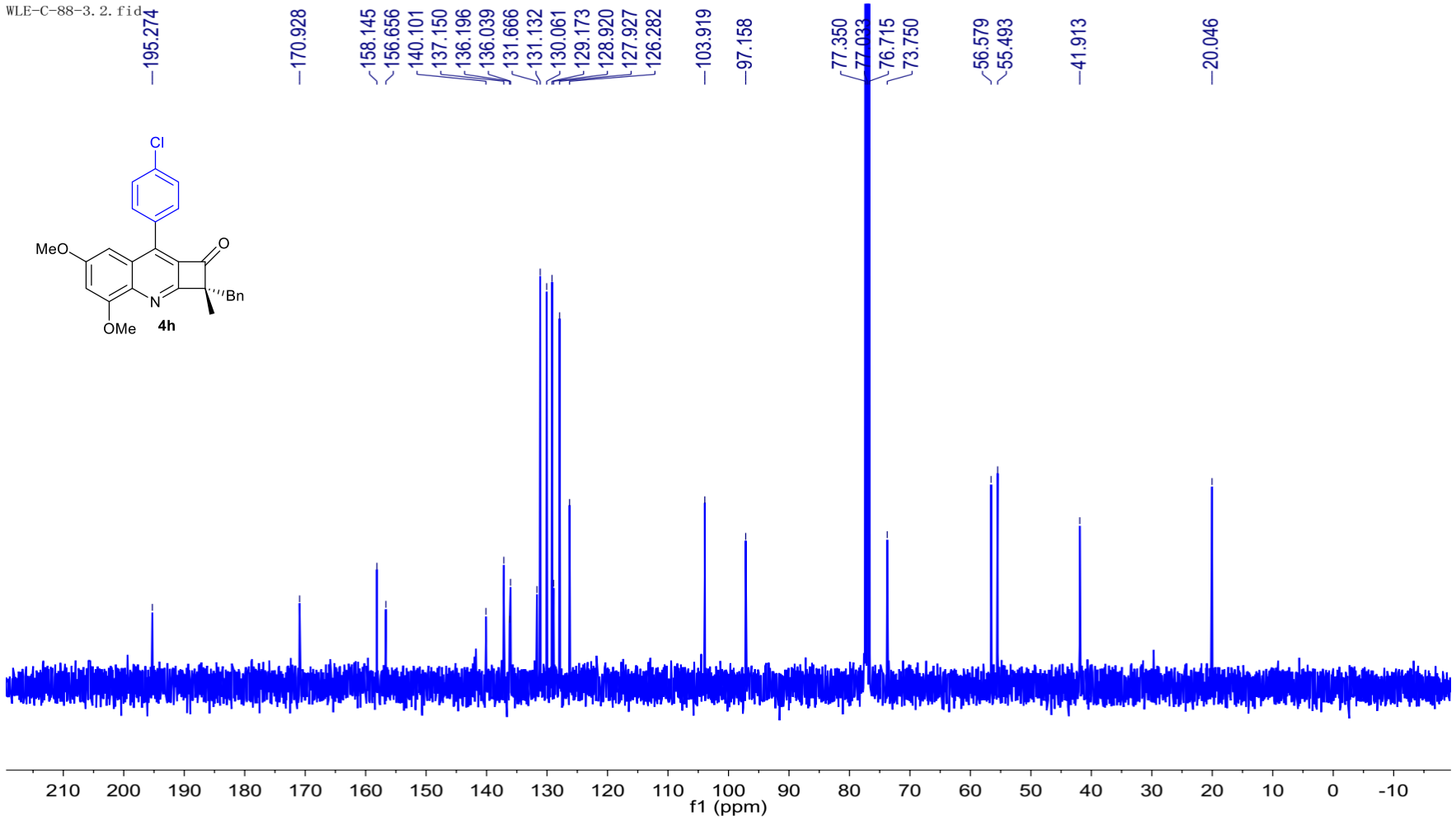
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4g**



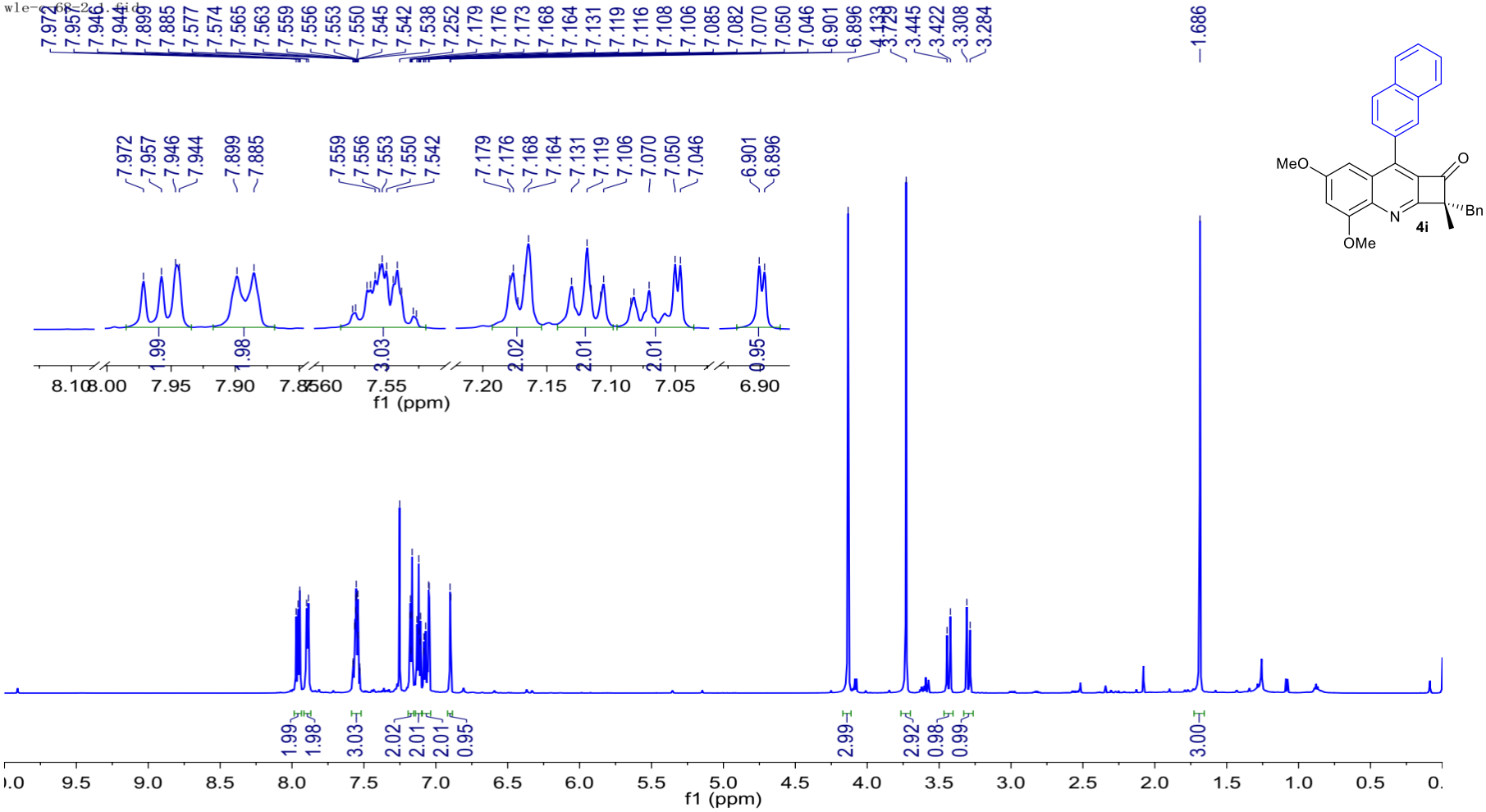
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **4h**



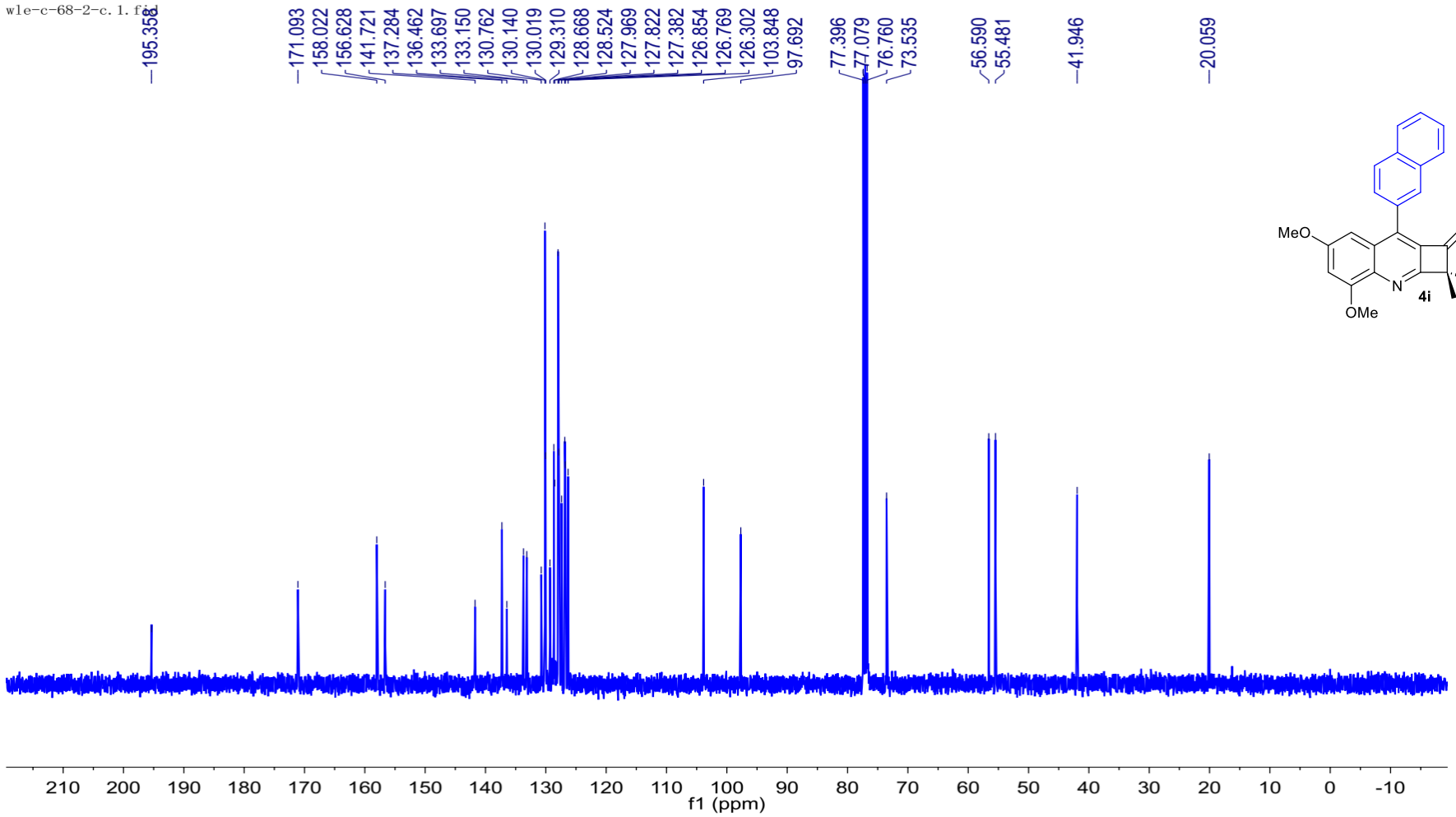
$^{13}C\{^{1}H\}$ NMR Spectrum (101 MHz, Chloroform-d) of **4h**



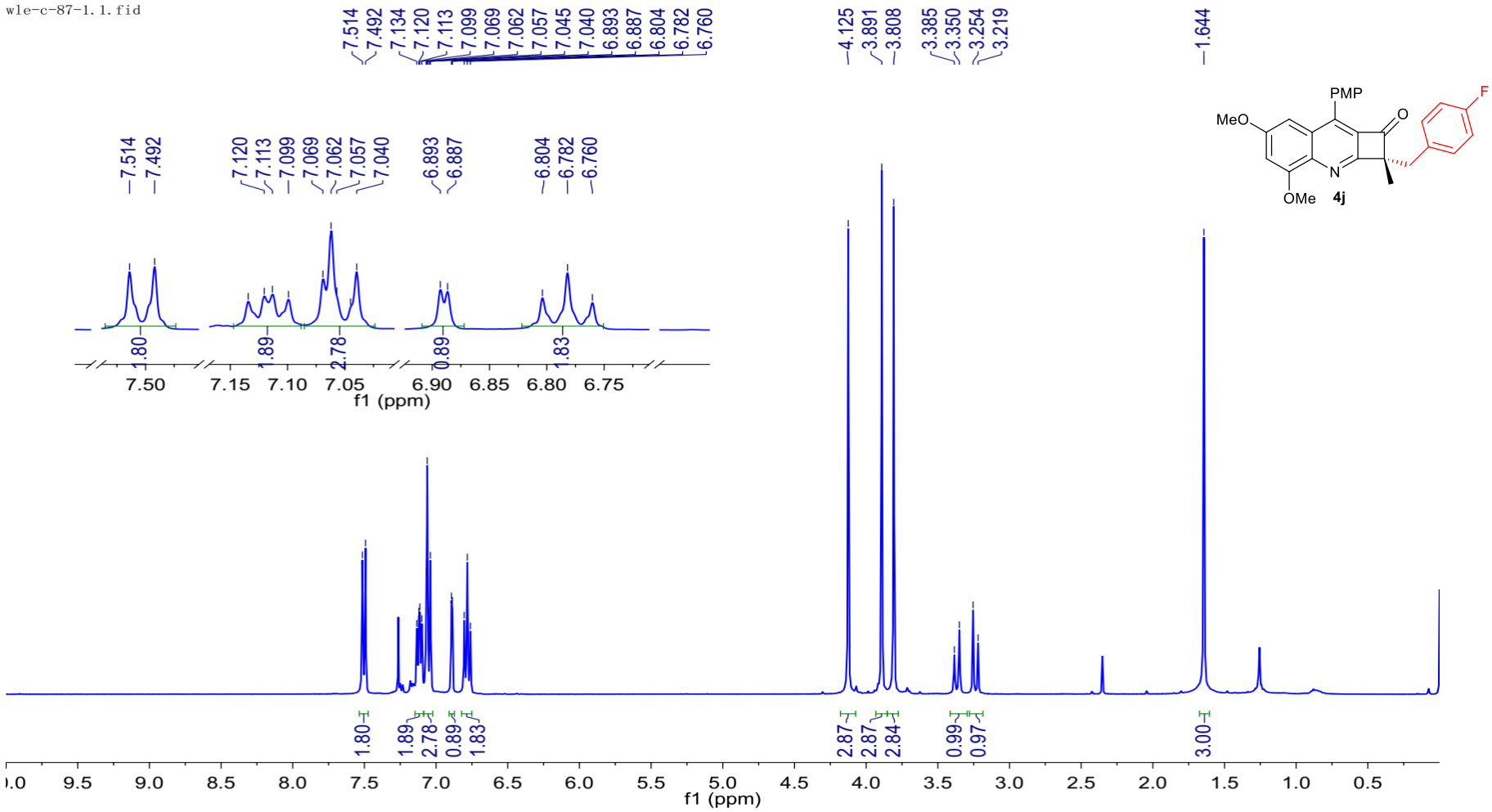
^{1}H NMR Spectrum (600 MHz, Chloroform-d) of **4i**



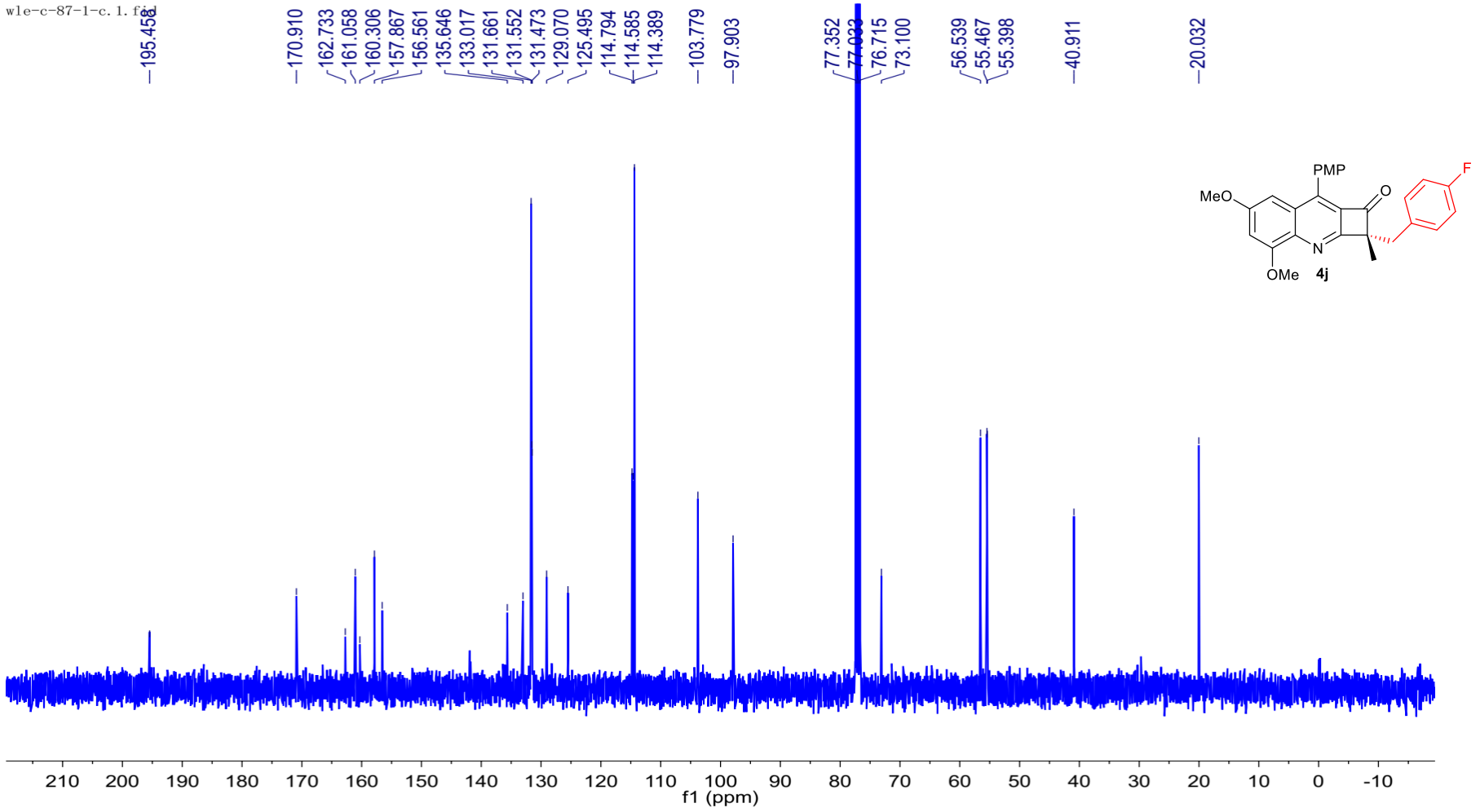
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4i**



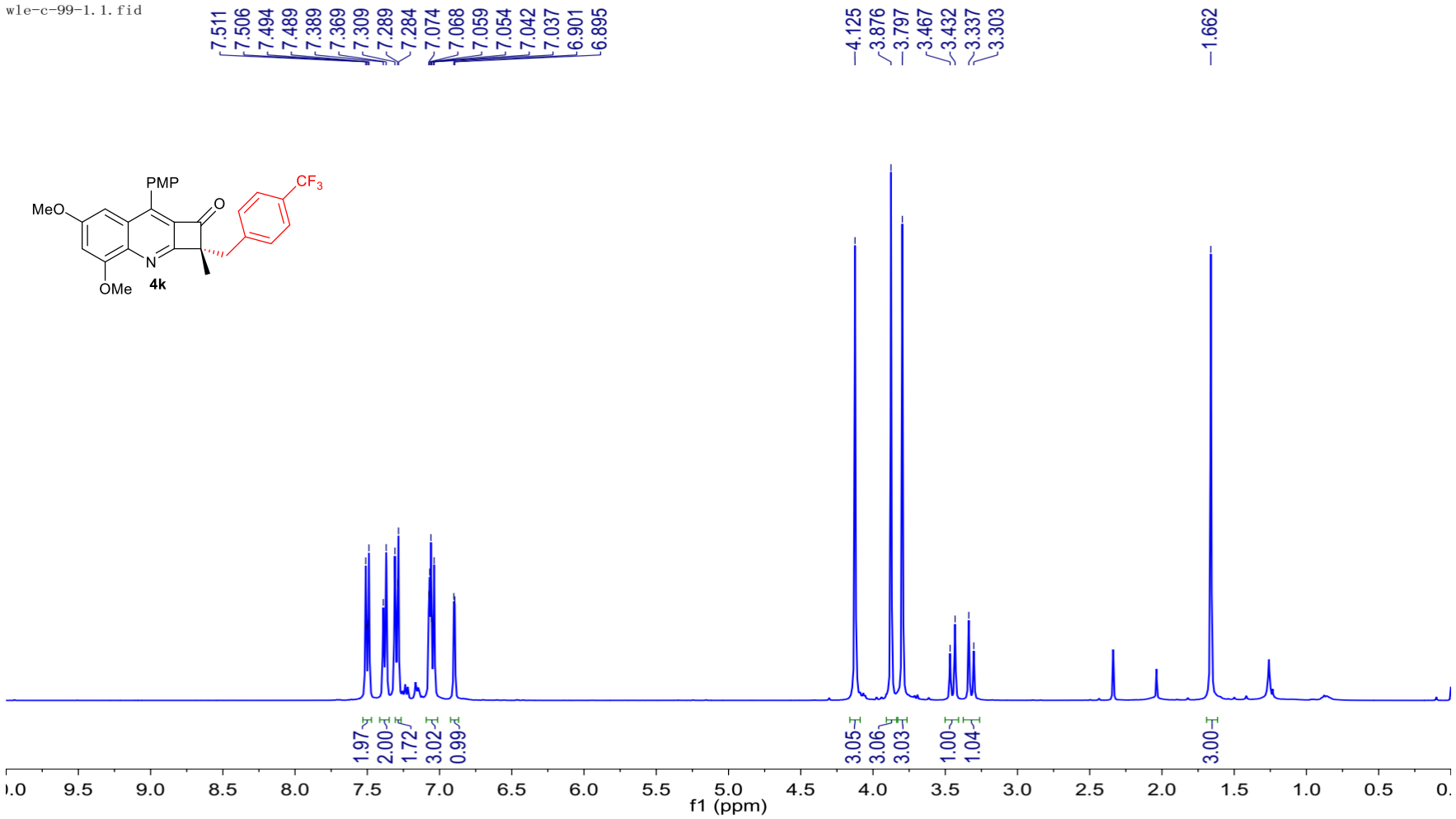
^{1}H NMR Spectrum (400 MHz, Chloroform-d) of **4j**



