

Biomimetic Total Synthesis of (\pm)-Carbocyclinone-534 Reveals Its Biosynthetic Pathway

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I Experimental Procedures and Spectroscopic Data of Compounds

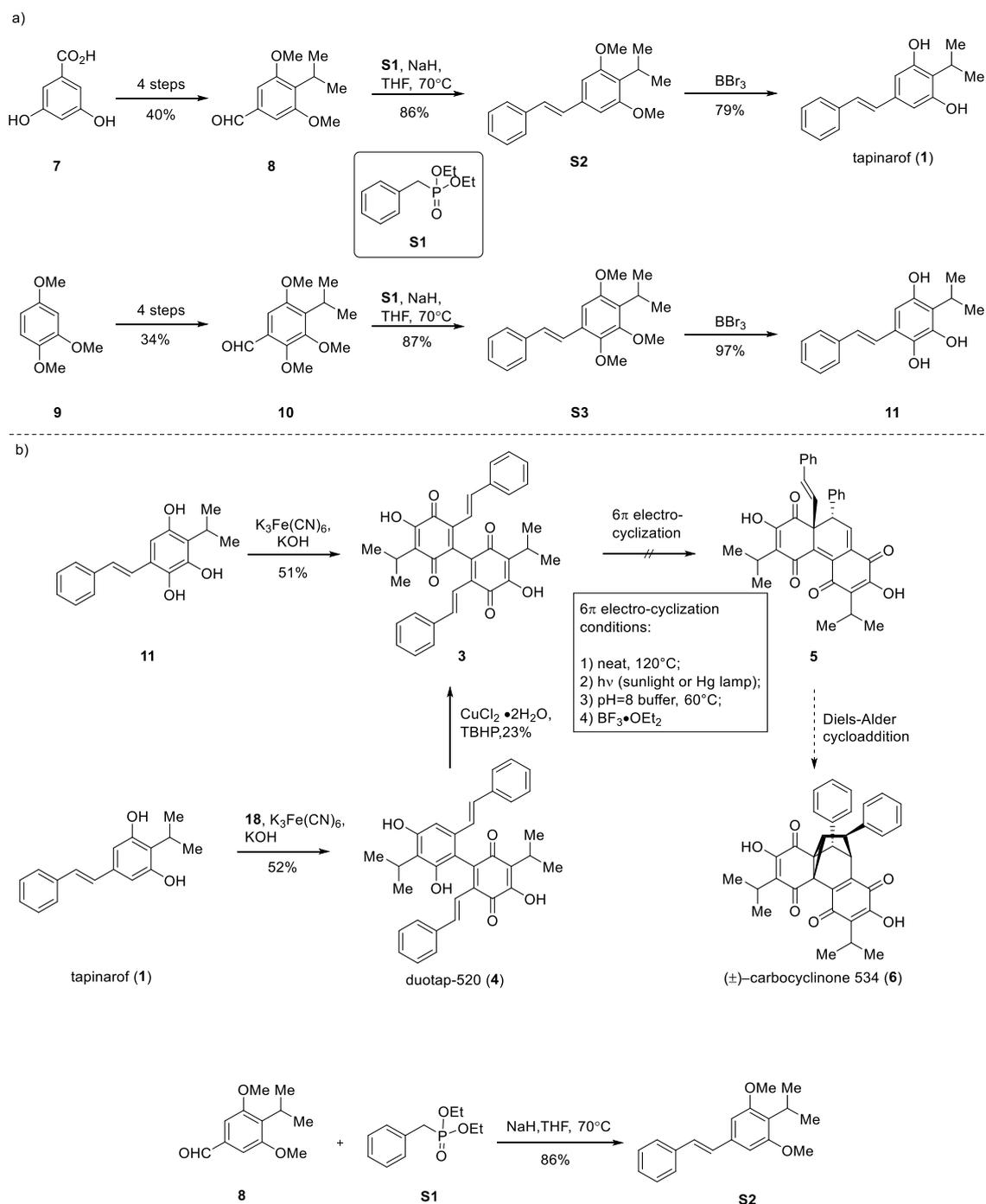
1. General Procedures

All reactions were carried out under an argon atmosphere with dry solvents under anhydrous conditions, unless otherwise noted. Tetrahydrofuran (THF) and Toluene were distilled immediately before use from sodium-benzophenoneketyl. Methylene chloride (CH_2Cl_2), *N,N*-Dimethylformamide (DMF) were distilled from calcium hydride and stored under an argon atmosphere. Reagents were purchased at the highest commercial quality and used without further purification, unless otherwise stated. Solvents for chromatography were used as supplied by Titan chemical. Reactions were monitored by thin layer chromatography (TLC) carried out on 0.2 mm Huanghai gel plates (60F-254) using UV light as visualizing agent and aqueous ammonium cerium nitrate/ammonium molybdate or basic aqueous potassium permanganate as developing agent. Huanghai silica gel (60, particle size 0.040–0.063 mm) was used for flash column chromatography. For the reactions require heating, dimethicone was used as the heat source.

NMR spectra were recorded on Bruker AV III 400, 500 or 600, The spectra were calibrated by using residual undeuterated solvents (for ^1H NMR) and deuterated solvents (for ^{13}C NMR) as internal references: chloroform ($\delta_{\text{H}} = 7.26$ ppm) and CDCl_3 ($\delta_{\text{C}} = 77.16$ ppm); methanol ($\delta_{\text{H}} = 3.31$ ppm) and methanol- d_4 ($\delta_{\text{C}} = 49.00$ ppm); The following abbreviations are used to designate multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, quint = quintet, br = broad. IR spectra were recorded on a BRUKER Tensor-27 FT-IR spectrometer. High-resolution mass spectra (HRMS) were recorded on Agilent G6230 ESI-FT and the analyzer type was TOF.

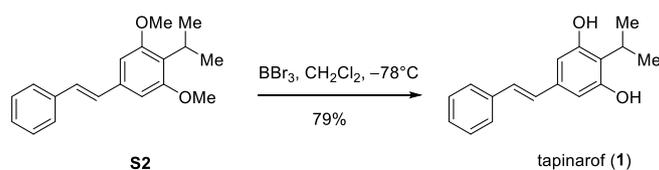
2. Synthetic Procedures

Scheme 1. Synthesis of tapinarof (1), 3, duotap-520 (4), S2, S3, and 11



To a stirred solution of **S1**, which is commercially available (6.31 g, 27.7 mmol) in THF (55 mL) were added NaH (983 mg, 60% dispersion in mineral oil, 24.6 mmol) at 0 °C. The mixture was allowed to stir at 0 °C for 30 min before **8**^[1] (3.2 g, 15.37 mmol) in THF (15 mL) was added. The resultant mixture was allowed to stir at 70 °C for 1h before it was quenched with H₂O (50 mL). The

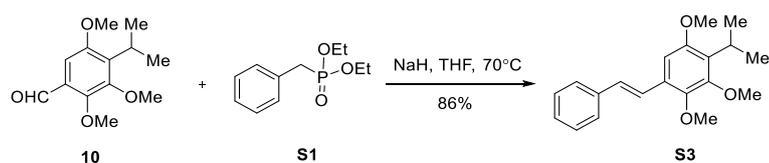
mixture so obtained was extracted with EtOAc (3 × 50 mL). The combined organic phases were washed with brine (50 mL), dried over anhydrous Na₂SO₄, filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (20:1) to give **S2** (3.73 g, 86%) as a pale yellow solid. **S2**: *R*_f = 0.85 (silica, petroleum ether:EtOAc = 30:1); IR (film): ν_{max} = 2989, 2744, 2835, 1598, 1497, 1235, 1141, 838, 724 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 7.54 (d, *J* = 8.1 Hz, 1H), 7.38 (t, *J* = 7.5 Hz, 1H), 7.29 (t, *J* = 7.3 Hz, 1H), 7.08 (s, 2H), 6.72 (s, 2H), 3.88 (s, 6H), 3.66 – 3.59 (m, 1H), 1.32 (d, *J* = 7.1 Hz, 6H) ppm; ¹³C NMR (101 MHz, CDCl₃): δ = 158.8, 137.4, 135.9, 129.1, 128.7, 128.0, 127.5, 126.5, 124.5, 103.0, 55.8, 24.2, 20.7 ppm; HRMS (*m/z*): [M+H]⁺ calcd for C₁₉H₂₃O₂⁺ 283.1693, found 283.1691. Melting point: 68-70 °C.



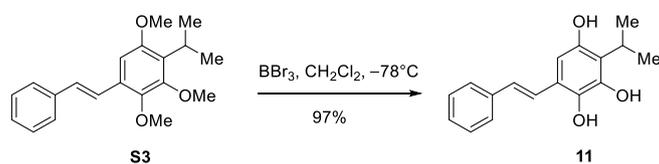
To a stirred solution of **S2** (1.6 g, 5.67 mmol) in CH₂Cl₂ (28 mL) were added BBr₃ (34 mL, 1 M in CH₂Cl₂, 34 mmol) at -78 °C. The mixture was allowed to stir at 25 °C for 3 h before the resultant mixture was quenched with H₂O (100 mL). The mixture so obtained was extracted with EtOAc (3 × 100 mL). The combined organic phases were washed with brine (50 mL), dried over anhydrous Na₂SO₄, filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (10:1) to give tapinarof (**1**) (1.14 g, 79%) as a white solid. tapinarof (**1**): *R*_f = 0.34 (silica, petroleum ether:EtOAc = 6:1); IR (film): ν_{max} = 3510, 2873, 2717, 1494, 1424, 1269, 1194, 864, 752 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 7.46 (d, *J* = 7.2 Hz, 2H), 7.33 (t, *J* = 7.6 Hz, 2H), 7.25 (t, *J* = 7.3 Hz, 1H), 6.97 (d, *J* = 16.3 Hz, 1H), 6.89 (d, *J* = 16.3 Hz, 1H), 6.48 (s, 2H), 4.74 (s, 2H), 3.44 (p, *J* = 7.1 Hz, 1H), 1.37 (d, *J* = 7.1 Hz, 6H) ppm; ¹³C NMR

(101 MHz, CDCl₃): δ = 155.1, 137.3, 136.4, 128.8, 127.9, 127.8, 126.6, 120.5, 107.0, 24.8, 20.9 ppm;

HRMS (m/z): [M-H]⁻ calcd for C₁₇H₁₇O₂⁻ 253.1234, found 253.1237.

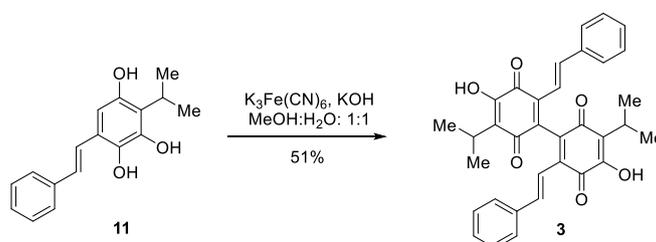


To a stirred solution of **S1** (9.31 g, 40.8 mmol) in THF (82 mL) were added NaH (1.45 g, 60% dispersion in mineral oil, 36.3 mmol) at 0 °C. The mixture was allowed to stir at 0 °C for 30 min before **10**^[2] (5.4 g, 22.7 mmol) in THF (23 mL) was added. The resultant mixture was allowed to stir at 70 °C for 1h before it was quenched with H₂O (150 mL). The mixture so obtained was extracted with EtOAc (3 × 100 mL). The combined organic phases were washed with brine (100 mL), dried over anhydrous Na₂SO₄, filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (20:1) to give **S3** (6.09 g, 86%) as a pale yellow solid. **S3**: *R*_f = 0.52 (silica, petroleum ether:EtOAc = 15:1); IR (film): ν_{max} = 2936, 2872, 2834, 1464, 1407, 1220, 1192, 857, 719 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 7.66 (d, *J* = 7.3 Hz, 2H), 7.55 (d, *J* = 16.5 Hz, 1H), 7.46 (t, *J* = 7.5 Hz, 2H), 7.35 (t, *J* = 7.4 Hz, 1H), 7.20 (d, *J* = 16.5 Hz, 1H), 6.97 (s, 1H), 3.98 (s, 3H), 3.94 (s, 6H), 3.66 (p, *J* = 7.1 Hz, 1H), 1.47 (d, *J* = 7.1 Hz, 6H) ppm; ¹³C NMR (101 MHz, CDCl₃): δ = 154.9, 152.2, 145.6, 137.8, 130.7, 128.9, 128.7, 128.6, 127.6, 126.6, 123.2, 103.0, 61.1, 61.0, 55.7, 25.4, 21.3 ppm; HRMS (m/z): [M+H]⁺ calcd for C₂₀H₂₅O₃⁺ 313.1798, found 313.1787. Melting point: 58-69 °C.



To a stirred solution of **S3** (2.0 g, 6.4 mmol) in CH₂Cl₂ (32 mL) were added BBr₃ (57.6 mL, 1 M in CH₂Cl₂, 57.6 mmol) at -78 °C. The mixture was allowed to stir at 25 °C for 3 h before the resultant mixture was quenched with H₂O (100 mL). The mixture so obtained was extracted with EtOAc (3 ×

100 mL). The combined organic phases were washed with brine (100 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum to give **11** (1.68 g, 97%) as an orange oil was used in next step without further purification. **11**: $R_f = 0.31$ (silica, petroleum ether:EtOAc = 3:1); IR (film): $\nu_{\text{max}} = 3439, 2873, 1634, 1447, 1393, 1231, 1030, 848, 749 \text{ cm}^{-1}$; $^1\text{H NMR}$ (400 MHz, methanol- d_4): $\delta = 7.44$ (d, $J = 7.6 \text{ Hz}$, 1H), 7.39 (d, $J = 16.4 \text{ Hz}$, 1H), 7.24 (t, $J = 7.6 \text{ Hz}$, 2H), 7.12 (t, $J = 7.3 \text{ Hz}$, 1H), 6.97 (d, $J = 16.4 \text{ Hz}$, 1H), 6.57 (s, 1H), 3.48 (p, $J = 7.0 \text{ Hz}$, 1H), 1.34 (d, $J = 7.0 \text{ Hz}$, 6H) ppm; $^{13}\text{C NMR}$ (101 MHz, methanol- d_4): $\delta = 150.5, 146.7, 139.1, 136.8, 129.5, 128.6, 128.0, 127.1, 124.4, 124.1, 123.0, 26.2, 21.0 \text{ ppm}$; HRMS (m/z): $[\text{M}-\text{H}]^-$ calcd for $\text{C}_{17}\text{H}_{17}\text{O}_3^-$ 269.1183, found 269.1183.

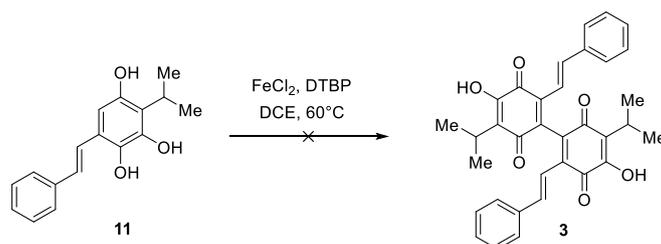


To a stirred solution of **11** (100 mg, 0.37 mmol) in MeOH (3.7 mL) was added $\text{K}_3\text{Fe}(\text{CN})_6$ (121.8 mg, 0.37 mmol), KOH (62.3 mg, 1.11 mmol) in H_2O (3.7 mL) at 25 °C. The mixture was allowed to stir at 25 °C for 5 min before it was quenched with 1N HCl (30 mL). The mixture so obtained was extracted with EtOAc ($3 \times 30 \text{ mL}$). The combined organic phases were washed with brine (30 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (3:1) to give **3** (51 mg, 51%) as a red solid. **3**: $R_f = 0.34$ (silica, petroleum ether:EtOAc = 6:1); IR (film): $\nu_{\text{max}} = 3391, 3083, 2874, 1494, 1325, 1000, 966, 751, 522 \text{ cm}^{-1}$; $^1\text{H NMR}$ (400 MHz, CDCl_3): $\delta = 7.71$ (d, $J = 16.3 \text{ Hz}$, 2H), 7.31 (m, 10H), 6.54 (d, $J = 16.3 \text{ Hz}$, 2H), 3.23 (p, $J = 7.1 \text{ Hz}$, 2H), 1.26 (dd, $J = 7.1, 5.4 \text{ Hz}$, 12H) ppm; $^{13}\text{C NMR}$ (101 MHz, CDCl_3): $\delta = 185.1, 183.2, 150.8, 141.7, 138.6, 136.7, 135.3, 129.7, 128.9, 127.5,$

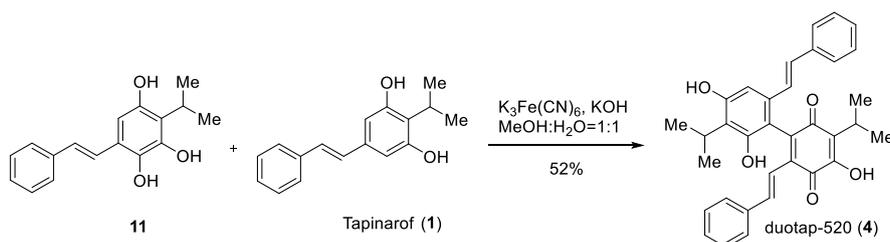
126.2, 119.4, 24.7, 20.1, 20.0 ppm; HRMS (m/z): $[M-H]^-$ calcd for $C_{34}H_{29}O_6^-$ 533.1970, found 533.1975. Melting point: 110-124 °C

When the reaction is over 1 mmol scale:

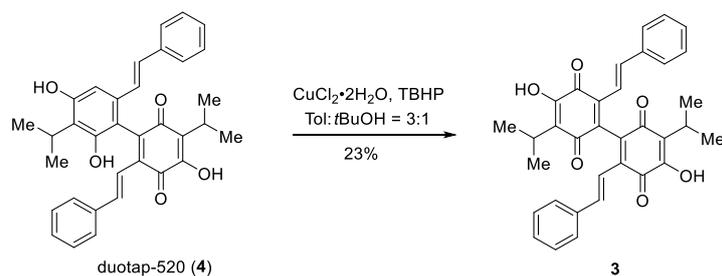
To a stirred solution of **11** (363 mg, 1.34 mmol) in MeOH (13 mL) was added $K_3Fe(CN)_6$ (442.1 mg, 1.34 mmol), KOH (226.0 mg, 4.03 mmol) in H_2O (13 mL) at 25 °C. The mixture was allowed to stir at 25 °C for 5 min before it was quenched with 1N HCl (100 mL). The mixture so obtained was extracted with EtOAc (3 × 50 mL). The combined organic phases were washed with brine (30 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum. The crude product (345mg, 95%) was obtained. The residue was purified by flash column chromatography with petroleum ether:EtOAc (3:1) to give **3** (179 mg, 49%) as a red solid. The crude product is quite pure by checking with NMR, but **3** seems instable during purifying by flash column chromatography.



To a stirred solution of **11** (15 mg, 0.06 mmol) in DCE (0.2 mL) was added $FeCl_2$ (1.43 mg, 0.01 mmol), DTBP (16.44 mg, 0.1 mmol) at 25 °C. The mixture was allowed to stir at 60°C for 2h before it was quenched with H_2O (2 mL). The mixture so obtained was extracted with EtOAc (3 × 3 mL). The combined organic phases were washed with brine (30 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum. The residue was checked by NMR, and we could not find the signal of compound **3**. But we find the signal of compound **12**, the main product was it.



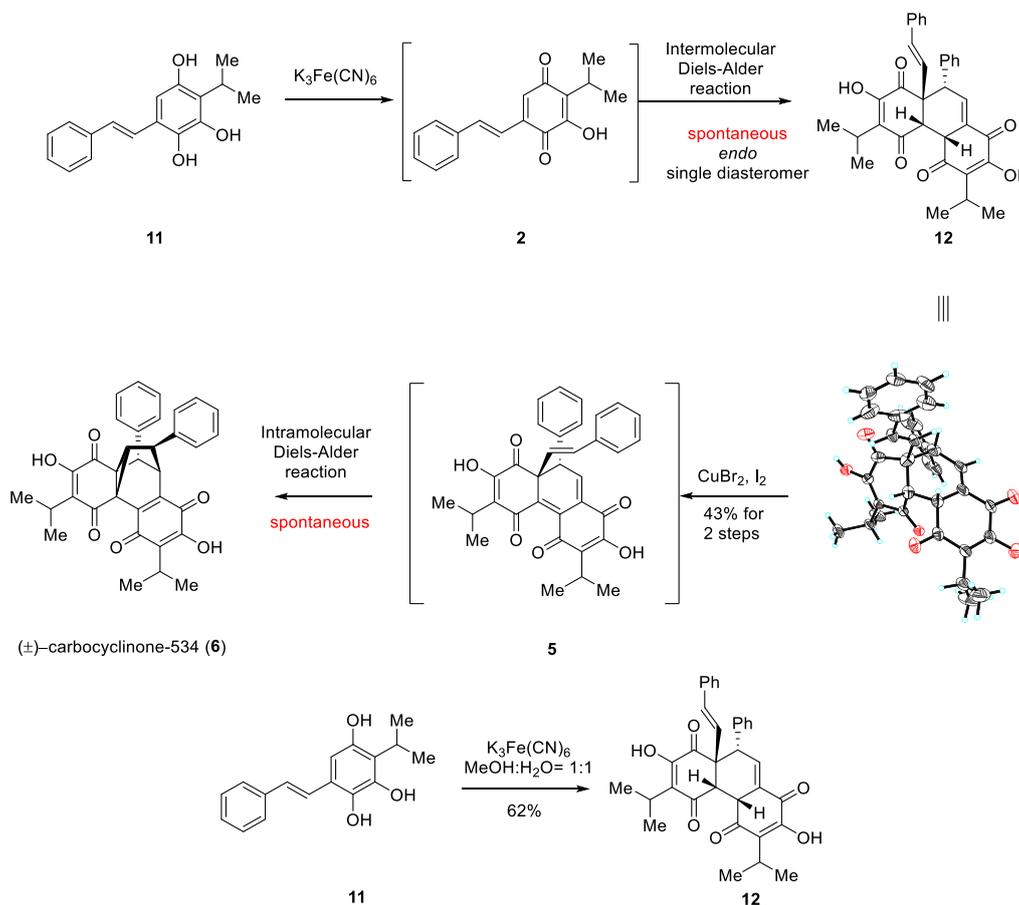
To a stirred solution of **1** (43.24 mg, 0.17 mmol) in MeOH (0.13 mL) and H₂O (0.1 mL) was added K₃Fe(CN)₆ (21.92 mg, 0.07 mmol), KOH (44.83 mg, 0.80 mmol) at 25 °C. The mixture was allowed to stir at 25 °C for 5 min before the resultant mixture was added **11** (18 mg, 0.07 mmol) in MeOH (0.1 mL). The mixture was allowed to stir at 25 °C for 30 min before the resultant mixture was quenched with 1N HCl (3 mL). The mixture so obtained was extracted with EtOAc (3 × 10 mL). The combined organic phases were washed with brine (20 mL), dried over anhydrous Na₂SO₄, filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (6:1) to give duotap-520 (**4**) (17.9 mg, 52%) as a red oil. duotap-520 (**4**): *R*_f = 0.30 (silica, petroleum ether:EtOAc = 6:1); IR (film): ν_{max} = 3399, 3105, 2873, 1448, 1321, 1008, 960, 751, 520 cm⁻¹; ¹H NMR (400 MHz, methanol-d₄): δ = 7.51 (d, *J* = 16.5 Hz, 1H), 7.29 (d, *J* = 7.3 Hz, 2H), 7.26 – 7.22 (m, 7H), 6.88 (d, *J* = 16.0 Hz, 1H), 6.79 (s, 1H), 6.67 (dd, *J* = 16.4, 14.1 Hz, 2H), 3.53 (p, *J* = 7.0 Hz, 1H), 3.26 (q, *J* = 7.1 Hz, 1H), 1.35 (d, *J* = 7.0 Hz, 6H), 1.26 (d, *J* = 2.8 Hz, 3H), 1.25 (d, *J* = 2.8 Hz, 3H) ppm; ¹³C NMR (126 MHz, methanol-d₄): δ = 187.4, 184.0, 156.9, 152.7, 141.3, 138.7, 137.5, 137.5, 136.1, 134.5, 129.0, 128.4, 128.3, 128.2, 127.1, 126.5, 126.5, 125.9, 125.3, 121.6, 120.6, 113.5, 104.3, 24.7, 24.4, 19.6, 19.5, 19.1, 18.9 ppm; HRMS (*m/z*): [M-H]⁻ calcd for C₃₄H₃₁O₅⁻ 519.2177, found 519.2182. Melting point: 92-101 °C.



To a stirred suspension of duotap-520 (**4**) (4.5 mg, 0.009 mmol) and CuCl₂·2H₂O (0.74 mg, 0.004 mmol) in toluene (60 μL) and *t*BuOH (20 μL) was added TBHP (4.7 μL, 5.5 mol/L in decane, 0.05 mmol) at 25 °C. The mixture was allowed to stir at 25 °C for 1 h before the resultant mixture was quenched with brine (10 mL). The mixture so obtained was extracted with EtOAc (3 × 10 mL).

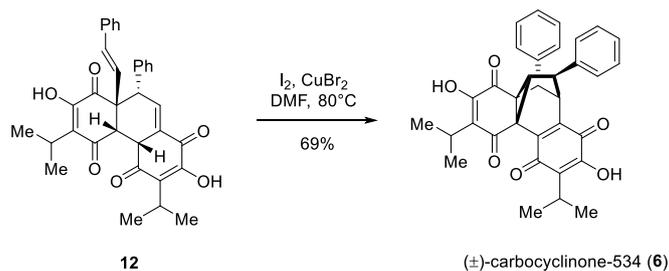
The combined organic phases were washed with brine (10 mL), dried over anhydrous Na₂SO₄, filtered, and concentrated under vacuum to give **3** (1.05 mg, 23%, NMR internal standard method, 2 mg 1,3,5-Trimethoxybenzene) as a red solid.

Scheme 2. Total Synthesis of **12**, (±)-carbocyclinone-534



To a stirred suspension of **11** (70 mg, 0.26 mmol) in MeOH:H₂O = 1:1 (2.6 mL) were added $K_3Fe(CN)_6$ (128 mg, 0.39 mmol) at 25 °C. The mixture was allowed to stir at 25 °C for 10 min. The resultant mixture was filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (3:1) to give **12** as a pale yellow oil. **12**: R_f = 0.64 (silica, petroleum ether:EtOAc = 3:1); IR (film): ν_{max} = 3401, 3030, 2876, 1452, 1330, 997, 878, 745, 724 cm⁻¹; ¹H NMR (400 MHz, methanol-d₄): δ = 7.48 (d, J = 7.1 Hz, 2H), 7.32 (t, J = 7.5 Hz, 2H), 7.25 (t, J = 7.3 Hz, 1H), 7.17 – 7.14 (m, 3H), 7.09 (t, J = 7.5 Hz, 2H), 6.83 (brs, 2H), 6.67 (d, J

= 16.4 Hz, 1H), 6.59 (d, $J = 16.4$ Hz, 1H), 4.43 (t, $J = 3.4$ Hz, 1H), 4.20 (d, $J = 4.5$ Hz, 1H), 3.40 – 3.26 (m, 1H), 2.72 (p, $J = 7.0$ Hz, 1H), 1.30 (d, $J = 7.3$ Hz, 3H), 1.28 (d, $J = 7.3$ Hz, 3H), 0.94 (d, $J = 7.1$ Hz, 3H), 0.77 (d, $J = 7.0$ Hz, 3H) ppm; ^{13}C NMR (101 MHz, CDCl_3): $\delta = 197.0, 194.3, 192.6, 181.1, 155.7, 152.8, 137.4, 136.7, 135.5, 133.0, 132.5, 132.5, 131.0, 130.0, 129.0, 128.8, 128.1, 126.9, 56.3, 52.6, 48.0, 42.7, 25.5, 25.2, 20.0, 19.6, 19.6, 18.8$ ppm; HRMS (m/z): $[\text{M}-\text{H}]^-$ calcd for $\text{C}_{34}\text{H}_{31}\text{O}_6^-$ 535.2126, found 535.2127.

