Supplementary Information

Total Synthesis of (–)-Cephalosporolide D

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ABSTRACT:

In this communication, a concise and efficient synthetic route for the synthesis of **(–)**-Cephalosporolide D in enantioselective way has been described. In this synthesis, Mitsunobu esterification and Ring Closing Metathesis (RCM) for macrocyclic ring formation have been applied as key steps.

KEYWORDS: (–)-Cephalosporolide D; Barbier allylation; Mitsunobu esterification; Ring Closing Metathesis (RCM)

Experimental Section

General

Solvents were dried over standard drying agents and freshly distilled prior to use. All commercially available chemicals were used without further purification. All reactions were performed under Nitrogen. ^{1}H NMR and ^{13}C NMR spectra were measured with Varian Gemini FT 200 MHz spectrometer, Bruker Avance 300 MHz, Unity 400 MHz and Inova 500 MHz with tetramethylsilane as internal standard for solutions in $CDCl_3$. *J* values are given in Hz. Chemical shifts were reported in ppm relative to solvent signal. All column chromatographic separations were performed using silica gel (Acme's, 60-120 mesh). Organic solutions were dried over anhydrous Na_2SO_4 and concentrated below 40 ºC in *vacuo*. IR-spectra were recorded on FT IR (Perkin-Elmer IR-683) spectrophotometer with NaCl optics. JASCO DIP 300 digital polarimeter was used for measurement of optical rotations at 25 °C. Mass spectra were recorded on direct inlet system or LC by MSD trap SL (Agilent Technologies), the HRMS data were obtained using Q-TOF mass spectrometry.

Experimental procedures

(R)-1-((S)-2,2-dimethyl-1,3-dioxolan-4-yl)but-3-en-1-ol (7):

To a stirred and cooled (0 ^{o}C) mixture of aldehyde **6** (4.6 g, 35.38 mmol) and dry Zinc (6.9 g, 106.15 mmol) in THF (100 mL), allyl bromide (4.6 mL, 126.30 mmol) was added very slowly for 15 min, followed by the addition of sat. NH_4Cl (72 mL) solution. After 6 h, reaction mixture was diluted with excess sat. NH_4Cl solution (50 mL) and extracted with ethyl acetate (2 x 100 mL). The organic layers were washed with water (2 x 50 mL), brine (50 mL), dried (Na_2SO_4), evaporated under reduced pressure and purified the residue by column chromatography (60-120 Silica gel, 5% EtOAc in pet. ether) to furnish **7** (4.8 g, 79%) as a yellow liquid. $[\alpha]_D$ +1.7 (*c* 2.5, $CHCl_3$); IR (neat): max: 3454 (br, OH), 2986, 1375, 1214, 1064 cm1 ; ^{1}H NMR (300 MHz, $CDCl_3$); δ 5.92–5.84 (m, 1H), 5.18–4.98 (m, 2H), 4.03– 3.92 (m, 3H), 3.77–3.64 (m, 1H), 2.37–

2.21 (m, 2H), 1.41 (s, 3H), 1.32 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): 134.1, 118.2, 109.1, 87.7, 71.1, 65.2, 37.5, 27.8, 25.1; ESIMS: 195 $[M+Na]^+$.

(S)-4-((R)-1-(4-methoxybenzyloxy)but-3-enyl)-2,2-dimethyl-1,3-dioxolane (5):

To a cooled (0 ^oC) solution of **7** (4.5 g, 26.16 mmol) in dry THF (40 mL), NaH (1.88 g, 78.48 mmol) was added, stirred for 30 min and treated with a solution of PMBBr (5.99 g, 31.39 mmol) in dry THF (40 mL). After stirring at room temperature for 6 h, the reaction mixture was quenched with sat. NH_4Cl solution (8 mL) and extracted with ethyl acetate (2 x 40 mL). The organic layers were washed with water (2 x 10 mL), brine (30 mL), dried (Na_2SO_4), evaporated under reduced pressure and purified the residue by column chromatography (60-120 Silica gel, 15% EtOAc in pet. ether) to furnish **5** (6.74 g, 88%) as a yellow liquid. $[\alpha]_D$ +41.7 (*c* 1.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.27 (d, 2H, J = 8.4 Hz), 6.86 (d, 2H, J = 8.7 Hz), 5.91-5.77 (m, 1H), 5.11–5.01 (m, 2H), 4.51 (d, 1H, J = 11.0 Hz), 4.43 (d, 1H, J = 11.0 Hz), 4.11–3.97 (m, 2H), 3.84 (m, 1H), 3.77 (s, 3H), 3.51-3.44 (m, 1H), 2.44–2.28 (m, 2H), 1.41 (s, 3H), 1.33 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ 158.7, 134.0, 130.3, 129.7, 128.5, 117.4, 113.5, 109.8, 78.6, 76.1, 72.2, 66.4, 55.7, 35.8, 26.2, 25.3; ESIMS: 315 $[M+Na]^+$.

(R)-2-(4-methoxybenzyloxy)pent-4-en-1-ol (8):

To a solution of diester **5** (1.9 g, 6.50 mmol) in dry ether (140 mL), H_5IO_6 (2.21 g, 9.76 mmol) was added at 0 °C and the reaction mixture was stirred for 6 h at room temperature for 6 h. Then it was neutralized with $NaHCO_3$ (10 g), stirred for 30 min, filtered through a pad of celite and evaporated to give the crude aldehyde **5a**, which was used as such for the next reaction.

A solution of the crude aldehyde **5a** in MeOH (100 mL) was treated with $NaBH_4$ (0.49 g, 13.0 mmol) at 0 ^oC. Stirring was continued for 6 h at room temperature. MeOH was evaporated under reduced pressure, diluted with water (50 mL) and extracted with EtOAc (2 x 100 mL). The organic layers were washed with brine (50 mL), dried (Na_2SO_4), evaporated and purified the residue by column chromatography (60-120 Silica gel, 20% EtOAc in pet. ether) to furnish **8** (1.21 g, 84%) as a colorless liquid. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.27 (d, J = 8.4 Hz, 2H), 6.87 (d, J

= 8.4 Hz, 2H), 5.87-5.78 (m, 1H), 5.13–5.07 (m, 2H), 4.59 (d, J = 11.1 Hz, 1H), 4.45 (d, J = 11.1 Hz, 1H), 3.79 (s, 3H), 3.74–3.63 (m, 2H), 3.57–3.49 (m, 1H) 2.39–2.27 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 158.5, 133.3, 129.8, 128.9, 117.2, 113.5, 78.7, 71.1, 63.8, 55.1, 35.2.; ESIMS: 245 $[M+Na]^+$.

(S)-1-methoxy-4-((pent-4-en-2-yloxy)methyl)benzene (9):

To a mixture of diol **8** (1.15 g, 5.18 mmol) in dry dichloromethane (30 mL) was added *p*-toluenesulfonyl chloride (1.18 g, 6.21 mmol), triethylamine (1.4 mL, 10.36 mmol) and reaction was stirred at room temperature under nitrogen. The reaction was monitored by TLC; after completion of reaction the mixture was quenched by adding water. The solution was extracted with DCM (3 x 20 mL) and then the combined organic phase was washed with water, dried (Na_2SO_4), and concentrated to give tosylate **8a.**

To a stirred suspension of LAH (0.24 g, 6.21 mmol) in dry THF (5 mL), The above crude tosylate **8a** in dry THF (20 mL) was added dropwise at 0 °C under nitrogen atmosphere and the mixture stirred for 12 h at room temperature. The reaction mixture was cooled to 0 °C, treated with saturated aq. Na_2SO_4 solution, filtered and the filtrate was dried (Na_2SO_4) and concentrated the residue was purified by column chromatography (60-120 Silica gel, 15% EtOAc in pet. ether) to give **9** (0.82 g, 77%) as a colorless syrup. ^{1}H NMR (CDCl3, 300 MHz), δ 7.26 (d, J = 8.7 Hz, 2H), 6.88 (d, J = 8.7 Hz, 2H), 5.86 (m, 1H), 5.07-4.96 (m, 2H), 4.49 (d, J = 11.2 Hz, 1H), 4.44 (d, J = 11.0 Hz, 1H), 3.79 (s, 3H), 3.56 (m, 1H), 2.39-2.24 (m, 2H) 1.20 (d, J = 6.4 Hz, 3H).^{13}C NMR ($CDCl_3$, 75 MHz) δ 159.2, 135.1, 131.0, 129.3, 116.6, 113.4, 74.1, 69.9, 55.1, 40.6, 19.5. ESIMS: 229 $[M+Na]^+$.

(S)-pent-4-en-2-ol (4):

To a solution of **9** (0.75 g, 3.64 mmol) in CH_2Cl_2 (19 mL) and H_2O (1 mL), DDQ (0.99 g, 4.36 mmol) was added and stirred at room temperature for 3 h. The reaction mixture was filtered through celite, dried (Na_2SO_4) and evaporated to give residue, which was purified by column chromatography (60-120 Silica gel, 15% EtOAc in pet. ether) to afford **4** (0.26 g, 85%) as colourless oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ

5.88-5.77 (m, 1H), 5.13-5.04 (m, 2H), 3.86-3.78 (m, 1H), 2.38-2.24 (m, 2H), 1.18 (d, J = 6.1 Hz, 3H); ^{13}C NMR (75 MHz, CDCl^3) δ 134.8, 116.7, 66.5, 43.2, 22.2 ppm; IR (CHCl3): n˜ =3400, 3078, 2931, 2975, 1562, 1457, 1432, 1243, 1071, 914 cm^{-1}

(R)-3-((S)-2,2-dimethyl-1,3-dioxolan-4-yl)-3-(4-methoxybenzyloxy)propanoic acid (10):

To a solution of olefin **10** (3.7g, 12.6 mmol) in a mixture of CCl_4 (6 mL)-CH_3CN (6 mL)-H_2O (9 mL), $NaIO_4$ (10.84 g, 50.68 mmol), followed by $RuCl_3$ (0.075 g, 0.31 mmol) was added and the entire mixture was stirred vigorously for 2 h at room temperature. The reaction mixture was diluted with CH_2Cl_2 (5 mL) and the upper aqueous phase was extracted with CH_2Cl_2 (2 x 10 mL). Combined organic layers were dried (Na_2SO_4) and concentrated to give crude residue which was purified by column chromatography (60-120 Silica gel, 1.5:1 EtOAc:*n*-Hexane) to give **5** (3.22 g 82%) in yield as a liquid. $[\alpha]_D$ +22.24 (*c* 0.42, $CHCl_3$) (isomer value); ^{1}H NMR (400MHz, $CDCl_3$) δ: 7.26 (d, 2H, *J* = 8.1 Hz), 6.87 (d, 2H, *J* = 8.4 Hz), 4.54 (d, 1H, J = 11.1 Hz), 4.45 (d, 1H, J = 11.1 Hz), 4.13-4.04 (m, 2H), 3.91-3.86 (m, 1H), 3.79 (s, 3H) 3.74-3.66 (m, 1H), 2.72 (dd, 1H, *J* = 15.8, 4.5 Hz), 2.61 (dd, 1H, J_1 = 15.8, 7.1 Hz), 1.40 (s, 3H) 1.32 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 177.3, 158.9, 129.9, 129.4, 129.1, 113.9, 109.7, 72.3, 66.5, 55.3, 36.9, 26.2 25.2; ESIMS: 311 $[M+H]^+$.