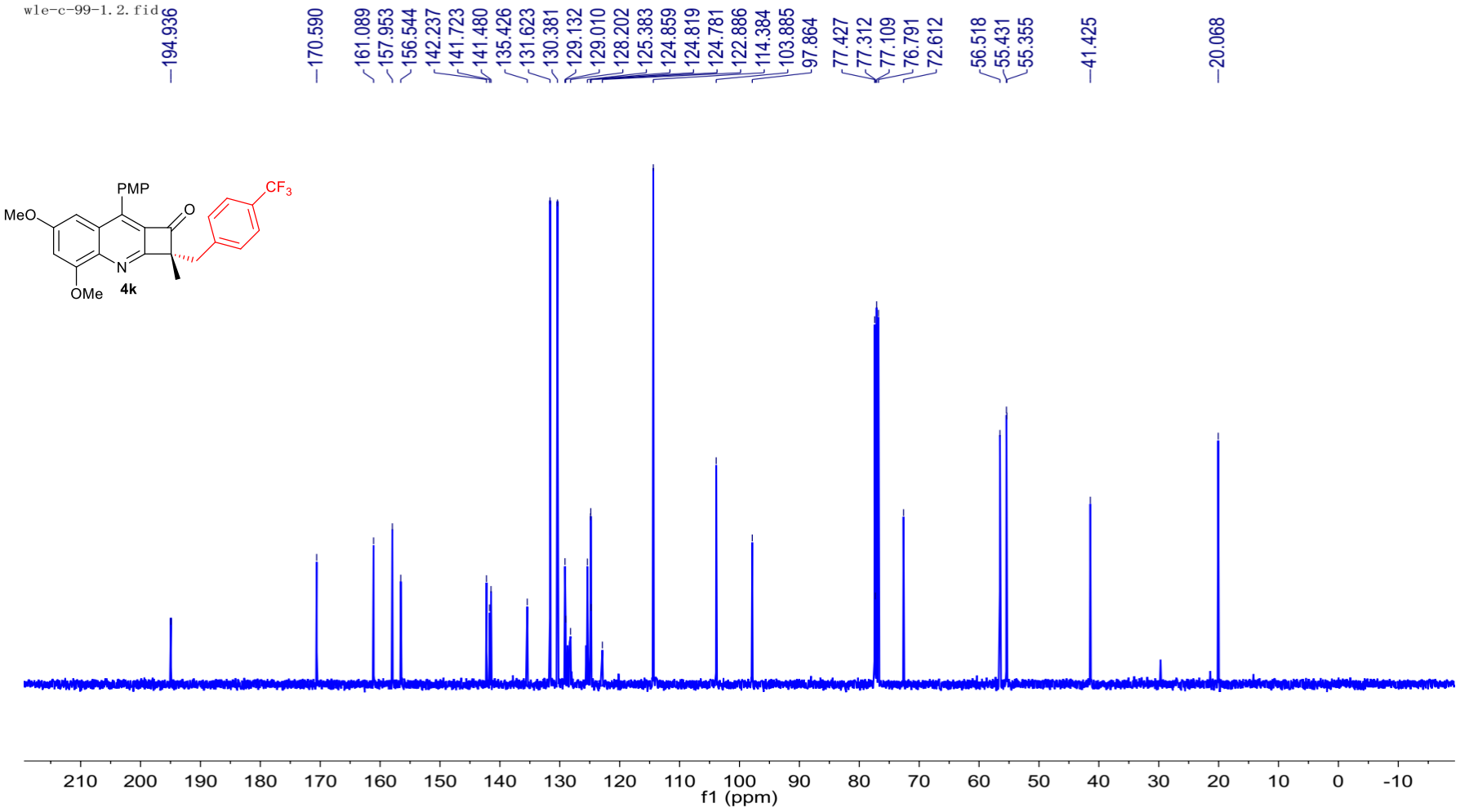
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4j**



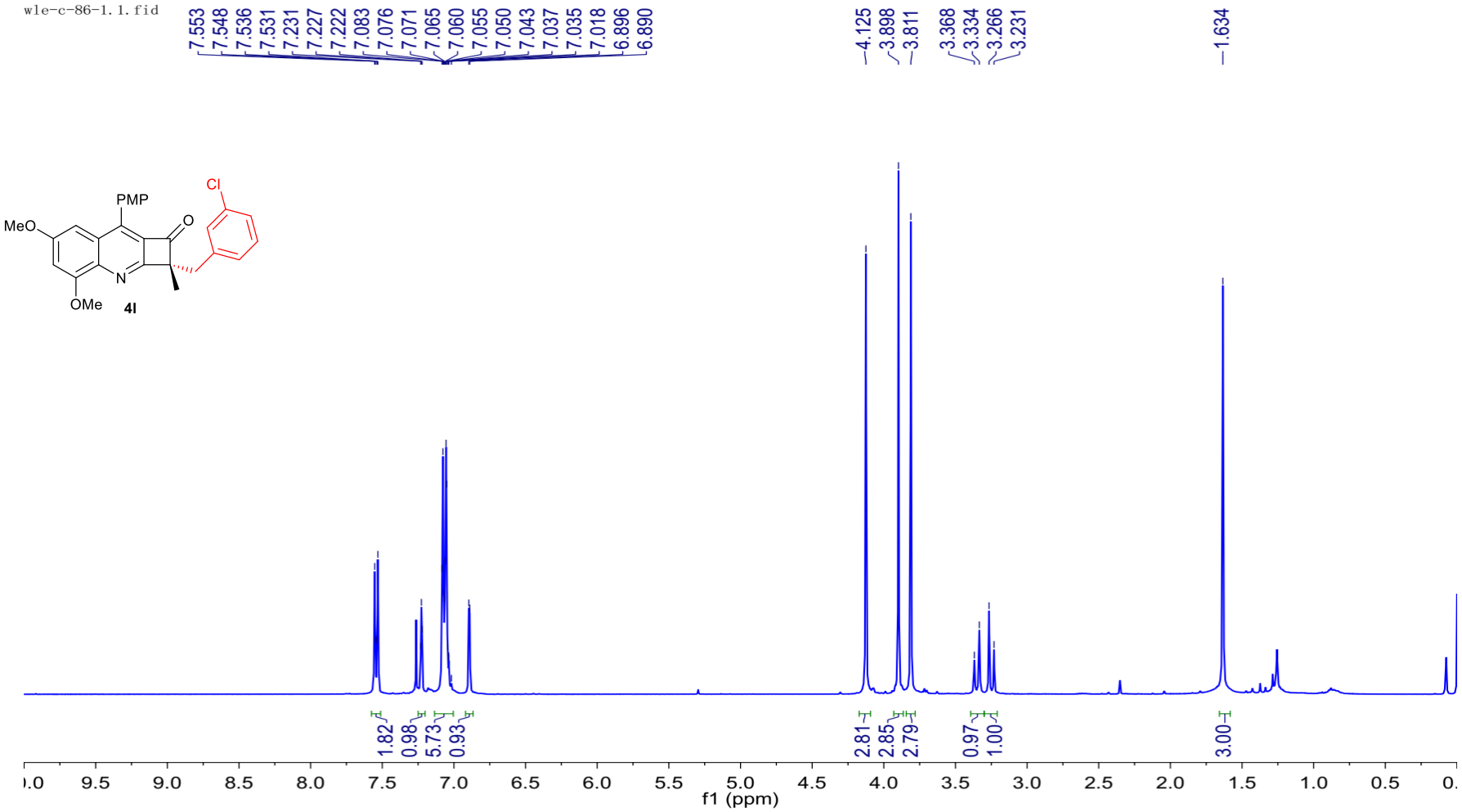
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **4k**



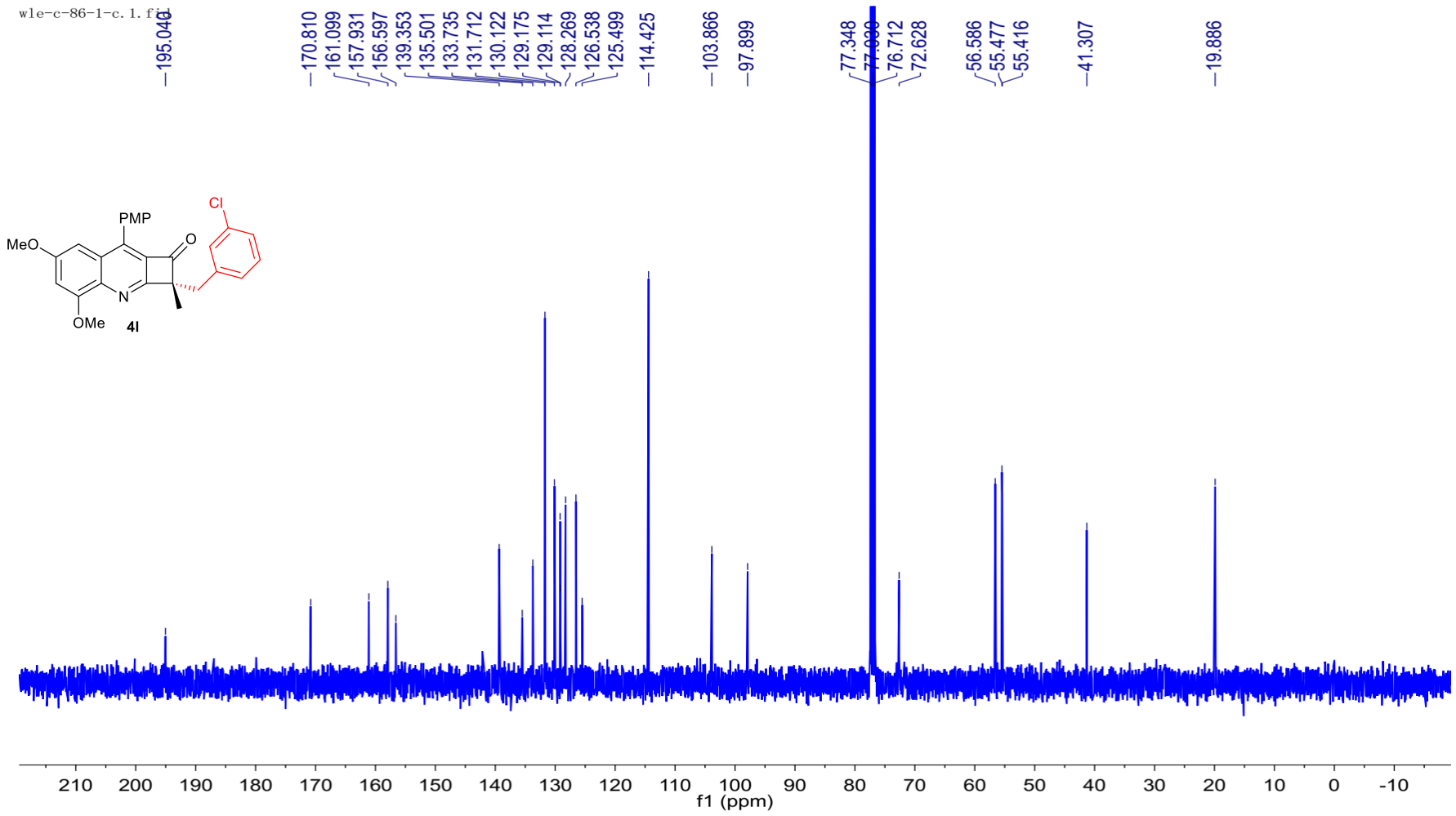
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4k**



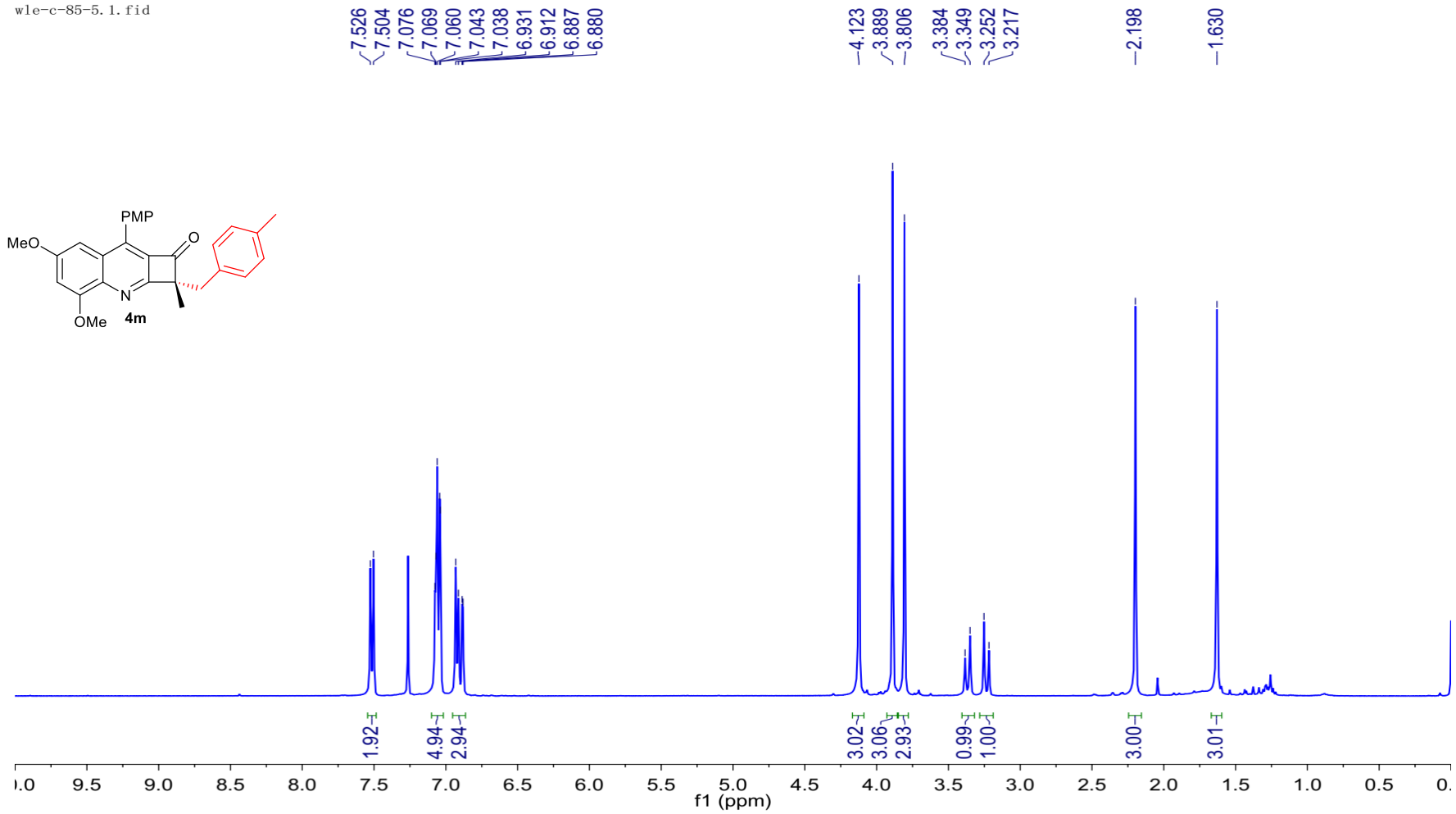
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **4l**



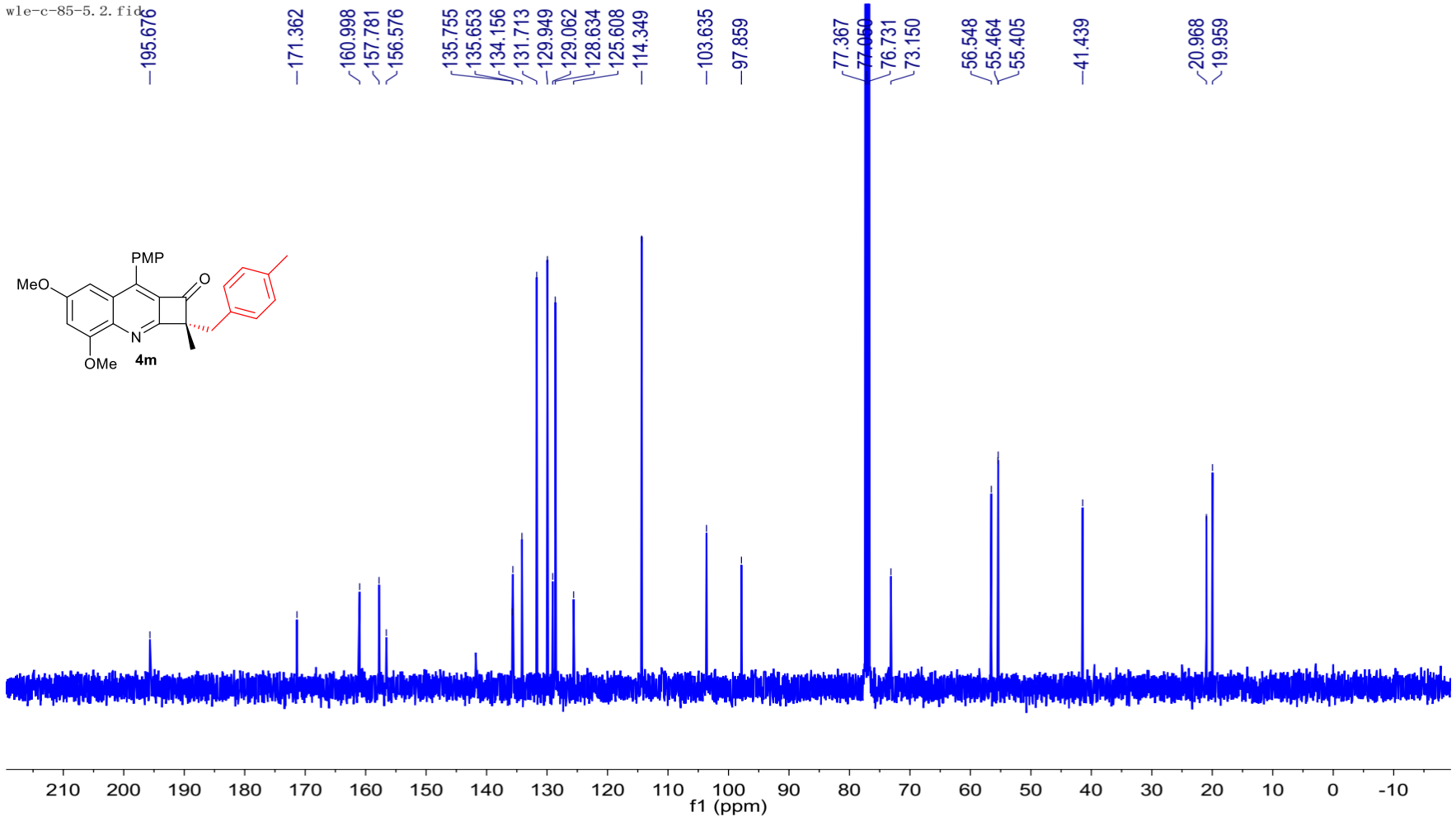
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4l**



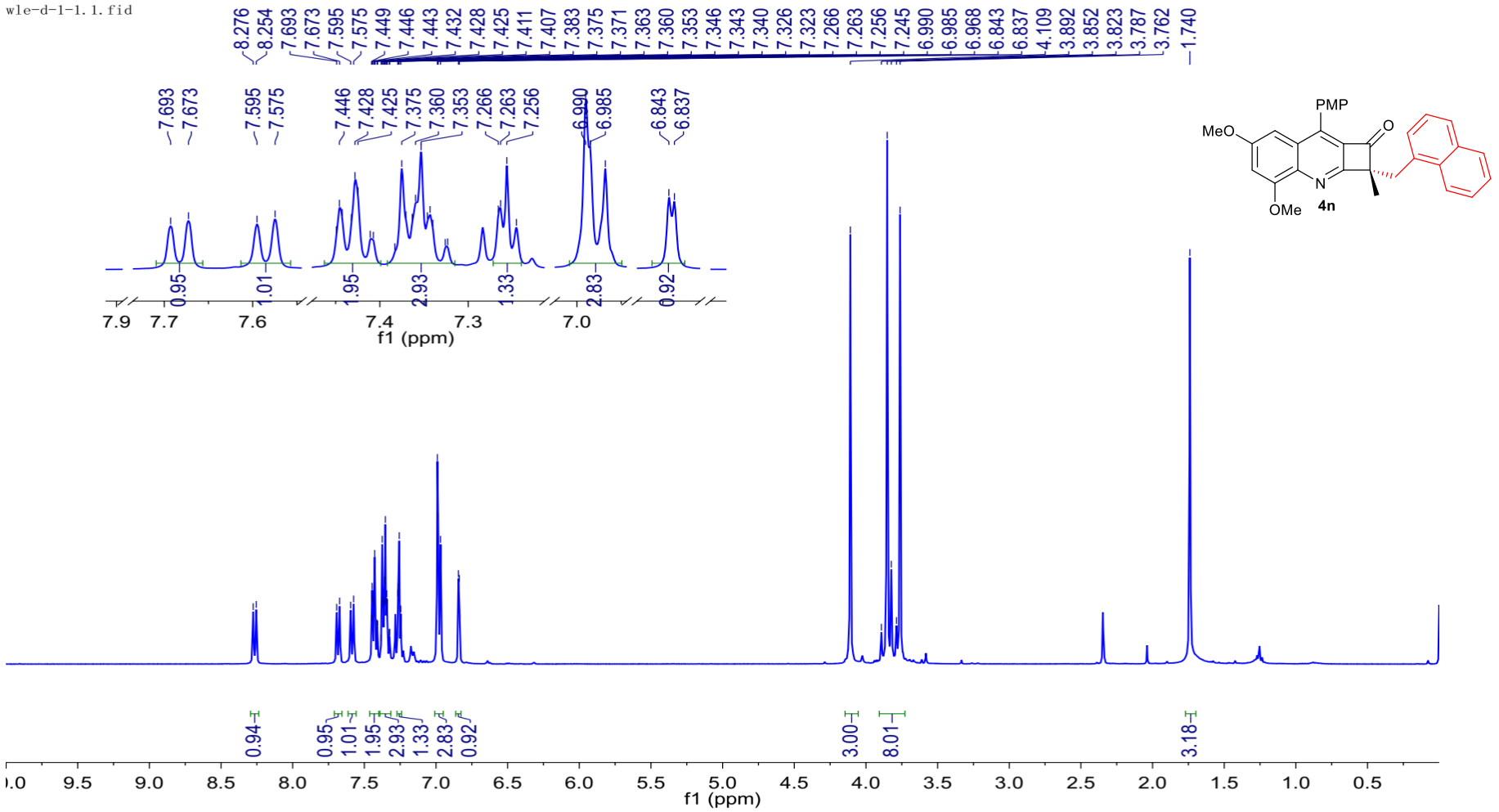
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **4m**



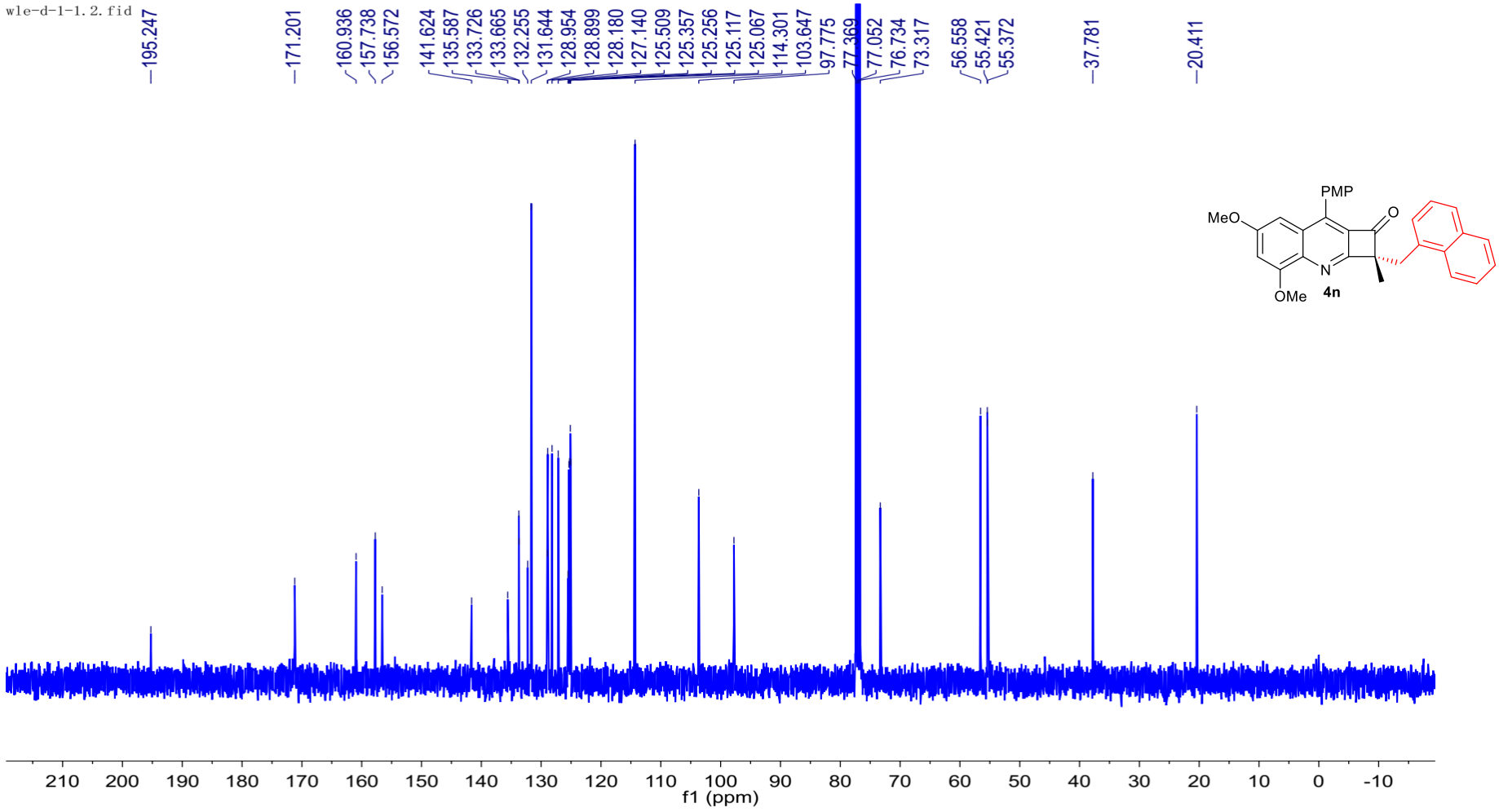
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4m**