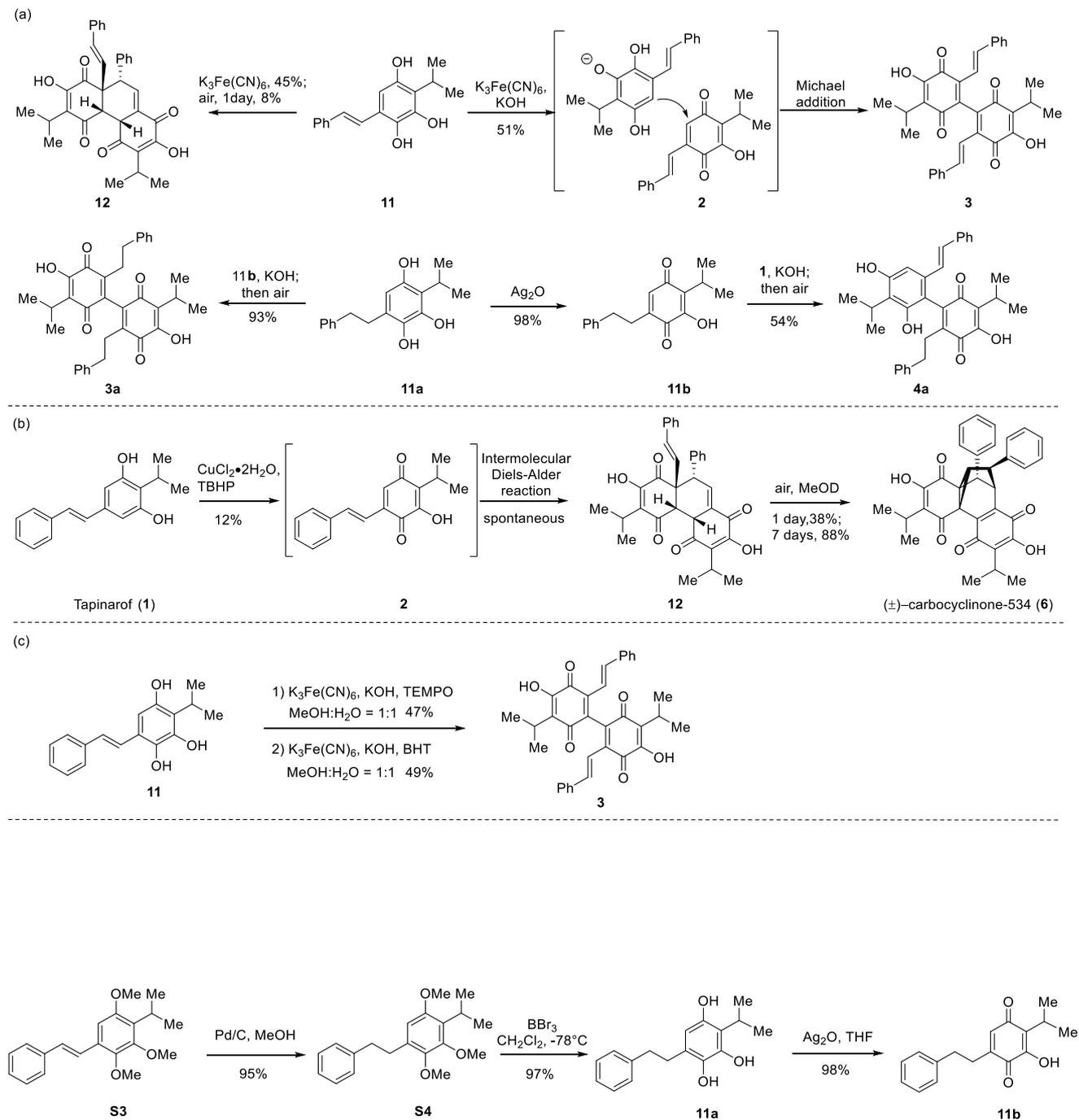


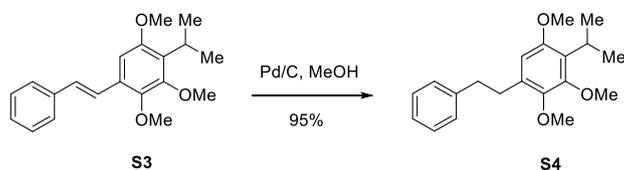
To a stirred solution of **12** (43 mg, 0.08 mmol) and I_2 (40.68 mg, 0.16 mmol), CuBr_2 (9.0 mg, 0.04 mmol) in DMF (0.16 mL). The mixture was allowed to stir at 80°C for 3 h before the resultant mixture was quenched with saturated aq. $\text{Na}_2\text{S}_2\text{O}_3$ (10 mL). The mixture so obtained was extracted with EtOAc (3×10 mL). The combined organic phases were washed with brine (10 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (6:1) to give (\pm) -carbocyclinone-534 (**6**) (29.5 mg, 69%) as a pale yellow solid. (\pm) -carbocyclinone-534 (**6**): $R_f = 0.40$ (silica, petroleum ether:EtOAc = 3:1); IR (film): $\nu_{\text{max}} = 3435, 2852, 2874, 1497, 1453, 1285, 1259, 845, 722$ cm^{-1} ; ^1H NMR (400 MHz, methanol- d_4): $\delta = 7.24 - 7.19$ (m, 4H), 7.17 – 7.13 (m, 1H), 7.11 – 7.04 (m, 3H), 6.87 – 6.85 (m, 2H), 4.46 (d, $J = 4.5$ Hz, 1H), 4.11 (dt, $J = 4.6, 2.5$ Hz, 1H), 3.98 (dd, $J = 4.9, 2.5$ Hz, 1H), 3.43 (hept, $J = 6.9$ Hz, 1H), 3.16 (brs, 1H), 2.99 (hept, $J = 7.1$ Hz, 1H), 1.39 (d, $J = 7.0$ Hz, 6H), 1.10 (d, $J = 7.1$ Hz, 3H), 1.04 (d, $J = 7.0$ Hz, 3H) ppm; ^{13}C NMR (126 MHz, methanol- d_4): $\delta = 192.2, 189.2, 184.8, 180.3, 157.1, 152.3, 143.3, 138.5, 137.1, 134.6, 130.3, 129.3, 128.7, 128.4, 128.1,$

127.9, 127.2, 48.1, 47.0, 46.0, 43.3, 43.0, 41.4, 26.2, 25.9, 20.3, 20.2, 20.1, 19.7 ppm; HRMS (m/z):

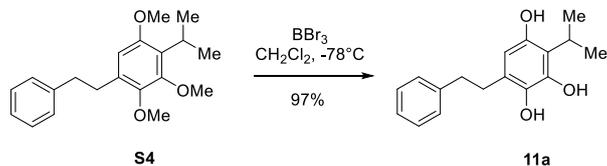
[M-H]⁻ calcd for C₃₄H₂₉O₆⁻ 533.1970, found 533.1975. Melting point: 128-134 °C.

Scheme 3. Control experiments and Biomimetic transformations



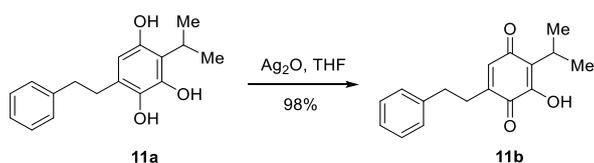


To a stirred solution of **S3** (300 mg, 0.96 mmol) in MeOH (1.85 mL) was added 10% Pd/C (207 mg) at 25 °C. The reaction mixture was allowed to stir at 25°C for 15 min under H₂ atmosphere. The resultant mixture was filtered and concentrated under vacuum to give **S4** (287 mg, 95%) as a colorless oil. **S4**: *R_f* = 0.54 (silica, petroleum ether:EtOAc = 15:1); IR (film): ν_{\max} = 3428, 3026, 2871, 1479, 1285, 987, 875, 750, 522 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 7.30 (t, *J* = 7.4 Hz, 2H), 7.28 – 7.24 (m, 2H), 7.21 (m, 1H), 6.41 (s, 1H), 3.84 (s, 3H), 3.79 (s, 3H), 3.73 (s, 3H), 3.51 (p, *J* = 7.1 Hz, 1H), 2.91 (s, 4H), 1.33 (d, *J* = 7.1 Hz, 6H) ppm; ¹³C NMR (101 MHz, CDCl₃): δ = 154.5, 151.9, 145.5, 142.3, 132.7, 128.6, 128.5, 128.5, 126.0, 107.8, 60.8, 60.6, 55.8, 37.4, 32.4, 25.2, 21.5 ppm; HRMS (*m/z*): [M+H]⁺ calcd for C₂₀H₂₇O₃⁺ 315.1955, found 315.1955.

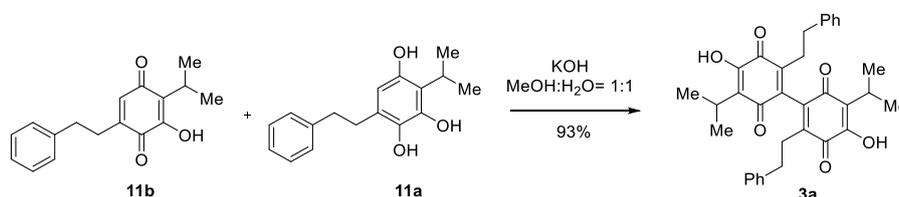


To a stirred solution of **S4** (200 mg, 0.64 mmol) in CH₂Cl₂ (3.2 mL) were added BBr₃ (5.76 mL, 1 mol/L in CH₂Cl₂, 5.76 mmol) at -78 °C. The mixture was allowed to stir at 25 °C for 2 h before the resultant mixture was quenched with H₂O (30 mL). The mixture so obtained was extracted with EtOAc (3 × 30 mL). The combined organic phases were washed with brine (30 mL), dried over anhydrous Na₂SO₄, filtered, and concentrated under vacuum to give **11a** (168 mg, 97%) as a pale yellow oil. **11a**: *R_f* = 0.17 (silica, petroleum ether:EtOAc = 6:1); IR (film): ν_{\max} = 3424, 2872, 1949, 1496, 1446, 1208, 1108, 844, 751 cm⁻¹; ¹H NMR (400 MHz, methanol-d₄): δ = 7.18 (m, 3H), 7.09 (m, 2H), 6.09 (s, 1H), 3.44 (p, *J* = 7.1 Hz, 1H), 2.89 – 2.63 (m, 4H), 1.31 (d, *J* = 7.1 Hz, 6H) ppm; ¹³C NMR (101 MHz, methanol-d₄): δ = 150.1, 146.4, 143.5, 136.2, 129.3, 129.1, 128.4, 126.6, 120.6,

108.2, 37.3, 33.2, 26.1, 21.1 ppm; HRMS (m/z): $[M-H]^-$ calcd for $C_{17}H_{19}O_3^-$ 271.1340, found 271.1345.

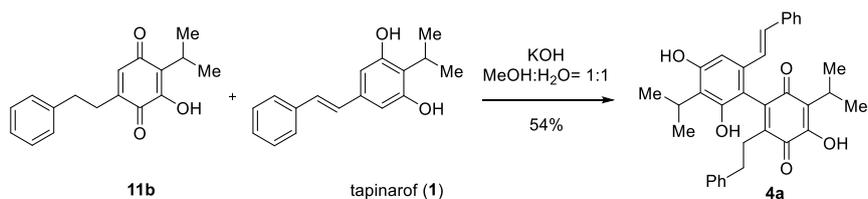


To a stirred solution of **11a** (90 mg, 0.33 mmol) in THF (1.65 mL) were added Ag_2O (115 mg, 0.5 mmol) at 25 °C. The mixture was allowed to stir at 25 °C for 10 min. The resultant mixture was filtered, and concentrated under vacuum to give **11b** (87.5 mg, 98%) as a yellow solid. **11b**: R_f = 0.53 (silica, petroleum ether:EtOAc = 20:1); IR (film): ν_{max} = 3451, 3085, 2874, 1454, 1303, 982, 895, 750, 725 cm^{-1} ; 1H NMR (400 MHz, $CDCl_3$): δ = 7.30 (t, J = 7.4 Hz, 2H), 7.20 (m, 3H), 7.04 (s, 1H), 6.41 (s, 1H), 3.19 (p, J = 7.0 Hz, 1H), 2.84 (m, 2H), 2.74 (m, 2H), 1.23 (d, J = 7.0 Hz, 3H) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 187.5, 184.3, 150.9, 143.4, 140.4, 135.4, 128.7, 128.5, 126.6, 125.6, 33.9, 30.2, 24.2, 20.0 ppm; H RMS (m/z): $[M-H]^-$ calcd for $C_{17}H_{17}O_3^-$ 269.1183, found 269.1189. Melting point: 101-103 °C



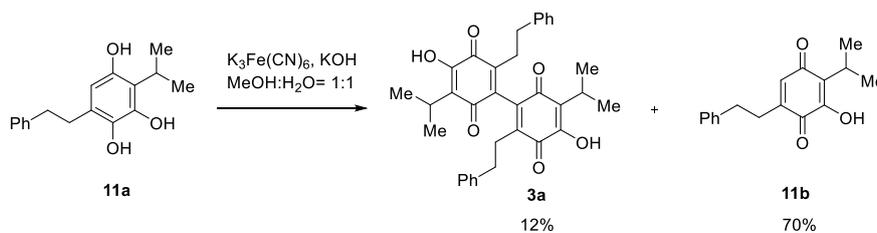
To a stirred suspension of **11a** (19.65 mg, 0.07 mmol) in MeOH (0.1 mL) and H_2O (0.1 mL) was added KOH (32.38 mg, 0.58 mmol) at 25 °C under argon atmosphere. The mixture was allowed to stir at 25 °C for 5 min before the resultant mixture was added **11b** (13 mg, 0.48 mmol) in MeOH (0.1 mL). The mixture was allowed to stir at 25 °C for 30 min before the resultant mixture was quenched with 1N HCl (5 mL) The mixture so obtained was extracted with EtOAc (3×10 mL) The combined organic phases were washed with brine (10 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (6:1) to give **3a** (24 mg, 93%) as a yellow oil. **3a**: R_f = 0.26 (silica,

petroleum ether:EtOAc = 20:1); IR (film): ν_{\max} = 3400, 3087, 2875, 1455, 1256, 1031, 750, 680, 531 cm^{-1} ; ^1H NMR (400 MHz, CDCl_3): δ = 7.17 (d, J = 7.6 Hz, 4H), 7.17 (m, 2H), 7.08 (m, 4H), 3.23 (p, J = 7.1 Hz, 2H), 2.72 (m, 2H), 2.58 (d, J = 9.2, 3.9 Hz, 4H), 2.27 (m, 2H), 1.27 (dd, J = 7.1, 5.5 Hz, 6H) ppm; ^{13}C NMR (101 MHz, CDCl_3): δ = 185.3, 183.3, 150.9, 141.4, 140.8, 140.2, 128.7, 128.3, 126.6, 125.9, 34.4, 30.7, 24.6, 20.1, 20.0 ppm; HRMS (m/z): $[\text{M}-\text{H}]^-$ calcd for $\text{C}_{34}\text{H}_{33}\text{O}_6^-$ 537.2283, found 537.2290. Melting point: 120-135 °C

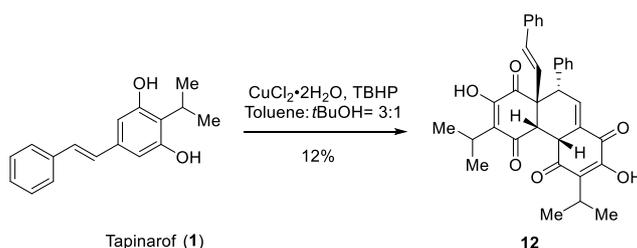


To a stirred suspension of **1** (23.52 mg, 0.09 mmol) in MeOH (0.05 mL) and H₂O (0.05 mL) was added KOH (24.91 mg, 0.44 mmol) at 25 °C under argon atmosphere. The mixture was allowed to stir at 25 °C for 5 min before the resultant mixture was added **11b** (10 mg, 0.37 mmol) in MeOH (0.08 mL). The mixture was allowed to stir at 25 °C for 30 min before the resultant mixture was quenched with 1N HCl (5 mL). The mixture so obtained was extracted with EtOAc (3 × 10 mL). The combined organic phases were washed with brine (10 mL), dried over anhydrous Na₂SO₄, filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (6:1) to give **4a** (10.4 mg, 54%) as a red solid. **4a**: R_f = 0.33 (silica, petroleum ether:EtOAc = 6:1); IR (film): ν_{\max} = 3747, 3443, 2852, 1427, 1315, 1031, 750, 697, 566 cm^{-1} ; ^1H NMR (400 MHz, methanol- d_4): δ = 7.35 – 7.23 (m, 4H), 7.22 – 7.15 (m, 1H), 7.10 (t, J = 7.4 Hz, 2H), 7.02 (dd, J = 8.3, 6.2 Hz, 1H), 6.94 – 6.84 (m, 2H), 6.78 (s, 1H), 6.55 (d, J = 16.1 Hz, 1H), 3.53 (m, 1H), 3.25 (m, 1H), 2.61 – 2.51 (m, 3H), 2.49 – 2.40 (m, 1H), 1.37 (d, J = 7.0 Hz, 6H), 1.26 (d, J = 3.7 Hz, 3H), 1.24 (d, J = 3.9 Hz, 3H) ppm; ^{13}C NMR (126 MHz, methanol- d_4): δ = 189.0, 185.1, 158.1, 154.3, 153.7, 144.7, 144.6, 142.9, 138.8, 135.5, 130.1, 129.7, 129.3, 129.2, 128.6, 127.9, 127.3, 126.9, 126.7, 123.0, 114.70, 105.4, 35.0, 31.1, 26.2, 25.7, 21.1, 20.9, 20.5, 20.3 ppm;

HRMS (m/z): $[M-H]^-$ calcd for $C_{34}H_{33}O_5^-$ 521.2333, found 521.2341. Melting point: 95-110 °C



To a stirred suspension of **11a** (25 mg, 0.092 mmol) in MeOH (1 mL) was added $\text{K}_3\text{Fe}(\text{CN})_6$ (30.22 mg, 0.092 mmol), KOH (15.45 mg, 0.28 mmol) in H_2O (1 mL) at 25 °C. The mixture was allowed to stir at 25 °C for 5 min before the resultant mixture was quenched with 1N HCl (10 mL). The mixture so obtained was extracted with EtOAc (3×10 mL) The combined organic phases were washed with brine (10 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (20:1) to give **3a** (3 mg, 12%) as yellow solid and **11b** (15.2 mg, 70%) as a yellow solid.



To a stirred suspension of **1** (20 mg, 0.08 mmol) and $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ (6.7 mg, 0.04 mmol) in Toluene (0.3 mL) and *t*BuOH (0.1 mL) was added TBHP (43 μL , 5.5 mol/L in decane, 0.24 mmol) at 25 °C. The mixture was allowed to stir at 25 °C for 1 h before the resultant mixture was quenched with brine (10 mL). The mixture so obtained was extracted with EtOAc (3×10 mL). The combined organic phases were washed with brine (20 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum to give crude **12** (2.57 mg, 12%, NMR internal standard method, 5 μL m-xylene) as a red oil.

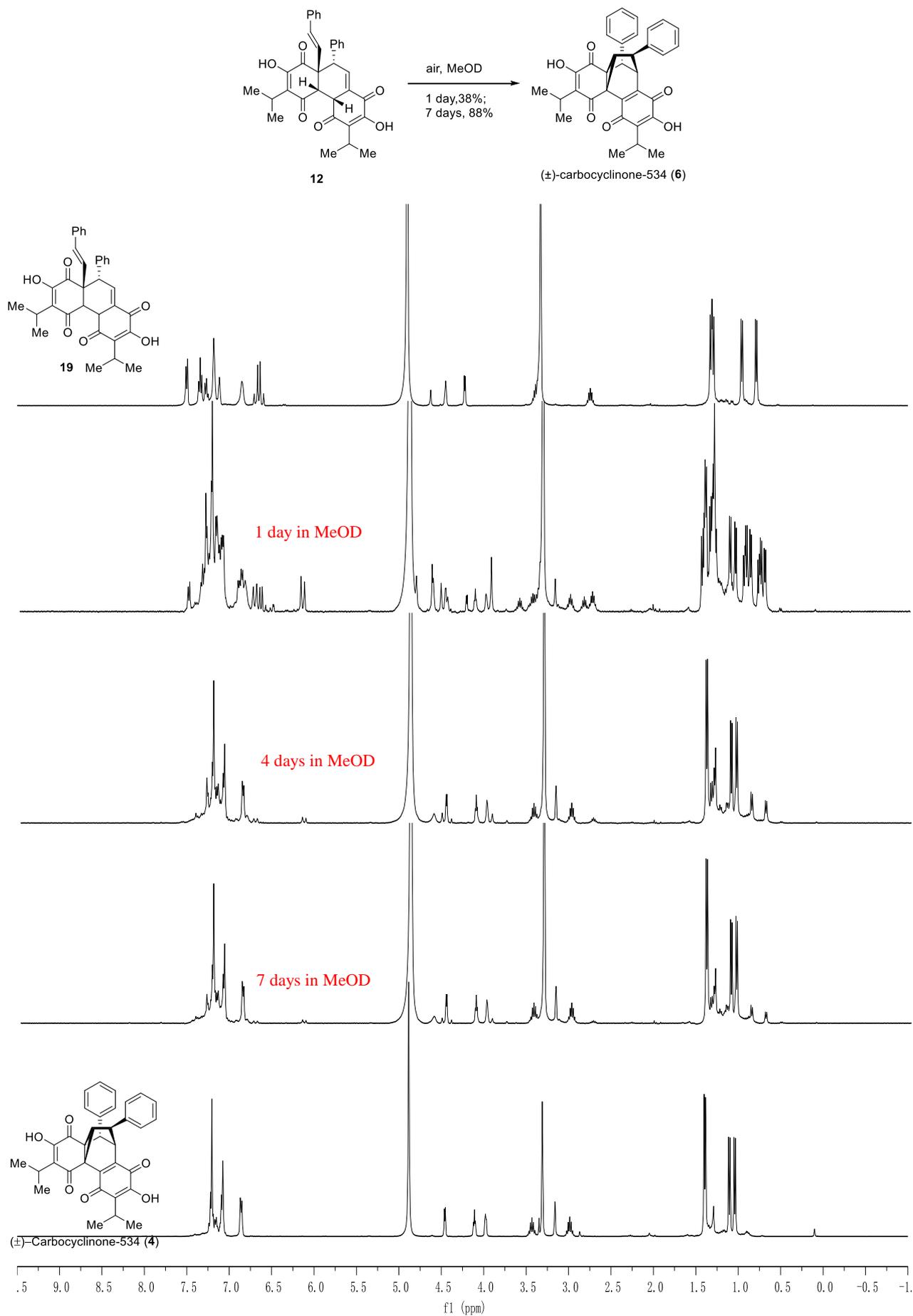
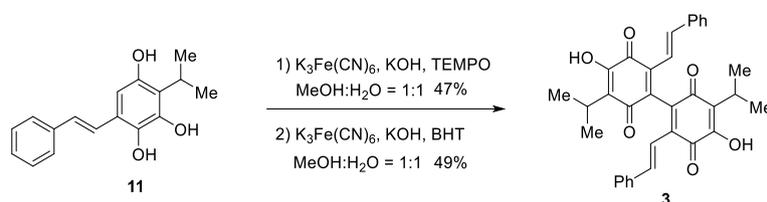


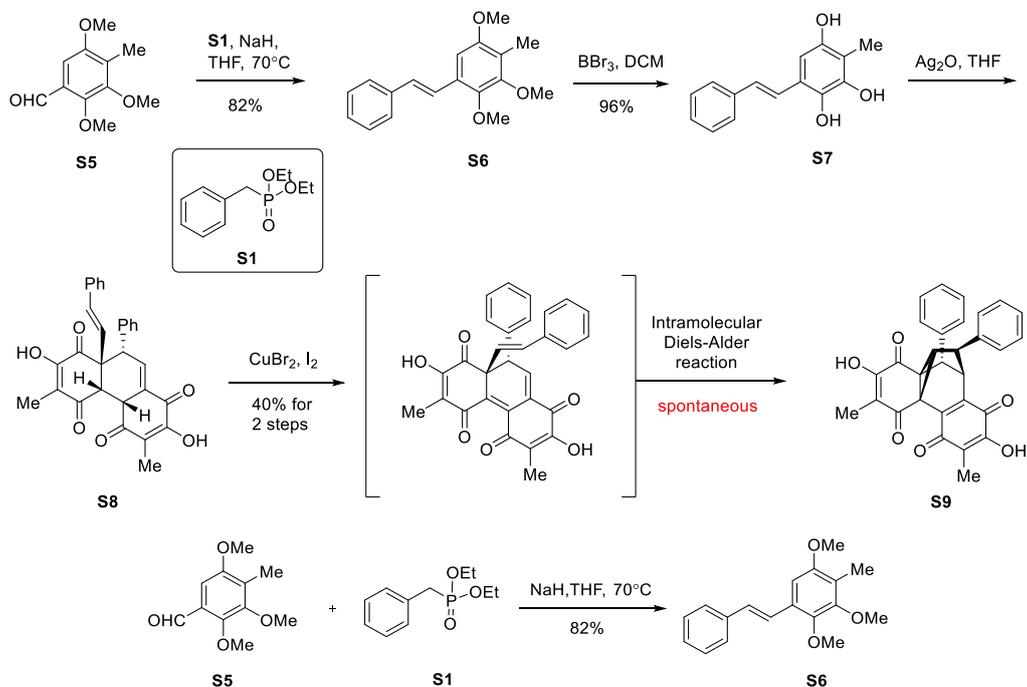
Figure 1. **12** transforms into **(±)-Carbocyclinone-534(6)** in MeOD



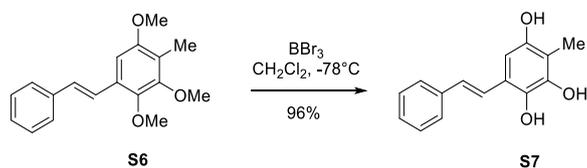
To a stirred suspension of **11** (10 mg, 0.037 mmol) in MeOH (0.09 mL) was added $\text{K}_3\text{Fe}(\text{CN})_6$ (12.18 mg, 0.037 mmol), KOH (6.23 mg, 0.11 mmol), TEMPO (8.67 mg, 0.055 mmol) in H₂O (0.09 mL) and MeOH (0.05 mL) at 25 °C. The mixture was allowed to stir at 25 °C for 5 min before the resultant mixture was quenched with 1N HCl (10 mL). The mixture so obtained was extracted with EtOAc (3 × 10 mL) The combined organic phases were washed with brine (10 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (3:1) to give **3** (4.7 mg, 47%) as a red solid.

To a stirred suspension of **11** (10 mg, 0.037 mmol) in MeOH (0.09 mL) was added $\text{K}_3\text{Fe}(\text{CN})_6$ (12.18 mg, 0.037 mmol), KOH (6.23 mg, 0.11 mmol), BHT (12.23 mg, 0.055 mmol) in H₂O (0.09 mL) and MeOH (0.05 mL) at 25 °C. The mixture was allowed to stir at 25 °C for 5 min before the resultant mixture was quenched with 1N HCl (30 mL). The mixture so obtained was extracted with EtOAc (3 × 10 mL). The combined organic phases were washed with brine (10 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (3:1) to give **3** (4.9 mg, 49%) as a red solid.

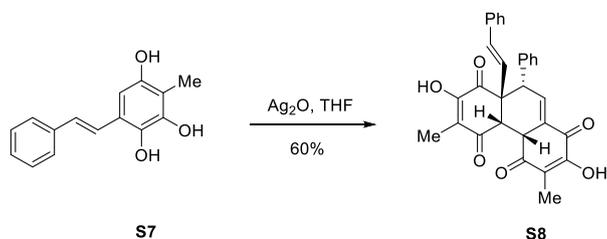
Scheme 4. Synthesis of (±)-Carbocyclinone-534 analogue (**S9**)



To a stirred solution of **S1** (755.37 mg, 3.31 mmol) in dry THF (8.5 mL) were added NaH (189.11 mg, 60% dispersion in mineral oil, 4.73 mmol) at 0 °C. The mixture was allowed to stir at 0 °C for 30 min before **S5**^[3] (497 mg, 2.36 mmol) in THF (2.4 mL) was added. The resultant mixture was allowed to stir at 70 °C for 1h before it was quenched with H₂O (50 mL). The mixture so obtained was extracted with EtOAc (3 × 50 mL). The combined organic phases were washed with brine (50 mL), dried over anhydrous Na₂SO₄, filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (30:1) to give **S6** (550 mg, 82%) as a pale yellow solid. **S6**: *R*_f = 0.4 (silica, petroleum ether:EtOAc = 30:1); IR (film): ν_{max} = 3080, 3043, 2856, 1462, 1403, 1225, 1131, 858, 723 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ = 7.61 (d, *J* = 7.7 Hz, 2H), 7.51 (d, *J* = 16.4, 1H), 7.42 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.3 Hz, 1H), 7.15 (d, *J* = 16.4 Hz, 1H), 6.91 (s, 1H), 3.92 (s, 6H), 3.90 (s, 3H), 2.24 (s, 3H) ppm; ¹³C NMR (101 MHz, CDCl₃): δ = 154.4, 152.3, 145.4, 137.8, 128.8, 128.7, 128.4, 127.6, 126.6, 123.3, 121.0, 102.0, 61.4, 60.5, 55.8, 9.2 ppm; HRMS (*m/z*): [M+H]⁺ calcd for C₁₈H₂₁O₃⁺ 285.1485, found 285.1481. Melting point: 49-53 °C

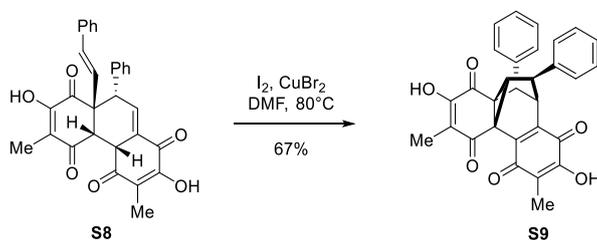


To a stirred solution of **S6** (300 mg, 1.06 mmol) in CH_2Cl_2 (5.3 mL) were added BBr_3 (9.5 mL, 1 M in CH_2Cl_2 , 9.5 mmol) at -78°C . The mixture was allowed to stir at 25°C for 3 h before the resultant mixture was quenched with H_2O (30 mL). The mixture so obtained was extracted with EtOAc (3×30 mL). The combined organic phases were washed with brine (30 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum to give **S7** (245 mg, 96%) as a yellow oil. **S7**: $R_f = 0.6$ (silica, petroleum ether:EtOAc = 1:1); IR (film): $\nu_{\text{max}} = 3433, 2855, 2955, 1495, 1453, 1201, 1120, 878, 748 \text{ cm}^{-1}$; $^1\text{H NMR}$ (400 MHz, methanol- d_4): $\delta = 7.50$ (d, $J = 7.1$ Hz, 2H), 7.43 (d, $J = 16.4$ Hz, 1H), 7.32 (t, $J = 7.6$ Hz, 2H), 7.20 (t, $J = 7.4$ Hz, 1H), 6.99 (d, $J = 16.4$ Hz, 1H), 6.58 (s, 1H), 2.09 (s, 3H). $^{13}\text{C NMR}$ (126 MHz, methanol- d_4): $\delta = 150.3, 146.3, 139.6, 137.6, 129.6, 128.4, 128.1, 127.8, 127.3, 124.7, 124.0, 113.5, 102.9, 9.3$ ppm; HRMS (m/z): $[\text{M}-\text{H}]^-$ calcd for $\text{C}_{15}\text{H}_{13}\text{O}_3^-$ 241.0870, found 241.0870.