(R)-methyl 3-((S)-2,2-dimethyl-1,3-dioxolan-4-yl)-3-(4-methoxybenzyloxy) propanoate (11):

To a solution of **10** (3.0 g, 9.67 mmol) and K_2CO_3 (2.0 g, 14.50 mmol) in acetone (50 mL), dimethyl sulfate (1.50 mL, 19.34 mmol) was added dropwise and stirred for 4 h at reflux temperature. Solvent was evaporated and extracted with ethyl acetate (2 x 100 mL). The organic layers were washed with water (2 x 100 mL), brine (50 mL), dried (Na_2SO_4), evaporated and purified the residue by column chromatography (60-120 Silica gel, 20% EtOAc in pet. ether) to furnish **11** (2.72 g, 87%) as a white solid.^{1}H NMR (400MHz, $CDCl_3$) δ: 7.22 (d, 2H, *J* = 8.3 Hz), 6.84 (d, 2H, *J* = 8.3 Hz), 4.51 (d, 1H, J = 11.2 Hz), 4.42 (d, 1H, J = 11.2 Hz), 4.07-3.94 (m, 2H), 3.88-3.80 (m, 1H), 3.74 (s, 3H) 3.69 (s, 3H), 3.57-3.49 (m, 1H), 2.69 (dd, 1H, *J* = 15.5, 4.4 Hz), 2.59 (dd, 1H, *J* = 15.5, 6.8 Hz), 1.39 (s, 3H) 1.33 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 172.3, 158.8, 129.8, 129.3, 128.8, 113.7, 108.9, 76.1, 72.3, 66.6, 55.1, 52.1, 37.1, 26.3 25.1; ESIMS: 347 $[M+Na]^+$.

(3R,4S)-methyl 4,5-dihydroxy-3-(4-methoxybenzyloxy)pentanoate (12):

A solution of **11** (2.6 g, 8.02 mmol) in aq. 60% acetic acid (100 mL) was stirred at room temperature for 12 h. After completion of reaction, it was quenched with $NaHCO_3$ and adjusted to pH 2-3. The reaction mixture was extracted with ethyl acetate (3 x 100 mL) and dried (Na_2SO_4). Evaporation of solvent under reduced pressure and purification of the residue by column chromatography (60-120 Silica gel, 40% EtOAc in pet. ether) furnished **12** (1.8 g, 79%) as a yellow liquid. $[\alpha]_D$ +42.9 (*c* 1.0, $CHCl_3$);^{1}H NMR (300MHz, $CDCl_3$) δ: 7.24 (d, 2H, *J* = 8.1 Hz), 6.87 (d, 2H, *J* = 8.1 Hz), 4.47 (s, 2H, 4.03-3.91 (m, 2H), 3.84-3.77 (m, 1H), 3.72 (s, 3H) 3.68 (s, 3H), 3.54-3.45 (m, 1H), 2.71 (dd, 1H, *J* = 15.8, 4.4 Hz), 2.62 (dd, 1H, *J* = 15.5, 6.8 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 171.9, 159.1, 130.1, 129.6, 129.1, 113.6, 78.9, 71.9, 68.9, 63.3, 55.3, 51.8, 37.2; ESIMS: 285 $[M+H]^+$.

(R)-methyl 3-(4-methoxybenzyloxy)pent-4-enoate (13):

To a solution of diol **12** (1.75 g, 6.16 mmol) in CH_2Cl_2 (20 mL) at 0 °C, Ph_3P (0.65 g, 2.5 mmol), imidazole (0.17 g, 2.5 mmol) and I_2 (0.31 g, 1.23 mmol) were added and stirred at room temperature for 4 h. A saturated solution of NaOH (3 mL) was added to the reaction mixture and extracted with $CHCl_3$ (50 mL). The organic layers were washed with sat. aq. Sodium thiosulphate (20 mL) and brine (20 mL). It was dried (Na_2SO_4), evaporated under reduced pressure and purified the residue by column chromatography (60-120 mesh silica gel, 8% EtOAc in pet. ether) to give olefin **13** (1.17 g, 76%) as a colorless syrup.^{1}H NMR (300MHz, $CDCl_3$) δ 7.22 (d, 2H, *J* = 8.2 Hz), 6.84 (d, 2H, *J* = 8.2 Hz), 5.91-5.83 (m, 1H), 5.14–5.05 (m, 2H), 4.51 (d, 1H, J = 11.1 Hz), 4.42 (d, 1H, J = 11.1 Hz), 4.14 (m, 1H), 3.77 (s, 3H), 3.71 (s, 3H), 2.64 (dd, 1H, J = 15.3, 7.4 Hz), 2.48 (dd, 1H, J = 15.3, 4.6 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.1, 159.2, 136.4, 130.1, 128.9, 117.6, 113.7, 76.2, 70.2, 55.2, 51.9, 38.6; ESIMS: 273 $[M+Na]^+$.

(R)-3-(4-methoxybenzyloxy)pent-4-enoic acid (3):

To a solution of **13** (1.1 g, 4.40 mmol) in THF: MeOH: water (3:1:1, 10 mL), LiOH (0.31 g, 13.2 mmol) was added and stirred at room temperature for 4 h. The pH of reaction mixture was adjusted to acidic with 1N HCl solution and extracted with ethyl acetate (30 mL). Organic layers were washed with water (10 mL), brine (10 mL), dried (Na_2SO_4), evaporated under reduced pressure and purified the residue by column chromatography (60-120 Silica gel, 25% EtOAc in pet. ether) to give **3** (0.91 g, 88%) as a colourless oil, $[\alpha]_D$ +15.7 (c 0.6, $CHCl_3$); IR (KBr): 3444, 2933, 1721, 1617, 1518, 1044, 822. ^{1}H NMR (300MHz, $CDCl_3$) δ 7.26 (d, 2H, *J* = 8.4 Hz), 6.87 (d, 2H, *J* = 8.4 Hz), 5.87-5.76 (m, 1H), 5.17–5.09 (m, 2H), 4.54 (d, 1H, J = 11.2 Hz), 4.37 (d, 1H, J = 11.2 Hz), 4.17 (m, 1H), 3.79 (s, 3H), 2.68 (dd, 1H, J = 15.5, 7.8 Hz), 2.49 (dd, 1H, J = 15.5, 4.8 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.3, 159.4, 136.6, 130.2, 129.9, 118.1, 113.8, 76.1, 70.3, 55.1, 39.8; ESIMS: 237 $[M+H]^+$.

(R)-((R)-pent-4-en-2-yl) 3-(4-methoxybenzyloxy)pent-4-enoate (2):

A solution of acid **3** (0.45 g, 1.90 mmol), alcohol **4** (0.16 g, 1.90 mmol) and Ph_3P (0.99 g, 3.8 mmol) in toluene: THF (10:1, 25 mL), DEAD (1.3 mL, 7.6 mmol) was added at 0 °C and stirred under N_2 atmosphere for 10 h at room temperature. Solvent was evaporated under reduced pressure and purified the residue by column chromatography (60-120 Silica gel, 10% EtOAc in pet. ether) to afford **2** (0.42 g, 73%) as a colorless oil. ^{1}H NMR (300MHz, $CDCl_3$) δ 7.22 (d, *J* = 8.3 Hz, 2H), 6.81 (d, *J* = 8.3 Hz, 2H), 5.91-5.83 (m, 1H), 5.79-5.68 (m, 1H), 5.24-5.11 (m, 4H), 5.07-4.97 (m, 1H, -OCH), 4.49 (d, *J* = 11.3 Hz, 1H), 4.31 (d, *J* = 11.3 Hz, 1H), 4.23-4.14 (m, 1H, -OCH), 3.76 (s, 3H, $-OCH_3$), 2.62 (dd, *J* = 8.3, 15.5 Hz, 1H), 2.47 (dd, *J* = 6.2, 15.6 Hz, 1H), 2.37–2.21 (m, 2H), 1.23 (d, *J* = 6.1 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.7, 158.9, 136.7, 135.1, 130.1, 128.9, 117.6, 115.9, 113.5, 76.4, 71.1, 70.2, 55.2, 42.9, 38.7, 21.9; ESIMS: 327 $[M+Na]^+$.

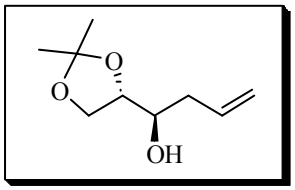
(4R,8R)-4-(4-methoxybenzyloxy)-8-methyl-3,4,7,8-tetrahydro-2H-oxocin-2-one (14):

To a stirred solution of **2** (0.2 g, 0.72 mmol) in dry CH_2Cl_2 (150 mL), 5 mol% Grubbs catalyst II (29 mg, 0.03 mmol) was added and stirred at reflux for 24 h. Then, it was worked up as described for 54 and purified the residue by column chromatography (60-120 Silica gel, 15% EtOAc in pet. ether) to afford **14** (0.12 g, 66%) as a gummy syrup.^{1}H NMR (300MHz, $CDCl_3$) δ 7.22 (d, *J* = 8.3 Hz, 2H), 6.81 (d, *J* = 8.3 Hz, 2H), 5.66 (m, 1H, olefinic-H), 5.47 (m, 1H, olefinic-H), 5.14-5.08 (m, 1H, -OCH), 4.51 (d, *J* = 11.3 Hz, 1H), 4.37 (d, *J* = 11.3 Hz, 1H), 4.19-4.11 (m, 1H,

-OCH), 3.77 (s, 3H, -OCH_3), 2.73 (dd, *J* = 8.9, 12.5 Hz, 1H), 2.53 (dd, *J* = 4.2, 12.6 Hz, 1H), 2.29–2.14 (m, 2H), 1.28 (d, *J* = 6.1 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 169.6, 159.1, 133.4, 132.1, 130.5, 129.3, 113.6, 73.1, 71.9, 66.9, 55.3, 42.5, 32.8, 21.6; ESIMS: 299 $[M+Na]^+$.

