Supporting Information

Short and efficient synthesis of alkylresorcinols: a route for the preparation of cannabinoids

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General Remarks

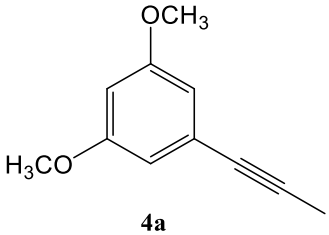
All reagents were purchased from Merck / Sigma-Aldrich and used without further purification. THF was distilled from 3Å MS and stored under an atmosphere of nitrogen. TLC was carried out on silica gel 60 F254 plates (Merck) and visualized with UV light and *p*-anisaldehyde solution followed by heating. Flash chromatography was performed on Merck silica gel (60, particle size: 0.040-0.063 mm). NMR spectra were recorded in $CDCl_3$ by a Varian 400 spectrometer or a Bruker 400 spectrometer, chemical shifts (δ) are reported in ppm and are internally referenced to residual solvent (^{1}H-NMR: 7.26 ppm and ^{13}C-NMR: 77.00 ppm for $CDCl_3$). Multiplicities are indicated by s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet) and bs (broad signal). Coupling constants (J) are reported in Hz. Yields are given for isolated products showing one spot on a TLC plate and no impurities detectable in the NMR spectrum. HRESIMS were performed on an OrbiTrap high-resolution mass spectrometer (Q Exactive) equipped with the heated electrospray ionization probe HESI-II (Thermo Fisher Scientific, Bremen, Germany) operating in both positive and negative ion modes.

Experimental Protocols and Characterization data

General procedure for the synthesis of 4

In a dry round-bottom flask, a solution of diisopropylamine (1.5 eq, 0.37 mmol, 52.6 µL) in dry THF (0.5 mL) was stirred at -10°C for 15 min under N_2 atmosphere. Then *n*BuLi (solution 2.5 M in hexanes, 2.0 eq, 0.50 mmol, 0.2 mL) was added dropwise followed by a solution of ethynyl-3,5-dimethoxybenzene **2** (0.25 mmol, 40.5 mg) in dry THF (1.0 mL). After 20 min, the appropriate alkyl iodide **3** (2.0 eq, 0.50 mmol) was added and the resulting mixture was allowed to stir for 3h (24h for **3b**) at rt. Then the mixture was diluted with H_2O (6.0 mL) and it was extracted with EtOAc (5.0 mL x 3). The organic layers were combined and dried over anhydrous Na_2SO_4. After filtration and evaporation of the solvent under reduced pressure, no purification of the crude product was required.

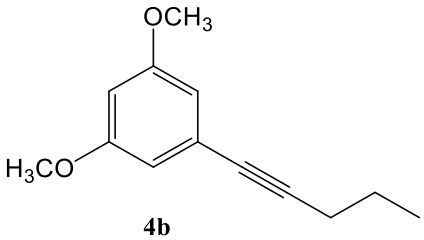
***1,3-dimethoxy-5-(prop-1'-ynyl)benzene* 4a**



4a

The spectroscopic data of **4a** matched the ones reported in the literature.[1] Pale yellow oil. Crude product. ^{1}H-NMR ($CDCl_3$): δ 6.55 (d, J=2.4 Hz, 2H), 6.40 (t, J=2.4 Hz, 1H), 3.77 (s, 6H), 2.04 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 160.4, 125.3, 109.3, 101.0, 85.5, 79.7, 55.3, 4.3.

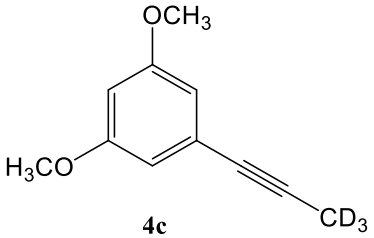
***1,3-dimethoxy-5-(pent-1'-ynyl)benzene* 4b**



4b

The spectroscopic data of **4b** matched the ones reported in the literature.[2] Yellow oil. Crude product. ^{1}H-NMR ($CDCl_3$): δ 6.56 (d, J=2.4 Hz, 2H), 6.40 (t, J=2.4 Hz, 1H), 3.77 (s, 6H), 2.37 (t, J=7.2 Hz, 2H), 1.67-1.58 (m, 2H), 1.04 (t, J=7.6 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 160.4, 125.3, 109.2, 101.0, 89.9, 80.6, 55.3, 22.1, 21.3, 13.5.

***1,3-dimethoxy-5-(prop-1'-ynyl[3',3',3'-d_3])benzene* 4c**



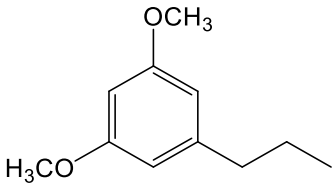
4c

Pale yellow oil. Crude product. ^{1}H-NMR ($CDCl_3$): δ 6.55 (d, J=2.4 Hz, 2H), 6.40 (t, J=2.4 Hz, 1H), 3.77 (s, 6H); ^{13}C-NMR ($CDCl_3$): δ 160.4, 125.3, 109.3, 101.0, 85.0, 79.8, 55.3. HRMS (ESI) m/z for $C_{11}H_{10}D_3O$ $[M+H]^+$ calcd 180.1098, found 180.1112.

General procedure for the synthesis of 5a-c

Pd/C (30 w %) and EtOH (3 mL) or H_2O (3 mL) were placed in a dry 50 mL two-neck round-bottom flask. After five vacuum/H_2 cycles, the mixture was stirred at room temperature overnight, then a solution of **4** (0.25 mmol) in THF (1.5 mL) was added. After 24 h stirring at room temperature, the reaction mixture was filtered or alternatively centrifuged, then, EtOAc and H_2O were added and the aqueous layer was extracted with EtOAc (2 x 5 mL). The organic layers were combined and dried over anhydrous Na_2SO_4. After filtration and evaporation of the solvent under reduced pressure, no purification of the crude product was required.

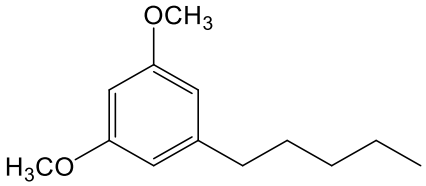
1,3-dimethoxy-5-propylbenzene **5a**



5a

The spectroscopic data of **5a** matched the ones reported in the literature.[3,4] Yellow oil. Crude product. ^{1}H-NMR ($CDCl_3$): δ 6.35 (d, J=2.4 Hz, 2H), 6.30 (t, J=2.4 Hz, 1H), 3.78 (s, 6H), 2.55-2.51 (m, 2H), 1.69-1.59 (m, 2H), 0.95 (t, J=7.2 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 160.6, 145.1, 106.5, 97.5, 55.2, 38.4, 24.3, 13.8.

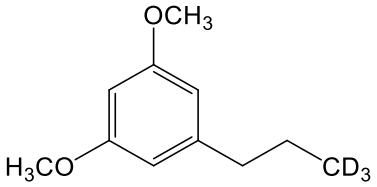
1,3-dimethoxy-5-pentylbenzene **5b**



5b

The spectroscopic data of **5b** matched the ones reported in the literature.[3] Yellow oil. Crude product. ^{1}H-NMR ($CDCl_3$): δ 6.35 (d, J=2.4 Hz, 2H), 6.30 (t, J=2.4 Hz, 1H), 3.78 (s, 6H), 2.54 (t, J=7.6 Hz, 2H), 1.65-1.57 (m, 2H), 1.37-1.29 (m, 4H), 0.89 (t, J=7.2 Hz, 3H); ^{13}C-NMR (CDCl3): δ 160.6, 145.2, 106.5, 97.5, 55.2, 36.5, 31.4, 31.0, 22.1, 13.9.

1,3-dimethoxy-5-[3',3',3'-d_3]propylbenzene **5c**



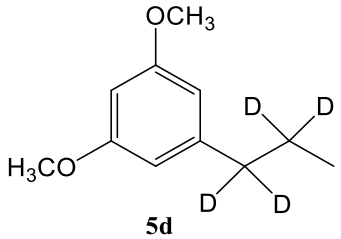
5c

The spectroscopic data of **5c** matched the ones reported in the literature.[5] Pale yellow oil. Crude product. ^{1}H-NMR ($CDCl_3$): δ 6.35 (d, J=2.4 Hz, 2H), 6.30 (t, J=2.4 Hz, 1H), 3.78 (s, 6H), 2.53 (t, J=7.6 Hz, 2H), 1.62 (t, J=7.6 Hz, 2H); ^{13}C-NMR ($CDCl_3$): δ 160.6, 145.1, 106.5, 97.5, 55.2, 38.3, 24.1.

General procedure for the preparation of 5d-e

Pd/C (30 w %) and D_2O (3 mL) were placed in a dry 50 mL two-neck round-bottom flask. After five vacuum/H_2 cycles, the system was closed and the mixture was stirred at room temperature for 24 h, then a solution of **4** (0.25 mmol) in THF (1.5 mL) was added. After 6 h stirring at room temperature the reaction mixture was filtered or alternatively centrifuged, then EtOAc and H_2O were added and the aqueous layer was extracted with EtOAc (2 x 5 mL). The organic layers were combined and dried over anhydrous Na_2SO_4. After filtration and evaporation of the solvent under reduced pressure, no purification of the crude product was required.

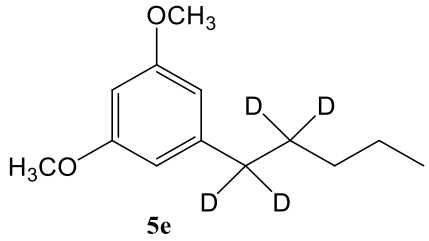
1,3-dimethoxy-5-[1',1',2',2'-d_4]propylbenzene **5d**



5d

Yellow oil. Crude product. ^{1}H-NMR ($CDCl_3$): δ 6.35 (d, J=2.4 Hz, 2H), 6.31 (t, J=2.4 Hz, 1H), 3.79 (s, 6H), 0.93 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 160.6, 145.0, 106.5, 97.5, 55.2, 13.6. HRMS (ESI) m/z for $C_{11}H_{13}D_4O_2$ $[M+H]^+$ calcd 185.1474, found 185.1487.

1,3-dimethoxy-5-[1',1',2',2'-d$_4$]pentylbenzene **5e**



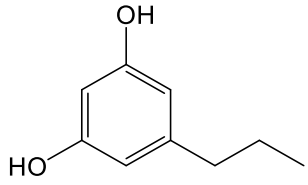
5e

Yellow oil. Crude product. ^{1}H-NMR ($CDCl_3$): δ 6.36 (d, J=2.4 Hz, 2H), 6.31 (t, J=2.4 Hz, 1H), 3.79 (s, 6H), 1.36-1.32 (m, 4H), 0.91 (t, J=7.2 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 160.6, 145.3, 106.4, 97.5, 55.1, 35.5 (m), 31.2, 30.0 (m), 22.5, 14.0. HRMS (ESI) m/z for $C_{13}H_{17}D_4O_2$ $[M+H]^+$ calcd 213.1787, found 213.1792.

General procedure for the preparation of 1

The adduct **5** (0.25 mmol) was dissolved in dry CH_2Cl_2 (5 mL) and the resulting solution was cooled to -78°C. A solution of BBr_3 in CH_2Cl_2 (sol. 1M, 4 eq, 1.0 mmol, 1.0 ml) was added dropwise. After warming at rt, the mixture was stirred overnight and then, after cooling the mixture to 0°C, H_2O (5 mL) was added dropwise until the evolution of gas ceased; the aqueous layer was extracted with CH_2Cl_2 (1 x 5 ml) and EtOAc (2 x 5 mL). The organic layers were combined and dried over anhydrous Na_2SO_4. After filtration and evaporation of the solvent under reduced pressure, the crude mixture was directly purified by column chromatography (silica gel, petroleum ether/EtOAc 7/3) to obtain pure products **1**.

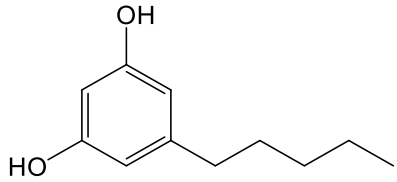
5-propylbenzene-1,3-diol **1a**



1a

The spectroscopic data of **1a** matched the ones reported in the literature.[4] Yellow oil. 33.3 mg (0.219 mmol, 88% yield from **2**). Rf 0.3 in Etp/AcOEt 7/3. ^{1}H-NMR ($CDCl_3$): δ 6.25 (d, J=2.4 Hz, 2H), 6.19 (t, J=2.4 Hz, 1H), 5.07 (bs, 1H), 2.42 (t, J=7.2 Hz, 2H), 1.60-1.50 (m, 2H), 0.89 (t, J=7.2 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 156.3, 146.0, 108.2, 100.3, 37.8, 24.1, 13.7.

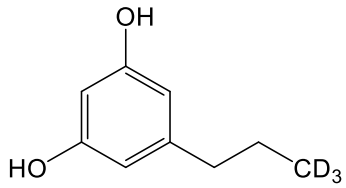
5-pentylbenzene-1,3-diol (olivetol) **1b**



1b

The spectroscopic data of **1b** matched the ones reported in the literature.[2] Yellow vax. 39.6 mg (0.22 mmol, 88% yield from **2**). Rf 0.3 in Etp/AcOEt 7/3. ^{1}H-NMR ($CDCl_3$): δ 6.24 (m, 2H), 6.17 (m, 1H), 4.65 (bs, 2H), 2.49 (t, J=7.6 Hz, 2H), 1.62-1.54 (m, 2H), 1.38-1.25 (m, 4H), 0.89 (t, J=7.2 Hz, 3H); ^{13}C-NMR (CDCl3): δ 156.6, 108.2, 100.5, 35.8, 31.4, 30.8, 22.5, 13.9.

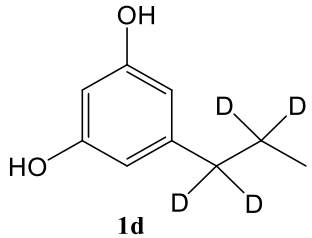
5-(propyl-3,3,3-d_3)benzene-1,3-diol **1c**



1c

The spectroscopic data of **1c** matched the ones reported in the literature.[5,6] Pale yellow oil. 33.7 mg (0.22 mmol, 87% yield from **2**). Rf 0.3 in Etp/AcOEt 7/3. ^{1}H-NMR ($CDCl_3$): δ 6.80 (bs, 2H), 6.27 (d, J=2.4 Hz, 2H), 6.22 (t, J=2.4 Hz, 1H), 2.35 (t, J=7.6 Hz, 2H), 1.47 (t, J=7.6 Hz, 2H); ^{13}C-NMR ($CDCl_3$): δ 155.9, 146.2, 108.4, 100.4, 37.7, 23.7.

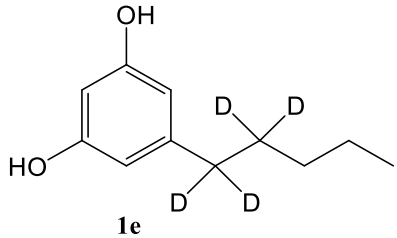
5-(propyl-1,1,2,2-d_4)benzene-1,3-diol **1d**



1d

Yellow oil. 33.5 mg (0.21 mmol, 86% yield from **2**). Rf 0.3 in Etp/AcOEt 7/3. ^{1}H-NMR ($CDCl_3$): δ 6.25 (d, J=2.4 Hz, 2H), 6.19 (t, J=2.4 Hz, 1H), 5.29 (bs, 2H), 0.87 (bs, 3H); ^{13}C-NMR ($CDCl_3$): δ 156.4, 145.9, 108.1, 100.2, 13.5. HRMS (ESI) m/z for $C_9H_8D_4NaO_2$ $[M+Na]^+$ calcd 179.0981, found 179.0970.

***5-(pentyl-1,1,2,2-d$_4$)benzene-1,3-diol* 1e**



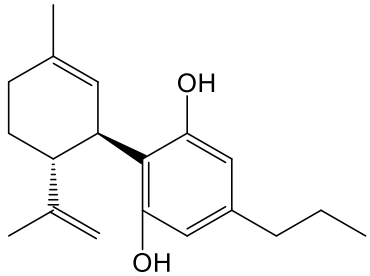
1e

Yellow oil. 42 mg (0.23 mmol, 91% yield from **2**). Rf 0.3 in Etp/AcOEt 7/3. ^{1}H-NMR ($CDCl_3$): δ 6.41 (bs, 2H), 6.26 (d, J=2.4 Hz, 2H), 6.21 (t, J=2.4 Hz, 1H), 1.32-1.21 (m, 4H), 0.86 (t, J=7.2 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 156.4, 146.0, 108.0, 100.2, 35.0 (m), 31.2, 29.7 (m), 22.4, 13.9. HRMS (ESI) m/z for $C_{11}H_{12}D_4NaO_2$ $[M+H]^+$ calcd 207.1294, found 207.1301.

General procedure for the preparation of 7 and 8

To a solution of alkylresorcinol **1** (0.19 mmol) and *p*TSA (33 mol %, 11.9 mg) in toluene (1.5 mL), a solution of terpene **6** (1 eq, 0.19 mmol, 28.9 mg) in toluene (0.5 mL) was added dropwise at 0°C. The mixture was stirred at this temperature for 3 h, then H_2O (5 mL) was added. After warming at rt, the aqueous layer was extracted with EtOAc (3 x 5 mL). The organic layers were combined and dried over anhydrous Na_2SO_4. After filtration and evaporation of the solvent under reduced pressure, the crude mixture was directly purified by column chromatography (silica gel, petroleum ether/EtOAc 9/1) to obtain pure products **7** and **8**.

***Cannabidivarin (CBDV)* 7a**

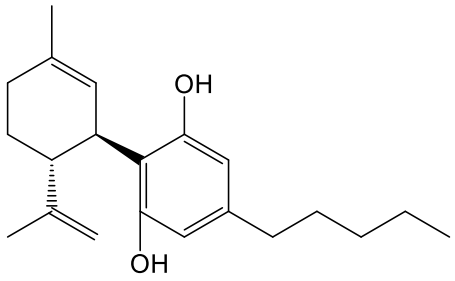


7a

The spectroscopic data of **7a** matched the ones reported in the literature.[4] Yellow vax. 13.6 mg (0.047 mmol, 25% yield). Rf 0.6 in Etp/AcOEt 9/1. ^{1}H-NMR ($CDCl_3$): δ 6.28-6.15 (m, 2H), 5.98 (bs, 1H), 5.57 (bs, 1H), 4.67-4.64 (m, 2H), 4.56-4.55 (m, 1H), 3.87-3.81 (m, 1H), 2.44-2.36 (m, 3H), 2.27-2.18 (m, 1H), 2.12-2.06 (m, 1H), 1.86-1.75 (m and s overlapping, total 5H, especially

1.79, s, 3H), 1.66 (s, 3H), 1.63-1.53 (m, 2H), 0.90 (t, J=7.2 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 149.4, 142.7, 140.1, 124.1, 113.7, 110.8, 46.1, 37.5, 37.2, 30.4, 28.4, 24.0, 23.7, 20.5, 13.8.

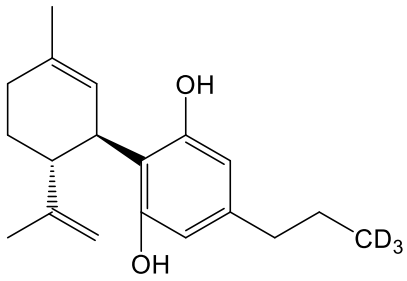
***Cannabidiol (CBD)* 7b**



7b

The spectroscopic data of **7b** matched the ones reported in the literature.[4,7,8] Pale yellow vax. 15.4 mg (0.049 mmol, 26% yield). Rf 0.6 in Etp/AcOEt 9/1. ^{1}H-NMR (CDCl3): δ 6.29-6.13 (m, 2H), 5.98 (bs, 1H), 5.57-5.56 (m, 1H), 4.67-4.62 (m, 2H), 4.56 (m, 1H), 3.88-3.81 (m, 1H), 2.46-2.36 (m, 3H), 2.29-2.18 (m, 1H), 2.13-2.05 (m, 1H), 1.86-1.72 (m and s overlapping, total 5H, especially 1.79, s, 3H), 1.65 (s, 3H), 1.60-1.51 (m, 2H), 1.35-1.22 (m, 4H), 0.88 (t, J=7.2 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 149.4, 143.0, 140.1, 124.1, 113.7, 110.8, 46.1, 37.2, 35.4, 31.5, 30.6, 30.4, 28.4, 23.7, 22.5, 20.5, 14.0.

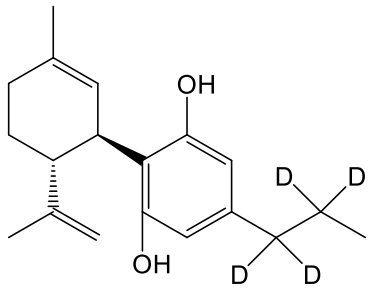
***Cannabidivarin-d_3 (CBDV-d_3)* 7c**



7c

The spectroscopic data of **7c** matched the ones reported in the literature.[8] Yellow vax. 13.2 mg (0.045 mmol, 24% yield). Rf 0.6 in Etp/AcOEt 9/1. ^{1}H-NMR ($CDCl_3$): δ 6.28-6.15 (m, 2H), 5.99 (bs, 1H), 5.57-5.56 (m, 1H), 4.80 (m, 1H), 4.67-4.65 (m, 1H), 4.56-4.55 (m, 1H), 3.89-3.82 (m, 1H), 2.44-2.36 (m, 3H), 2.27-2.18 (m, 1H), 2.12-2.06 (m, 1H), 1.86-1.75 (m and s, overlapping, total 5H, especially 1.79, s, 3H), 1.66 (s, 3H), 1.56 (t, J=7.2 Hz, 2H); ^{13}C-NMR ($CDCl_3$): δ 149.4, 142.8, 140.1, 124.1, 113.7, 110.8, 46.1, 37.5, 37.2, 30.4, 28.4, 23.7, 20.5.

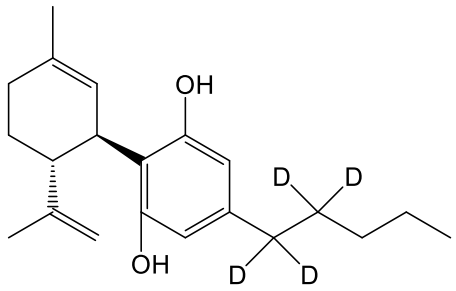
Cannabidivarin-d_4 (CBDV-d_4) **7d**



7d

Yellow vax. 11.6 mg (0.040 mmol, 21% yield). Rf 0.6 in Etp/AcOEt 9/1. ^{1}H-NMR ($CDCl_3$): δ 6.30-6.13 (m, 2H), 5.98 (bs, 1H), 5.57 (m, 1H), 4.67-4.60 (m, 2H), 4.56-4.55 (m, 1H), 3.89-3.80 (m, 1H), 2.39 (td, J=11.2, 3.6 Hz, 1H), 2.30-2.18 (m, 1H), 2.13-2.04 (m, 1H), 1.86-1.74 (m and s overlapping, total 5H, especially 1.79, s, 3H), 1.65 (bs, 3H), 0.88 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 149.4, 142.7, 140.1, 124.1, 113.7, 110.8, 46.1, 37.2, 30.4, 28.4, 23.7, 20.5, 13.5; HRMS (ESI) m/z for $C_{19}H_{23}D_4O_2$ $[M+H]^+$ calcd 291.2257, found 291.2221.

