Supporting Information for

Synthesis of Neurotrophic *Seco*-prezizaane Sesquiterpenes (1*R*,10*S*)-2-oxo-3,4-dehydroneomajucin, (2*S*)-hydroxy-3,4-dehydroneomajucin, and (–)-Jiadifenin

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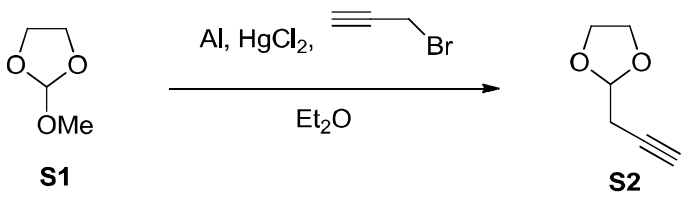
1. Materials and Methods

All reactions were conducted in flame-dried glassware under a nitrogen atmosphere with dry solvents, unless otherwise noted. All reagents and starting materials were purchased from commercial sources and used as supplied, unless otherwise indicated. Anhydrous tetrahydrofuran (THF), diethyl ether (Et_2O), dichloromethane (CH_2Cl_2) and toluene (PhMe) were dried using a Glass Contour solvent purification system by Pure Process Technology, LLC. Anhydrous 1,2-Dimethoxyethane (DME), pyridine, dimethyl sulfoxide (DMSO) and acetonitrile (MeCN) were purchased from Sigma-Aldrich. Titanium isopropoxide (Ti(O*i*-Pr)$_4$) was distilled before use. Solutions of *n*-BuLi were purchased from Sigma-Aldrich and titrated against *N*-benzylbenzamide. Yields refer to chromatographically and spectroscopically (^{1}H NMR) homogeneous materials, unless otherwise stated. Flash column chromatography was performed on the Biotage® Automated Liquid Chromatography System Isolera One® using Biotage® SNAP KP-Sil 10-100 g silica gel cartridges or performed using a forced flow of the indicated solvent system on Sorbent Technologies® Silica Gel 60Å. Thin layer chromatography (TLC) analyses were performed on EMD TLC Silica gel 60 F254 Glass Plates and the spots were visualized by UV-light (254 nm) or appropriate stains, including *p*-anisaldehyde and potassium permanganate. ^{1}H NMR data were recorded on a Bruker Avance III 500 MHz spectrometer (TBI probe) and a Bruker Avance III 600 MHz spectrometer (BBFO probe) with calibration of spectra to $CDCl_3$ (7.26 ppm), CD_3OD (49.15 ppm), $(CD_3)_2SO$ (2.50 ppm), or C_5D_5N-TMS (0.00 ppm). ^{13}C NMR data were recorded at 125 MHz on a Bruker Avance III 500 MHz spectrometer (TBI probe) and at 150 MHz on a Bruker Avance III 600 MHz spectrometer (BBFO probe) with calibration to the central line of $CDCl_3$ (77.23 ppm), CD_3OD (49.15 ppm), $(CD_3)_2SO$ (39.51 ppm), C_5D_5N-TMS (0.00 ppm). ^{2}H NMR data were recorded at 77 MHz on a Bruker Avance III 500 MHz spectrometer (TBI probe) calibration of spectra to trace $CDCl_3$ (7.26 ppm). Two-dimensional NMR spectra, including COSY, HMQC, HMBC, TOCSY and NOESY were recorded on a Bruker Avance III 500 MHz spectrometer (TBI probe) and a Bruker Avance III 600 MHz spectrometer (BBFO probe). Infrared spectra were recorded on a JASCO FT/IRM4100 Fourier Transform Infrared Spectrometer. HRMS (ESI-TOF and EI) analyses were performed at the Mass Spectrometry Laboratory of University of Illinois at Urbana-Champaign. LRMS of compound **9** was performed on a Hewlett-Packard 6890 Series GC system and a Hewlett-Packard 5973 Mass Selective Detector. All compounds purified by chromatography were sufficiently pure for use in further experiments, unless indicated otherwise.

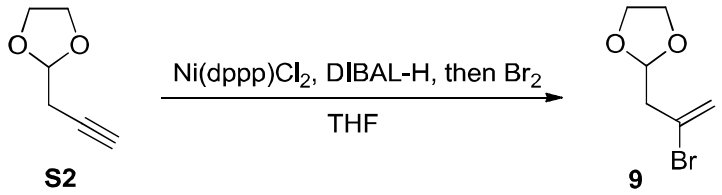
2. Experimental Procedures



2-(prop-2-yn-1-yl)-1,3-dioxolane (S2). This compound was prepared by modification of a literature procedure by Tan *et al*.[1] To a stirred suspension of aluminum powder (29.8 g, 1105 mmol) in refluxing anhydrous Et_2O (110 mL) in a three-necked round-bottom flask was quickly added $HgCl_2$ (1.71 g, 6.24 mmol). Ice water was used for the reflux condenser to ensure efficient condensation. A solution of propargyl bromide (80 wt% in PhMe, 80.2 mL, 720 mmol) in Et_2O (480 mL) was then added via an addition funnel over 30 min. Note: The rate of addition should be adjusted depending on how vigorous the reflux appears in order to prevent violent reaction. During the addition, as the reaction became more vigorous, the heat bath was removed and the reaction mixture was able to maintain a steady reflux. After another approx. 40 to 50 min, the reflux significantly slowed down and the mixture was heated for another 30 min at reflux. This solution of the newly formed organoaluminum reagent was allowed to cool to rt and then further cooled down to –78 °C. A solution of 2-methoxy-1,3-dioxolane (**S1**, 50.0 g, 480 mmol) in Et_2O (60 mL) was added dropwise. The reaction mixture was stirred at –78 °C for 4 h. The reaction was quenched by addition of water (1 L) and 1 M aqueous NaOH (300 mL) at –78 °C. After warming to rt, the reaction mixture was stirred for another 15 min. Celite (96 g) was added and the reaction mixture was filtered through Celite with Et_2O. The filtrate was transferred to a separatory funnel and the aqueous layer was further extracted with Et_2O (three times). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The above procedure was repeated and the crude material from both batches was combined and purified by vacuum distillation (50–52 mbar) through a 5-inch Vigreux column to give **S2** (59.5 g, 55%) as a volatile colorless liquid with > 90% purity. This material was used directly in the next synthetic step without further purification. An analytical sample of **S2** was obtained as a colorless liquid by purification of 50 mg of the distillate (85:15 to 80:20 pentane:Et_2O).

[1] Shang, S.; Iwadare, H.; Macks, D. E.; Ambrosini, L. M.; Tan, D. S. *Org. Lett.* **2007**, *9*, 1895–1898.

Data for **S2**: R_f = 0.34 (80:20 hexanes:Et_2O); bp 75–81°C (50–52 mbar); IR (thin film) 3631, 3531, 3286, 2935, 2957, 2891, 2123, 1475, 1419, 1397, 1137, 1047, 948, 829 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ 5.05 (t, J = 4.6 Hz, 1H), 4.05–3.99 (m, 2H), 3.96–3.87 (m, 2H), 2.55 (dd, J = 4.5, 2.7 Hz, 1H), 2.05 (t, J = 2.7 Hz, 1H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 102.2, 78.9, 70.3, 65.6 (2C), 25.3; HRMS (EI) calculated for $C_6H_7O_2$ $[M–H]^+$ 111.0446, found 111.0449.

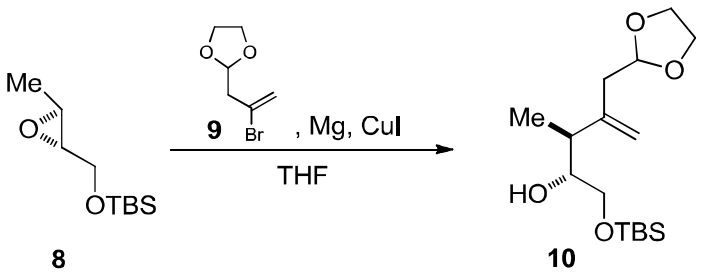


S2 **9**

2-(2-bromoallyl)-1,3-dioxolane (9). This compound was prepared by modification of a literature procedure by Hoveyda *et al*.[2] To a flame-dried flask was added THF (530 mL) and Ni(dppp)Cl_2 (0.29 g, 0.53 mmol) and the flask was purged with N_2 for 10 min. DIBAL-H (1.0 M in hexanes, 584 mL, 584 mmol) was added via cannula over 40 min. The resulting light brown solution was cooled to 0 °C and **S2** (59.5 g, 530.6 mmol) was added over 15 min. The reaction was then warmed to rt and stirred at rt for 2 h. In case too much heat is generated during the course of the reaction, an ice bath is kept handy next to the reaction. The reaction is then cooled to –78 °C and Br_2 (40.8 mL, 796 mmol) was added via syringe over 20 min. The reaction was very vigorous and THF (20 mL) was used to rinse the side of the flask. The reaction was warmed to approx. 0 °C over 1 h, and stirred without cooling for 15 min. Then the reaction was cooled down to –78 °C and a saturated solution of Rochelle's salt (sodium potassium tartrate, 300 mL) was added over 20 min. The mixture was stirred and gradually warmed to rt overnight. The THF was removed *in vacuo* and the contents of the flask were transferred to a separatory funnel with Et_2O and water. The separated aqueous layer was extracted with Et_2O (four times). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The crude product was purified by vacuum distillation (5 mbar) through a 5-inch Vigreux column to give **9** (contaminated with <10% the β-brominated regioisomer,[2] 69.44 g, 68%) as a colorless liquid which turned yellow upon standing. This material was used without further purification.

[2] Gao, F.; Hoveyda, A. H. *J. Am. Chem. Soc.* **2010**, *132*, 10961–10963.

Data for **9**: R_f = 0.36 (90:10 hexanes: Et_2O); bp 60–71°C (5 mbar); IR (thin film) 3495, 2954, 2928, 2886, 1633, 1472, 1401, 1361, 1254, 1210, 1127, 1046, 945, 894, 838, 573, 534 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 5.74–5.73 (m, 1H), 5.55 (d, J = 1.7 Hz, 1H), 5.15 (t, J = 5.0 Hz, 1H), 4.02–3.97 (m, 2H), 3.92–3.86 (m, 2H), 2.77 (d, J = 5.0 Hz, 2H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 127.3, 120.0, 102.3, 65.2 (2C), 46.2; LRMS (EI) calculated for $C_6H_9{}^{79}BrO_2$ and $C_6H_9{}^{81}BrO_2$ $[M–H]^+$ 190.9702 and 192.9682, found 190.9 and 192.9.



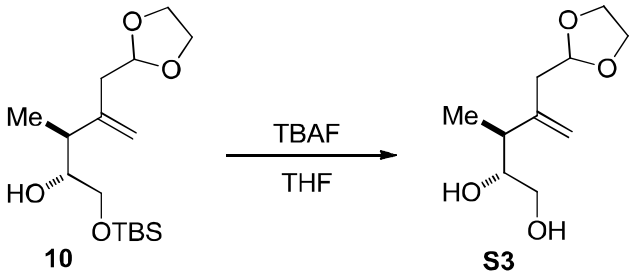
(2*R*,3*S*)-4-((1,3-dioxolan-2-yl)methyl)-1-((*tert*-butyldimethylsilyl)oxy)-3-methylpent-4-en-2-ol (10). Epoxide **8** was prepared according to the literature procedure by Sharpless *et al*. from commercially available crotyl alcohol, (+)-diisopropyl L-tartrate ((+)-DIPT)), Ti(O*i*-Pr)$_4$ and *tert*-butyldimethylsilyl chloride.[3] Due to the presence of ca. 5% *cis* alkene isomer in the commercial crotyl alcohol, **8** was contaminated with a small amount (5%) of *cis*-epoxide diastereomer. Therefore, the enantiomeric excess (*ee*) was determined for pure compound **10** instead of **8**.

A two-necked round bottom flask equipped with a reflux condenser and an addition funnel was charged with Mg (5.38 g, 221.4 mmol), THF (350 mL) and 1,2-dibromoethane (1.70 mL, 19.68 mmol). To this stirred suspension of Mg in THF was added a solution of **9** (38.0 g, 196. 85 mmol) in THF (120 mL) via the addition funnel over 30 min. The addition rate was limited to 1–3 drops/sec to control the heat generation. During the course of addition, the reaction mixture warmed up and eventually reached a gentle reflux. Several drops of 1,2-dibromoethane were added every few minutes to maintain a reflux. After all the solution of **9** was added, the reaction flask was placed in a 70 °C bath and heated for 30 min. Nearly all the Mg was dissolved during this period and the reaction mixture became a homogeneous reddish-brown solution. Upon cooling to rt, the Grignard solution was quickly transferred into a dry addition funnel via a 16

[3] Gao, Y.; Klunder, J. M.; Hanson, R. M.; Masamune, H.; Ko, S. Y.; Sharpless, K. B. *J. Am. Chem. Soc.* **1987**, *109*, 5765–5780.

gauge cannula (this large cannula was effective for preventing clogging). This Grignard reagent was then added slowly to a suspension of CuI (2.81 g, 14.76 mmol) in THF (60 mL) at –60 °C over 30 min. The reaction mixture was warmed to –40 °C over 30 min and a solution of epoxide **8** (9.95 g, 49.21 mmol) in THF (70 mL) was added. The reaction mixture was gradually warmed to 0 °C over 2 h and stirred at 0 °C for 16 h. The reaction was then quenched at –30 °C with saturated aqueous NH_4Cl and warmed to rt. After removing the THF *in vacuo*, the reaction mixture was partitioned between CH_2Cl_2 and aqueous NH_4Cl, and the aqueous layer was further extracted with CH_2Cl_2 (twice). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The crude product was purified by flash chromatography (silica gel, 90:10:1 to 85:15:1 to 80:20:1 hexanes:EtOAc:Et_3N) to afford **10** (9.11 g, 59%, 91% *ee* by Mosher's ester[4]) as a pale yellow oil.

Data for **10**: R_f = 0.37 (80:20 hexanes:Et_2O); $[\alpha]_D^{24}$ = –20.5° (*c* 0.57, $CHCl_3$); IR (thin film) 3500, 2954, 2929, 2884, 2858, 1642, 1471, 1404, 1254, 1131, 1044, 989, 837, 778, 668 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 5.01 (dd, *J* = 2.4, 1.2 Hz, 1H), 4.99 (t, *J* = 5.1 Hz, 1H), 4.97 (s, 1H), 3.99–3.96 (m, 2H), 3.88–3.84 (m, 2H), 3.65–3.59 (m, 2H), 3.47 (dd, *J* = 9.2, 6.4 Hz, 1H), 2.43 (d, *J* = 3.5 Hz, 1H), 2.39 (ddd, *J* = 5.2, 5.2, 0.9 Hz, 2H), 2.31 (dq, *J* = 6.8, 6.8 Hz, 1H), 1.12 (d, *J* = 6.9 Hz, 3H), 0.90 (s, 9H), 0.06 (s, 6H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 146.9, 113.4, 104.1, 73.8, 65.5, 65.1, 65.0, 42.8, 39.5, 26.1 (3C), 18.5, 15.3, –5.1 (2C); HRMS (ESI-TOF) calculated for $C_{16}H_{32}O_4NaSi$ $[M+Na]^+$ 339.1968, found 339.1968.

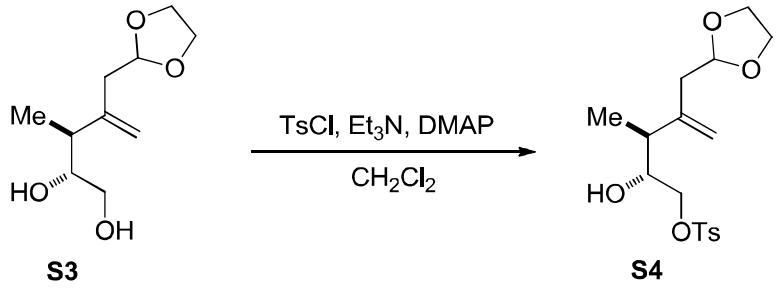


(2*R*,3*S*)-4-((1,3-dioxolan-2-yl)methyl)-3-methylpent-4-ene-1,2-diol (S3). To a solution of the silyl ether **10** (15.35 g, 48.54 mmol) in THF (200 mL) at 0 °C was added TBAF (1.0 M in THF, 53.4 mL, 53.4 mmol). The solution was stirred at 0 °C for 1 h. After addition of saturated aqueous $NaHCO_3$ (30 mL), the THF was carefully removed *in vacuo*. The mixture was then

[4] Hoye, T. R.; Jeffrey, C. S.; Shao, F. *Nature Protocols* **2007**, *2*, 2451–2458.

extracted with CH_2Cl_2 (four times) and the combined organic layers were dried over Na_2SO_4 and concentrated *in vacuo*. The crude product was purified by flash chromatography (silica gel, 50:50:1:1 to 50:50:5:1 to 50:50:10:1 to 50:50:15:1 hexanes:EtOAc:MeOH:Et_3N) to give diol **S3** (7.92 g, 81%) as a colorless oil.

Data for **S3**: R_f = 0.34 (50:50:10 hexanes:EtOAc:MeOH); $[\alpha]_D^{24}$ = –10.4° (*c* 1.01, $CHCl_3$); IR (thin film) 3408, 2963, 2930, 2886, 1643, 1403, 1215, 1135, 1044, 1005, 943, 904, 840, 630 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 5.04 (d, *J* = 1.1 Hz, 1H), 4.97 (t, *J* = 5.1 Hz, 1H), 4.96 (s, 1H), 4.02–3.96 (m, 2H), 3.90–3.84 (m, 2H), 3.70 (ddd, *J* = 5.0, 5.0, 5.0 Hz, 1H), 3.62 (dd, *J* = 5.7, 4.9 Hz, 2H), 2.45 (ddd, *J* = 14.7, 4.7, 0.7 Hz, 1H), 2.38 (ddd, *J* = 14.7, 5.4, 0.8 Hz, 1H), 2.31 (dq, *J* = 6.8, 6.8 Hz, 1H), 2.24 (t, *J* = 6.0 Hz, 1H), 1.67 (brs, 1H), 1.11 (d, *J* = 6.9 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 146.8, 114.1, 104.6, 74.2, 65.2, 65.1, 65.0, 42.8, 39.9, 15.3. HRMS (ESI-TOF) calculated for $C_{10}H_{18}O_4Na$ $[M+Na]^+$ 225.1103, found 225.1101.

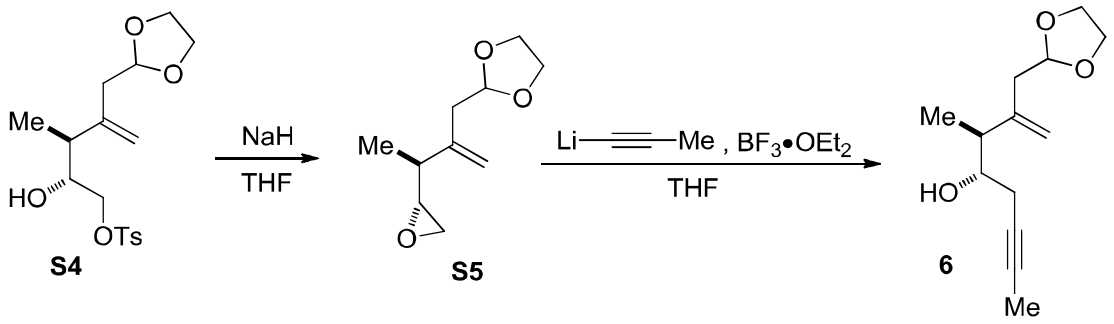


S3 **S4**

(2*R*,3*S*)-4-((1,3-dioxolan-2-yl)methyl)-2-hydroxy-3-methylpent-4-en-1-yl 4-methylbenzene-sulfonate (S4). To a solution of the diol **S3** (7.90 g, 39.06 mmol) in CH_2Cl_2 (160 mL) at 0 °C was added Et_3N (16.42 mL, 117.18 mmol), TsCl (8.94 g, 46.87 mmol) and DMAP (0.95 g, 7.81 mmol). The reaction mixture was stirred at 0 °C for 3 h. The reaction mixture was then partitioned between saturated aqueous $NaHCO_3$ and CH_2Cl_2 and the aqueous layer was extracted with CH_2Cl_2 (twice). The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. The crude product was purified by flash chromatography (silica gel, 80:20 to 67:33 to 50:50 hexanes:EtOAc, 1% Et_3N added when packing the column) to afford **S4** (12.85 g, 92%) as a pale yellow oil.