To a stirred suspension of **S7** (42 mg, 0.17 mmol) in THF (0.87 mL) were added Ag_2O (60.26 mg, 0.26 mmol) at 25°C . The mixture was allowed to stir at 25°C for 10 min. The resultant mixture was filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (3:1) to give **S8** (25 mg, 60%) as a pale yellow oil. **S8**: $R_f = 0.65$ (silica, petroleum ether:EtOAc = 1:1); IR (film): $\nu_{\text{max}} = 3400, 3084, 2855, 1451, 1352, 967, 847, 746, 702 \text{ cm}^{-1}$; $^1\text{H NMR}$ (400 MHz, methanol- d_4): $\delta = 7.48$ (d, $J = 7.5$ Hz, 2H), 7.32 (t, $J = 7.4$ Hz, 2H), 7.28 – 7.20 (m, 2H), 7.19 – 7.06 (m, 3H), 6.78 (s, 2H), 6.67 (d, $J = 16.4$ Hz, 1H), 6.60 (d, $J = 16.4$ Hz, 1H),

4.42 (t, $J = 3.3$ Hz, 1H), 4.22 (d, $J = 4.4$ Hz, 1H), 3.39 (d, $J = 3.7$ Hz, 1H), 1.99 (s, 3H), 1.38 (s, 3H) ppm; ^{13}C NMR (126 MHz, methanol- d_4) $\delta = 197.0, 196.9, 196.3, 181.5, 159.6, 158.2, 139.3, 137.8, 137.7, 133.3, 132.1, 129.7, 129.2, 129.1, 128.8, 127.8, 58.4, 52.7, 43.7, 30.8, 9.2, 8.4$ ppm; HRMS (m/z): $[\text{M}-\text{H}]^-$ calcd for $\text{C}_{30}\text{H}_{23}\text{O}_6^-$ 479.1500, found 479.1503.



To a stirred solution of **S8** (25 mg, 0.05 mmol) and I_2 (26.41 mg, 0.1 mmol), CuBr_2 (5.81 mg, 0.03 mmol) in DMF (0.25 mL). The mixture was allowed to stir at 80°C for 3 h before the resultant mixture was quenched with saturated aq. $\text{Na}_2\text{S}_2\text{O}_3$ (5 mL) The mixture so obtained was extracted with EtOAc (3×10 mL). The combined organic phases were washed with brine (20 mL), dried over anhydrous Na_2SO_4 , filtered, and concentrated under vacuum. The residue was purified by flash column chromatography with petroleum ether:EtOAc (2:1) to give **S9** (16.7 mg, 67%) as a pale yellow solid. **S9**: $R_f = 0.25$ (silica, petroleum ether:EtOAc = 2:1); IR (film): $\nu_{\text{max}} = 3401, 2952, 2924, 1497, 1451, 1282, 1239, 861, 747$ cm^{-1} ; ^1H NMR (400 MHz, methanol- d_4): $\delta = 7.26 - 7.13$ (m, 5H), 7.09 (d, $J = 6.9$ Hz, 3H), 6.90 – 6.83 (m, 2H), 4.48 (d, $J = 4.5$ Hz, 1H), 4.17 (t, $J = 4.7$ Hz, 1H), 3.99 (dd, $J = 5.1, 2.5$ Hz, 1H), 3.26 – 3.14 (m, 1H), 2.08 (s, 3H), 1.70 (s, 3H) ppm; ^{13}C NMR (126 MHz, methanol- d_4): $\delta = 192.4, 188.4, 185.2, 179.7, 157.5, 152.8, 142.3, 138.4, 137.1, 135.3, 129.4, 129.3, 128.7, 128.4, 128.1, 127.9, 122.1, 118.7, 47.9, 47.3, 46.2, 43.4, 42.9, 41.1, 9.6, 8.1$ ppm; HRMS (m/z): $[\text{M}-\text{H}]^-$ calcd for $\text{C}_{30}\text{H}_{21}\text{O}_6^-$ 477.1344, found 477.1346.

Melting point: $158-164^\circ\text{C}$

II DFT calculation

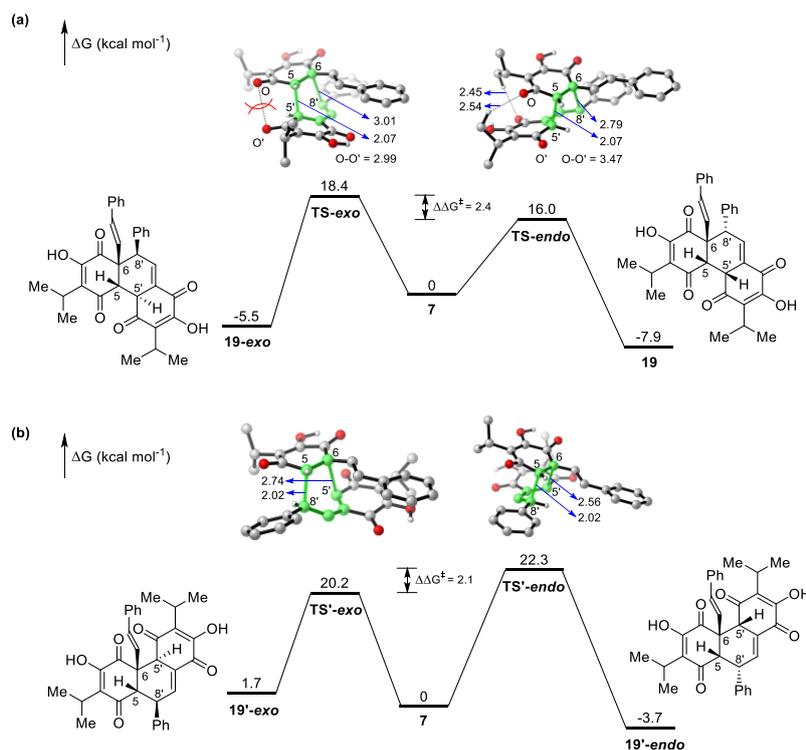


Figure 2. Calculated energy profiles for the formation of (a) **19** and **19-exo** and (b) the other regioisomers **19'-endo** and **19'-exo** at the SMD-(THF)-RI-PWPB95-D3-(BJ)/def2-QZVPP//SMD-(THF)- ω B97X-D/6-31G(d) level of theory.

Computational Details:

Geometry optimizations and frequency calculations of stationary points were conducted at the SMD-(THF)- ω B97X-D/6-31G(d) level of theory using Gaussian 16 package^[4]. Computations of single-point energy at the theoretical level of SMD-(THF)-RI-PWPB95-D3-(BJ)/def2-QZVPP^[5,6] were performed in ORCA program package^[7]. PWPB95 is a spin-opposite-scaled double hybrid functional developed by Grimme^[8], along with RI approximation, SMD solvation module^[5], D3 dispersion correction and Becke-Johnsson damping (BJ)^[9] to provide reliable electronic energy. Auxiliary basis set def2/J^[10] and def2-QZVPP/C^[11] were utilized to accelerate SCF and perturbation calculations respectively. Gibbs free energy was provided by Paton's GoodVibes^[12] where Grimme's quasi-harmonic approximation^[13] was utilized to correct entropy; meanwhile, enthalpy

was corrected by Head-Gordon's method^[14]. 3D representations of molecular structures were generated by CYLview^[15]. Electrostatic potential maps were displayed via PyMOL^[16].

Coordinates and energy

Single-point energy (hartree): -882.924015

Gibbs free energy corrected by GoodVibes (hartree): -882.675475

C	-4.64417	-1.34706	0.00001
C	-6.01947	-1.13753	0.00029
C	-6.52535	0.15932	0.00033
C	-5.64645	1.24301	0.00008
C	-4.27356	1.03408	-0.00018
C	-3.74878	-0.26811	-0.0002
C	-2.30899	-0.55602	-0.00044
C	-1.3142	0.34628	0.00001
C	0.11033	0.01786	-0.0002
C	0.65652	-1.21291	-0.00053
C	2.11956	-1.46233	-0.00073
O	2.51287	-2.62229	-0.00076
C	3.06421	-0.32145	-0.00027
C	2.52806	0.91595	0.00011
O	3.25584	2.03958	0.00059
H	2.61353	2.77687	0.00077
C	1.0532	1.16829	0.00006
O	0.68417	2.33398	0.00065

C	4.54852	-0.61018	-0.00013
C	5.23308	-0.0818	-1.26816
H	4.76221	-0.48956	-2.16938
H	5.18661	1.01054	-1.32089
H	6.28834	-0.37784	-1.27448
C	5.2324	-0.08327	1.26889
H	6.2877	-0.37914	1.27537
H	4.76114	-0.49222	2.16937
H	5.18572	1.00899	1.32294
H	4.63987	-1.70031	-0.00074
H	0.04872	-2.11271	-0.00069
H	-1.53395	1.40959	0.00057
H	-2.06232	-1.61713	-0.00099
H	-3.60841	1.89234	-0.00041
H	-6.03462	2.2574	0.00009
H	-7.59823	0.32801	0.00053
H	-6.69491	-1.98803	0.00047
H	-4.25387	-2.36189	-0.00002

TS-endo

Single-point energy (hartree): -1765.849862

Gibbs free energy corrected by GoodVibes (hartree): -1765.325536

C	-5.73137	0.77799	0.79422
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C	-4.51415	1.47609	0.78116
C	-4.55055	2.87017	0.61872
C	-5.76125	3.53459	0.46524
C	-6.96225	2.82532	0.47168
C	-6.94293	1.44278	0.63839
H	-5.71907	-0.30152	0.92216
H	-3.63084	3.44781	0.61939
H	-5.76868	4.61386	0.34255
H	-7.90604	3.34911	0.35148
H	-7.87221	0.88046	0.64914
C	-3.27503	0.70189	0.924
H	-3.40576	-0.3529	1.13952
C	-2.02143	1.18505	0.79958
H	-1.8716	2.24028	0.5757
C	-0.78355	0.43732	0.92245
C	0.44283	1.12003	0.85944
C	-0.72756	-0.98018	1.26046
C	1.65932	0.53841	1.50828
H	0.40535	2.2049	0.9268
C	0.61927	-1.61651	1.48645
C	1.77887	-0.92361	1.59175
O	2.5286	1.29322	1.92347
O	-1.69577	-1.7252	1.43308

O	0.52311	-2.93334	1.66394
H	-0.44298	-3.11519	1.63526
C	-2.22524	-2.83358	-1.38723
C	-2.28353	-1.45056	-1.64069
C	-3.53988	-0.8502	-1.83051
C	-4.70304	-1.60971	-1.79393
C	-4.62803	-2.97976	-1.55511
C	-3.38763	-3.58866	-1.35301
H	-1.26916	-3.31412	-1.2026
H	-3.59505	0.21782	-2.01967
H	-5.66565	-1.13093	-1.94525
H	-5.53525	-3.5759	-1.52164
H	-3.33225	-4.65503	-1.15628
C	-1.10965	-0.6046	-1.6474
H	-1.31926	0.46065	-1.68344
C	0.19602	-1.01915	-1.71401
H	0.43279	-2.06985	-1.85619
C	1.28493	-0.14792	-1.51366
C	1.14819	1.17719	-1.08196
C	2.63699	-0.71259	-1.59729
C	2.35963	2.06244	-0.97307
H	0.26461	1.7377	-1.37198
C	3.8077	0.14476	-1.24492

C	3.70668	1.45644	-0.93747
O	2.19016	3.2705	-0.90355
O	2.8742	-1.85788	-1.97188
O	4.96946	-0.51671	-1.2909
H	4.74259	-1.42291	-1.58484
C	3.12238	-1.4908	2.00071
C	3.48349	-2.82061	1.33212
C	3.2036	-1.60364	3.53042
H	3.86408	-0.74701	1.68808
H	3.35127	-2.77927	0.2471
H	4.5348	-3.05334	1.53604
H	2.87366	-3.64381	1.71345
H	3.02031	-0.63471	4.00544
H	2.4641	-2.32007	3.90644
H	4.19842	-1.95001	3.83398
C	4.88454	2.34426	-0.60552
C	5.79869	2.54205	-1.82282
C	5.66554	1.83304	0.61216
H	4.45904	3.31842	-0.34756
H	5.24148	2.95344	-2.67174
H	6.60601	3.2414	-1.57678
H	6.25294	1.59608	-2.13558
H	4.99782	1.69342	1.46764

H	6.15924	0.87991	0.39883
H	6.43756	2.56012	0.88971

TS-*exo*

Single-point energy (hartree): -1765.846837

Gibbs free energy corrected by GoodVibes (hartree): -1765.321653

C	3.83528	1.80527	1.42026
C	2.4655	2.11006	1.37859
C	2.08098	3.45568	1.26019
C	3.03866	4.45946	1.20754
C	4.39634	4.14236	1.26166
C	4.79271	2.8112	1.3665
H	4.14548	0.76644	1.49936
H	1.02974	3.72099	1.19898
H	2.72645	5.49556	1.11585
H	5.14129	4.93126	1.2155
H	5.84759	2.55602	1.40397
C	1.51023	1.0087	1.40425
H	1.96151	0.01963	1.35643
C	0.15953	1.11129	1.51894
H	-0.31155	2.07893	1.66739
C	-0.72523	0.01214	1.3303
C	-0.28488	-1.27529	0.99612

C	-2.16647	0.25487	1.40707
C	-1.26155	-2.41574	1.03164
H	0.70646	-1.57481	1.32744
C	-3.10239	-0.86317	1.05652
C	-2.69754	-2.13178	0.82814
O	-0.84756	-3.54615	1.2317
O	-2.67691	1.31798	1.75164
O	-4.38226	-0.47538	1.03009
H	-4.36747	0.47352	1.27808
C	-3.62624	-3.28484	0.51741
C	-4.41338	-3.04394	-0.7773
C	-4.5593	-3.59942	1.6946
H	-2.98294	-4.15677	0.36478
H	-3.73894	-2.83847	-1.61658
H	-5.00292	-3.9328	-1.02906
H	-5.10161	-2.19898	-0.67439
H	-3.98479	-3.81424	2.60209
H	-5.23159	-2.76088	1.90325
H	-5.17226	-4.47862	1.46506
C	-2.08099	3.45569	-1.26025
C	-2.4655	2.11007	-1.37858
C	-3.83528	1.80527	-1.42019
C	-4.79271	2.81121	-1.36644

C	-4.39634	4.14236	-1.26167
C	-3.03866	4.45947	-1.20761
H	-1.02974	3.72101	-1.19909
H	-4.14548	0.76643	-1.49922
H	-5.84759	2.55601	-1.40386
H	-5.1413	4.93127	-1.21552
H	-2.72645	5.49558	-1.11598
C	-1.51023	1.00871	-1.40422
H	-1.9615	0.01964	-1.35638
C	-0.15954	1.1113	-1.51893
H	0.31154	2.07895	-1.66738
C	0.72523	0.01215	-1.33028
C	0.28488	-1.27528	-0.99612
C	2.16646	0.25488	-1.40705
C	1.26155	-2.41574	-1.03164
H	-0.70646	-1.5748	-1.32744
C	3.10239	-0.86316	-1.05651
C	2.69754	-2.13178	-0.82815
O	0.84755	-3.54614	-1.23171
O	2.67691	1.318	-1.7516
O	4.38226	-0.47537	-1.03009
H	4.36747	0.47354	-1.27806
C	3.62625	-3.28484	-0.51744

C	4.55931	-3.5994	-1.69464
C	4.41338	-3.04396	0.77727
H	2.98295	-4.15677	-0.36483
H	3.98479	-3.81419	-2.60214
H	5.17226	-4.4786	-1.46512
H	5.2316	-2.76085	-1.90327
H	3.73895	-2.83852	1.61656
H	5.10161	-2.199	0.67438
H	5.00293	-3.93282	1.02901

TS-endo'

Single-point energy (hartree): -1765.839387

Gibbs free energy corrected by GoodVibes (hartree): -1765.315438

C	-5.37375	-1.66194	0.62632
C	-4.02761	-2.04586	0.54898
C	-3.72839	-3.40041	0.33658
C	-4.7464	-4.34082	0.23465
C	-6.08106	-3.94838	0.33289
C	-6.39186	-2.60418	0.52508
H	-5.61976	-0.61363	0.77859
H	-2.69523	-3.71605	0.22454
H	-4.49744	-5.38479	0.06737
H	-6.87394	-4.68598	0.24983

H	-7.42866	-2.28813	0.59523
C	-2.98534	-1.02003	0.68174
H	-3.32383	0.00313	0.51958
C	-1.70215	-1.25778	1.0092
H	-1.3687	-2.27152	1.21237
C	-0.64933	-0.25585	1.05605
C	-0.88574	1.12621	0.88392
C	0.66641	-0.66989	1.53704
C	0.12531	2.11876	1.37374
H	-1.90266	1.47088	1.05243
C	1.74872	0.36112	1.62574
C	1.52956	1.6925	1.52086
O	-0.23495	3.25665	1.63872
O	0.95771	-1.80882	1.90644
O	2.94463	-0.16582	1.90438
H	2.78283	-1.12674	2.01337
C	2.58379	2.75285	1.75614
C	3.75403	2.64596	0.77221
C	3.06803	2.7395	3.21314
H	2.08611	3.71253	1.58576
H	3.41008	2.73823	-0.26234
H	4.47327	3.45096	0.96255
H	4.27971	1.6912	0.87309

H	2.22798	2.85733	3.90615
H	3.58226	1.80275	3.45103
H	3.76801	3.56536	3.38453
C	-1.12667	4.11839	-1.1409
C	-1.7639	2.87293	-1.16302
C	-3.15904	2.82913	-1.26979
C	-3.90234	4.00015	-1.36808
C	-3.25737	5.23476	-1.35588
C	-1.86968	5.28923	-1.24154
H	-0.04891	4.18347	-1.03297
H	-3.663	1.86531	-1.28458
H	-4.98345	3.94825	-1.45636
H	-3.83385	6.15201	-1.43178
H	-1.36231	6.24914	-1.2237
C	-1.02689	1.58897	-1.07248
H	-1.67578	0.72461	-1.22117
C	0.29879	1.46337	-1.52142
H	0.89171	2.34563	-1.74117
C	0.94353	0.22447	-1.53574
C	0.30669	-0.95691	-1.20887
C	2.41238	0.18437	-1.71193
C	1.03547	-2.23799	-1.05693
H	-0.76518	-1.06649	-1.30729

C	3.13977	-1.07477	-1.36404
C	2.51599	-2.23362	-1.05246
O	0.38961	-3.26974	-0.92101
O	3.07438	1.1295	-2.11555
O	4.46891	-0.94485	-1.42294
H	4.63751	-0.02504	-1.71002
C	3.23453	-3.52371	-0.72743
C	4.17183	-3.97712	-1.85441
C	3.96961	-3.42414	0.61667
H	2.45225	-4.28081	-0.62231
H	3.63712	-4.04264	-2.8084
H	4.57318	-4.97034	-1.62354
H	5.01419	-3.29089	-1.97983
H	3.25975	-3.24567	1.43147
H	4.71205	-2.61919	0.60915
H	4.49071	-4.36398	0.83181

TS-*exo*'

Single-point energy (hartree): -1765.841989

Gibbs free energy corrected by GoodVibes (hartree): -1765.318733

C	2.51939	3.50368	-1.3298
C	2.39481	2.10862	-1.39977
C	3.56543	1.33518	-1.46211

C	4.81439	1.94222	-1.46614
C	4.92239	3.33158	-1.40303
C	3.77003	4.11092	-1.33476
H	1.62202	4.11506	-1.2709
H	3.50505	0.25139	-1.49462
H	5.70861	1.32736	-1.50952
H	5.90097	3.80246	-1.40158
H	3.84512	5.193	-1.28112
C	1.05522	1.52062	-1.3537
H	0.25155	2.23216	-1.1789
C	0.7538	0.21025	-1.52866
H	1.53537	-0.50699	-1.7624
C	-0.53599	-0.34705	-1.27108
C	-1.66433	0.44023	-0.95196
C	-0.70502	-1.79357	-1.3952
C	-3.02365	-0.20654	-0.9934
H	-1.68588	1.44879	-1.35444
C	-2.01788	-2.39496	-0.98738
C	-3.13056	-1.66029	-0.76307
O	-4.00739	0.4908	-1.19032
O	0.15562	-2.56529	-1.81136
O	-1.98308	-3.72688	-0.92841
H	-1.06087	-3.97286	-1.14988

C	-4.48454	-2.23945	-0.41425
C	-4.44877	-2.98461	0.92654
C	-5.03993	-3.12563	-1.53716
H	-5.15863	-1.38378	-0.30817
H	-4.08822	-2.33315	1.7312
H	-5.45507	-3.32603	1.19519
H	-3.79466	-3.86087	0.87842
H	-5.09545	-2.57158	-2.48049
H	-4.41295	-4.00911	-1.69377
H	-6.05056	-3.46609	-1.28364
C	-2.14432	3.52276	0.46583
C	-2.56479	2.28342	0.96154
C	-3.85806	2.162	1.47555
C	-4.70738	3.26351	1.51996
C	-4.27764	4.49574	1.0346
C	-2.99468	4.62175	0.50328
H	-1.1484	3.62766	0.04095
H	-4.19771	1.1988	1.84708
H	-5.70773	3.15656	1.92892
H	-4.94131	5.35492	1.06385
H	-2.65722	5.57809	0.11469
C	-1.66548	1.10102	0.95518
H	-2.14069	0.18609	1.31136

C	-0.31617	1.26267	1.31642
H	0.10121	2.25812	1.42899
C	0.55327	0.16801	1.45229
C	0.17373	-1.13601	1.2515
C	2.00286	0.4521	1.58596
C	1.14237	-2.2357	1.11305
H	-0.86472	-1.44374	1.30024
C	2.97039	-0.65229	1.31748
C	2.59214	-1.92576	1.07085
O	0.72686	-3.38435	0.98691
O	2.45544	1.54921	1.87666
O	4.24806	-0.25359	1.34742
H	4.22485	0.70958	1.51667
C	3.55721	-3.04723	0.76067
C	4.52035	-3.32514	1.92232
C	4.3126	-2.78281	-0.54963
H	2.94075	-3.9392	0.61742
H	3.97133	-3.5385	2.84602
H	5.14272	-4.19692	1.69017
H	5.18291	-2.47365	2.10561
H	3.61473	-2.64119	-1.38223
H	4.94684	-1.89365	-0.47199
H	4.95485	-3.6373	-0.79187

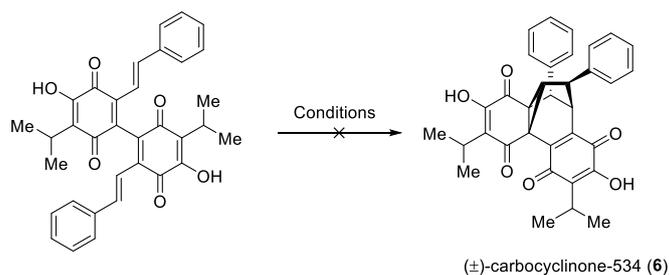
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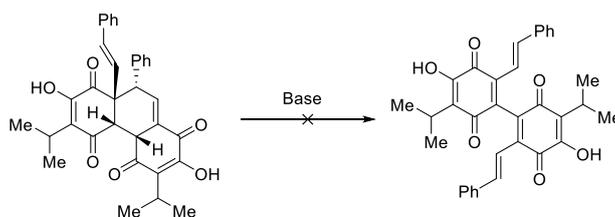
IV. Conditions screened for the synthesis of (±)-carbocyclinone-534 (6)

1. 6π electrocyclization and Diels-Alder approaches



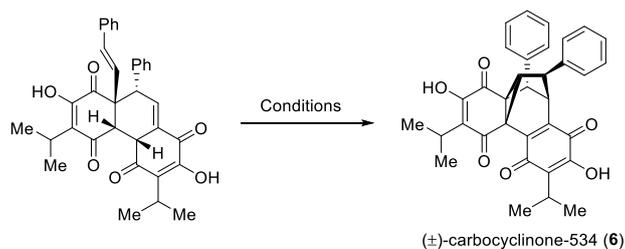
Entry	Condition	Product (%)
1	$\text{BF}_3 \cdot \text{OEt}_2$, DCM, 0°C - 25°C	Decomposed
2	Toluene, 80°C - 170°C	Decomposed
3	pH= 8 buffer, THF, 60°C	Decomposed
4	Hg lamp (250W), 5 min	Decomposed
5	Benzene, sunlight, 2h	Decomposed
6	Neat, 80°C	Decomposed

2. The base stability test of compound 12



Entry	Condition	Solvent	Temperature	Product (%)
1	KOH(1eq)	MeOH:H ₂ O=1:1	25°C	Decomposed
2	Et ₃ N(1eq)	THF	25°C	Decomposed
3	NaOMe(1eq)	MeOH	25°C	Decomposed

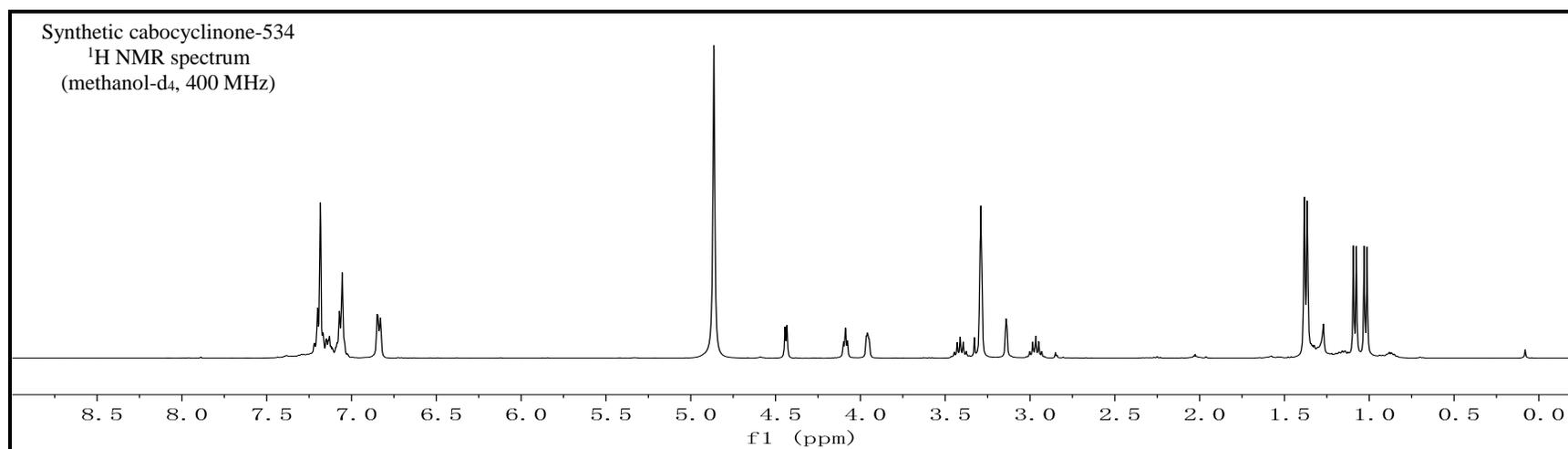
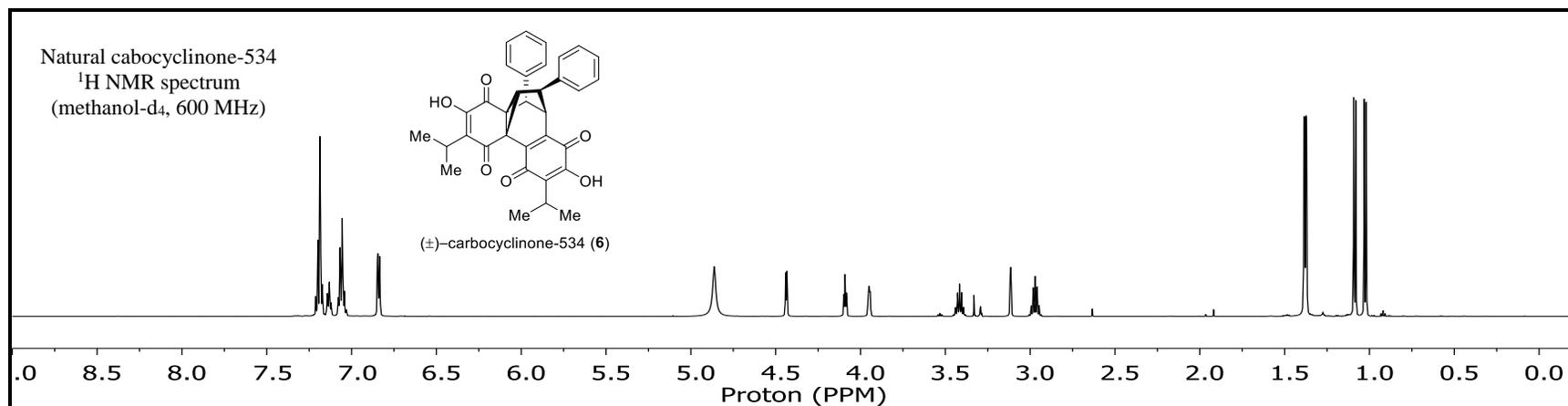
3. Dehydrogenation and Diels-Alder approaches