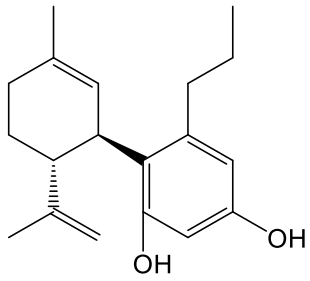
Cannabidiol-d_4 (CBD-d_4) **7e**



7e

Pale yellow vax. 14.5 mg (0.045 mmol, 24% yield). Rf 0.6 in Etp/AcOEt 9/1. ^{1}H-NMR (CDCl3): δ 6.28-6.15 (m, 2H), 6.00 (bs, 1H), 5.57 (m, 1H), 5.09 (bs, 1H), 4.65-4.63 (m, 1H), 4.54 (m, 1H), 3.90-3.83 (m, 1H), 2.46-2.36 (m, 1H), 2.29-2.18 (m, 1H), 2.13-2.05 (m, 1H), 1.86-1.72 (m and s overlapping, total 5H, especially 1.79, s, 3H), 1.66 (s, 3H), 1.35-1.22 (m, 4H), 0.86 (t, J=7.2 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 149.0, 142.8, 139.9, 124.1, 113.7, 110.8, 109.5, 107.9, 46.1, 36.9, 31.2, 30.3, 28.3, 23.6, 22.4, 20.2, 14.0. HRMS (ESI) m/z for $C_{19}H_{23}D_4O_2$ $[M+H]^+$ calcd 319.2570, found 319.2579.

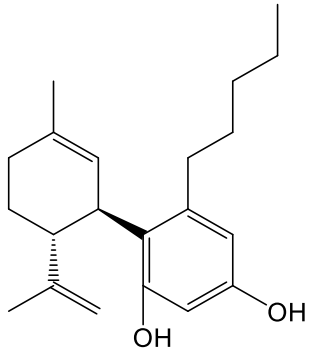
***Abn-Cannabidivarin (abn-CBDV)* 8a**



8a

The spectroscopic data of **8a** matched the ones reported in the literature.[4] Yellow oil. 16.2 mg (0.057 mmol, 30% yield). Rf 0.2 in Etp/AcOEt 9/1. ^{1}H-NMR ($CDCl_3$): δ 6.21 (d, J=2.8 Hz, 1H), 6.19 (d, J=2.8 Hz, 1H), 6.05 (bs, 1H), 5.52 (bs, 1H), 4.65-4.62 (m, 2H), 4.46 (bs, 1H), 3.54-3.51 (m, 1H), 2.62-2.54 (m, 1H), 2.51-2.44 (td, J=11.6, 3.2 Hz, 1H), 2.27-2.20 (m, 2H), 2.12-2.06 (m, 1H), 1.87-1.72 (m and s overlapping, total 5H, especially 1.79, s, 3H), 1.53 (s, 3H), 1.51-1.41 (m, 2H), 0.92 (t, J=7.2 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 156.4, 154.5, 147.6, 143.7, 139.8, 124.7, 120.0, 111.4, 108.6, 102.1, 44.9, 39.9, 36.1, 30.2, 28.1, 24.5, 23.6, 21.3, 14.2.

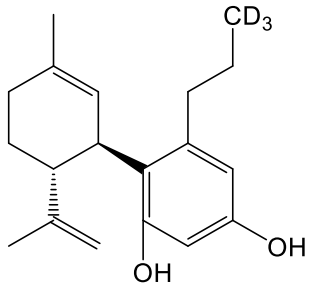
***abn-Cannabidiol (abn-CBD)* 8b**



8b

The spectroscopic data of **8b** matched the ones reported in the literature.[4,8] Yellow oil. 22.7 mg (0.072 mmol, 38% yield). Rf 0.2 in Etp/AcOEt 9/1. ^{1}H-NMR ($CDCl_3$): δ 6.21 (d, J=2.8 Hz, 1H), 6.19 (d, J=2.8 Hz, 1H), 6.06 (bs, 1H), 5.52 (bs, 1H), 4.67-4.62 (m, 2H), 4.45 (bs, 1H), 3.56-3.50 (m, 1H), 2.62-2.55 (m, 1H), 2.50-2.44 (m, 1H), 2.29-2.16 (m, 2H), 2.12-2.06 (m, 1H), 1.87-1.72 (m and s overlapping, total 5H, especially 1.79, s, 3H), 1.53 (s, 3H), 1.52-1.42 (m, 2H), 1.37-1.24 (m, 4H), 0.92 (t, J=7.2 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 156.4, 154.5, 147.6, 143.9, 139.8, 124.7, 119.9, 111.4, 108.5, 102.1, 44.9, 39.9, 33.9, 31.9, 31.1, 30.2, 28.1, 23.6, 22.5, 21.3, 14.0.

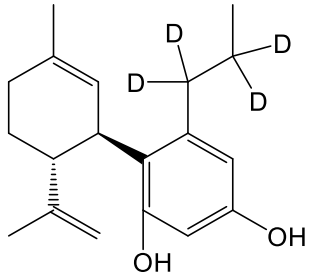
***Abn-Cannabidivarin-d_3 (CBDV-d_3)* 8c**



8c

The spectroscopic data of **8c** matched the ones reported in the literature.[8] Yellow oil. 11.0 mg (0.038 mmol, 20% yield). Rf 0.2 in Etp/AcOEt 9/1. ^{1}H-NMR ($CDCl_3$): δ 6.21 (d, J=2.8 Hz, 1H), 6.19 (d, J=2.8 Hz, 1H), 6.05 (bs, 1H), 5.52 (bs, 1H), 4.65-4.62 (m, 2H), 4.46 (bs, 1H), 3.56-3.51 (m, 1H), 2.62-2.54 (m, 1H), 2.51-2.44 (td, J=11.6, 3.2 Hz, 1H), 2.27-2.19 (m, 2H), 2.12-2.06 (m, 1H), 1.87-1.72 (m and s, overlapping, total 5H, especially 1.79, s, 3H), 1.53 (s, 3H), 1.51-1.41 (m, 2H); ^{13}C-NMR ($CDCl_3$): δ 156.4, 154.5, 147.6, 143.7, 139.8, 124.7, 120.0, 111.4, 108.6, 102.1, 44.9, 39.9, 36.0, 30.2, 28.1, 24.2, 23.6, 21.3.

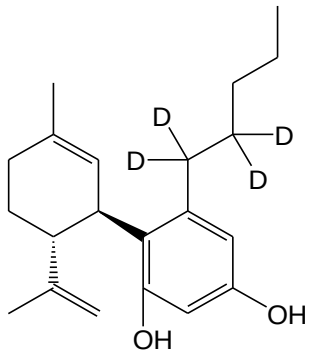
***Abn-Cannabidivarin-d_4 (abn-CBDV-d_4)* 8d**



8d

Yellow oil. 14.9 mg (0.051 mmol, 27% yield). Rf 0.2 in Etp/AcOEt 9/1. ^{1}H-NMR ($CDCl_3$): δ 6.21 (d, J=2.8 Hz, 1H), 6.18 (d, J=2.8 Hz, 1H), 6.04 (bs, 1H), 5.52 (bs, 1H), 4.65-4.62 (m, 1H), 4.46 (bs, 1H), 3.56-3.51 (m, 1H), 2.62-2.54 (m, 1H), 2.51-2.44 (m, 1H), 2.27-2.18 (m, 1H), 2.12-2.06 (m, 1H), 1.87-1.72 (m and s overlapping, total 5H, especially 1.78, bs, 3H), 1.53 (s, 3H), 0.90 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 156.4, 154.5, 147.6, 143.7, 139.8, 124.7, 120.0, 111.4, 108.5, 102.1, 44.9, 39.9, 30.2, 28.1, 23.6, 21.3, 13.9. HRMS (ESI) m/z for $C_{19}H_{23}D_4O_2$ $[M+H]^+$ calcd 291.2257, found 291.2228.

***abn-Cannabidiol-d$_4$ (abn-CBD-d$_4$)* 8e**



8e

Yellow oil. 15.7 mg (0.049 mmol, 26% yield). Rf 0.2 in Etp/AcOEt 9/1. ^{1}H-NMR ($CDCl_3$): δ 6.21 (d, J=2.8 Hz, 1H), 6.19 (d, J=2.8 Hz, 1H), 6.09 (bs, 1H), 5.52 (bs, 1H), 5.33 (bs, 1H), 4.67-4.62 (m, 1H), 4.46 (bs, 1H), 3.56-3.50 (m, 1H), 2.50-2.44 (m, 1H), 2.29-2.16 (m, 1H), 2.12-2.06 (m, 1H), 1.87-1.72 (m and s overlapping, total 5H, especially 1.79, s, 3H), 1.53 (s, 3H), 1.37-1.24 (m, 4H), 0.89 (t, J=7.2 Hz, 3H); ^{13}C-NMR ($CDCl_3$): δ 156.2, 154.6, 147.6, 143.9, 139.8, 124.7, 119.8, 111.4, 108.6, 102.1, 44.9, 40.0, 31.6, 30.2, 28.0, 23.6, 22.4, 21.3, 14.0. HRMS (ESI) m/z for $C_{19}H_{23}D_4O_2$ $[M+H]^+$ calcd 319.2570, found 319.2582.

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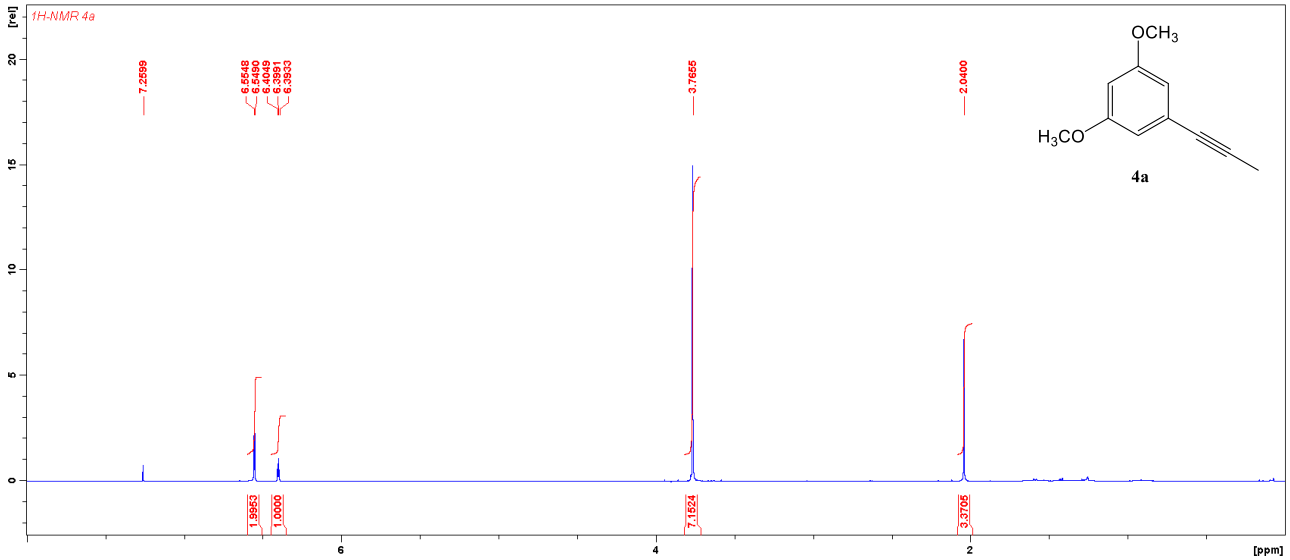
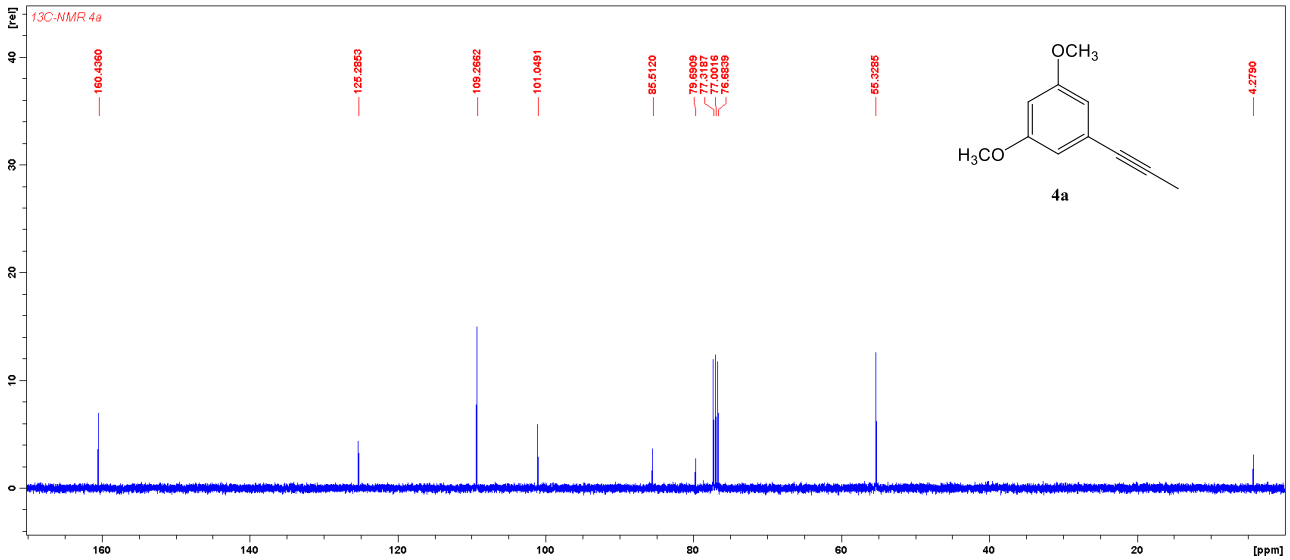
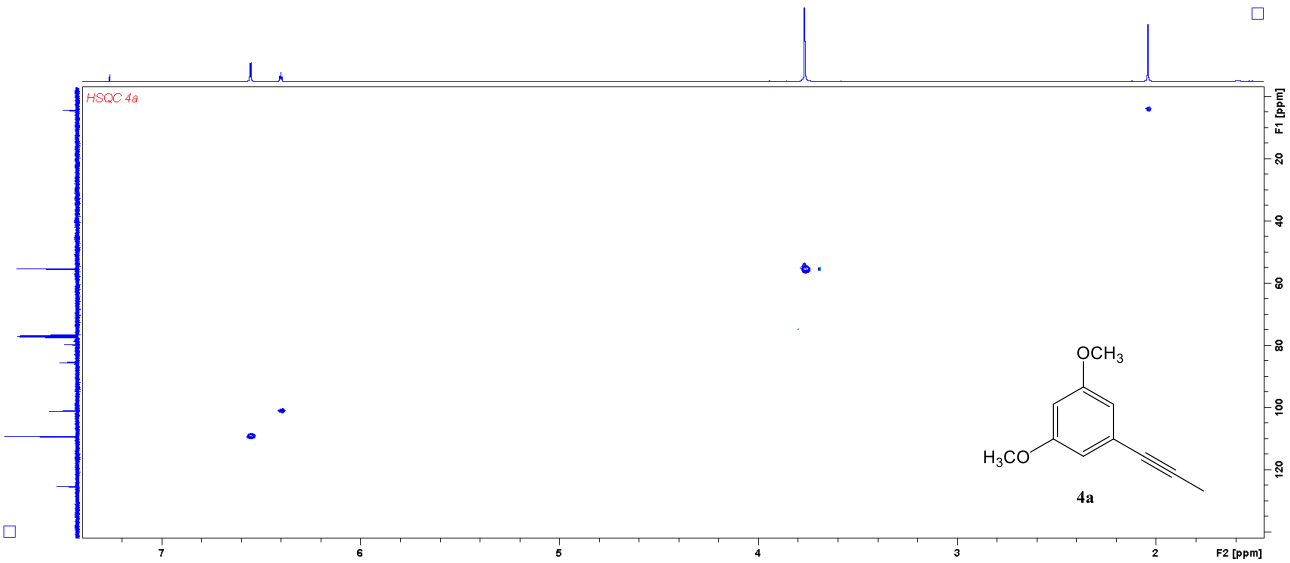
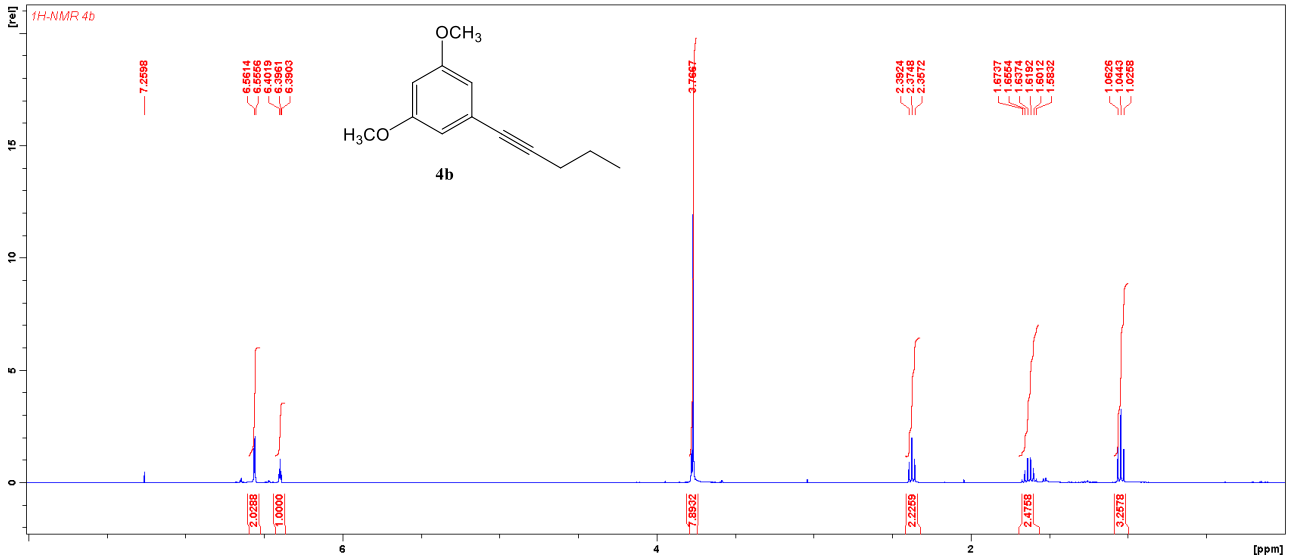
^{1}H-NMR, ^{13}C-NMR, gHSQC spectra