Data for **S4**: R_f = 0.25 (67:33 hexanes:EtOAc); $[\alpha]_D^{23}$ = –35.6° (*c* 0.77, $CHCl_3$); IR (thin film) 3550, 3070, 2968, 2922, 2877, 1598, 1454, 1362, 1190, 1170, 1097, 974, 896, 816, 780, 665, 554 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ 7.79 (d, *J* = 8.3 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 5.01 (d, *J*

= 0.9 Hz, 1H), 4.94 (s, 1H), 4.92 (t, *J* = 5.0 Hz, 1H), 4.09 (dd, *J* = 10.1, 3.8 Hz, 1H), 3.97–3.93 (m, 3H), 3.87–3.81 (m, 3H), 2.44 (s, 3H), 2.38 (brs, 1H), 2.35–2.30 (m, 3H), 1.03 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 145.6, 145.1, 133.0, 130.1 (2C), 128.1 (2C), 114.8, 104.2, 72.7, 70.9, 65.0, 64.9, 42.6, 39.1, 21.8, 14.2; HRMS (ESI-TOF) calculated for $C_{17}H_{24}O_6NaS$ $[M+Na]^+$ 379.1191, found 379.1189.

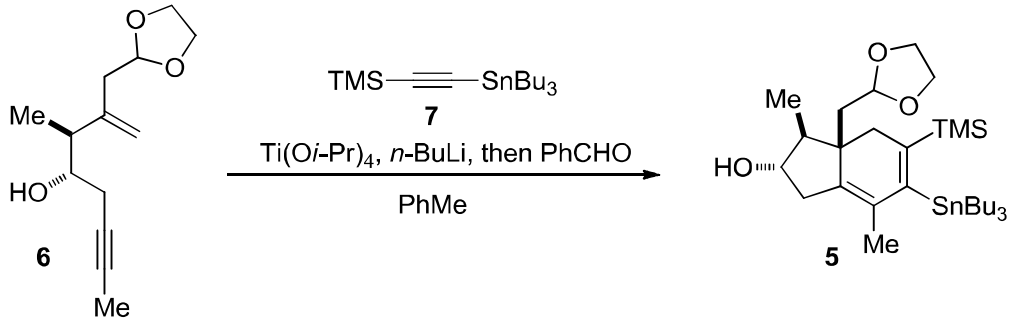


(3*S*,4*S*)-2-((1,3-dioxolan-2-yl)methyl)-3-methyloct-1-en-6-yn-4-ol (6). NaH (60% dispersion in mineral oil, 8.56 g, 214.0 mmol) was washed with hexanes and placed under high vacuum for 10 min before use. To a solution of the tosylate **S4** (12.70 g, 35.66 mmol) in THF (160 mL) at 0 °C was added the above NaH in small portions. After 20 min at 0 °C, the reaction mixture was allowed to warm to rt. After 4 h at rt, more NaH (60% dispersion in mineral oil, 8.40 g, 210 mmol, washed with hexanes and dried under vacuum before use) was added and the reaction mixture was stirred at rt for another 5.5 h. The reaction mixture was then cooled back to 0 °C and quenched by addition of saturated aqueous NH_4Cl dropwise over 20 min. After gas evolution ceased, water was added and THF was removed *in vacuo*. The resulting mixture was extracted with CH_2Cl_2 (three times) and the combined organic extracts were dried over Na_2SO_4. After removing the solvent *in vacuo*, the residue was purified by a short column (silica gel, 90:10:1 to 85:15:1 to 80:20:1 to 75:25:1 hexanes:EtOAc:Et_3N) to afford **S5** (4.97 g, 76%) as a colorless volatile liquid and was used immediately without further purification.

To a solution of *n*-BuLi (2.54 M in hexanes, 31.8 mL, 80.77 mmol) in THF (100 mL) at –78 °C was bubbled propyne using a balloon for 35 min. A solution of the epoxide **S5** (4.96 g, 26.92 mmol) in THF (60 mL) was added, followed by BF_3•OEt_2 (8.31 mL, 67.30 mmol). The reaction mixture was stirred at –78 °C for 1 h. After addition of saturated aqueous NH_4Cl, the reaction mixture was allowed to warm to rt and THF was removed *in vacuo*. The mixture was then diluted with water and CH_2Cl_2. After separation of phases, the aqueous layer was extracted with CH_2Cl_2 (three times) and the combined organic layers were dried over Na_2SO_4 and concentrated

in vacuo. The crude material was purified by flash chromatography (silica gel, 80:20:1 to 75:25:1 to 67:33:1 hexanes:EtOAc:Et_3N) to give enyne **6** (5.52 g, 91%) as a colorless oil.

Data for **6**: R_f = 0.28 (75:25 hexanes:EtOAc); $[\alpha]_D^{23}$ = –21.2° (*c* 0.34, $CHCl_3$); IR (thin film) 3459, 2966, 2919, 2888, 1807, 1775, 1732, 1643, 1402, 1330, 1226, 1137, 1037, 1037, 984, 944, 903, 841 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 5.06 (dd, *J* = 2.2, 1.1 Hz, 1H), 5.00 (t, *J* = 5.1 Hz, 1H), 4.99 (s, 1H), 4.01–3.96 (m, 2H), 3.89–3.84 (m, 2H), 3.74–3.70 (m, 1H), 2.45–2.39 (m, 3H), 2.36–2.33 (m, 2H), 2.12 (d, *J* = 4.2 Hz, 1H), 1.80 (t, *J* = 2.6 Hz, 3H), 1.09 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 146.9, 113.9, 104.2, 78.3, 75.8, 71.8, 65.1, 65.0, 44.6, 39.6, 25.3, 13.9, 3.8; HRMS (ESI-TOF) calculated for $C_{13}H_{20}O_3Na$ $[M+Na]^+$ 247.1310, found 247.1306.

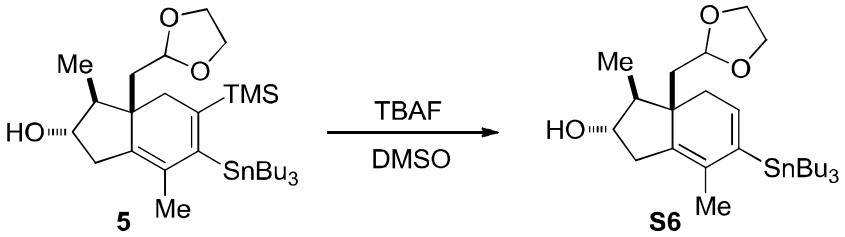


(2*S*,3*S*,3a*S*)-3a-((1,3-dioxolan-2-yl)methyl)-3,7-dimethyl-6-(tributylstannyl)-5-(trimethylsilyl)-2,3,3a,4-tetrahydro-1*H*-inden-2-ol (5). To a solution of Ti(O*i*-Pr)$_4$ (6.94 mL, 23.43 mmol) in PhMe (110 mL) at –78 °C was added *n*-BuLi (2.54 M in hexanes, 18.19 mL, 46.20 mmol) dropwise by syringe over 15 min. After another 5 min at –78 °C, a solution of alkyne **7**[5] (9.20 g, 23.76 mmol) in PhMe (32 mL) was added slowly. After this period, the cooling bath was removed and the reaction was allowed to warm to rt (approx. 20 to 30 min). The reaction mixture was then heated to 50 °C (no reflux condenser required) for 1 h and allowed to cool to rt before it was placed into a –78 °C cooling bath. In the meantime, enyne **6** (1.48 g, 6.60 mmol) was dissolved in PhMe (88 mL), treated with *n*-BuLi (2.54 M in hexanes, 2.60 mL, 6.60 mmol,) at –78 °C, and the resulting solution was stirred at –78 °C for 15 min and then allowed to warm to between 0 °C and rt over 15 min. Next, this alkoxide solution was added dropwise by syringe to the above Ti-alkyne complex solution at –78 °C. The reaction mixture was then allowed to warm slowly to rt overnight

[5] (a) Logue, M. W.; Teng, K. *J. Org. Chem.* **1982**, *47*, 2549–2553. (b) Dallaire, C.; Brook, M. A. *Organometallics* **1993**, *12*, 2332–2338.

(approx. 17 h). Then the reaction mixture was cannulated into a solution of benzaldehyde (3.58 mL, 35.18 mmol) in PhMe (250 mL) at rt and stirred for 1 h. Water was added and the reaction mixture was transferred to a separatory funnel. After separation of phases, the aqueous layer was extracted with Et_2O (four times). The combined organic extracts were dried over $MgSO_4$ and concentrated *in vacuo*. The crude material was purified by flash chromatography (silica gel, 90:10 to 85:15 to 80:20 to 75:25 hexanes:EtOAc, 1% Et_3N added when packing the column) to afford **5** (2.93 g, 73%) as a pale yellow solid.

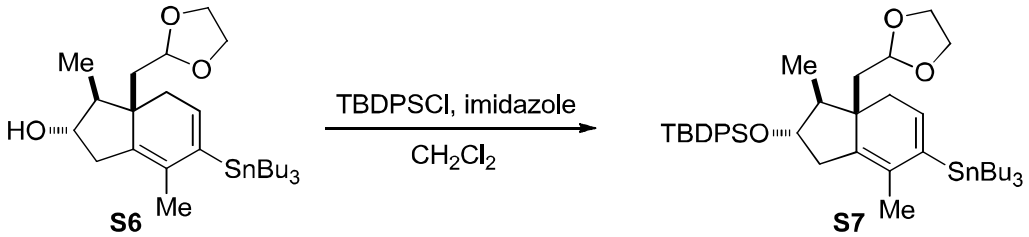
Data for **5**: R_f = 0.30 (80:20 hexanes:EtOAc); $[\alpha]_D^{23}$ = –67.1° (*c* 0.55, $CHCl_3$); IR (thin film) 3399, 2955, 2923, 2871, 1711, 1606, 1454, 1406, 1375, 1247, 1127, 1058, 1012, 858, 835, 751, 699 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 4.58 (dd, *J* = 5.8, 3.6 Hz, 1H), 4.13 (ddd, *J* = 17.7, 8.2, 6.1 Hz, 1H), 3.87–3.80 (m, 2H), 3.72–3.62 (m, 2H), 2.81 (dd, *J* = 18.0, 8.4 Hz, 1H), 2.33 (app. d, *J* = 16.6 Hz, 1H), 2.20 (dd, *J* = 18.0, 7.4 Hz, 1H), 1.84 (dd, *J* = 14.6, 3.6 Hz, 1H), 1.80 (app. d, *J* = 16.7 Hz, 1H), 1.73 (s, 3H), 1.52–1.41 (m, 7H), 1.36–1.26 (m, 7H), 1.09 (d, *J* = 7.0 Hz, 3H), 0.96–0.88 (m, 16H), 0.14 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 154.7, 148.6, 136.3, 130.8, 103.8, 76.3, 64.8, 64.4, 56.2, 43.6, 42.6, 38.7, 34.3, 29.4 (3C), 27.8 (3C), 20.1, 13.9 (3C), 13.2 (3C), 11.5, 0.1 (3C); HRMS (ESI-TOF) calculated for $C_{30}H_{57}O_3SiSn$ $[M+H]^+$ 613.3099, found 613.3104.



(2*S*,3*S*,3a*R*)-3a-((1,3-dioxolan-2-yl)methyl)-3,7-dimethyl-6-(tributylstannyl)-2,3,3a,4-tetrahydro-1*H*-inden-2-ol (S6). To a solution of the vinyl silane **5** (2.53 g, 4.137 mmol) in DMSO (16.5 mL) was added TBAF (1.0 M in THF, 24.8 mL, 24.8 mmol). After removing the THF *in vacuo*, the reaction mixture was heated at 100 °C for 3 h before another portion of TBAF in DMSO (prepared by dissolving TBAF (1.0 M in THF, 10 mmol) in DMSO (6 mmol) and removing the THF *in vacuo*) was added. The reaction mixture was stirred at 100 °C for another 2 h. Upon cooling to rt, the reaction mixture was diluted with EtOAc, washed with water (three times) and brine. The resulting organic layer was dried over $MgSO_4$ and concentrated *in vacuo*.

Purification of the crude mixture by flash chromatography (silica gel, 94:6 to 50:50 hexanes:EtOAc) afforded **S6** (1.46 g mg, 65%) as a yellow oil.

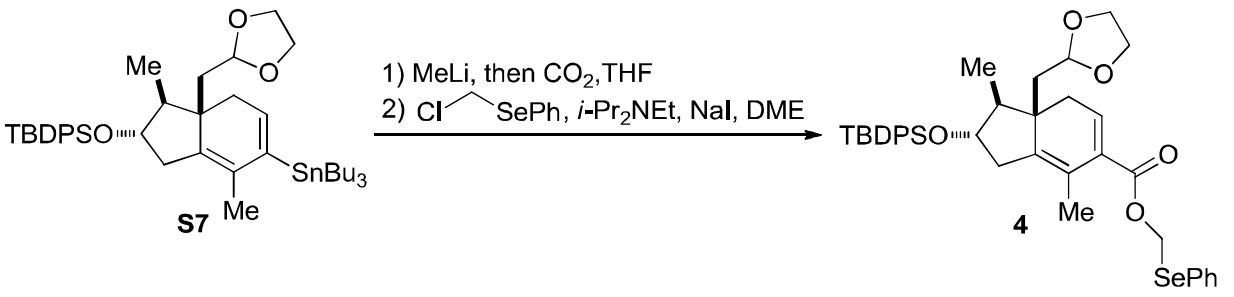
Data for **S6**: R_f = 0.30 (75:25 hexanes:EtOAc); $[\alpha]_D^{24}$ = –2.9° (*c* 0.38, $CHCl_3$); IR (thin film) 3370, 2955, 2924, 2871, 1457, 1418, 175, 1247, 1126, 1062, 1010, 944, 860, 860, 832, 689, 652, 597 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ 5.83 (dd, *J* = 6.0, 1.7 Hz, 1H), 4.75 (dd, *J* = 5.0, 4.1 Hz, 1H), 4.03 (ddd, *J* = 15.3, 9.2, 7.0 Hz, 1H), 3.90–3.83 (m, 2H), 3.72–3.65 (m, 2H), 2.88 (dd, *J* = 18.3, 8.9 Hz, 1H), 2.33 (dd, *J* = 16.6, 6.2 Hz, 1H), 2.21 (dd, *J* = 18.3, 6.8 Hz, 1H), 2.07 (d, *J* = 16.5 Hz, 1H), 1.70 (s, 3H), 1.68–1.62 (m, 2H), 1.58 (d, *J* = 5.9 Hz, 1H), 1.52–1.42 (m, 6H), 1.39 (dd, *J* = 14.4, 10.6 Hz, 1H), 1.35–1.28 (m, 6H), 1.04 (d, *J* = 6.9 Hz, 3H), 0.94–0.83 (m, 15H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 140.1, 135.1, 134.9, 128.3, 103.4, 76.4, 64.8, 64.5, 56.3, 42.9, 38.0, 37.3, 37.2, 29.4 (3C), 27.6 (3C), 20.2, 13.9 (3C), 11.4, 10.4(3C); HRMS (ESI-TOF) calculated for $C_{27}H_{49}O_3Sn$ $[M+H]^+$ 541.2704, found 541.2720.



(((2*S*,3*S*,3a*R*)-3a-((1,3-dioxolan-2-yl)methyl)-3,7-dimethyl-6-(tributylstannyl)-2,3,3a,4-tetrahydro-1*H*-inden-2-yl)oxy)(*tert*-butyl)diphenylsilane (S7). To a solution of alcohol **S6** (2.40 g, 4.44 mmol) in CH_2Cl_2 (44 mL) at rt was added imidazole (484 mg, 7.11 mmol) and TBDPSCl (1.73 mL, 7.11 mmol). The reaction mixture was stirred at rt for 6.5 h. The reaction mixture was then diluted with saturated aqueous $NaHCO_3$ and CH_2Cl_2. After separation of phases, the aqueous layer was extracted with CH_2Cl_2 (twice). The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. Purification of the crude product by flash chromatography (silica gel, 99:1 to 90:10 hexanes:EtOAc) afforded **S7** (3.32 g, 96%) as a colorless oil.

Data for **S7**: R_f = 0.38 (95:5 hexanes:EtOAc); $[\alpha]_D^{24}$ = +33.2° (*c* 0.46, $CHCl_3$); IR (thin film) 2955, 2927, 2856, 1463, 1427, 1375, 1112, 1087, 874, 822, 740, 701, 666, 610 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.69–7.67 (m, 4H), 7.44–7.35 (m, 6H), 5.80 (dd, *J* = 6.1, 1.8 Hz, 1H), 4.59 (dd, *J* = 5.4, 3.7 Hz, 1H), 4.08 (ddd, *J* = 8.9, 7.3, 1.6 Hz, 1H), 3.84–3.74 (m, 2H), 3.63–3.55 (m, 2H), 2.46 (dd, *J* = 18.4, 8.4 Hz, 1H), 2.29 (dd, *J* = 16.7, 6.2 Hz, 1H), 2.22 (dd, *J* = 18.3, 6.6 Hz,

1H), 2.07 (d, J = 16.4 Hz, 1H), 1.83 (dq, J = 9.3, 6.9 Hz, 1H), 1.60 (s, 3H), 1.52 (dd, J = 14.4, 5.5 Hz, 1H), 1.49–1.41 (m, 6H), 1.34–1.26 (m, 6H), 1.20 (dd, J = 14.4, 3.6 Hz, 1H), 1.08 (s, 9H), 0.89–0.85 (m, 18H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 139.9, 136.20 (2C), 136.16 (2C), 135.5, 135.1, 134.9, 134.6, 129.7 (2C), 127.8, 127.67 (2C), 127.65 (2C), 103.4, 77.4, 64.7, 64.3, 56.3, 42.1, 38.1, 37.2 (2C), 29.4 (3C), 27.7 (3C), 27.3 (3C), 20.1, 19.5, 13.9 (3C), 11.6, 10.4 (3C); HRMS (ESI-TOF) calculated for $C_{43}H_{67}O_3SiSn$ $[M+H]^+$ 779.3881, found 779.3885.

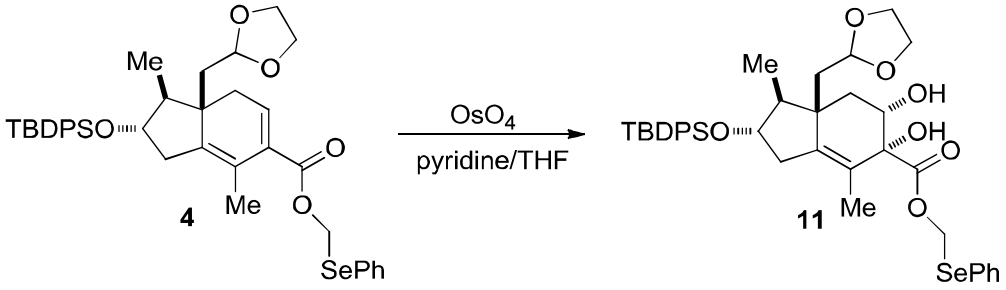


(1*S*,2S,7a*R*)-(phenylselanyl)methyl 7a-((1,3-dioxolan-2-yl)methyl)-2-((*tert*-butyldiphenylsilyl)oxy)-1,4-dimethyl-2,3,7,7a-tetrahydro-1*H*-indene-5-carboxylate (4). To a solution of the vinyl stannane **S7** (720 mg, 0.93 mmol) in THF (8 mL) at –78 °C was added MeLi (1.6 M in Et_2O, 1.16 mL, 1.85 mmol) dropwise. After 5 min at –78 °C, the reaction mixture was allowed to warm to rt over 20 min and stirred at rt for another 50 min. After cooling back down to –78 °C, CO_2 gas was bubbled into the reaction mixture using a balloon for 15 min. The reaction was then quenched at –78 °C by addition of pH 7 buffer (8 mL) and THF was removed *in vacuo* upon warming to rt. The resulting mixture was extracted with CH_2Cl_2 (four times) and the combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo* to give a crude carboxylic acid (748 mg) which was used without further purification.