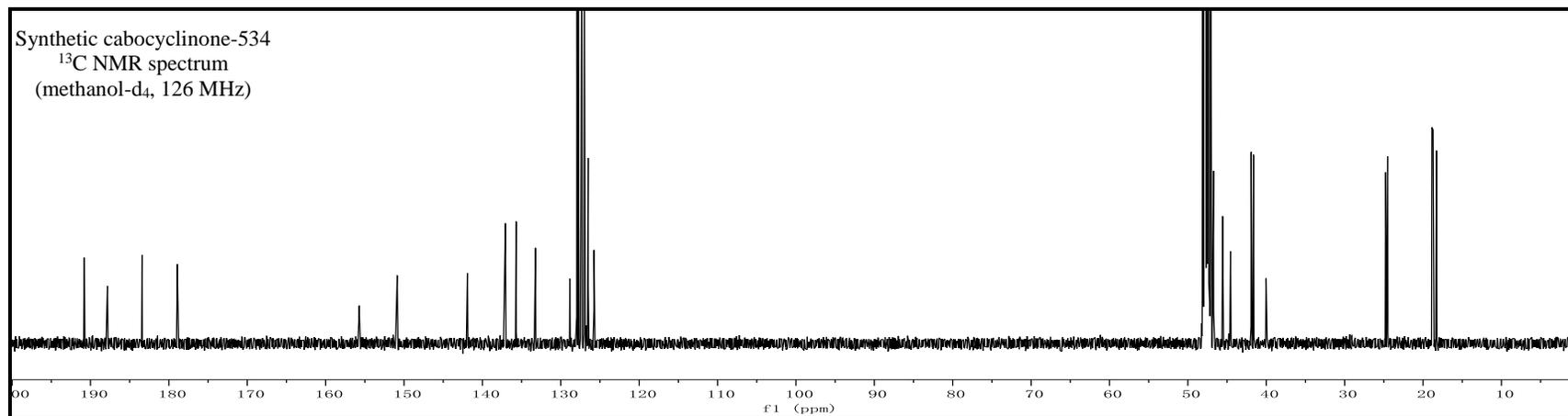
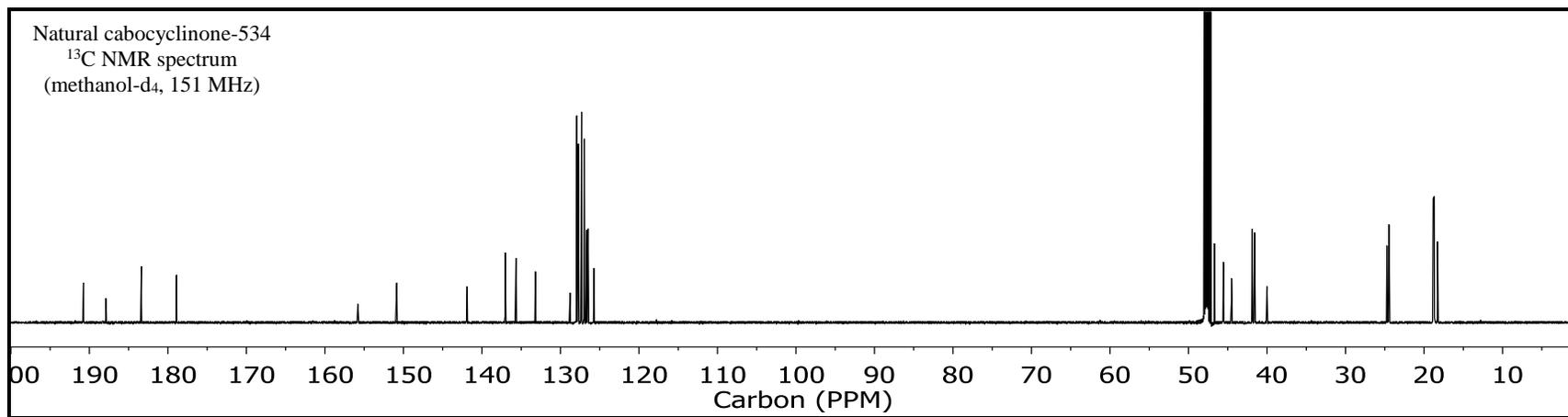


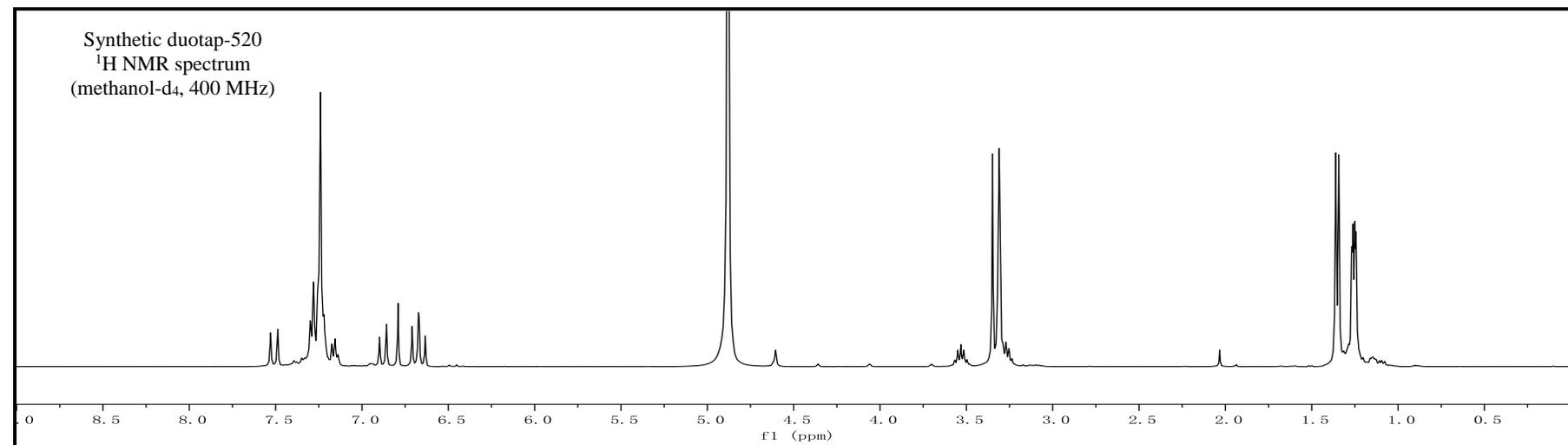
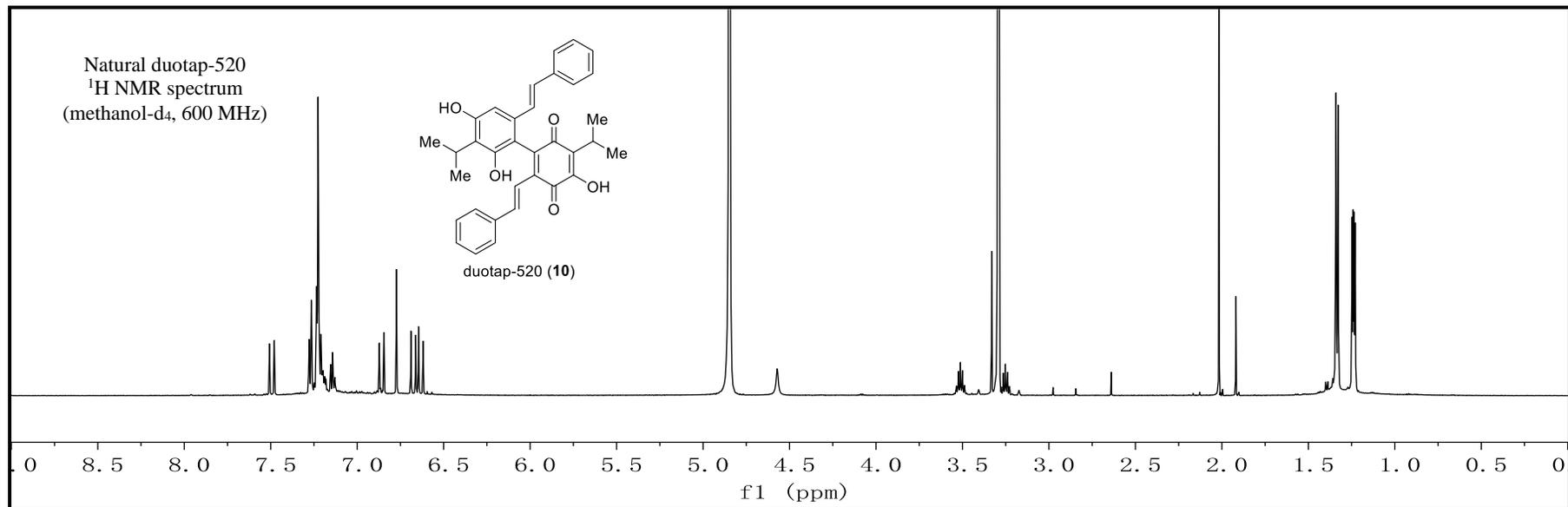
Entry	Condition	Solvent	Concentrations	Product (%)
1	SeO ₂ (2eq), 80°C, 3h	1,4-dioxane:THF = 1:1	0.2mol/L	Decomposed
2	IBX(1.5eq), 25°C, 1h	Toluene:DMSO = 2:1	0.2mol/L	Decomposed
3	Sc(OTf) ₃ (1eq), 25°C-60°C, 3h	DCM	0.1mol/L	Decomposed
4	DBU, air, 25°C, 12h	-	0.1mol/L	Decomposed
5	Et ₃ N(1eq), 25°C, 2h	DCM	0.2 mol/L	Decomposed
6	BF ₃ •OEt ₂ (1eq), 0°C -25°C, 4h	DCM	0.2 mol/L	Decomposed
7	MnO ₂ (2eq), 25°C, 30 min	THF	0.1mol/L	Decomposed
8	DDQ(2eq), 25°C-80°C, 8h	DCM	0.2 mol/L	No reaction
9	Neat, air, 80°C, 2h	-	-	No reaction
10	Pd(OAc) ₂ , 25°C, 1h	THF	0.2 mol/L	No reaction
11	DDQ(2eq), 120°C, 3h	Toluene	0.2 mol/L	No reaction

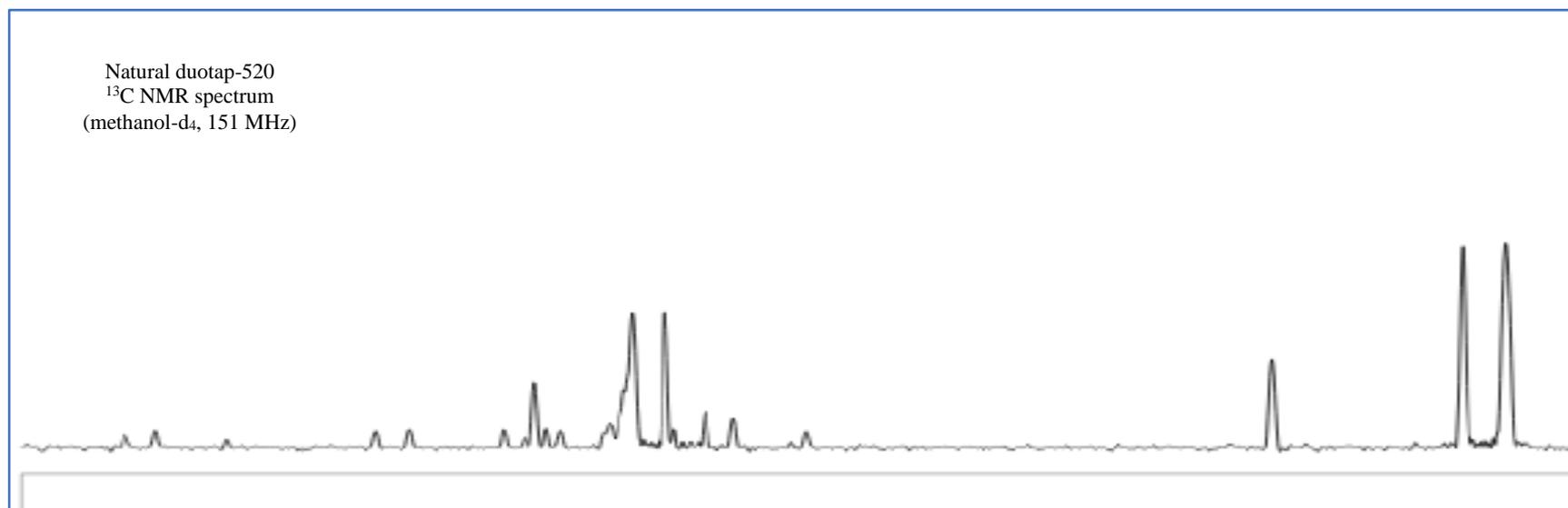
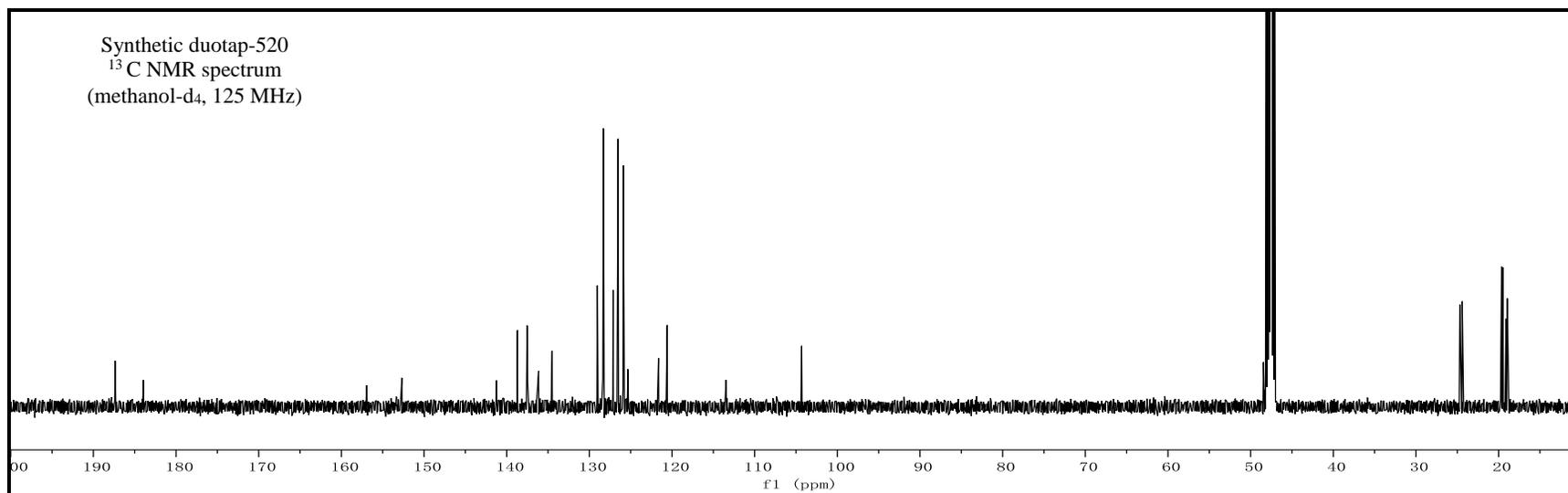
V. Comparison of the Spectra and Data of Natural and Synthetic (\pm)-carbocyclinone-534 and duotap-520.

1. Comparison of the Spectra Natural and Synthetic (\pm)-carbocyclinone-534 and duotap-520



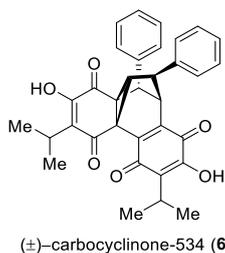






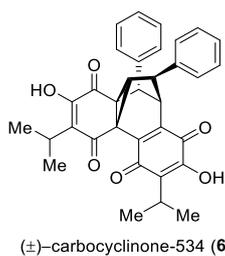
2. Comparison of the Data of Natural and Synthetic Carbocyclinone-534 and Duotap-520

Table 1. Comparison of the ^1H NMR spectroscopic data (methanol- d_4) of natural and synthetic (\pm)-Carbocyclinone-534.



Natural		Synthetic		Err
δ_{H} [ppm, mult, J (Hz)]		δ_{H} [ppm, mult, J (Hz)]		(Natural–Synthetic)
600 MHz		400 MHz		$\Delta\delta_{\text{H}}$ (ppm)
7.22-7.16	2 H, m	7.22-7.17	2 H, m	–
7.22-7.16	2 H, m	7.22-7.17	2 H, m	–
7.15-7.11	1 H, m	7.15-7.11	1 H, m	–
7.09-7.03	3 H, m	7.09-7.02	3 H, m	–
6.86-6.81	2 H, m	6.85-6.83	2 H, m	–
4.44	1 H, d, 4.5	4.44	1 H, d, 4.5	0
4.09	1 H, dt, 4.8 1.0	4.09	1 H, m	0
3.95	1 H, dd, 4.7 2.3	3.96	1 H, dd, 4.9 2.5	–0.01
3.42	1 H, h, 7.0	3.41	1 H, h, 6.9	+0.01
3.12	1 H, brs	3.14	1 H, brs	–0.02
2.97	1 H, h, 7.0	2.97	1 H, h, 7.1	0
1.38	6 H, d, 7.0	1.37	6 H, d, 7.0	+0.01
1.09	3 H, d, 7.0	1.08	3 H, d, 7.1	+0.01
1.02	3 H, d, 7.0	1.02	3 H, d, 7.0	0

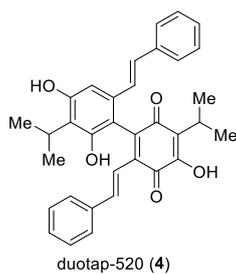
Table 2. Comparison of the ^{13}C NMR spectroscopic data (methanol- d_4) of natural and synthetic (\pm)-Carbocyclinone-534



Natural δ_{C} (ppm) 151 MHz	Synthetic δ_{C} (ppm) 126 MHz	Err (Natural–Synthetic) $\Delta\delta_{\text{C}}$ (ppm)
190.7	190.8	−0.1
187.9	187.8	+0.1
183.4	183.4	0
178.9	178.9	0
155.8	155.7	+0.1
150.9	150.9	0
141.9	141.9	0
137.0	137.0	0
135.7	135.7	0
133.2	133.2	0
128.8	128.9	−0.1
127.9	127.9	0
127.7	127.8	−0.1
127.3	127.3	0
127.0	127.0	0
126.6	126.7	−0.1
126.5	126.5	0
125.7	125.8	−0.1
46.7	46.7	0
45.6	45.6	0
44.5	44.6	−0.1

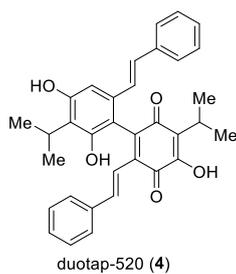
41.9	41.9	0
41.6	41.6	0
40.0	40.3	-0.3
24.7	24.8	-0.1
24.5	24.5	0
18.8	18.9	-0.1
18.8	18.8	0
18.7	18.7	0
18.3	18.3	0

Table 3. Comparison of the ^1H NMR spectroscopic data (methanol- d_4) of natural and synthetic Duotap-520 (4).



Natural		Synthetic		Err
δ_{H} [ppm, mult, J (Hz)]		δ_{H} [ppm, mult, J (Hz)]		(Natural–Synthetic)
600 MHz		400 MHz		$\Delta\delta_{\text{H}}$ (ppm)
7.49	1 H, d, 16.5	7.49	1 H, d, 16.5	0
7.27	2 H, d, 7.6	7.27	2 H, d, 7.3	0
7.24-7.17	7 H, m	7.24-7.19	7 H, m	–
7.14	1 H, t, 7.2	7.14	1 H, td, 6.8 3.1	0
6.86	1 H, d, 16.1	6.86	1 H, d, 16.0	0
6.77	1 H, s	6.77	1 H, s	0
6.68	1 H, d, 16.5	6.67	1 H, d, 16.6	+0.01
6.63	1 H, d, 16.1	6.63	1 H, d, 16.1	0
3.51	1 H, h, 7.0	3.50	1 H, h, 7.0	+0.01
3.25	1 H, m	3.27	1 H, m	–0.02
1.33	6 H, d, 7.0	1.33	6 H, d, 7.0	0
1.25-1.23	6 H, m	1.25-1.22	6 H, m	–

Table 4. Comparison of the ^{13}C NMR spectroscopic data (methanol- d_4) of natural and synthetic Duotap-520 (4).

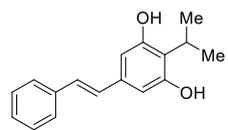


Natural δ_{C} (ppm) 151 MHz	Synthetic δ_{C} (ppm) 126 MHz	Err (Natural–Synthetic) $\Delta\delta_{\text{C}}$ (ppm)
187.3	187.4	–0.1
183.8	184.0	–0.2
156.9	157.0	–0.1
152.6	152.7	–0.1
141.1	141.2	–0.1
138.7	138.7	0
137.4	137.5	–0.1
136.1	136.1	0
134.5	134.5	0
129.0	129.0	0
128.2	128.4	–0.2
128.2	128.3	–0.1
128.2	128.2	0
127.1	127.1	0
126.5	126.5	0
126.5	126.5	0
126.4	126.5	–0.1
125.8	125.9	–0.1
125.4	125.3	+0.1
121.6	121.6	0
120.5	120.6	–0.1
113.4	113.5	–0.1
104.3	104.3	0

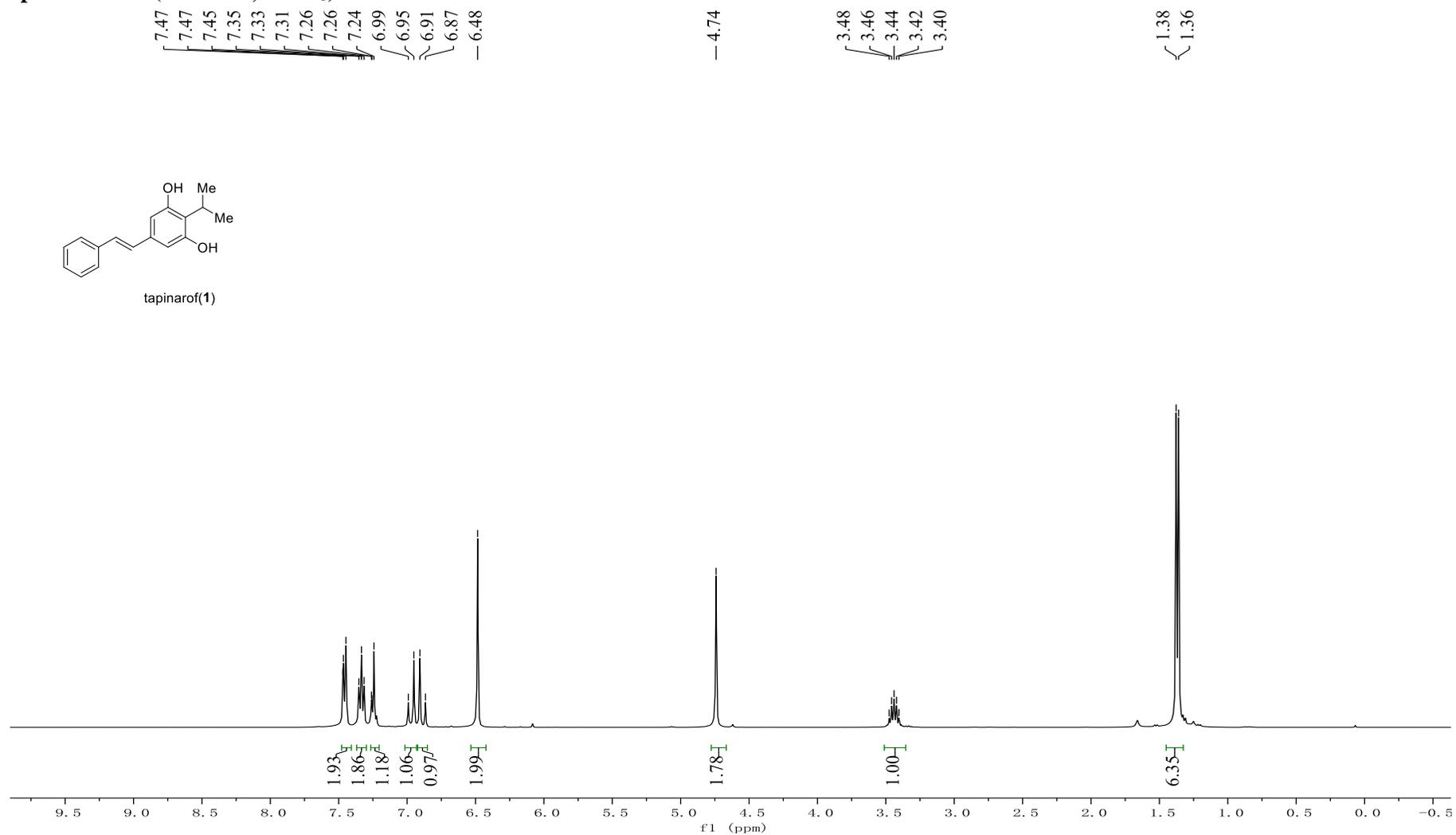
24.6	24.7	-0.1
24.4	24.4	0
19.5	19.6	-0.1
19.5	19.5	0
19.0	19.1	-0.1
19.0	18.9	+0.1

VI ^1H and ^{13}C NMR Spectra of Compounds

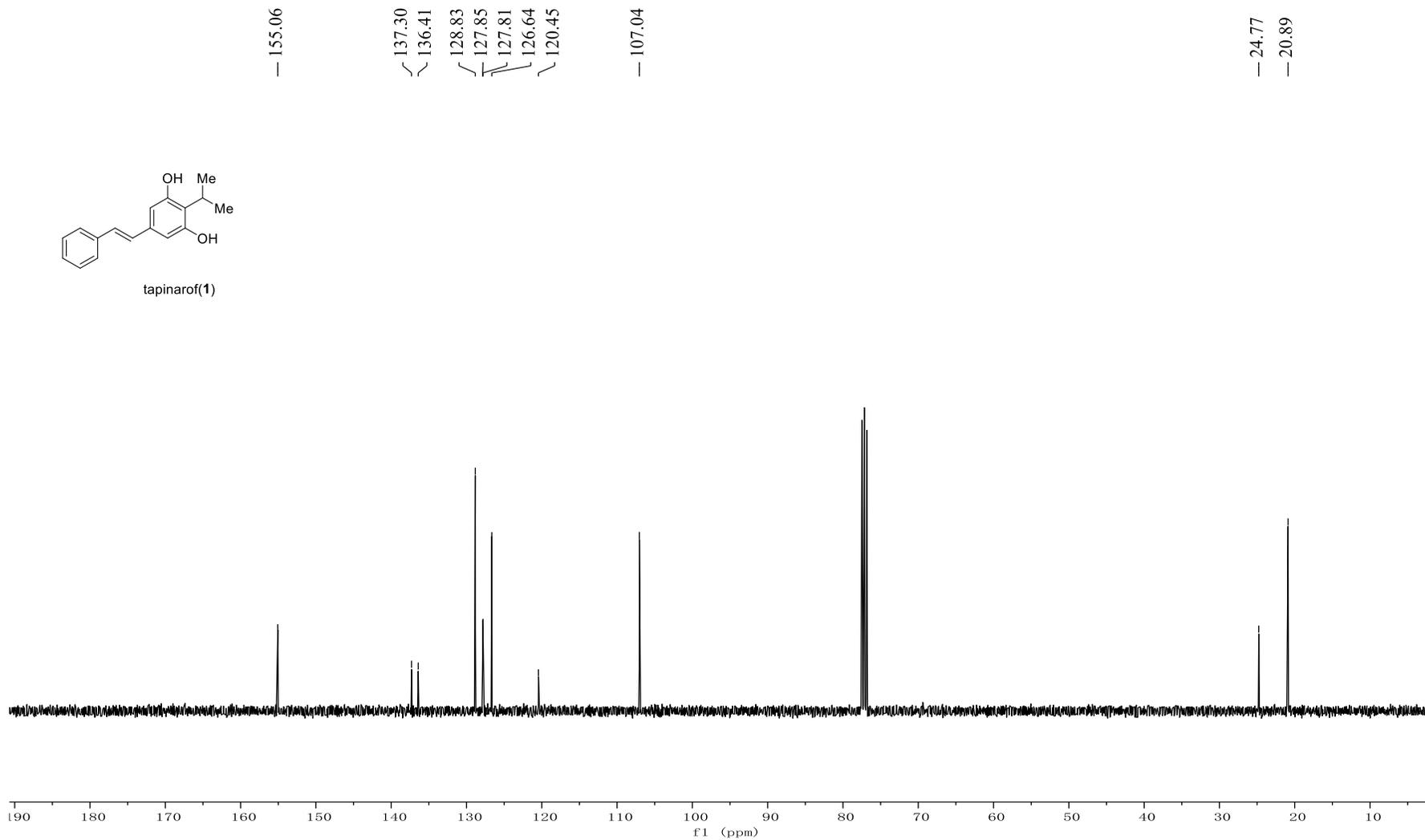
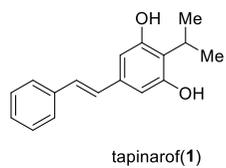
^1H NMR Spectrum of 1 (400 MHz, CDCl_3)



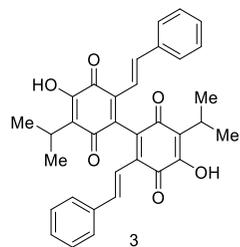
tapinarof(1)



¹³C NMR Spectrum of 1 (101 MHz, CDCl₃)