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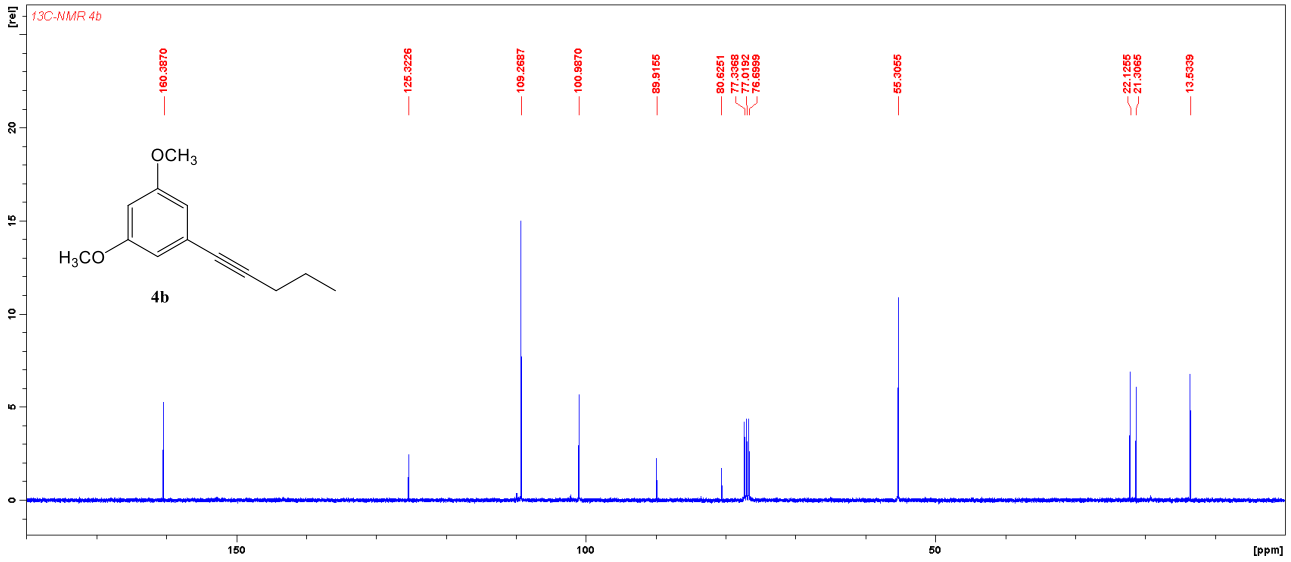
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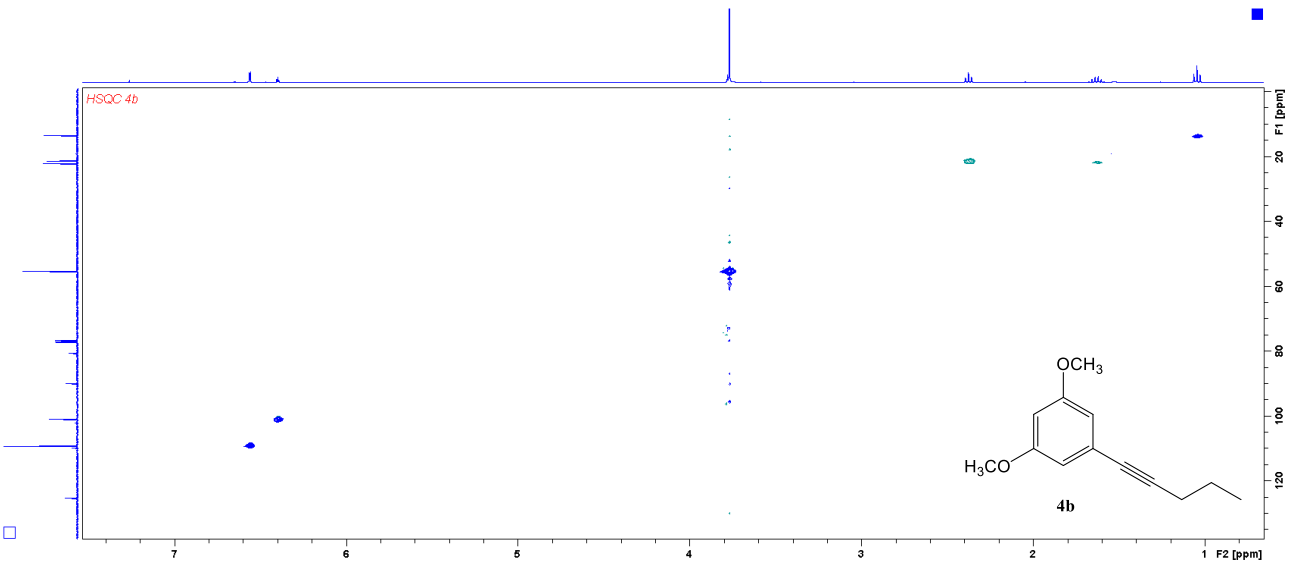
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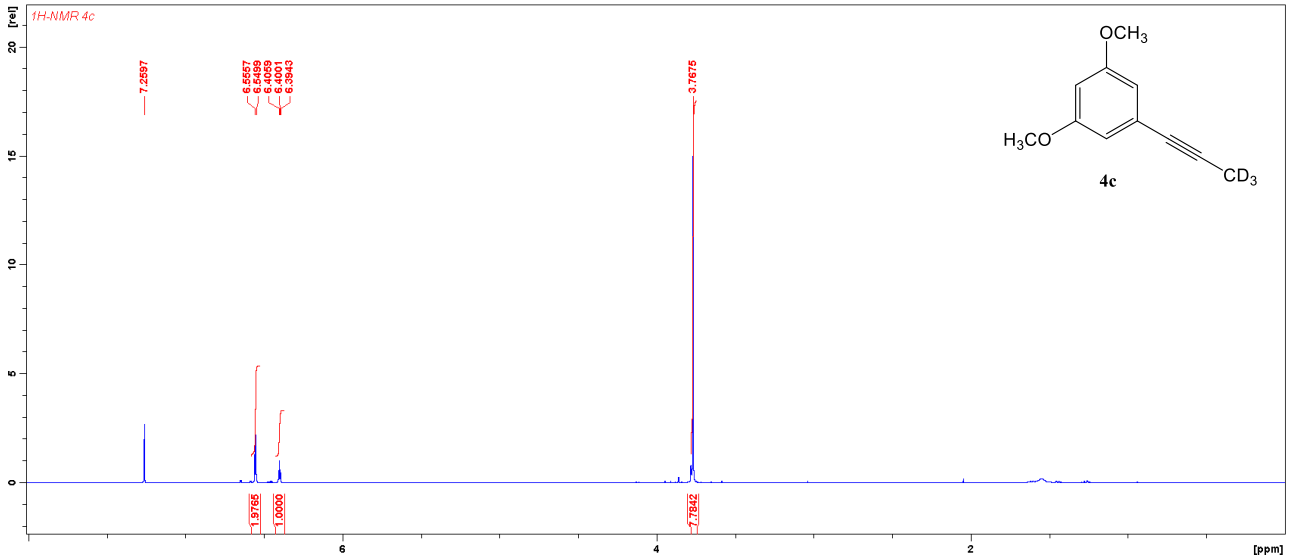
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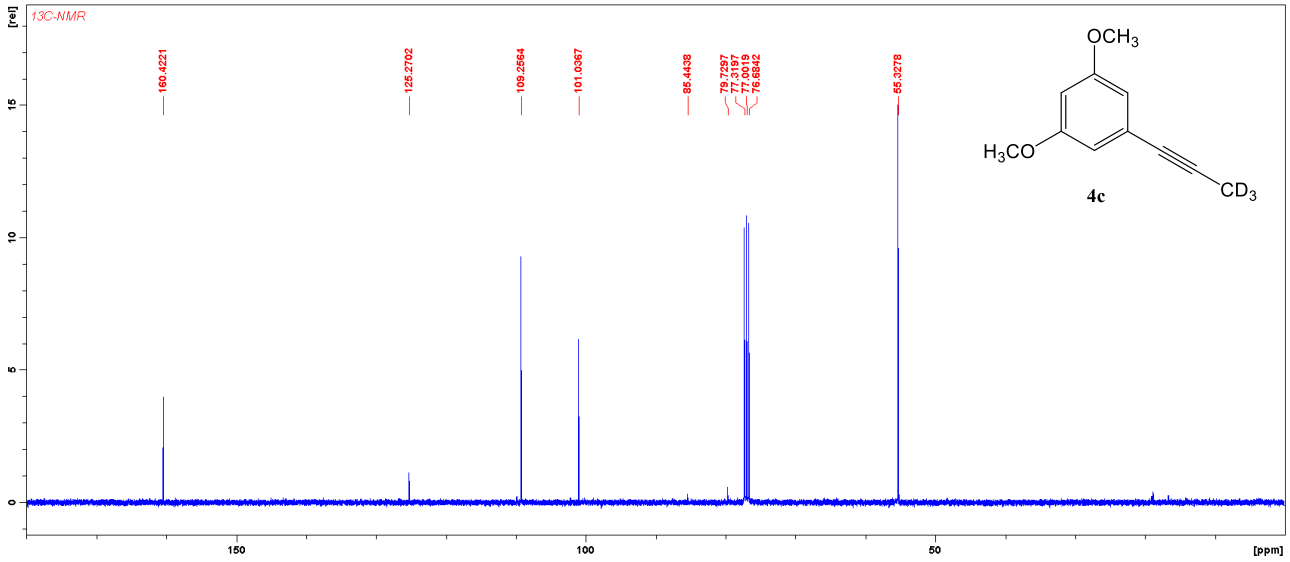
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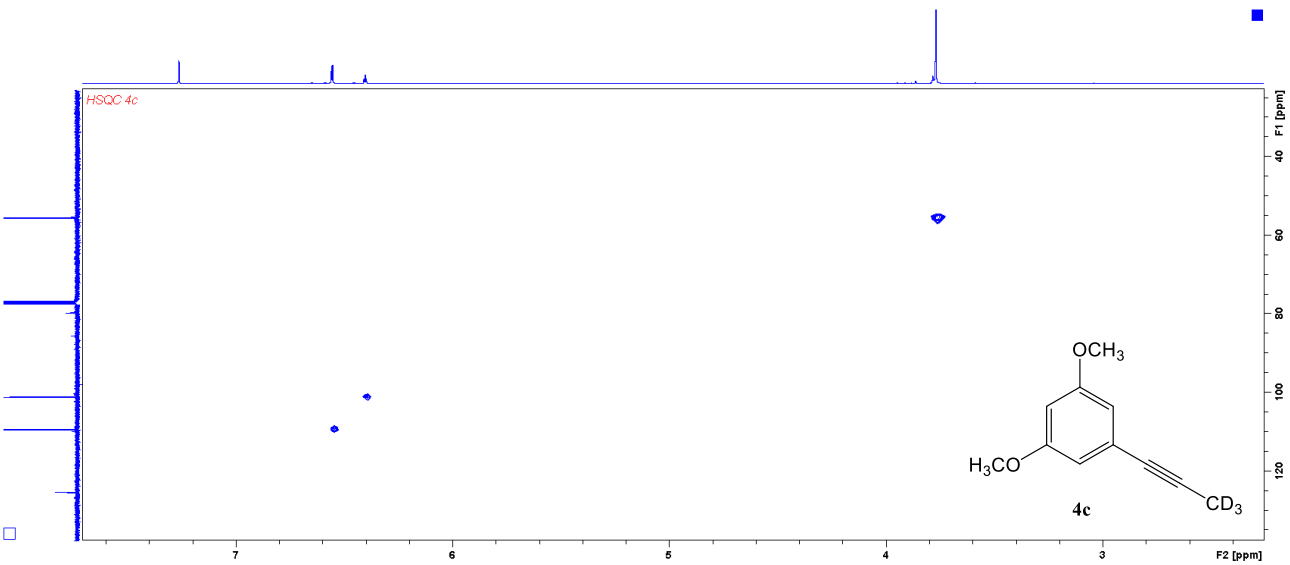
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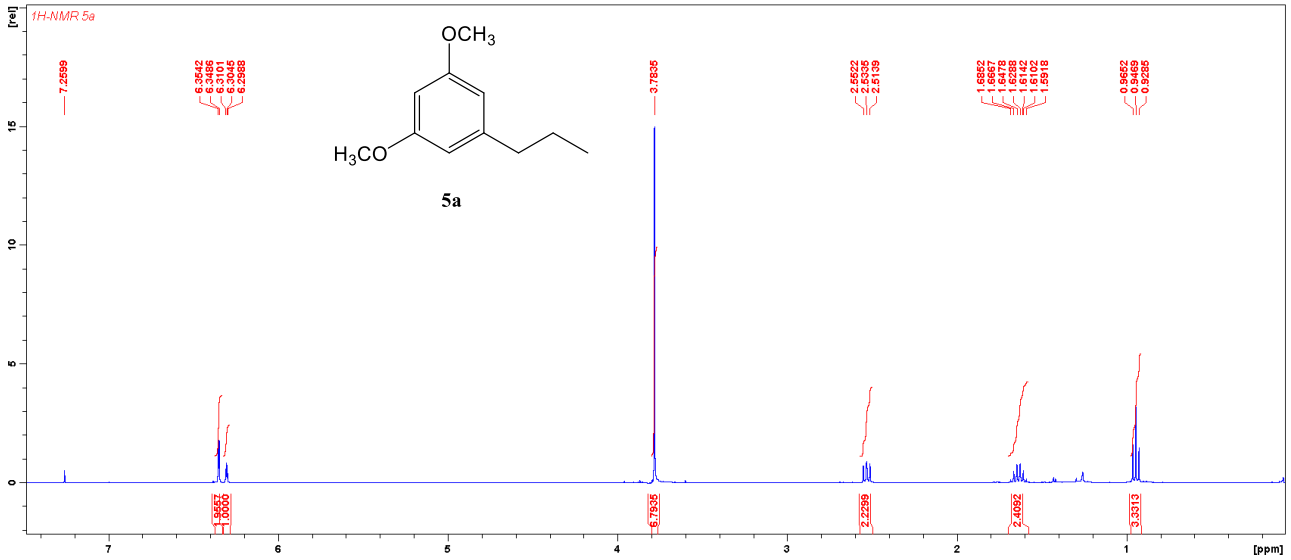
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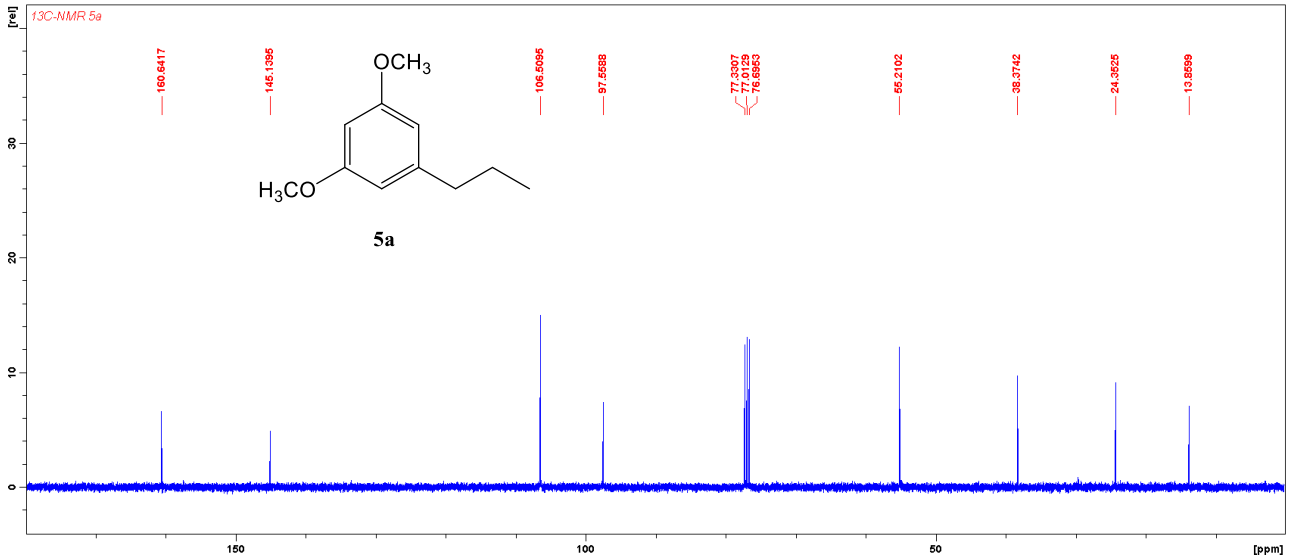
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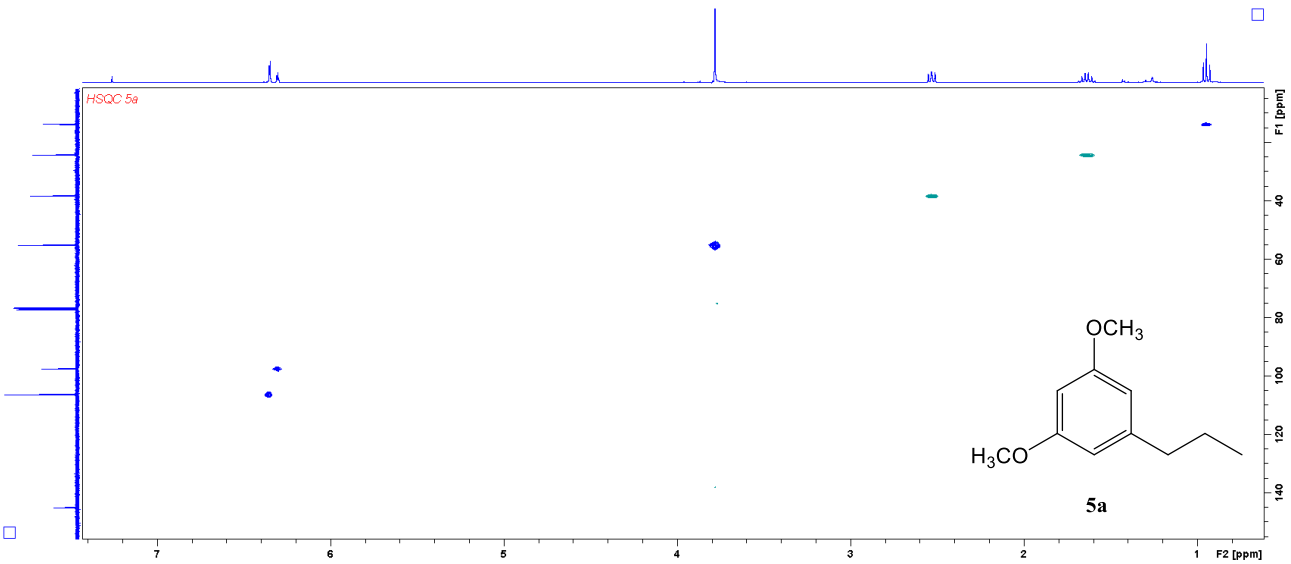
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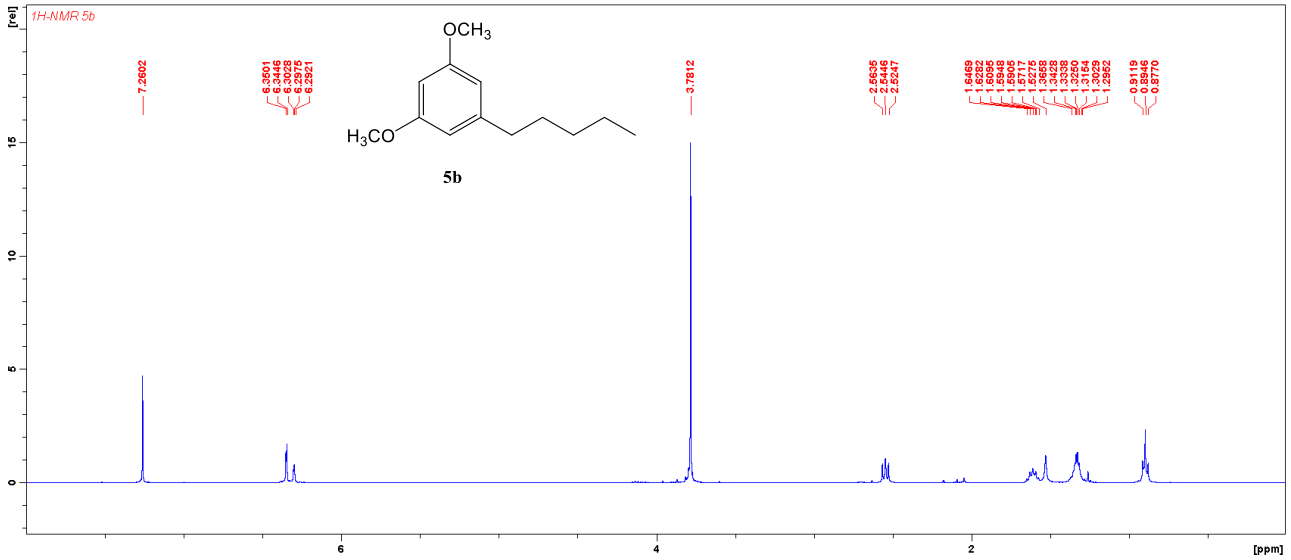
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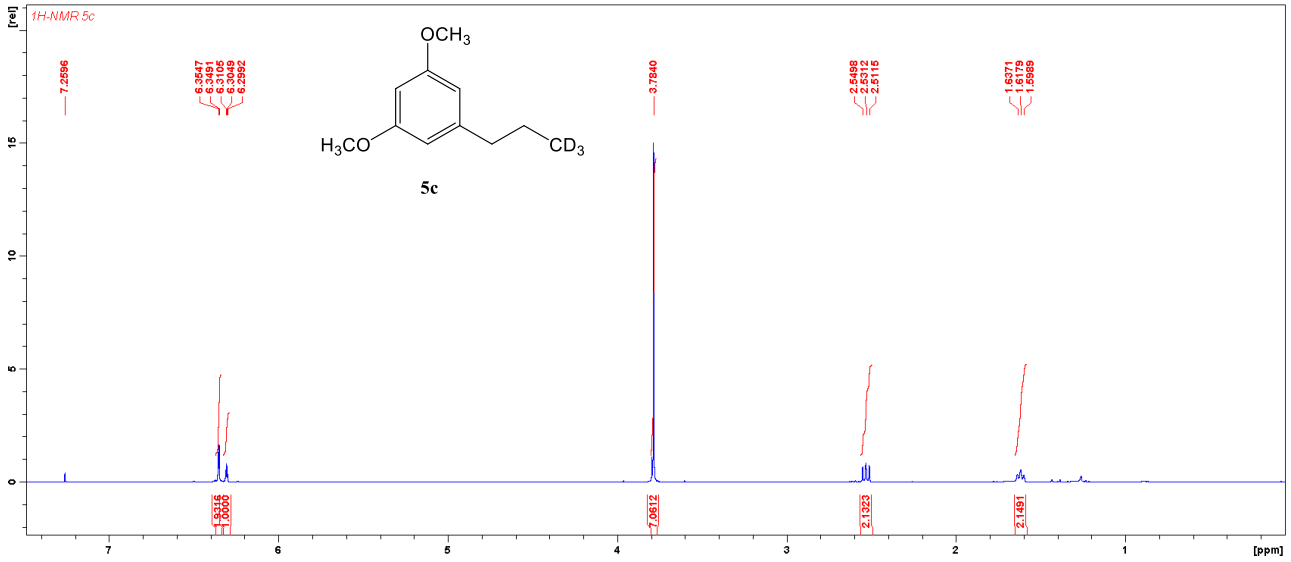