(–)-Cephalosporolide D (1):

To a stirred solution of **14** (0.12 g, 0.36 mmol) in EtOAc (1 mL) 10% Pd adsorbed on carbon (Pd/C) was added and stirred under H_2 atmosphere for 6 h. The reaction mixture was filtered through celite, the filtrate was concentrated and the crude residue purified by column chromatography (Silica gel 60-120, 20% EtOAc in pet. ether) to afford **1** (46 mg, 81%) as colorless syrup. $[\alpha]_D$ –40.6 (*c* 0.7, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ 4.67–4.60 (m, 1H), 4.16–3.95 (m, 1H), 2.92 (dd, *J* = 4.9, 11.8 Hz, 1H), 2.61 (dd, *J* = 5.8, 11.9 Hz, 1H), 1.89–1.50 (m, 6H), 1.33 (d, *J* = 5.9 Hz, 3H); ^{13}CNMR (75 MHz, $CDCl_3$): δ 172.1, 75.1, 71.4, 43.3, 38.5, 36.6, 25.7, 19.1; IR (neat): 3422, 2931, 1721, 1646, 1439, 1283, 1159, 1118 cm^{-1}; ESIMS: *m*/*z* 181 $[M + Na]^+$.



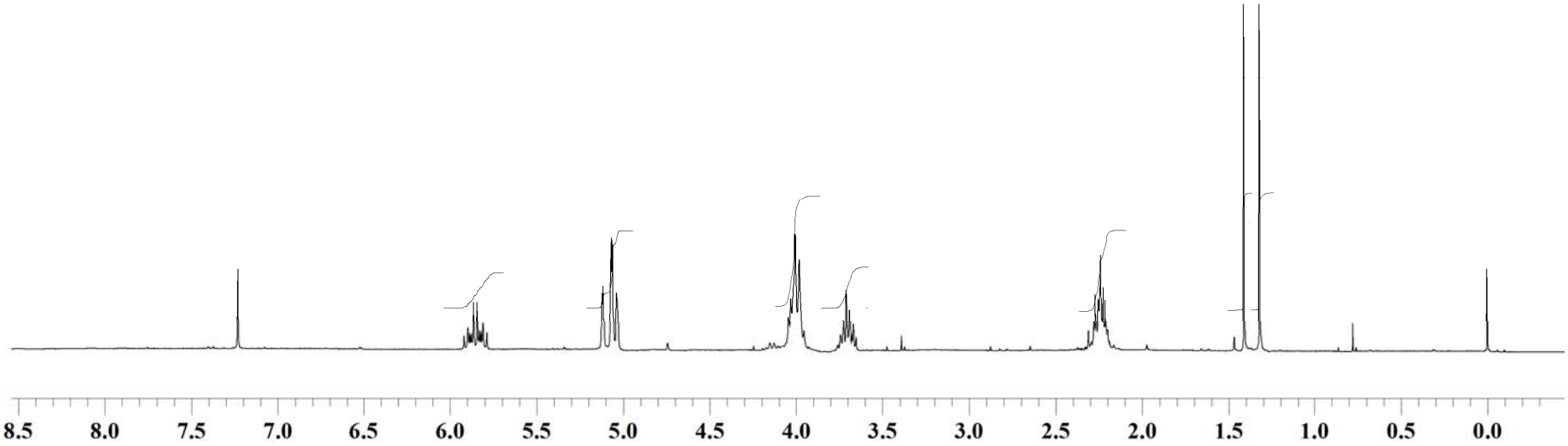
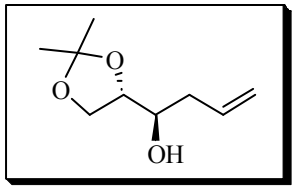


Figure S1: ^{1}H NMR Spectrum of compound **7** (300 MHz, $CDCl_3$)



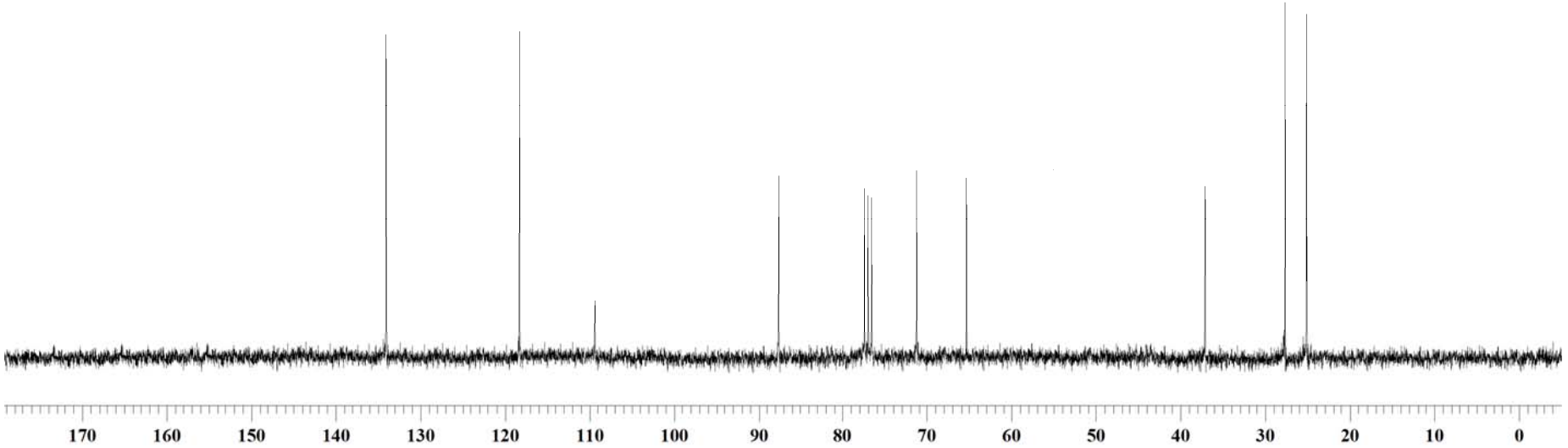
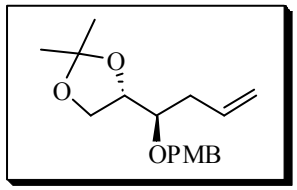


Figure S2: ^{13}C NMR Spectrum of compound **7** (75 MHz, $CDCl_3$)



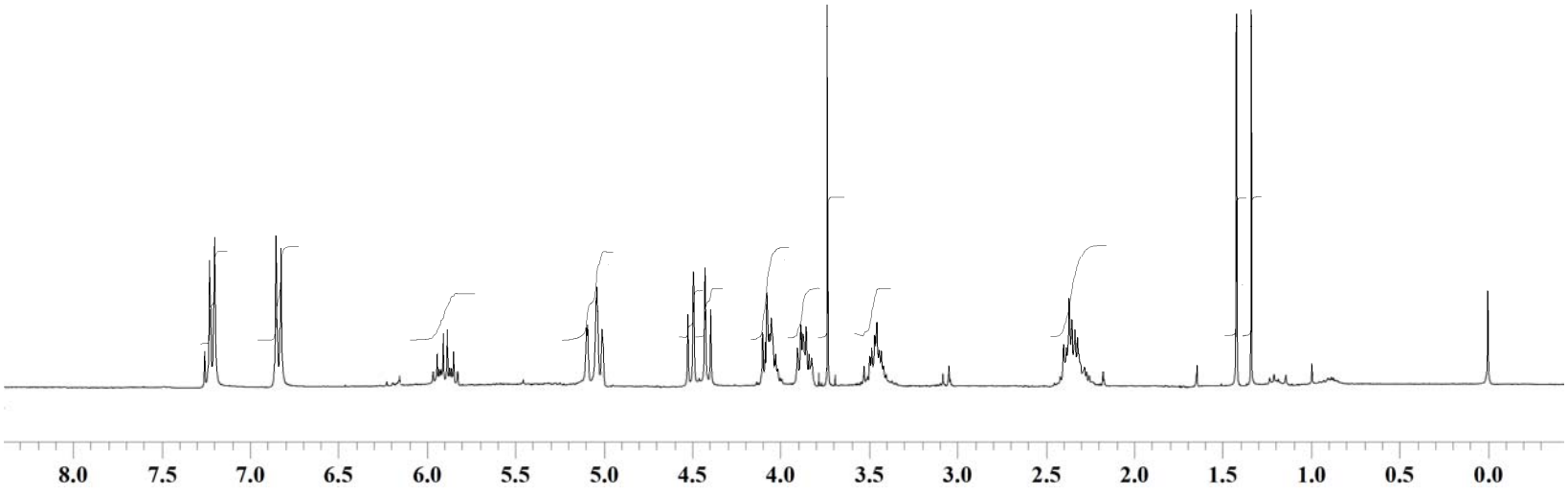


Figure S3: ^{1}H NMR Spectrum of compound **5** (300 MHz, $CDCl_3$)