To the above crude acid in anhydrous DME (8 mL) was added $PhSeCH_2Cl$[6] (476 mg, 2.31 mmol), *i*-Pr_2NEt (0.16 mL, 0.93 mmol) and NaI (416 mg, 2.78 mmol). The reaction mixture was heated at 80 °C for 24 h. Upon cooling to rt, saturated aqueous $NaHCO_3$ was added and DME was removed *in vacuo*. The resulting mixture was extracted with CH_2Cl_2 (four times) and concentrated *in vacuo*. The crude material was purified by flash chromatography (silica gel, 97:3 to 70:30 hexanes:EtOAc) and afforded **4** (322 mg, 50% over two steps) as a colorless oil.

[6] (a) Beckwith, A. L. J.; Pigou, P. E. *Aust. J. Chem.* **1986**, *39*, 77–87. (b) Huang, X.; Duan, D.-H. *Synlett* **1998**, 1191–1192.

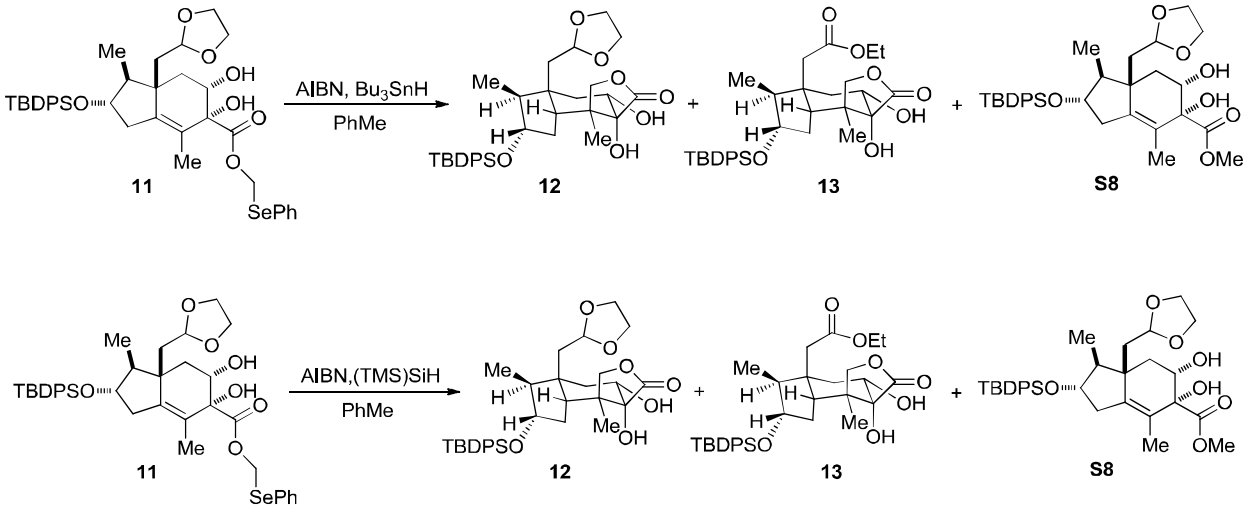
Data for **4**: R_f = 0.43 (85:15 hexanes:EtOAc); $[\alpha]_D^{23}$ = +4.2° (*c* 0.90, $CHCl_3$); IR (thin film) 3068, 2956, 2887, 2859, 1720, 1584, 1472, 1425, 1292, 1228, 1110, 1020, 945, 874, 822, 739, 703, 610, 503 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ 7.68–7.66 (m, 4H), 7.59–7.58 (m, 2H), 7.45–7.41 (m, 2H), 7.39–7.36 (m, 4H), 7.30–7.28 (m, 3H), 6.75 (dd, *J* = 6.6, 2.4 Hz, 1H), 5.71 (app. d, *J* = 9.9 Hz, 1H), 5.56 (app. d, *J* = 9.9 Hz, 1H), 4.51 (dd, *J* = 6.1, 3.3 Hz, 1H), 4.08 (ddd, *J* = 10.6, 8.6, 8.6 Hz, 1H), 3.78–3.75 (m, 1H), 3.72–3.69 (m, 1H), 3.60–3.54 (m, 2H), 2.49 (dd, *J* = 17.5, 6.7 Hz, 1H), 2.46 (dd, *J* = 18.3, 8.5 Hz, 1H), 2.26 (dd, *J* = 18.5, 7.1 Hz, 1H), 2.13 (d, *J* = 16.8 Hz, 1H), 1.84 (dq, *J* = 9.3, 6.9 Hz, 1H), 1.72 (s, 3H), 1.45 (dd, *J* = 14.5, 6.1 Hz, 1H), 1.22 (dd, *J* = 14.4, 3.3 Hz, 1H), 1.09 (s, 9H), 0.90 (d, *J* = 6.9 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 166.2, 140.2, 138.0, 136.14 (2C), 136.11 (2C), 134.6, 134.3, 133.2 (2C), 131.2, 130.3, 129.85 (2C), 129.83 (2C), 129.4 (2C), 127.8, 127.7 (2C), 122.1, 102.7, 77.4, 64.9, 64.2, 62.2, 56.0, 42.5, 37.9, 37.0, 35.6, 27.3 (3C), 19.5, 16.1, 11.4; HRMS (ESI-TOF) calculated for $C_{39}H_{47}O_5SiSe$ $[M+H]^+$ 703.2358, found 703.2361.



(1*S*,2*S*,5*R*,6*S*,7a*R*)-(phenylselanyl)methyl 7a-((1,3-dioxolan-2-yl)methyl)-2-((*tert*-butyldiphenylsilyl)oxy)-5,6-dihydroxy-1,4-dimethyl-2,3,5,6,7,7a-hexahydro-1*H*-indene-5-carboxylate (11). To a solution of the diene **4** (1.24 g, 1.765 mmol) in THF (18 mL) and pyridine (15 mL) at 0 °C was added of OsO_4 (0.2 M in THF, 9.71 mL, 1.94 mmol). After stirring at 0 °C for 2 h, a 5% $NaHSO_3$ aqueous solution (60 mL) was added. The reaction mixture was slowly warmed to rt and stirred overnight. The mixture was then extracted with CH_2Cl_2 (four times) and dried over $MgSO_4$. After removing the solvent *in vacuo*, the crude material was purified by flash chromatography (silica gel, 90:10 to 20:80 hexanes:EtOAc) to afford **11** (1.10 g, 85%) as a white foam.

Data for **11**: R_f = 0.35 (60:40 hexanes:EtOAc); $[\alpha]_D^{24}$ = +40.4° (*c* 0.77, $CHCl_3$); IR (thin film) 3489, 3070, 2957, 2889, 2857, 1740, 1472, 1427, 1253, 1206, 1111, 1020, 985, 939, 876, 822, 739, 703, 611, 507 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.67–7.64 (m, 4H), 7.52–7.50 (m, 2H),

7.45–7.41 (m, 2H), 7.39–7.36 (m, 4H), 7.30–7.21 (m, 3H), 5.73 (app. d, J = 10.1 Hz, 1H), 5.55 (app. d, J = 10.1 Hz, 1H), 4.76 (dd, J = 4.5, 4.5 Hz, 1H), 4.44 (ddd, J = 12.4, 10.4, 3.8 Hz, 1H), 3.82–3.73 (m, 3H), 3.62–3.57 (m, 2H), 2.34 (ddd, J = 17.6, 9.0, 1.5 Hz, 1H), 2.25 (d, J = 10.3 Hz, 1H), 2.17 (dd, J = 17.2, 5.0 Hz, 1H), 2.02 (dd, J = 12.0, 3.8 Hz, 1H), 1.67 (dq, J = 8.7, 7.0 Hz, 1H), 1.62 (dd, J = 15.2, 4.0 Hz, 1H), 1.48 (dd, J = 15.1, 5.0 Hz, 1H), 1.44 (s, 3H), 1.36 (dd, J = 12.4, 12.4 Hz, 1H), 1.06 (s, 9H), 0.90 (d, J = 7.0 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 175.8, 144.3, 136.15 (2C), 136.13 (2C), 134.6, 134.3, 133.6 (2C), 129.8 (2C), 129.47 (2C), 128.2 (2C), 127.75 (2C), 127.73 (2C), 123.0, 103.0, 77.7, 77.3, 68.6, 64.74, 64.70, 64.3, 55.3, 46.2, 39.1, 38.1, 37.6, 27.2 (3C), 19.4, 14.3, 11.7; HRMS (ESI-TOF) calculated for $C_{39}H_{49}O_7SiSe$ $[M+H]^+$ 737.2413, found 737.2430.

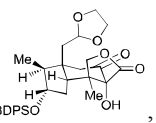


(3a*R*,4*S*,5a*S*,6*S*,7*S*,8a*R*,8b*R*)-5a-((1,3-dioxolan-2-yl)methyl)-7-((*tert*-butyldiphenylsilyl)oxy)-3a,4-dihydroxy-6,8b-dimethyloctahydro-1*H*-indeno[4,5-*c*]furan-3(8b*H*)-one (12) and ethyl 2-((3a*R*,4*S*,5a*S*,6*S*,7*S*,8a*R*,8b*R*)-7-((*tert*-butyldiphenylsilyl)oxy)-3a,4-dihydroxy-6,8b-dimethyl-3-oxodecahydro-1*H*-indeno[4,5-*c*]furan-5a-yl)acetate (13). Typical procedure using Bu_3SnH as the reducing agent: To a solution of **11** (391 mg, 0.531 mmol), AIBN (17.5 mg, 0.106 mmol) and Bu_3SnH (0.071 mL, 0.266 mmol) in PhMe (18 mL) at 80 °C was added a solution of AIBN (157 mg, 0.957 mmol) and Bu_3SnH (0.64 mL, 2.39 mmol) in PhMe (54 mL) via syringe pump over a period of 3 h. The reaction mixture was stirred at 80 °C for another 2 h. Upon cooling to rt, the reaction mixture was concentrated *in vacuo* and the residue was purified by flash chromatography (silica gel, 90:10 to 0:100 hexanes:EtOAc) to afford **12** (contaminated with a

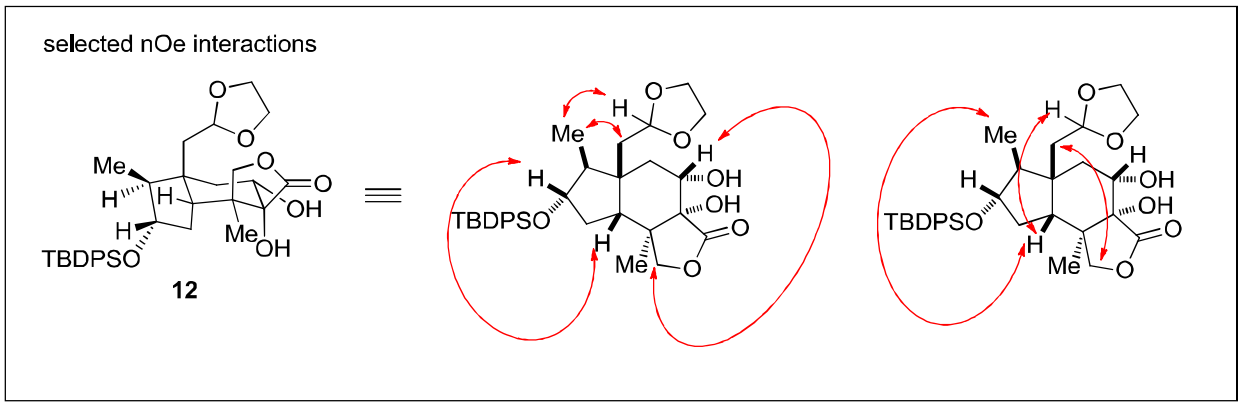
small amount of **S11**,[7] see ^{1}H NMR for details, 125 mg, 40%), **13** (124 mg, 40%) and **S8** (46 mg, 15%) as white foams.

Procedure with TMS_3SiH as the reducing agent: To a solution of **11** (61.5 mg, 0.0836 mmol), AIBN (2.8 mg, 0.0167 mmol) and TMS_3SiH (12.9 μL, 0.0418 mmol) in PhMe (2.8 mL) at 80 °C was added a solution of AIBN (24.7 mg, 0.151 mmol) and TMS_3SiH (0.12 mL, 0.3769 mmol) in PhMe (8.5 mL) via syringe pump over a period of 3 h. The reaction mixture was stirred at 80 °C for another 2.5 h. Upon cooling to rt, the reaction mixture was concentrated *in vacuo* and the residue was purified by flash chromatography (silica gel, 90:10 to 0:100 hexanes:EtOAc) afforded **12** (4.0 mg, 8%), **13** (18.6 mg, 38%) and **S8** (4.4 mg, 9%) as white foams.

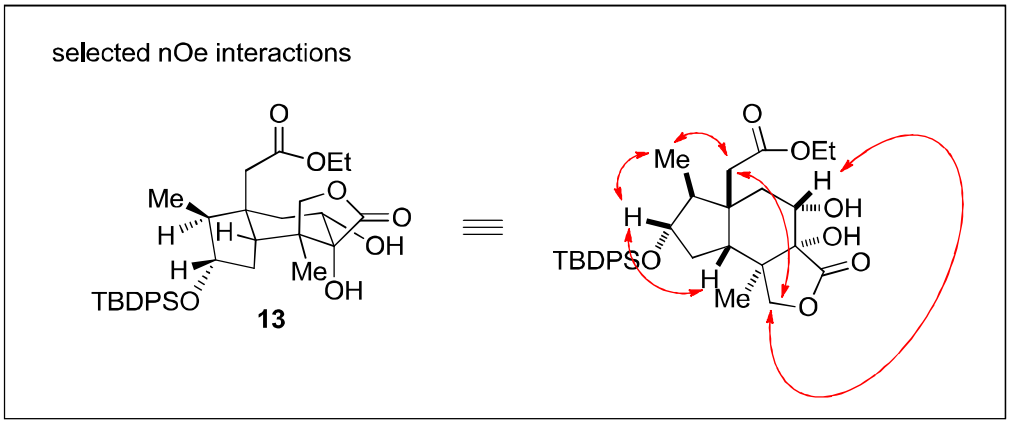
Data for **12**: R_f = 0.34 (50:50 hexanes:EtOAc); $[\alpha]_D^{24}$ = +1.4° (*c* 0.50, $CHCl_3$); IR (thin film) 3469, 2957, 2930, 2888, 2857, 1779, 1471, 1427, 1391, 1246, 1111, 1077, 1059, 1007, 1059, 1007, 979, 886, 822, 800, 740, 703, 665, 612, 505 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.66–7.64 (m, 4H), 7.44–7.36 (m, 6H), 4.68 (dd, *J* = 5.4, 2.4 Hz, 1H), 4.34 (app. d, *J* = 9.6 Hz, 1H), 4.08 (ddd, *J* = 12.0, 4.6, 4.6 Hz, 1H), 3.97 (ddd, *J* = 6.8, 6.8, 6.3 Hz, 1H), 3.90 (ddd, *J* = 6.9, 6.9, 6.0 Hz, 1H), 3.83 (ddd, *J* = 7.3, 7.3, 5.8 Hz, 1H), 3.75 (ddd, *J* = 7.1, 7.1, 6.0 Hz, 1H), 3.73 (app. d, *J* = 9.5 Hz, 1H), 3.69 (ddd, *J* = 7.5, 5.8, 3.4 Hz, 1H), 3.54 (s, 1H), 2.37 (dd, *J* = 13.0, 13.0 Hz, 1H), 2.29 (d, *J* = 5.1 Hz, 1H), 2.07 (ddd, *J* = 13.7, 11.8, 5.6 Hz, 1H), 2.00–1.90 (m, 3H), 1.83 (dd, *J* = 13.4, 3.7 Hz, 1H), 1.77 (d, *J* = 14.2 Hz, 1H), 1.59 (dd, *J* = 11.5, 8.3 Hz, 1H), 1.11 (s, 3H), 1.06 (s, 9H), 0.67 (d, *J* = 7.5 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.5, 136.1 (2C), 136.0 (2C), 134.4, 134.3, 129.84, 129.82, 127.78 (2C), 127.76 (2C), 103.4, 78.9, 77.2, 74.9, 67.1, 65.2, 64.5, 53.4, 44.5, 44.0, 43.5, 40.2, 37.6, 33.9, 27.2 (3C), 22.0, 19.3, 14.8; HRMS (ESI-TOF) calculated for $C_{33}H_{44}O_7NaSi$ $[M+Na]^+$ 603.2754, found 603.2751.

[7] The formation of a minor amount of **S11** (< 5% yield), 

, is believed to result from an additional intramolecular hydrogen atom transfer from radical **III**.

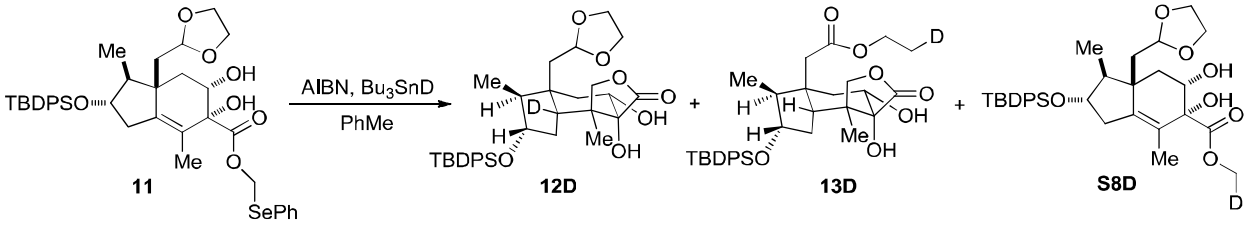


Data for **13**: R_f = 0.35 (67:33 hexanes:EtOAc); $[\alpha]_D^{24}$ = +12.4° (*c* 0.33, $CHCl_3$); IR (thin film) 3478, 2958, 2930, 2898, 2857, 1782, 1732, 1463, 1427, 1373, 1147, 1111, 1083, 1023, 822, 741, 703, 665, 613 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.66–7.64 (m, 4H), 7.43–7.35 (m, 6H), 4.18 (app. d, *J* = 9.6 Hz, 1H), 4.08 (q, *J* = 7.1 Hz, 2H), 4.02 (ddd, *J* = 12.2, 3.8, 3.8 Hz, 1H), 3.77 (app. d, *J* = 9.5 Hz, 1H), 3.73 (ddd, *J* = 7.5, 5.5, 3.1 Hz, 1H), 3.61 (s, 1H), 2.58 (app. d, *J* = 16.1 Hz, 1H), 2.44 (dd, *J* = 13.1, 13.1 Hz, 1H), 2.31 (app. d, *J* = 16.1 Hz, 1H), 2.13–2.10 (m, 1H), 2.10–2.07 (m, 1H), 1.96 (dd, *J* = 13.9, 6.4 Hz, 1H), 1.92 (dd, *J* = 14.0, 3.8 Hz, 1H), 1.87 (dd, *J* = 11.2, 8.4 Hz, 1H), 1.67–1.60 (m, 1H), 1.22 (t, *J* = 7.1 Hz, 3H), 1.12 (s, 3H), 1.06 (s, 9H), 0.66 (d, *J* = 7.5 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.4, 171.7, 136.1 (2C), 136.0 (2C), 134.4, 134.3, 129.8 (2C), 127.78 (2C), 127.76 (2C), 78.5, 77.2, 74.7, 66.9, 60.7, 53.8, 45.0, 44.5, 42.7, 40.0, 37.5, 34.1, 27.1 (3C), 21.8, 19.3, 14.7, 14.3; HRMS (ESI-TOF) calculated for $C_{33}H_{44}O_7NaSi$ $[M+Na]^+$ 603.2754, found 603.2747.