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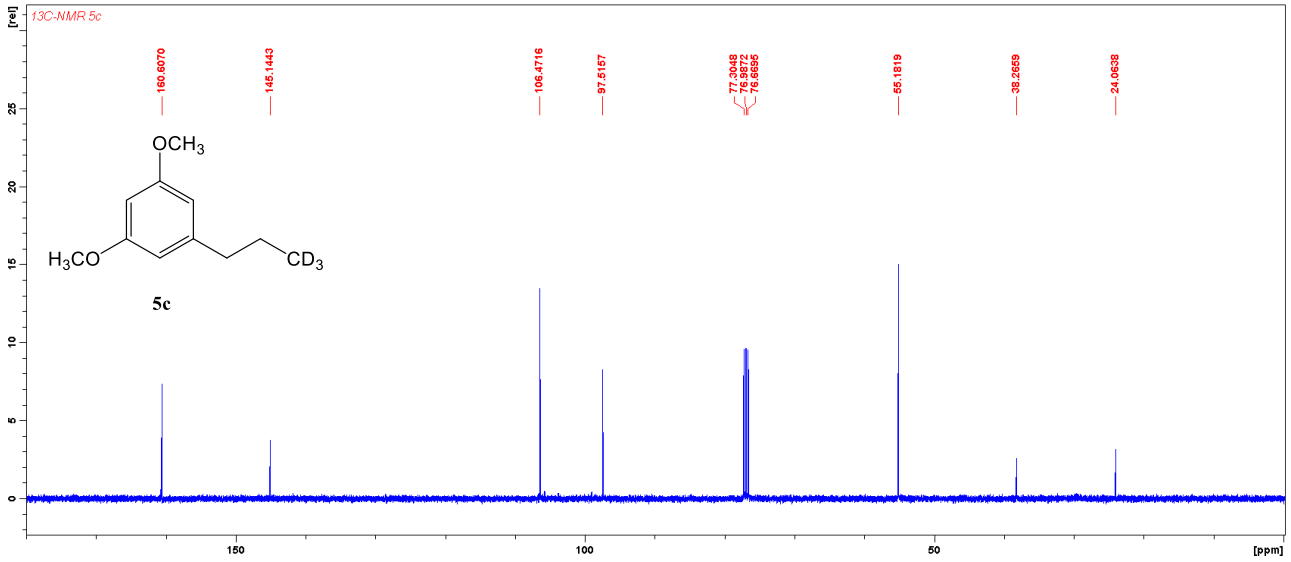
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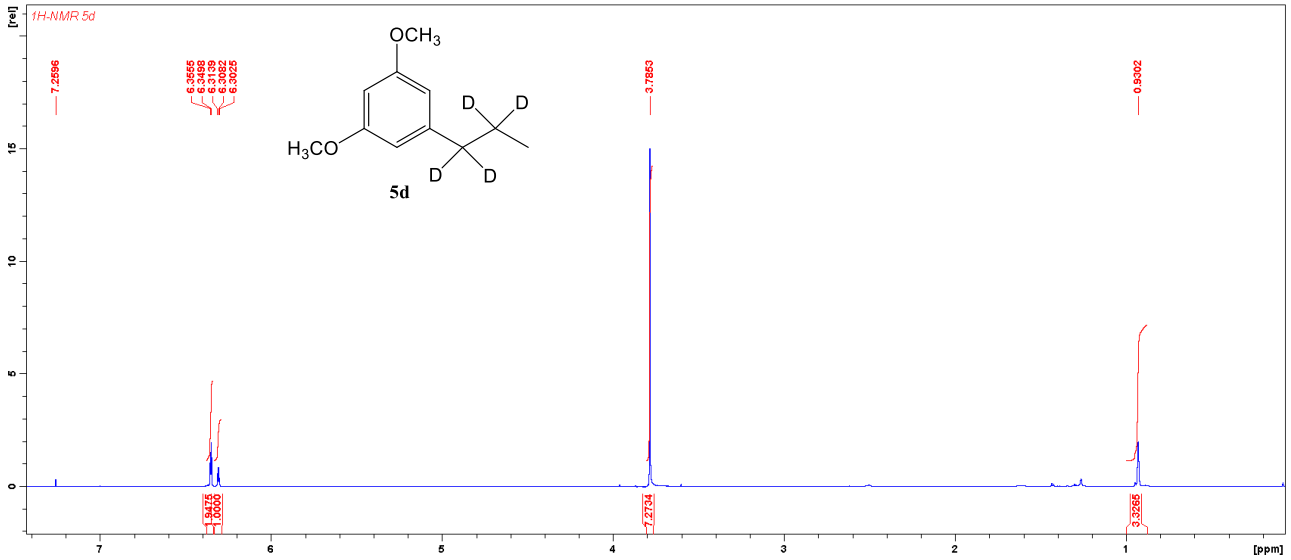
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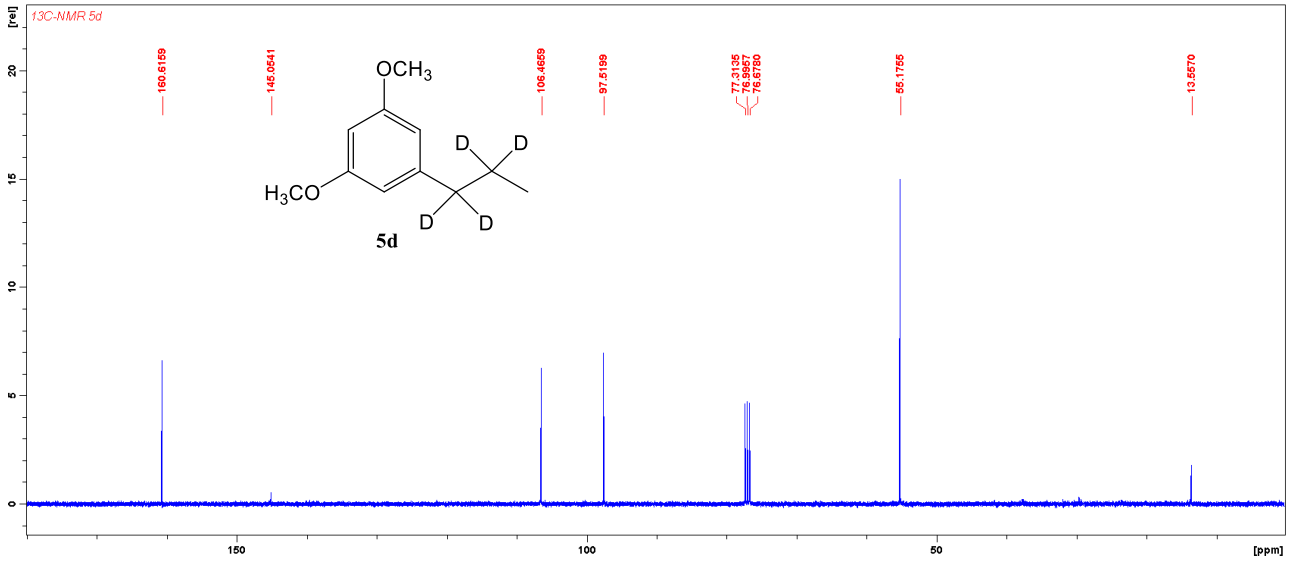
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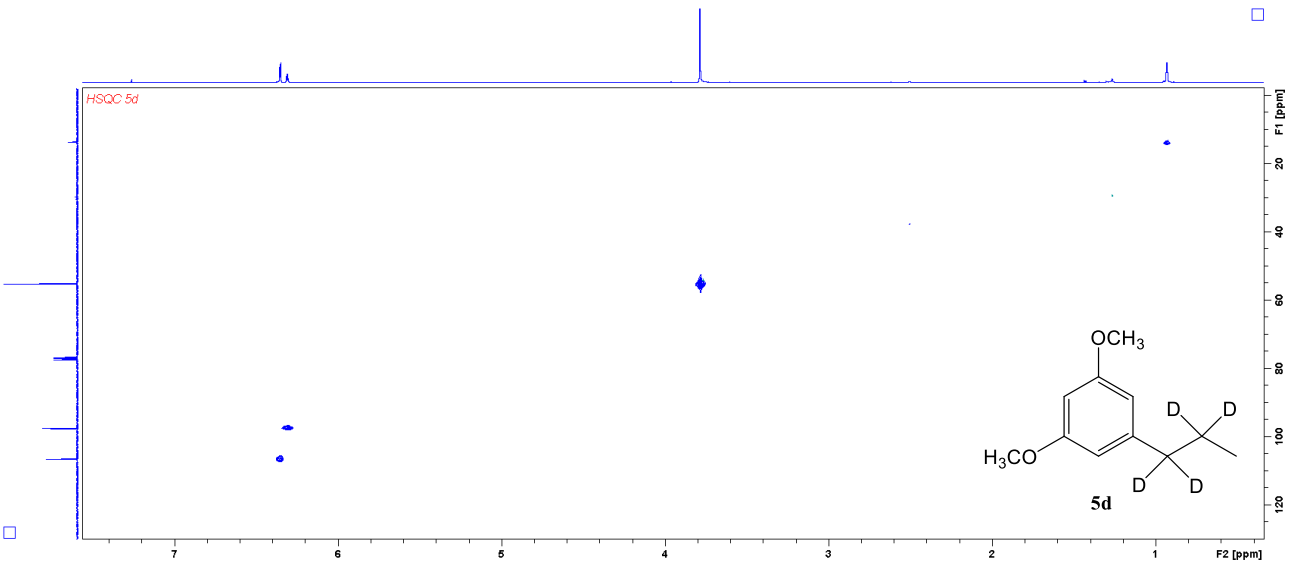
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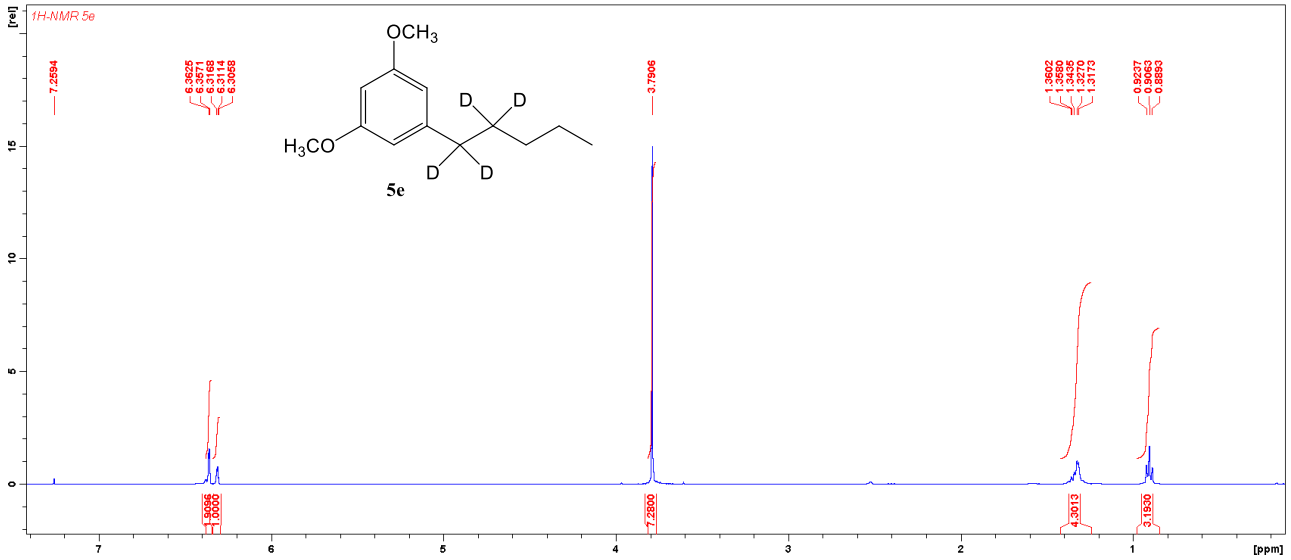
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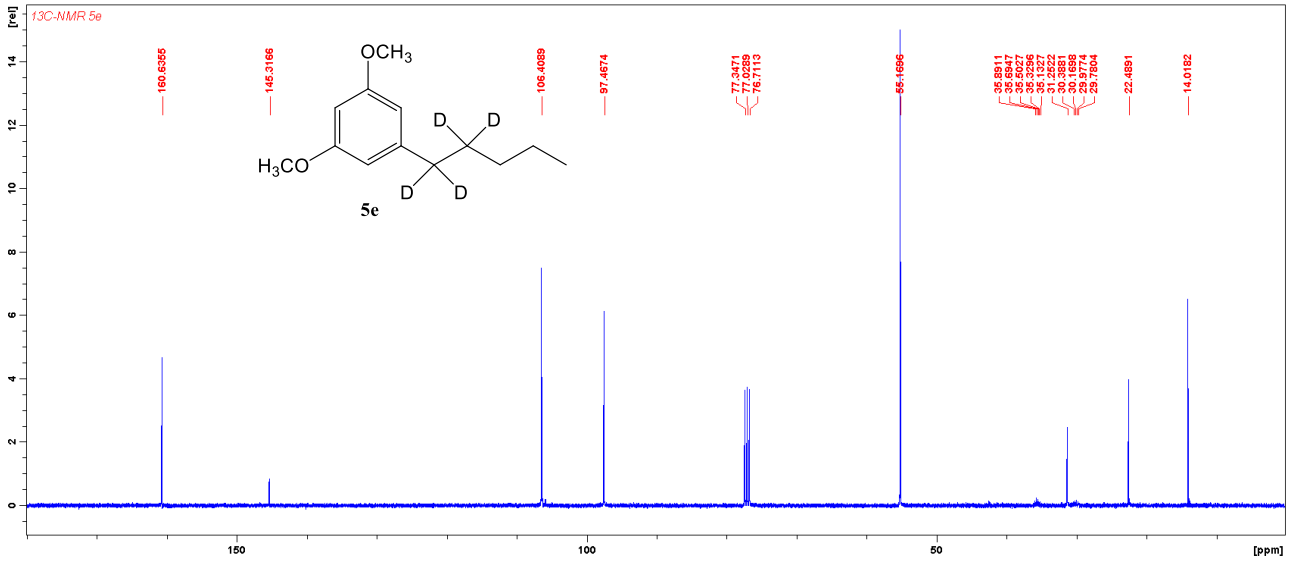
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D
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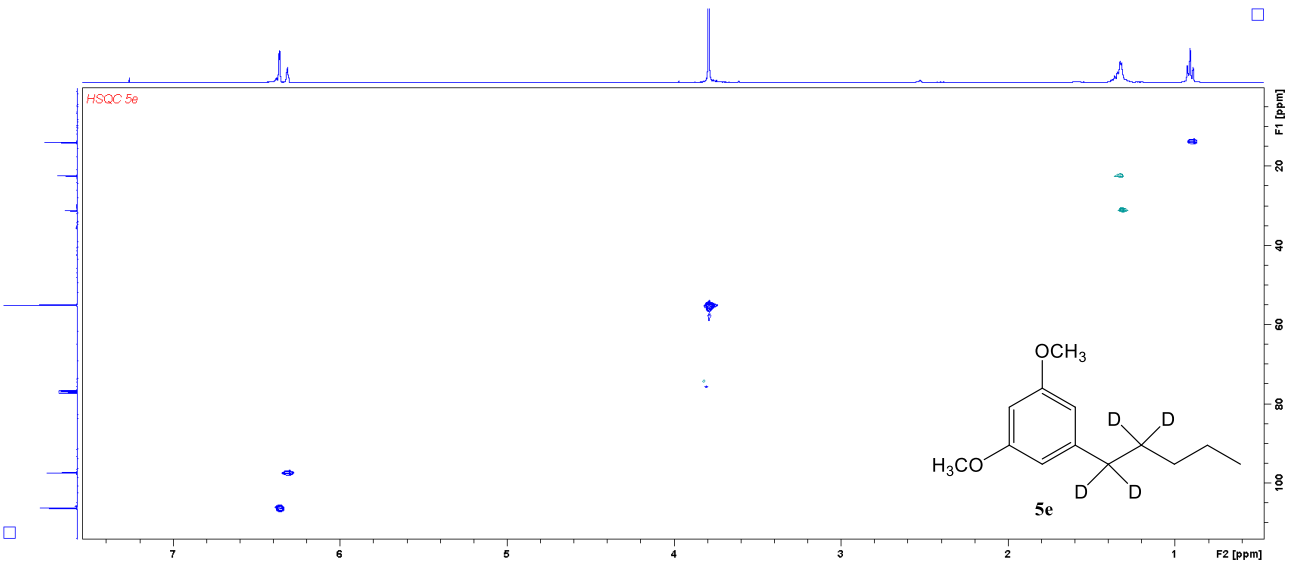
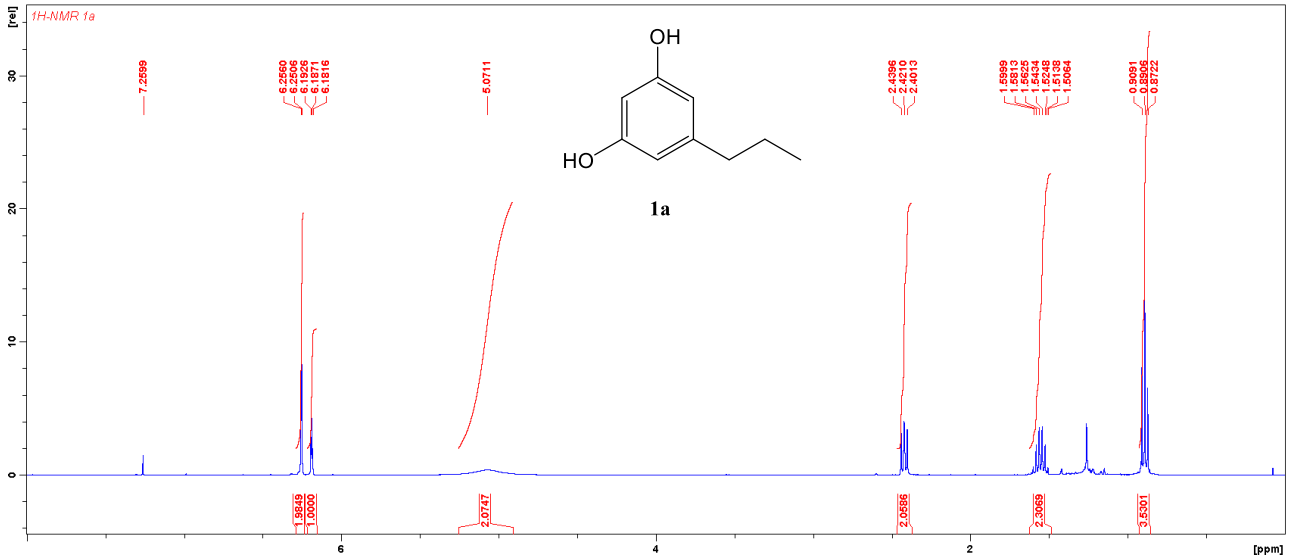
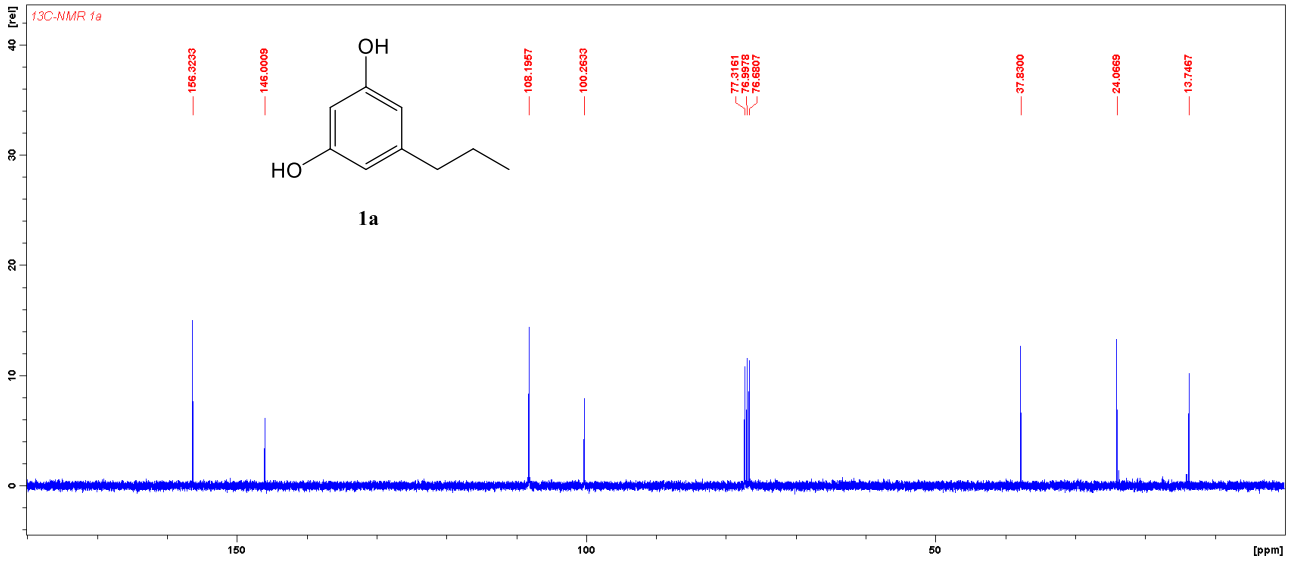
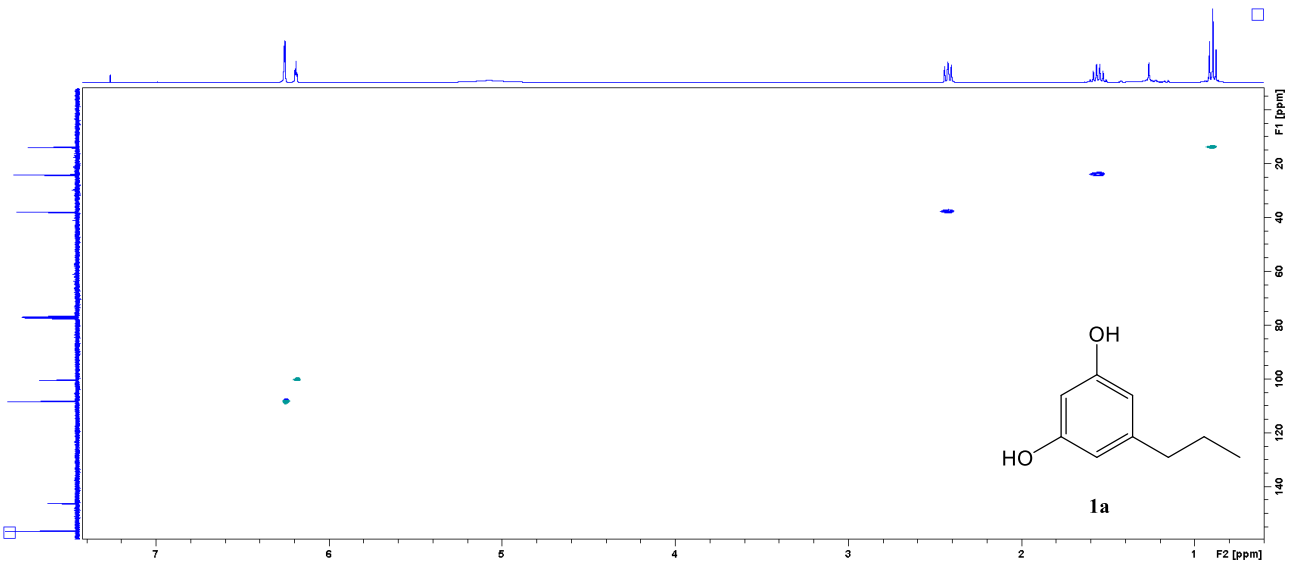
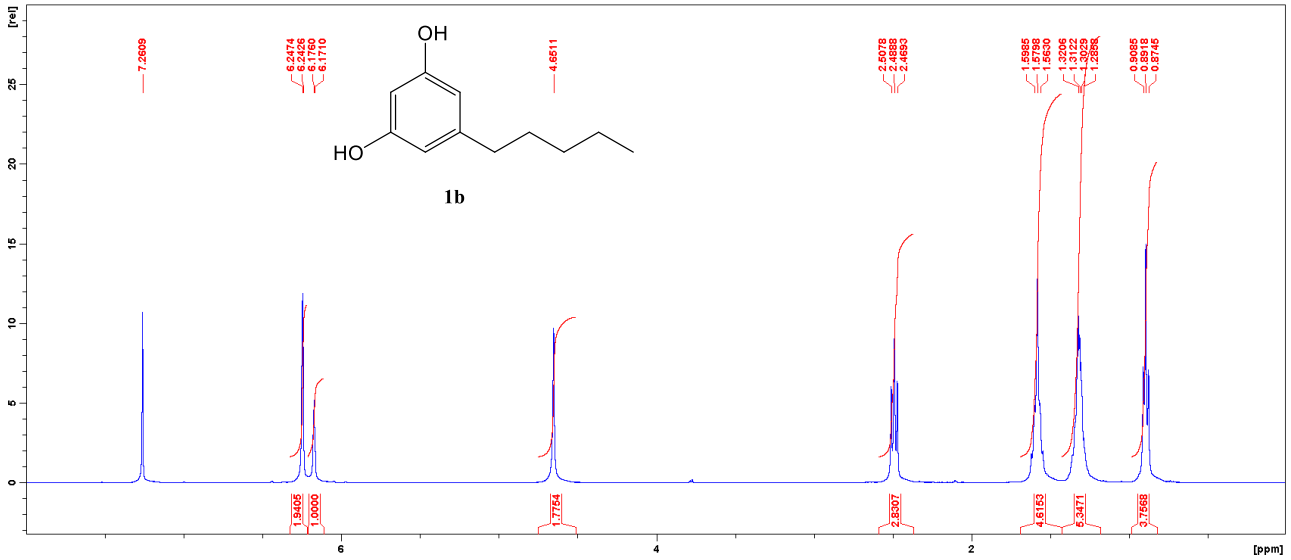
D
5e