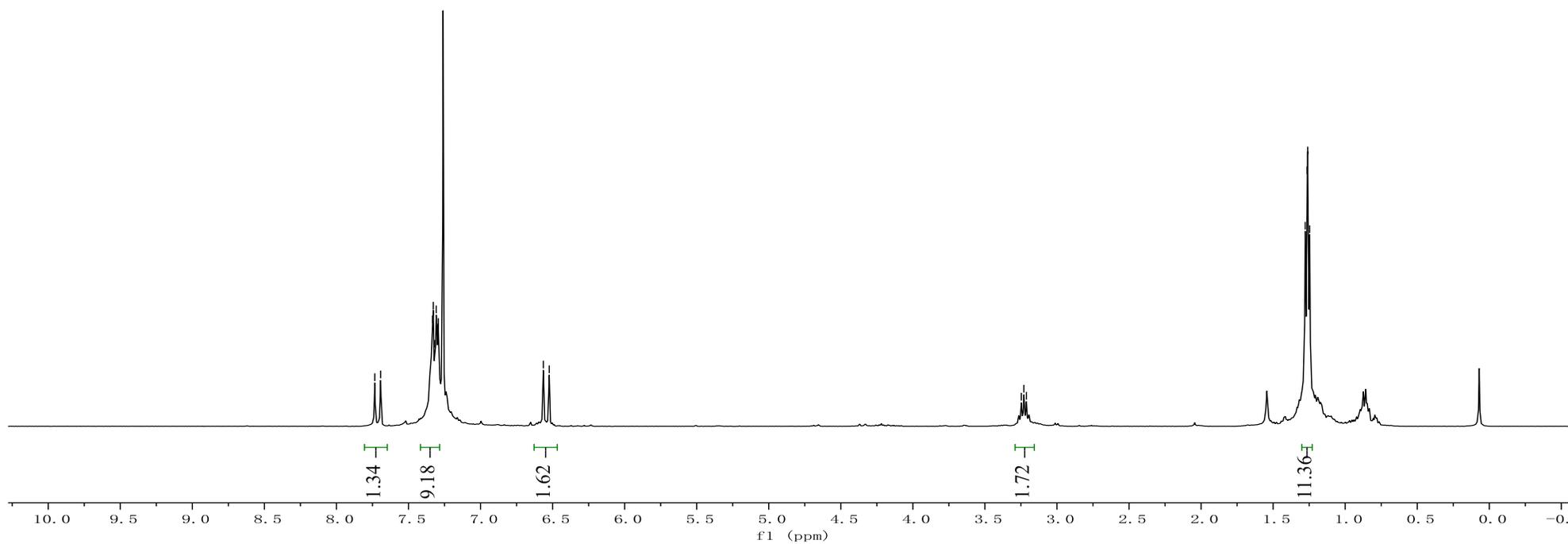
¹H NMR Spectrum of 3 (400 MHz, CDCl₃)



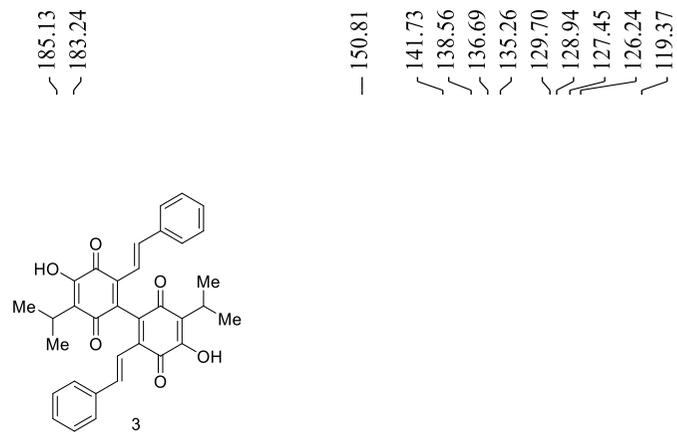
7.73
7.69
7.33
7.33
7.32
7.31
7.30
7.29
6.56
6.52

3.25
3.23
3.21

1.28
1.26
1.26
1.25



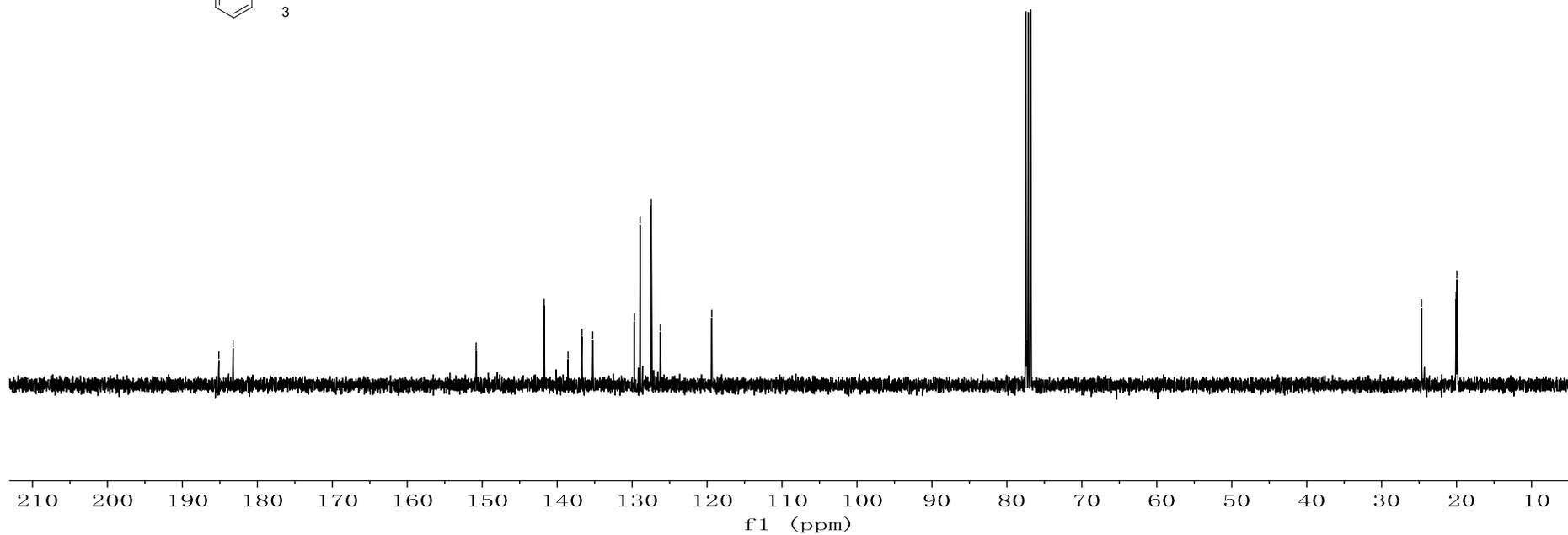
¹³C NMR Spectrum of 3 (101 MHz, CDCl₃)



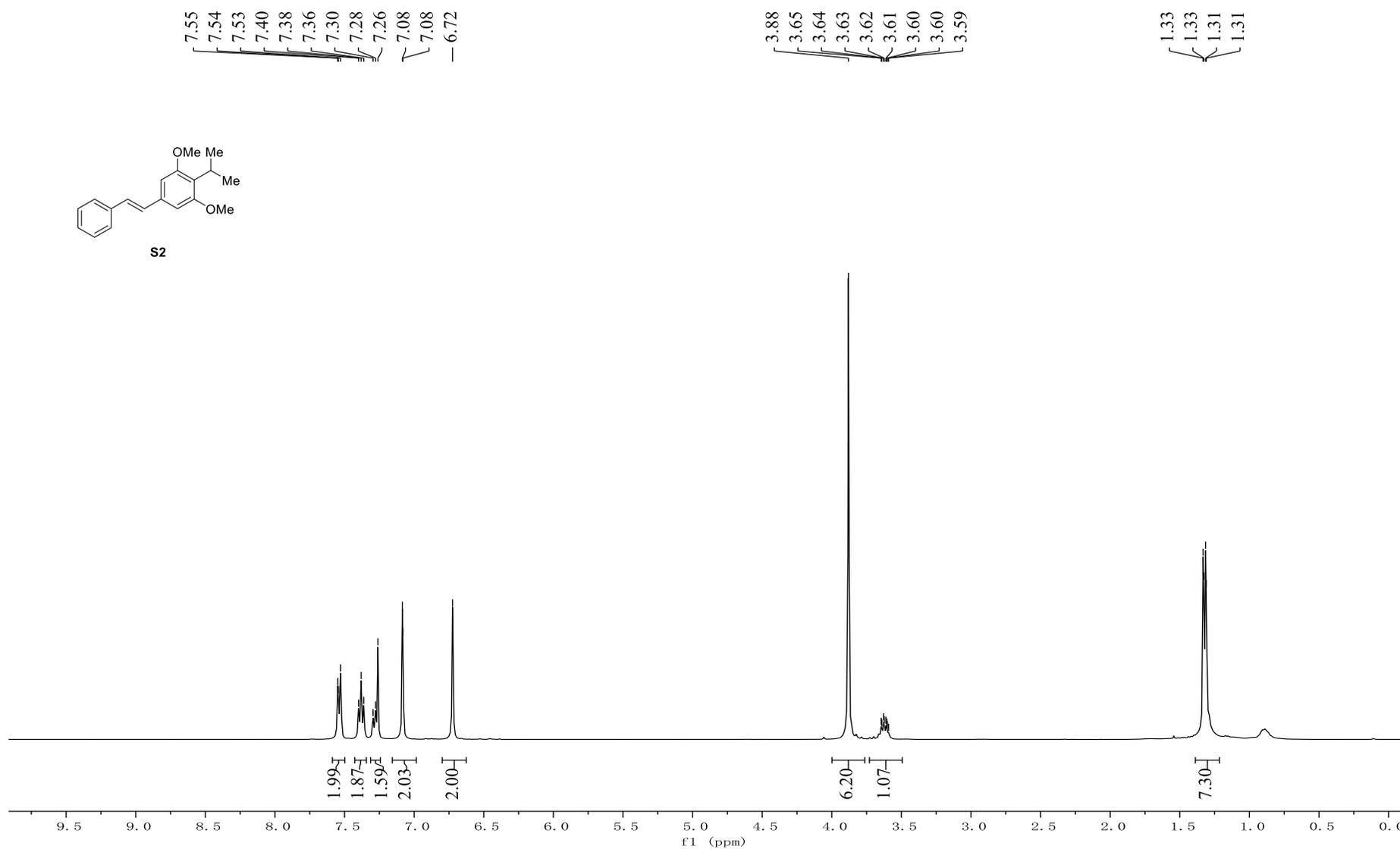
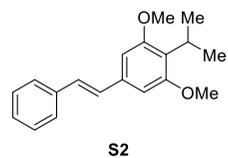
185.13
183.24

150.81
141.73
138.56
136.69
135.26
129.70
128.94
127.45
126.24
119.37

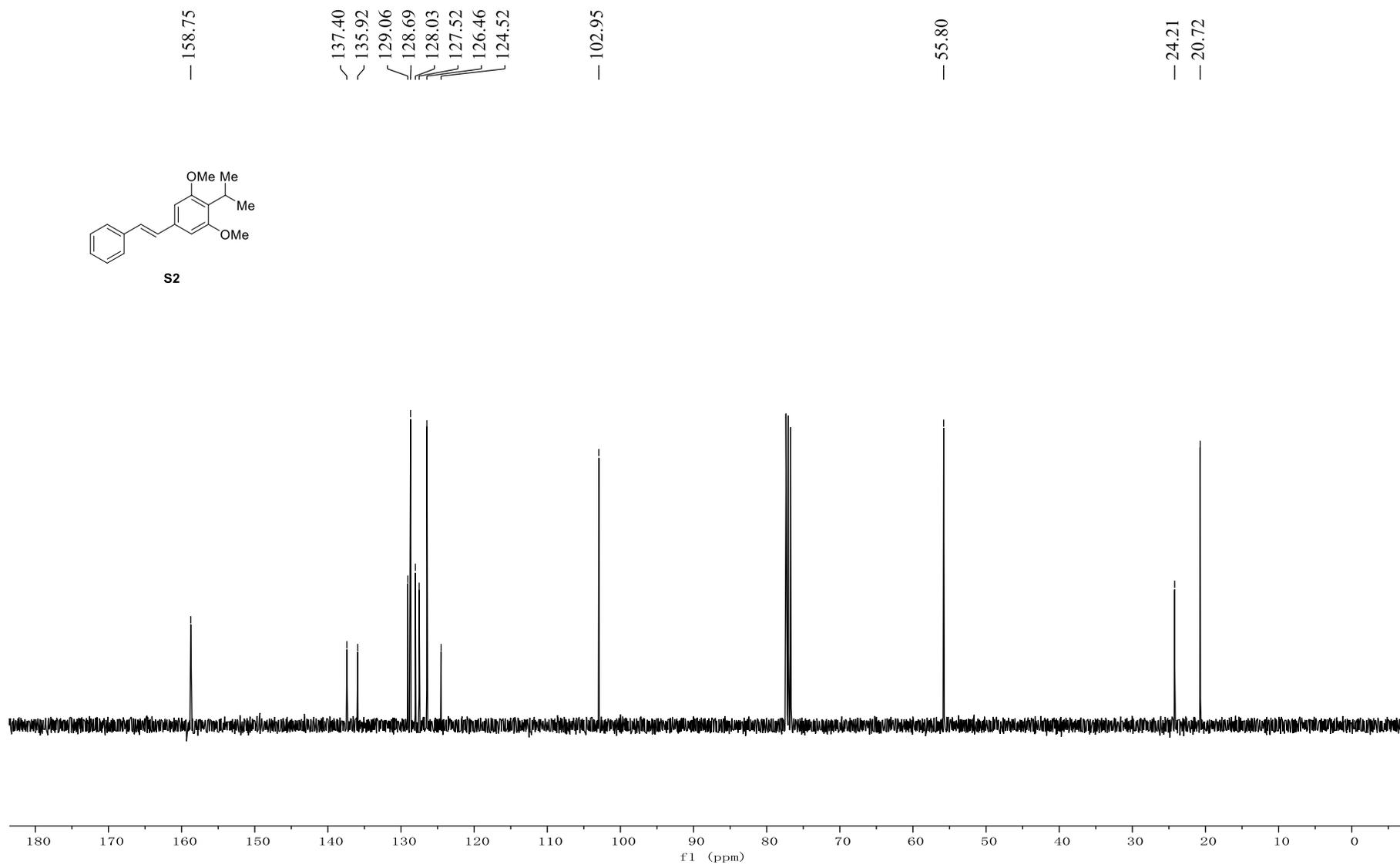
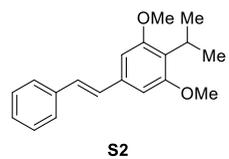
24.68
20.06
19.97



¹H NMR Spectrum of S2 (400 MHz, CDCl₃)



¹³C NMR Spectrum of S2 (101 MHz, CDCl₃)

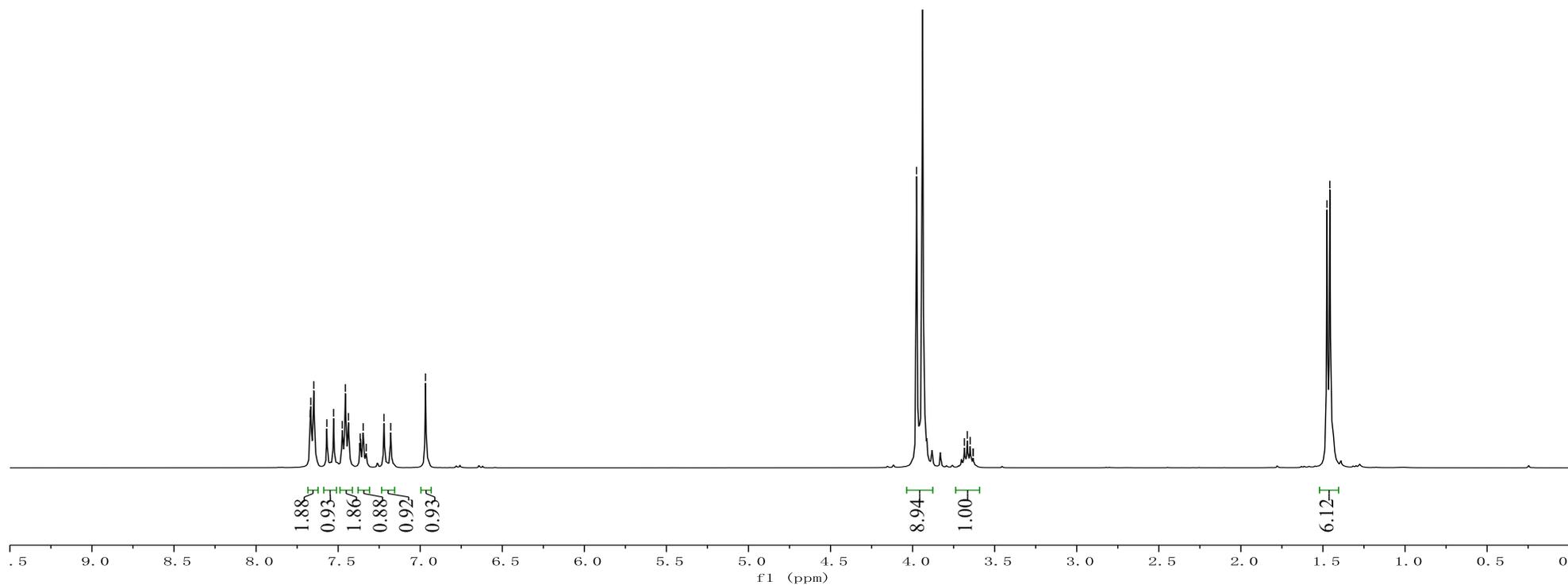
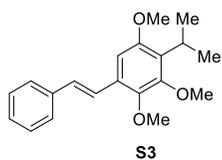


¹H NMR Spectrum of S3 (400 MHz, CDCl₃)

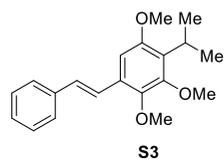
7.67
7.67
7.65
7.57
7.53
7.47
7.46
7.44
7.37
7.37
7.36
7.35
7.33
7.22
7.18
6.97

3.98
3.94
3.94
3.68
3.67
3.65
3.63
3.63

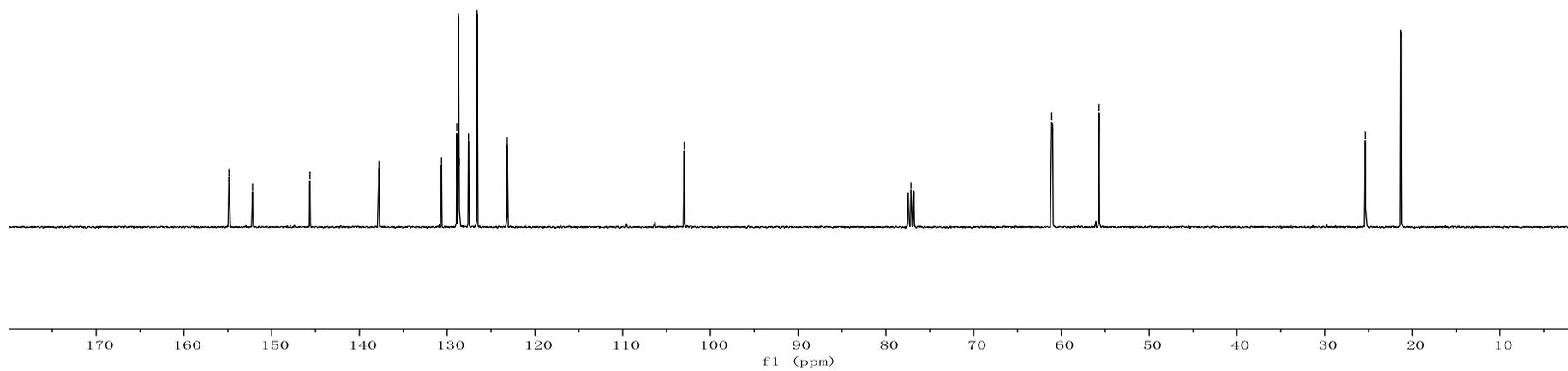
1.48
1.46



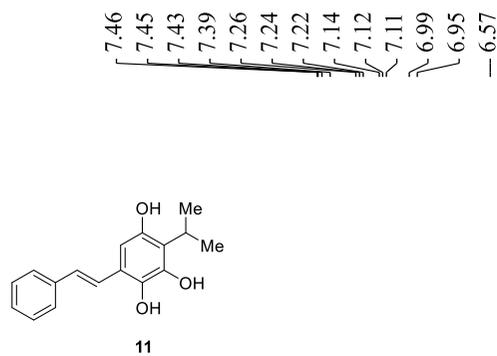
¹³C NMR Spectrum of S3 (101 MHz, CDCl₃)



154.87
152.18
145.63
137.76
130.65
128.90
128.71
128.63
127.58
126.59
123.16
102.97
77.15
61.10
60.98
55.69
25.37
21.32



¹H NMR Spectrum of 11 (400 MHz, methanol-d₄)

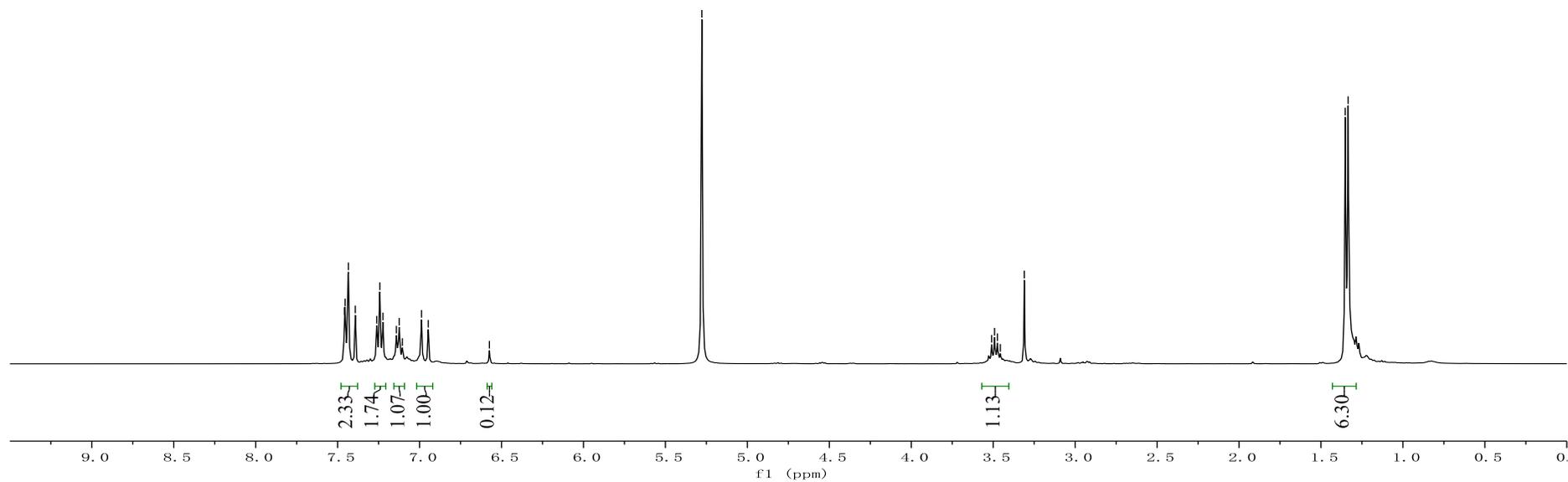


7.46
7.45
7.43
7.39
7.26
7.24
7.22
7.14
7.12
7.11
6.99
6.95
— 6.57

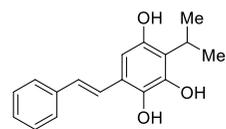
— 5.28

3.51
3.49
3.47
3.46
3.31

1.35
1.33



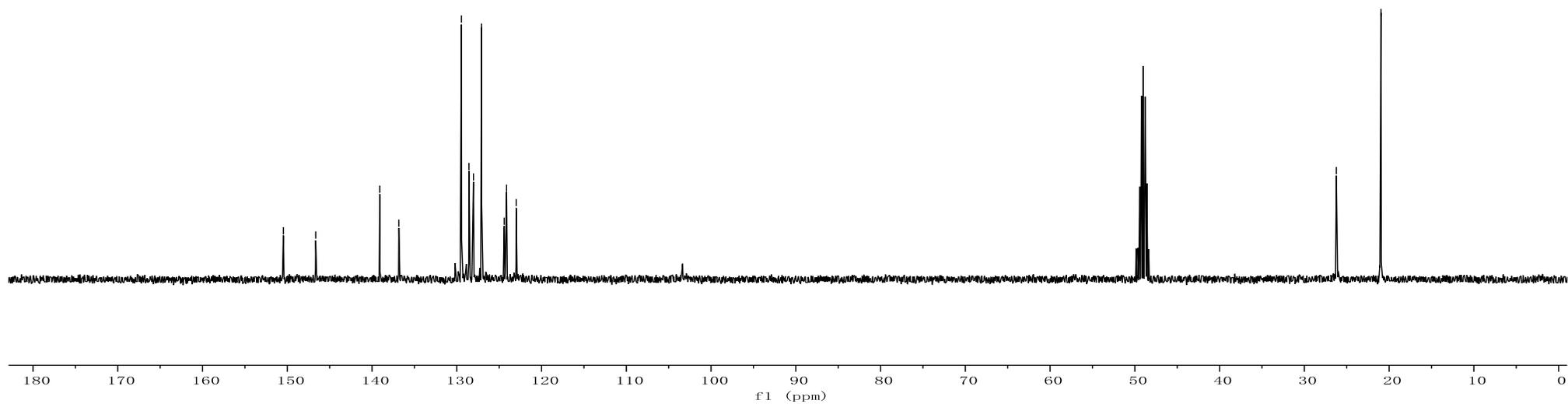
¹³C NMR Spectrum of 11 (101 MHz, methanol-d₄)



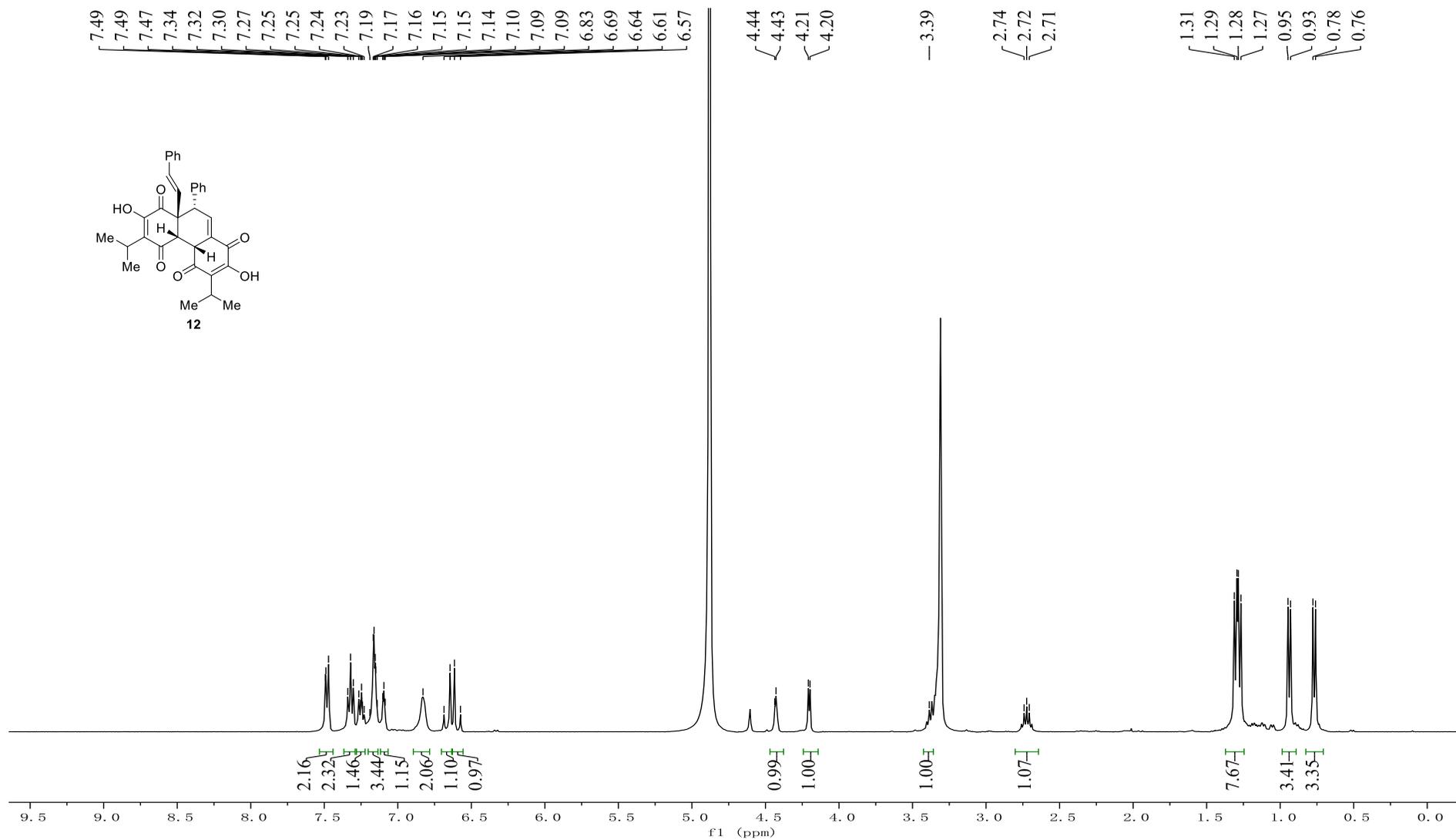
11

— 150.46
— 146.65
~ 139.09
~ 136.84
/ 129.45
/ 128.56
/ 128.03
/ 127.08
/ 124.41
/ 124.13
/ 122.99