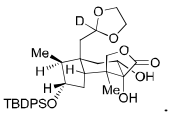
Data for **S8**: R_f = 0.22 (50:50 hexanes:EtOAc); $[\alpha]_D^{24}$ = +56.4° (*c* 0.22, $CHCl_3$); IR (thin film) 3480, 2956, 2930, 2892, 2857, 1776, 1737, 1462, 1428, 1376, 1255, 1112, 1087, 1018, 876, 822, 741, 703, 611 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ 7.68–7.64 (m, 4H), 7.43–7.35 (m, 6H), 4.79

(dd, J = 4.5, 4.5 Hz, 1H), 4.39 (ddd, J = 12.7, 10.9, 3.7 Hz, 1H), 4.12 (ddd, J = 8.9, 8.9, 5.3 Hz, 1H), 3.91 (s, 1H), 3.89–3.83 (m, 2H), 3.77 (s, 3H), 3.73–3.68 (m, 2H), 2.48 (d, J = 9.8 Hz, 1H), 2.36 (ddd, J = 17.6, 9.0, 1.2 Hz, 1H), 2.17 (dd, J = 17.5, 5.1 Hz, 1H), 2.01 (dd, J = 12.0, 3.8 Hz, 1H), 1.67 (dq, J = 8.6, 7.0 Hz, 1H), 1.63 (dd, J = 15.1, 4.0 Hz, 1H), 1.49 (dd, J = 15.1, 5.0 Hz, 1H), 1.43 (s, 3H), 1.36 (dd, J = 12.3, 12.3 Hz, 1H), 1.06 (s, 9H), 0.91 (d, J = 7.0 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.6, 143.8, 136.1 (2C), 136.0 (2C), 134.5, 134.2, 129.8 (2C), 127.66 (2C), 127.65 (2C), 123.1, 103.0, 77.6, 77.3, 68.7, 65.0 (2C), 55.2, 53.4, 46.1, 39.1, 38.0, 37.6, 27.2 (3C), 19.3, 14.3, 11.6; HRMS (ESI-TOF) calculated for $C_{33}H_{44}O_7NaSi$ $[M+Na]^+$ 603.2754, found 603.2751.



12D and 13D. To a solution of **11** (90 mg, 0.1223 mmol), AIBN (4.0 mg, 0.0245 mmol) and Bu_3SnD (16.5 μL, 0.0612 mmol) in PhMe (4.2 mL) at 80 °C was added a solution of AIBN (36.1 mg, 0.2201 mmol) and Bu_3SnD (0.15 mL, 0.5504 mmol) in PhMe (12.4 mL) via syringe pump over a period of 3 h. The reaction mixture was stirred at 80 °C for another 2.5 h. Upon cooling to rt, the reaction mixture was concentrated *in vacuo* and the residue was purified by flash chromatography (silica gel, 90:10 to 0:100 hexanes:EtOAc) to afford **12D** (23.8 mg, 33%, contaminated with a small amount of isomer **12D'**,[8] see ^{1}H, ^{2}H and ^{13}C spectra for details), **13D** (23.8 mg, 46%) and **S8D** (13.8 mg, 19%) as white foams.

Data for **12D**: R_f = 0.34 (50:50 hexanes:EtOAc); $[\alpha]_D^{24}$ = +3.6° (*c* 1.0, $CHCl_3$); IR (thin film) 3465, 2957, 2930, 2892, 2856, 1778, 1462, 1427, 1390, 1257, 1225, 1111, 1162, 999, 822, 741, 703, 665, 611 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.66–7.63 (m, 4H), 7.44–7.35 (m, 6H), 4.68 (dd, J = 5.3, 2.6 Hz, 1H), 4.33 (app. d, J = 9.5 Hz, 1H), 4.08 (ddd, J = 12.3, 4.6, 4.6 Hz, 1H),

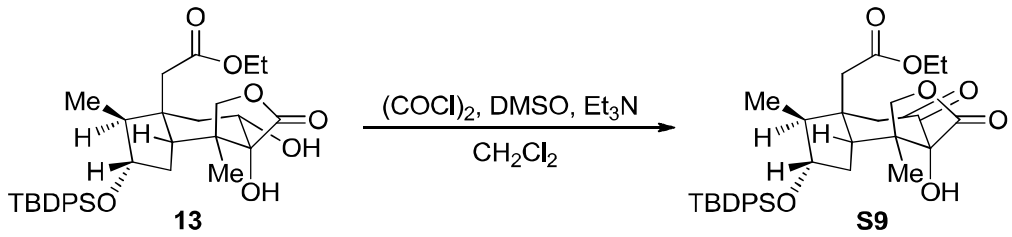
[8] Structure of **12D'**:  . The fact that **12D'** was isolated in only a small amount (ca.19% of **12D**, see ^{1}H, ^{2}H and ^{13}C spectra for details) indicates that under the reaction conditions, the fragmentation of radical **III** was fast relative to the intermolecular reduction with Bu_3SnD.

3.97 (ddd, *J* = 6.9, 6.9, 6.2 Hz, 1H), 3.89 (ddd, *J* = 6.9, 6.9, 5.9 Hz, 1H), 3.82 (ddd, *J* = 7.2, 7.2, 5.9 Hz, 1H), 3.75 (ddd, *J* = 7.1, 7.1, 6.0 Hz, 1H), 3.73 (app. d, *J* = 9.6 Hz, 1H), 3.68 (ddd, *J* = 7.3, 5.7, 3.6 Hz, 1H), 3.59 (s, 1H), 2.41 (d, *J* = 5.0 Hz, 1H), 2.37–2.32 (m, 2H), 2.06 (dd, *J* = 13.7, 5.8 Hz, 1H), 1.99–1.89 (m, 2H), 1.83 (dd, *J* = 13.5, 3.9 Hz, 1H), 1.77 (dd, *J* = 14.8, 2.0 Hz, 1H), 1.59* (minor regioisomer **12D'**, dd, *J* = 11.6, 8.4 Hz, 1H), 1.11 (s, 3H), 1.06 (s, 9H), 0.68 (d, *J* = 7.5 Hz, 3H); ^{2}H NMR (77 MHz, $CHCl_3$) 4.69*, 1.59; ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.6, 136.1 (2C), 136.0 (2C), 134.4, 134.3, 129.83, 129.81, 127.78 (2C), 127.75 (2C), 103.4, 78.88*, 78.86, 77.2, 74.9, 67.0, 65.2, 64.5, 53.48, 53.45*, 44.5*, 44.4, 43.9*, 43.8, 43.5*, 40.14, 40.08*, 37.6*, 37.5, 34.1, 34.0*, 27.22 (3C)*, 27.1 (3C), 21.95*, 21.91, 19.3, 14.75*, 14.72; HRMS (ESI-TOF) calculated for $C_{33}H_{43}DO_7NaSi$ $[M+Na]^+$ 604.2817, found 604.2821.

Data for **13D**: R_f = 0.35 (67:33 hexanes:EtOAc); $[\alpha]_D^{24}$ = +15.8° (*c* 0.46, $CHCl_3$); IR (thin film) 3478, 2958, 2892, 2860, 1780, 1730, 1466, 1427, 1389, 1242, 1110, 1055, 1019, 822, 741, 704, 611, 505 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.66–7.64 (m, 4H), 7.43–7.35 (m, 6H), 4.18 (app. d, *J* = 9.6 Hz, 1H), 4.08 (ddd, *J* = 7.0, 7.0, 1.0 Hz, 2H), 4.01 (ddd, *J* = 12.5, 4.8, 4.8 Hz, 1H), 3.78 (app. d, *J* = 9.5 Hz, 1H), 3.73 (ddd, *J* = 7.6, 5.4, 3.0 Hz, 1H), 3.53 (s, 1H), 2.58 (app. d, *J* = 16.0 Hz, 1H), 2.45 (dd, *J* = 13.1, 13.1 Hz, 1H), 2.35 (d, *J* = 5.1 Hz, 1H), 2.31 (app. d, *J* = 16.0 Hz, 1H), 2.14–2.09 (m, 1H), 2.08 (dd, *J* = 11.6, 5.4 Hz, 1H), 1.99–1.85 (m, 3H), 1.23 (app. d, *J* = 7.1 Hz, 1H), 1.19 (app. dd, *J* = 7.1, 1.9 Hz, 1H), 1.13 (s, 3H), 1.05 (s, 9H), 0.66 (d, *J* = 7.5 Hz, 3H); ^{2}H NMR (77 MHz, $CHCl_3$) 1.23; ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.3, 171.6, 136.1 (2C), 136.0 (2C), 134.4, 134.3, 129.8 (2C), 127.79 (2C), 127.76 (2C), 78.5, 77.1, 74.7, 67.1, 60.6, 53.8, 45.1, 44.5, 42.8, 40.0, 37.5, 34.0, 27.2 (3C), 21.8, 19.3, 14.8, 14.1 (t, *J* = 19.4 Hz); HRMS (ESI-TOF) calculated for $C_{33}H_{43}DO_7NaSi$ $[M+Na]^+$ 604.2817, found 604.2820.

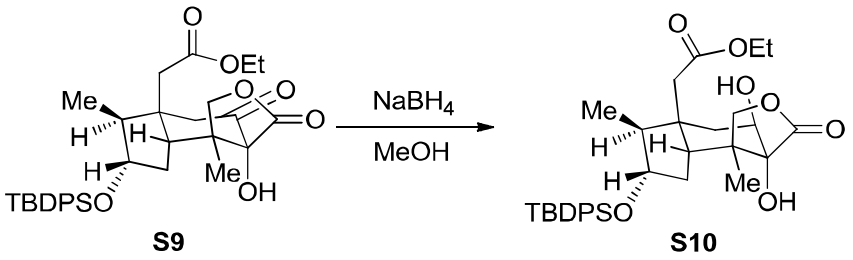
Data for **S8D**: R_f = 0.22 (50:50 hexanes:EtOAc); $[\alpha]_D^{24}$ = +67.8° (*c* 0.48, $CHCl_3$); IR (thin film) 3477, 2957, 2930, 2857, 1736, 1462, 1427, 1254, 1112, 1087, 1017, 943, 876, 822, 741, 703, 666, 611 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.66–7.63 (m, 4H), 7.44–7.35 (m, 6H), 4.78 (dd, *J* = 4.8, 4.2 Hz, 1H), 4.39 (ddd, *J* = 12.6, 10.8, 3.8 Hz, 1H), 4.10 (ddd, *J* = 8.9, 8.9, 5.3 Hz, 1H), 3.89–3.84 (m, 2H), 3.85 (s, 1H), 3.78–3.76 (m, 2H), 3.74–3.68 (m, 2H), 2.35 (ddd, *J* = 17.6, 9.0, 1.5 Hz, 1H), 2.24 (d, *J* = 10.8 Hz, 1H), 2.16 (dd, *J* = 17.0, 5.2 Hz, 1H), 2.02 (dd, *J* = 12.0, 3.8 Hz, 1H), 1.66 (dq, *J* = 8.8, 7.0 Hz, 1H), 1.62 (dd, *J* = 15.0, 4.0 Hz, 1H), 1.47 (dd, *J* = 15.0, 5.0 Hz, 1H), 1.42 (s, 3H), 1.34 (dd, *J* = 12.5, 12.5 Hz, 1H), 1.06 (s, 9H), 0.90 (d, *J* = 7.0 Hz, 3H); ^{2}H NMR (77 MHz, $CHCl_3$) 3.79; ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.8, 144.0, 136.2 (2C), 136.1 (2C), 134.6, 134.3, 129.8 (2C), 127.75 (2C), 127.73 (2C), 123.1, 103.1, 77.6, 77.4, 68.8, 64.8

(2C), 55.3, 53.3 (t, J = 22.7 Hz) 46.2, 39.2, 38.0, 37.7, 27.2 (3C), 19.4, 14.3, 11.7; HRMS (ESI-TOF) calculated for $C_{33}H_{43}DO_7NaSi$ $[M+Na]^+$ 604.2817, found 604.2820.



Ethyl 2-((3a*R*,5a*S*,6*S*,7*S*,8a*R*,8b*R*)-7-((*tert*-butyldiphenylsilyl)oxy)-3a-hydroxy-6,8b-dimethyl-3,4-di-oxodecahydro-1*H*-indeno[4,5-*c*]furan-5a-yl)acetate (S9). To CH_2Cl_2 (1.2 mL) at –78 °C was added oxalyl chloride (freshly prepared 0.2 M stock solution in CH_2Cl_2, 1.45 mL, 0.2893 mmol), followed by DMSO (freshly prepared 0.5 M stock solution in CH_2Cl_2, 1.16 mL, 0.5785 mmol) dropwise. After 5 min at –78 °C, a solution of **13** (84 mg, 0.1446 mmol) in CH_2Cl_2 (2.5 mL) was added. After stirring for another 20 min at the same temperature, Et_3N (0.4 mL, 2.89 mmol) was added. After another 5 min, the reaction mixture was allowed to warm to rt over 20 min before water was added. After separation of phases, the aqueous layer was extracted with CH_2Cl_2 (three times), and the combined organic extracts were dried over Na_2SO_4. Concentration of this solution *in vacuo* followed by purification of the crude material by flash chromatography (silica gel, 92:8 to 34:66 hexanes:EtOAc) yielded **S9** (59.3 mg, 80%) as a white foam.

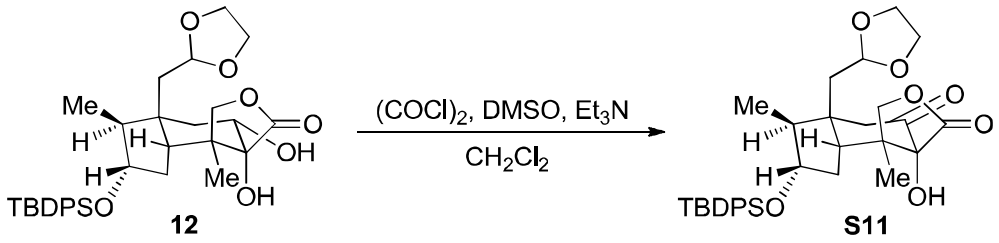
Data for **S9**: R_f = 0.49 (67:33 hexanes:EtOAc); $[\alpha]_D^{24}$ = +99.3° (*c* 0.29, $CHCl_3$); IR (thin film) 3462, 3071, 2962, 3934, 2888, 2858, 1787, 1719, 1589, 1472, 1428, 1393, 1372, 1184, 1113, 1058, 1020, 822, 739, 703, 665, 612 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.66–7.61 (m, 4H), 7.45–7.25 (m, 6H), 4.32 (app. d, J = 9.7 Hz, 1H), 4.28 (s, 1H), 4.08–4.01 (m, 2H), 4.01 (app. d, J = 9.6 Hz, 1H), 3.72 (ddd, J = 9.5, 9.5, 6.2 Hz, 1H), 2.79 (app. d, J = 14.0 Hz, 1H), 2.54 (app. d, J = 14.0 Hz, 1H), 2.22–2.13 (m, 3H), 1.79 (ddd, J = 12.8, 7.7, 6.2 Hz, 1H), 1.63 (dq, J = 9.5, 6.9 Hz, 1H), 1.37 (ddd, J = 12.7, 10.7, 9.5 Hz, 1H), 1.21 (t, J = 7.1 Hz, 3H), 1.11 (s, 3H), 1.04 (s, 9H), 0.79 (d, J = 6.9 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 204.5, 172.4, 171.5, 136.0 (4C), 134.3, 133.9, 129.9 (2C), 127.8 (2C), 127.7 (2C), 82.2, 76.5, 75.6, 61.1, 51.3, 48.8, 46.6, 43.8, 42.7, 42.6, 37.0, 27.1 (3C), 20.9, 19.4, 14.3, 10.9; HRMS (ESI-TOF) calculated for $C_{33}H_{42}O_7NaSi$ $[M+Na]^+$ 601.2597, found 601.2587.



S9 **S10**

Ethyl 2-((3a*R*,4*R*,5a*S*,6*S*,7*S*,8a*R*,8b*R*)-7-((*tert*-butyldiphenylsilyl)oxy)-3a,4-dihydroxy-6,8b-dimethyl-3-oxodecahydro-1*H*-indeno[4,5-*c*]furan-5a-yl)acetate (S10). To a solution of ketone **S9** (98 mg, 0.1693 mmol) in MeOH (3 mL) at –78 °C was added $NaBH_4$ (32 mg, 0.8466 mmol). The reaction mixture was stirred at at –78 °C for 1.5 h and quenched with brine. After removing the MeOH *in vacuo*, the resulting mixture was extracted with CH_2Cl_2 (four times) and the combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. Purification of the crude product by flash chromatography (silica gel, 92:8 to 34:66 hexanes:EtOAc) yielded **S10** (95.8 mg, 97%) as a white foam.

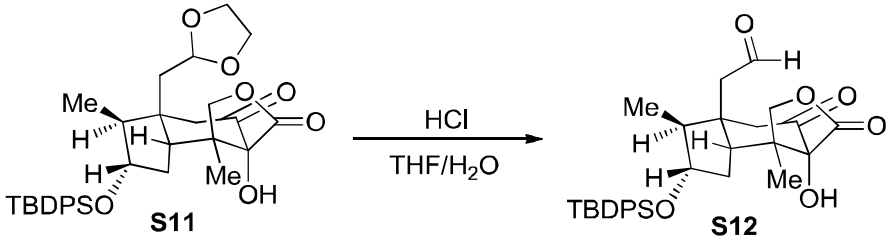
Data for **S10**: R_f = 0.34 (67:33 hexanes:EtOAc); $[\alpha]_D^{24}$ = –10.0° (*c* 0.21, $CHCl_3$); IR (thin film) 3462, 2960, 2933, 2888, 2858, 1768, 1730, 1589, 1472, 1427, 1390, 1372, 1180, 1154, 1111, 1079, 1044, 910, 736, 703, 665, 612 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.66–7.63 (m, 4H), 7.45–7.36 (m, 6H), 4.05 (q, *J* = 7.1 Hz, 2H), 4.03–4.01 (m, 1H), 3.99 (app. d, *J* = 8.6 Hz, 1H), 3.93 (app. d, *J* = 8.6 Hz, 1H), 3.92–3.89 (m, 1H), 3.64 (s, 1H), 3.02 (d, *J* =8.5 Hz, 1H), 2.20 (app. d, *J* = 14.7 Hz, 1H), 2.10 (app. d, *J* = 14.7 Hz, 1H), 2.10–2.00 (m, 4H), 1.90 (dd, *J* = 14.4, 10.7 Hz, 1H), 1.74–1.69 (m, 1H), 1.23 (s, 3H), 1.20 (t, *J* = 7.1 Hz, 3H), 1.07 (s, 9H), 0.70 (d, *J* = 6.9 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.3, 172.1, 136.12 (2C), 136.09 (2C), 134.19, 134.17, 129.93, 129.89, 127.80 (2C), 127.78 (2C), 78.7, 77.6, 77.5, 70.5, 60.8, 50.0, 45.7, 45.5, 44.6, 41.2, 35.9, 34.8, 27.2 (3C), 19.4, 18.0, 14.3, 11.9; HRMS (ESI-TOF) calculated for $C_{33}H_{44}O_7NaSi$ $[M+Na]^+$ 603.2754, found 603.2749.



12 **S11**

(3a*R*,5a*R*,6*S*,7*S*,8a*R*,8b*R*)-5a-((1,3-dioxolan-2-yl)methyl)-7-((*tert*-butyldiphenylsilyl)oxy)-3a-hydroxy-6,8b-dimethylhexahydro-1*H*-indeno[4,5-*c*]furan-3,4(3a*H*,8b*H*)-dione (S11). To CH_2Cl_2 (4 mL) at –78 °C was added oxalyl chloride (freshly prepared 0.2 M stock solution in CH_2Cl_2, 4.48 mL, 0.8953 mmol), followed by DMSO (freshly prepared 0.5 M stock solution in CH_2Cl_2, 3.58 mL, 1.7907 mmol) dropwise. After 5 min at –78 °C, a solution of **12** (260 mg, 0.4477 mmol) in CH_2Cl_2 (7 mL) was added. After stirring for another 20 min at the same temperature, Et_3N (1.25 mL, 8.95 mmol) was added. After another 5 min, the reaction mixture was allowed to warm to rt over 20 min before water was added. After separation of phases, the aqueous layer was extracted with CH_2Cl_2 (three times), and the combined organic extracts were dried over Na_2SO_4. Concentration of this solution *in vacuo* followed by purification of the crude material by flash chromatography (silica gel, 92:8 to 34:66 hexanes:EtOAc) yielded **S11** (183.2 mg, 71%) as a white foam.