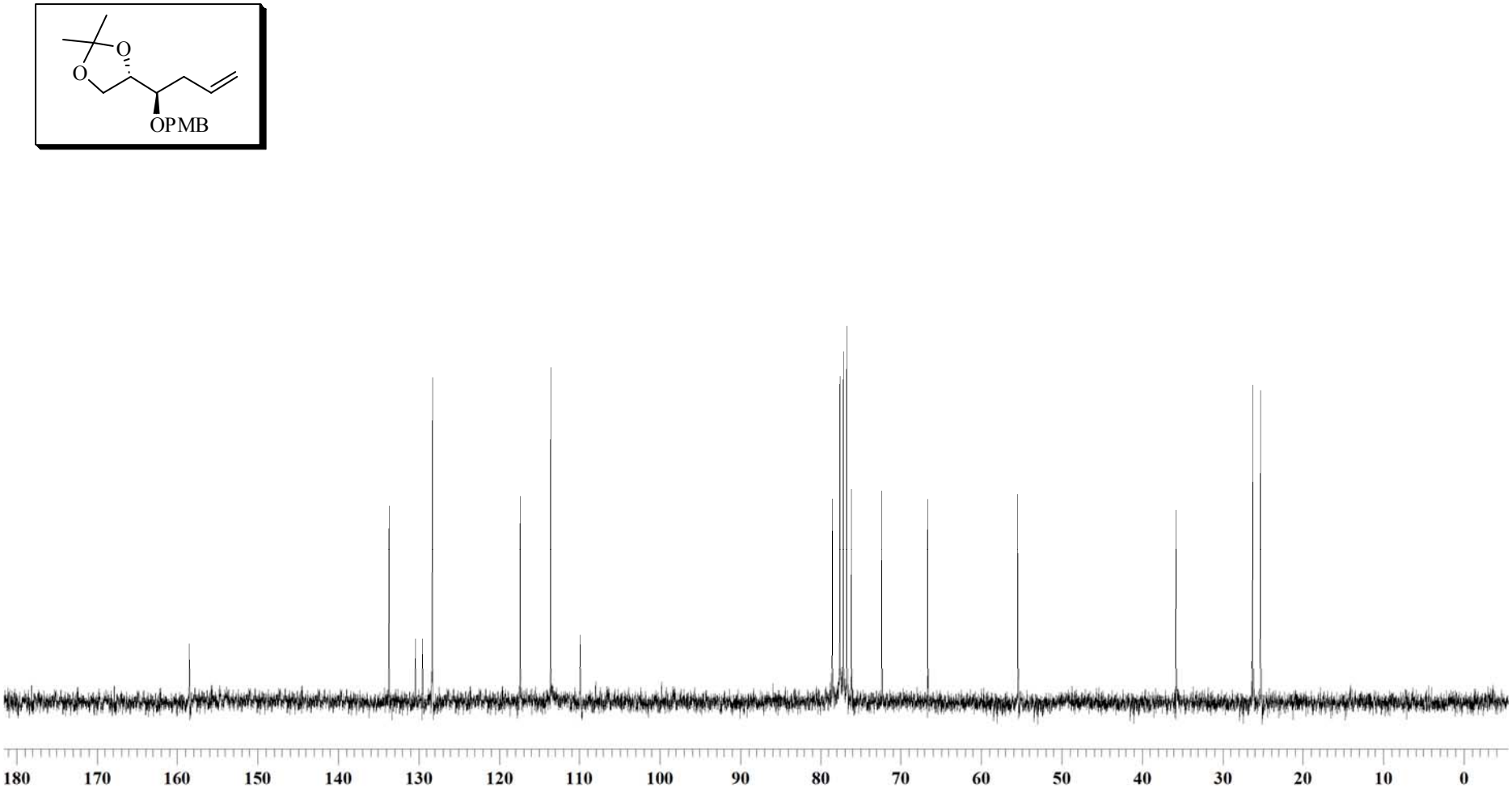
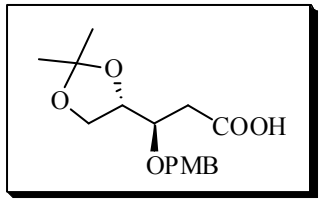


Figure S4: ^{13}C NMR Spectrum of compound **5** (75 MHz, $CDCl_3$)



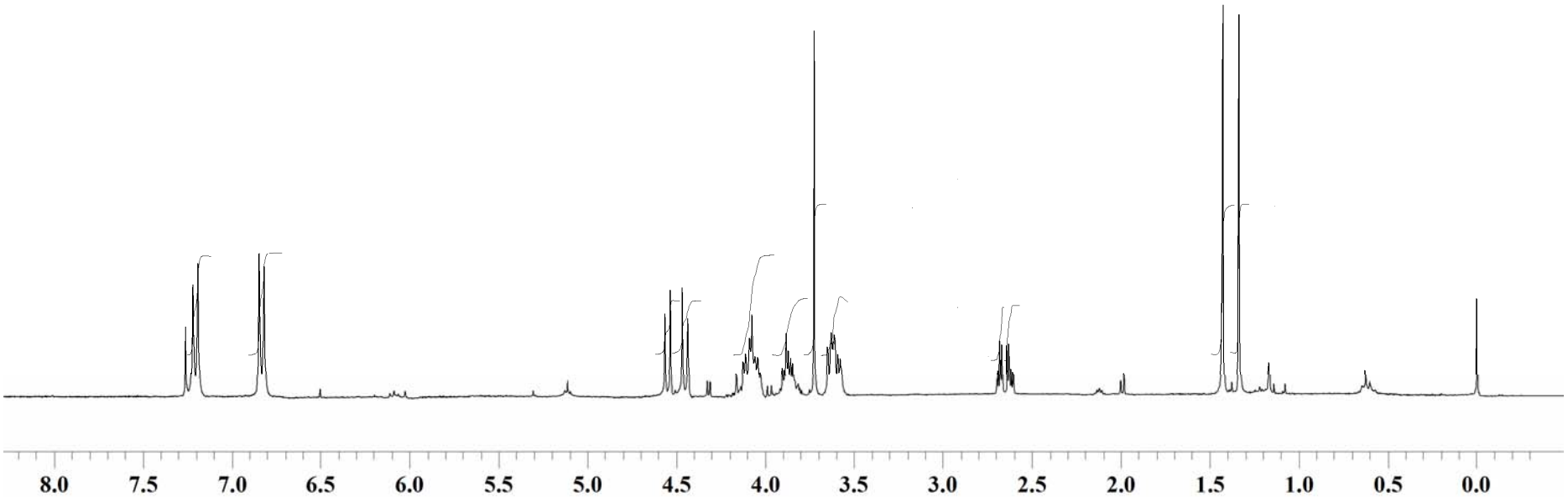
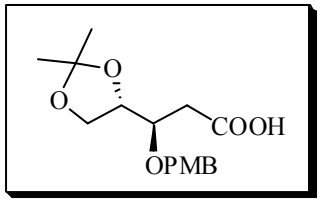


Figure S5: ^{1}H NMR Spectrum of compound **10** (300 MHz, $CDCl_3$)



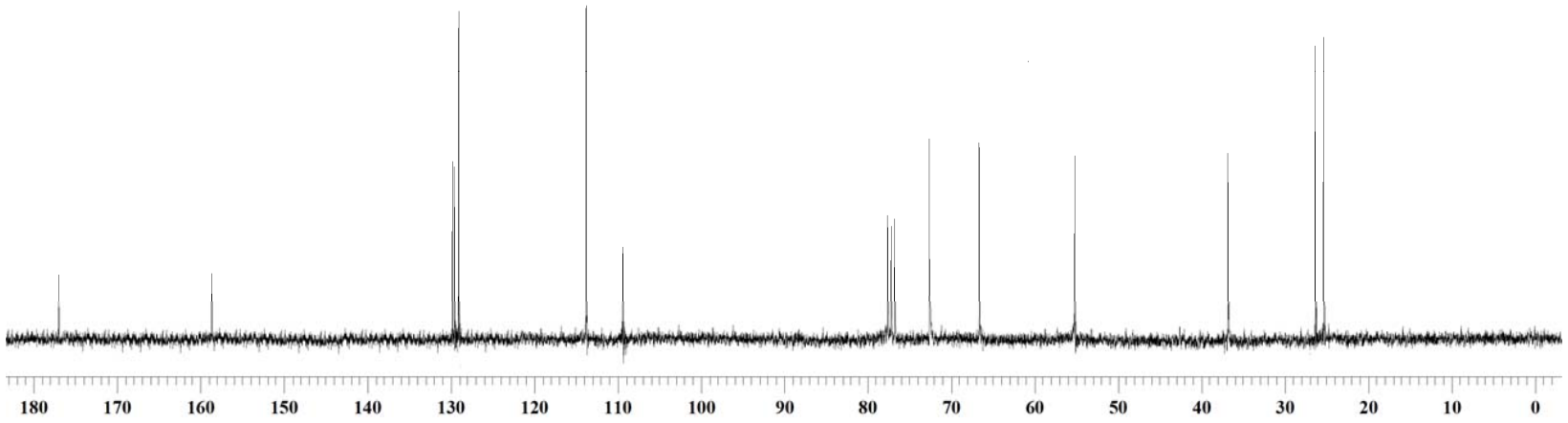


Figure S6: ^{13}C NMR Spectrum of compound **10** (75 MHz, $CDCl_3$)