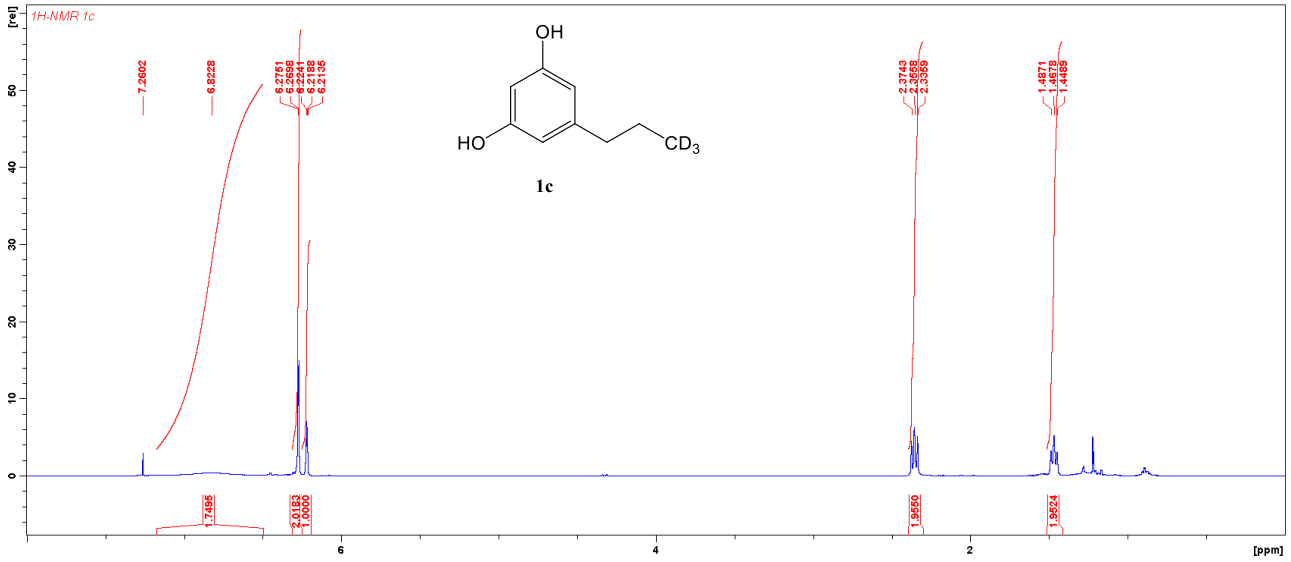

HSQC 5e
F1 [ppm]
F2 [ppm]
OCH3
H3CO
D
D
D
D
5e

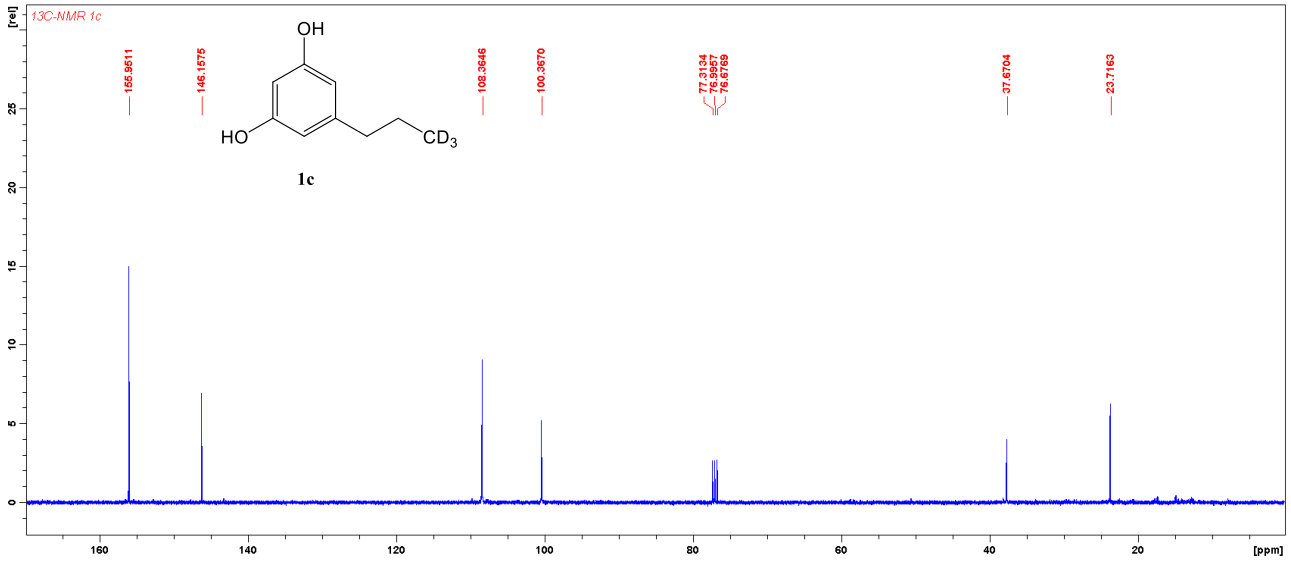

1H-NMR 1a
OH
HO
1a
7.2599
6.2560
6.2506
6.1926
6.1871
6.1816
5.0711
2.4396
2.4210
2.4013
1.5899
1.5813
1.5625
1.5434
1.5248
1.5138
1.5064
0.9091
0.8906
0.8722
1.9846
1.0000
2.0747
2.0586
2.3069
3.6301
[rel]
[ppm]

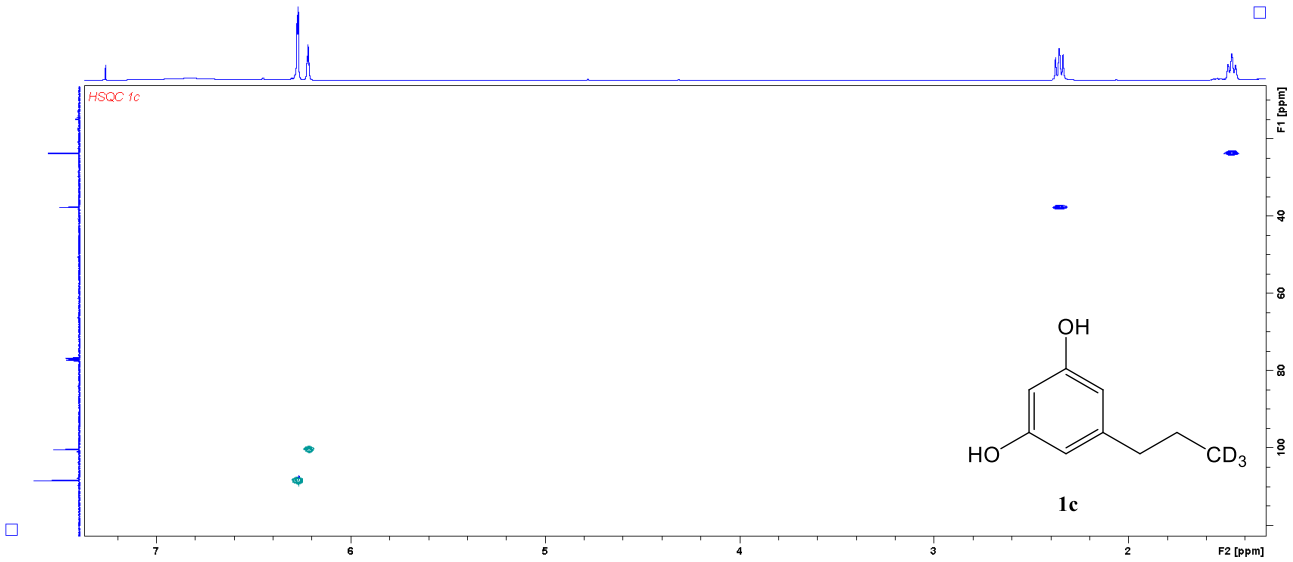

13C-NMR 1a
OH
HO
1a
156.3233
146.0009
108.1957
100.2633
77.3161
77.0000
76.6807
37.8300
24.0669
13.7467
[rel]
[ppm]

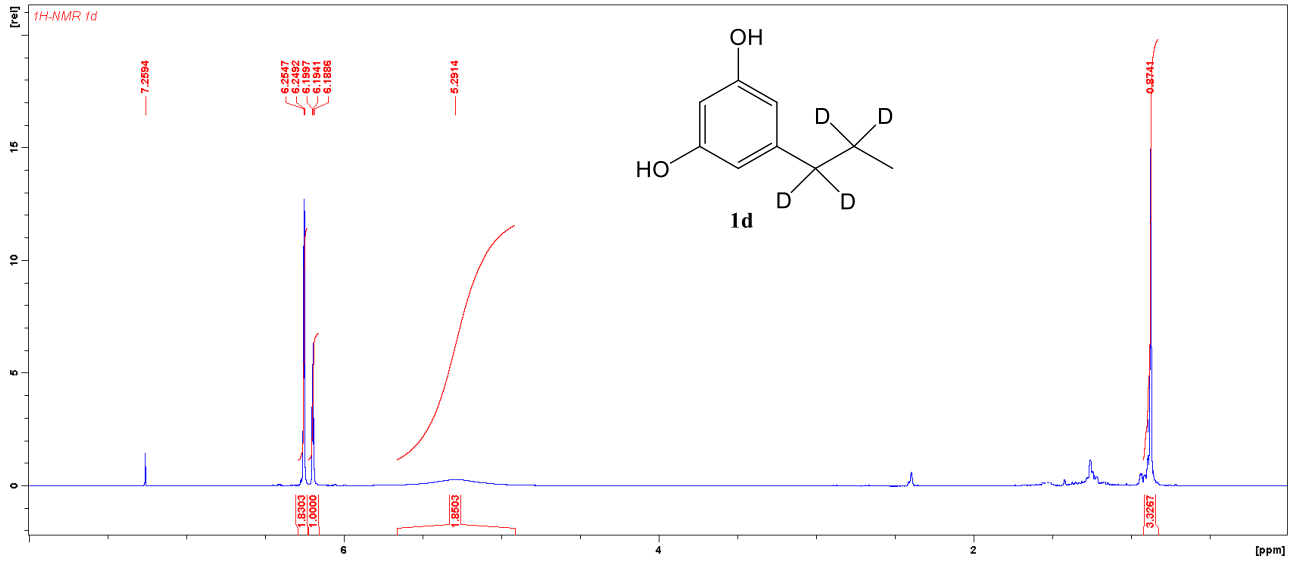

OH
HO
1a
F1 [ppm]
F2 [ppm]

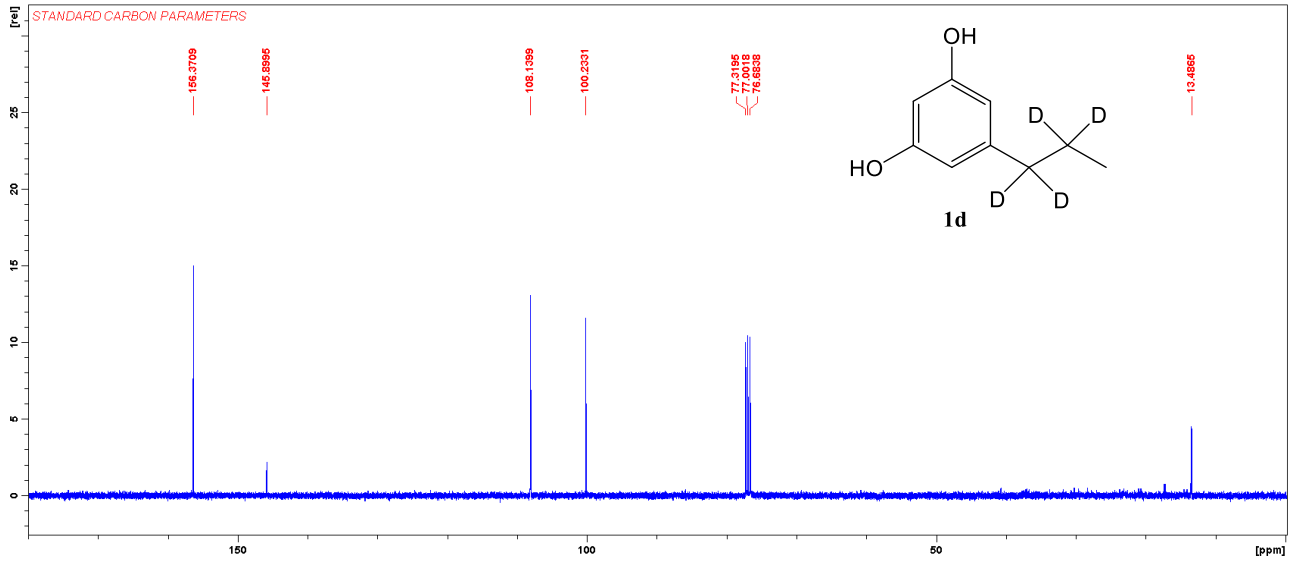

[rel]
7.2609
6.2474
6.2426
6.1760
6.1710
4.6511
2.5078
2.4888
2.4693
1.5985
1.5798
1.5630
1.3206
1.3122
1.2939
1.2858
0.9085
0.8918
0.8746
1.9405
1.0000
1.7754
2.8307
4.6153
5.3471
3.7568
6
4
2
[ppm]
OH
HO
1b

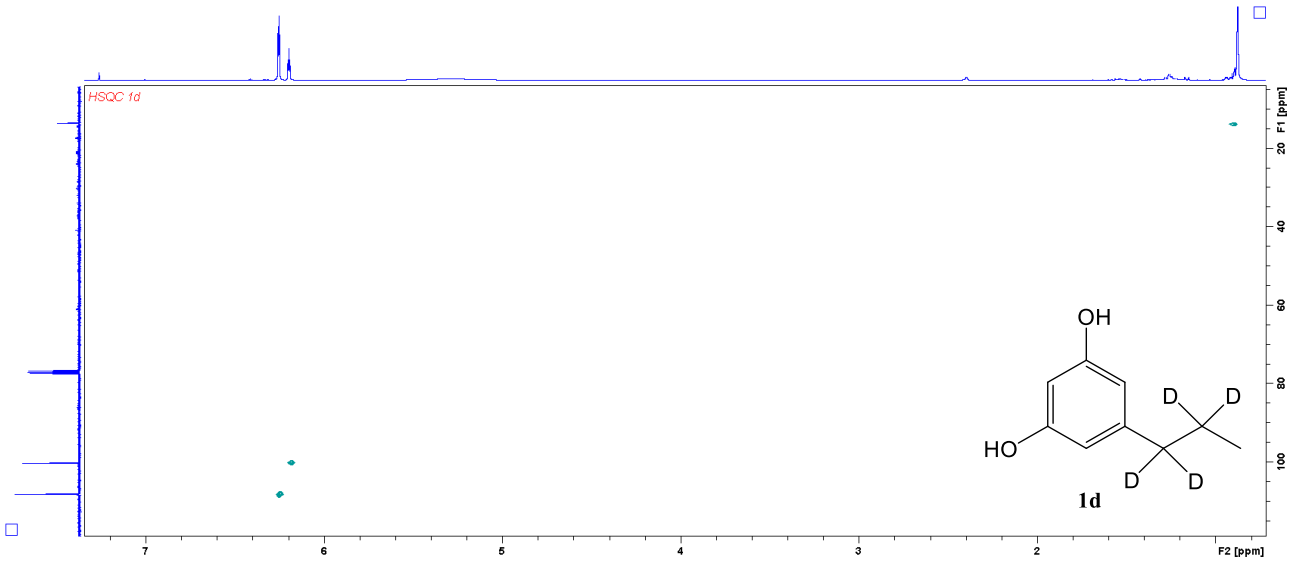

1H-NMR 1c
[rel]
7.2602
6.8228
6.2751
6.2698
6.2241
6.2188
6.2135
2.3743
2.3593
2.3359
1.4671
1.4573
1.4469
1.7495
2.0183
1.0000
1.9550
1.9524
6
4
2
[ppm]
OH
HO
CD3
1c

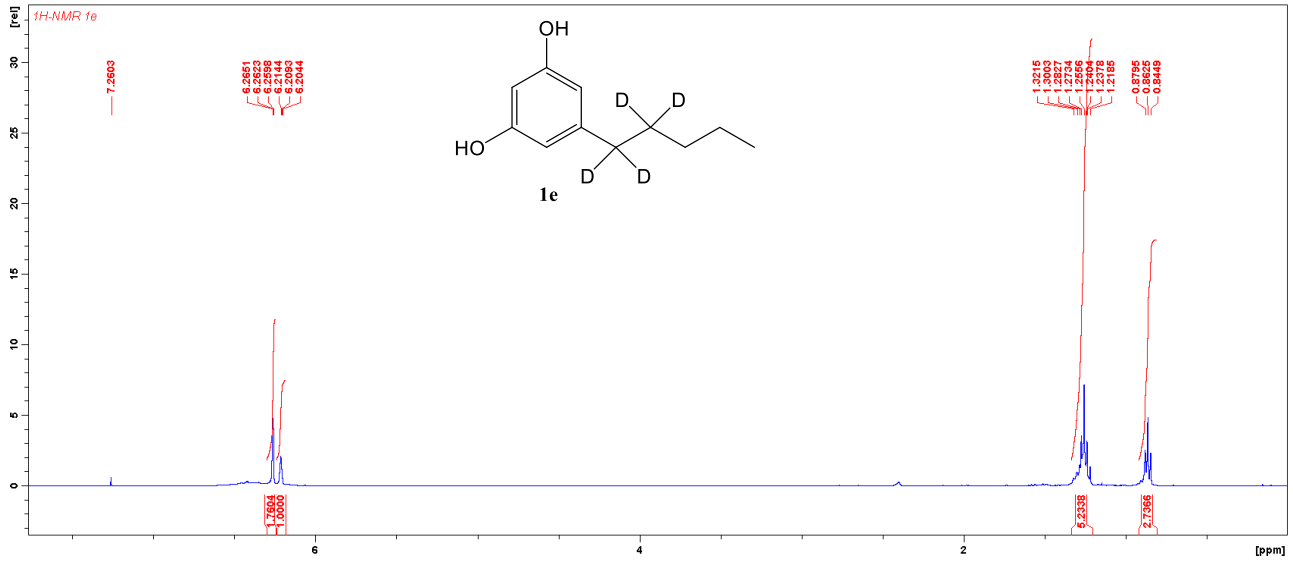

13C-NMR 1c
[rel]
155.9511
146.1575
108.3646
100.3670
77.3134
76.9957
76.6769
37.6704
23.7163
160
140
120
100
80
60
40
20
[ppm]
OH
HO
CD3
1c

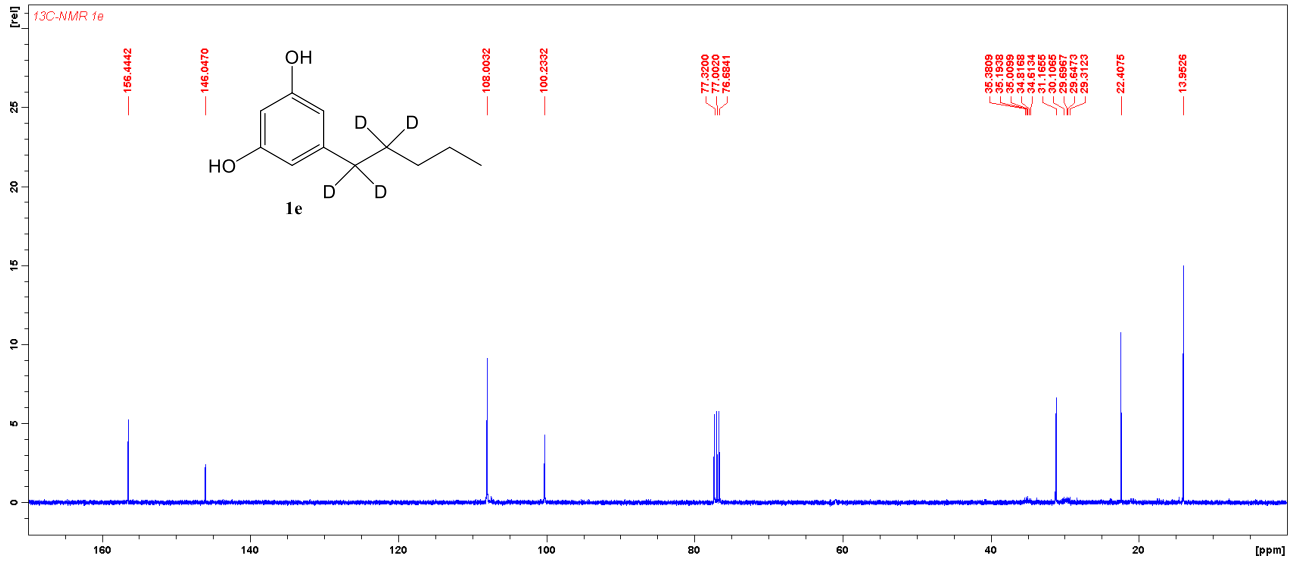

HSQC 1c
F1 [ppm]
F2 [ppm]
OH
HO
CD3
1c


1H-NMR 1d
[rel]
7.2594
6.2547
6.2492
6.1997
6.1941
6.1898
5.2914
0.8741
1.9393
1.0000
1.8503
3.3267
[ppm]
OH
HO
D
D
D
D
1d


STANDARD CARBON PARAMETERS
[rel]
156.3709
146.8995
108.1399
100.2331
77.3165
77.0018
76.6838
13.4865
[ppm]
OH
HO
D
D
D
D
1d


HSQC 1d
F1 [ppm]
F2 [ppm]
OH
HO
D
D
D
D
1d


1H-NMR 1e
[rel]
[ppm]
OH
HO
D
D
D
D
1e
7.2603
6.2651
6.2521
6.2598
6.2144
6.2093
6.2044
1.3215
1.3003
1.2857
1.2734
1.2556
1.2404
1.2378
1.2186
0.8795
0.8625
0.8449
1.7604
1.0000
6.2338
2.7366