Data for **S11**: R_f = 0.41 (67:33 hexanes:EtOAc); $[\alpha]_D^{24}$ = +108.9° (*c* 0.90, $CHCl_3$); IR (thin film) 3460, 2960, 2933, 2890, 2857, 1785, 1718, 1407, 1427, 1389, 1123, 1083, 1055, 1013, 822, 736, 705, 612 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.66–7.61 (m, 4H), 7.44–7.35 (m, 6H), 4.62 (dd, *J* = 5.1, 4.4 Hz, 1H), 4.54 (app. d, *J* = 9.6 Hz, 1H), 4.34 (s, 1H), 4.04 (app. d, *J* = 9.6 Hz, 1H), 3.93–3.87 (m, 2H), 3.75–3.69 (m, 2H), 3.61 (ddd, *J* =10.0, 10.0, 6.0 Hz, 1H), 2.80 (app. d, *J* = 13.8 Hz, 1H), 2.34 (app. d, *J* = 13.8 Hz, 1H), 2.11 (dd, *J* = 11.2, 7.8 Hz, 1H), 1.74 (ddd, *J* = 12.4, 7.7, 6.1 Hz, 1H), 1.62–1.56 (m, 3H), 1.32 (ddd, *J* = 11.3, 11.3, 10.9 Hz, 1H), 1.11 (s, 3H), 1.03 (s, 9H), 0.82 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 204.9, 172.6, 136.1 (4C), 134.3, 133.9, 129.94, 129.91, 127.81 (2C), 127.76 (2C), 102.1, 82.4, 76.6, 75.5, 65.1, 64.5, 51.3, 49.1, 45.3, 44.1, 42.6, 42.4, 37.1, 27.2 (3C), 21.3, 19.4, 10.7; HRMS (ESI-TOF) calculated for $C_{33}H_{42}O_7NaSi$ $[M+Na]^+$ 601.2597, found 601.2596.

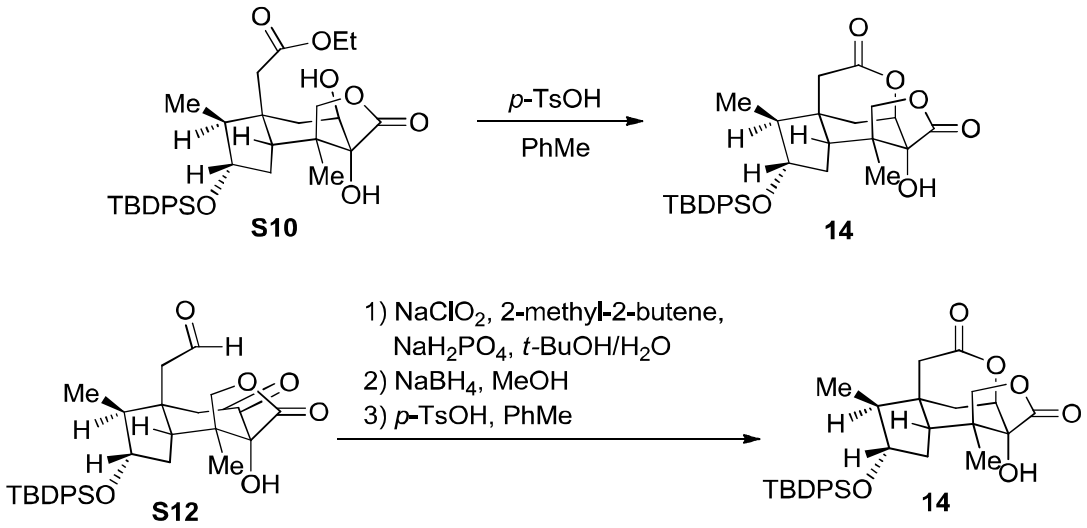


S11 **S12**

2-((3a*R*,5a*R*,6*S*,7*S*,8a*R*,8b*R*)-7-((*tert*-butyldiphenylsilyl)oxy)-3a-hydroxy-6,8b-dimethyl-3,4-dioxodecahydro-1*H*-indeno[4,5-*c*]furan-5a-yl)acetaldehyde (S12). To A solution of the acetal **S11** (231 mg, 0.3991 mmol) in THF (4 mL) was added HCl (2 M in water, 4 mL, 8.0 mmol). The

reaction was heated at 50 °C for 1.5 h and more HCl (4 M in water, 1 mL, 4.0 mmol) and THF (1 mL) were added. After another 8 h at 50 °C, the reaction was quenched by addition of saturated aqueous $NaHCO_3$ and the THF was removed *in vacuo*. The reaction mixture was then extracted with CH_2Cl_2 (four times) and the combined organic extracts were dried over Na_2SO_4. Concentration of the solution followed by purification of the crude product by flash chromatography (silica gel, 90:10 to 20:80 hexanes:EtOAc) provided **S12** (181.4 mg, 85%) as a white foam.

Data for **S12**: R_f = 0.47 (60:40 hexanes:EtOAc); $[\alpha]_D^{23}$ = +82.1° (*c* 0.19, $CHCl_3$); IR (thin film) 3470, 3071, 2960, 2932, 2891, 2857, 1783, 1718, 1471, 1427, 1393, 1373, 1238, 1125, 1112, 1057, 1008, 951, 875, 822, 740, 703 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 9.59 (t, *J* = 2.0 Hz, 1H), 7.66–7.61 (m, 4H), 7.46–7.36 (m, 6H), 4.43 (app. d, *J* = 9.7 Hz, 1H), 4.30 (s, 1H), 4.08 (app. d, *J* = 9.7 Hz, 1H), 3.67 (ddd, *J* = 9.6, 9.6, 6.1 Hz, 1H), 2.63 (app. d, *J* = 13.6 Hz, 1H), 2.58 (app. d, *J* = 13.6 Hz, 1H), 2.46 (app. dd, *J* = 16.1, 1.7 Hz, 1H), 2.39 (app. dd, *J* = 16.1, 2.4 Hz, 1H) 1.94 (dd, *J* = 11.5, 7.8 Hz, 1H), 1.78 (ddd, *J* = 12.7, 7.6, 6.1 Hz, 1H), 1.69 (dq, *J* = 9.5, 7.0 Hz, 1H), 1.35 (ddd, *J* = 12.5, 11.7, 9.7 Hz, 1H), 1.11 (s, 3H), 1.04 (s, 9H), 0.80 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 203.8, 200.1, 172.4, 136.0 (4C), 134.1, 133.8, 130.01, 129.99, 127.85 (2C), 127.79 (2C), 82.4, 76.4, 75.6, 52.6, 51.0, 49.1, 47.0, 44.5, 43.7, 37.1, 27.1 (3C), 21.4, 19.3, 12.0; HRMS (ESI-TOF) calculated for $C_{31}H_{38}O_6NaSi$ $[M+Na]^+$ 557.2335, found 557.2342.



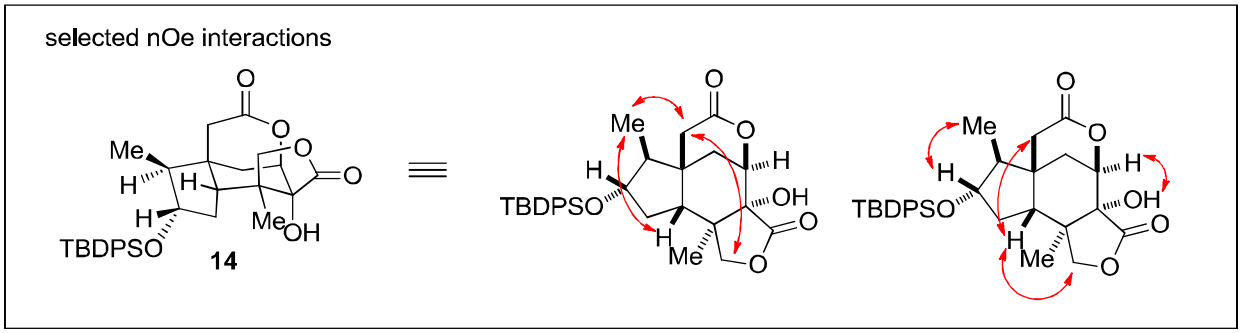
(3a*R*,4*R*,7a*S*,8*S*,9*S*,10a*R*,10b*R*)-9-((*tert*-butyldiphenylsilyl)oxy)-3a-hydroxy-8,10b-dimethylhexahydro-1*H*-4,7a-methanocyclopenta[*e*]furo[3,4-*c*]oxocine-3,6(7*H*,10b*H*)-dione (14). From **S10**: a solution of the hydroxylester **S10** (90 mg, 0.1550 mmol) and *p*-TsOH (15 mg, 0.0775 mmol) in PhMe (4.5 mL) was heated at 60 °C for 1.5 h. After cooling down to rt, saturated aqueous $NaHCO_3$ was added and the resulting mixture was extracted with CH_2Cl_2 (four times). The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. Purification of the crude product by flash chromatography (silica gel, 92:8 to 34:66 hexanes:EtOAc) provided **14** (70.9 mg, 86%) as a white foam.

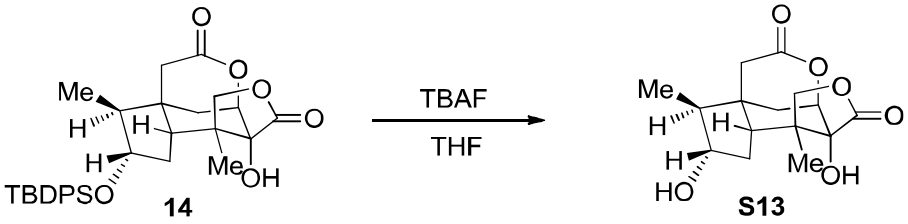
From **S12**: To a solution of the aldehyde **S12** (170 mg, 0.3179 mmol) in *t*-BuOH (4 mL) and water (2 mL) at 0 °C was added NaH_2PO_4•H_2O (175.5 mg, 1.2717 mmol), 2-methyl-2-butene (0.34 mL, 3.179 mmol) and $NaClO_2$ (115 mg, 1.2717 mmol). The reaction mixture was stirred at 0 °C for 1.5 h. The *t*-BuOH was carefully removed *in vacuo* and the resulting mixture was cooled to 0 °C before 4 M HCl (2 mL) was added. The acidified mixture was extracted with CH_2Cl_2 (three times). The pH value of the aqueous layer was measured (approx. pH 0) to make sure it was completely acidified. The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo* to afford the crude carboxylic acid (189 mg) as a white foam which was used immediately without purification.

The above crude acid was dissolved in MeOH (4.5 mL) and cooled to –78 °C. $NaBH_4$ (60.1 mg, 1.5895 mmol) was added and the resulting mixture was stirred at –78 °C for 1.5 h. The reaction was quenched by addition of 4 M HCl (2 mL) and the acidified mixture was extracted with CH_2Cl_2 (four times). The acidity of the aqueous layer was analyzed (approx. pH 0). The combined organic layers were dried with Na_2SO_4 and concentrated *in vacuo* to yield a crude hydroxyacid (193.6 mg) which started to undergo lactonization spontaneously at rt. The cyclization was driven to completion by dissolving this crude material and *p*-TsOH (30 mg, 0.1589 mmol) in PhMe (8 mL) and heating at 60 °C for 1.5 h. Upon cooling to rt, the reaction mixture was neutralized with saturated aqueous $NaHCO_3$ and the resulting solution was extracted with CH_2Cl_2 (four times). The combined organic layers were dried over Na_2SO_4 and concentrated *in vacuo*. Purification of the crude product by flash chromatography (silica gel, 92:8 to 34:66 hexanes:EtOAc) provided **14** (118.2 mg, 70% over three steps) as a white foam.

Data for **14**: R_f = 0.35 (67:33 hexanes:EtOAc); $[\alpha]_D^{23}$ = –19.5° (*c* 0.20, $CHCl_3$); IR (thin film) 3431, 3073, 2959, 2930, 2857, 1781, 1745, 1741, 1727, 1370, 1243, 1214, 1150, 1112, 1086, 1068, 997, 909, 877, 822, 738, 703, 612 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ 7.65–7.62 (m, 4H), 7.46–7.37 (m, 6H), 4.63 (dd, *J* = 3.8, 1.3 Hz, 1H), 3.85 (app. d, *J* = 10.0 Hz, 1H), 3.78 (app. d, *J*

= 10.0 Hz, 1H), 3.74 (ddd, *J* = 7.7, 4.8, 1.1 Hz, 1H), 3.11 (s, 1H), 2.94 (ddd, *J* = 15.0, 1.8, 1.8 Hz, 1H), 2.60 (app. d, *J* = 19.1 Hz, 1H), 2.43 (app. dd, *J* = 19.1, 2.7 Hz, 1H), 2.16 (ddd, *J* = 14.2, 8.0, 8.0 Hz, 1H) 2.00 (ddd, *J* = 14.2, 12.2, 4.8 Hz, 1H), 1.83 (q, *J* = 7.5 Hz, 1H), 1.79 (dd, *J* = 12.0, 8.5 Hz, 1H), 1.75 (dd, *J* = 14.9, 4.0 Hz, 1H), 1.14 (s, 3H), 1.07 (s, 9H), 0.54 (d, *J* = 7.6 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.0, 169.3, 136.0 (4C), 134.1, 133.9, 130.1, 130.0, 127.95 (2C), 127.91 (2C), 79.5, 77.8, 76.0, 75.9, 54.2, 44.4, 41.0, 40.3, 39.9, 38.4, 28.5, 27.2 (3C), 22.8, 19.2, 13.3; HRMS (ESI-TOF) calculated for $C_{31}H_{38}O_6NaSi$ $[M+Na]^+$ 557.2335, found 557.2329.

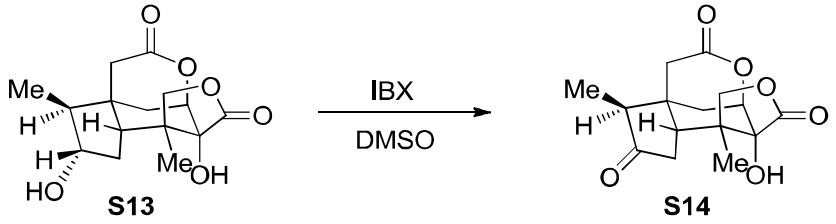




(3a*R*,4*R*,7a*S*,8*S*,9*S*,10a*R*,10b*R*)-3a,9-dihydroxy-8,10b-dimethylhexahydro-1*H*-4,7a-methanocyclopenta[*e*]furo[3,4-*c*]oxocine-3,6(7*H*,10b*H*)-dione (S13). To a solution of the silyl ether **14** (182 mg, 0.3404 mmol) in THF (5 mL) at rt was added TBAF (1.0 M in THF, 0.41 mL, 0.41 mmol). The reaction mixture was stirred at rt for 17 h. After addition of saturated aqueous $NaHCO_3$, the THF was removed *in vacuo* and the resulting mixture was extracted with CH_2Cl_2 (four times).[9] The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. The crude product was purified by flash chromatography (silica gel, 95:5 to 90:10 CH_2Cl_2:MeOH) and provided **S13** (87.5 mg, 87%) as a white solid.

[9] The solubility of **S13** was very low in conventional organic solvents and therefore, a large amount of CH_2Cl_2 was needed for extractions to minimize material loss. The same applies to compounds **S14**, **1**, **2**, and **3**.

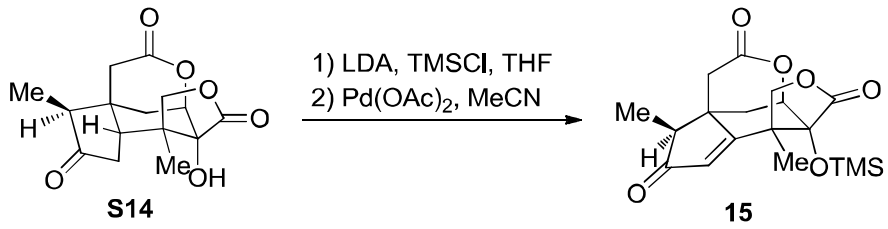
Data for **S13**: R_f = 0.45 (90:10 CH_2Cl_2:MeOH); $[\alpha]_D^{24}$ = –24.7° (*c* 0.17, EtOH); IR (thin film) 3403, 2963, 2931, 2878, 1779, 1734, 1457, 1370, 1244, 1220, 1151, 1120, 1088, 997, 579 cm^{-1}; ^1H NMR (600 MHz, CD_3OD) δ 4.59 (dd, *J* = 4.4, 1.3 Hz, 1H), 3.91 (app. d, *J* = 10.1 Hz, 1H), 3.74 (app. d, *J* = 10.2 Hz, 1H), 3.72 (ddd, *J* = 7.1, 7.1, 3.4 Hz, 1H), 2.78 (app. d, *J* = 19.0 Hz, 1H), 2.59 (app. dd, *J* = 19.0, 2.6 Hz, 1H), 2.54 (dd, *J* = 14.7, 1.3 Hz, 1H), 2.26 (ddd, *J* = 13.3, 7.4, 7.4 Hz, 1H), 2.03 (dd, *J* = 12.6, 7.3 Hz, 1H), 1.83–1.77 (m, 2H), 1.74 (dq, *J* = 7.4, 3.5 Hz, 1H), 1.16 (s, 3H), 0.98 (d, *J* = 7.5 Hz, 3H); ^{13}C NMR (150 MHz, CD_3OD) δ 179.6, 172.5, 80.8, 78.0, 77.1, 76.9, 54.2, 45.2, 41.6, 40.9, 40.4, 38.1, 29.6, 23.1, 14.8; HRMS (ESI-TOF) calculated for $C_{15}H_{20}O_6Na$ $[M+Na]^+$ 319.1158, found 319.1155.



(3a*R*,4*R*,7a*S*,8*S*,10a*R*,10b*R*)-3a-hydroxy-8,10b-dimethyltetrahydro-1*H*-4,7a-methanocyclopenta[*e*]furo[3,4-*c*]oxocine-3,6,9(7*H*,8*H*,10b*H*)-trione (S14). To a solution of **S13** (83 mg, 0.2801 mmol) in anhydrous DMSO (2 mL) at rt was added IBX (235 mg, 0.8403 mmol). The reaction mixture was stirred at rt for 1h. To the reaction mixture was then added a 1:1 mixture of saturated aqueous $Na_2S_2O_3$ and water and the resulting mixture was diluted with EtOAc. The separated organic phase was then washed with a 1:1 mixture of saturated aqueous $NaHCO_3$ and water (twice) and dried over $MgSO_4$. Concentration of the mixture *in vacuo* followed with purification by flash chromatography (silica gel, 75:25 to 0:100 hexanes:EtOAc) afforded **S14** (65.2 mg, 79%) as a white solid.

Data for **S14**: R_f = 0.66 (100% EtOAc); $[\alpha]_D^{24}$ = –124.1° (*c* 0.14, EtOH); IR (thin film) 3402, 2970, 2938, 2877, 1780, 1738, 1452, 1372, 1248, 1215, 1146, 1120, 1100, 1064, 998, 930, 895, 815 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ 4.63 (dd, *J* = 4.0, 1.6 Hz, 1H), 4.01 (app. d, *J* = 10.0 Hz, 1H), 3.93 (app. d, *J* = 10.0 Hz, 1H), 3.13 (brs, 1H), 2.76 (app. d, *J* = 19.2 Hz, 1H), 2.81 (app. dd, *J* = 19.2, 2.7 Hz, 1H), 2.53–2.50 (m, 2H), 2.37 (dd, *J* = 10.7, 9.7 Hz, 1H), 2.24 (app. d, *J* = 14.5 Hz, 1H), 2.21 (q, *J* = 7.8 Hz, 1H), 1.79 (app. dd, *J* = 14.6, 4.0 Hz, 1H), 1.22 (s, 3H), 1.09 (d, *J* = 7.8 Hz, 3H); ^{13}C NMR (150 MHz, $(CD_3)_2SO$) δ 217.0, 176.9, 168.9, 77.9, 75.3, 74.6, 54.3, 39.7,

38.03, 37.99, 37.95, 26.54, 26.51, 22.3, 10.4; HRMS (ESI-TOF) calculated for $C_{15}H_{18}O_6Na$ $[M+Na]^+$ 317.1001, found 317.1010.