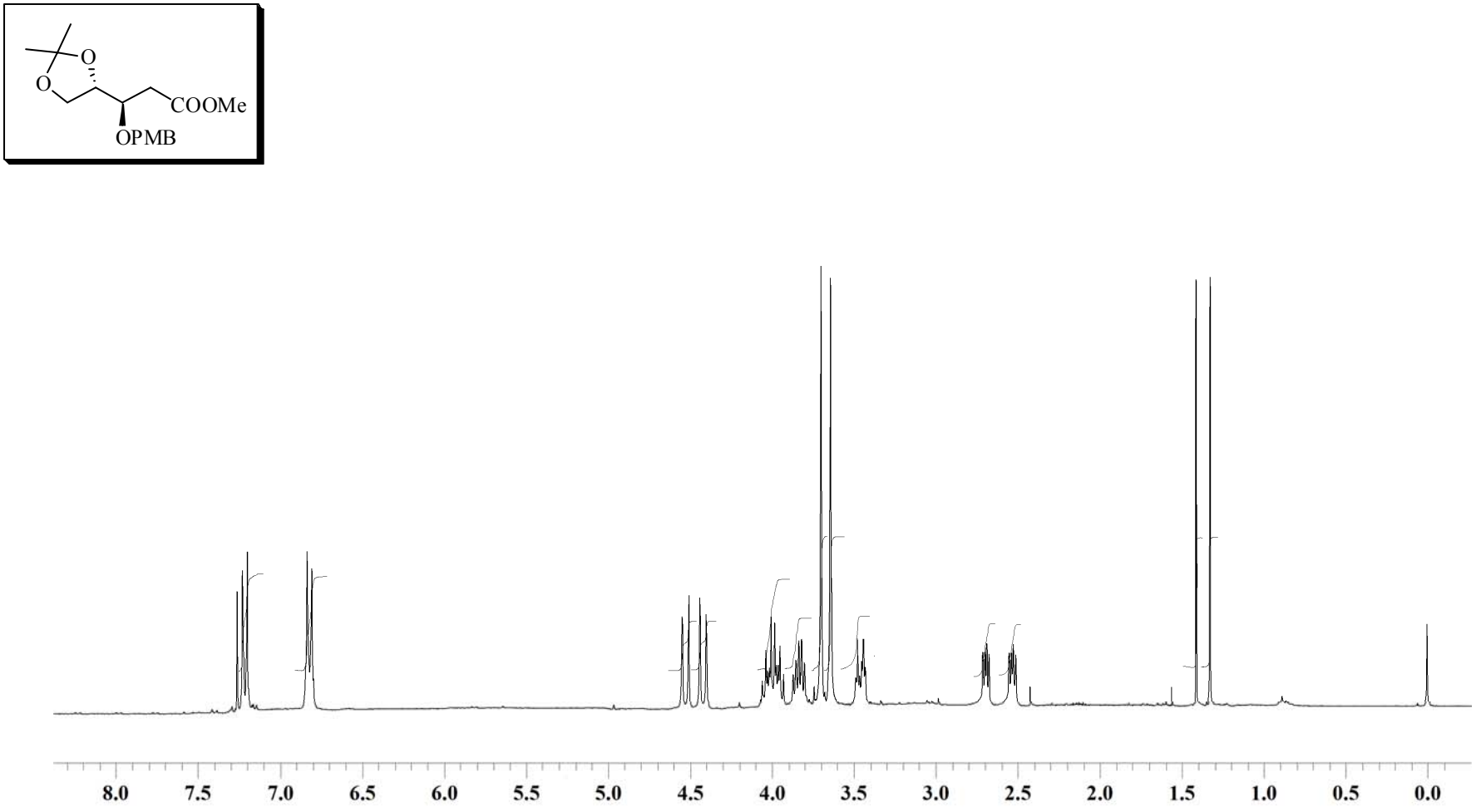
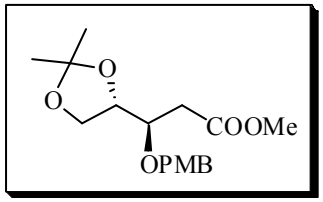


Figure S7: ^{1}H NMR Spectrum of compound **11** (300 MHz, $CDCl_3$)



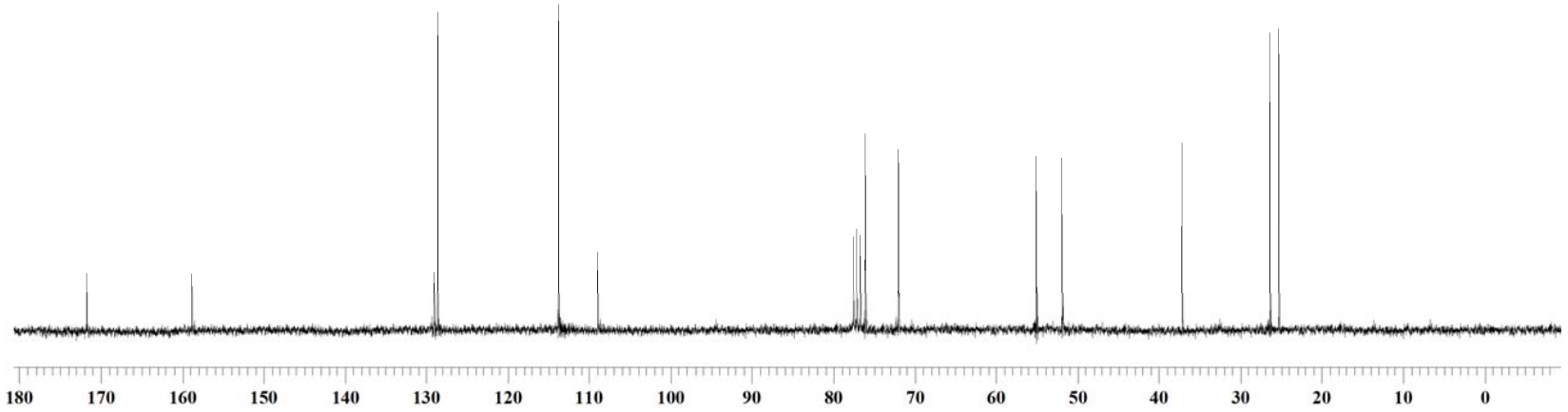
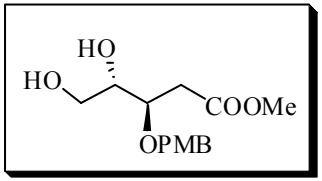


Figure S8: ^{13}C NMR Spectrum of compound **11** (75 MHz, $CDCl_3$)



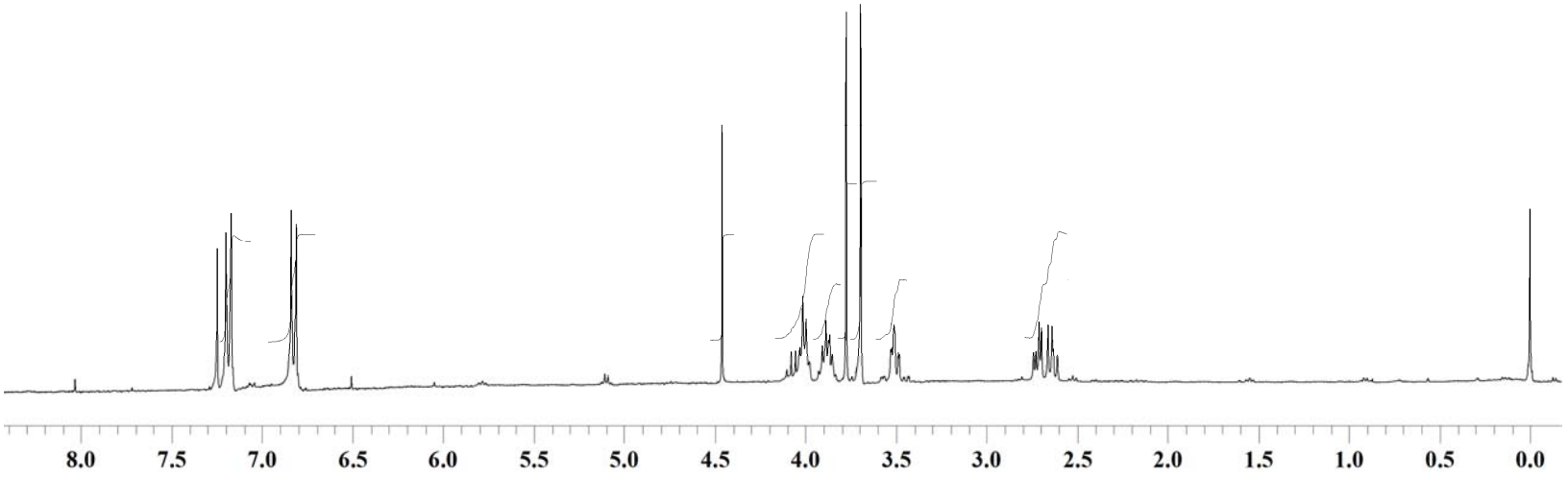
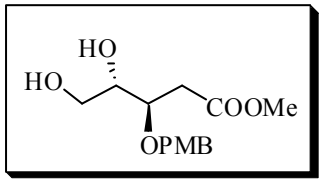


Figure S9: ^{1}H NMR Spectrum of compound **12** (300 MHz, $CDCl_3$)



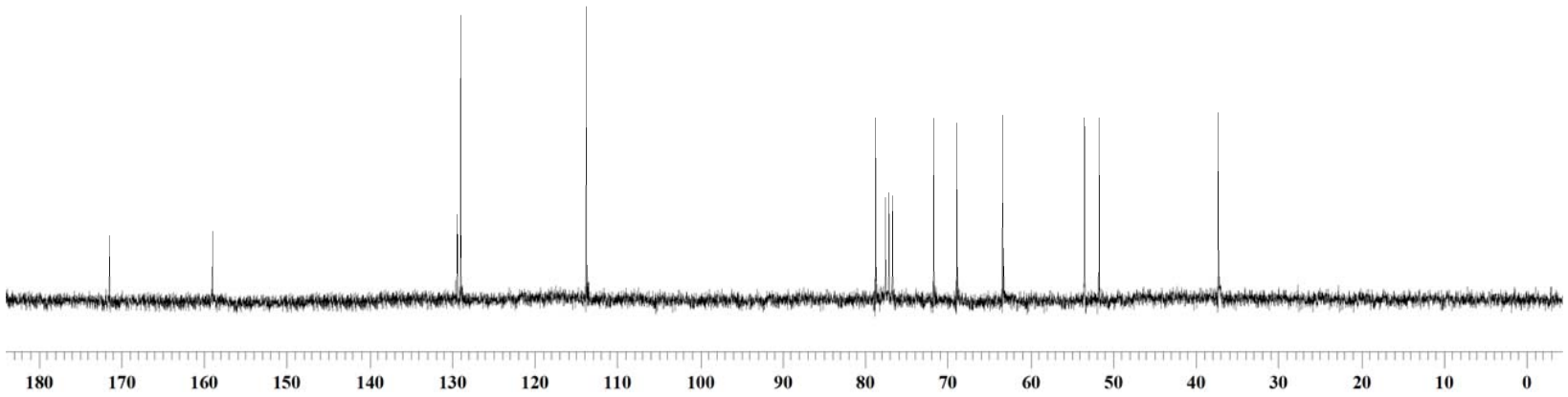
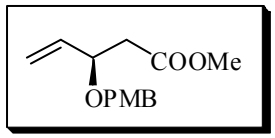