13C-NMR 1e
[rel]
[ppm]
OH
HO
D
D
D
D
1e
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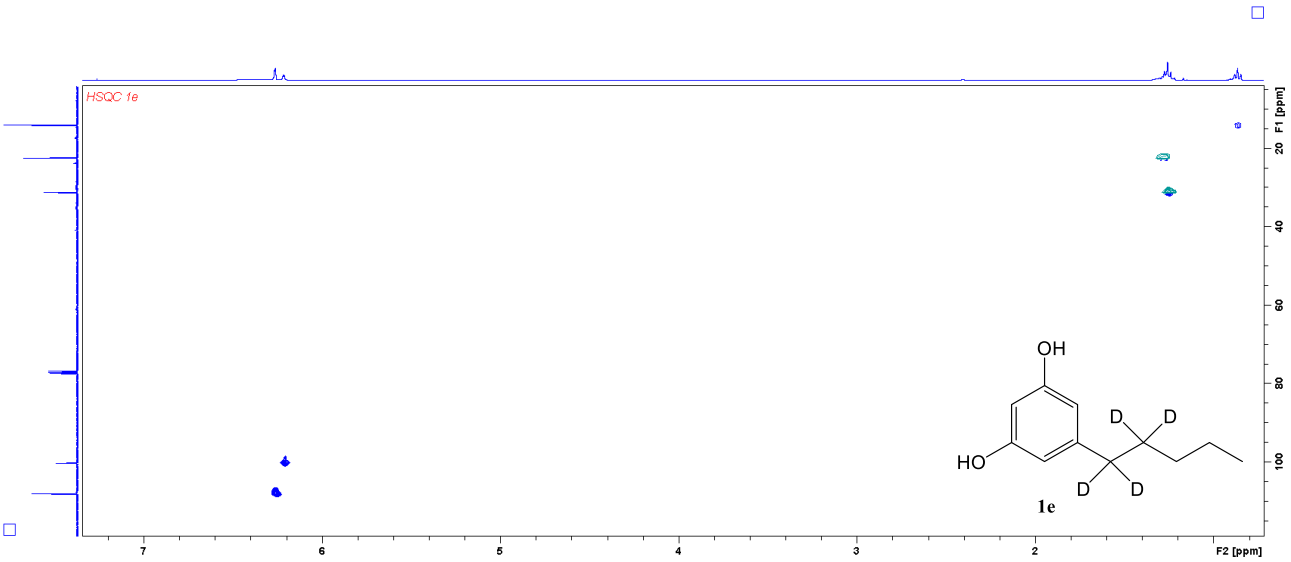
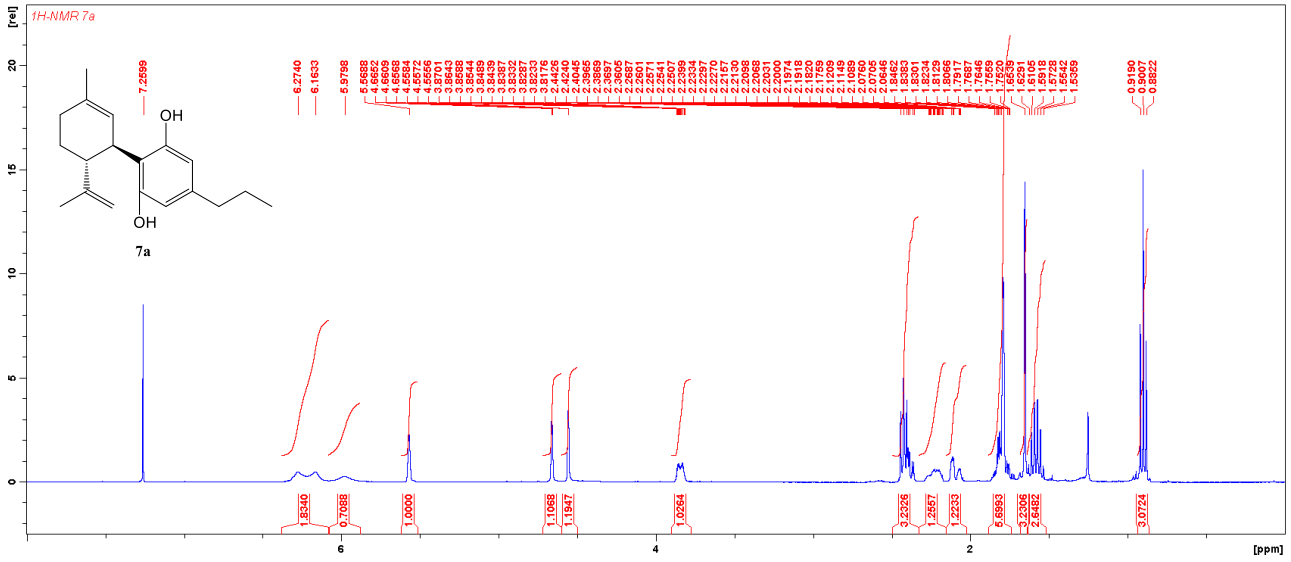
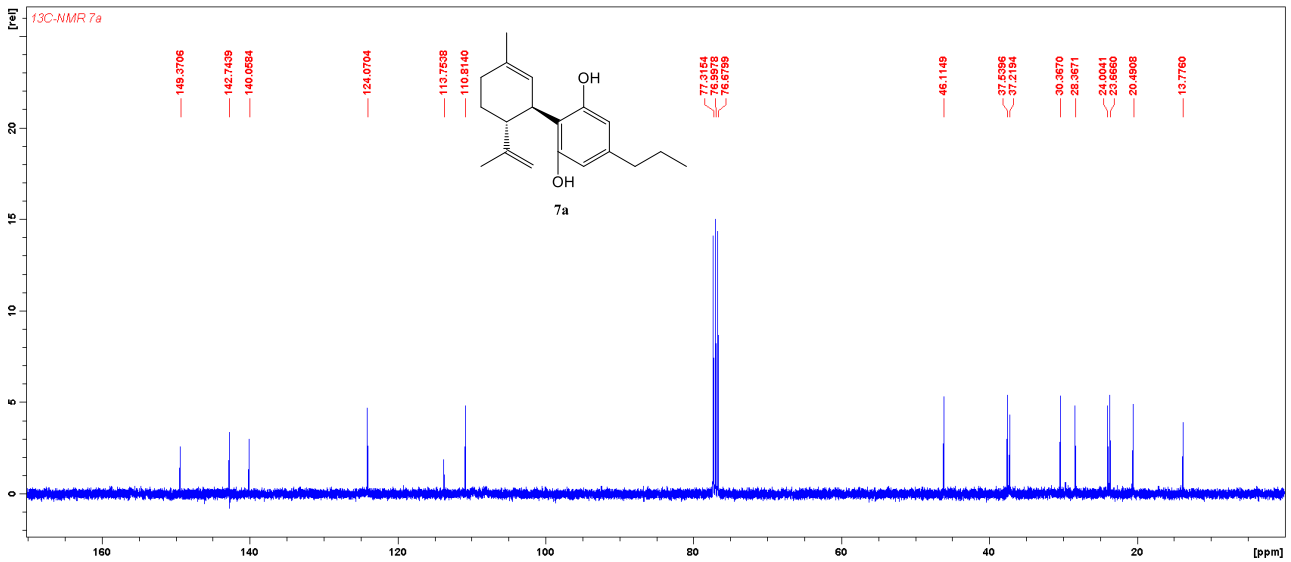
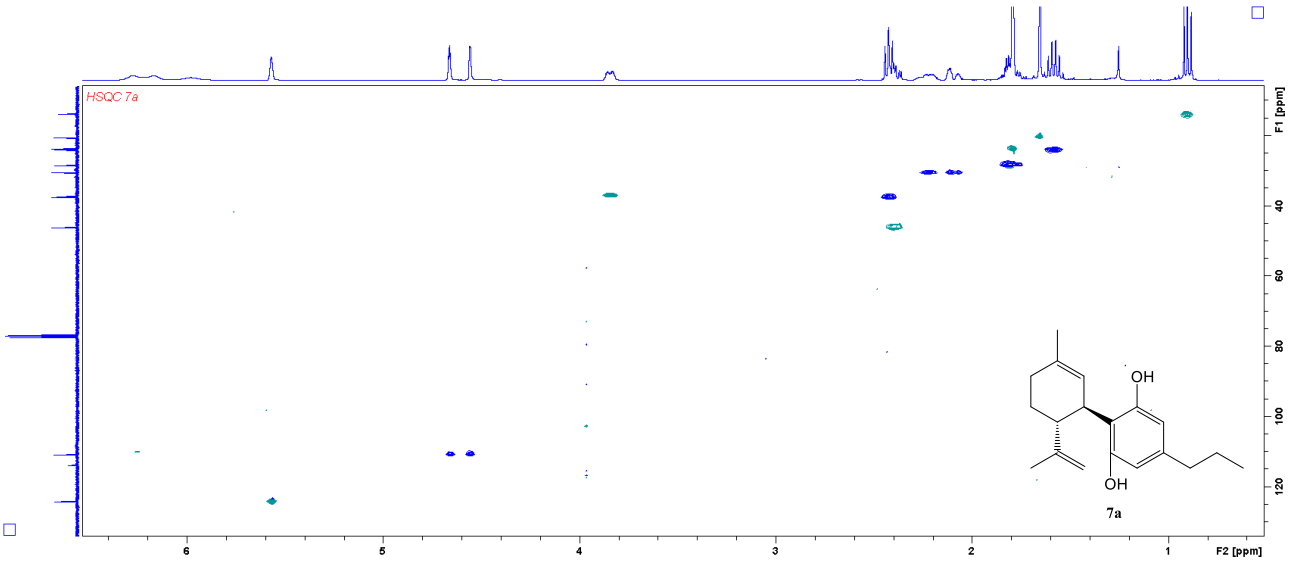
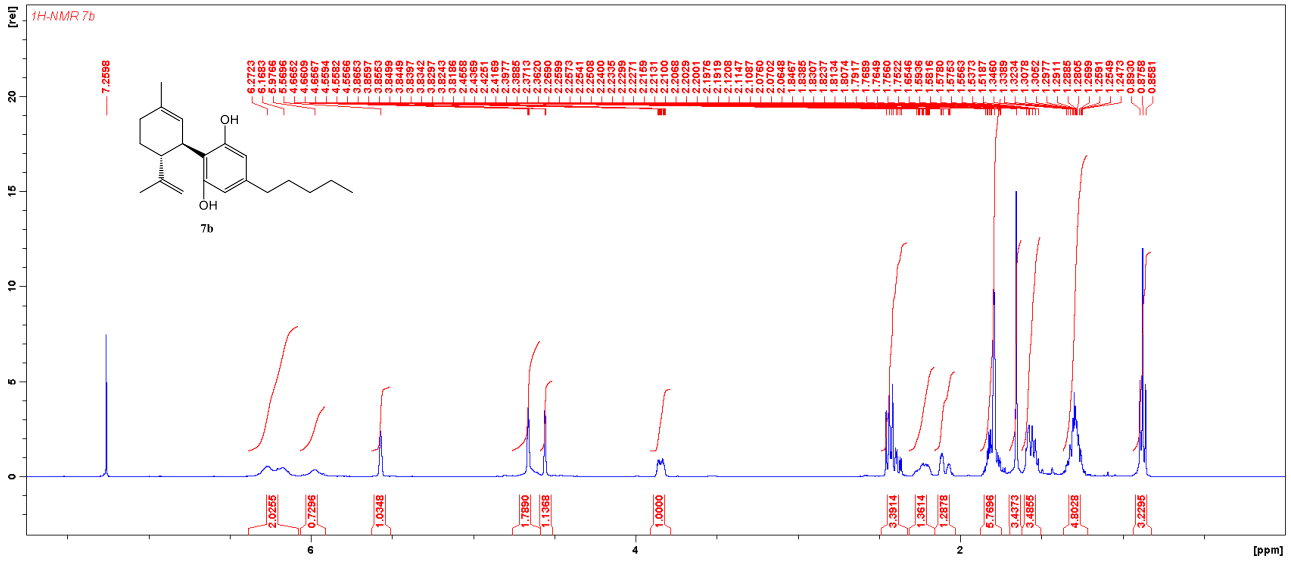
108.0032
100.2332
77.3200
77.0020
76.6841
35.3898
35.1588
35.0089
34.8168
34.6134
31.1565
30.1065
29.6967
29.6473
29.3123
22.4075
13.9526