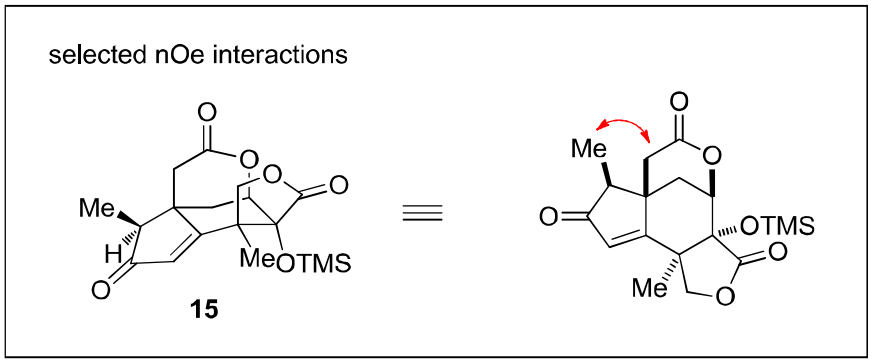


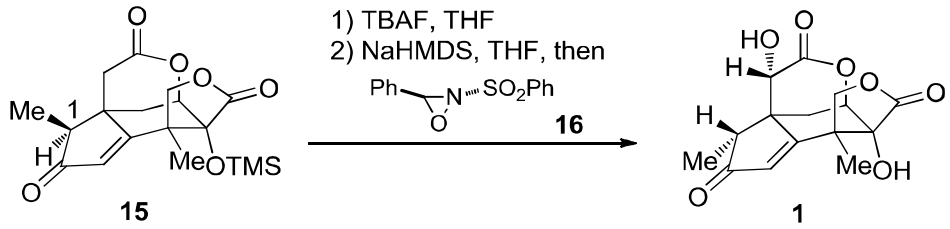
(3a*R*,4*R*,7a*R*,8*S*,10b*R*)-3a-hydroxy-8,10b-dimethyl-3a,4-dihydro-1*H*-4,7a-methanocyclopenta[*e*]furo[3,4-*c*]oxocine-3,6,9(7*H*,8*H*,10b*H*)-trione (15). A 0.637 M LDA stock solution was freshly prepared at –78 °C and allowed to warm to between 0 °C and rt over 15 min. To a solution of the ketone **S14** (20 mg, 0.06796 mmol) in THF (3 mL) at –78 °C was added the above LDA solution (0.637 M in THF, 0.53 mL, 0.34 mmol). After 1 h at –78 °C, TMSCl (52 μL, 0.4077 mmol) was added. The reaction mixture was allowed to warm to rt over 3 h and stirred for 1 h. The volatile contents of the flask were removed *in vacuo* and the residue was diluted with 1 M NaOH and CH_2Cl_2. The separated organic phase was further washed with 1 M NaOH and dried over Na_2SO_4. Concentration of this solution *in vacuo* provided the crude silyl enol ether (44.7 mg) which was used immediately without purification.

To the above silyl enol ether in dry MeCN (1 mL) at rt was added $Pd(OAc)_2$ (17 mg, 0.07476 mmol). After 3 h at rt, another portion of $Pd(OAc)_2$ (25 mg, 0.1114 mmol) was added. After another 16 h at rt, the reaction was heated at 50 °C for 2 h. Upon cooling to rt, the dark reaction mixture was filtered through a pad of Celite and silica gel mixture. The resulting clear solution was concentrated *in vacuo* and the crude material was purified by flash chromatography (silica gel, 90:10 to 20:80 hexanes:EtOAc) to afford **15** (20.7 mg, 83% over two steps) as a white foam.

Data for **15**: R_f = 0.30 (60:40 hexanes:EtOAc); $[\alpha]_D^{23}$ = –69.5° (*c* 0.10, $CHCl_3$); IR (thin film) 2957, 2931, 1788, 1748, 1714, 1611, 1456, 1367, 1252, 1201, 1164, 1140, 1064, 1035, 1008, 889, 847, 759, 734, 702 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ 6.28 (s, 1H), 4.75 (dd, *J* = 4.2, 1.6 Hz, 1H), 4.08 (app. d, *J* = 10.2 Hz, 1H), 3.98 (app. d, *J* = 10.3 Hz, 1H), 2.90 (app. d, *J* = 18.7 Hz, 1H), 2.47 (q, *J* = 7.4 Hz, 1H), 2.31 (app. dd, *J* = 18.7, 2.7 Hz, 1H), 2.26 (app. dd, *J* = 14.0, 4.2 Hz, 1H), 2.20 (app. ddd, *J* = 14.0, 1.7, 1.7 Hz, 1H), 1.42 (s, 3H), 1.14 (d, *J* = 7.4 Hz, 3H), 0.23 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 205.7, 177.1, 174.1, 167.6, 132.3, 81.3, 78.2, 73.7, 53.4,

44.6, 44.1, 40.1, 30.3, 23.3, 9.3, 2.0 (3C); HRMS (ESI-TOF) calculated for $C_{18}H_{24}O_6NaSi$ $[M+Na]^+$ 387.1240, found 387.1237.





(1*R*,10*S*)-2-oxo-3,4-dehydroneomajucin (1). To a solution of enone **15** (42 mg, 0.1152 mmol) in THF at rt was added TBAF (1.0 M in THF, 0.17 mL, 0.17 mmol). After 1 h at rt, saturated aqueous $NaHCO_3$ and water were added and the THF was removed *in vacuo*. The resulting mixture was extracted with EtOAc (four times) and the combined organic layers were dried over Na_2SO_4 and concentrated *in vacuo*. The residue was purified by flash chromatography (silica gel, 83:17 to 0:100 hexanes:EtOAc) and afforded a mixture of desilylated enone epimers at C1 (22.8 mg, 70%) as white solids which were used without further purification.

The above enone products were dried by azeotroping with PhMe (three times) and placed under high vacuum overnight. To a solution of the enone epimers (22 mg, 0.07527 mmol) in THF (1.5 mL) at –78 °C was added NaHMDS (0.5 mL in THF, 0.47 mL, 0.23 mmol). After 30 min at –78 °C, a solution of Davis Oxaziridine **16**[10] (21.6 mg, 0.08280 mmol) in THF (1 mL) was added. After another 1.5 h at –78 °C, the reaction was quenched by addition of saturated aqueous NH_4Cl. Upon

[10] (a) Davis, F. A.; Vishwakarma, L. C.; Billmers, J. G.; Finn, J. *J. Org. Chem.* **1984**, *49*, 3241–3243. (b) Davis, F. A.; Sheppard, A. C. *Tetrahedron* **1989**, *45*, 5703–5742.

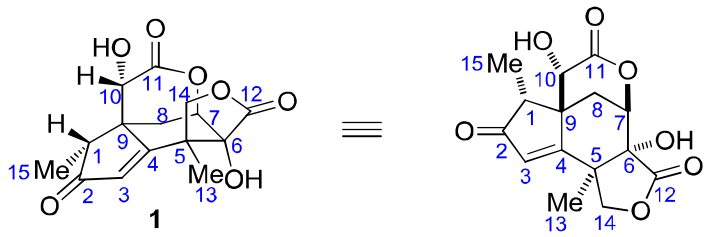
warming to rt, THF was removed *in vacuo* and the mixture was extracted with EtOAc (four times). The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. The crude mixture was purified by preparative TLC plate (20 X 20 cm, 95:5 CH_2Cl_2:MeOH, twice) to give **1** (contaminated with a very small amount of **16**, see ^{1}H NMR spectra for details, 12.5 mg, 54%) as an amorphous white solid, as well as recovered enone starting materials (1.9 mg, 9%). In order to remove the residual **16**, 2 mg of the above sample of **1** was purified by flash chromatography using a 10 mm ID glass column (silica gel, 20–45 μm mesh, 50:50 to 40:60 hexanes:EtOAc).

Data for **1**: R_f = 0.10 (95:5 CH_2Cl_2:MeOH); $[\alpha]_D^{24}$ = –144.6° (*c* 0.18, dioxane); IR (thin film) 3408, 2976, 2928, 2875, 1783, 1750, 1700, 1608, 1457, 1369, 1293, 1227, 1160, 1112, 1063, 998, 886, 850, 689, 552 cm^{-1}; ^{1}H NMR (500 MHz, CD_3OD) δ 6.36 (s, 1H), 4.79 (dd, *J* = 4.4, 1.6 Hz, 1H), 4.13 (app. d, *J* = 10.6 Hz, 1H), 3.91 (app. d, *J* = 10.6 Hz, 1H), 3.88 (d, *J* = 1.7 Hz, 1H), 2.83 (q, *J* = 7.7 Hz, 1H), 2.58 (dd, *J* = 14.2, 4.4 Hz, 1H), 2.10 (ddd, *J* = 14.2, 1.5, 1.5 Hz, 1H), 1.45 (s, 3H), 1.13 (d, *J* = 7.7 Hz, 3H); ^{1}H NMR (600 MHz, C_5D_5N-TMS) δ 6.61 (s, 1H), 5.29 (d, *J* = 4.1 Hz, 1H), 4.40 (brs, 1H), 4.38 (app. d, *J* = 10.4 Hz, 1H), 4.26 (app. d, *J* = 10.5 Hz, 1H), 3.29 (q, *J* = 7.7 Hz, 1H), 2.88 (dd, *J* = 13.9, 4.1 Hz, 1H), 2.46 (d, *J* = 13.9 Hz, 1H), 1.65 (s, 3H), 1.31 (d, *J* = 7.8 Hz, 3H); ^{13}C NMR (150 MHz, C_5D_5N-TMS) δ 208.6, 177.1, 176.2, 170.6, 133.6, 79.8, 79.4, 73.7, 73.5, 51.4, 49.1, 44.8, 23.1, 22.7, 13.2; HRMS (ESI-TOF) calculated for $C_{15}H_{16}O_7Na$ $[M+Na]^+$ 331.0794, found 331.0793.

Full structural assignments of **1** based on 2D NMR and comparison with data for natural **1**[11] and from previous syntheses:[12]

[11] Kouno, I.; Baba, N.; Hashimoto, M.; Kawano, N.; Takahashi, M.; Kaneto, H.; Yang, C.-S. *Chem. Pharm. Bull.* **1990**, *38*, 422–425.

[12] (a) Cho, Y. S.; Carcache, D. A.; Tian, Y.; Li, Y.-M.; Danishefsky, S. J. *J. Am. Chem. Soc.* **2004**, *126*, 14358–14359. (b) Carcache, D. A.; Cho, Y. S.; Hua, Z.; Tian, Y.; Li, Y.-M.; Danishefsky, S. J. *J. Am. Chem. Soc.* **2006**, *128*, 1016–1022. (c) Trzoss, L.; Xu, J.; Lacoske, M. H.; Mobley, W. C.; Theodorakis, E. A. *Org. Lett.* **2011**, *13*, 4554–4557. (d) Trzoss, L.; Xu, J.; Lacoske, M. H.; Mobley, W. C.; Theodorakis, E. A. *Chem. Eur. J.* **2013**, *19*, 6398–6408. (e) Yang, Y.; Fu, X.; Chen, J.; Zhai, H. *Angew. Chem. Int. Ed.* **2012**, *51*, 9825–9828.

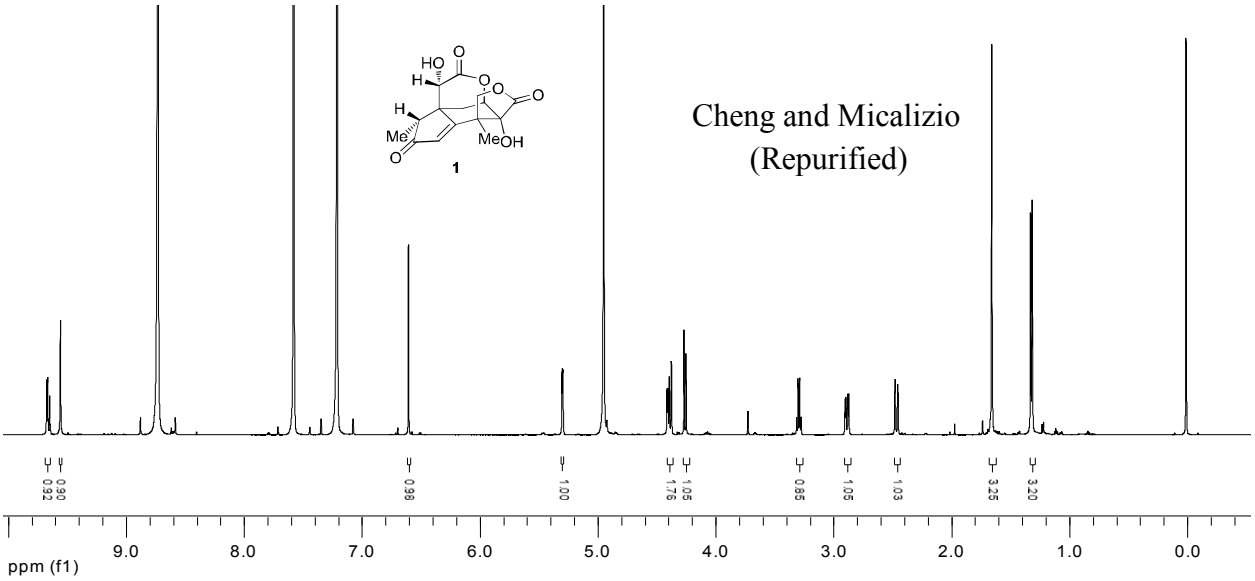


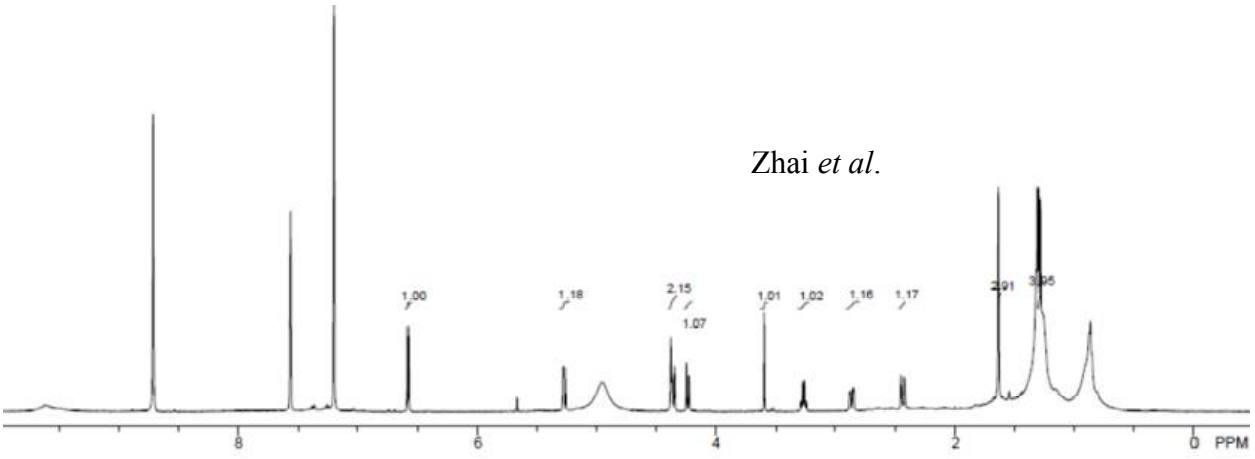
1

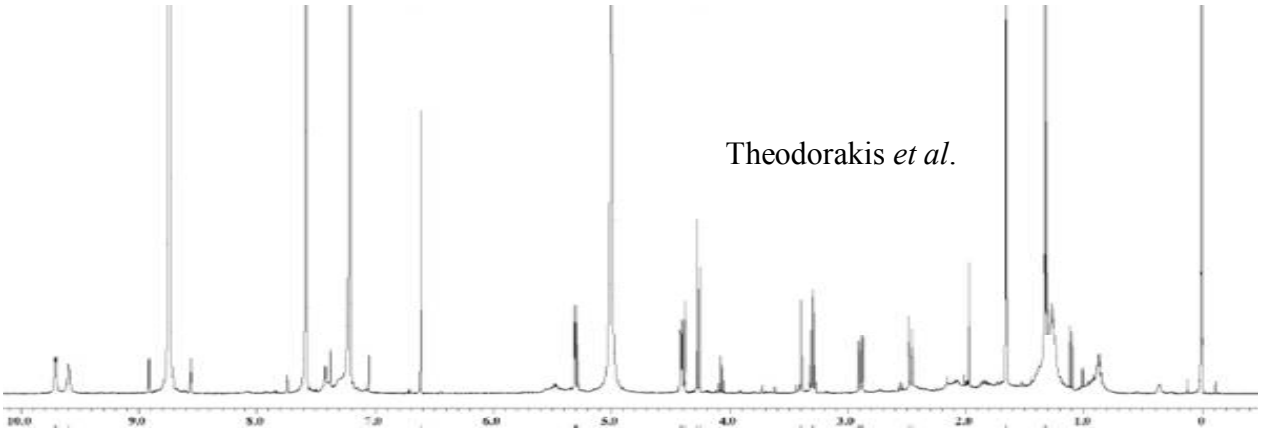
position	^{1}H shifts (C_5D_5N-TMS, ppm; *J* (Hz) in parentheses)				
	Micalizio	natural **1**	Danishefsky	Theodorakis	Zhai
1	**3.29** (q, 7.7)	**3.27** (q, 7.7)	**3.28** (q, 7.7)	**3.30** (q, 7.7)	**3.27** (q, 7.5)
3	**6.61** (s)	**6.58** (s)	**6.57** (s)	**6.62** (s)	**6.58** (s)
7	**5.29** (d, 4.1)	**5.27** (dd, 4.4, 1.5)	**5.29** (m)	**5.31** (dd, 4.6, 1.5)	**5.29–5.26** (m)
8	**2.88** (dd, 13.9, 4.1)	**2.87** (dd, 14.3, 4.4)	**2.88** (dd, 14.0, 4.3)	**2.89** (dd, 13.7, 4.6)	**2.86** (dd, 14.0, 4.0)
	2.46 (d, 13.9)	**2.44** (ddd, 14.3, 1.8, 1.5)	**2.46** (14.0)	**2.47** (d, 13.8)	**2.44** (d, 14.0)
10	**4.40** (brs)	**4.37** (d, 1.8)	**4.40** (brs)	**4.41** (d, 1.6)	**4.38** (brs)
13	**1.65** (s)	**1.64** (s)	**1.65** (s)	**1.66** (s)	**1.63** (s)
14	**4.38** (app. d, 10.4)	**4.35** (d, 10.6)	**4.38** (d, 10.5)	**4.39** (d, 10.3)	**4.36** (d, 10.5)
	4.26 (app. d, 10.5)	**4.24** (d, 10.6)	**4.26** (d, 10.5)	**4.27** (d, 10.3)	**4.23** (dd, 10.5, 2.0)
15	**1.31** (d, 7.8)	**1.30** (d, 7.7)	**1.31** (d, 7.7)	**1.32** (d, 8.1)	**1.30** (d, 8.0)

position	^{13}C shifts (C_5D_5N-TMS, ppm)				
	Micalizio	natural **1**	Danishefsky	Theodorakis	Zhai
1	**49.1**	**49.1**	**49.0**	**49.0**	**49.0**
2	**208.6**	**208.6**	**208.6**	**208.7**	**208.5**
3	**133.6**	**133.6**	**133.6**	**133.6**	**133.5**
4	**176.2**	**176.2**	**176.1**	**176.2**	**176.2**
5	**44.8**	**44.8**	**44.8**	**44.9**	**44.7**
6	**79.4**	**79.4**	**79.4**	**79.5**	**79.3**
7	**79.8**	**79.8**	**79.8**	**79.8**	**79.7**
8	**22.7**	**22.7**	**22.6**	**22.6**	**22.6**
9	**51.4**	**51.4**	**51.3**	**51.4**	**51.3**
10	**73.5**	**73.6**	**73.4**	**73.5**	**73.5**
11	**170.6**	**170.6**	**170.6**	**170.7**	**170.5**
12	**177.1**	**177.0**	**177.1**	**177.2**	**177.0**
13	**23.1**	**23.1**	**23.0**	**23.2**	**23.0**
14	**73.7**	**73.7**	**73.7**	**73.8**	**73.6**
15	**13.2**	**13.2**	**13.1**	**13.3**	**13.1**