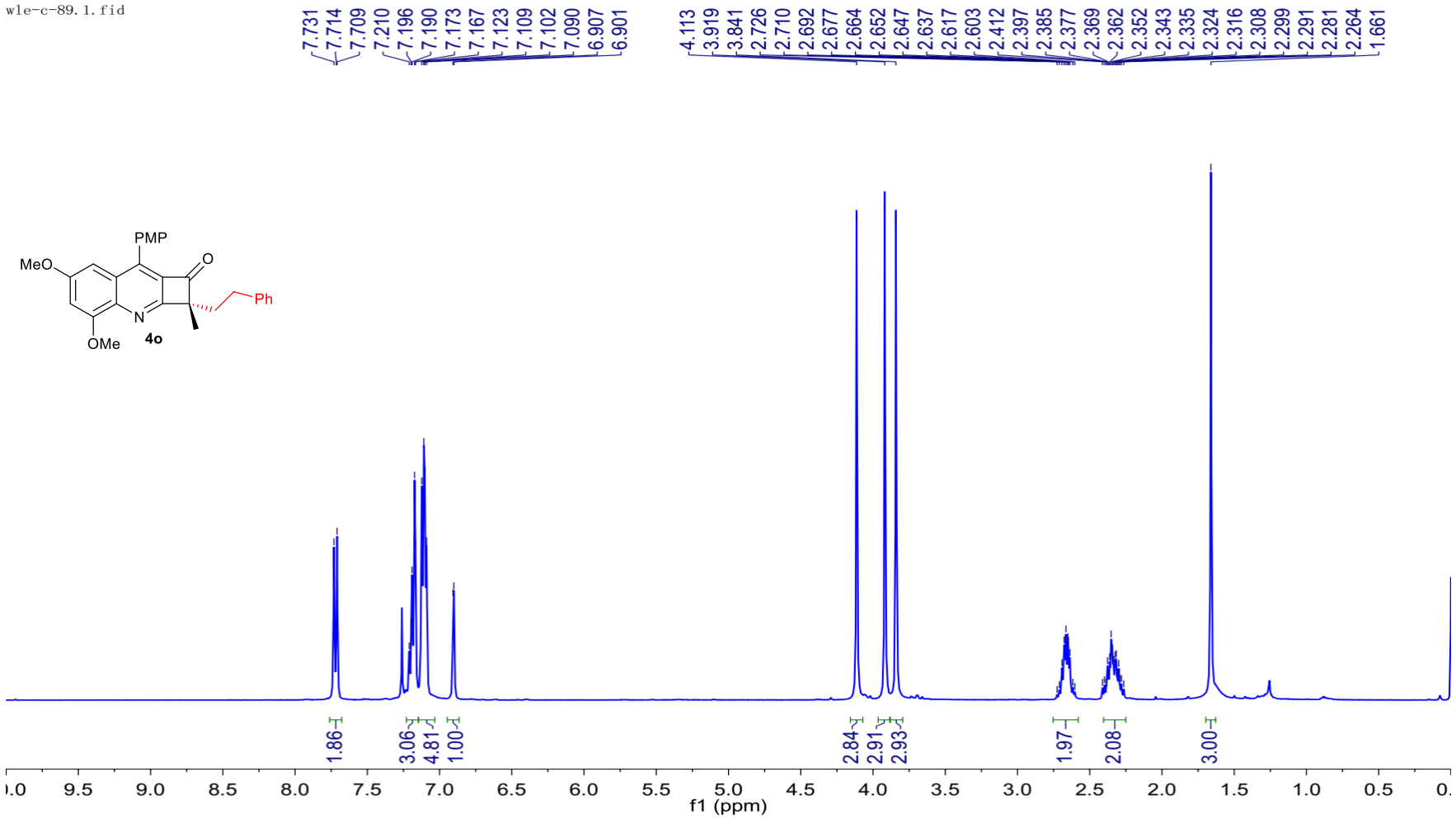
^{1}H NMR Spectrum (400 MHz, Chloroform-d) of **4n**



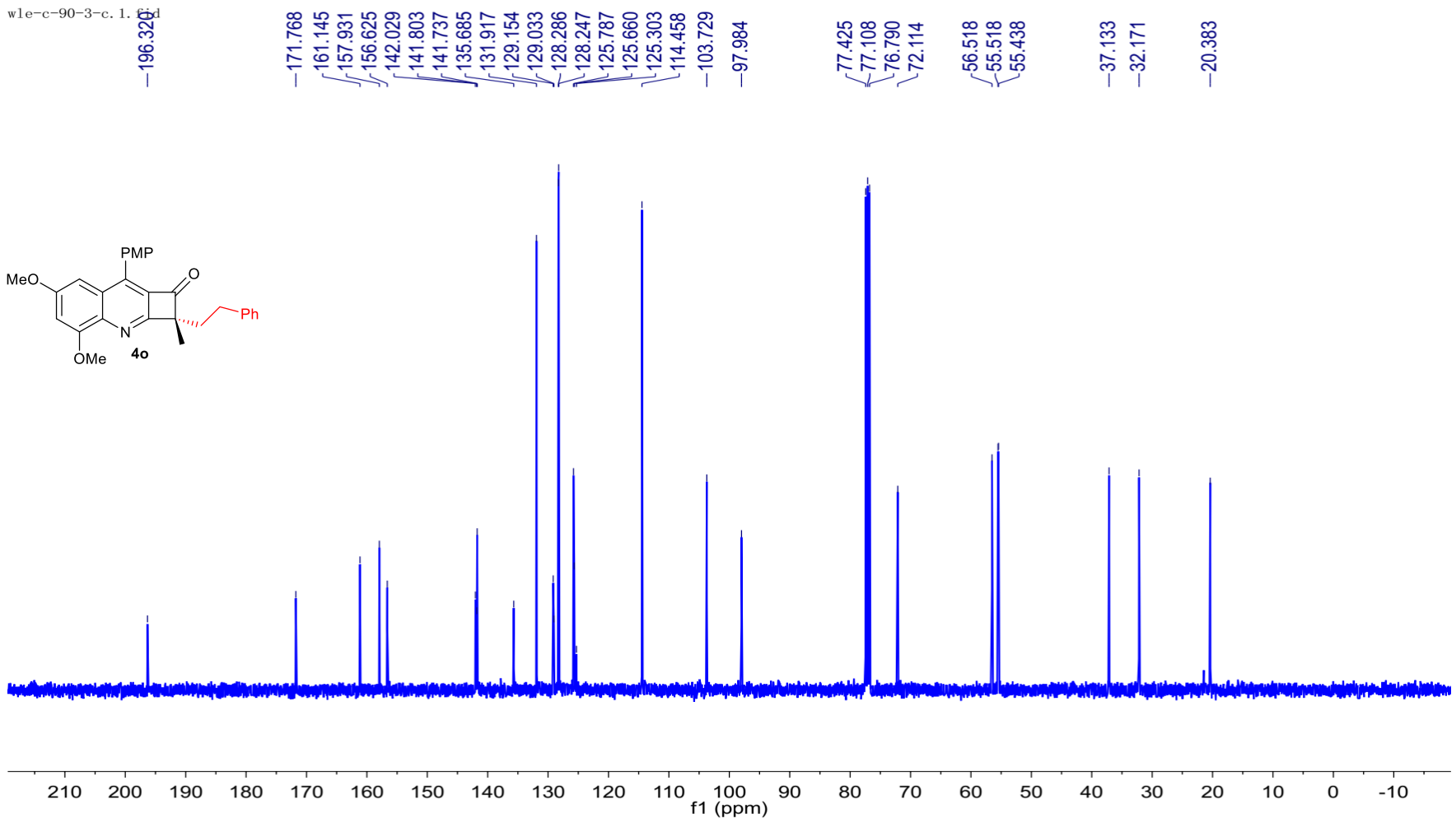
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4n**



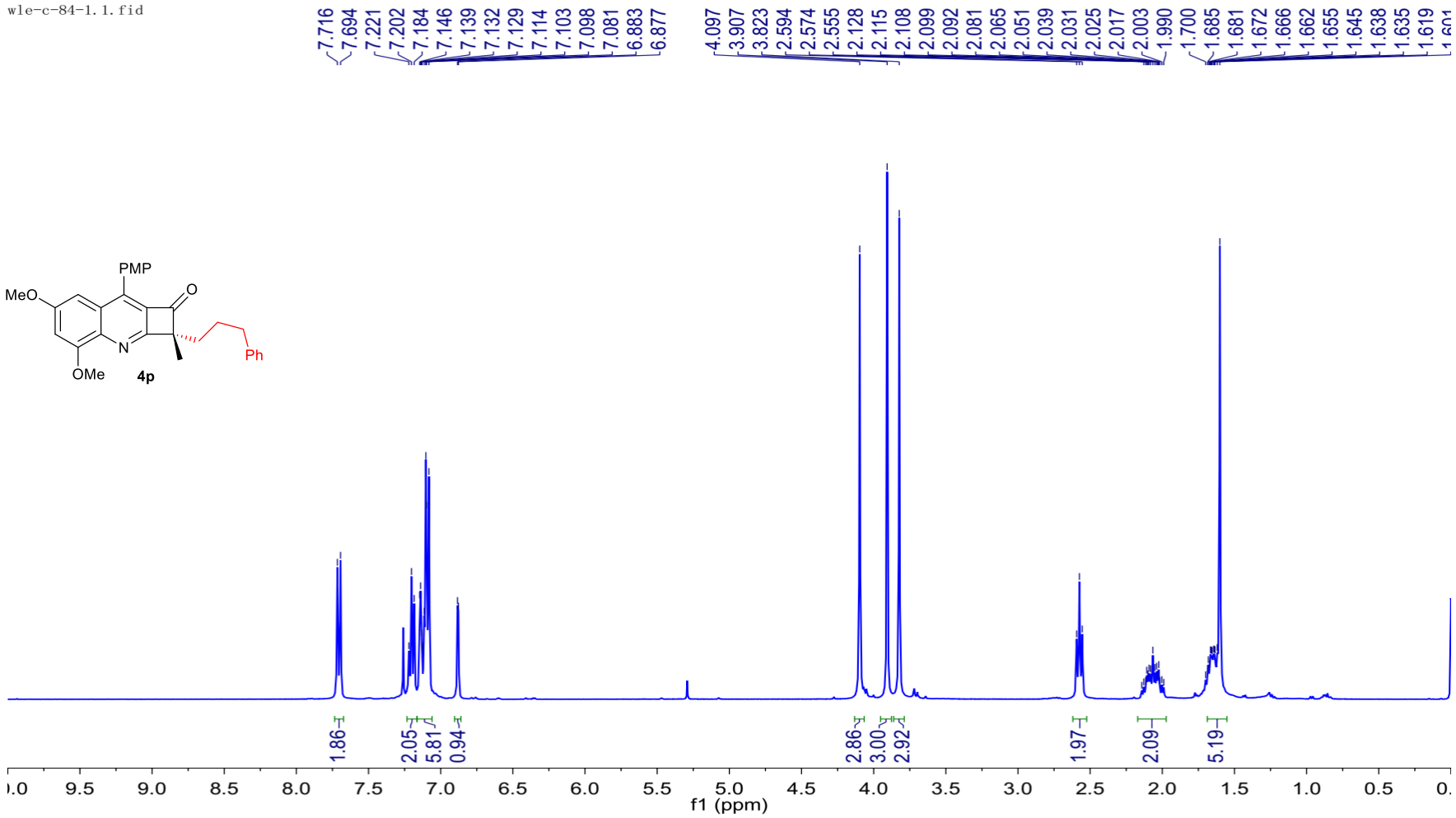
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **4o**



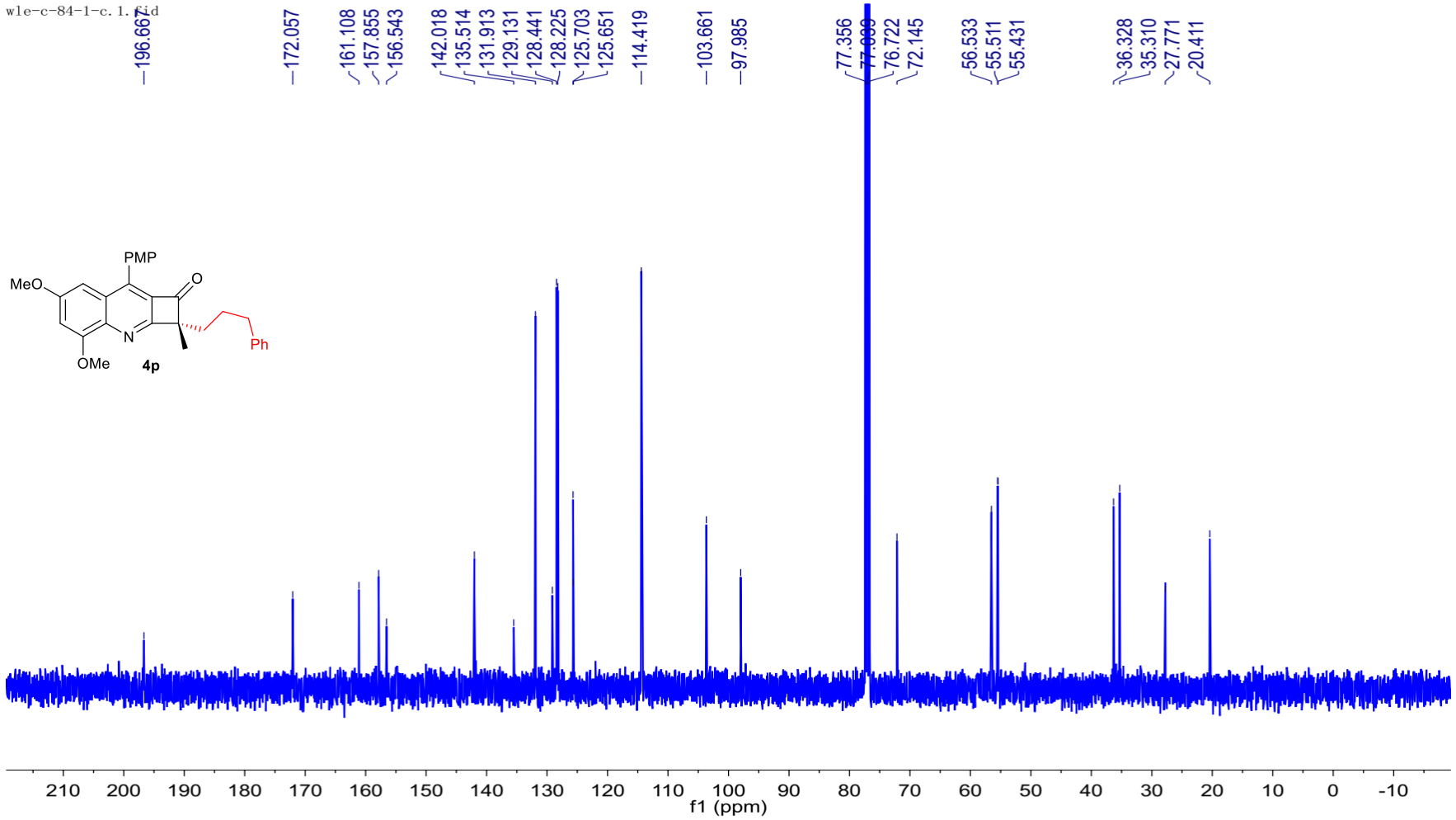
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4o**



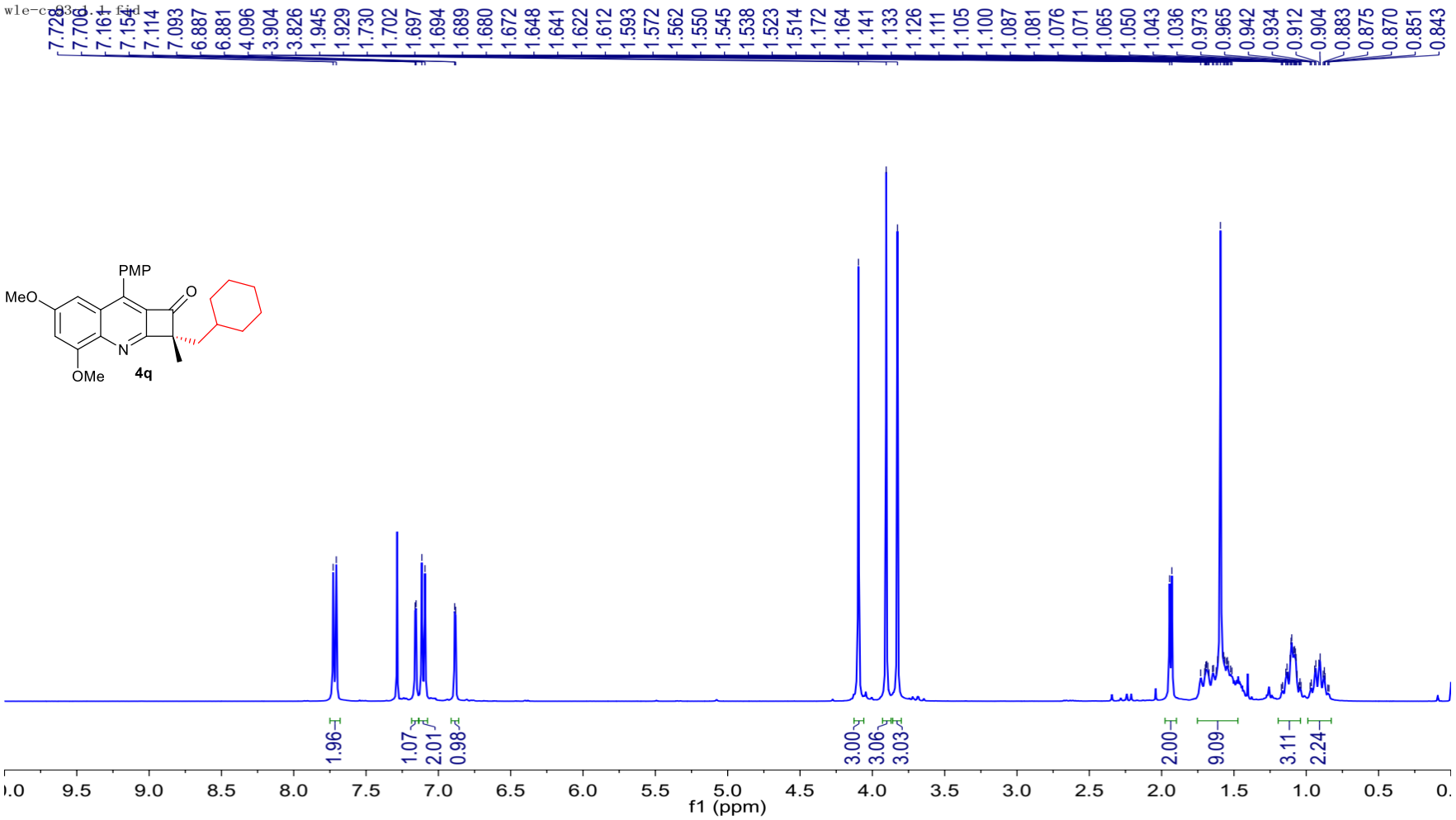
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **4p**



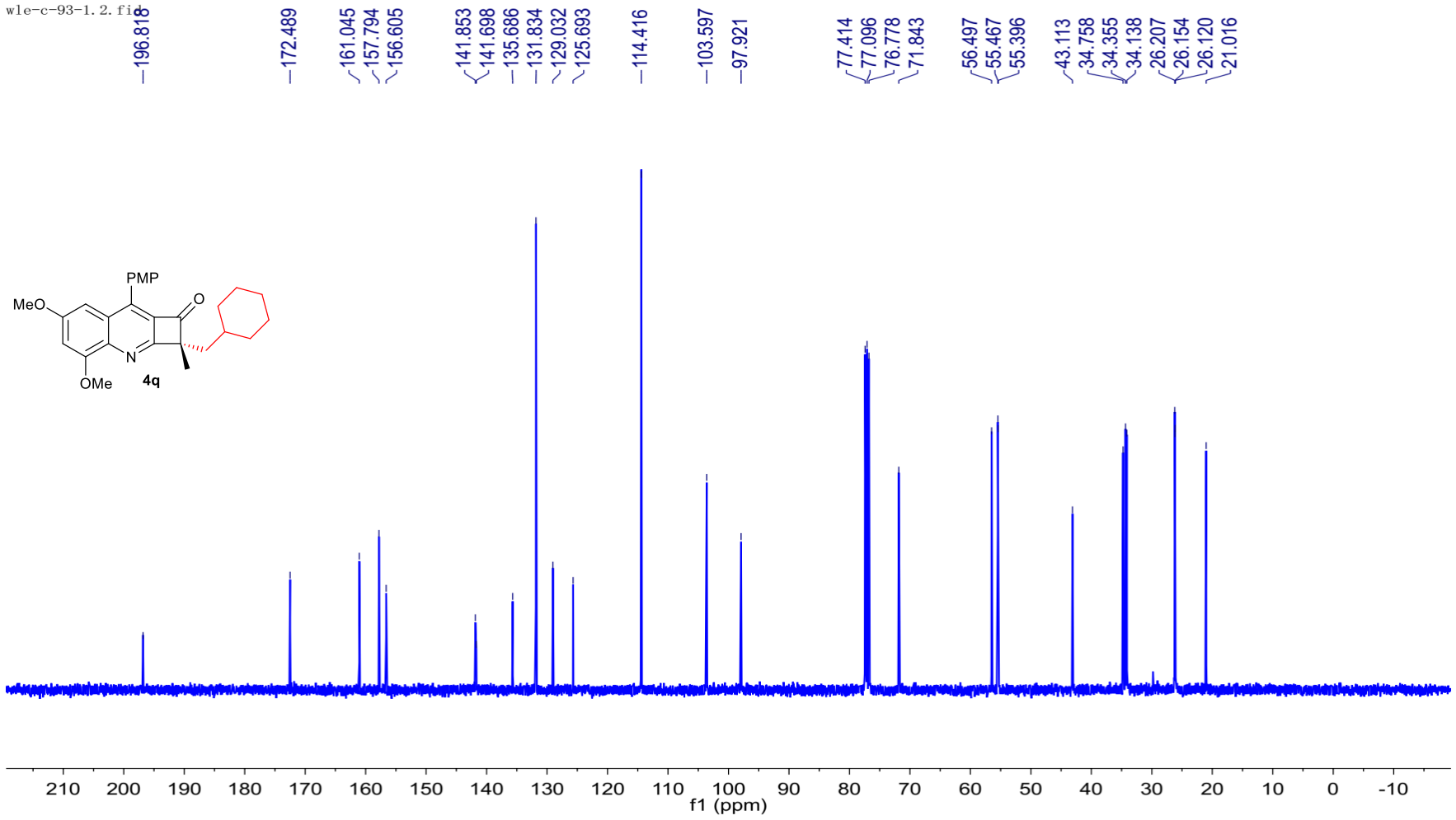
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4p**