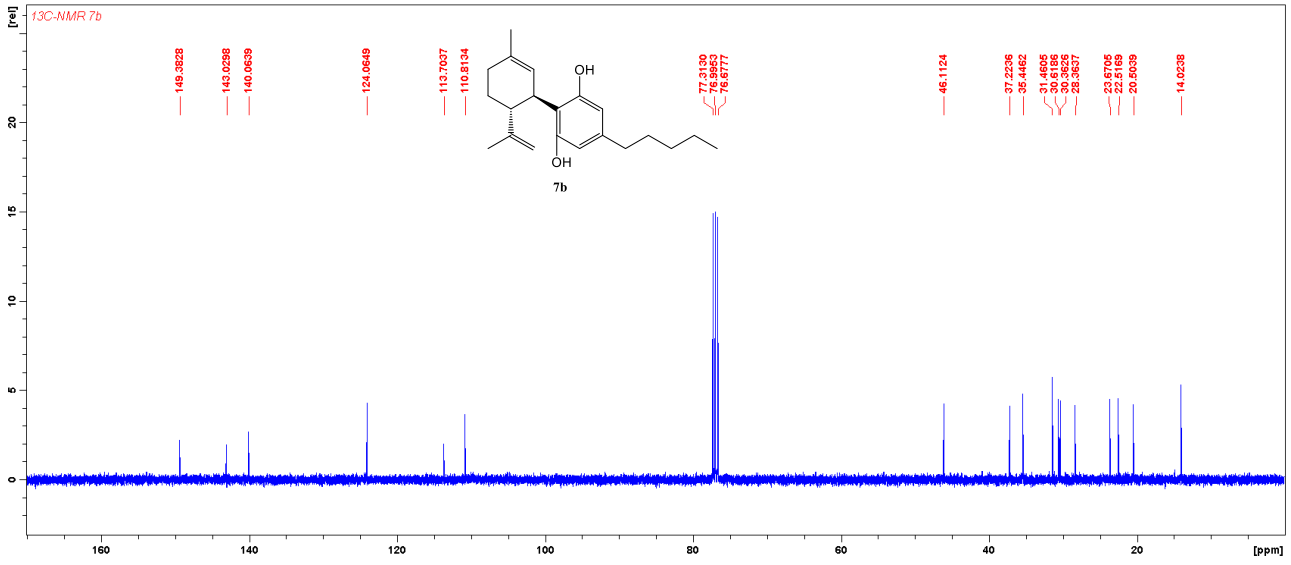

HSQC 1e
F1 [ppm]
F2 [ppm]
OH
HO
D
D
D
D
1e

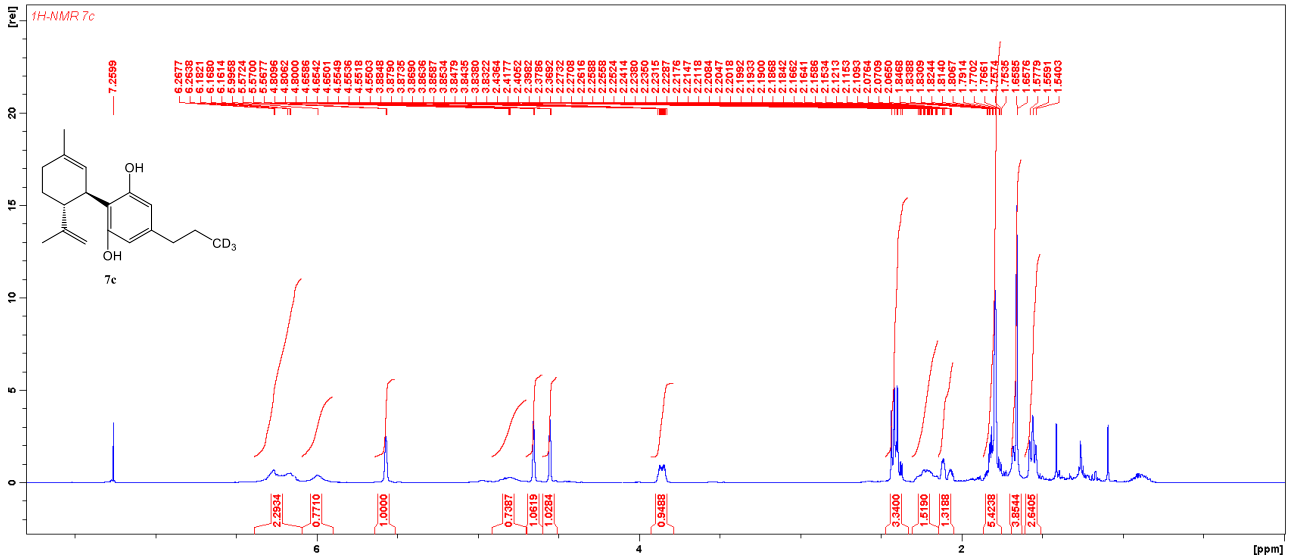

1H-NMR 7a
[rel]
[ppm]
OH
OH
7a

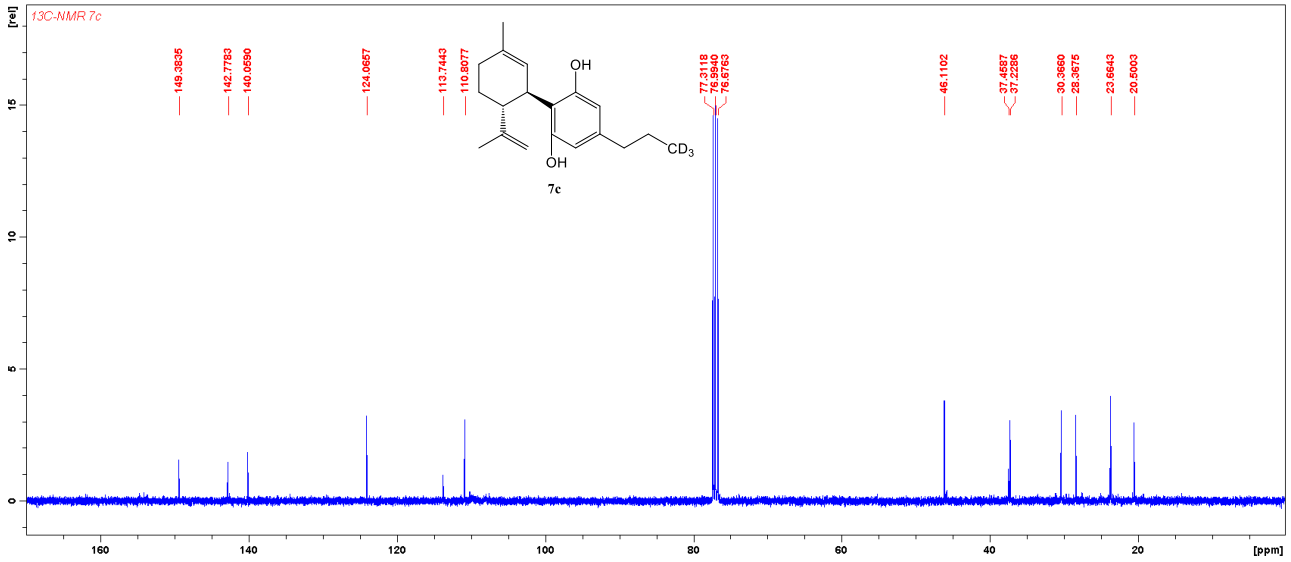

13C-NMR 7a
[rel]
[ppm]
OH
OH
7a

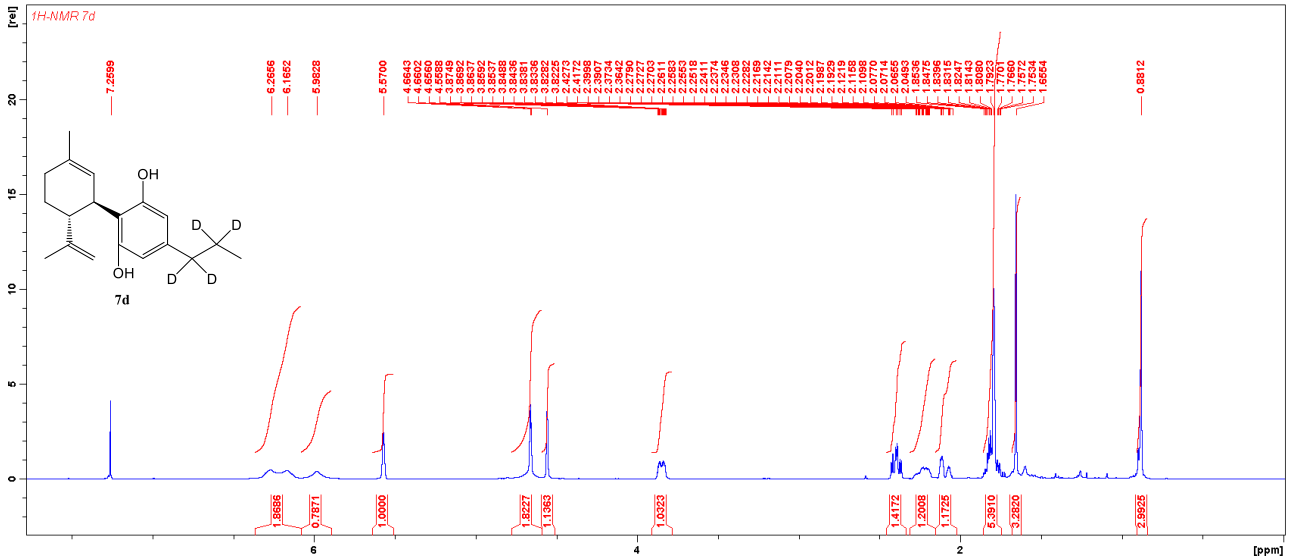

HSQC 7a
F1 [ppm]
F2 [ppm]
OH
OH
7a

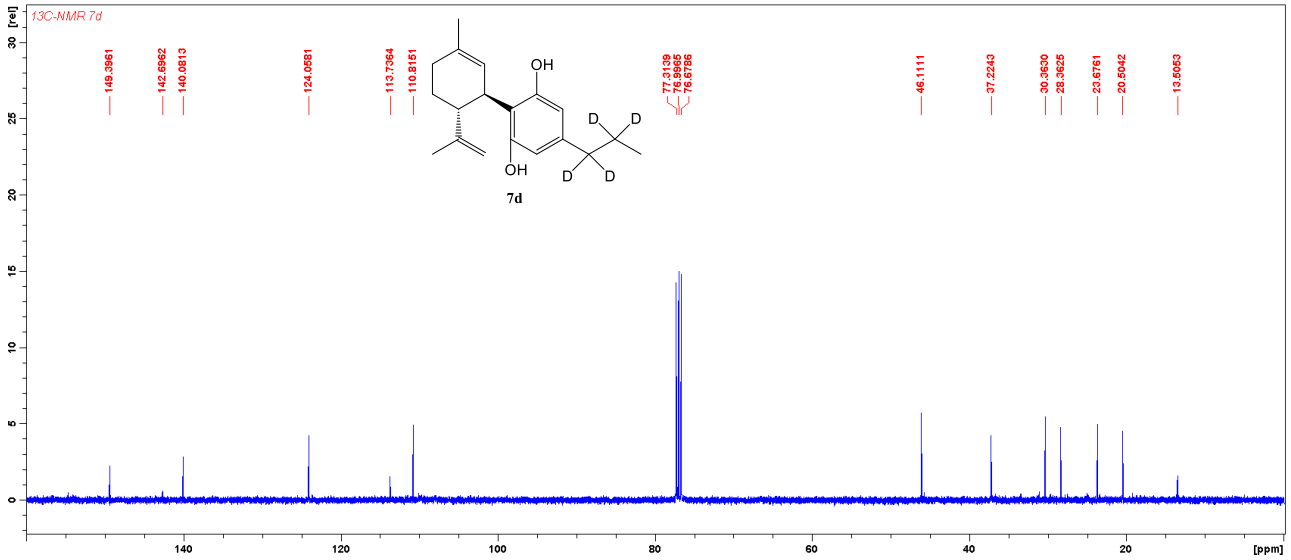

1H-NMR 7b
[rel]
[ppm]
OH
OH
7b

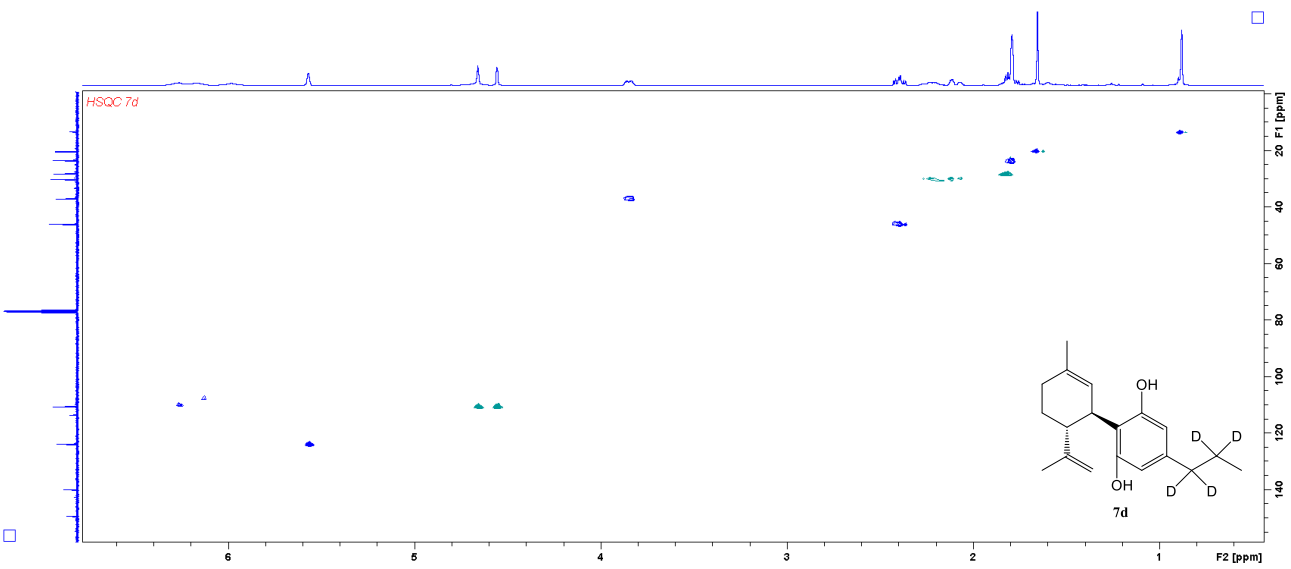

13C-NMR 7b
[rel]
[ppm]
OH
OH
7b

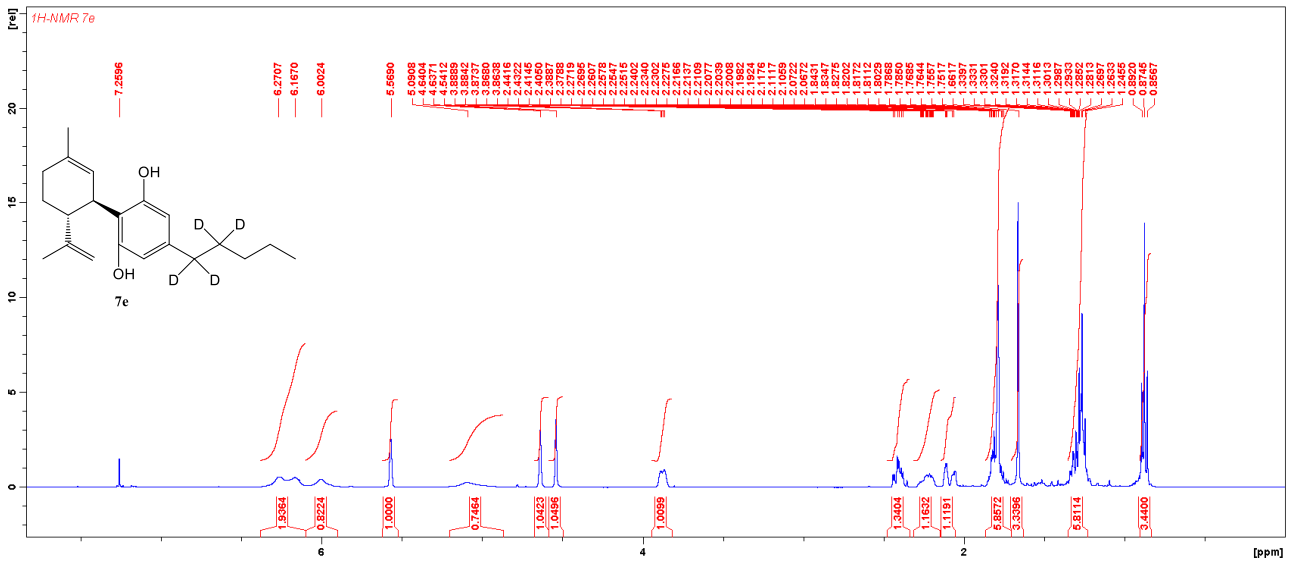

1H-NMR 7c
[rel]
[ppm]
OH
OH
CD3
7c

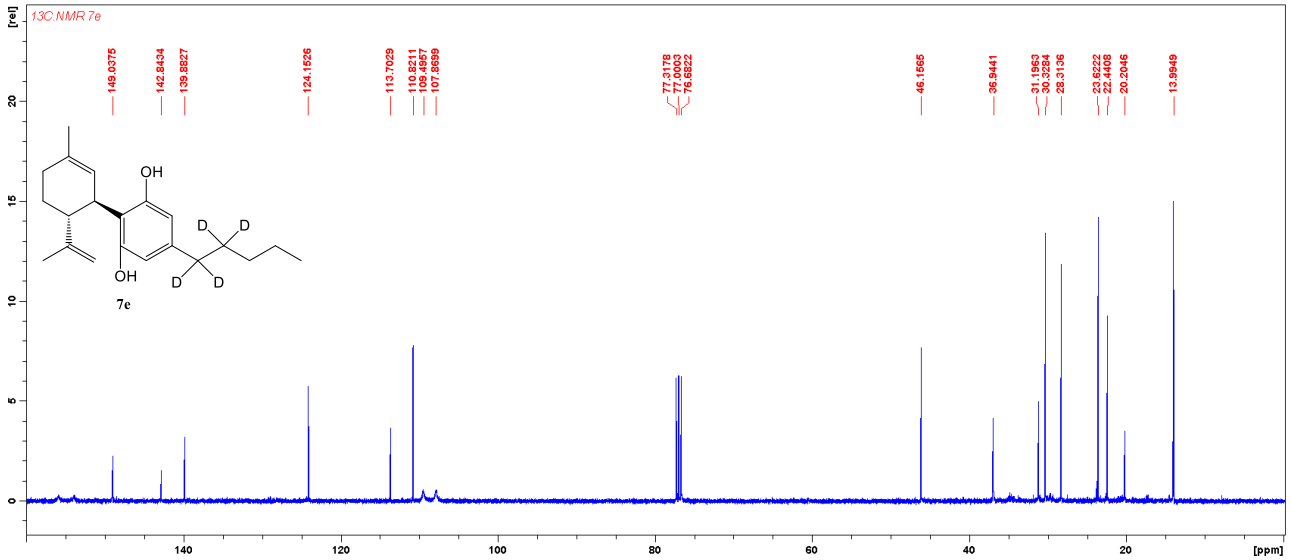

13C-NMR 7c
[rel]
[ppm]
OH
OH
CD3
7c


1H-NMR 7d
[rel]
[ppm]
OH
OH
D
D
D
D
7d


13C-NMR 7d
149.3961
142.6962
140.0813
124.0581
113.7364
110.8151
77.3139
77.0965
76.8788
46.1111
37.2243
30.3630
28.3625
23.6761
20.5042
13.5053
OH
OH
D
D
D
D
7d
[rel]
[ppm]


HSQC 7d
OH
OH
D
D
D
D
7d
F1 [ppm]
F2 [ppm]


1H-NMR 7e
7.2596
6.2707
6.1670
6.0024
5.6890
OH
OH
D
D
D
D
7e
1.3364
0.8224
1.0000
0.7464
1.0423
1.0496
1.0099
1.3404
1.1632
1.1191
5.8572
3.3396
5.8114
3.4400
[rel]
[ppm]


13C NMR 7e
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124.1626
113.7029
110.8211
105.4857
107.8699
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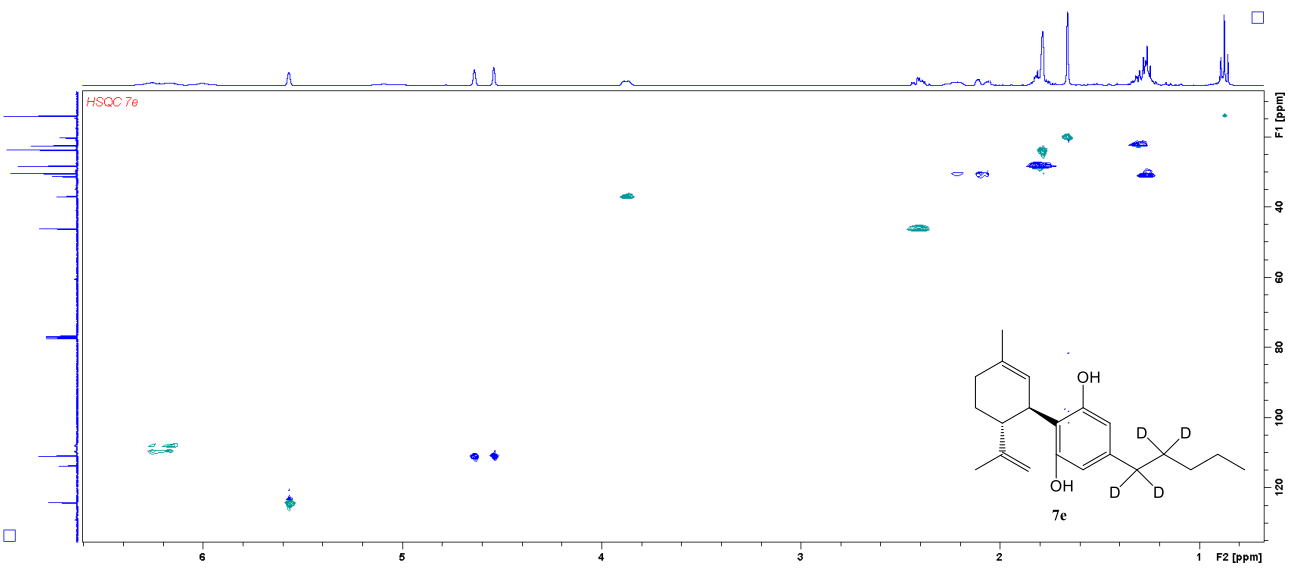
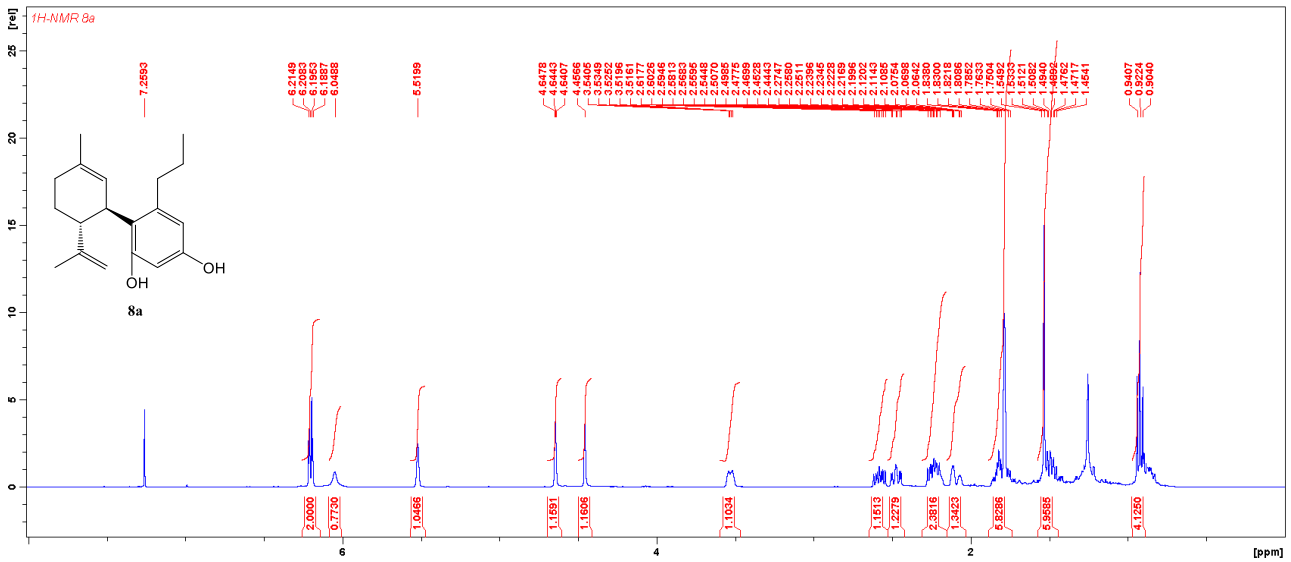
77.0003
76.6822
46.1565
36.9441
31.1963
30.3284
28.3136
23.6222
22.4408
20.2046
13.9949
OH
OH
D
D
D
D
7e
[rel]
[ppm]


HSQC 7e
OH
OH
D
D
D
D
7e
F1 [ppm]
F2 [ppm]


1H-NMR 8a
7.2593
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6.2083
6.1957
6.1887
6.0488
5.5199
4.6478
4.6443
4.6407
4.4566
3.5405
3.5349
3.5292
3.5236
3.5161
2.6177
2.6026
2.5846
2.5813
2.5683
2.5596
2.5446
2.5070
2.4885
2.4775
2.4688
2.4528
2.4443
2.2747
2.2690
2.2511
2.2396
2.2345
2.2283
2.2169
2.1996
2.1202
2.1143
2.1085
2.0754
2.0698
2.0642
1.8380
1.8300
1.8218
1.7986
1.7852
1.7633
1.7504
1.5482
1.5121
1.5082
1.4940
1.4880
1.4762
1.4717
1.4541
0.9407
0.9344
0.9049
OH
OH
8a
2.0000
0.7730
1.0466
1.1891
1.1606
1.1034
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1.2279
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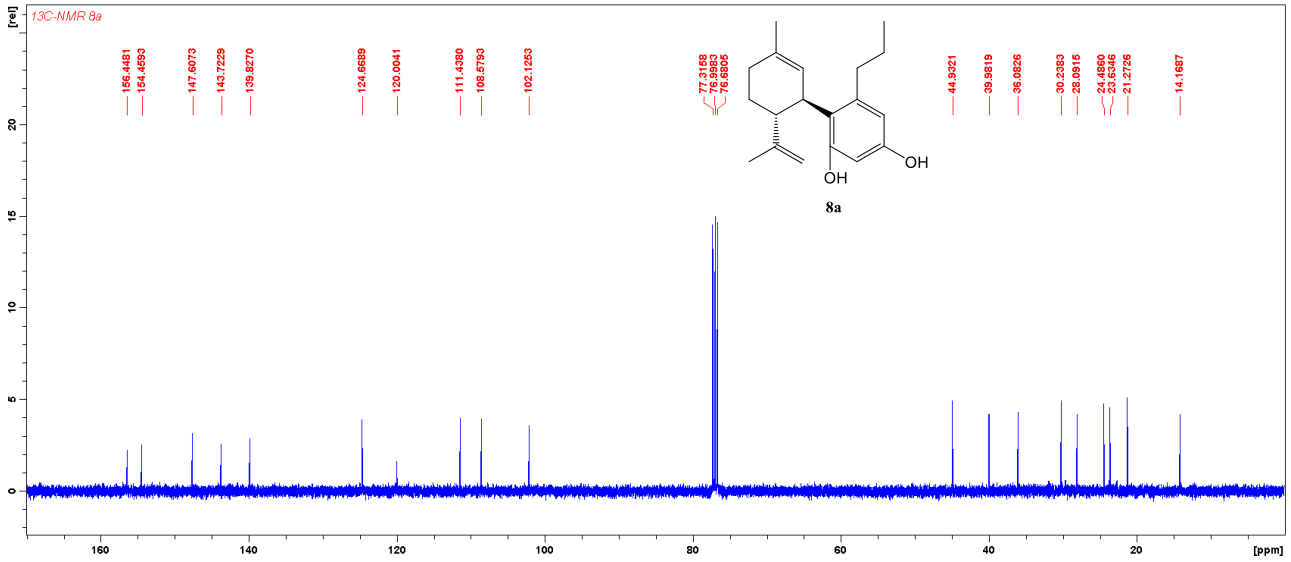
1.3423
5.8286
5.9585
4.1250
[rel]
[ppm]


13C-NMR 8a
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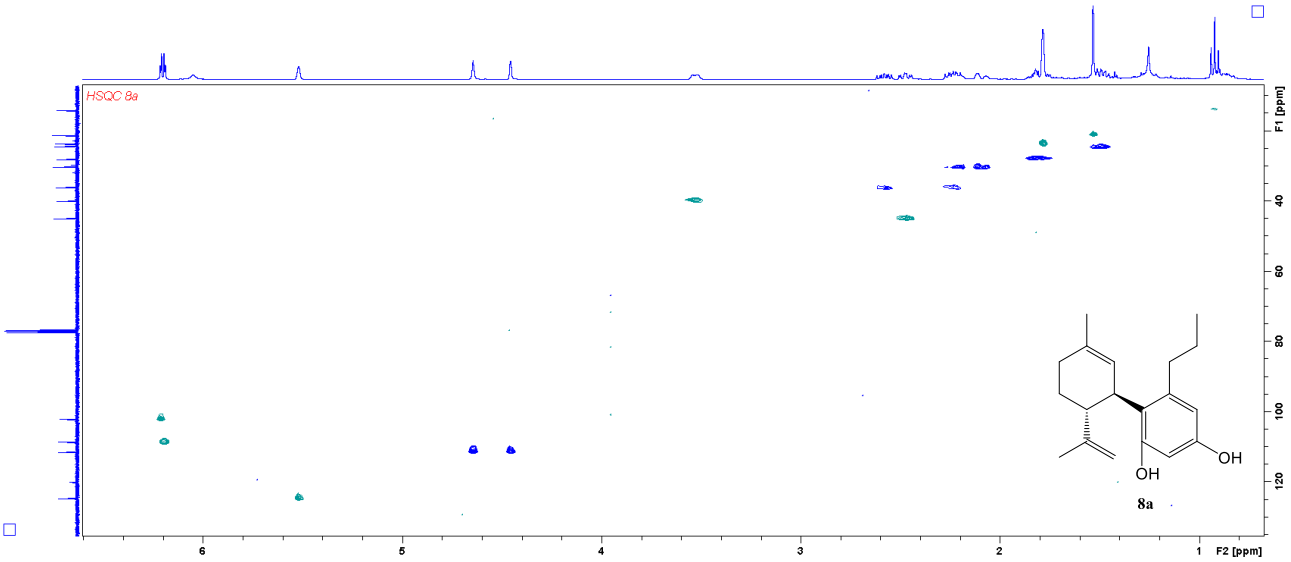
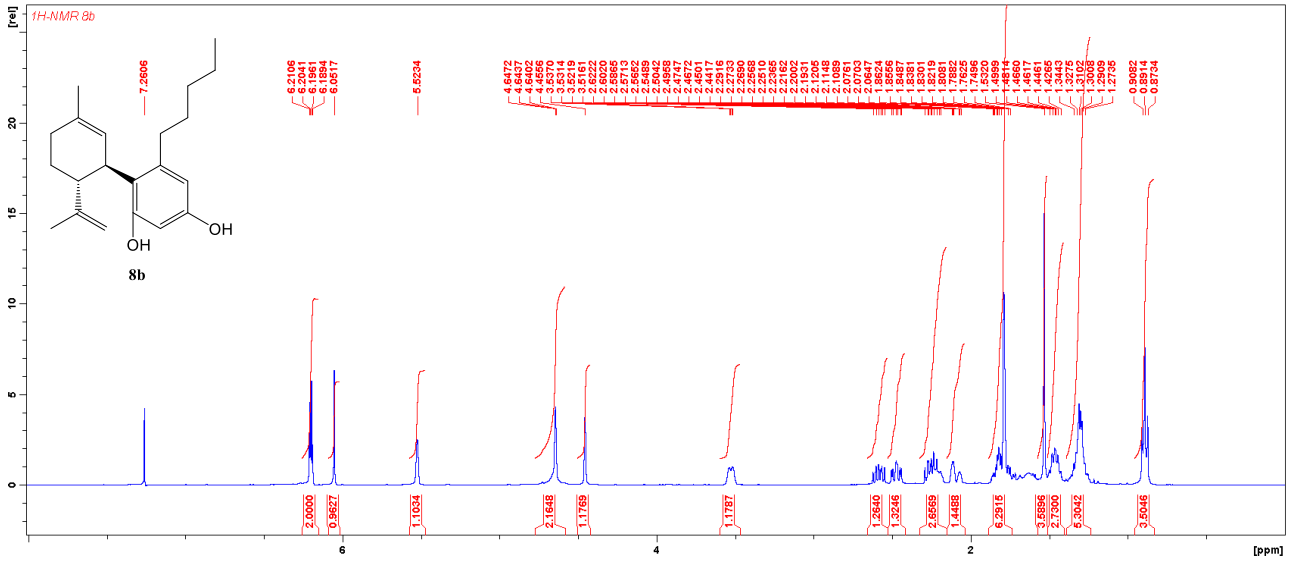
147.6073
143.7229
139.8270
124.6689
120.0041
111.4380
108.5793
102.1253
77.3168
76.9983
76.6805
44.9321
39.9819
36.0826
30.2383
28.0915
24.4860
23.6346
21.2726
14.1687
OH
OH
8a
[rel]
[ppm]


HSQC 8a
OH
OH
8a
F1 [ppm]
F2 [ppm]