— 26.23
— 20.96



¹H NMR Spectrum of 12 (400 MHz, methanol-d₄)



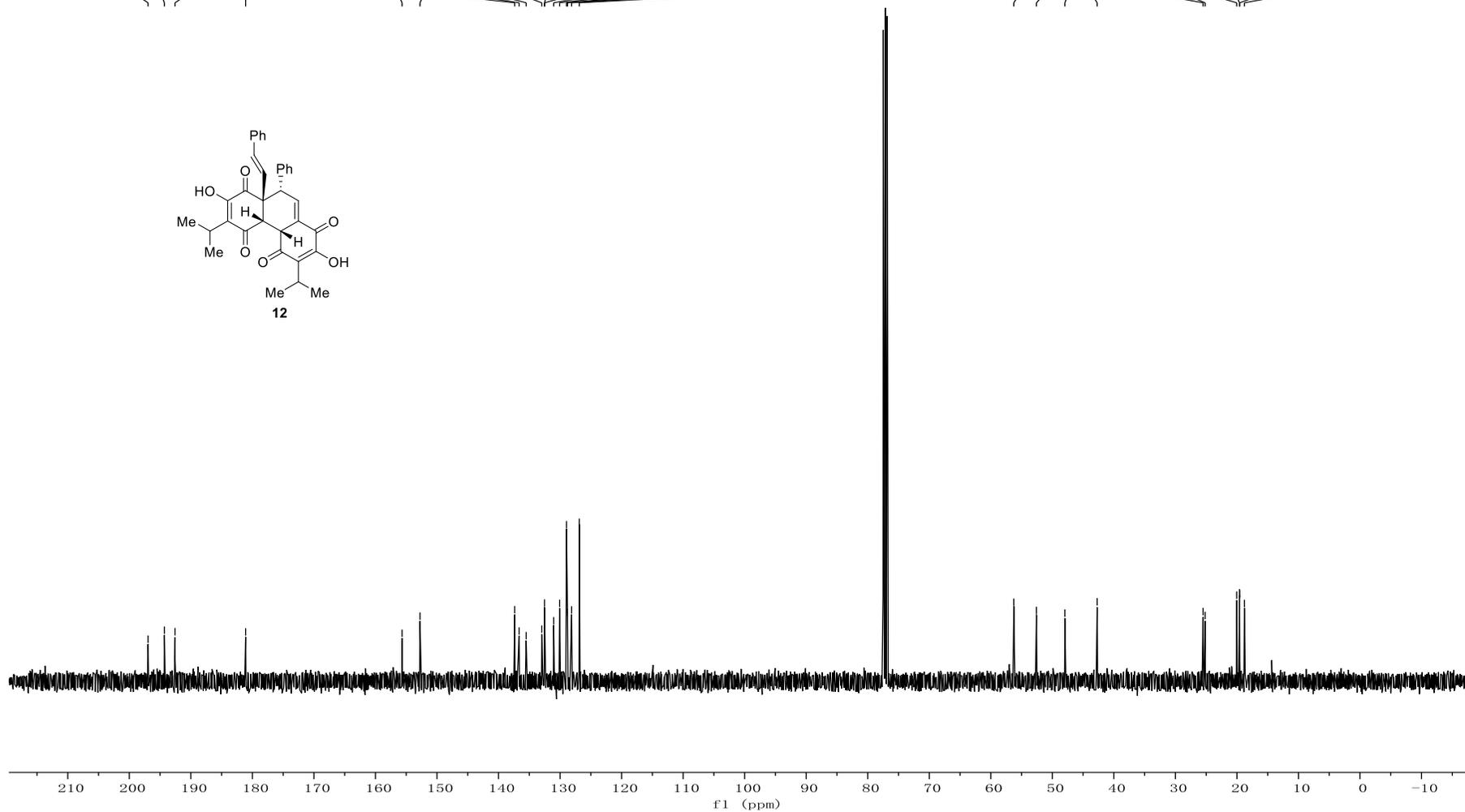
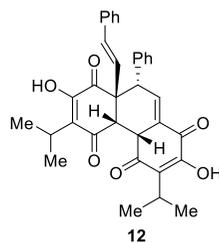
¹³C NMR Spectrum of 12 (101 MHz, CDCl₃)

196.95
194.30
192.57
181.10

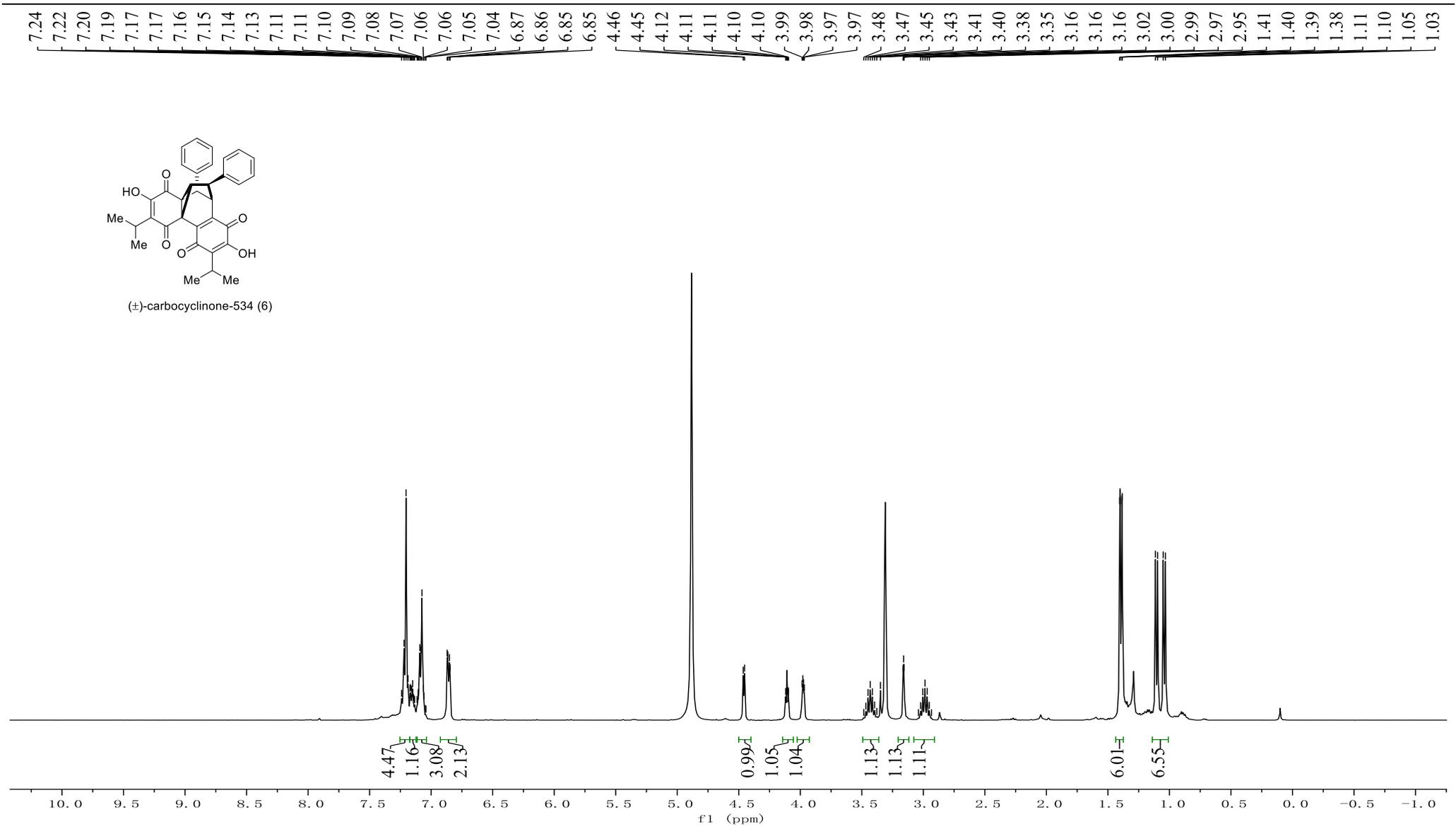
155.67
152.76
137.37
136.65
135.50
132.97
132.53
132.50
131.03
130.07
128.96
128.78
128.12
126.88

56.26
52.58
47.96
42.71

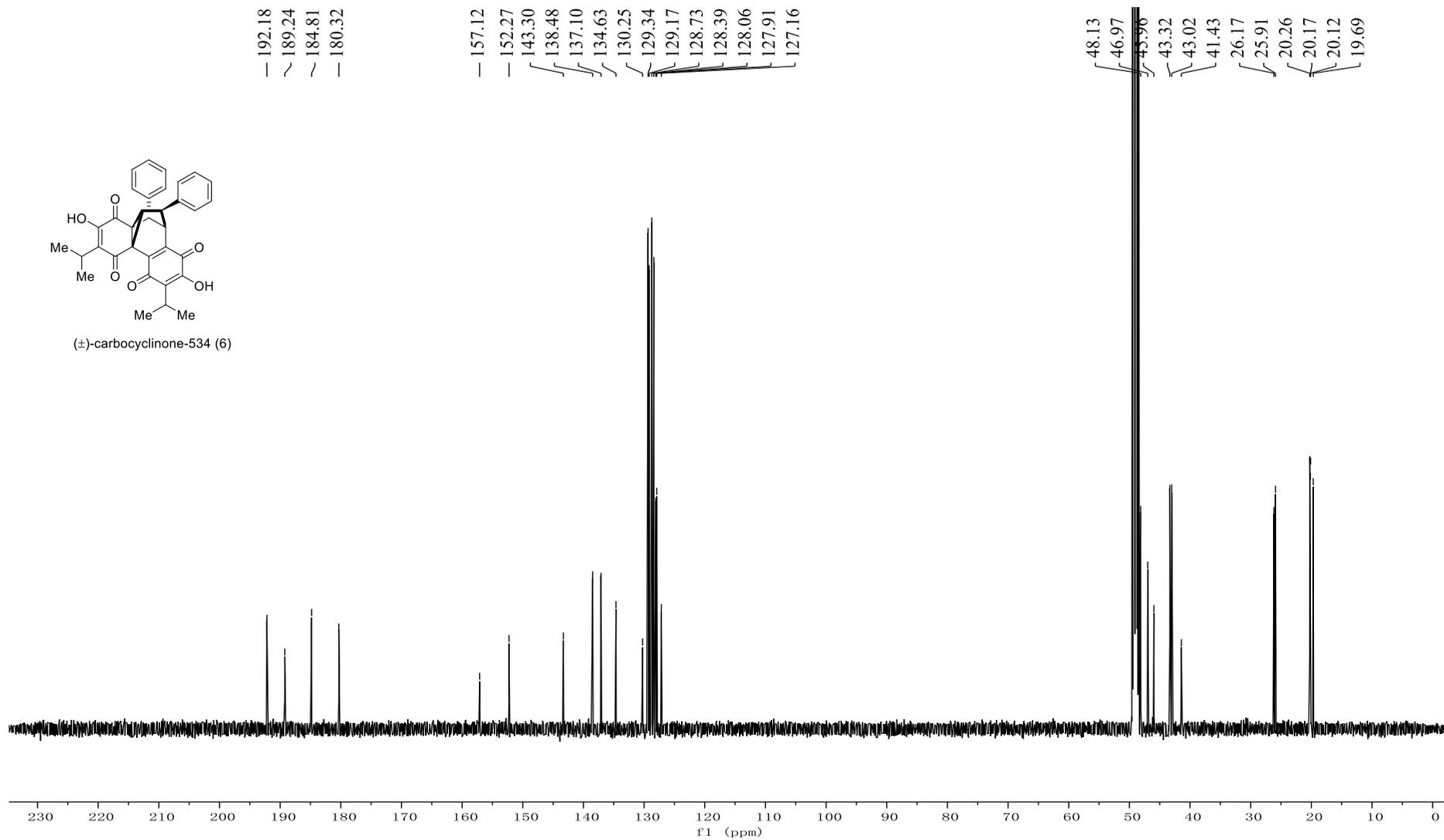
25.50
25.17
20.04
19.58
19.56
18.78



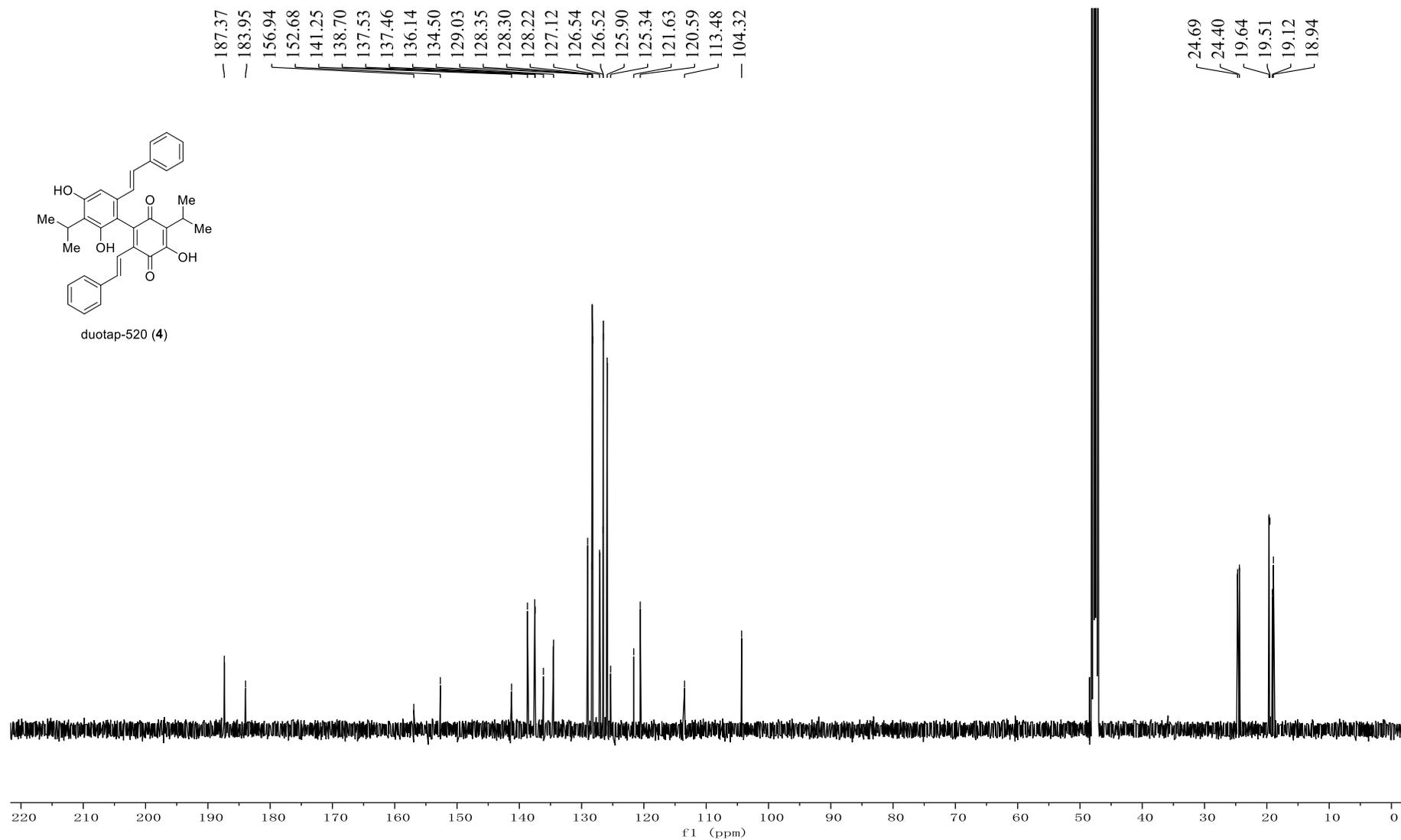
¹H NMR Spectrum of (±)-Carbocyclinone-534 (6) (400 MHz, methanol-d₄)



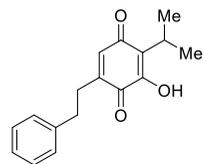
¹³C NMR Spectrum of (±)-Carbocyclinone-534 (6) (126 MHz, methanol-d₄)



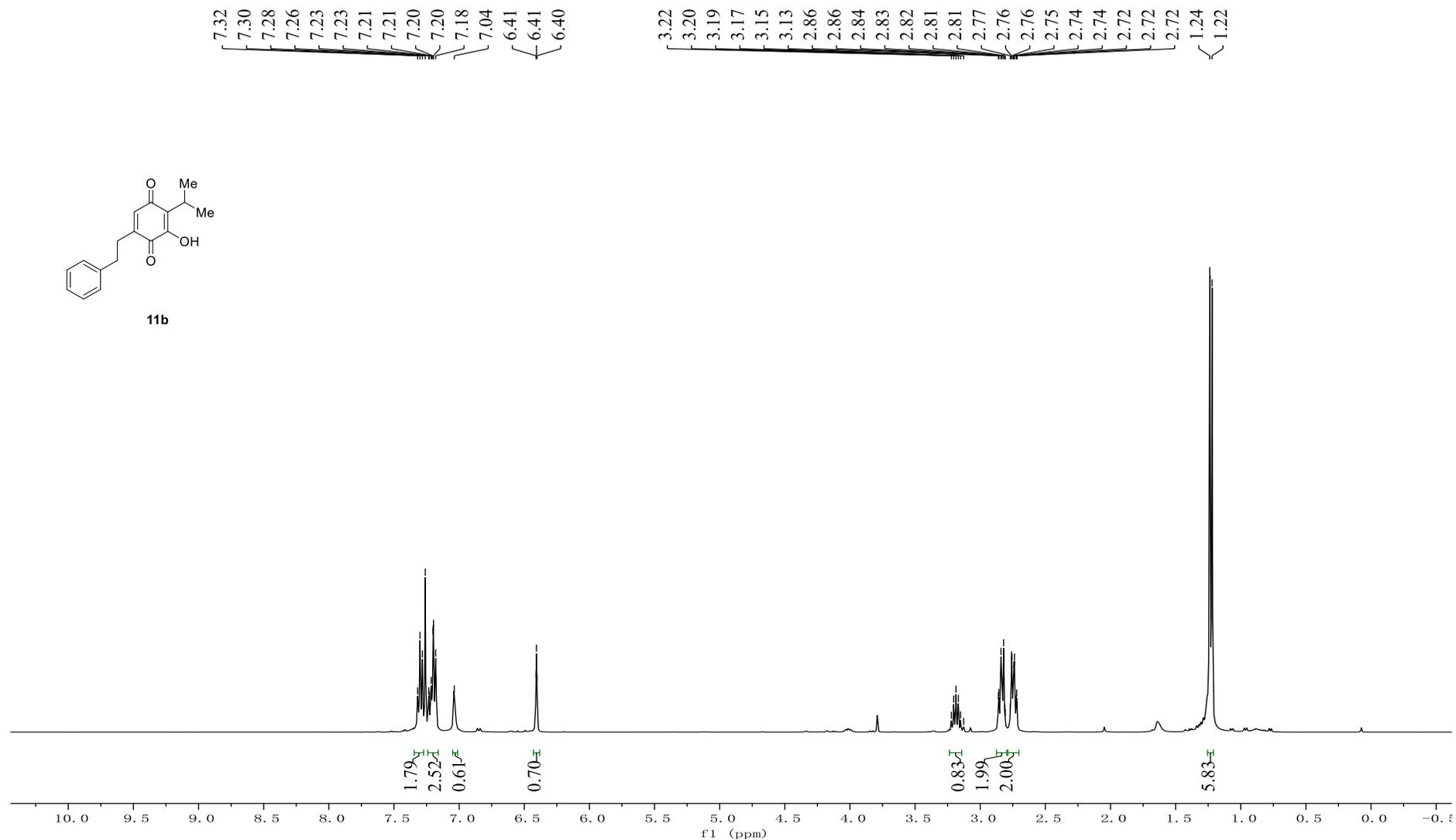
¹³C NMR Spectrum of duotap-520 (4) (126 MHz, methanol-d₄)



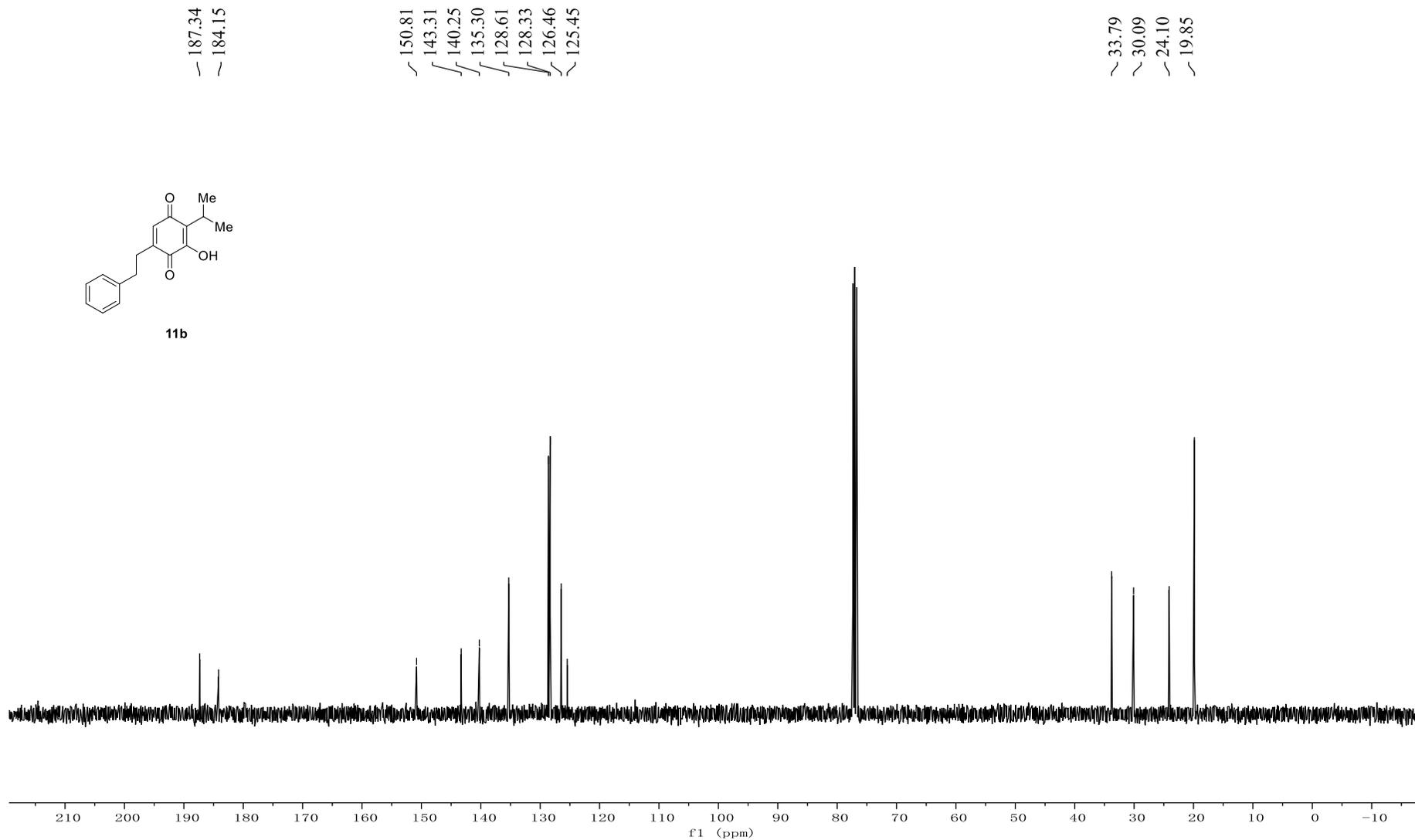
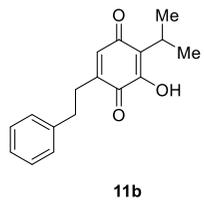
¹H NMR Spectrum of 11b (400 MHz, CDCl₃)



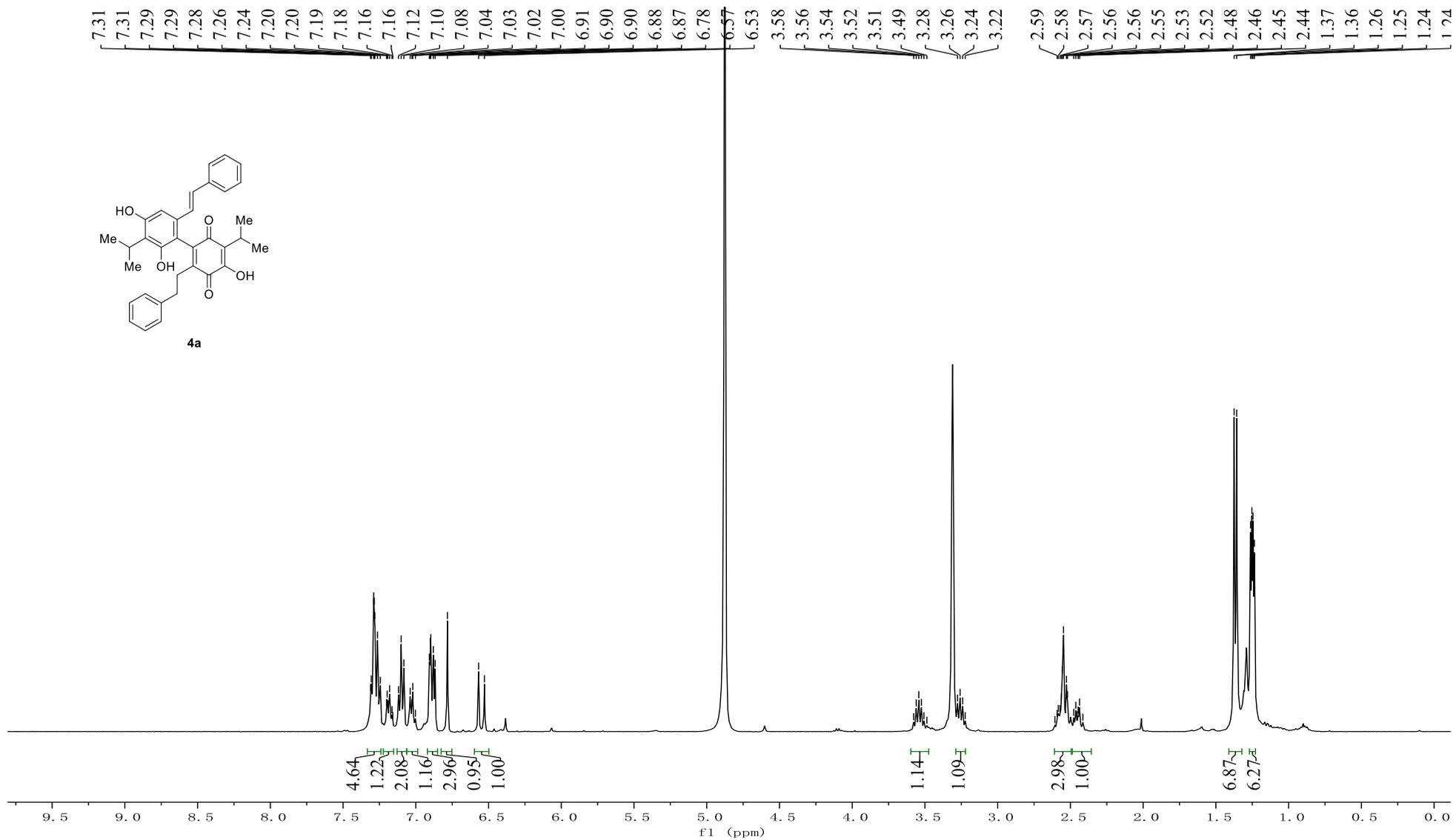
11b



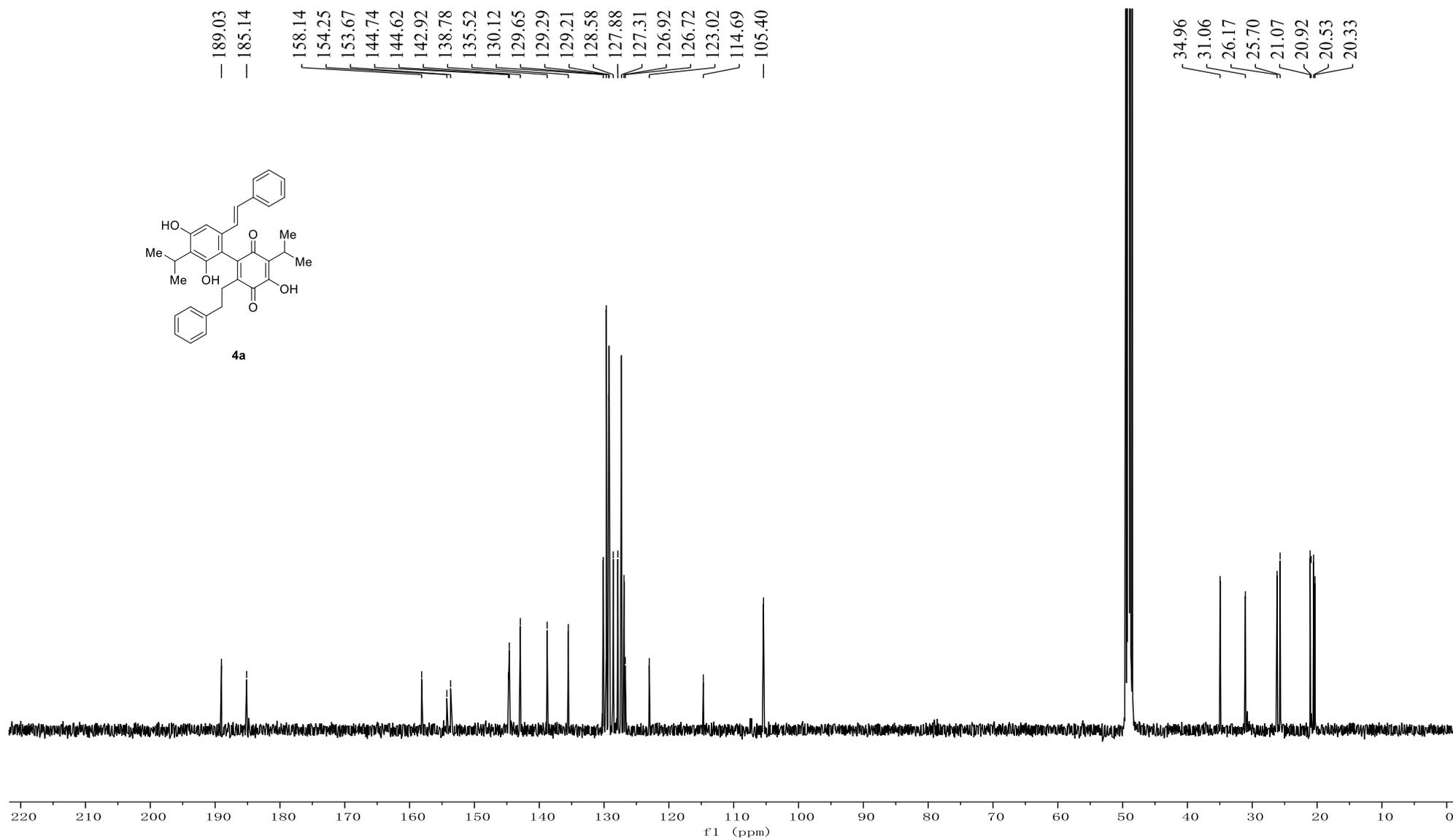
¹³C NMR Spectrum of 11b (400 MHz, CDCl₃)