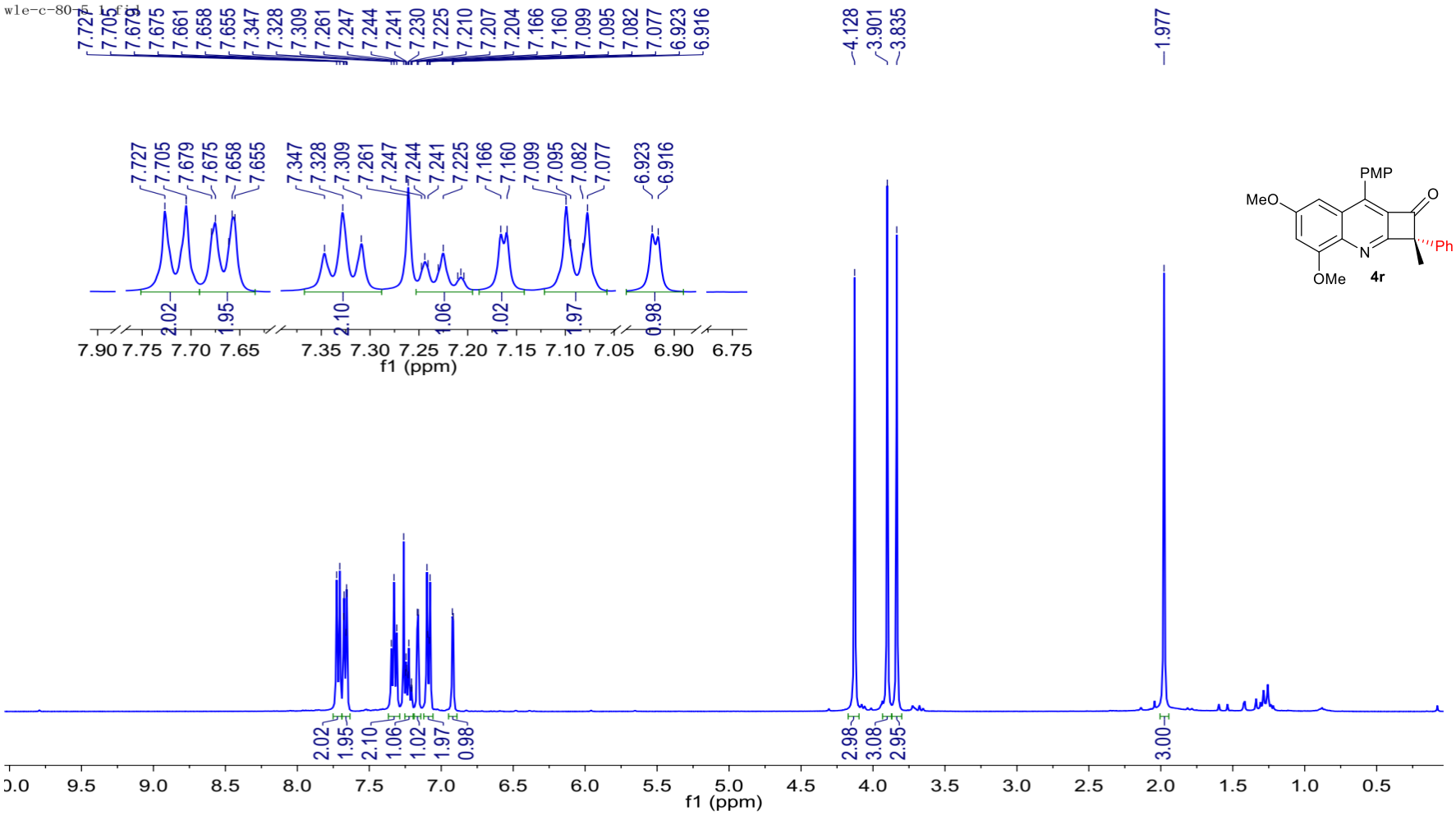
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **4q**



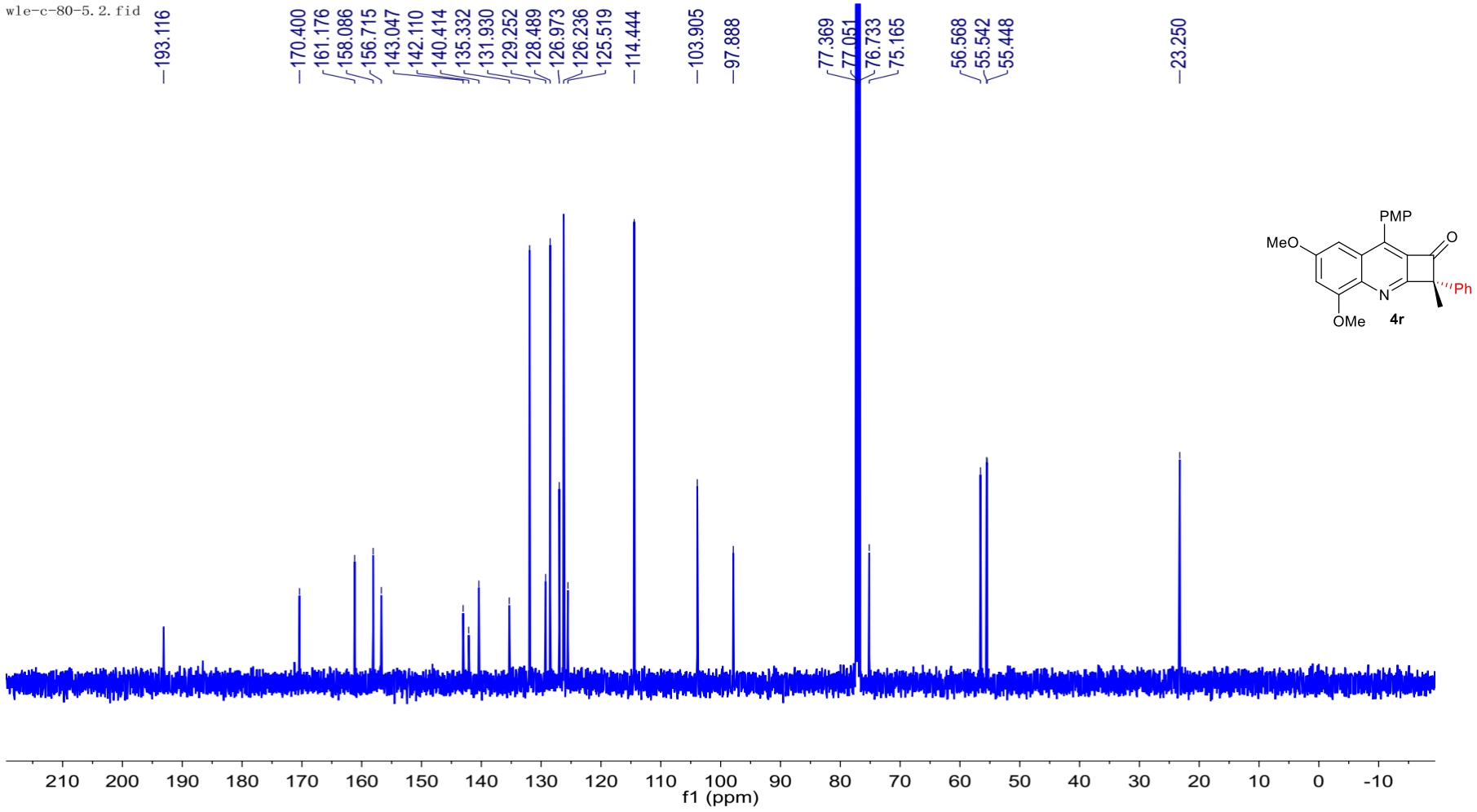
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4q**



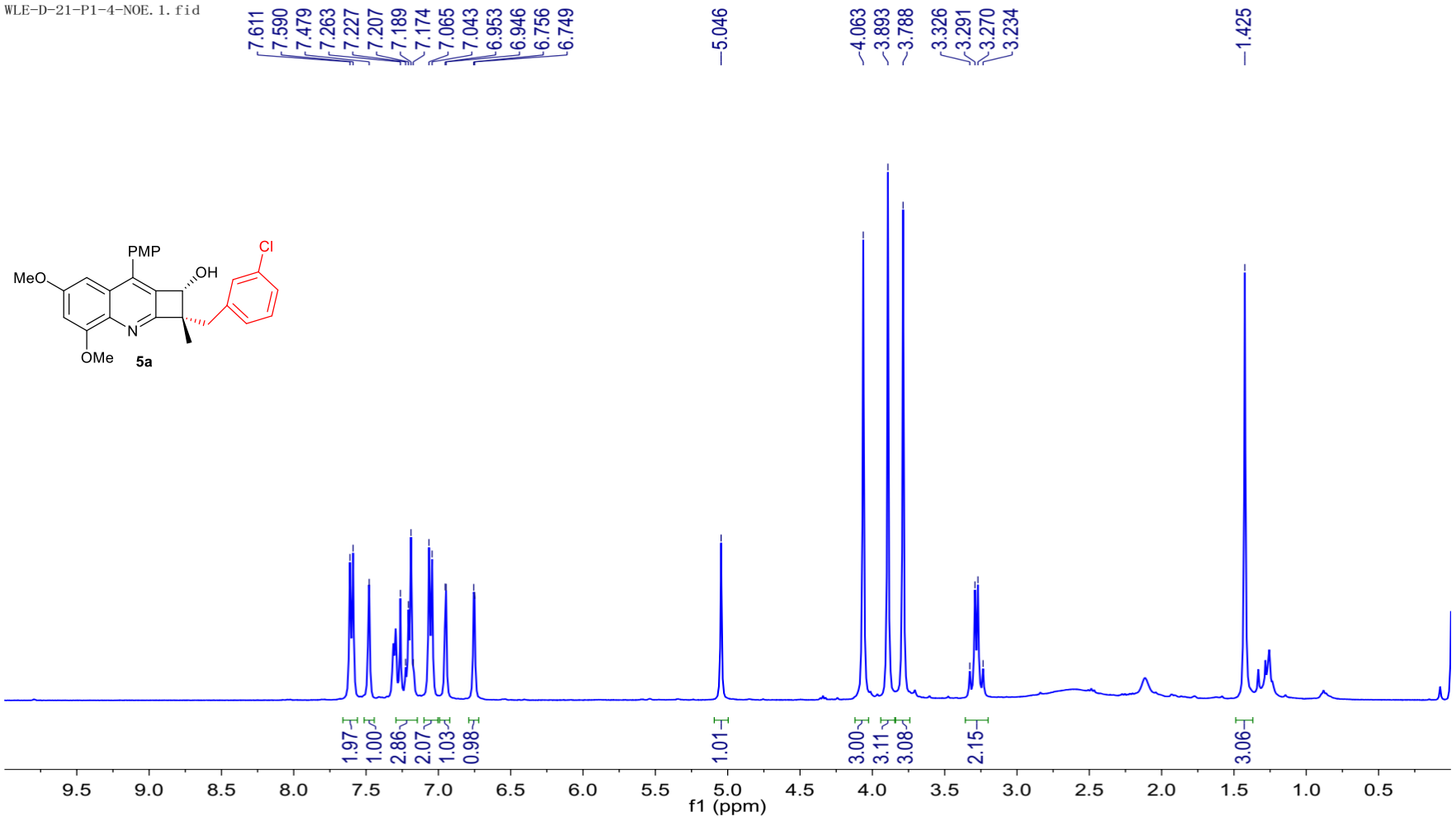
^{1}H NMR Spectrum (400 MHz, Chloroform-d) of **4r**



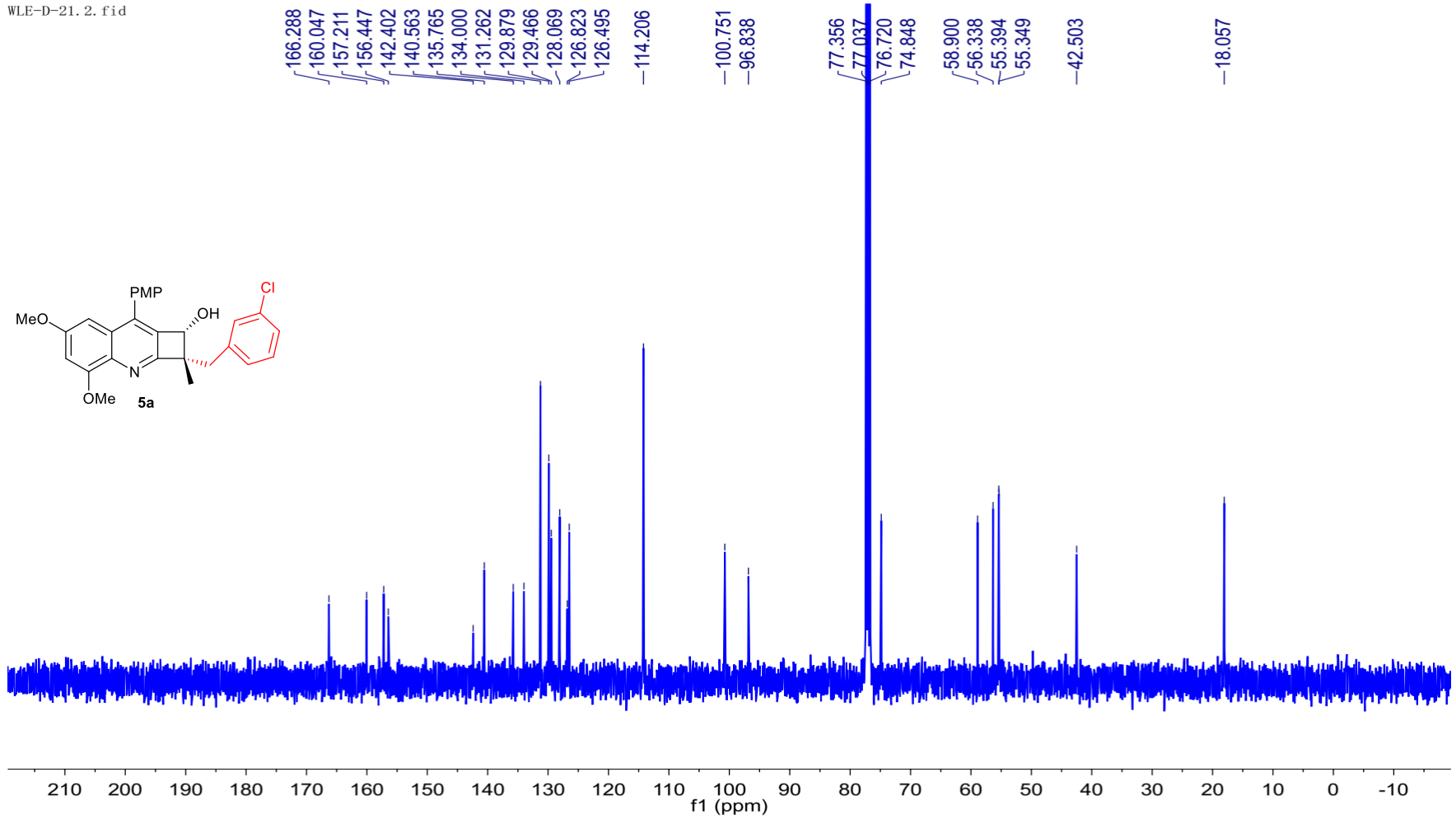
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **4r**



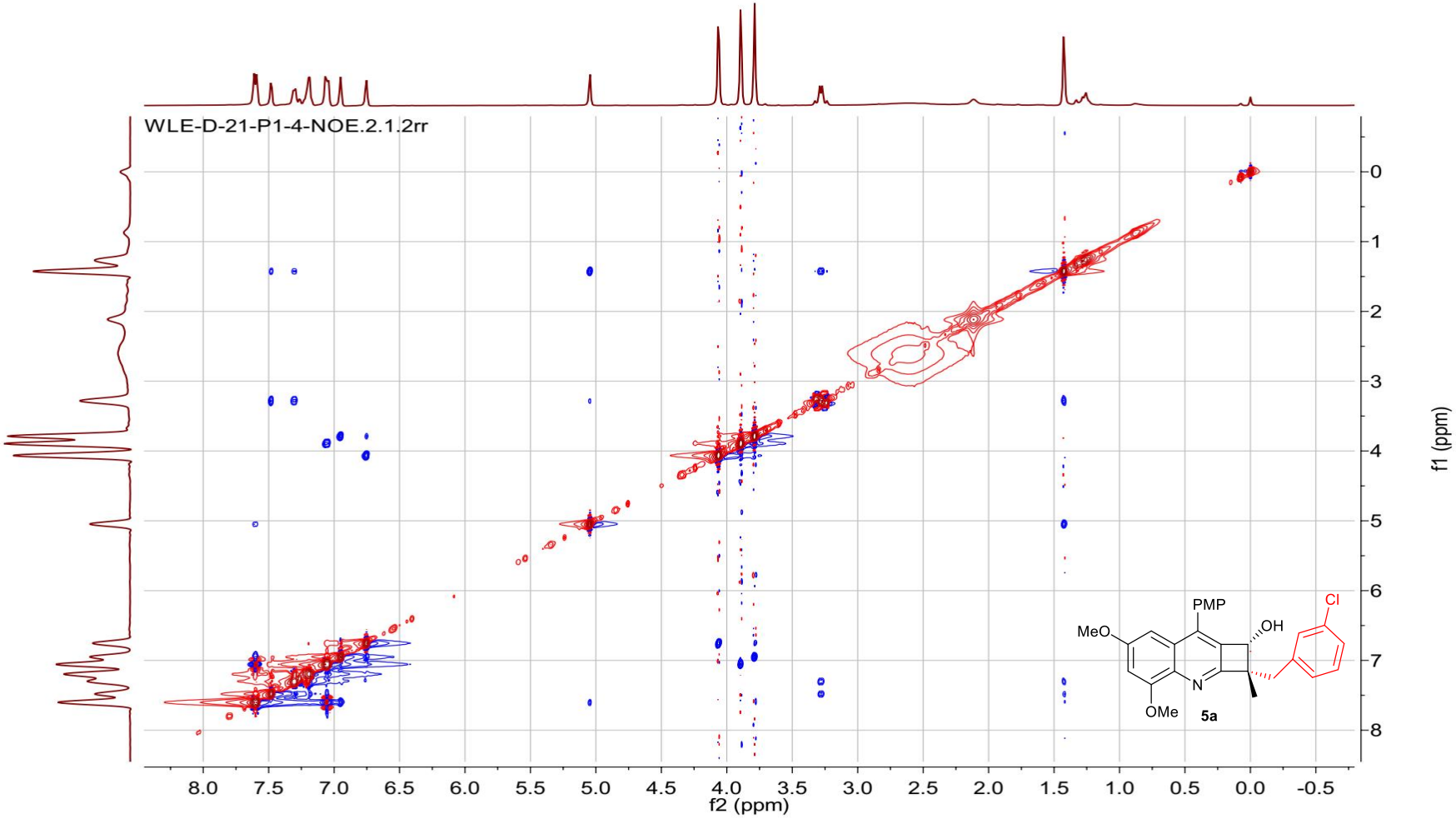
[1]H NMR Spectrum (400 MHz, Chloroform-d) of **5a**



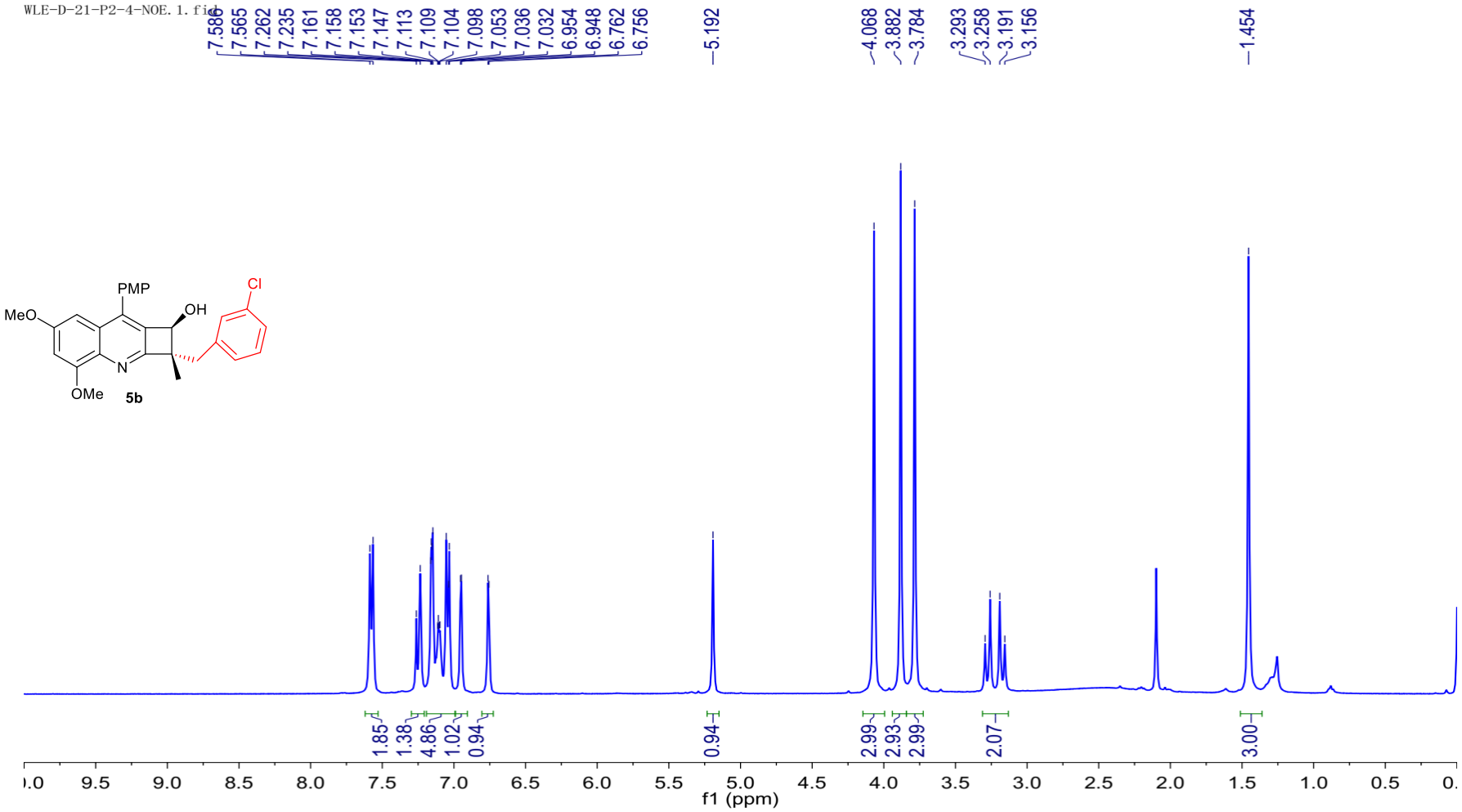
^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **5a**