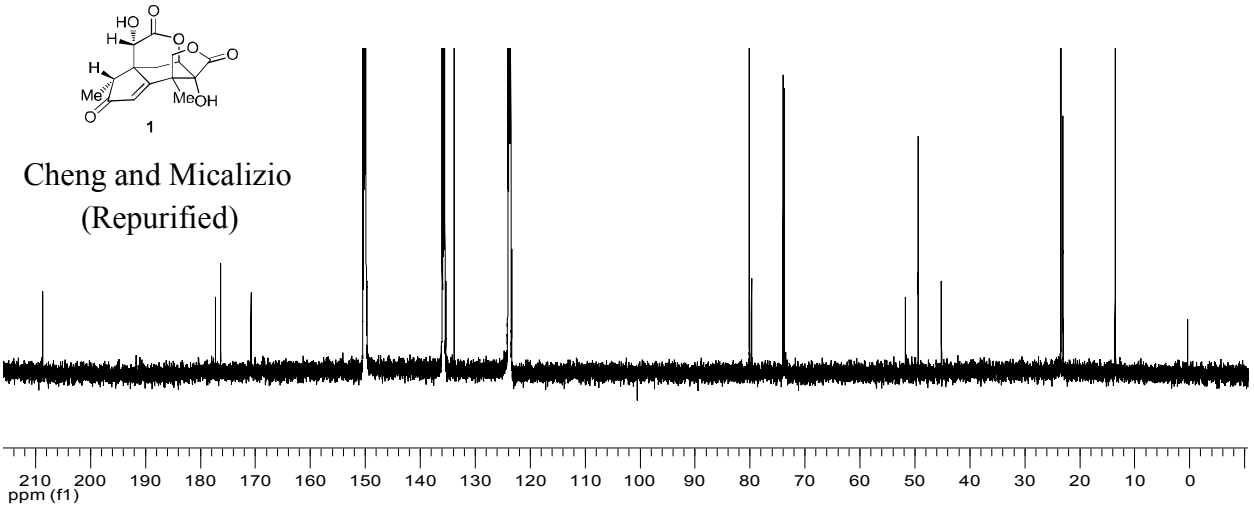
Comparison of ^{1}H NMR of an analytical sample of **1** with previous reported ^{1}H NMR spectra of **1** (C_5D_5N-TMS):[12]

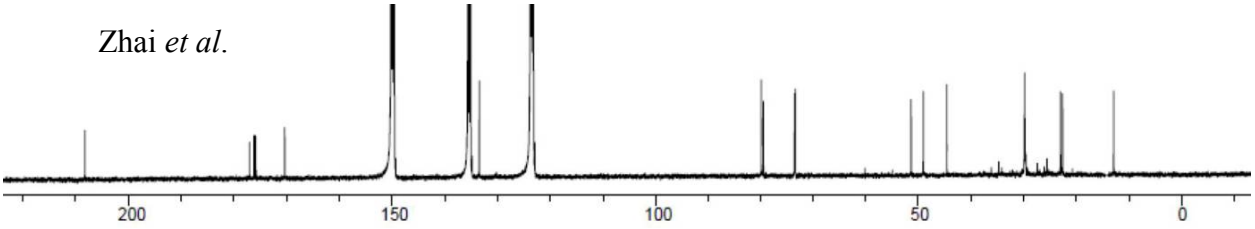


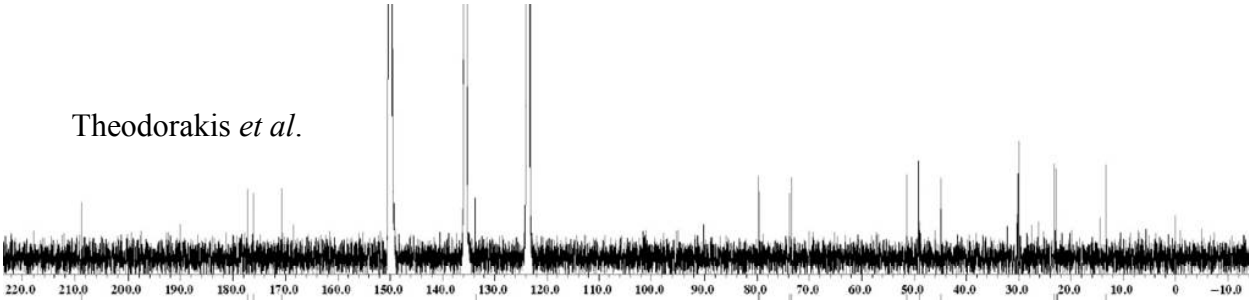


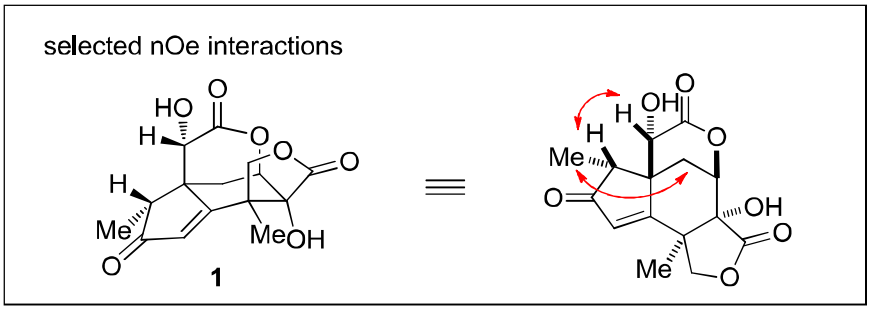


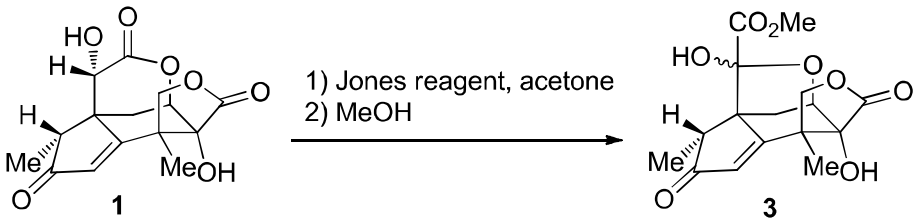
Comparison of ^{13}C NMR of **1** with previous reported ^{1}H NMR spectra of **1** (C_5D_5N-TMS):[12]









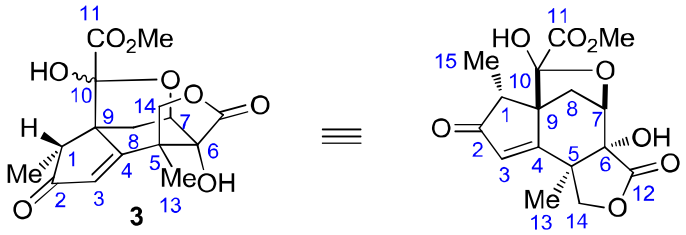


(–)-Jiadifenin (3). This step was performed following previous work by Danishefsky, Theodorakis and Zhai [12] To a solution of (1*R*,10*S*)-2-oxo-3,4-dehydroneomajucin (**1**, 7 mg, 0.02271 mmol) in acetone (2 mL) was added Jones reagent (2.98 M, 0.14 mL, 0.415 mmol). After 34 min at rt, MeOH (2 mL) was added. After another 20 min, the reaction mixture was quenched at 0 °C with saturated aqueous $NaHCO_3$ and the solvents were removed *in vacuo*. The mixture was then diluted with water and extracted with EtOAc (four times). The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. The crude mixture was purified by preparative TLC (20 X 10 cm, 95:5 CH_2Cl_2:MeOH, three times) and provided **3** (contaminated with a small amount of **16** which was present in the starting material **1**, see ^{1}H NMR spectra for details 2.8 mg, 35% over two steps) as an amorphous white solid. In order to remove the residual **16**, 1 mg of the above sample of **3** was purified by flash chromatography using a 10 mm ID glass column (silica gel, 20–45 μm mesh, 50:50 to 40:60 hexanes:EtOAc).

Data for **3**: R_f = 0.15 (95:5 CH_2Cl_2:MeOH); $[\alpha]_D^{24}$ = –144.6° (*c* 0.07, EtOH); IR (thin film) 3387, 2954, 2924, 2853, 1775, 1745, 1706, 1607, 1455, 1372, 1334, 1258, 1190, 1038, 938, 849, 720, 592, 567 cm^{-1}; ^{1}H NMR (600 MHz, C_5D_5N-TMS) δ 10.88 (major C-10 anomer, brs), 10.57* (minor C-10 anomer, brs), 9.08* (brs), 9.02 (brs), 6.57 (brs, 1H), 6.50* (s, 1H), 5.87 (d, *J* = 8.5 Hz, 1H), 5.12* (d, *J* = 6.2 Hz, 1H), 5.06 (d, *J* = 6.2 Hz, 1H), 4.43* (d, *J* = 9.0 Hz, 1H), 4.20 (d, *J* = 8.4 Hz, 1H), 4.17* (d, *J* = 9.0 Hz, 1H), 3.68 (s, 3H), 3.56* (s, 3H), 3.51* (q, *J* = 7.8 Hz, 1H), 3.17* (dd, *J* = 11.8, 6.3 Hz, 1H), 3.03 (dd, *J* = 12.4, 6.2 Hz, 1H), 2.96 (q, *J* = 7.7 Hz, 1H), 2.62* (d, *J* = 11.8 Hz, 1H), 2.53 (d, *J* = 12.4 Hz, 1H), 1.69 (s, 3H), 1.64* (s, 3H), 1.38* (d, *J* = 7.9, 3H), 1.24 (d, *J* = 7.8 Hz, 3H); ^{13}C NMR (150 MHz, C_5D_5N-TMS) δ 209.7*, 208.9, 180.1, 178.9,

178.6*, 177.3*, 171.5, 169.1*, 131.2*, 130.6, 105.9, 104.0*, 80.9, 80.5, 80.3*, 79.4*, 76.0, 75.3*, 61.4*, 60.2, 52.6, 52.0*, 45.1, 44.8*, 44.7*, 42.9, 31.5*, 31.3, 23.2, 23.1*, 14.4, 13.0*; HRMS (ESI-TOF) calculated for $C_{16}H_{18}O_8Na$ $[M+Na]^+$ 361.0899, found 361.0898.

Comparison of full NMR data of **3** with data for natural (–)-jiadifenin[13] and from previous syntheses:[12]

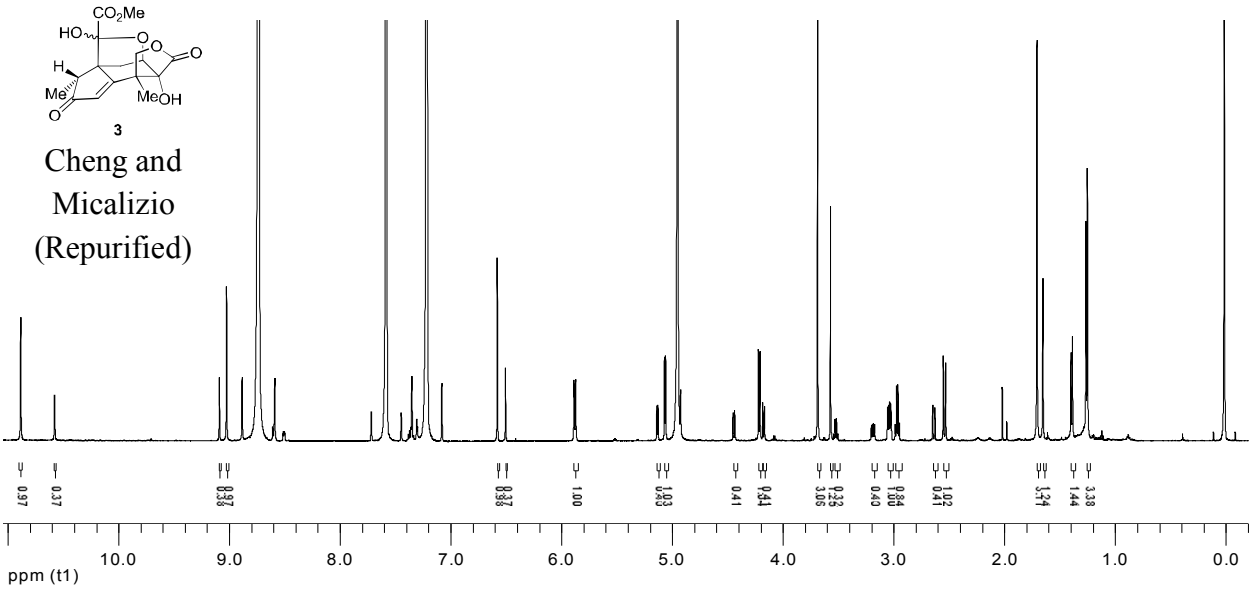


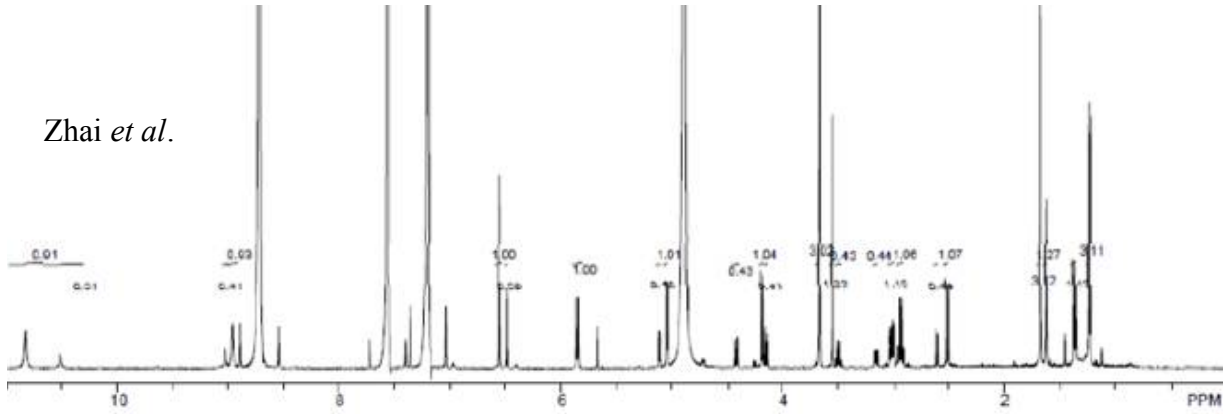
	^{1}H shifts (C_5D_5N-TMS, ppm; *J* (Hz) in parentheses)				
position	Micalizio	natural **3**	Danishefsky	Theodorakis	Zhai
1	**2.96** (q, 7.7)	**2.93** (q, 7.7)	**2.95** (q, 7.6)	**2.97** (q, 7.6)	**2.94** (q, 7.5)
1*	**3.51** (q, 7.8)	**3.49** (q, 7.7)	**3.51** (q, 7.7)	**3.52** (q, 7.5)	**3.49** (q, 7.5)
3	**6.57** (brs)	**6.56** (s)	**6.57** (s)	**6.59** (s)	**6.55** (s)
3*	**6.50** (s)	**6.48** (s)	**6.50** (s)	**6.52** (s)	**6.48** (s)
7	**5.06** (d, 6.2)	**5.03** (d, 6.3)	**5.05** (d, 6.2)	**5.07** (d, 6.3)	**5.04** (d, 6.5)
7*	**5.12** (d, 6.2)	**5.11** (d, 6.3)	**5.12** (d, 6.2)	**5.14** (d, 6.3)	**5.11** (d, 6.0)
8	**2.53** (d, 12.4)	**2.55** (d, 12.3)	**2.53** (d, 12.4)	**2.54** (d, 12.6)	**2.51** (d, 12.5)
	3.03 (dd, 12.4, 6.2)	**3.00** (dd, 12.3, 6.3)	**3.03** (dd, 12.4, 6.2)	**3.04** (dd, 12.6, 6.3)	**3.01** (dd, 12.5, 6.0)
8*	**2.62** (d, 11.8)	**2.60** (d, 11.8)	**2.62** (d, 11.8)	**2.64** (d, 12.1)	**2.61** (d, 12.0)
	3.17 (dd, 11.8, 6.3)	**3.15** (dd, 11.8, 6.3)	**3.17** (dd, 11.8, 6.3)	**3.19** (dd, 12.0, 6.3)	**3.16** (dd, 11.5, 6.0)
13	**1.69** (s)	**1.67** (s)	**1.69** (s)	**1.70** (s)	**1.68** (s)
13*	**1.64** (s)	**1.62** (s)	**1.64** (s)	**1.65** (s)	**1.63** (s)
14	**4.20** (d, 8.4)	**4.19** (d, 8.5)	**4.20** (d, 8.4)	**4.22** (d, 8.6)	**4.19** (d, 8.5)
	5.87 (d, 8.5)	**5.85** (d, 8.5)	**5.87** (d, 8.5)	**5.89** (d, 8.6)	**5.85** (d, 8.5)
14*	**4.17** (d, 9.0)	**4.15** (d, 9.1)	**4.16** (d, 9.0)	**4.18** (d, 9.2)	**4.15** (d, 8.5)
	4.43 (d, 9.0)	**4.41**, (d, 9.1)	**4.43** (d, 9.0)	**4.44** (d, 9.2)	**4.42** (d, 9.0)
15	**1.24** (d, 7.8)	**1.22** (d, 7.7)	**1.24** (d, 7.7)	**1.25** (d, 8.0)	**1.23** (d, 8.0)
15*	**1.38** (d, 7.9)	**1.32** (d, 7.7)	**1.38** (d, 7.7)	**1.39** (d, 7.4)	**1.37** (d, 8.0)
OCH_3	**3.68** (s)	**3.66** (s)	**3.68** (s)	**3.69** (s)	**3.67** (s)
OCH_3*	**3.56** (s)	**3.54** (s)	**3.56** (s)	**3.57** (s)	**3.55** (s)

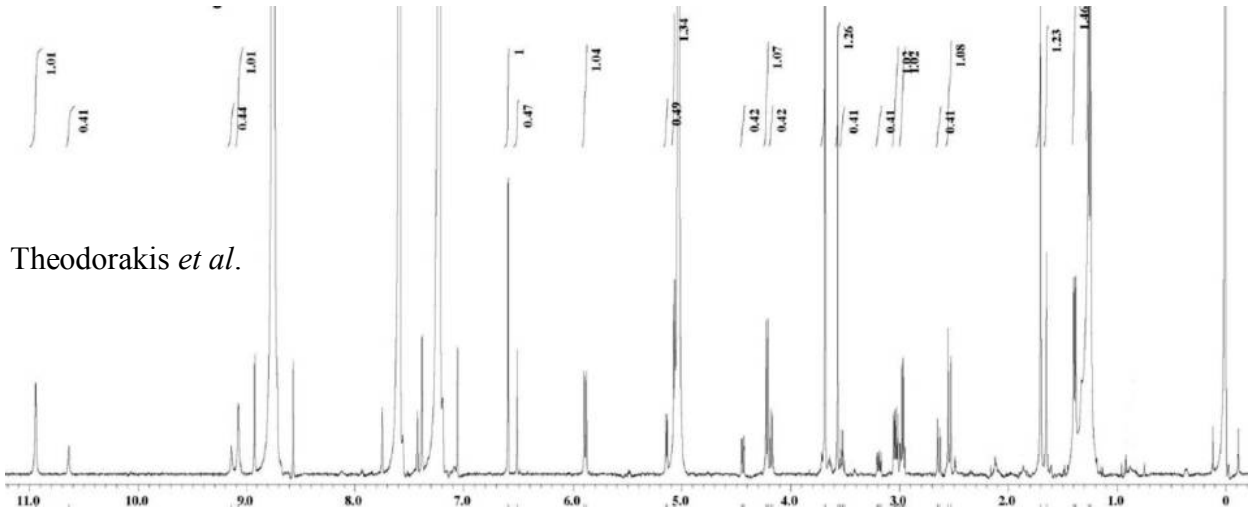
[13] Yokoyama, R.; Huang, J.-M.; Yang, C.-S.; Fukuyama, Y. *J. Nat. Prod.* **2002**, *65*, 527–531.