Figure S10: ^{13}C NMR Spectrum of compound **12** (75 MHz, $CDCl_3$)



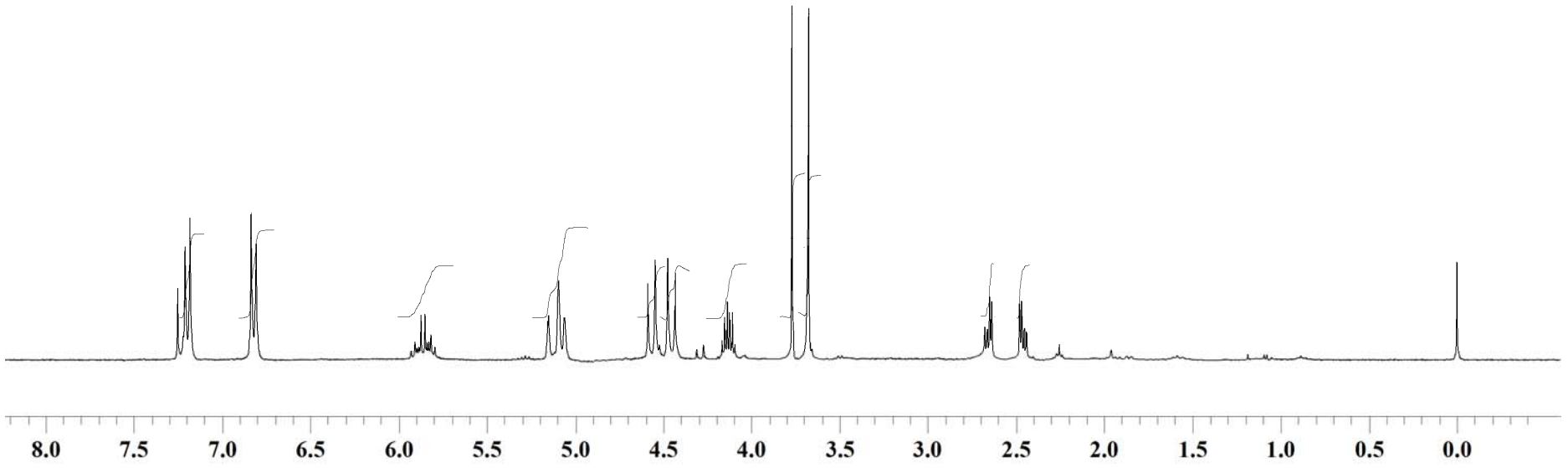
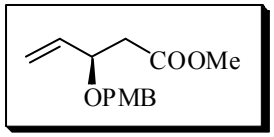


Figure S11: ^{1}H NMR Spectrum of compound **13** (300 MHz, $CDCl_3$)



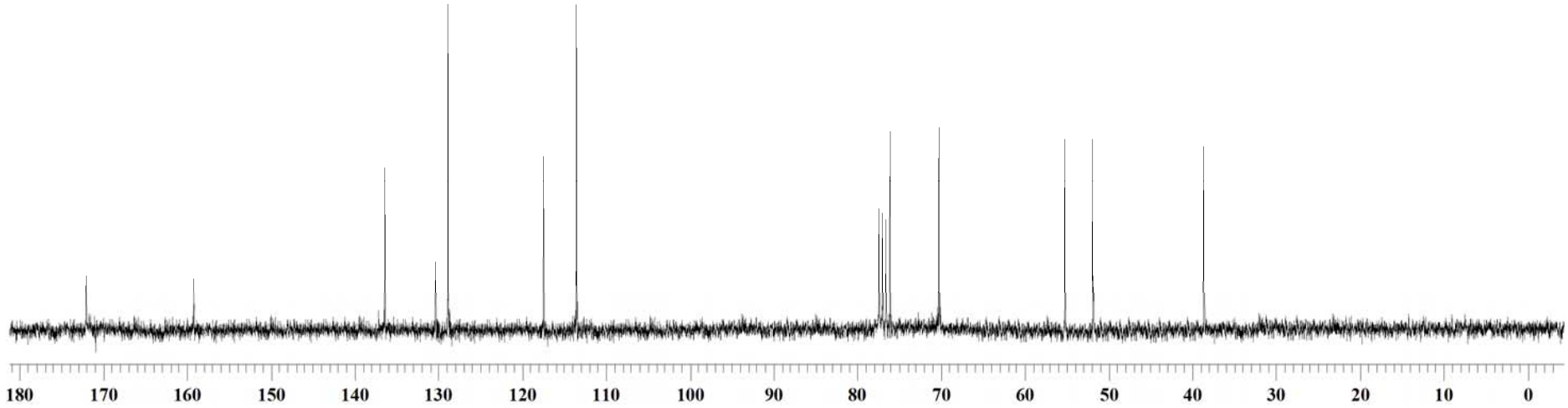


Figure S12: ^{13}C NMR Spectrum of compound **13** (75 MHz, $CDCl_3$)

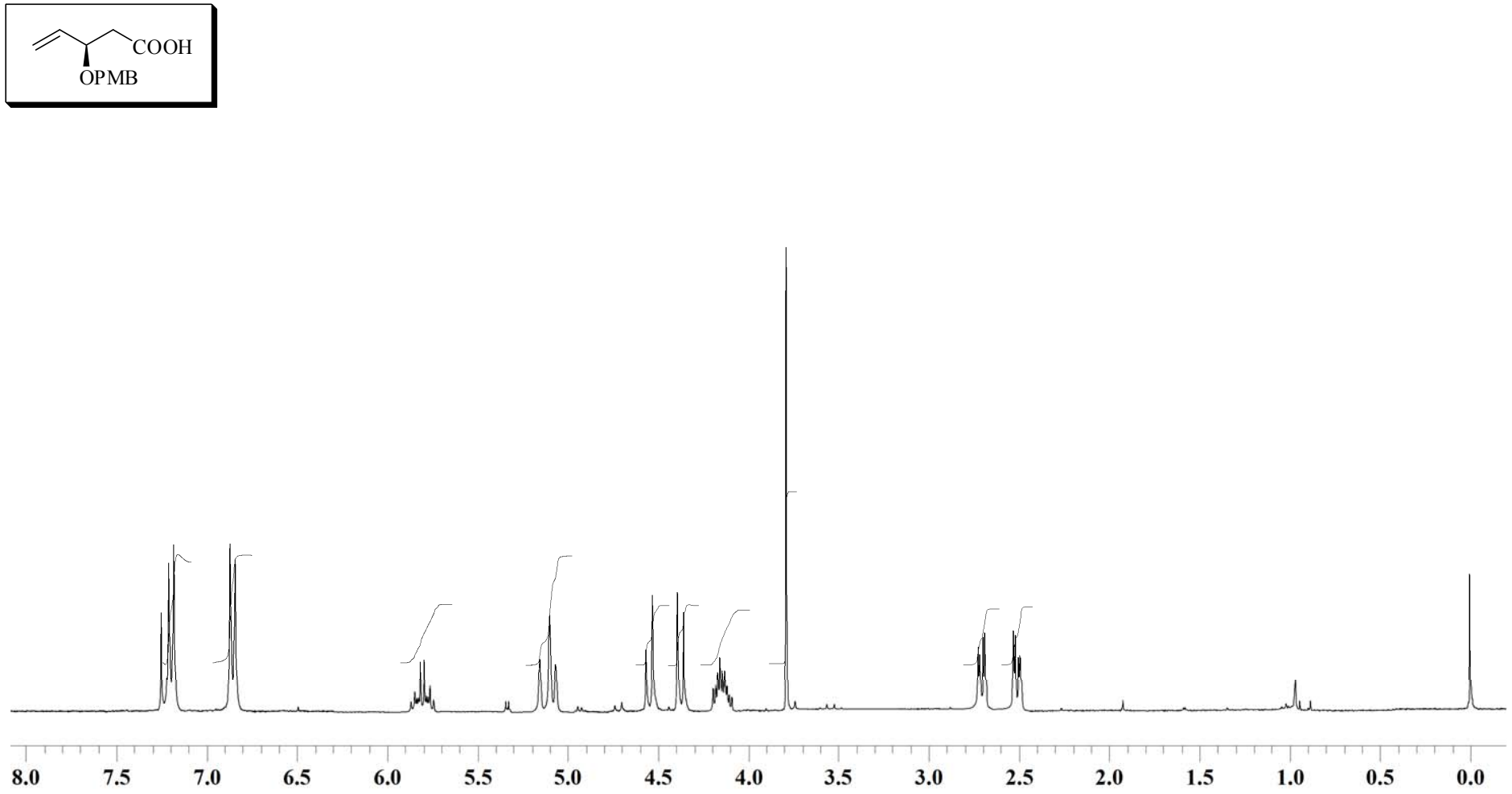
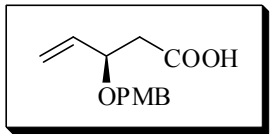


Figure S13: ^{1}H NMR Spectrum of compound **3** (300 MHz, $CDCl_3$)



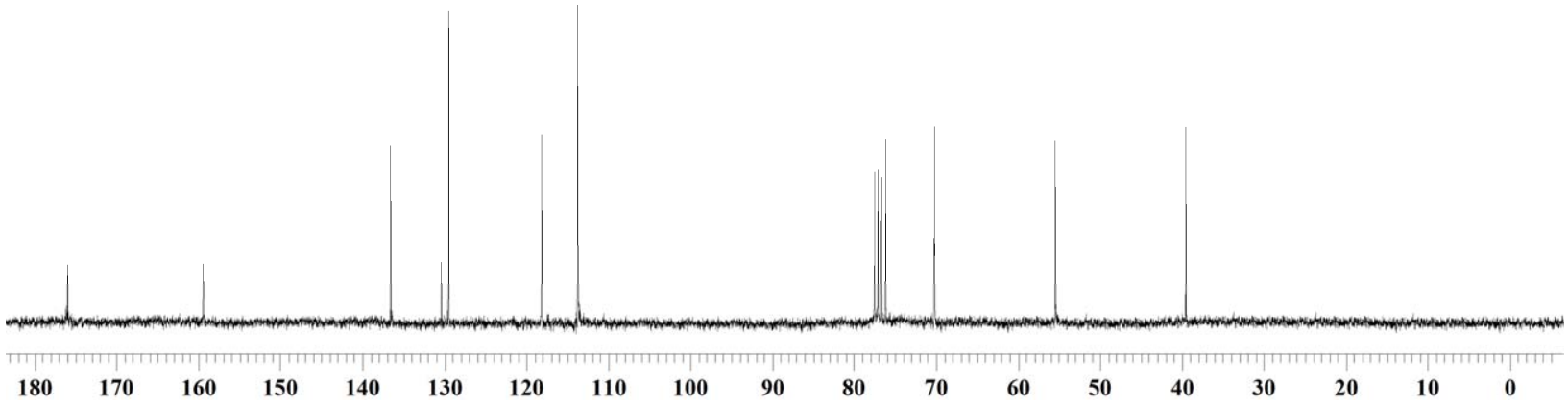
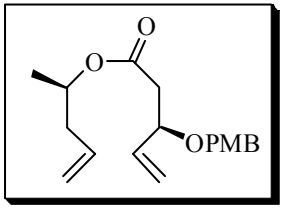