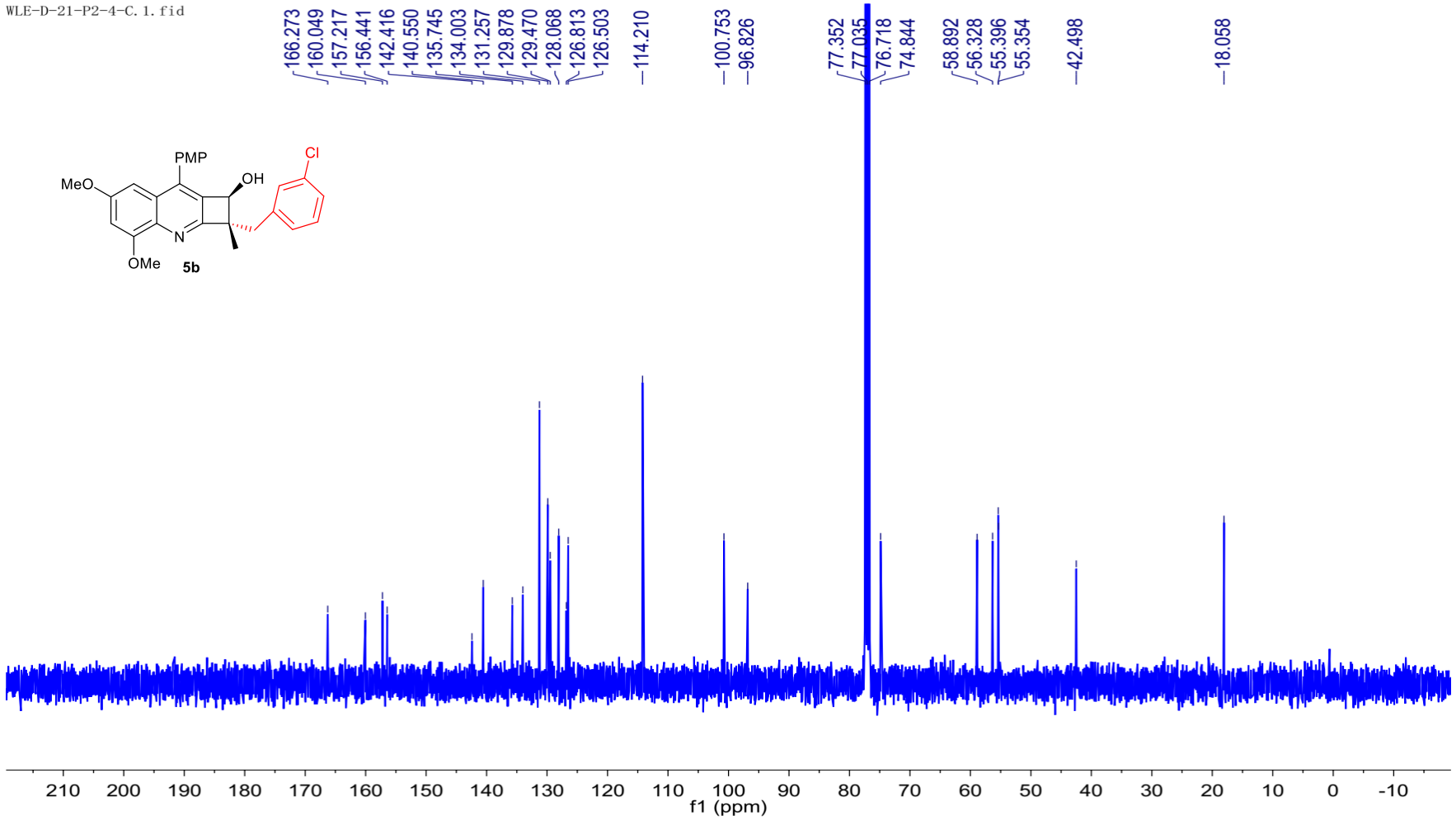
NOESY {^{1}H} NMR Spectrum (101 MHz, Chloroform-*d*) of **5a**



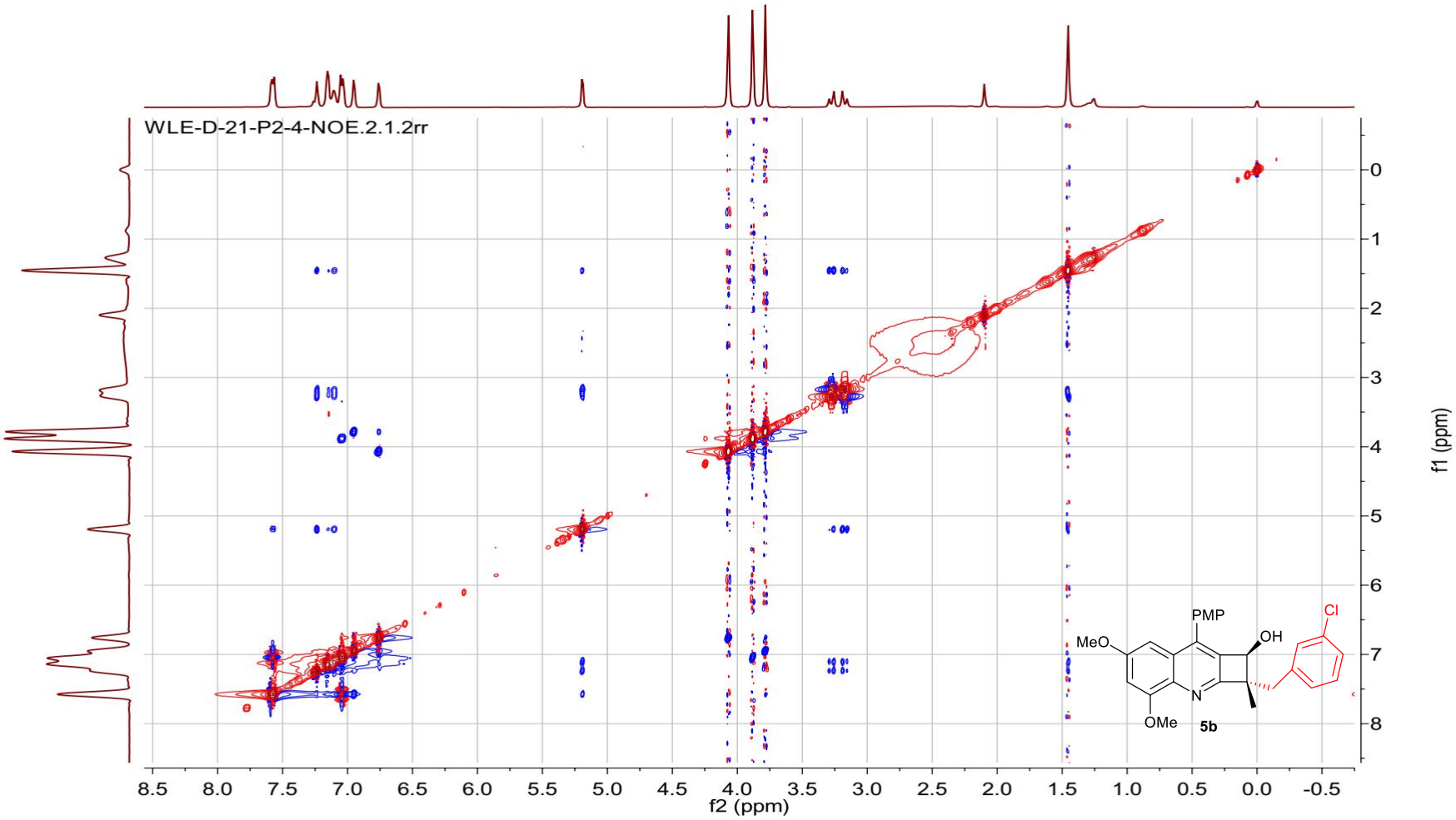
^{1}H NMR Spectrum (400 MHz, Chloroform-d) of **5b**

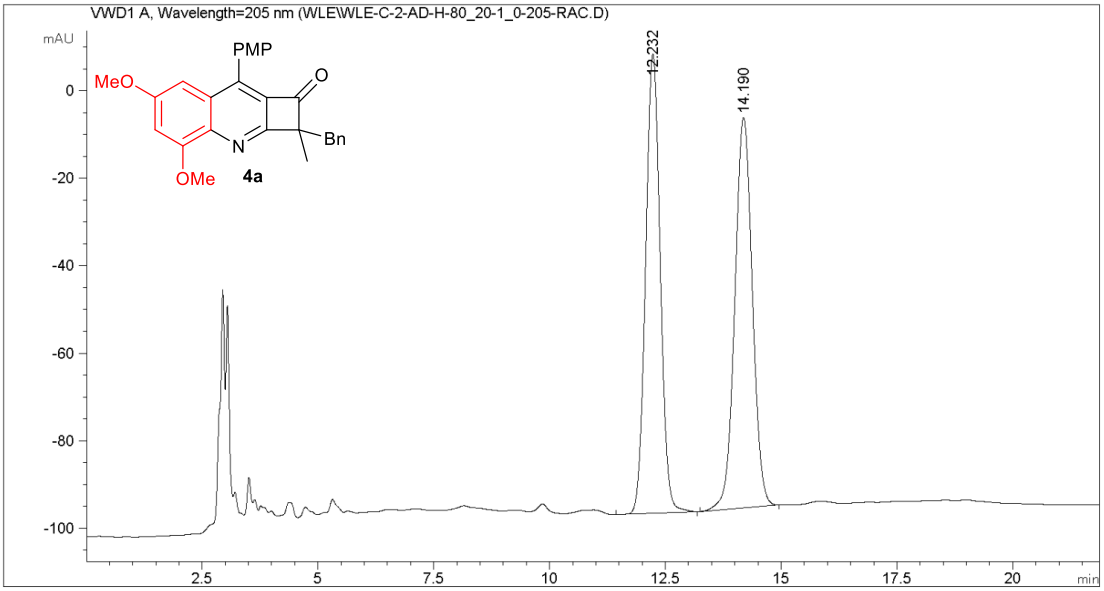


^{13}C {^{1}H} NMR Spectrum (101 MHz, Chloroform-d) of **5b**



NOESY {^{1}H} NMR Spectrum (101 MHz, Chloroform-*d*) of **5b**





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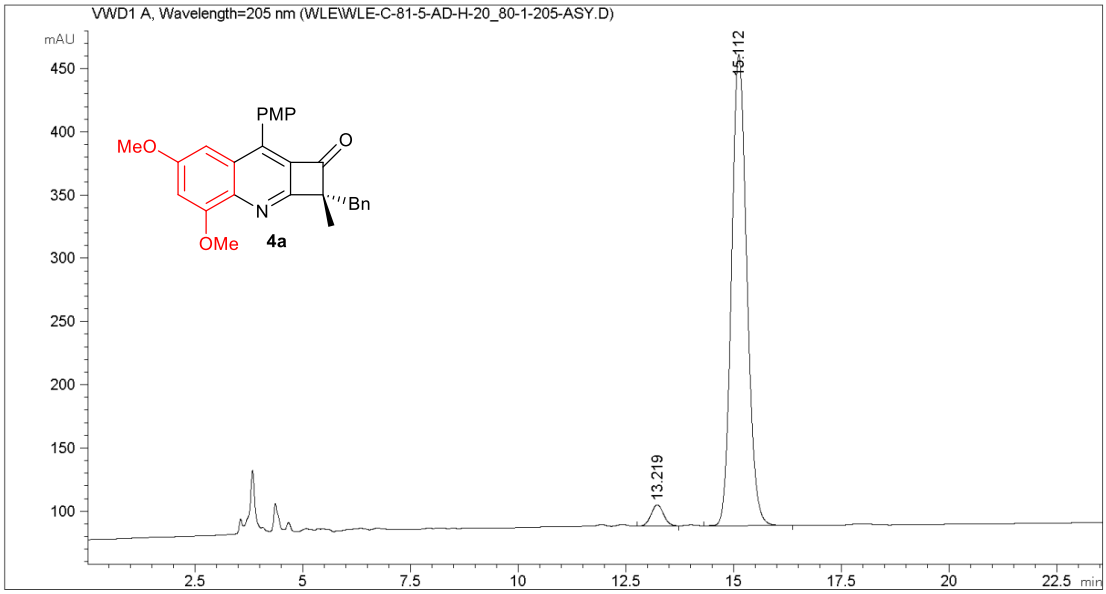

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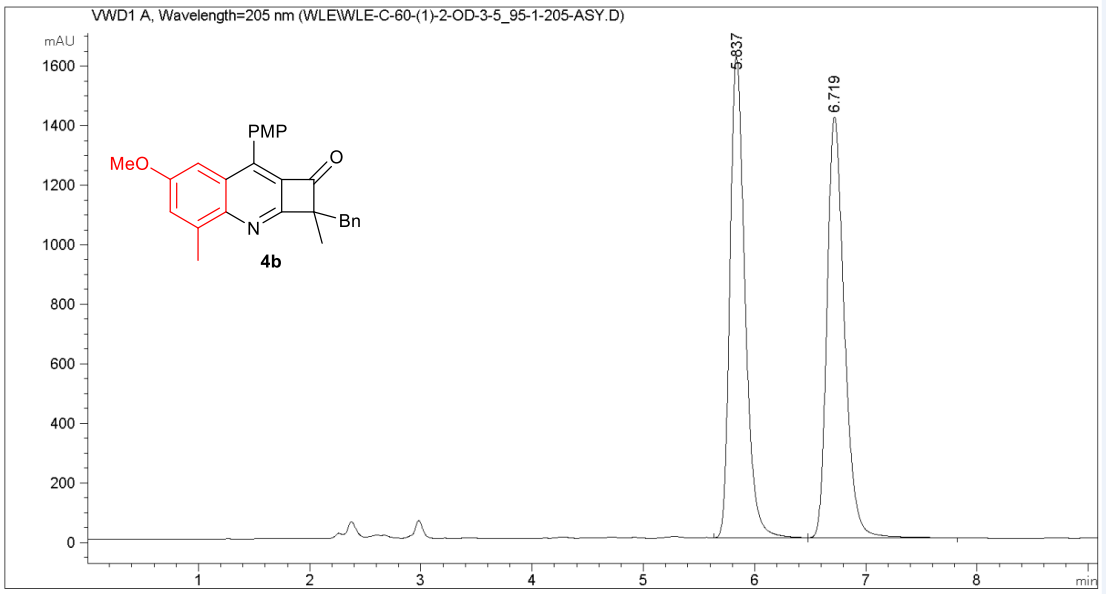

No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
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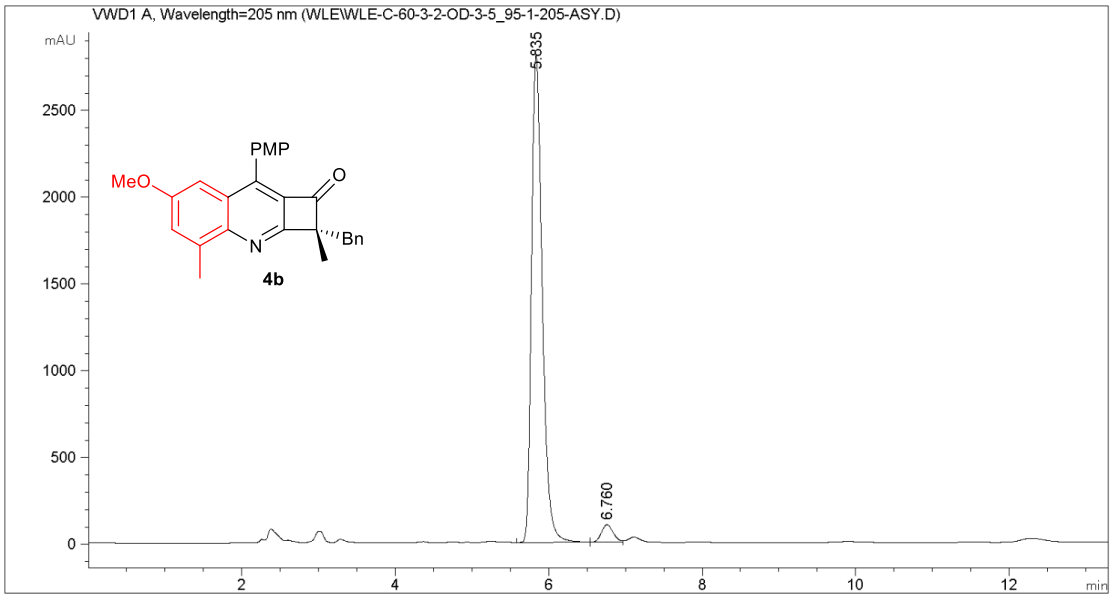

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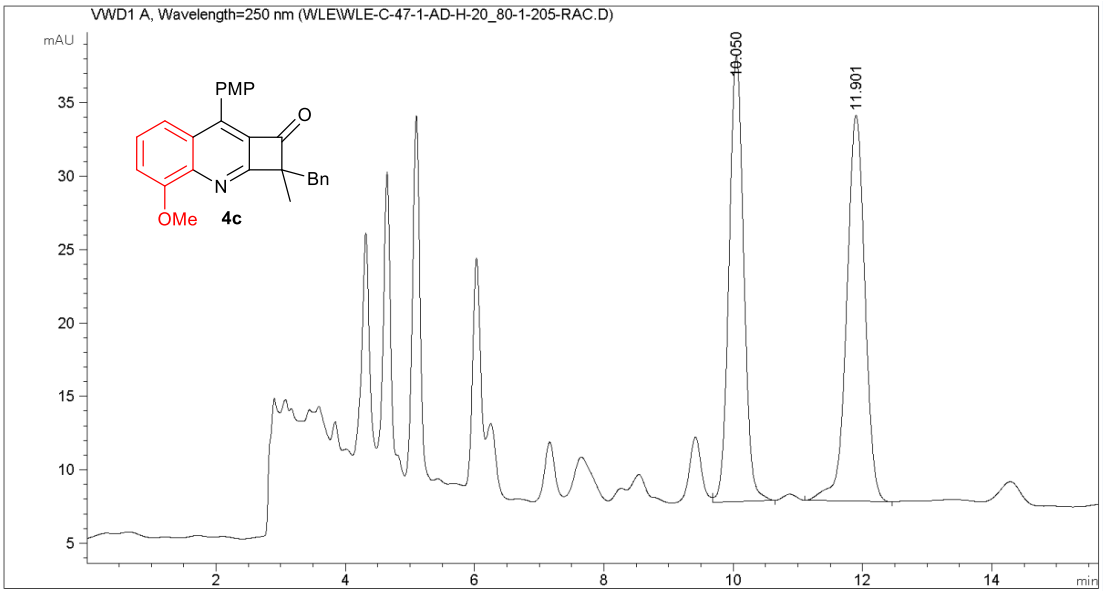

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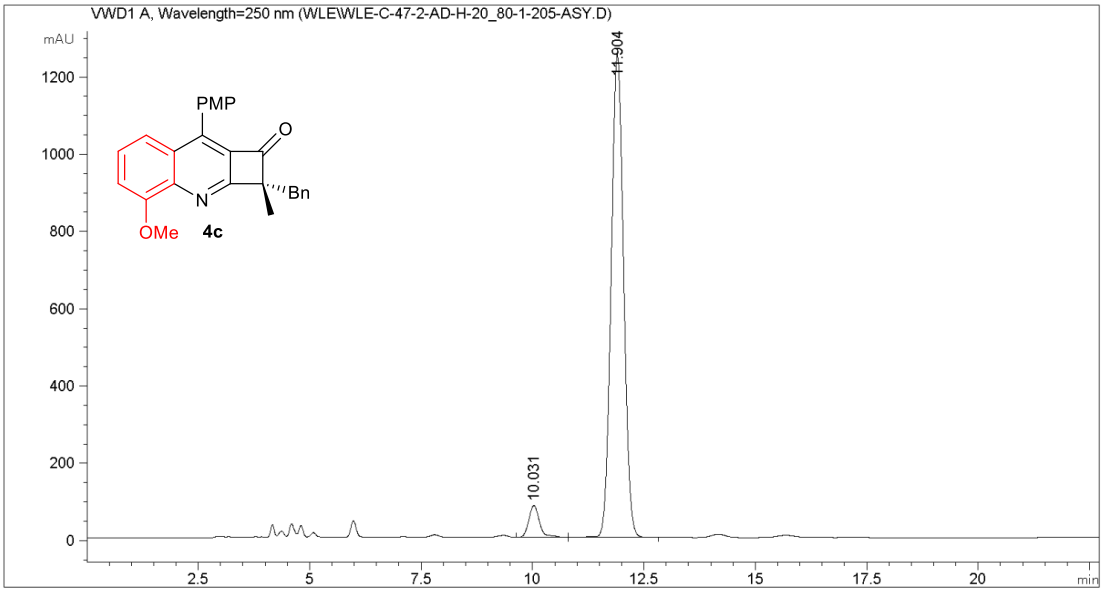

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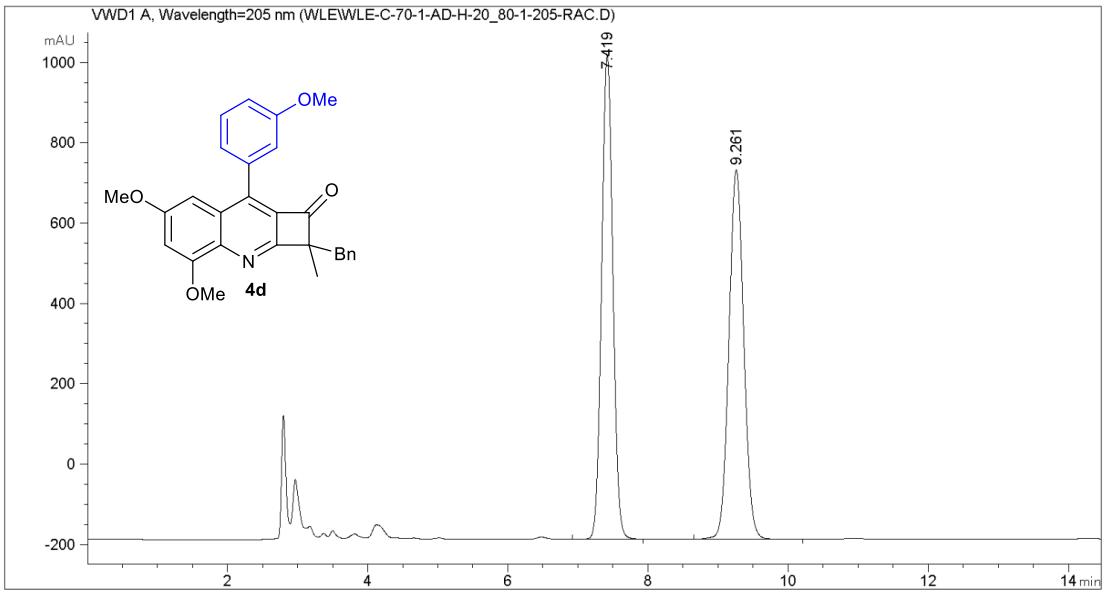

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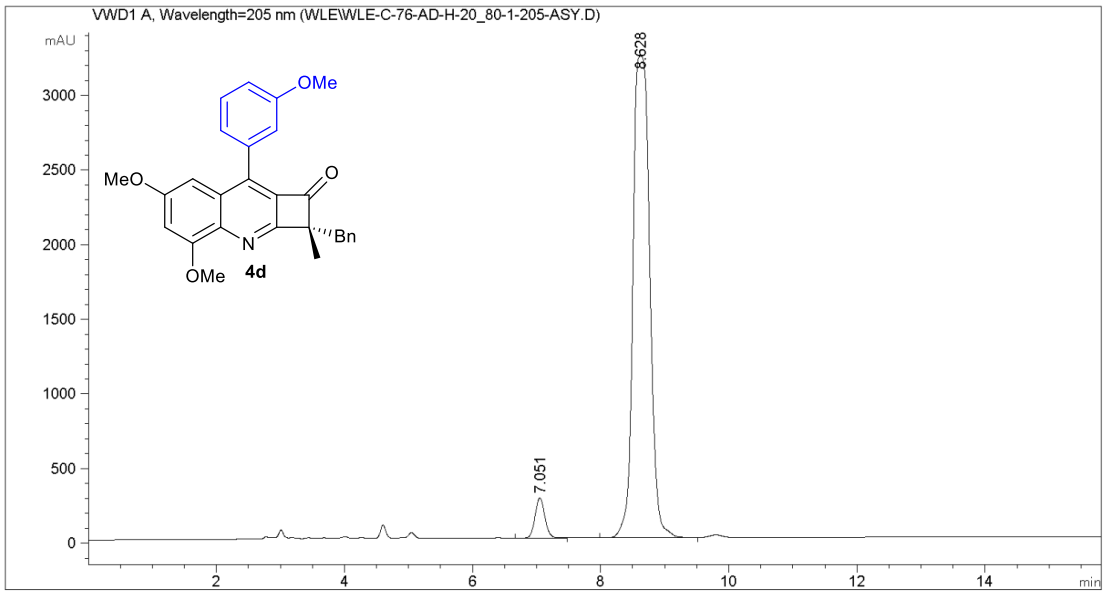