1H-NMR 8b
7.2606
6.2106
6.2041
6.1961
6.1894
6.0517
5.5234
4.6472
4.6437
4.6402
4.4586
4.4550
3.5314
3.5219
3.5161
2.6222
2.6020
2.5865
2.5713
2.5662
2.5489
2.5042
2.4958
2.4777
2.4672
2.4501
2.4417
2.4316
2.2713
2.2690
2.2568
2.2510
2.2268
2.2162
2.2002
2.1931
2.1705
2.1148
2.1089
2.0761
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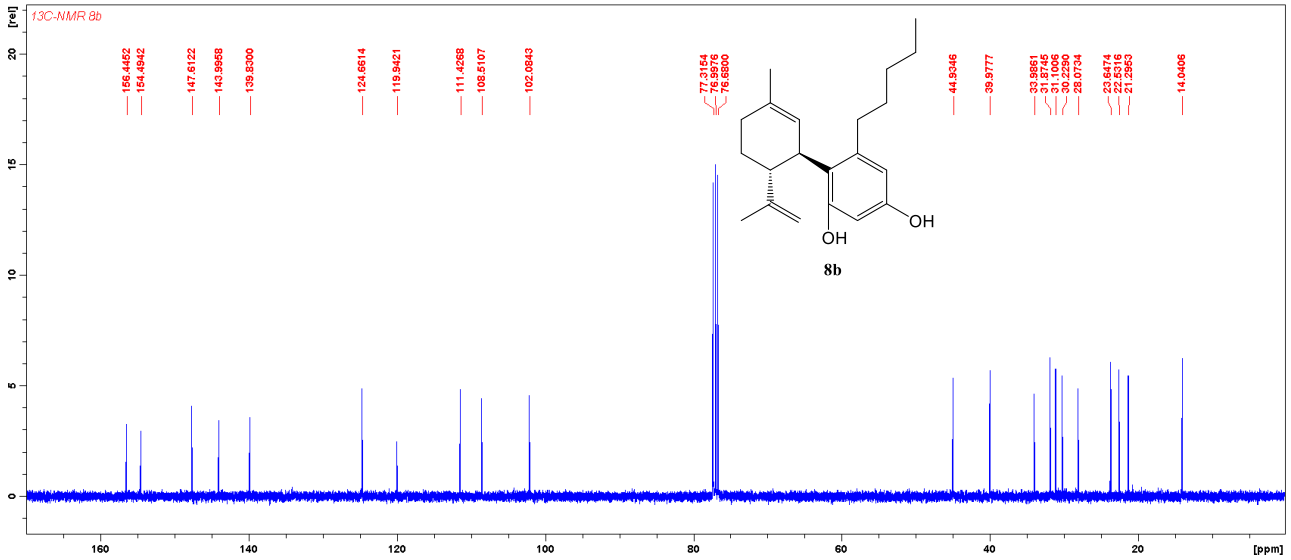
1.8556
1.8487
1.8381
1.8301
1.8219
1.8081
1.7882
1.7625
1.7496
1.7430
1.4959
1.4814
1.4660
1.4617
1.4461
1.4265
1.3443
1.3375
1.3102
1.3008
1.2909
1.2735
0.9082
0.8914
0.8734
OH
OH
8b
2.0000
0.9627
1.1034
2.1648
1.1769
1.1787
1.2640
1.3246
2.8569
1.4488
6.2915
2.5896
2.7300
5.3042
3.5046
[rel]
[ppm]


13C-NMR 8b
[rel]
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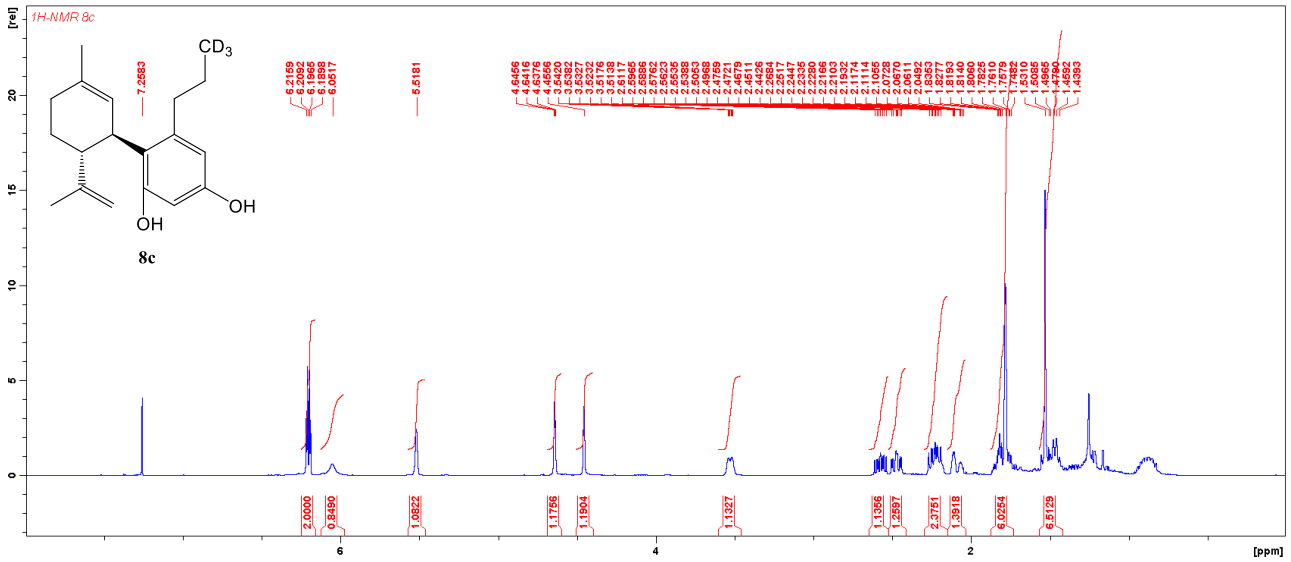
154.4942
147.6122
143.9968
139.8300
124.6614
119.9421
111.4268
108.5107
102.0843
77.3154
76.9976
76.6800
44.9346
39.9777
33.9861
31.8746
31.1056
30.2290
28.0734
23.6474
22.5316
21.2953
14.0406
OH
OH
8b
[ppm]


1H-NMR 8c
[rel]
CD3
7.2583
6.2159
6.2022
6.1885
6.1898
6.0517
5.5181
4.6456
4.6416
4.6376
4.4556
3.5420
3.5382
3.5327
3.5232
3.5176
3.5138
3.5117
2.5965
2.5886
2.5762
2.5653
2.5634
2.5388
2.5053
2.4768
2.4753
2.4721
2.4679
2.4511
2.4426
2.2584
2.2517
2.2447
2.2335
2.2280
2.2166
2.2103
2.1932
2.1174
2.1114
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2.0611
2.0492
2.0253
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1.8140
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1.7512
1.5310
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1.4965
1.4852
1.4682
1.4393
OH
OH
8c
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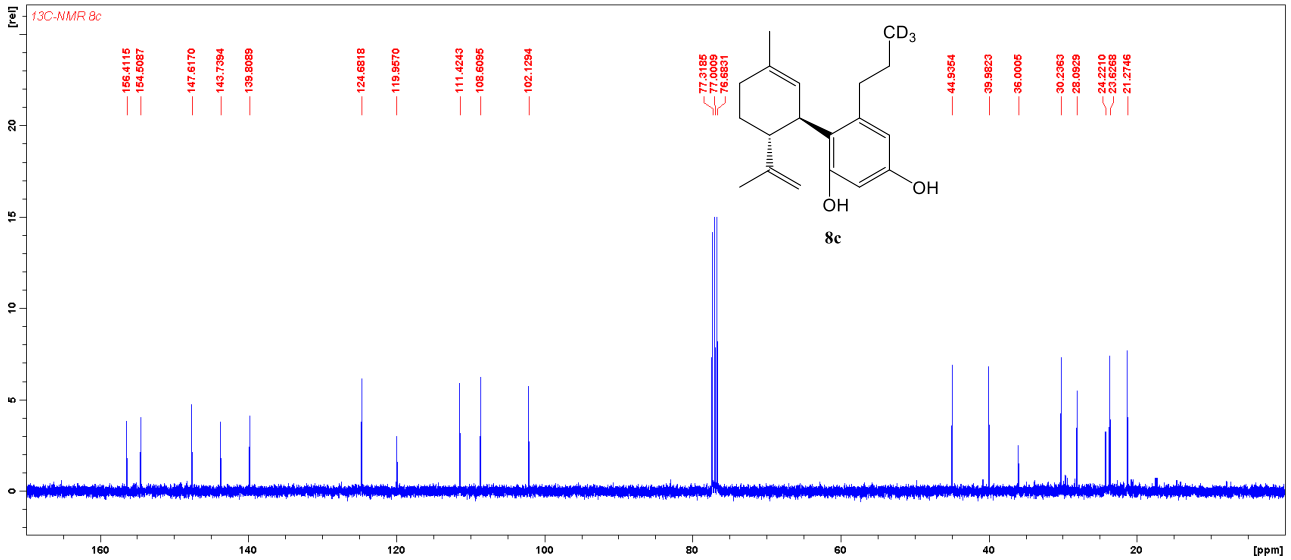
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8c
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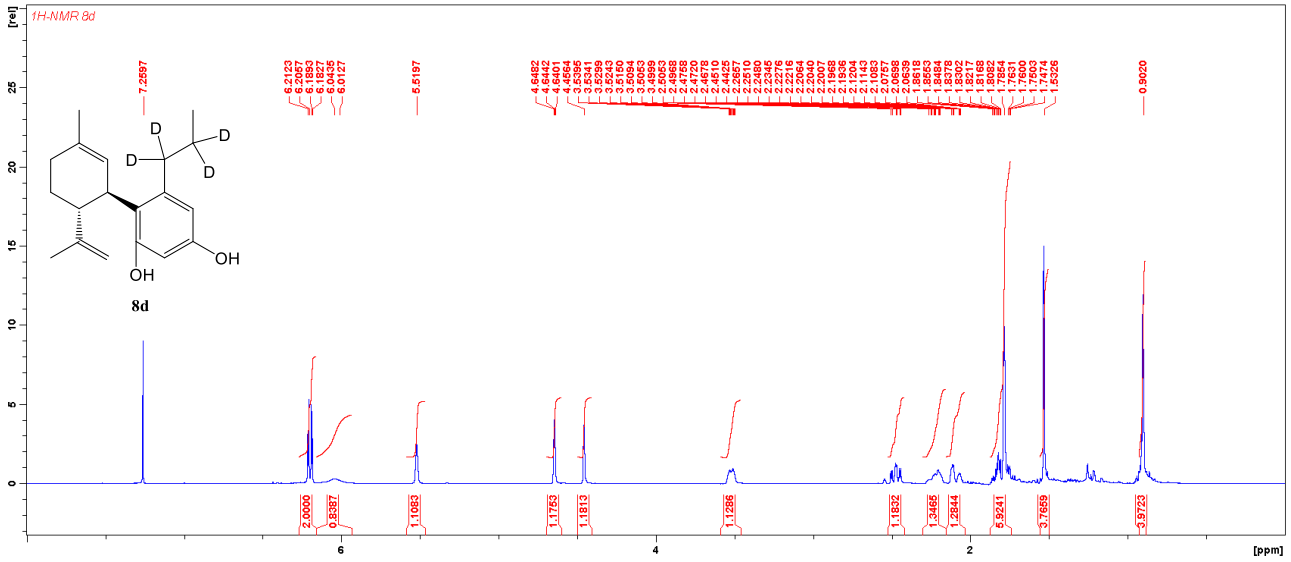
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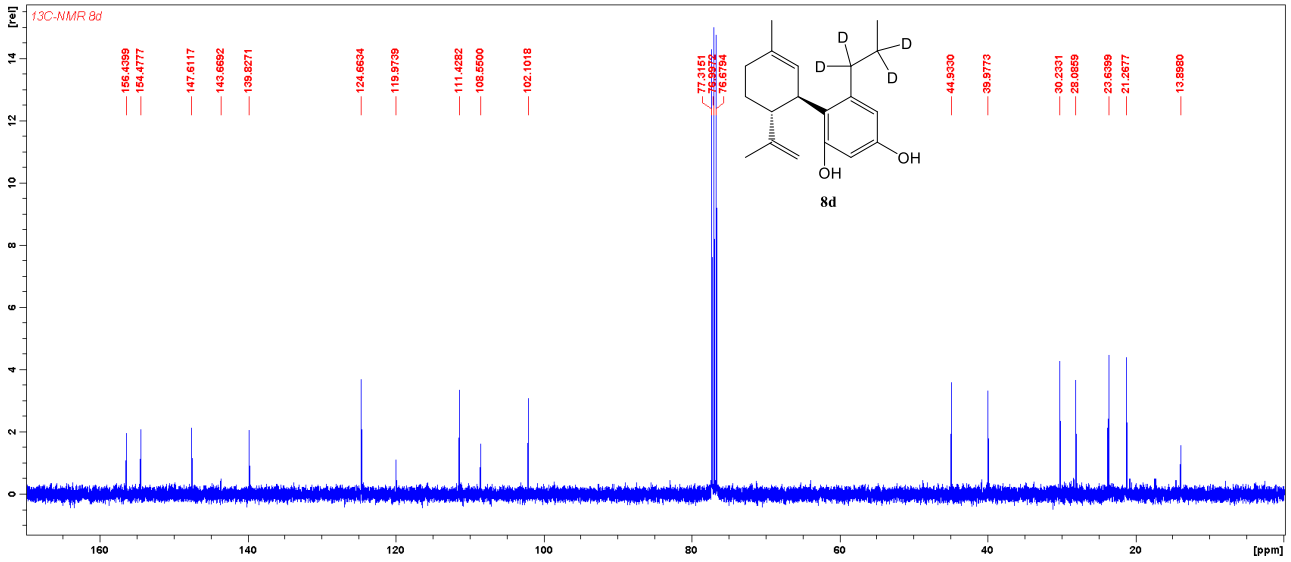
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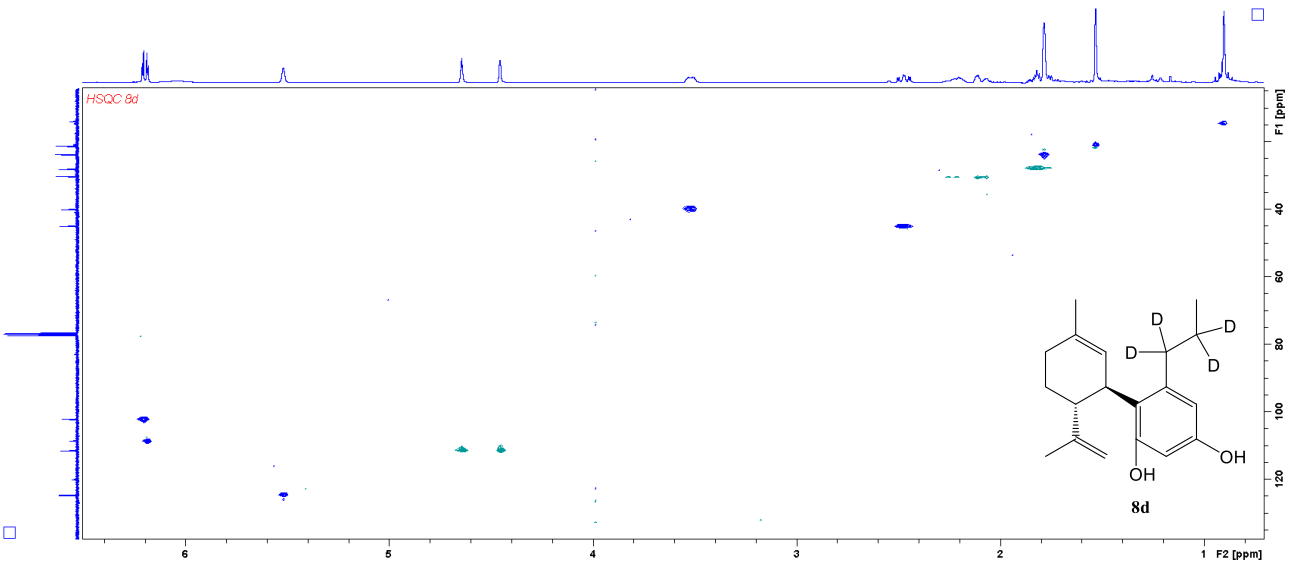
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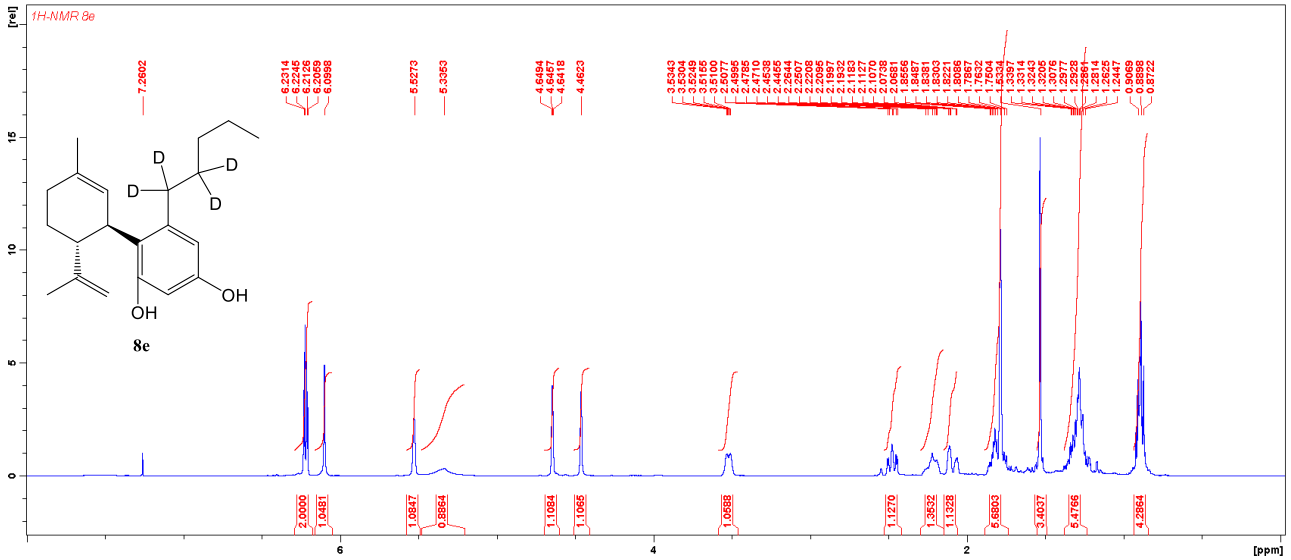
8d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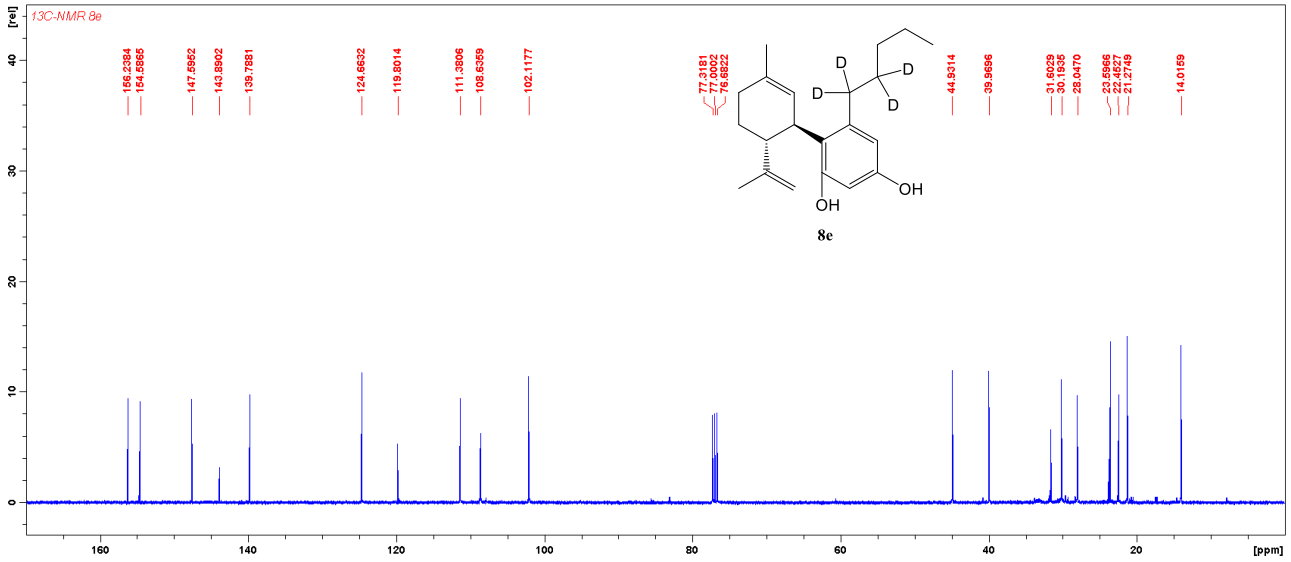
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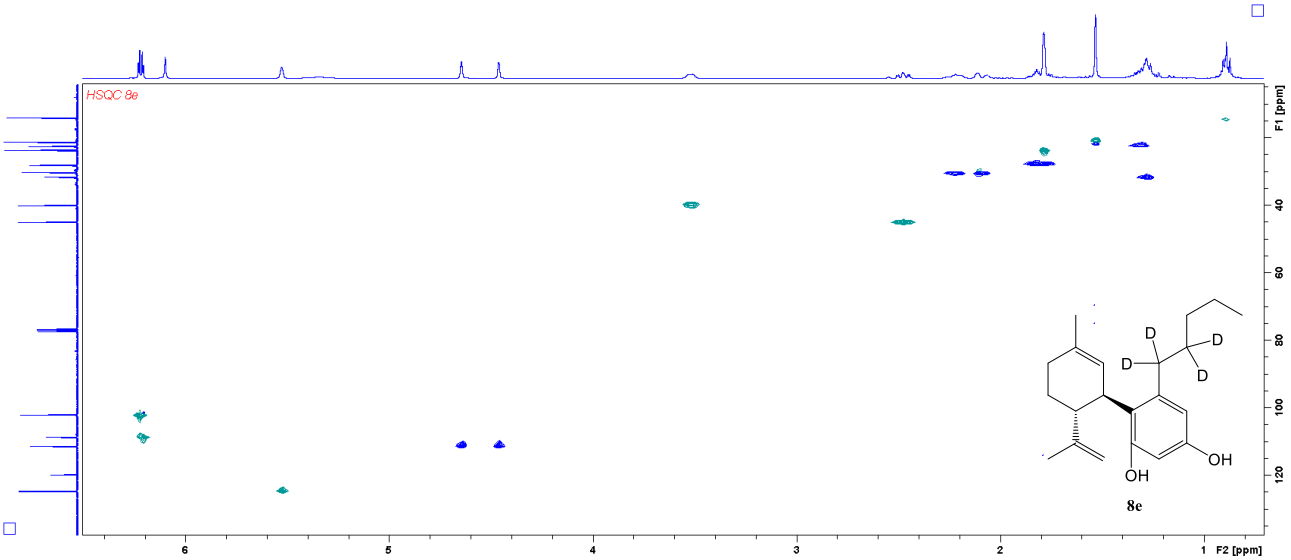
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8e