Figure S14: ^{13}C NMR Spectrum of compound **3** (75 MHz, $CDCl_3$)



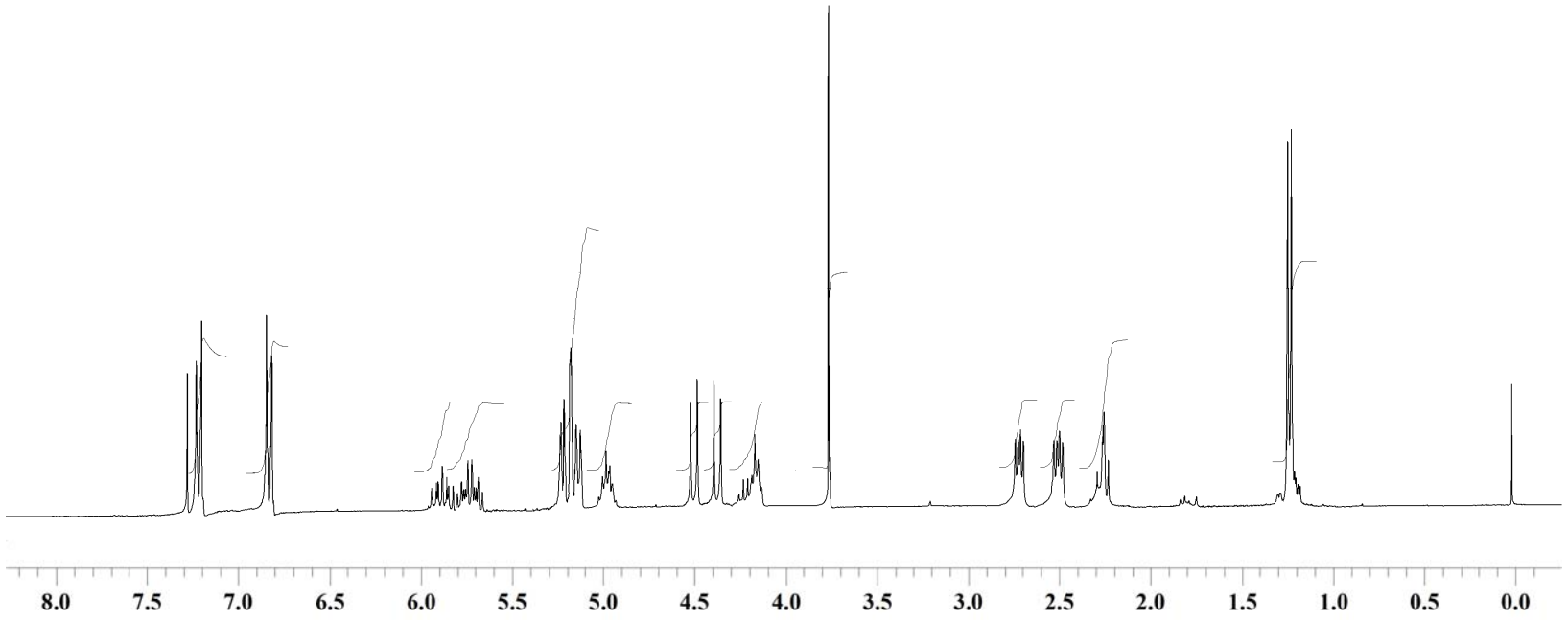


Figure S15: ^{1}H NMR Spectrum of compound **2** (300 MHz, $CDCl_3$)

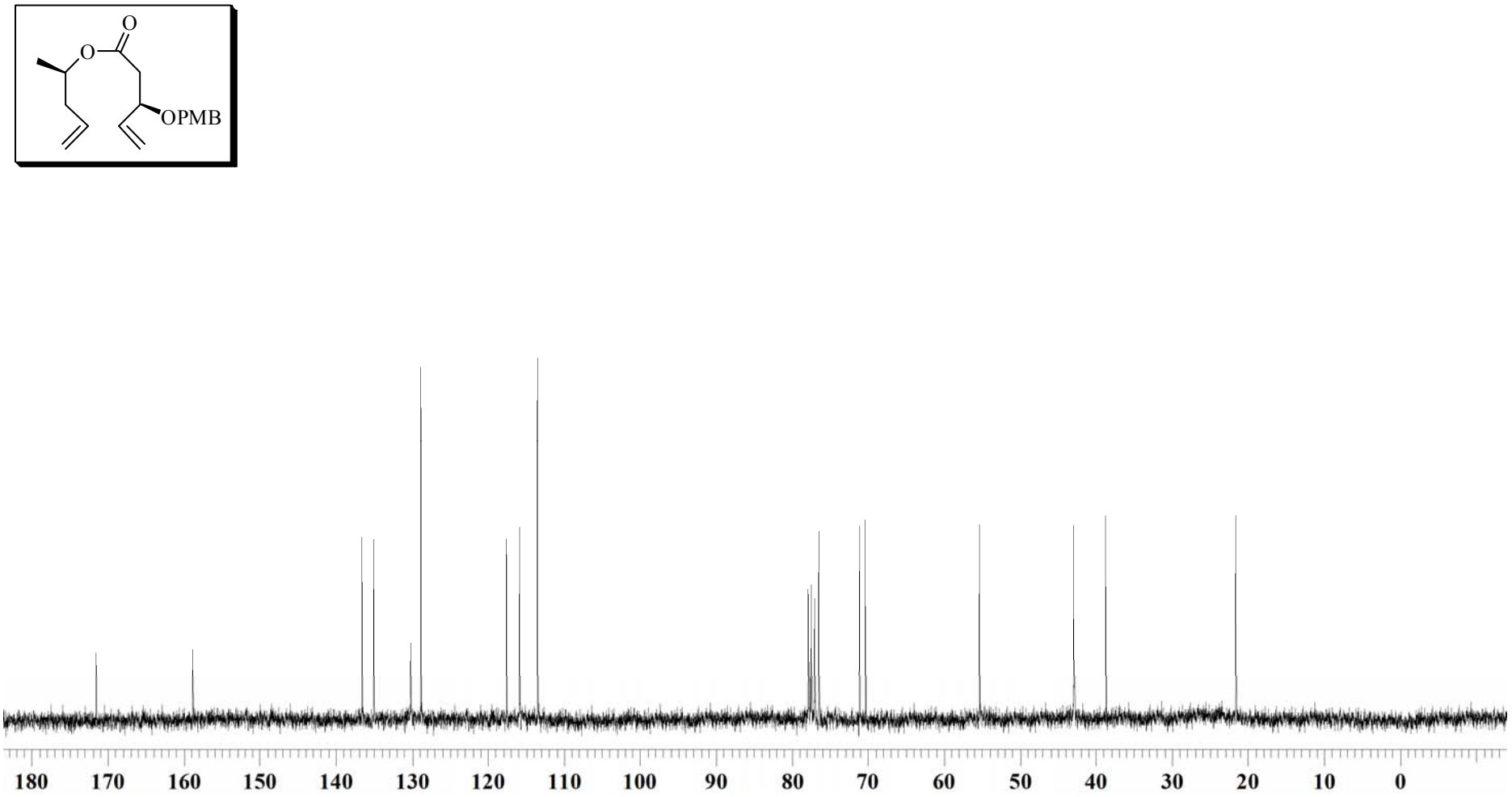
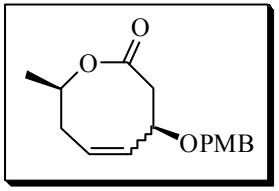


Figure S16: ^{13}C NMR Spectrum of compound **2** (75 MHz, $CDCl_3$)