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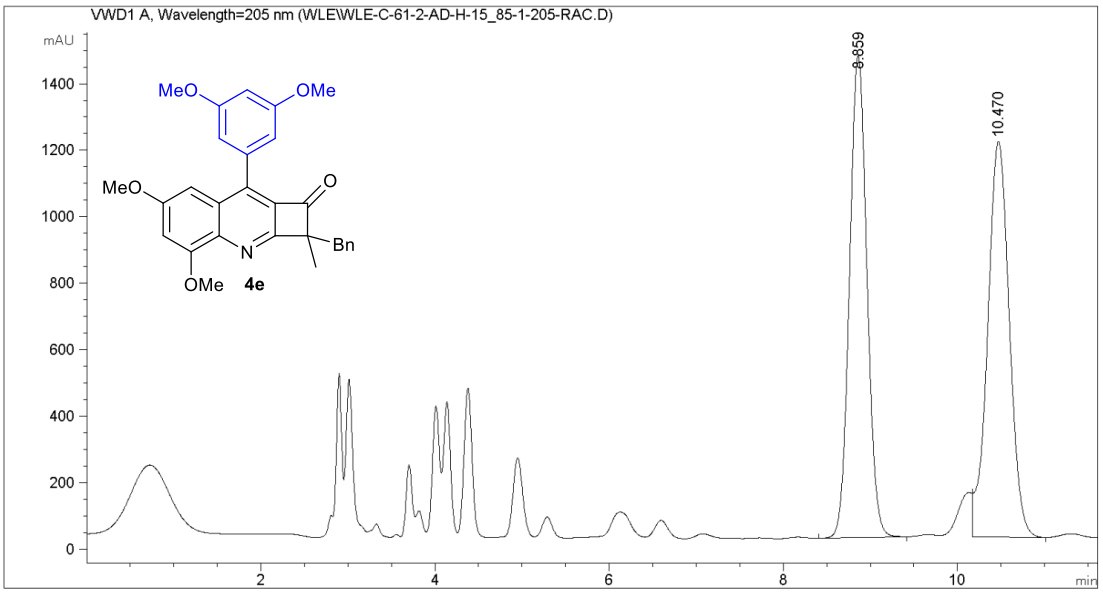

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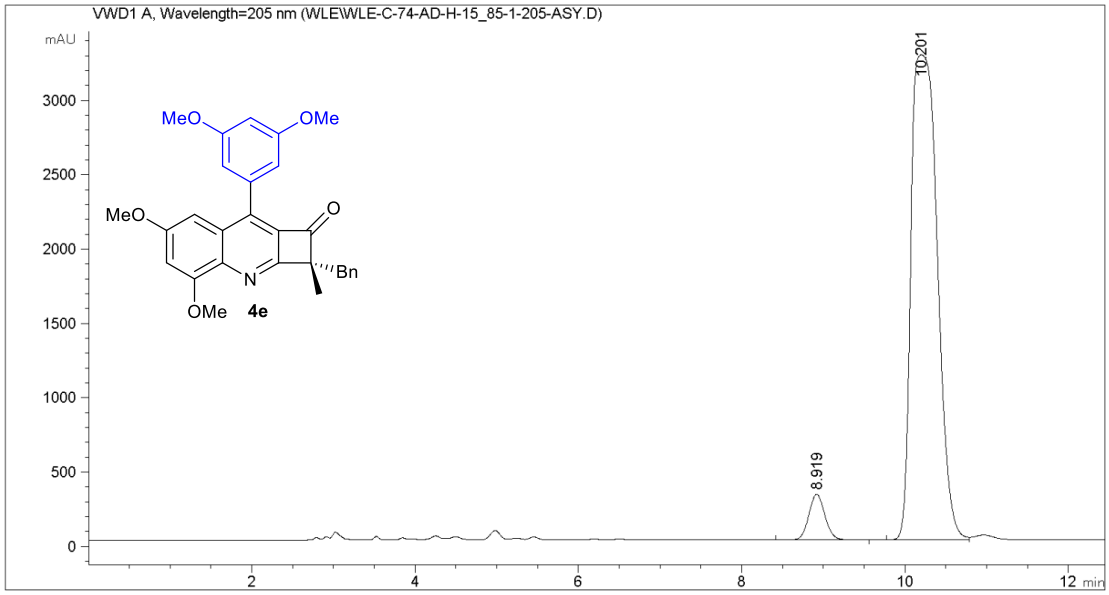

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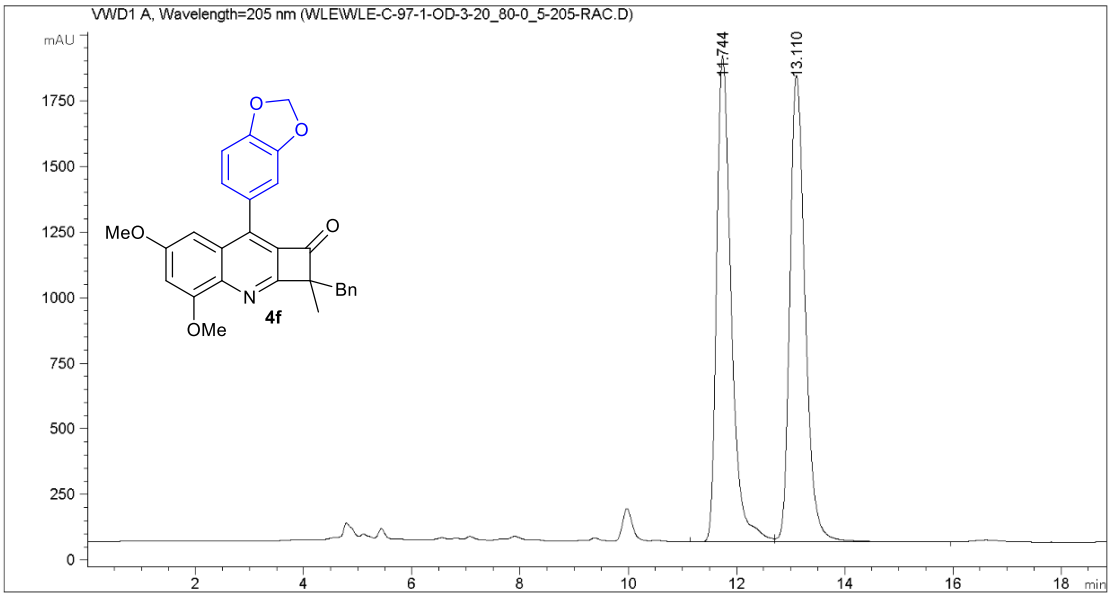

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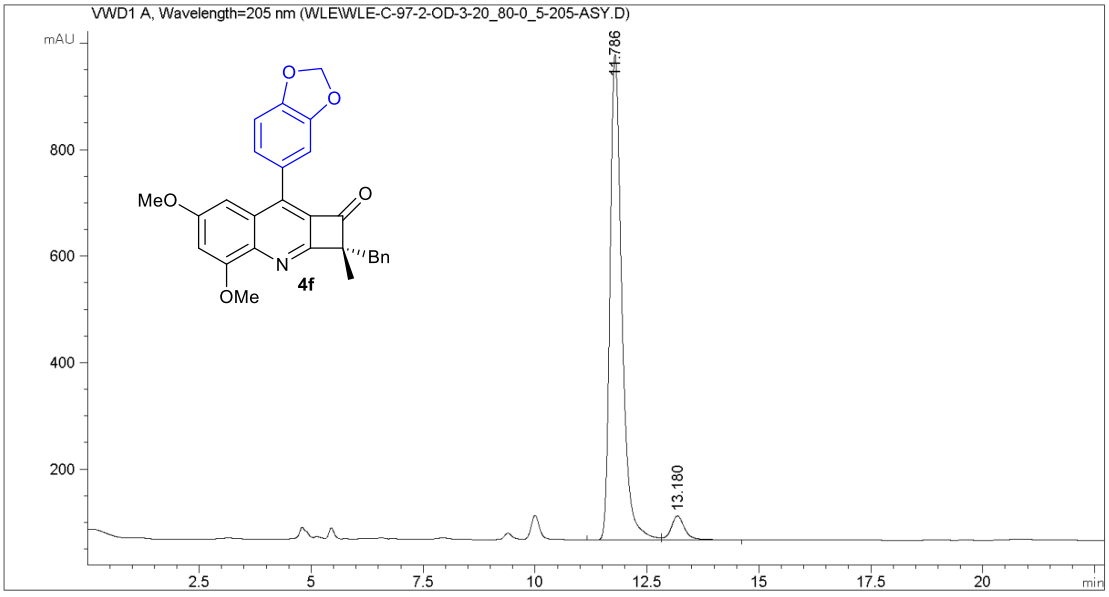

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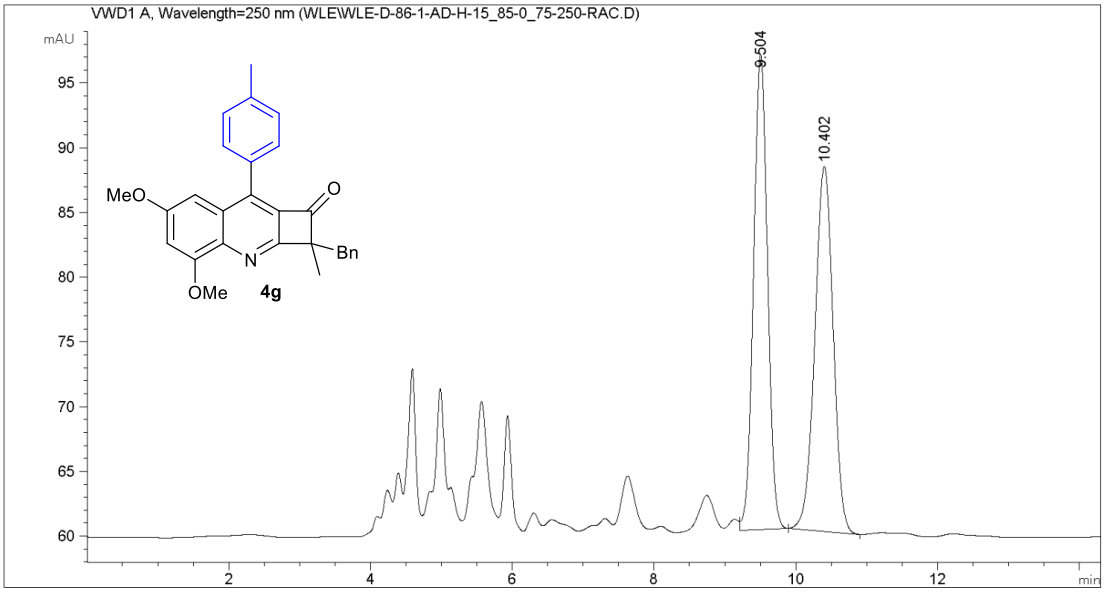

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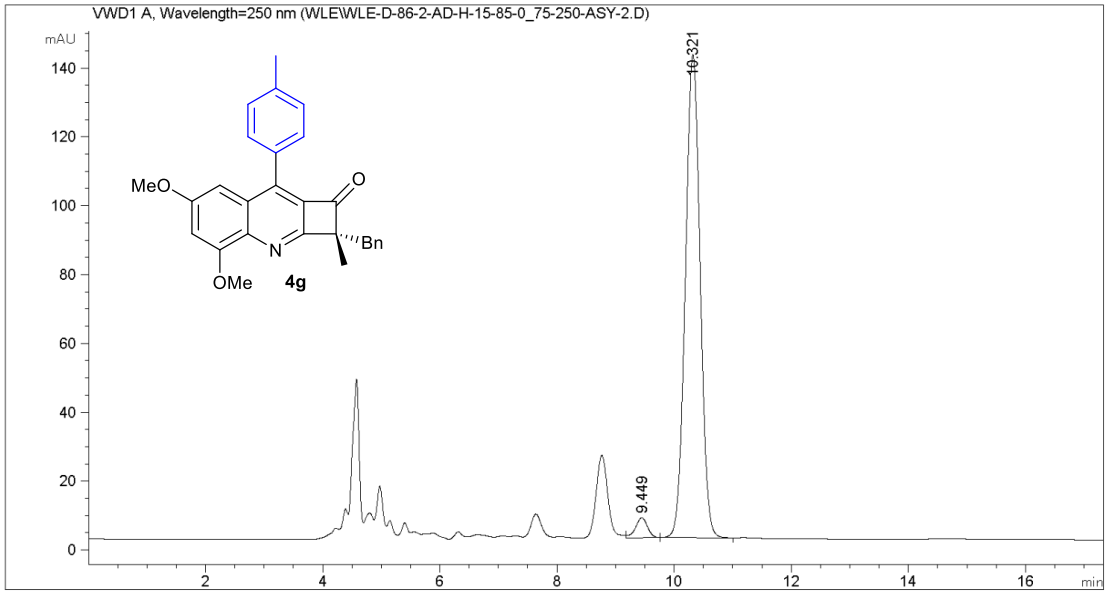

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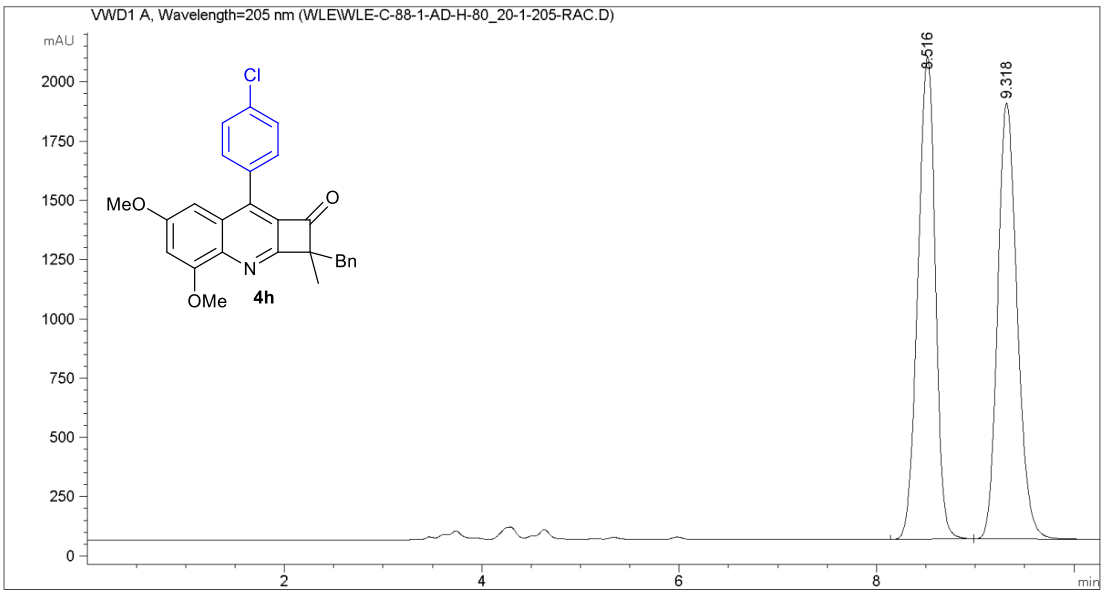
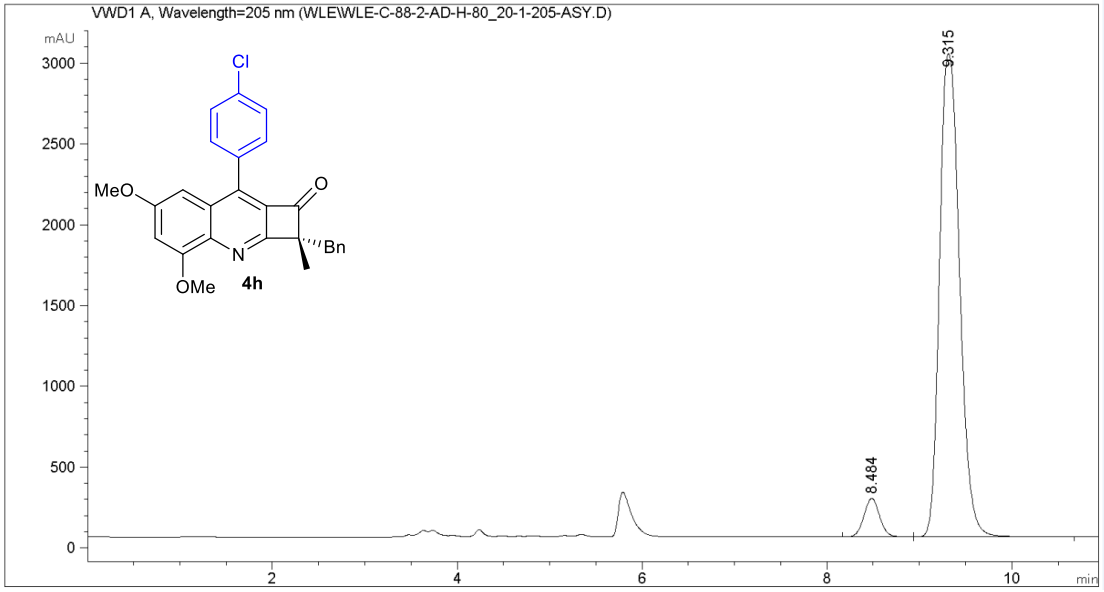
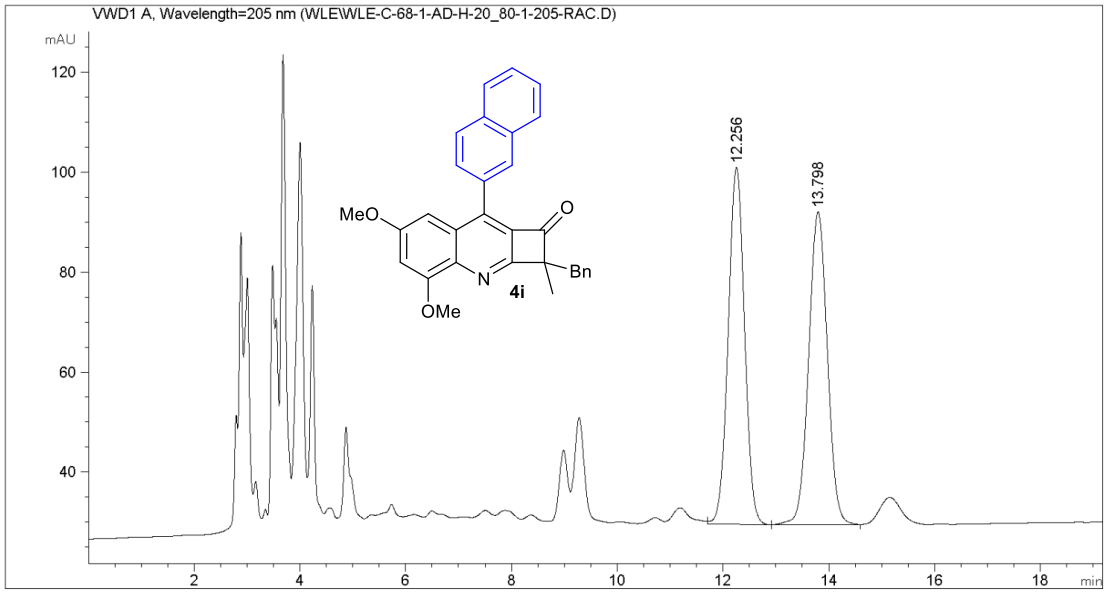
1	9.449	VB	0.2174	82.38947	5.81208	3.2456
2	10.321	BB	0.2732	2456.08789	140.34109	96.7544



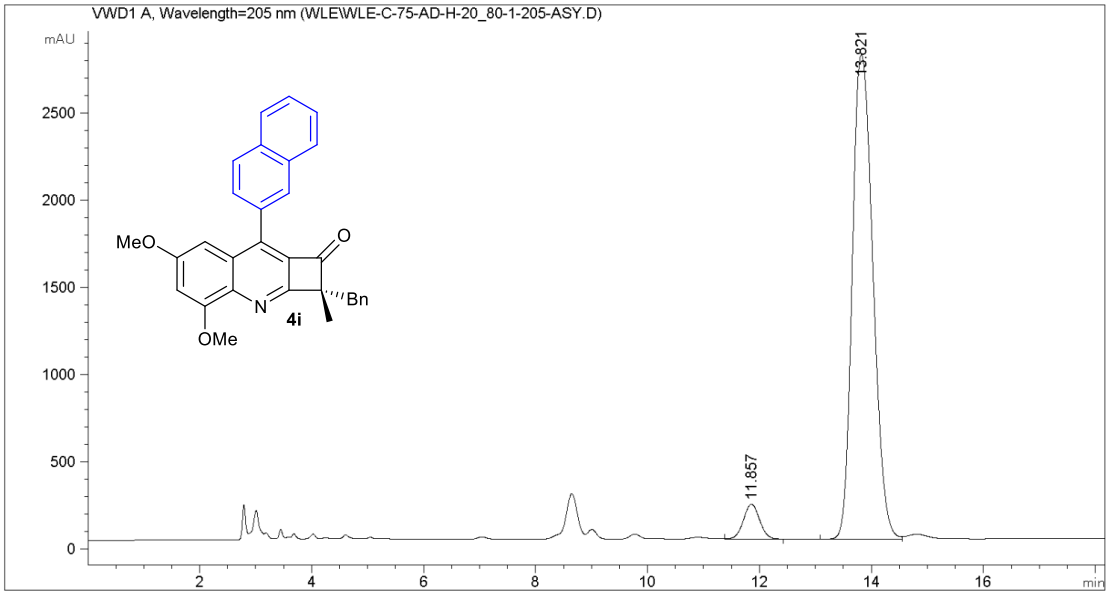
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.516	BB	0.1922	2.50142e4	2038.53149	49.7220
2	9.318	BBA	0.2124	2.52939e4	1839.36304	50.2780



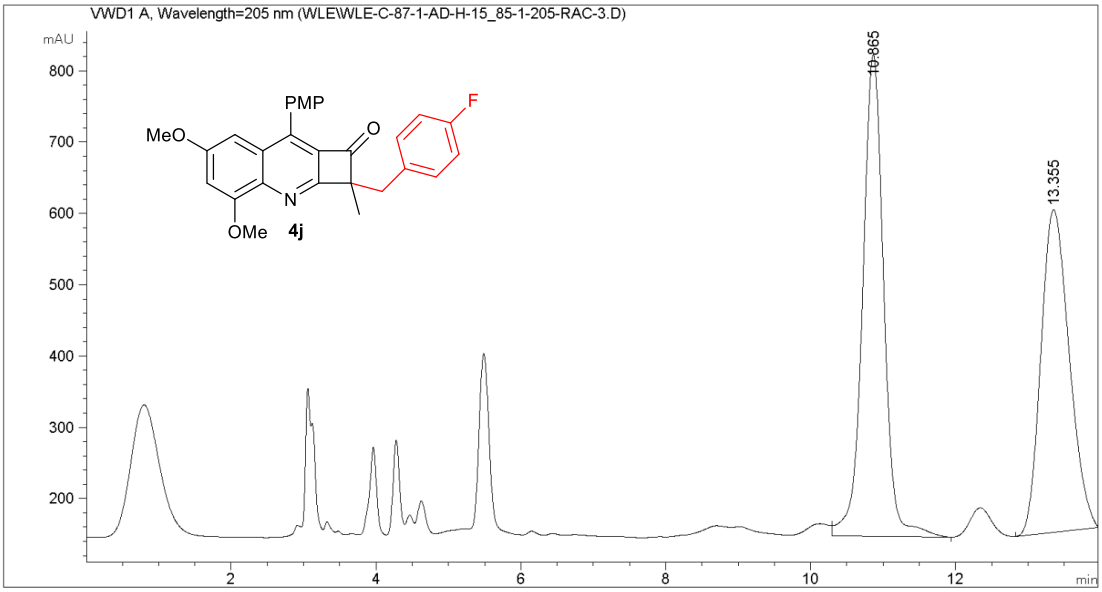
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.484	VB	0.1827	2816.00439	238.62781	5.8956
2	9.315	BB	0.2354	4.49483e4	2989.49365	94.1044