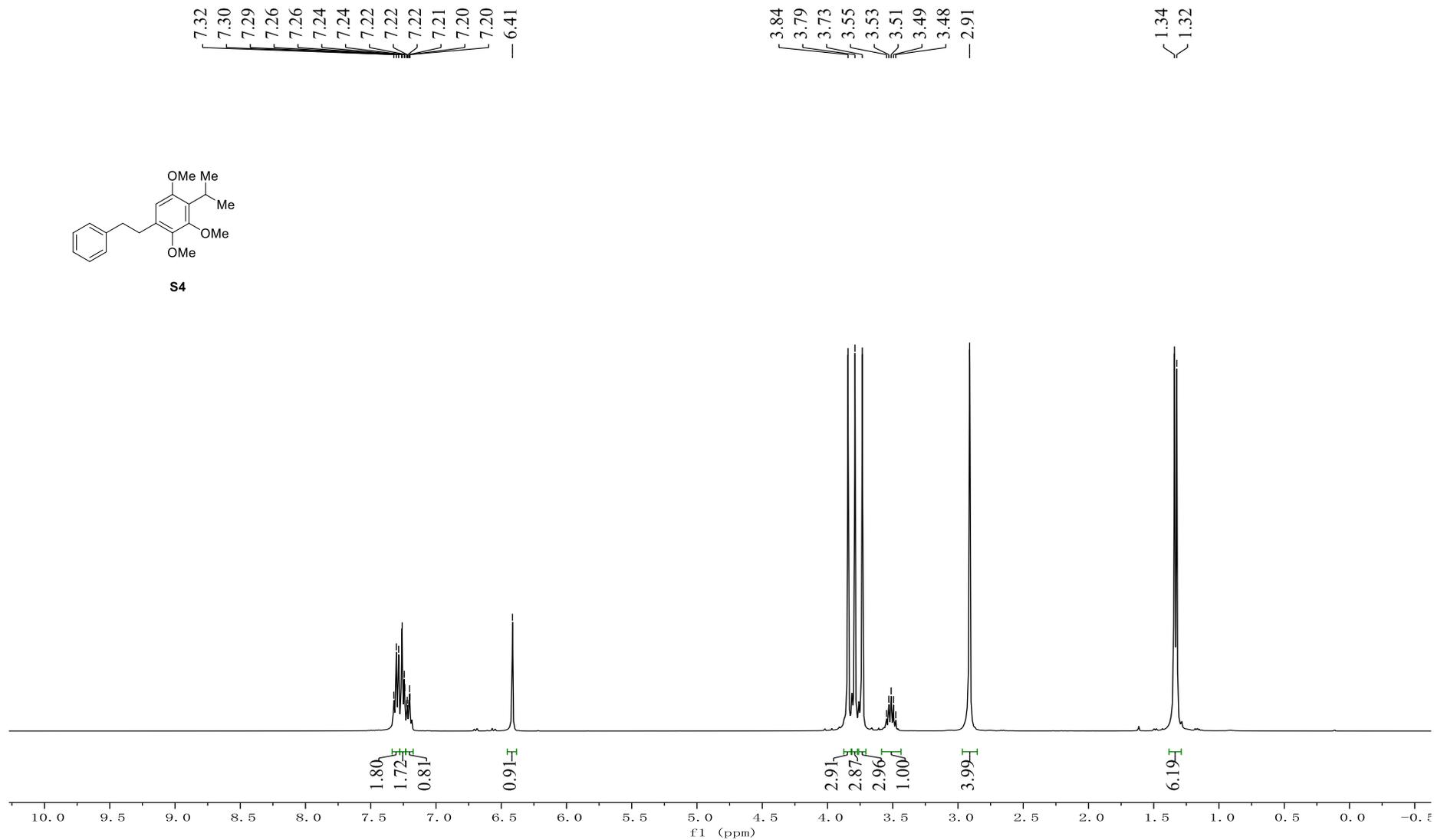
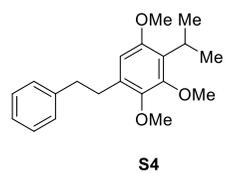
¹H NMR Spectrum of 4a (400 MHz, methanol-d₄)



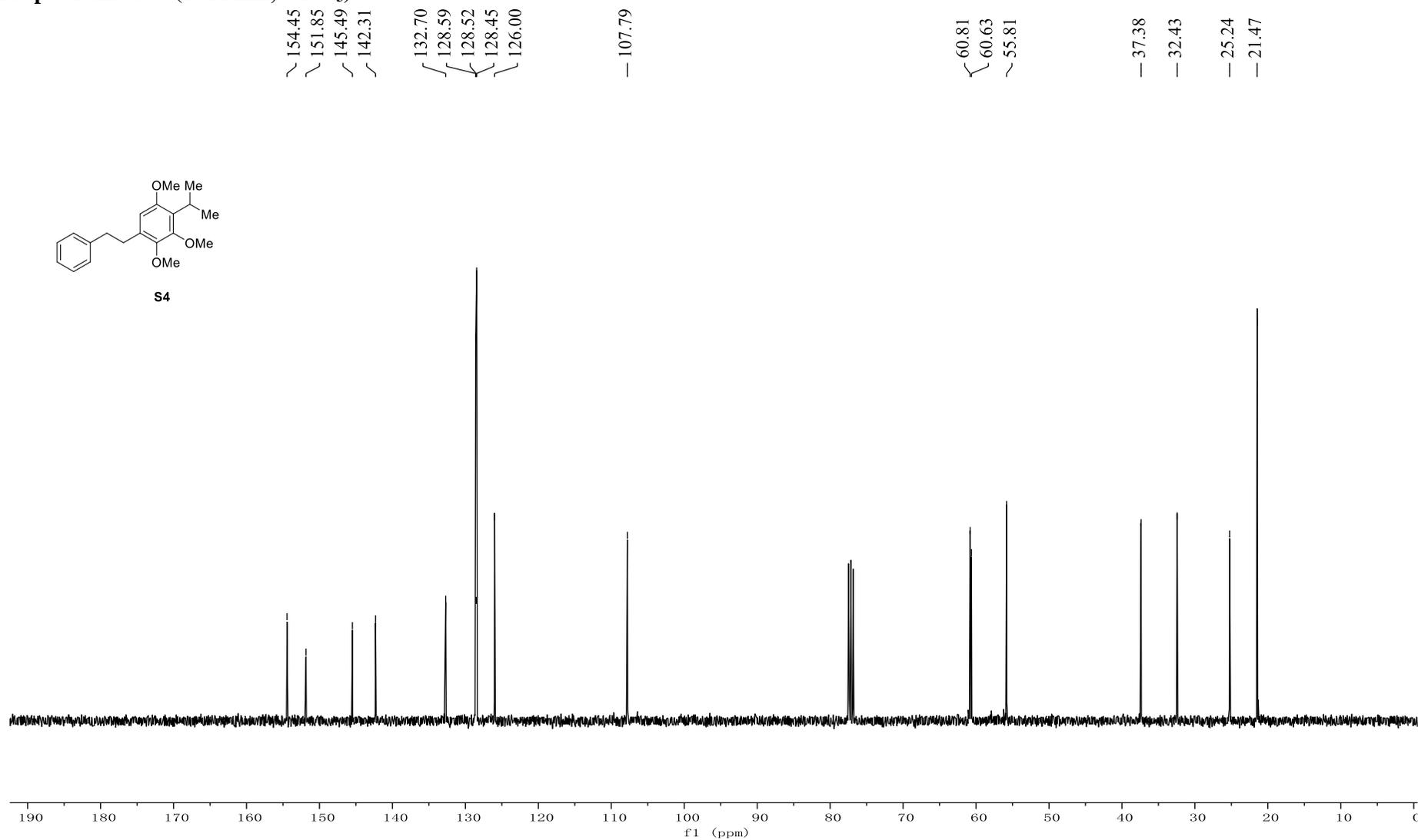
¹³C NMR Spectrum of 4a (126 MHz, methanol-d₄)



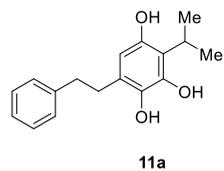
¹H NMR Spectrum of S4 (400 MHz, CDCl₃)



¹³C NMR Spectrum of S4 (101 MHz, CDCl₃)



¹H NMR Spectrum of 11a (400 MHz, CDCl₃)



7.20
7.19
7.18
7.17
7.16
7.15
7.10
7.10
7.09
7.08
7.08
— 6.09

3.46
3.44
3.42
3.31
2.84
2.83
2.82
2.82
2.81
2.80
2.80
2.78
2.77
2.76
2.75
2.75
2.74
2.73
1.32
1.30

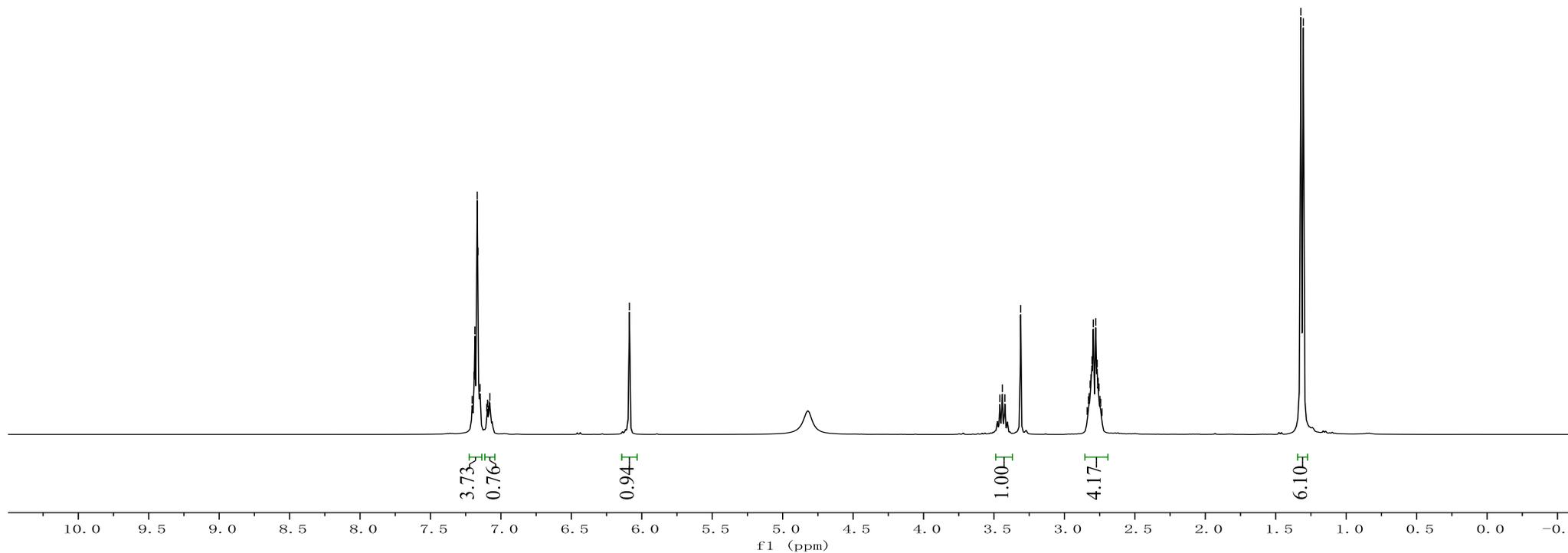
3.73
0.76

0.94

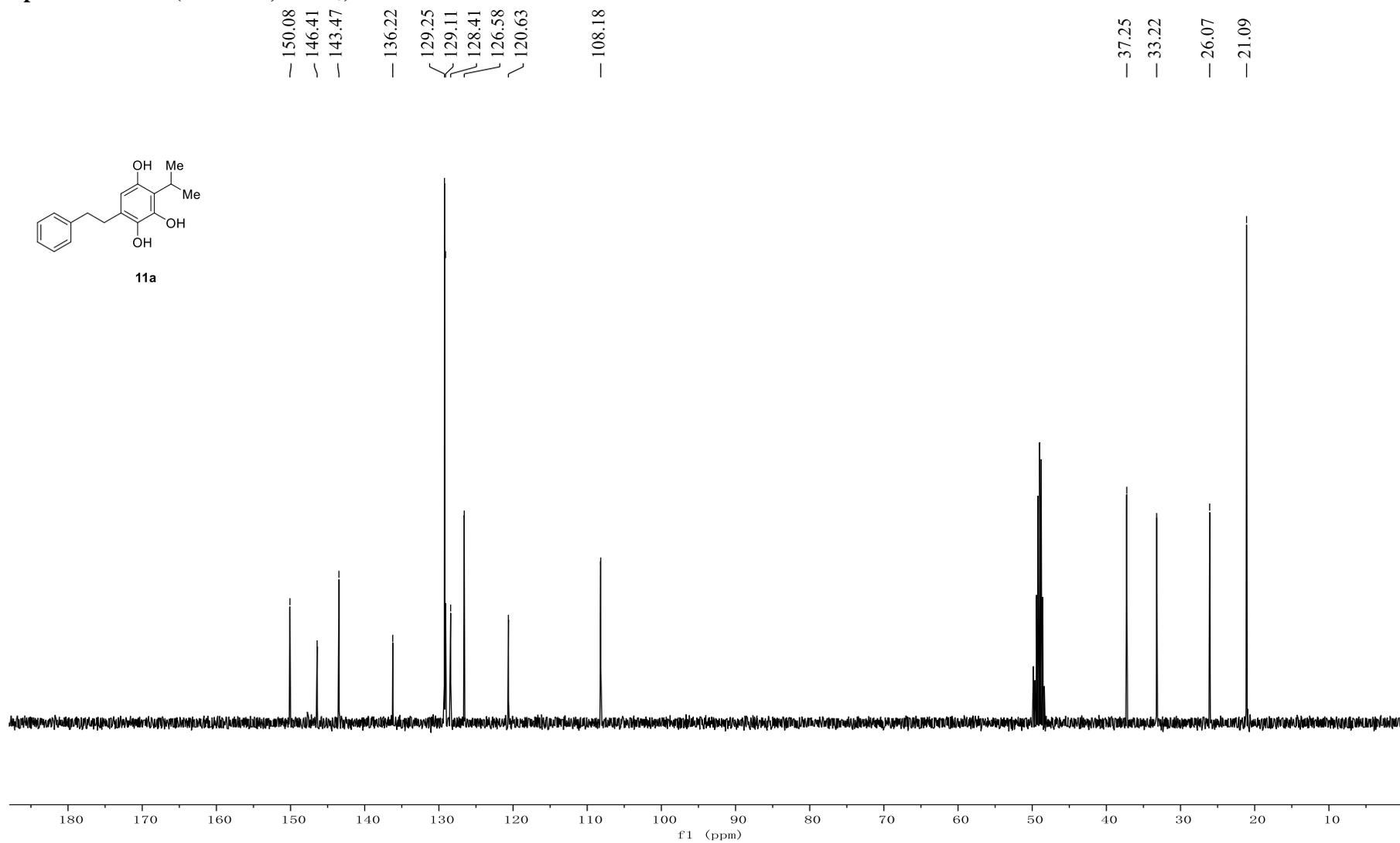
1.00

4.17

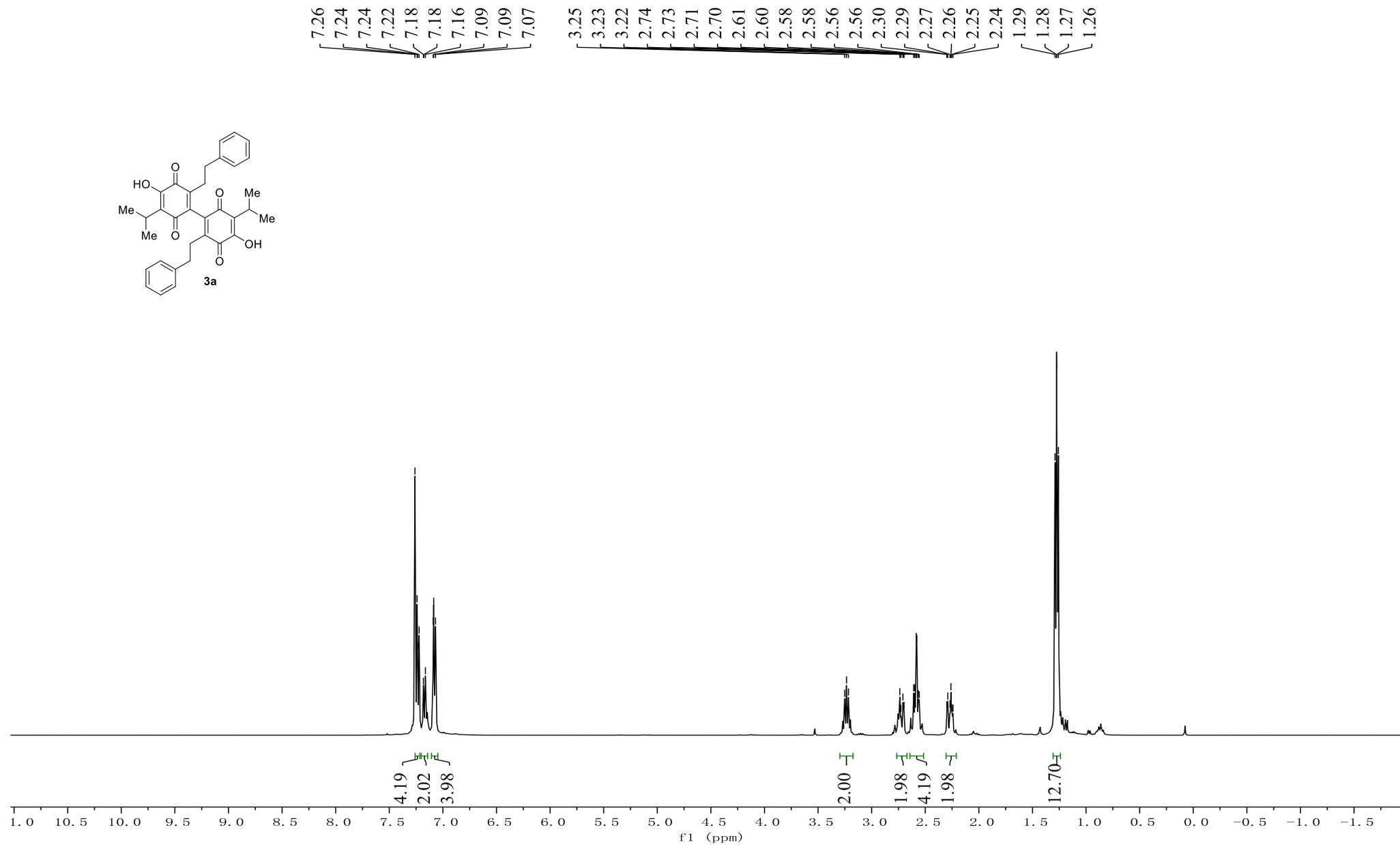
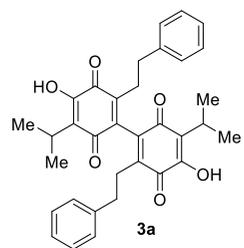
6.10



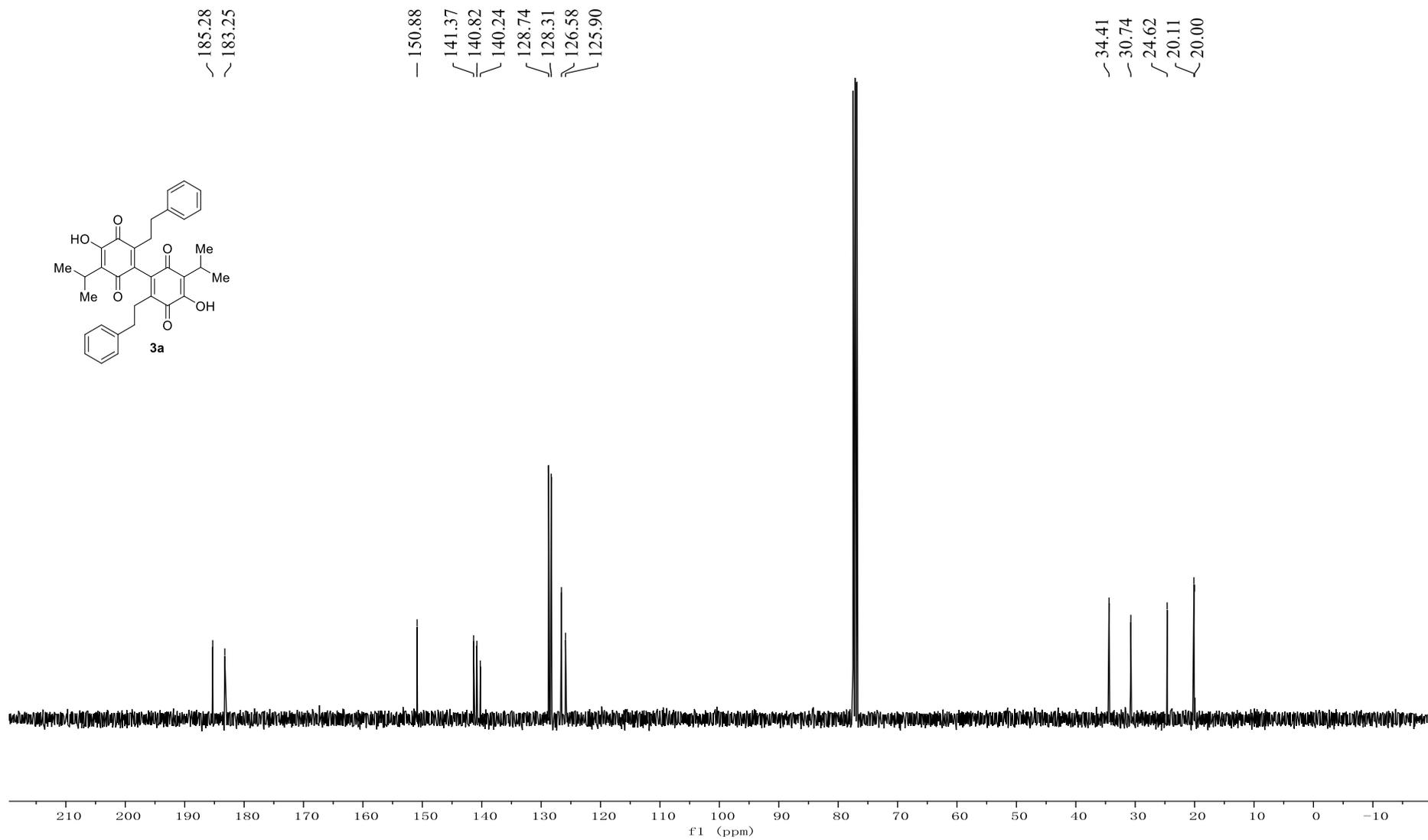
¹³C NMR Spectrum of 11a (101 MHz, CDCl₃)



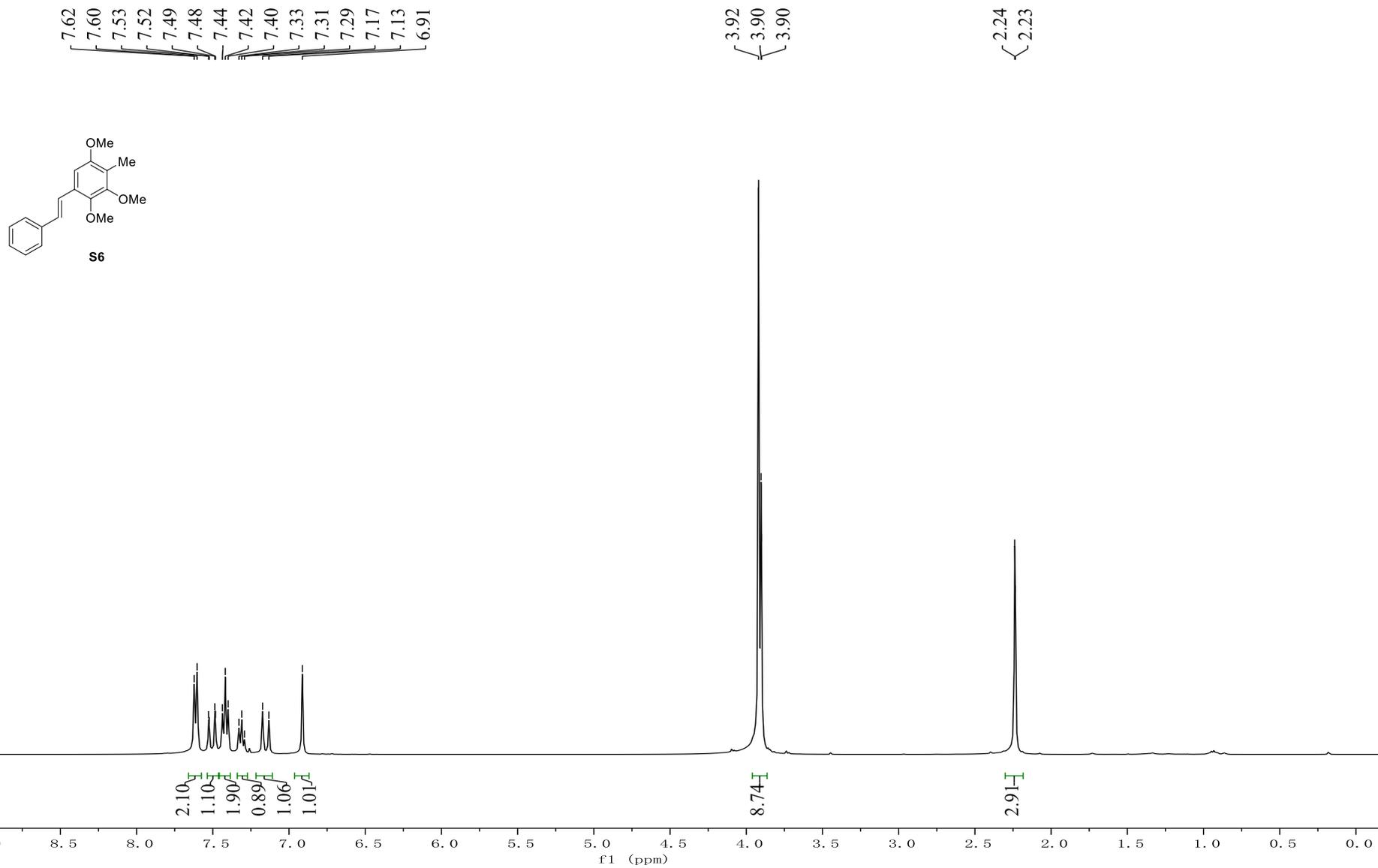
¹H NMR Spectrum of 3a (400 MHz, CDCl₃)



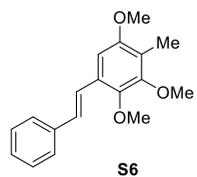
¹³C NMR Spectrum of 3a (101 MHz, CDCl₃)



¹H NMR Spectrum of S6 (400 MHz, CDCl₃)



¹³C NMR Spectrum of S6 (101 MHz, CDCl₃)