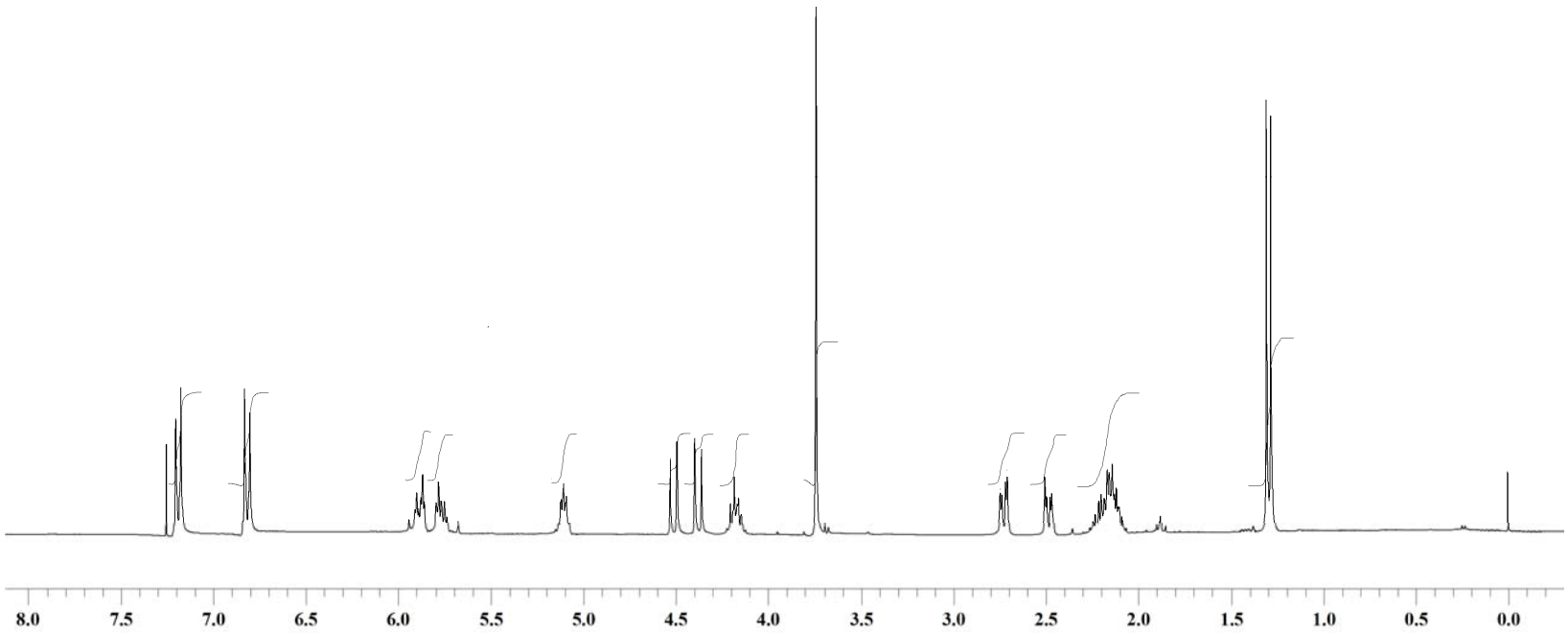
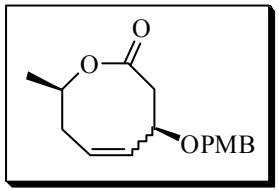


Figure S17: ^{1}H NMR Spectrum of compound **14** (300 MHz, $CDCl_3$)



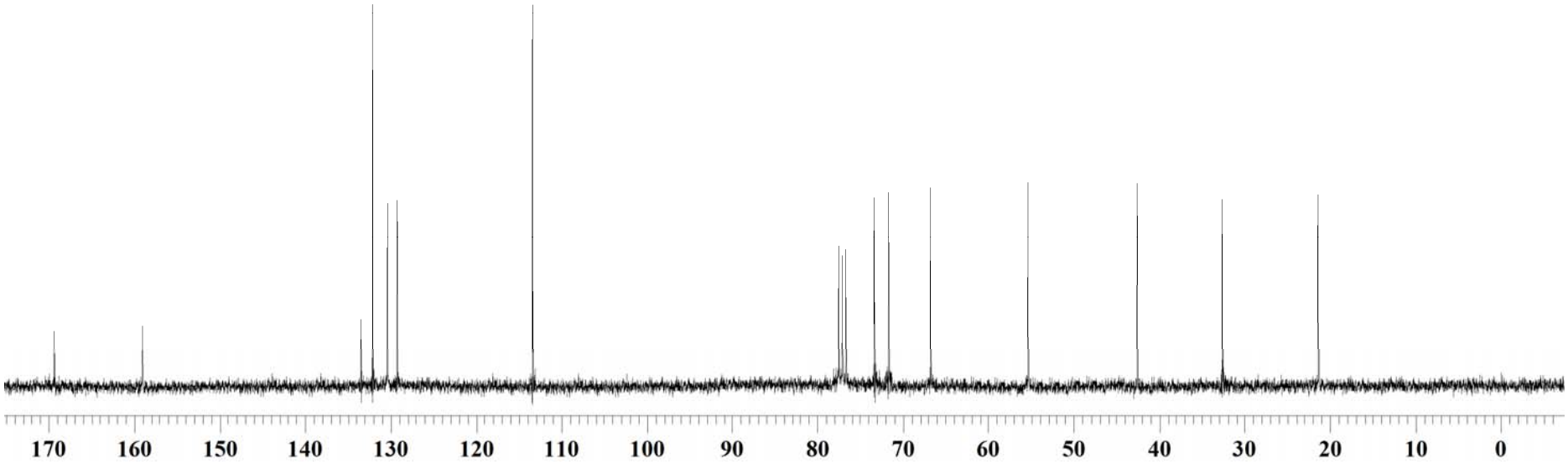


Figure S18: ^{13}C NMR Spectrum of compound **14** (75 MHz, $CDCl_3$)

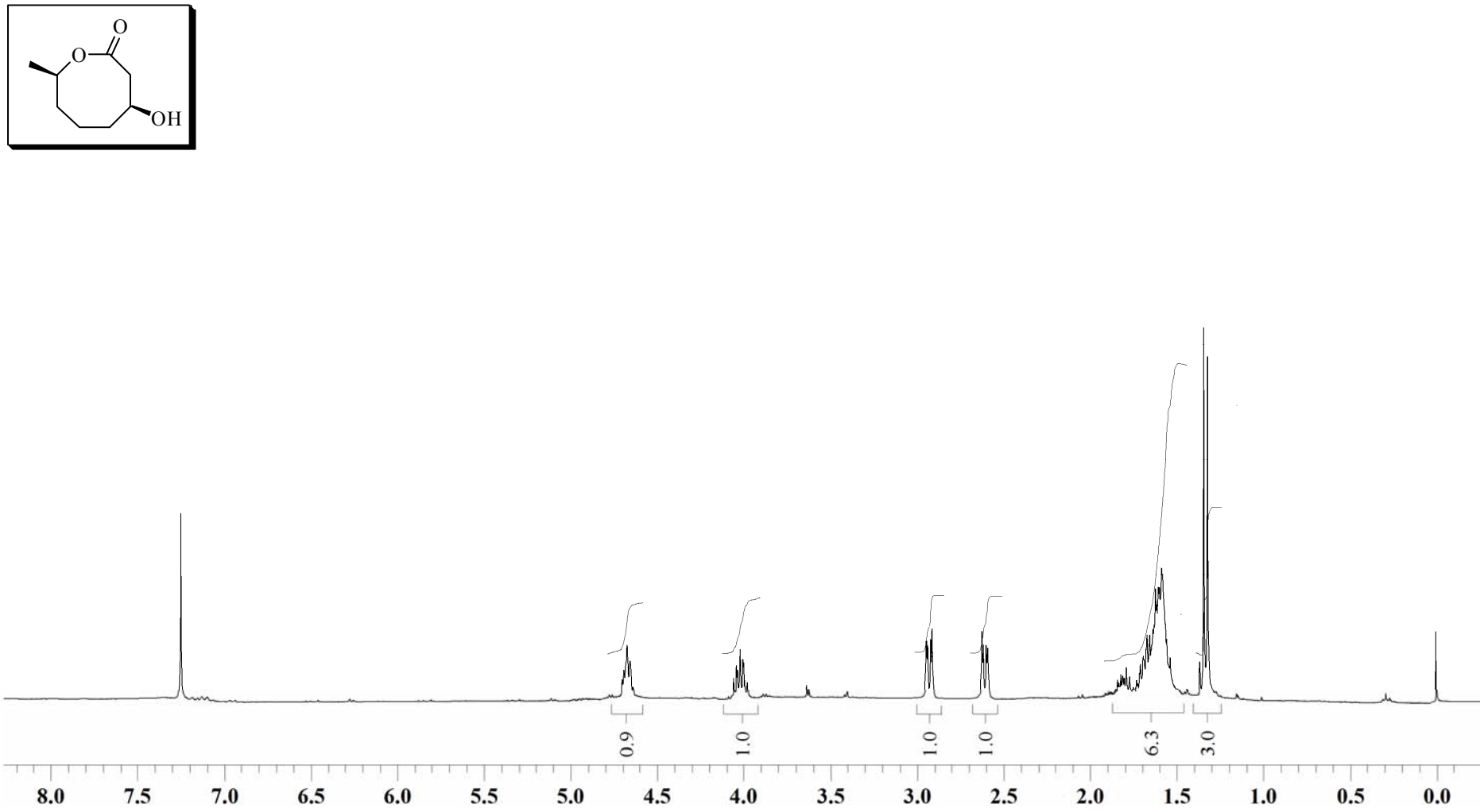
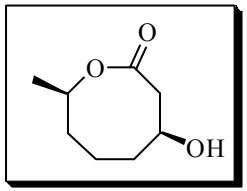


Figure S19: ^{1}H NMR Spectrum of compound **1** (300 MHz, $CDCl_3$)



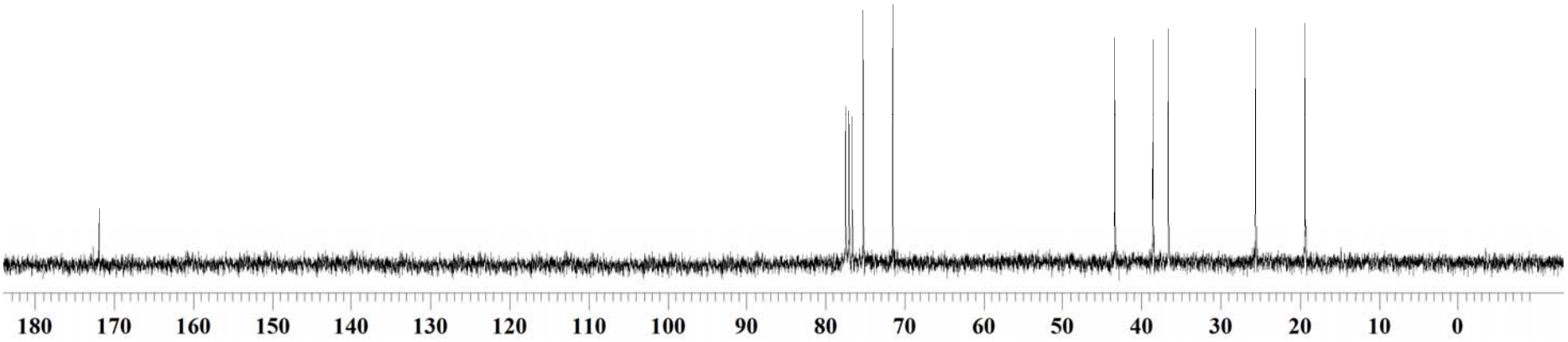


Figure S20: ^{13}C NMR Spectrum of compound **1** (75 MHz, $CDCl_3$)