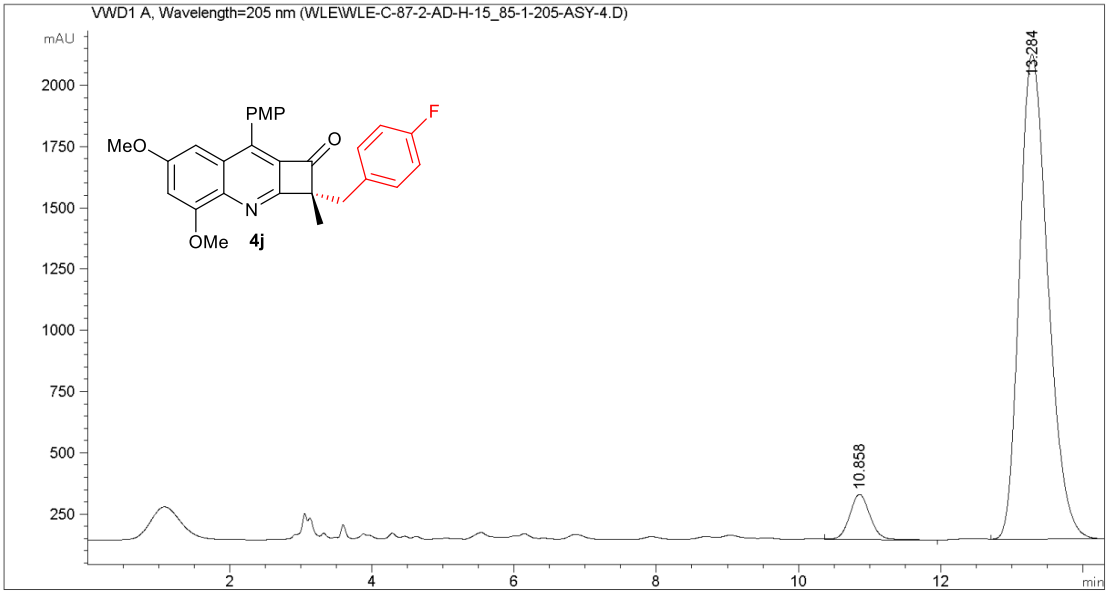
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.256	VB	0.3347	1535.12598	71.43362	49.9792
2	13.798	BB	0.3817	1536.40503	62.52917	50.0208



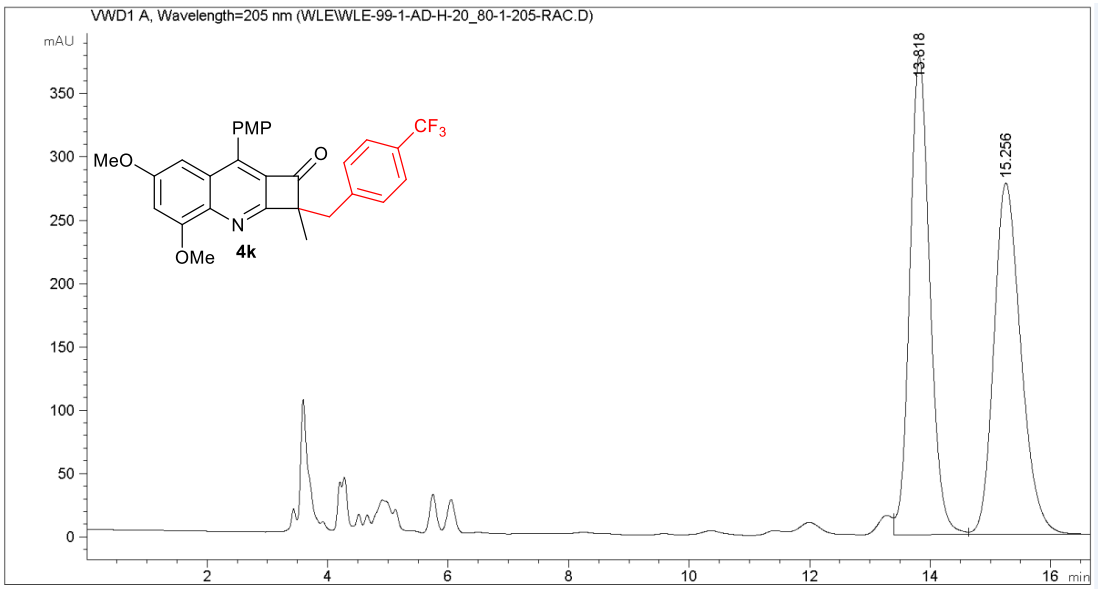
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.857	VV	0.3130	4047.57983	200.92456	5.3861
2	13.821	BV	0.4014	7.11004e4	2780.26855	94.6139



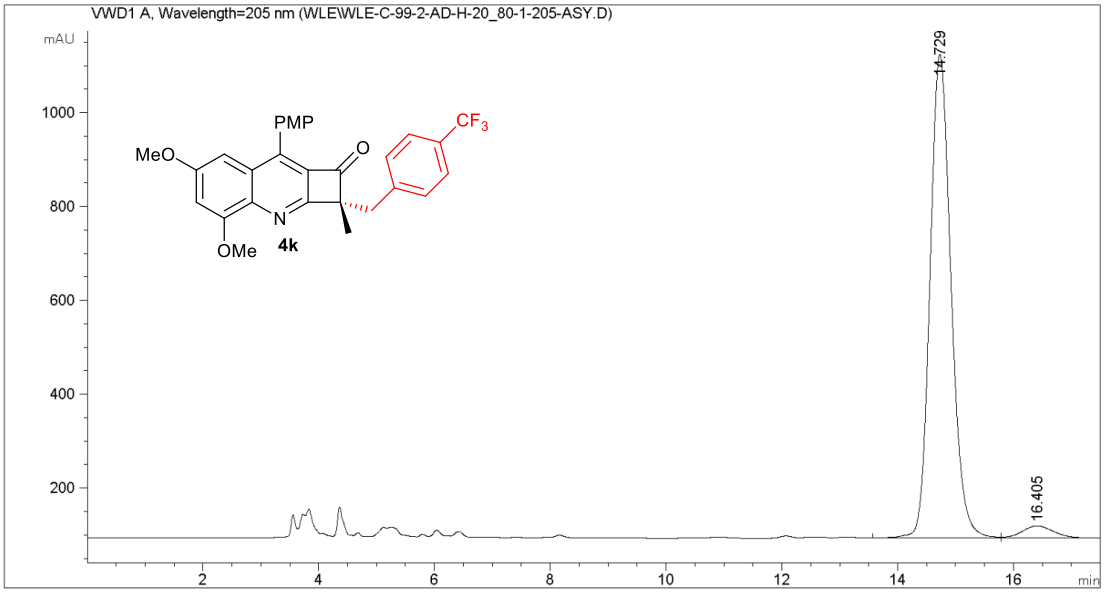
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.865	VB	0.3093	1.36814e4	675.58118	52.7814
2	13.355	BBA	0.4206	1.22394e4	452.42776	47.2186



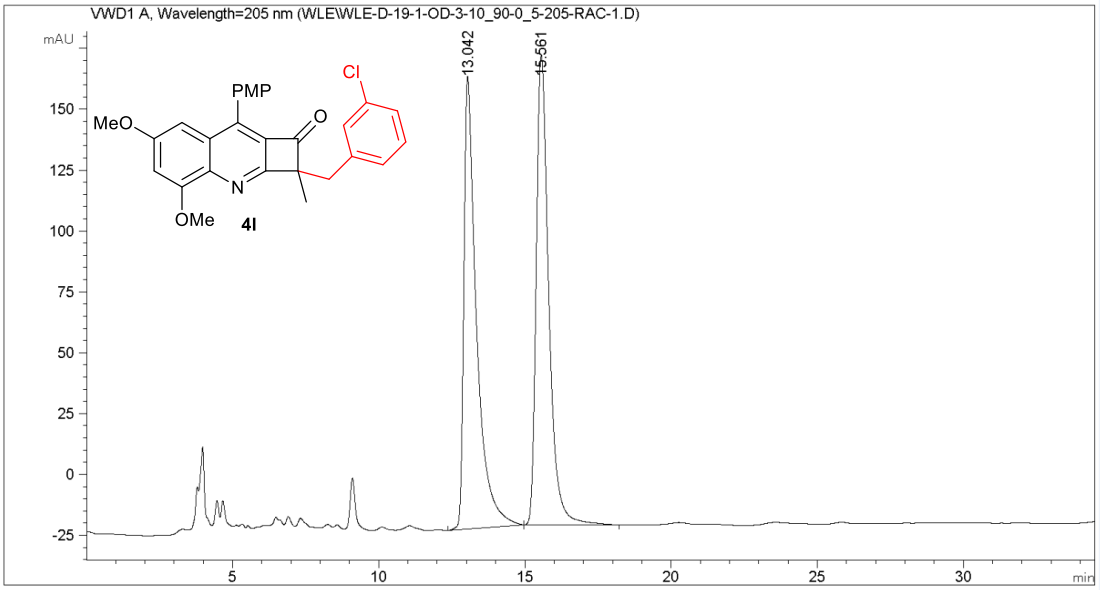
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.858	VB	0.3079	3689.60352	184.84261	6.2949
2	13.284	VBA	0.4296	5.49234e4	1980.27686	93.7051



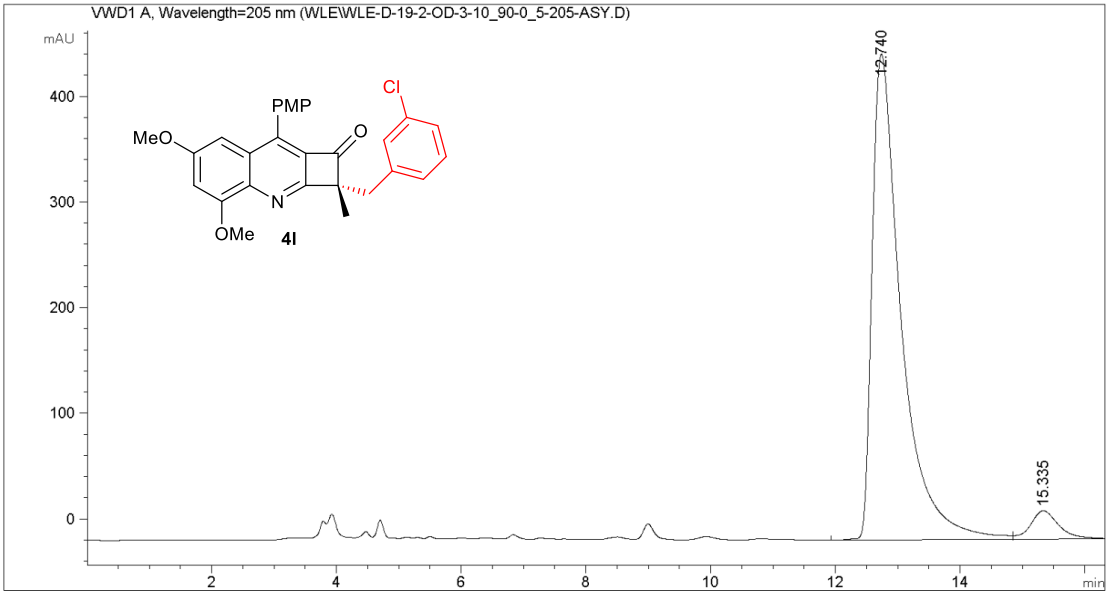
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.818	VV	0.3564	8721.87891	377.71152	50.2257
2	15.256	VBA	0.4773	8643.49609	277.54532	49.7743



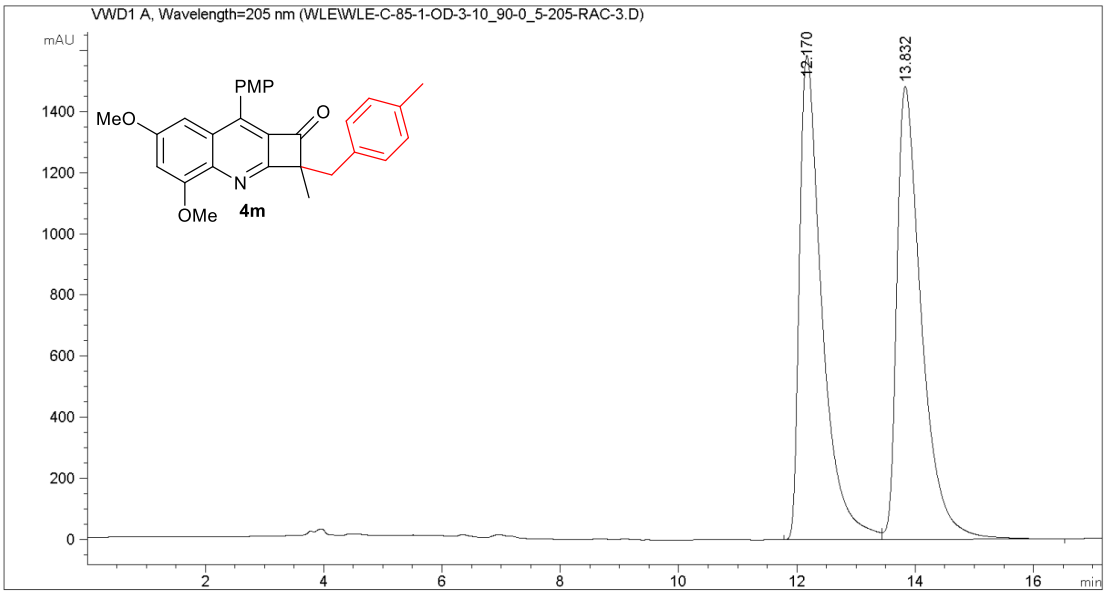
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.729	BV	0.3894	2.60117e4	1030.92615	96.3849
2	16.405	VBA	0.5791	975.61224	25.86177	3.6151



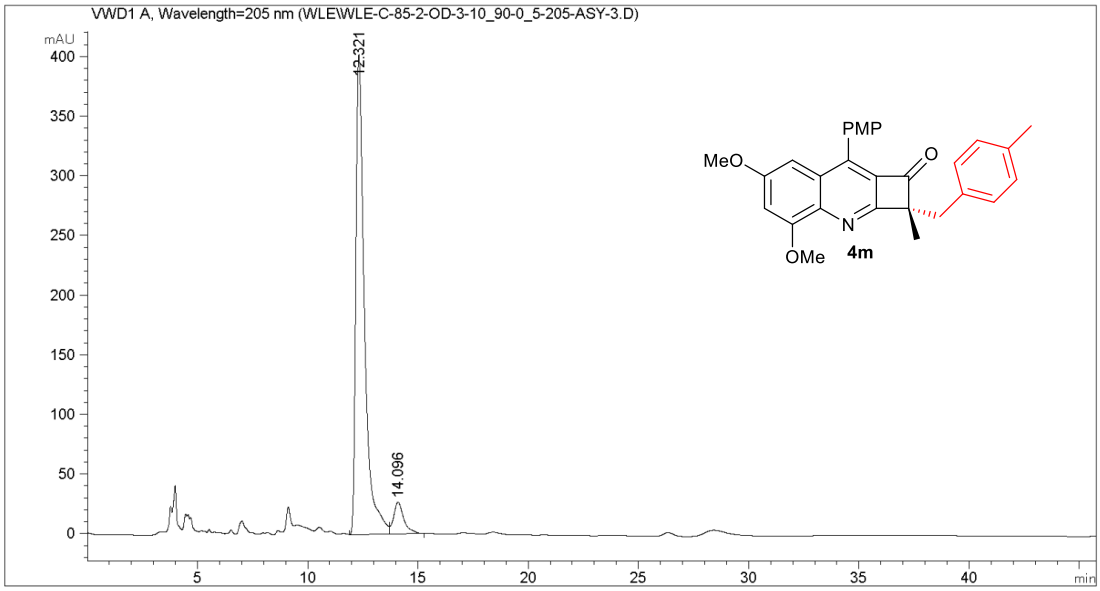
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.042	BB	0.4284	5566.97266	185.87175	49.2288
2	15.561	BB	0.4508	5741.39746	193.16600	50.7712



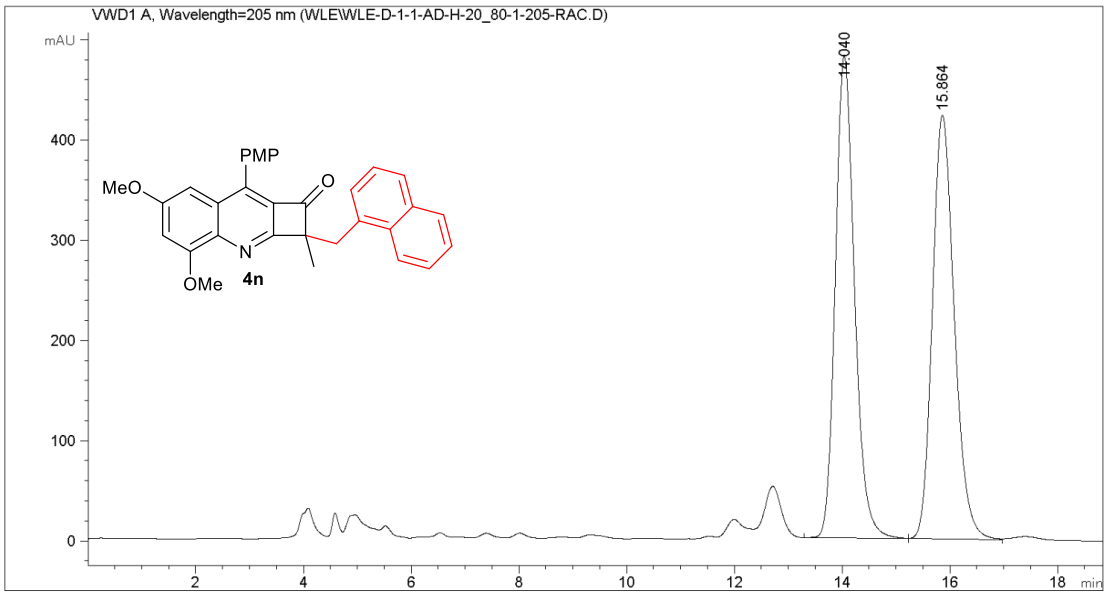
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.740	BV	0.4795	1.48836e4	459.92599	94.7682
2	15.335	VBA	0.4642	821.67438	26.53792	5.2318



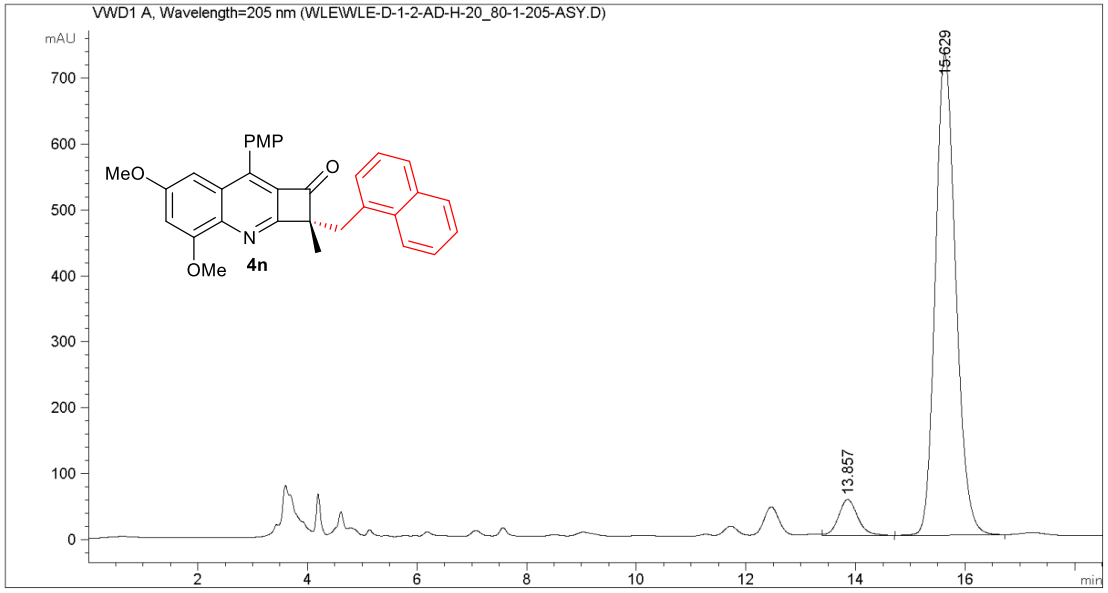
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.170	BV	0.3918	4.18152e4	1585.16211	49.3320
2	13.832	VB	0.4320	4.29476e4	1482.59155	50.6680



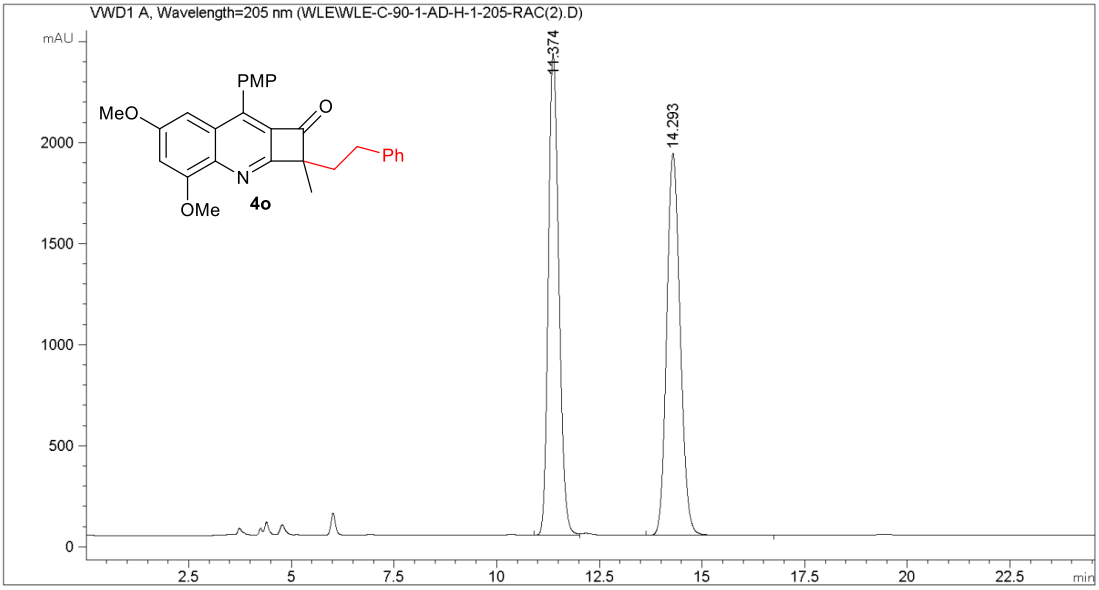
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.321	BV	0.4059	1.09570e4	402.14716	92.6417
2	14.096	VB	0.4793	870.29291	26.76643	7.3583



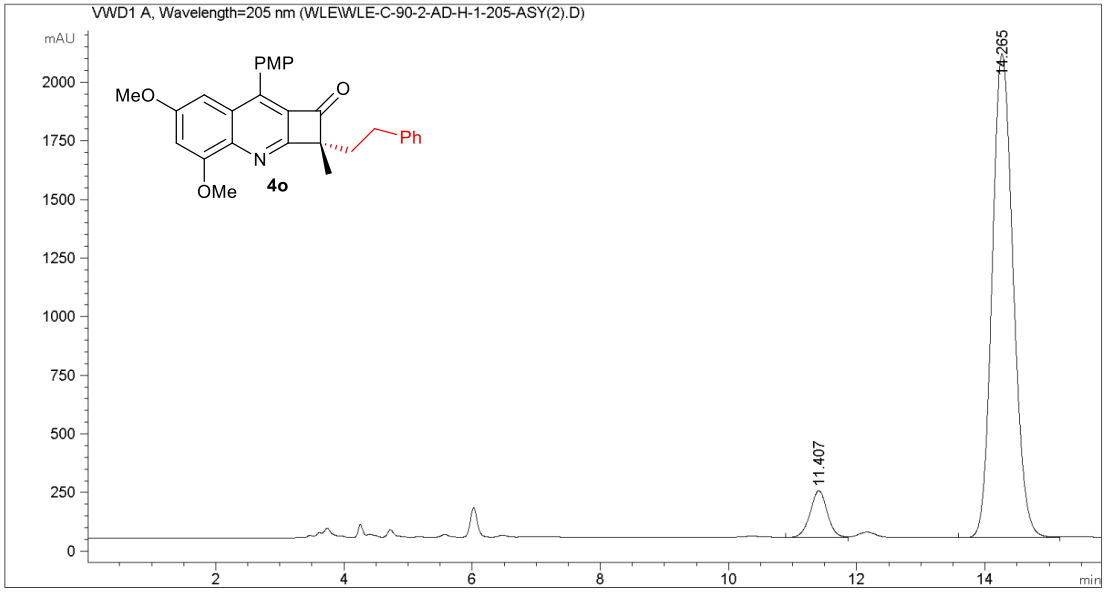
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.040	BB	0.3806	1.18889e4	480.57648	49.9313
2	15.864	BV	0.4352	1.19216e4	422.45511	50.0687