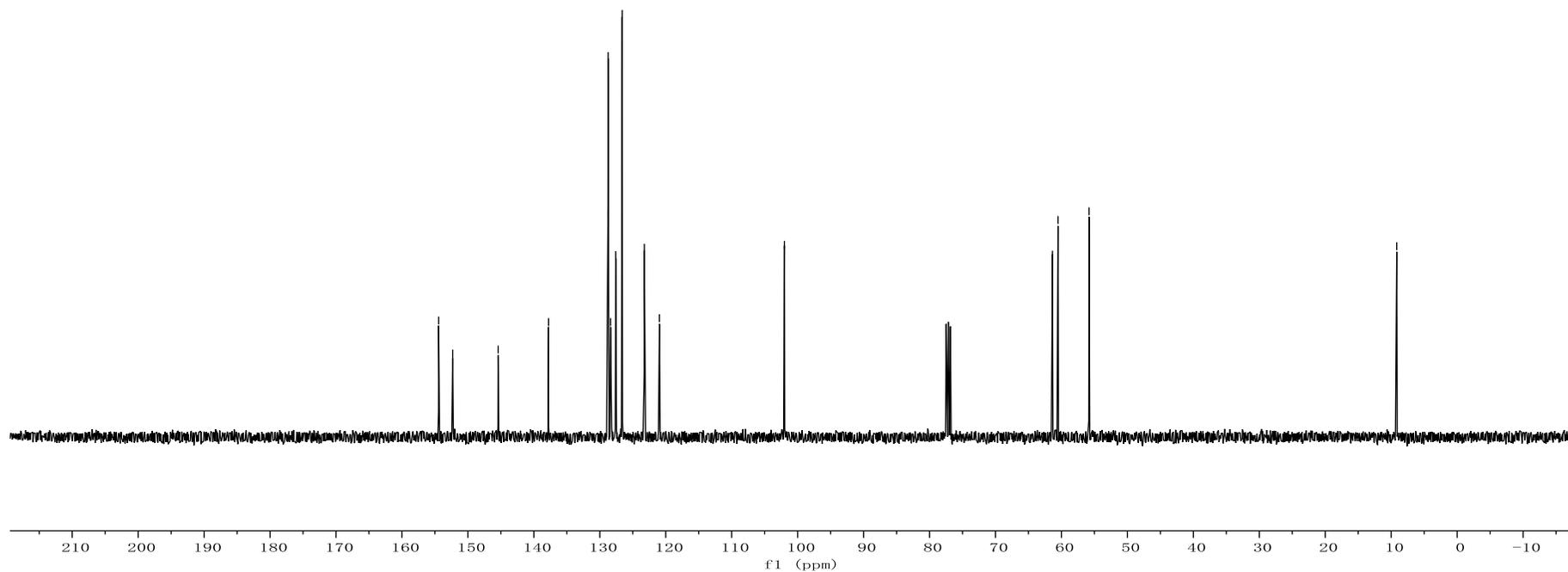


154.43
152.30
145.41
137.77
128.77
128.73
128.37
127.59
126.60
123.25
120.96

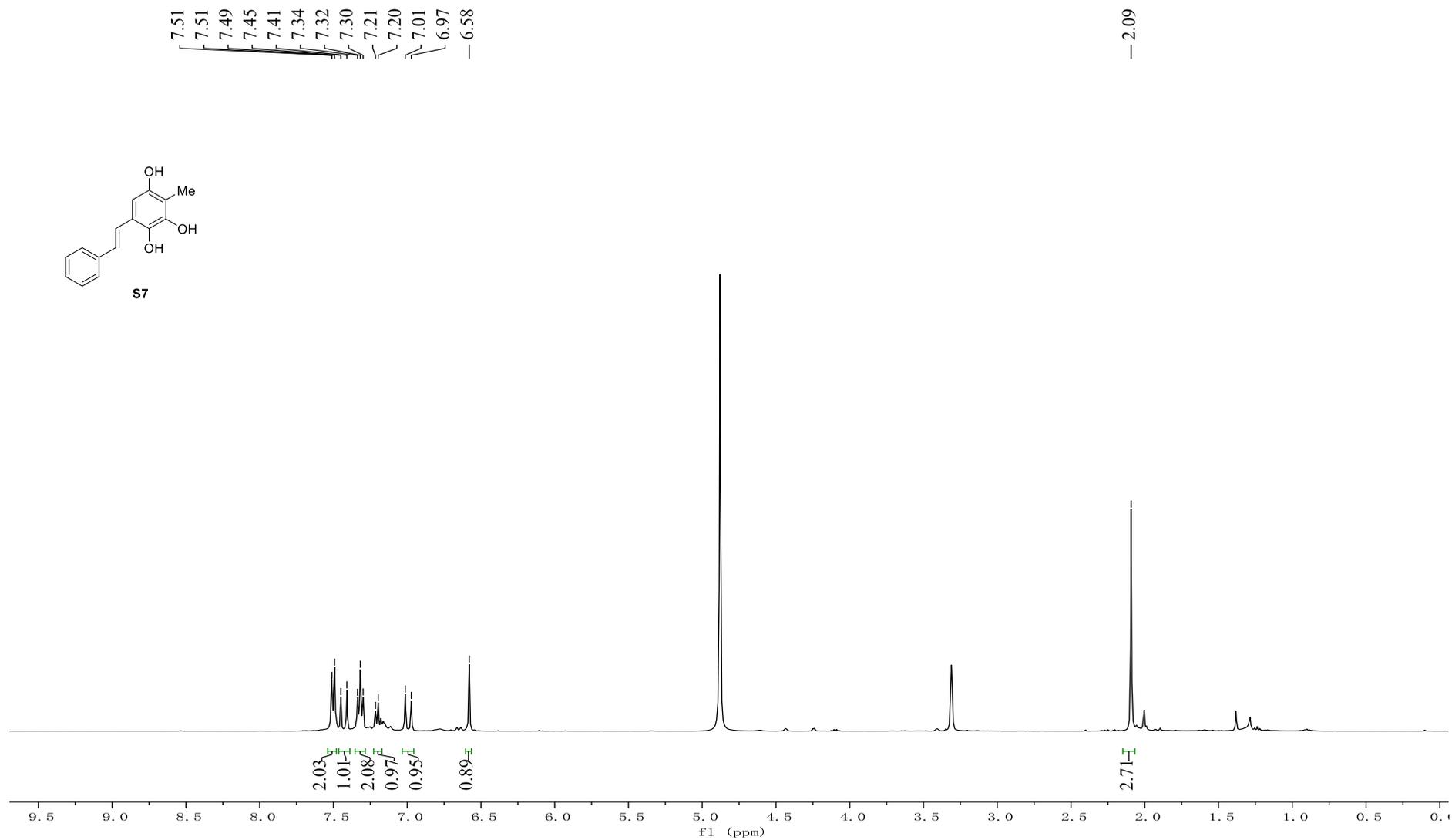
102.00

61.36
60.51
55.81

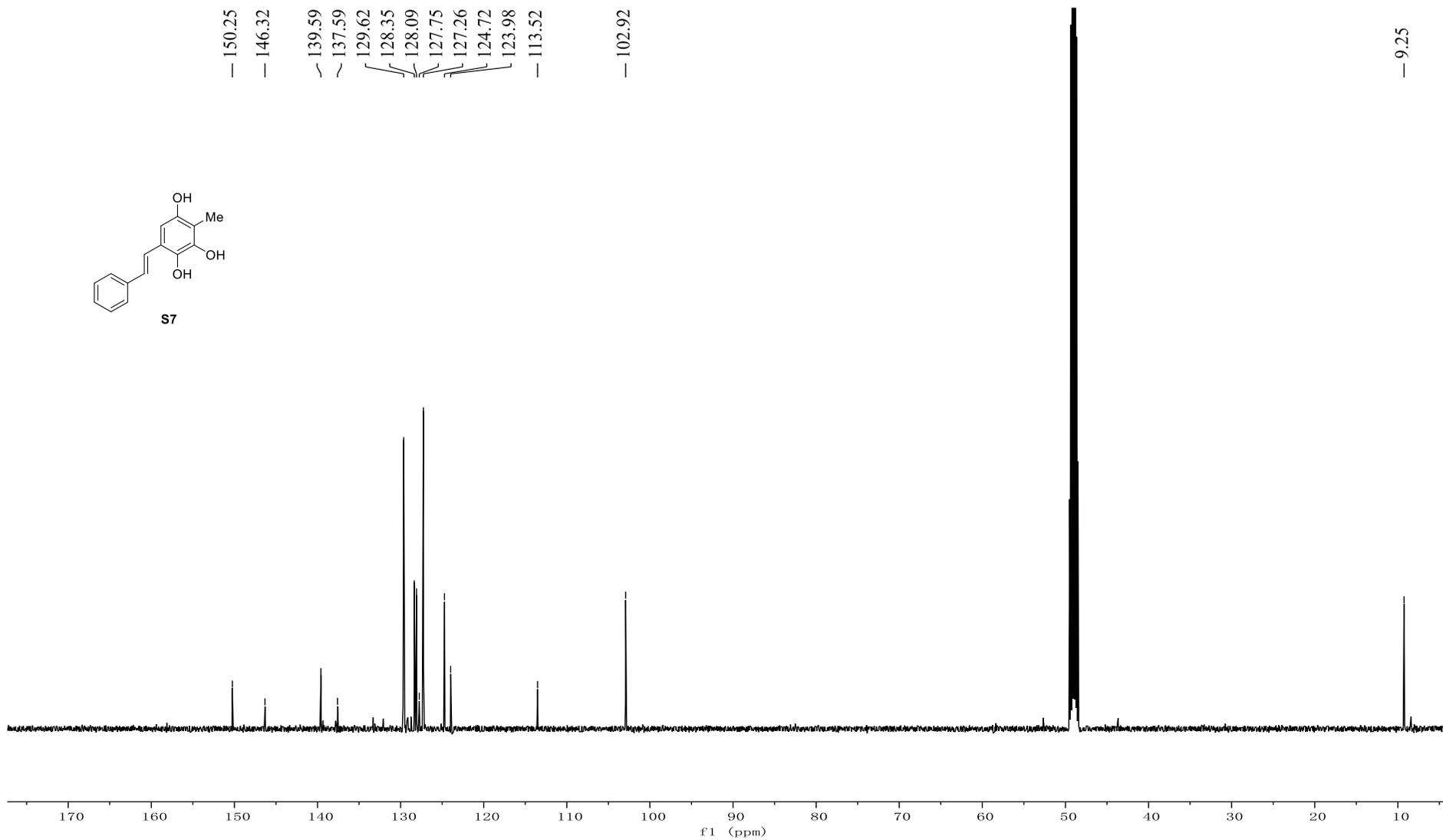
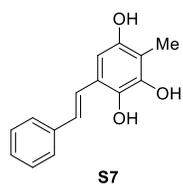
9.15



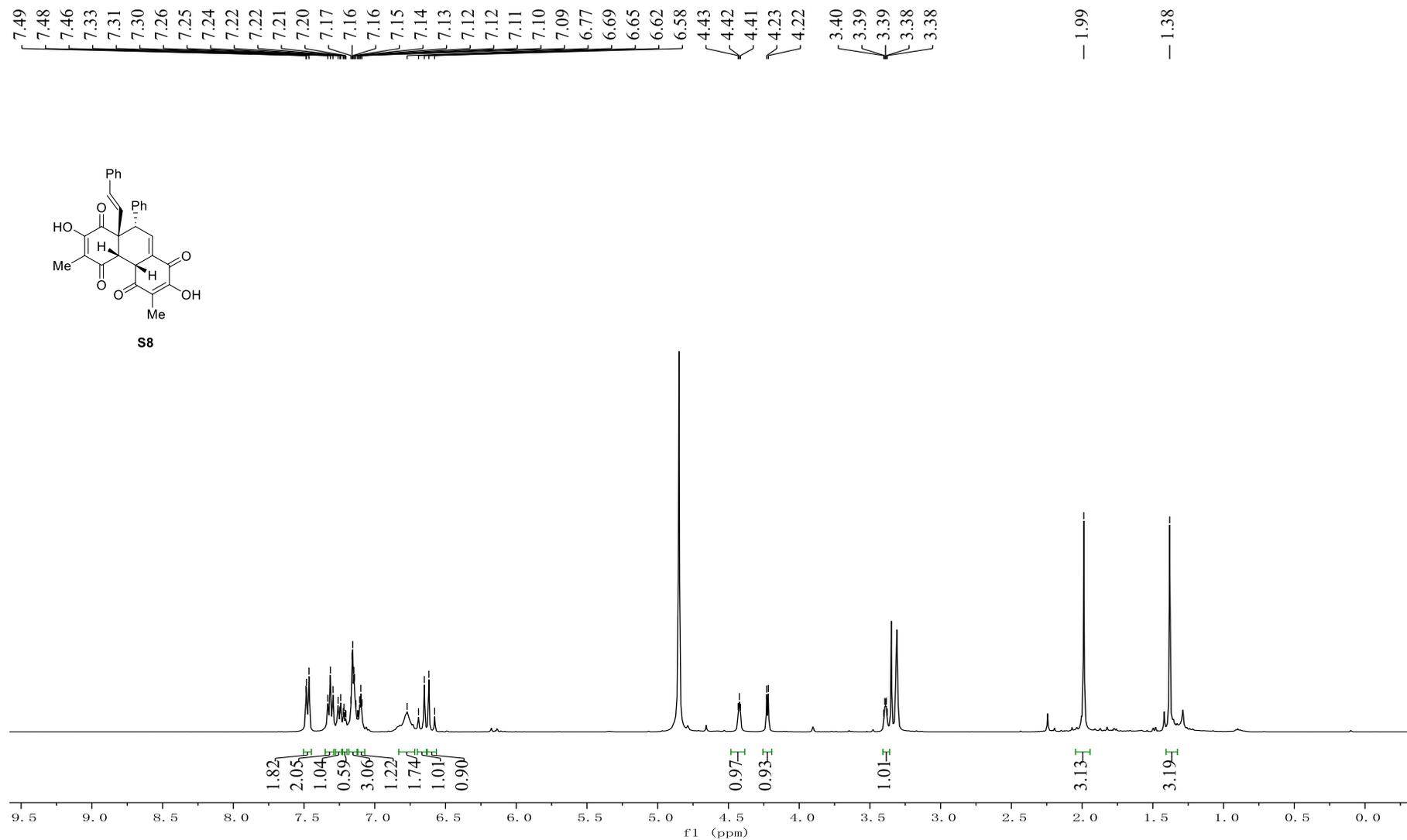
¹H NMR Spectrum of S7 (400 MHz, methanol-d₄)



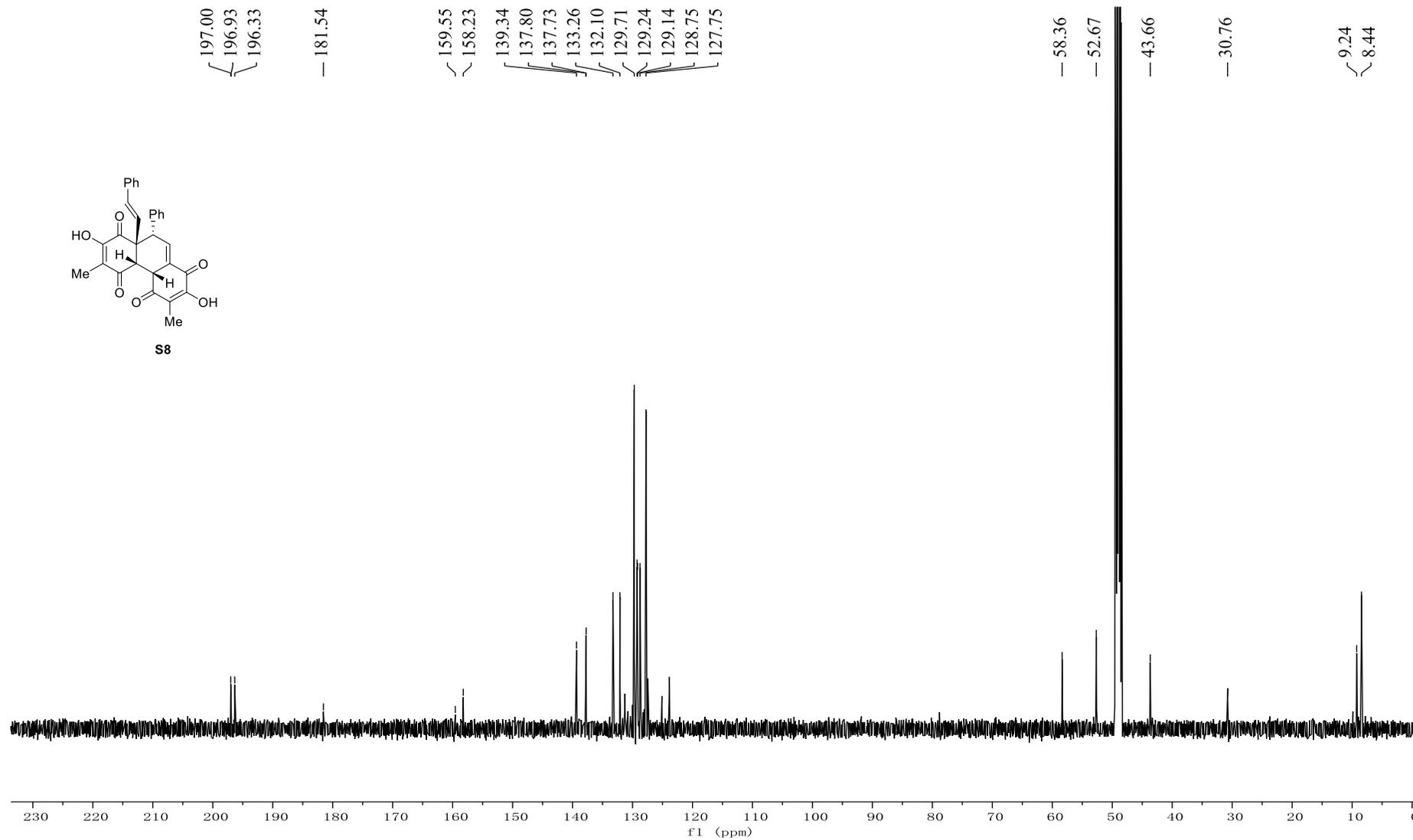
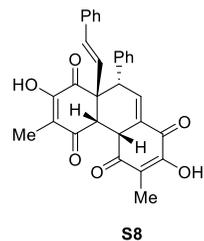
¹³C NMR Spectrum of S7 (126 MHz, methanol-d₄)



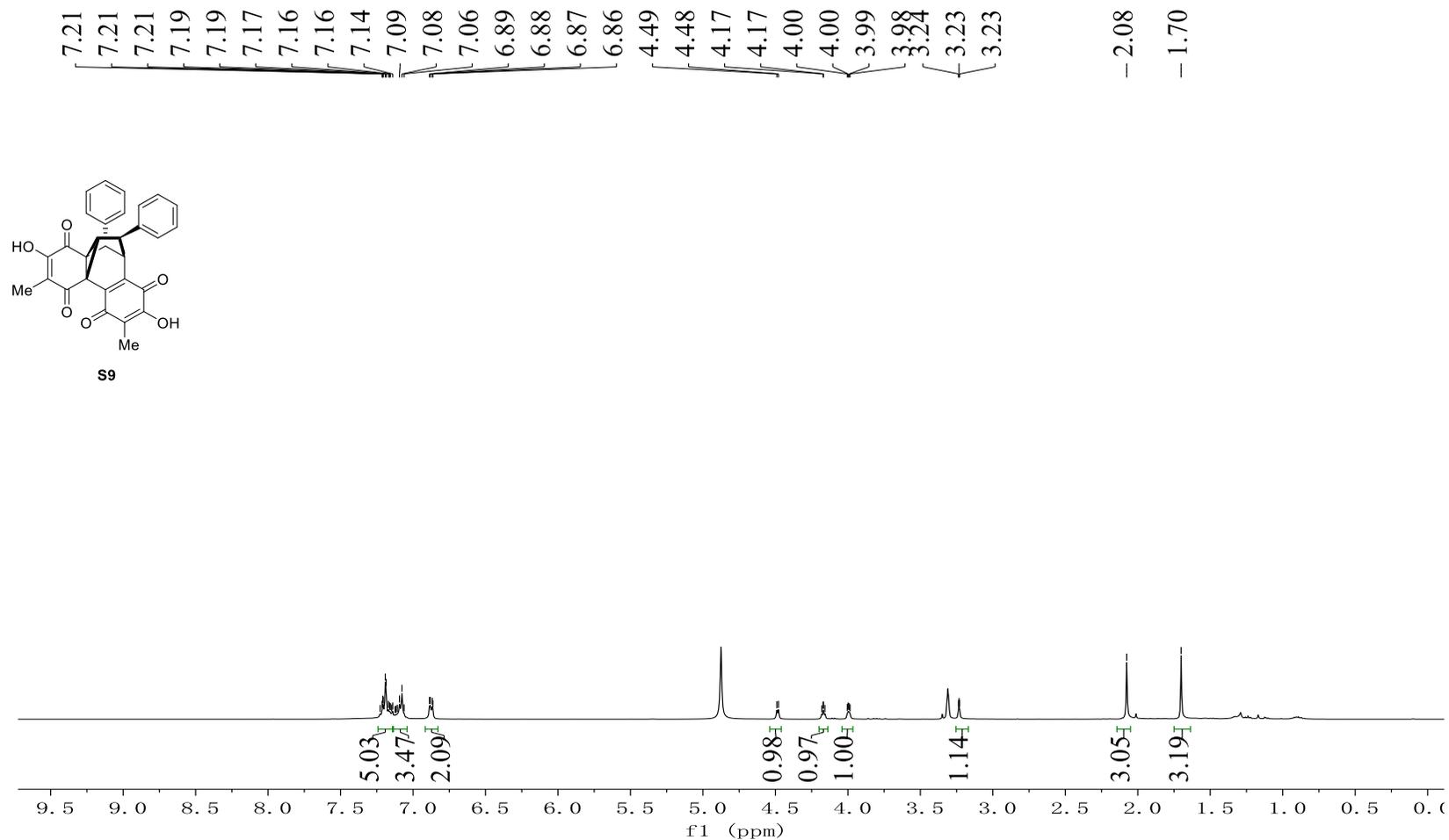
¹H NMR Spectrum of S8 (400 MHz, methanol-d₄)



¹³C NMR Spectrum of S8 (126 MHz, methanol-d₄)



¹H NMR Spectrum of S9 (400 MHz, methanol-d₄)



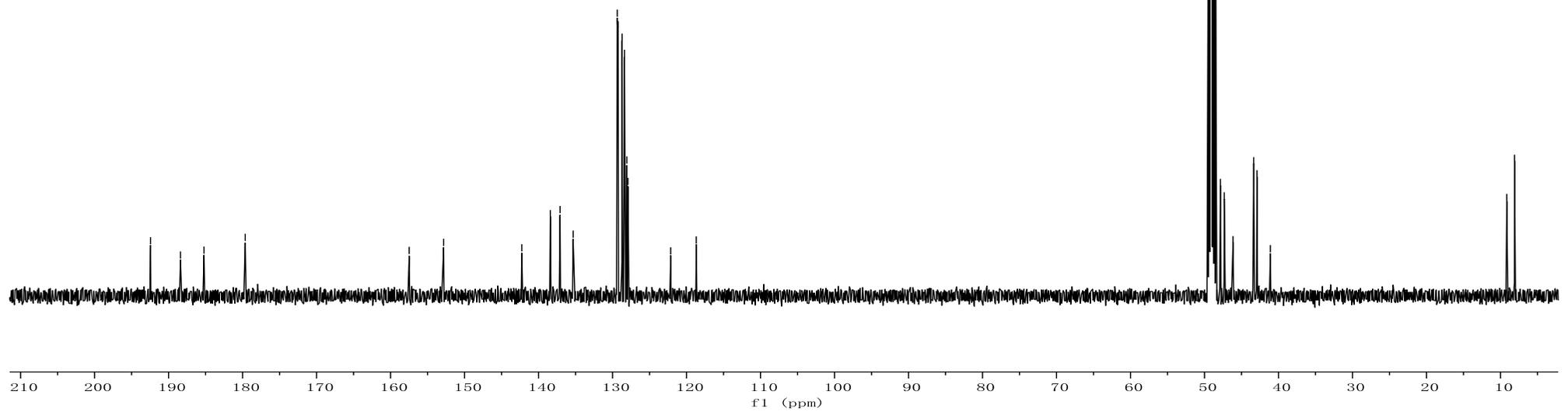
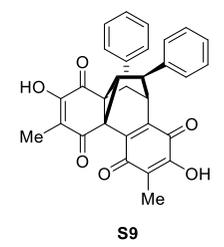
¹³C NMR Spectrum of S9 (126 MHz, methanol-d₄)

~ 192.44
~ 188.39
~ 185.21
~ 179.65

— 157.48
— 152.82
142.27
138.41
137.10
135.33
129.36
129.25
128.71
128.39
128.07
127.92
122.14
118.69

47.85
47.33
46.15
43.35
42.90
41.10

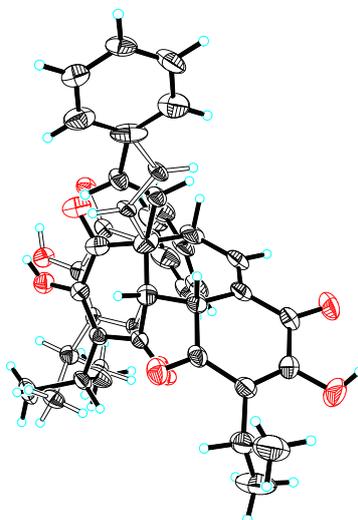
~ 9.15
~ 8.10



VII X-Ray Crystallography Data for compounds 12(CCDC 2014357)

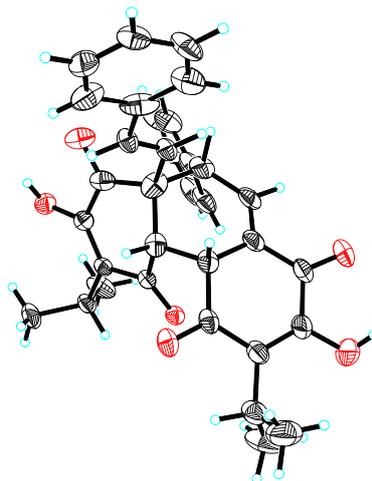
The method for culturing the crystal: dissolving 3 mg of the compound in a solution of DCM/n-hexane=1:2, and volatilizing at room temperature for two days.

Crystal data for dl9131: $C_{34}H_{32}O_6$, $M = 536.59$, $a = 18.7778(6) \text{ \AA}$, $b = 16.0317(5) \text{ \AA}$, $c = 20.4129(7) \text{ \AA}$, $\alpha = 90^\circ$, $\beta = 116.347(2)^\circ$, $\gamma = 90^\circ$, $V = 5506.8(3) \text{ \AA}^3$, $T = 100.(2) \text{ K}$, space group $C12/c1$, $Z = 8$, $\mu(\text{Cu K}\alpha) = 0.712 \text{ mm}^{-1}$, 34913 reflections measured, 5444 independent reflections ($R_{int} = 0.1338$). The final R_I values were 0.0957 ($I > 2\sigma(I)$). The final $wR(F^2)$ values were 0.2509 ($I > 2\sigma(I)$). The final R_I values were 0.1278 (all data). The final $wR(F^2)$ values were 0.2914 (all data). The goodness of fit on F^2 was 1.027.

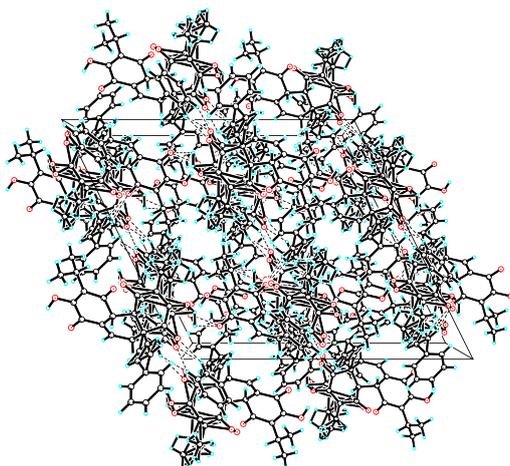


View of the molecules in an asymmetric unit.

Displacement ellipsoids are drawn at the 30% probability level.



View of a molecule of dl9131 with the atom-labelling scheme.
Displacement ellipsoids are drawn at the 30% probability level.



View of the pack drawing of dl9131.
Hydrogen-bonds are shown as dashed lines.

Table 1. Crystal data and structure refinement for dl9131_0m.

Identification code	global	
Empirical formula	C ₃₄ H ₃₂ O ₆	
Formula weight	536.59	
Temperature	100(2) K	
Wavelength	1.54178 Å	
Crystal system	Monoclinic	
Space group	C 1 2/c 1	
Unit cell dimensions	a = 18.7778(6) Å	$\alpha = 90^\circ$.

	$b = 16.0317(5) \text{ \AA}$	$\beta = 116.347(2)^\circ$
	$c = 20.4129(7) \text{ \AA}$	$\gamma = 90^\circ$
Volume	$5506.8(3) \text{ \AA}^3$	
Z	8	
Density (calculated)	1.294 Mg/m^3	
Absorption coefficient	0.712 mm^{-1}	
F(000)	2272	
Crystal size	$0.450 \times 0.060 \times 0.050 \text{ mm}^3$	
Theta range for data collection	$3.81 \text{ to } 72.38^\circ$	
Index ranges	$-23 \leq h \leq 20, -19 \leq k \leq 19, -23 \leq l \leq 25$	
Reflections collected	34913	
Independent reflections	5444 [R(int) = 0.1338]	
Completeness to $\theta = 72.38^\circ$	99.9 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.96 and 0.48	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	5444 / 490 / 481	
Goodness-of-fit on F^2	1.027	
Final R indices [$I > 2\sigma(I)$]	$R1 = 0.0957, wR2 = 0.2509$	
R indices (all data)	$R1 = 0.1278, wR2 = 0.2914$	
Extinction coefficient	$0.0010(2)$	
Largest diff. peak and hole	$0.388 \text{ and } -0.330 \text{ e.\AA}^{-3}$	