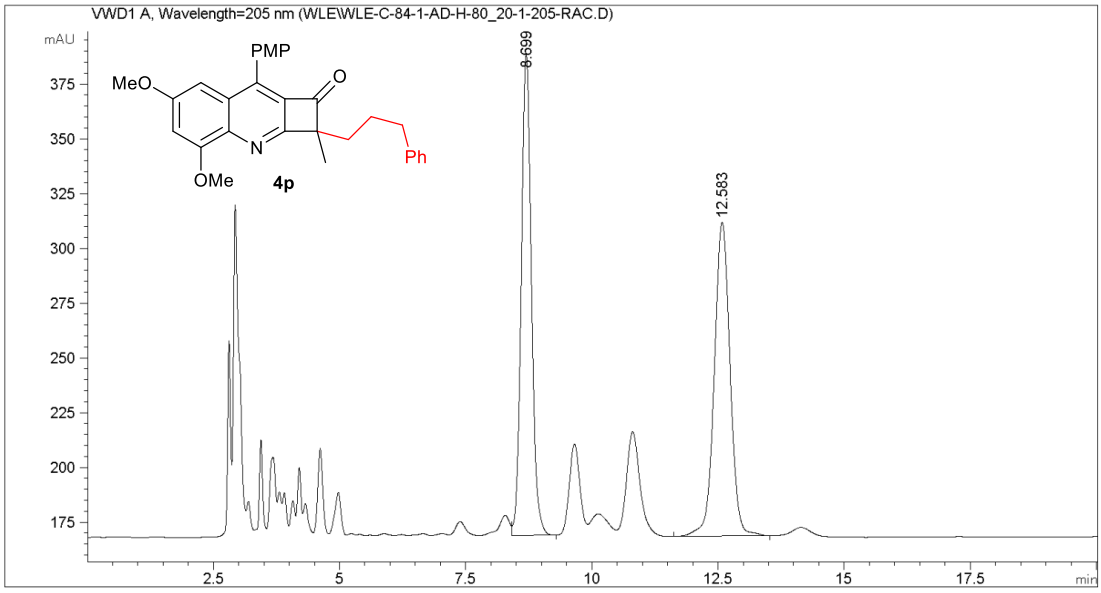
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.857	VB	0.3715	1323.14063	54.64806	6.5572
2	15.629	BB	0.3993	1.88554e4	730.16913	93.4428



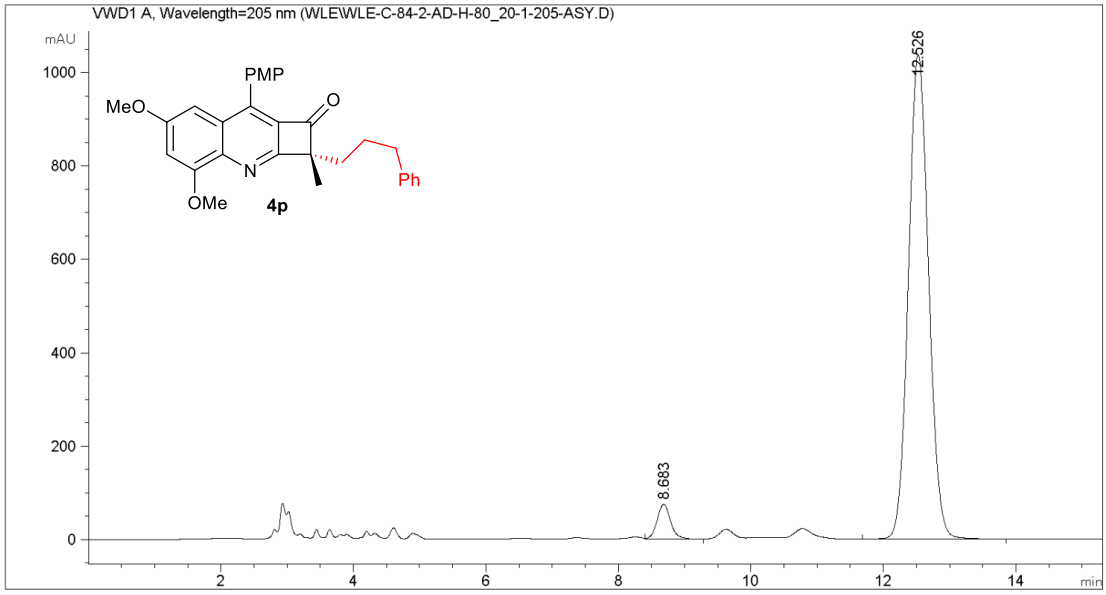
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.374	BV	0.2778	4.24515e4	2383.16553	49.5962
2	14.293	BB	0.3553	4.31427e4	1890.29260	50.4038



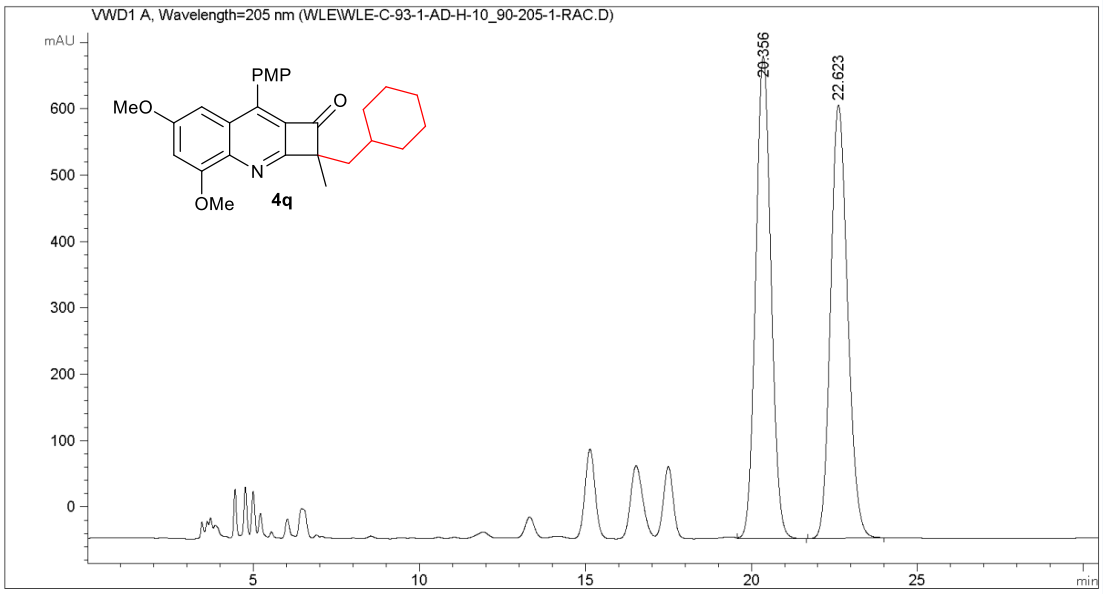
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.407	BV	0.2835	3697.09790	199.25688	7.3000
2	14.265	BV	0.3546	4.69483e4	2061.87524	92.7000



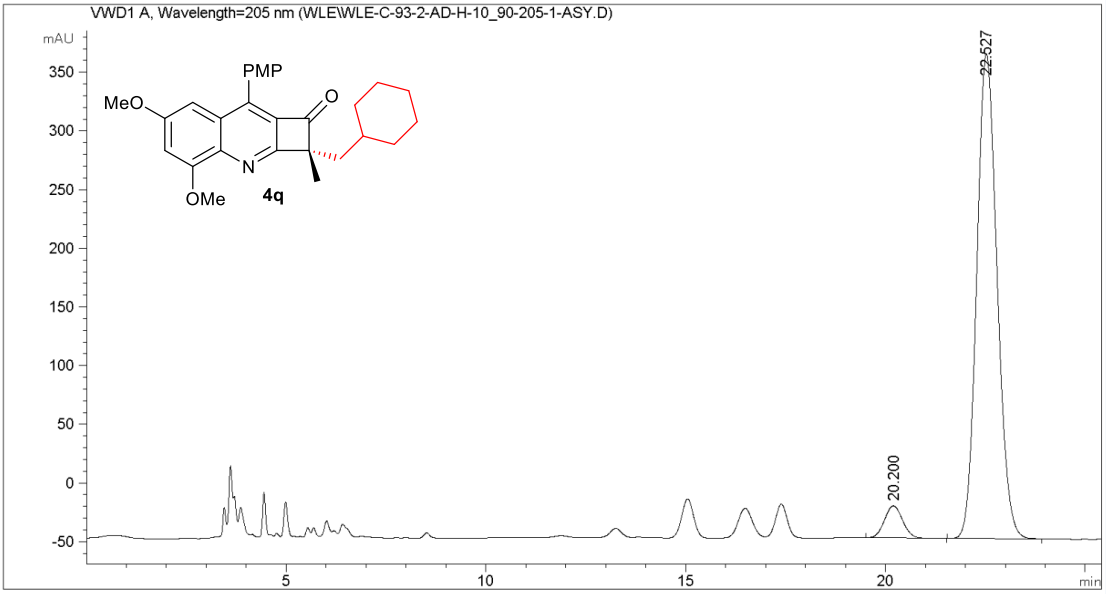
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.699	VB	0.2162	3068.22388	219.37254	49.5035
2	12.583	BB	0.3359	3129.76465	143.22482	50.4965



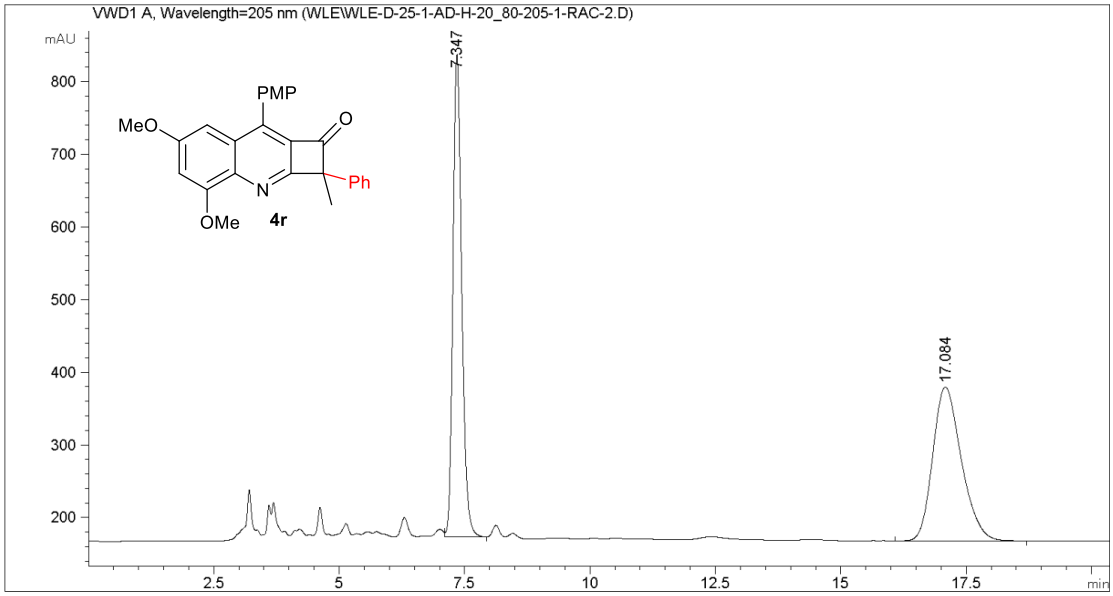
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.683	VB	0.2169	1041.38989	74.13898	4.5396
2	12.526	BB	0.3281	2.18989e4	1037.99890	95.4604



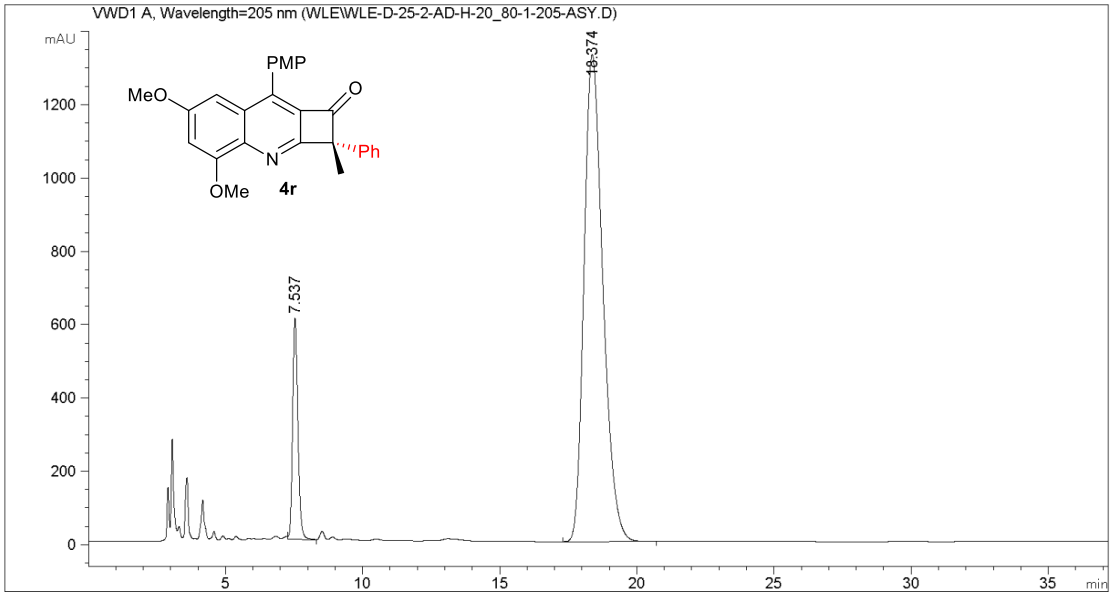
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.356	VB	0.4990	2.33221e4	727.55328	50.0588
2	22.623	BB	0.5505	2.32674e4	653.29877	49.9412



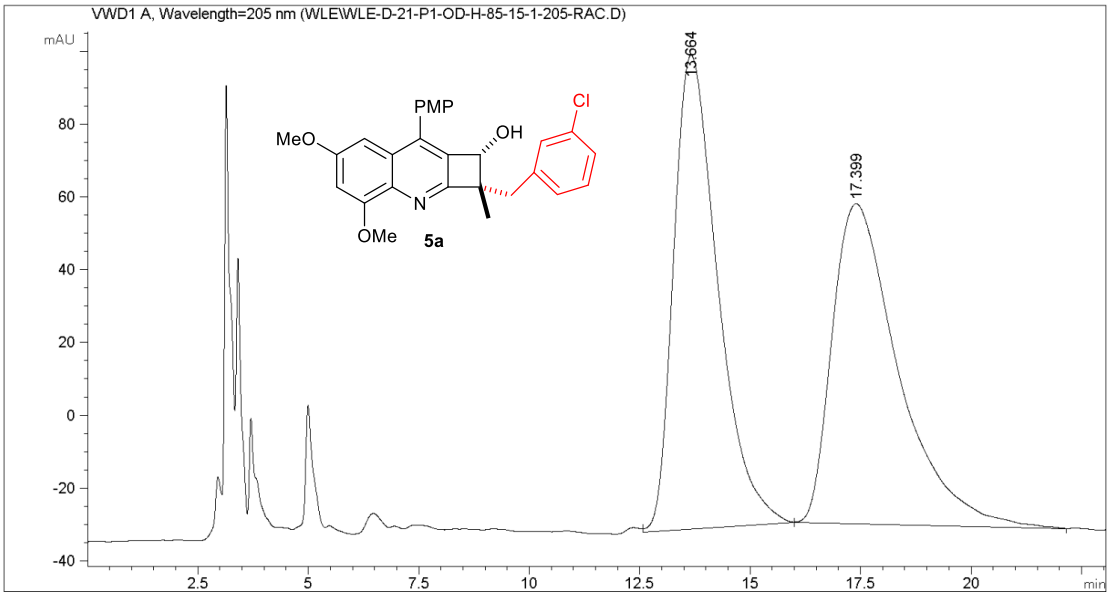
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.200	BB	0.4930	861.54956	27.31194	5.5692
2	22.527	BB	0.5487	1.46085e4	412.97748	94.4308



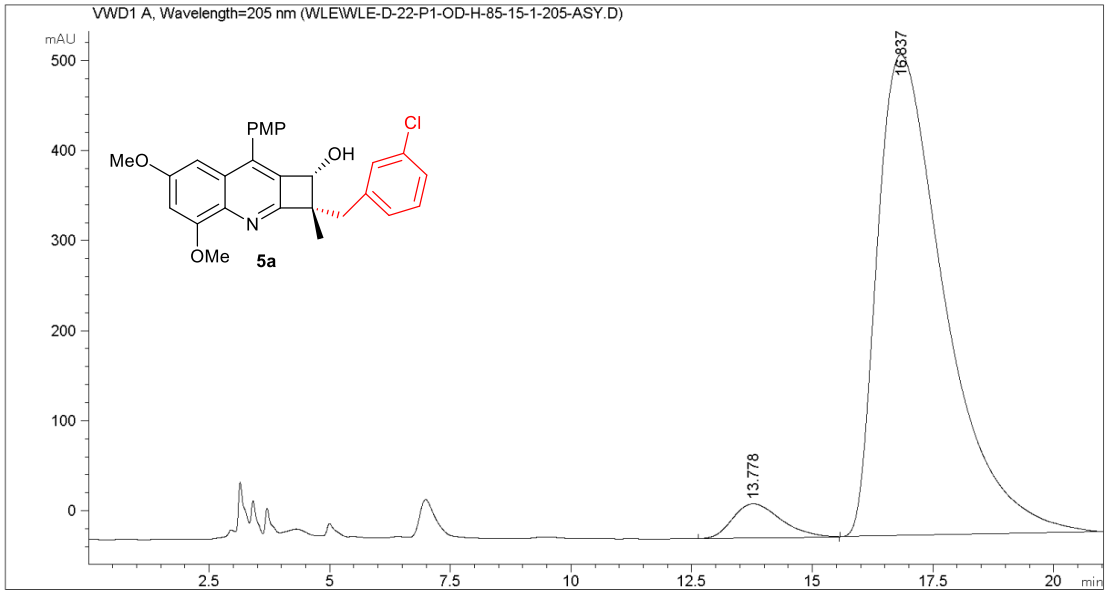
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.347	VB	0.1869	8071.18652	663.78351	49.0603
2	17.084	BB	0.6059	8380.38965	211.67906	50.9397



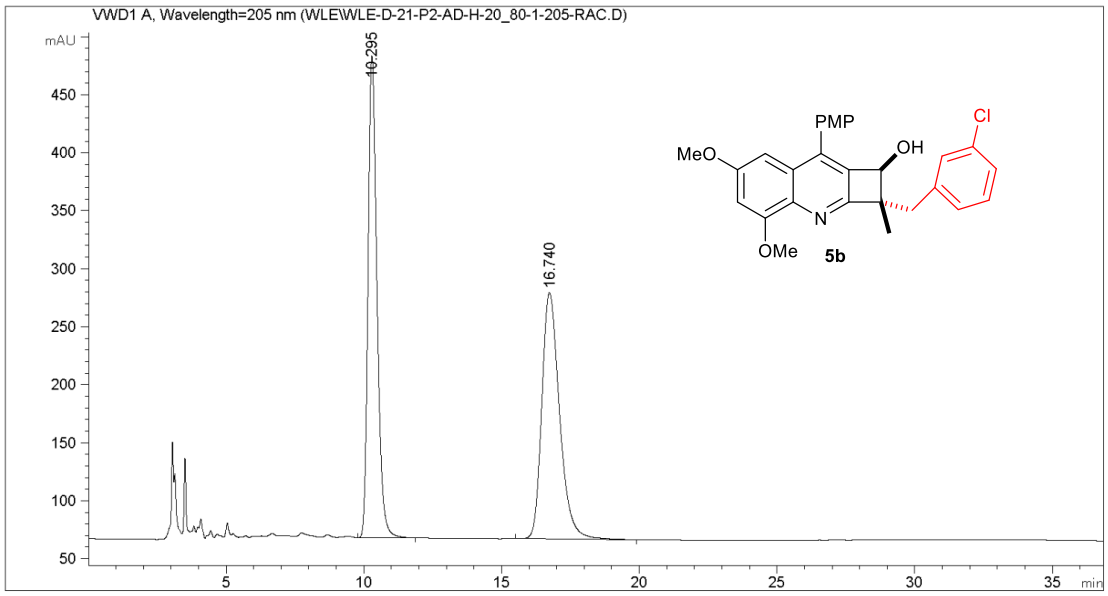
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.537	VB	0.2049	8058.68311	602.98492	11.2594
2	18.374	BB	0.7329	6.35141e4	1328.10400	88.7406



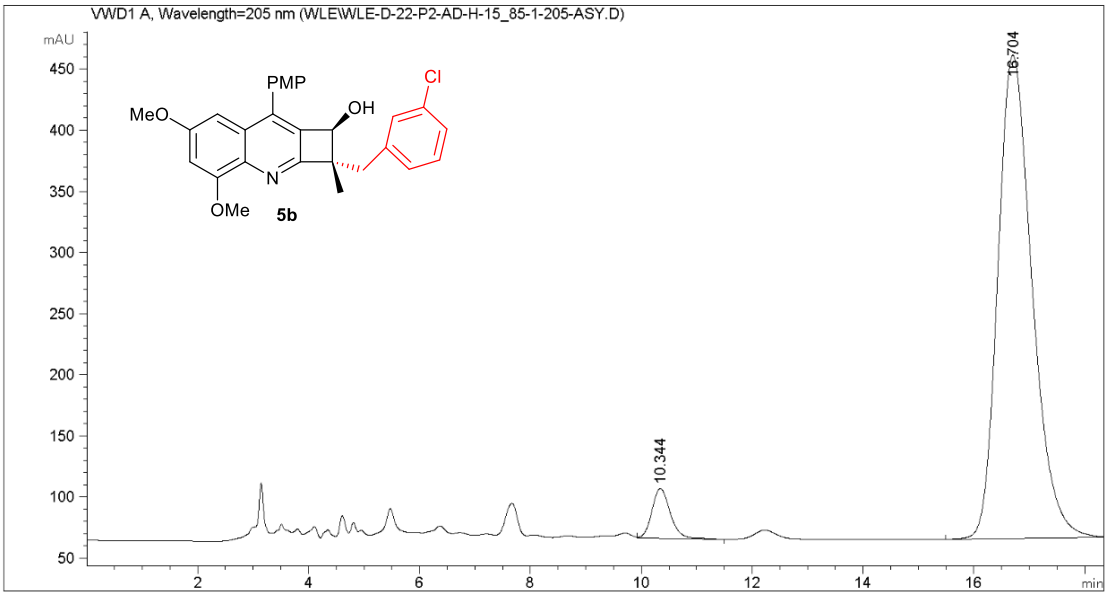
No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.664	VB	1.0584	9041.19629	130.16530	49.7591
2	17.399	BB	1.5667	9128.75000	87.89259	50.2409



No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.778	BB	1.0712	2611.14746	37.83109	4.8014
2	16.837	BBA	1.4707	5.17720e4	534.20831	95.1986



No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.295	BB	0.3452	9373.14648	415.45020	49.6079
2	16.740	BB	0.6857	9521.29785	212.51022	50.3921



No.	Ret. Time [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.344	VB	0.3522	939.66241	40.87000	5.2607
2	16.704	BBA	0.6586	1.69224e4	395.14832	94.7393