	^{13}C shifts (C_5D_5N-TMS, ppm)				
position	Micalizio	natural **1**	Danishefsky	Theodorakis	Zhai
1	**42.9**	**42.9**	**42.8**	**43.0**	**42.8**
1	**44.7**	**44.8**	**44.7**	**44.9**	**44.6**
2	**208.9**	**208.9**	**208.7**	**208.9**	**208.7**
2*	**209.7**	**209.8**	**209.6**	**209.7**	**209.5**
3	**130.6**	**130.6**	**130.5**	**130.7**	**130.4**
3*	**131.2**	**131.2**	**131.1**	**131.3**	**131.0**
4	**180.1**	**180.2**	**180.0**	**180.2**	**180.0**
4*	**177.3**	**177.4**	**177.2**	**177.4**	**177.2**
5	**45.1**	**45.2**	**45.1**	**45.2**	**45.0**
5*	**44.8**	**44.8**	**44.6**	**44.8**	**44.6**
6	**80.5**	**80.5**	**80.4**	**80.6**	**80.4**
6*	**79.4**	**79.4**	**79.3**	**79.5**	**79.2**
7	**80.9**	**80.9**	**80.8**	**81.0**	**80.8**
7*	**80.3**	**80.3**	**80.2**	**80.4**	**80.2**
8	**31.3**	**31.4**	**31.3**	**31.4**	**31.2**
8*	**31.5**	**31.6**	**31.5**	**31.6**	**31.4**
9	**60.2**	**60.2**	**60.1**	**60.3**	**60.1**
9*	**61.4**	**60.2**	**61.3**	**61.5**	**61.3**
10	**105.9**	**105.9**	**105.8**	**106.0**	**105.8**
10*	**104.0**	**104.1**	**103.9**	**104.1**	**104.0**
11	**171.5**	**171.5**	**171.4**	**171.6**	**171.5**
11*	**169.1**	**169.2**	**169.0**	**169.2**	**169.0**
12	**178.9**	**178.9**	**178.8**	**179.0**	**178.7**
12*	**178.6**	**178.9**	**178.6**	**178.7**	**178.5**
13	**23.2**	**23.2**	**23.1**	**23.3**	**23.1**
13*	**23.1**	**23.1**	**23.0**	**23.2**	**23.0**
14	**76.0**	**76.0**	**75.9**	**76.1**	**75.9**
14*	**75.3**	**75.3**	**75.2**	**75.4**	**75.2**
15	**13.0**	**13.6**	**12.9**	**13.1**	**12.8**
15*	**14.4**	**14.5**	**14.4**	**14.5**	**14.3**
OCH_3	**52.6**	**52.7**	**52.6**	**52.7**	**52.5**
OCH_3*	**52.0**	**52.0**	**51.9**	**52.0**	**51.8**

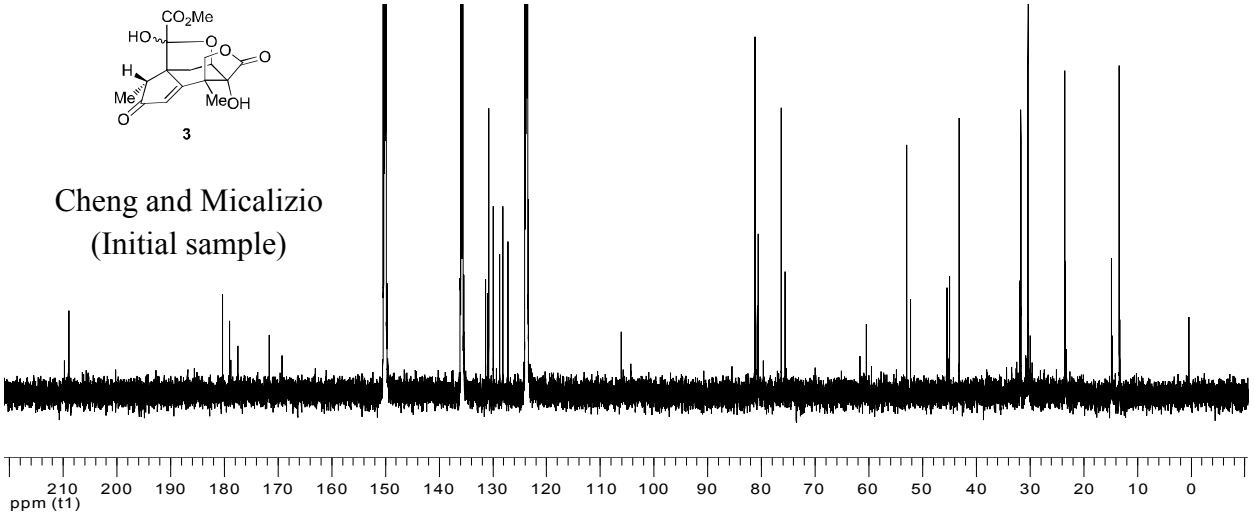
Comparison of ^{1}H NMR of an analytical sample of **3** with previous reported ^{1}H NMR spectra of **3** (C_5D_5N-TMS):[12]

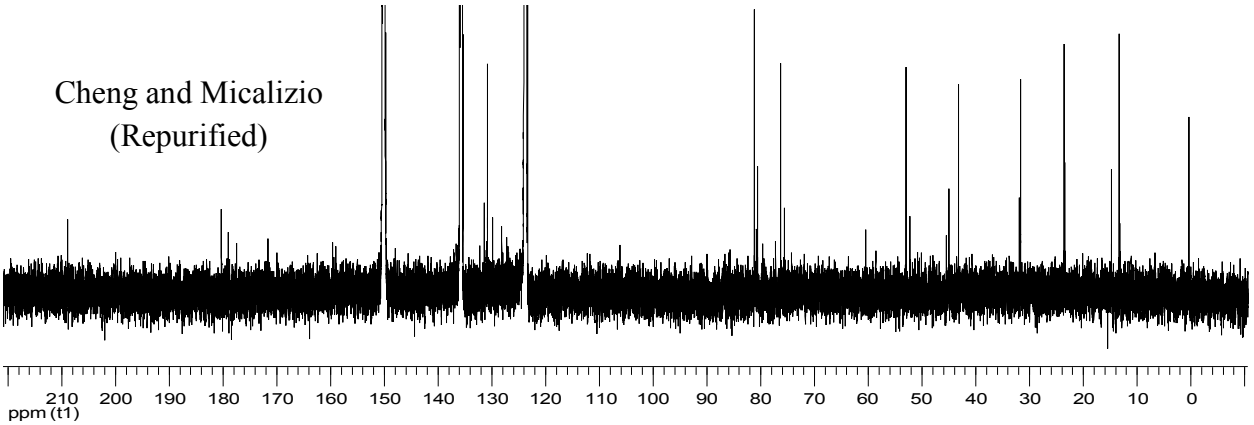


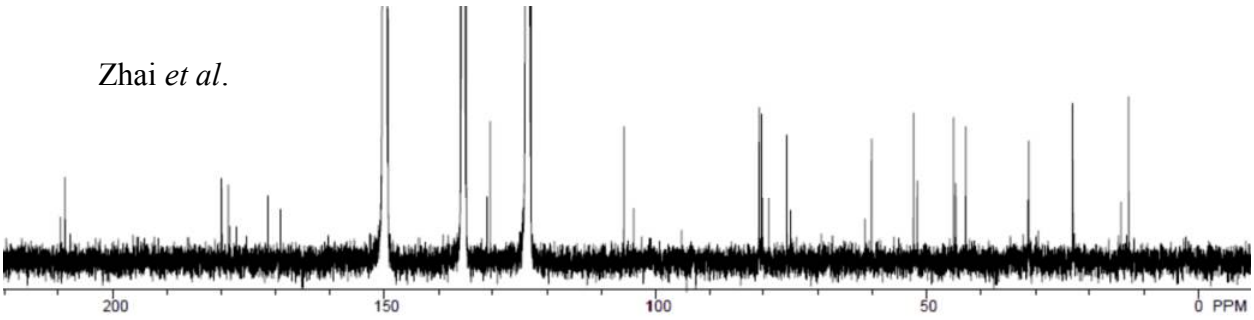


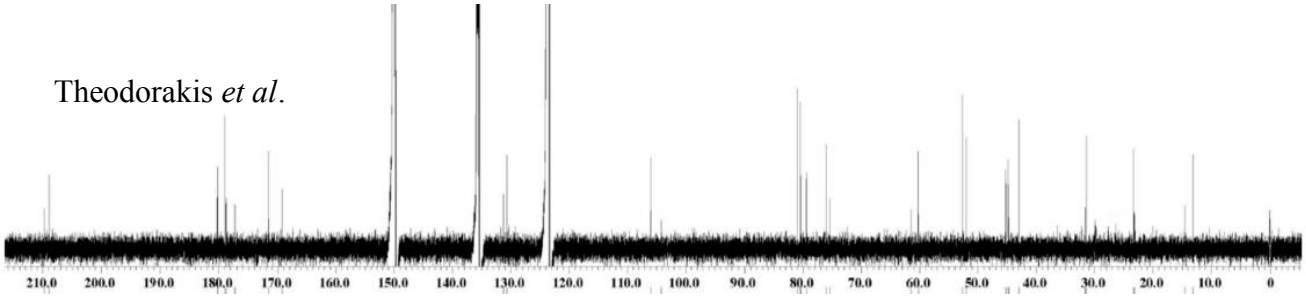


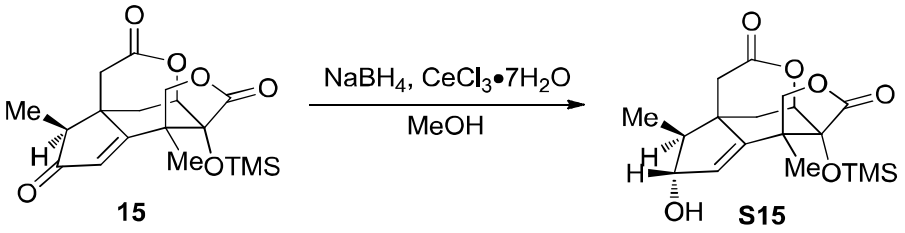
Comparison of ^{13}C NMR of **3** with previous reported ^{1}H NMR spectra of **3** (C_5D_5N-TMS):[12]





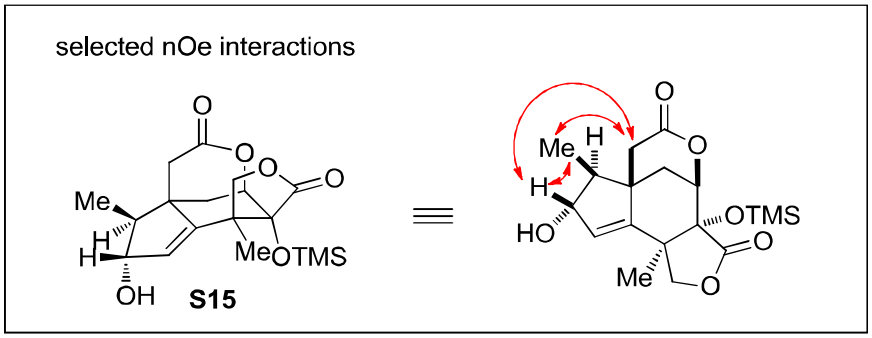


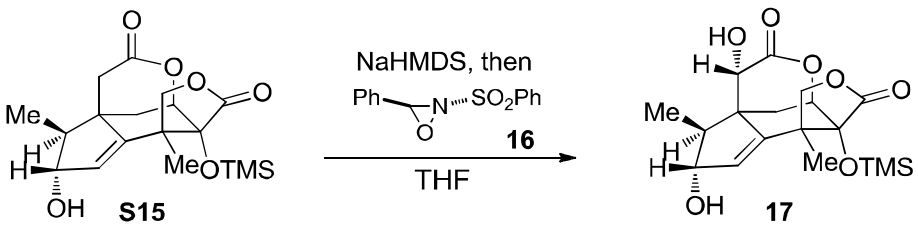




(3a*R*,4*R*,7a*R*,8*S*,9*S*,10b*R*)-9-hydroxy-8,10b-dimethyl-3a-((trimethylsilyl)oxy)-3a,4,8,9-tetrahydro-1*H*-4,7a-methanocyclopenta[*e*]furo[3,4-*c*]oxocine-3,6(7*H*,10b*H*)-dione (S15). To a solution of the enone **15** (16.7 mg, 0.04582 mmol) and $CeCl_3•7H_2O$ (136.6 mg, 0.3666 mmol) in MeOH (2 mL) at –78 °C was added $NaBH_4$ (10.4 mg, 0.2749 mmol). The reaction mixture was stirred at –78 °C for 40 min. After quenching the reaction with pH 7 buffer and warming to rt, the MeOH was removed *in vacuo*. The resulting mixture was extracted with CH_2Cl_2 (four times) and the combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo* to provide the alcohol **S15** (15.4 mg, 92%) as a colorless oil which was sufficiently pure of use in the next step.

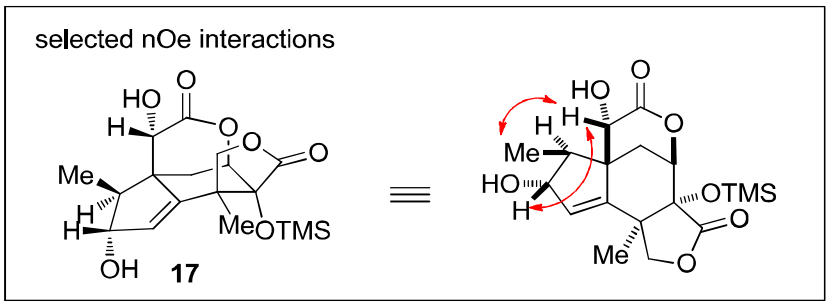
Data for **S15**: R_f = 0.30 (1:1 hexanes:EtOAc); $[\alpha]_D^{23}$ = –2.7° (*c* 0.11, $CHCl_3$); IR (thin film) 3445, 2959, 1784, 1742, 1455, 1366, 1252, 1187, 1145, 1070, 1005, 890, 846, 759 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 5.88 (d, *J* = 0.9 Hz, 1H), 4.69 (dd, *J* = 3.0, 3.0 Hz, 1H), 4.46 (d, *J* = 8.4 Hz, 1H), 3.94 (app. d, *J* = 10.0 Hz, 1H), 3.80 (app. d, *J* = 10.0 Hz, 1H), 2.75 (app. d, *J* = 18.5 Hz, 1H), 2.31 (app. d, *J* = 18.4 Hz, 1H), 1.99 (d, *J* = 2.9 Hz, 2H), 1.90 (dq, *J* = 7.1, 7.1 Hz, 1H), 1.85 (brs, 1H), 1.31 (s, 3H), 1.12 (d, *J* = 7.1 Hz, 3H), 0.21 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 175.2, 169.1, 148.0, 133.9, 81.0, 79.2, 75.1, 54.4, 45.2, 42.8, 39.1, 30.3, 30.2, 23.1, 11.5, 2.1 (3C); HRMS (ESI-TOF) calculated for $C_{18}H_{26}O_6NaSi$ $[M+Na]^+$ 389.1396, found 389.1396.

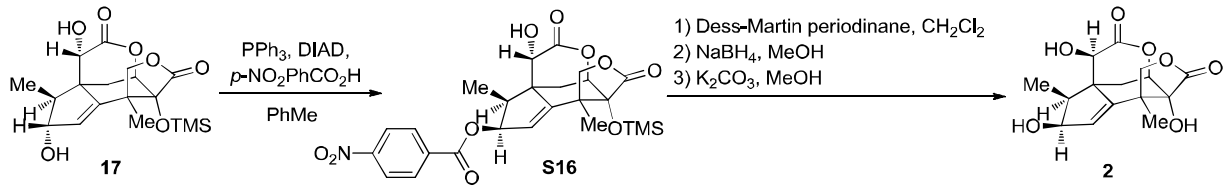




(3a*R*,4*R*,7*S*,7a*R*,8*S*,9*S*,10b*R*)-7,9-dihydroxy-8,10b-dimethyl-3a-((trimethylsilyl)oxy)-3a,4,8,9-tetrahydro-1*H*-4,7a-methanocyclopenta[*e*]furo[3,4-*c*]oxocine-3,6(7*H*,10b*H*)-dione (17). Alcohol **S15** was dried by azeotroping with PhMe (three times) and placed under high vacuum overnight. To a solution of **S15** (35 mg, 0.09550 mmol) in THF (1.5 mL) at –78 °C was added NaHMDS (0.5 mL in THF, 0.57 mL, 0.29 mmol). After 30 min at –78 °C, a solution of Davis Oxaziridine **16** (27.5 mg, 0.1051 mmol) in THF (1 mL) was added. After another 1.5 h at –78 °C, the reaction was quenched by addition of saturated aqueous NH_4Cl. Upon warming to rt, THF was removed *in vacuo* and the mixture was extracted with EtOAc (four times). The combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. The crude mixture was purified by flash chromotography (95:5 CH_2Cl_2:MeOH) to give **17** (26.8 mg) contaminated with **S15** and a small amount **16** (see ^{1}H NMR for more details). The slightly impure **17** (containing 18.4 mg of pure **17**, calculated based on ^{1}H NMR, 50%) was used in the next step without further purification. The pure fractions from the column were used to fully characterize **17**.

Data for **17**: R_f = 0.17 (95:5 CH_2Cl_2:MeOH); $[\alpha]_D^{23}$ = –11.4° (*c* 0.07, $CHCl_3$); IR (thin film) 3430, 2960, 2931, 2879, 1783, 1743, 1455, 1369, 1338, 1252, 1181, 1144, 1003, 892, 846, 757 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.01 (s, 1H), 4.72 (d, *J* = 4.3 Hz, 1H), 4.58 (d, *J* = 8.7 Hz, 1H), 4.08 (d, *J* = 1.2 Hz, 1H), 3.92 (app. d, *J* = 10.0 Hz, 1H), 3.71 (app. d, *J* = 10.0 Hz, 1H), 3.04 (brs, 1H), 2.72 (dd, *J* = 13.9, 4.9 Hz, 1H), 1.98 (brs, 1H), 1.92 (dq, *J* = 8.5, 7.4 Hz, 1H), 1.83 (d, *J* = 13.9 Hz, 1H), 1.32–1.28 (m, 6H), 0.21 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 175.6, 170.4, 145.6, 137.7, 80.5, 79.8, 75.6, 72.4, 57.1, 49.9, 42.4, 24.5, 23.69, 23.66, 13.5, 2.0 (3C); HRMS (ESI-TOF) calculated for $C_{18}H_{26}O_7NaSi$ $[M+Na]^+$ 405.1345, found 405.1342.





(2*S*)-hydroxy-3,4-dehydroneomajucin (2). To a solution of the allylic alcohol **17** (23.2 mg, contaminated with a small amount of **S15** and **16**, containing 15.6 mg pure **17** based on ^{1}H NMR, 0.04079 mmol), PPh_3 (16 mg, 0.06118 mmol) and 4-nitrobenzoic acid (10.2 mg, 0.06118 mmol) in THF (1.5 mL) at 0 °C was added a solution of DIAD (13.2 mg, 0.06118) in THF (1 mL) dropwise to over 3 min. After 5 h at the same temperature, the reaction was quenched with saturated aqueous $NaHCO_3$. After removal of THF *in vacuo*, the reaction mixture was extracted with CH_2Cl_2 (four times) and the combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo*. Removal of residual reagents by elution of the above residue with a short column (silica gel, 80:20 to 50:50 hexanes:EtOAc) provided the crude product (17.6 mg) which contained the desired ester **S16**. For characterization purposes, a small portion of this crude material (4 mg) was purified by preparative TLC (20 X 10 cm, 4:1 hexanes:EtOAc) and provided pure **S16** (1.3 mg) a white solid. This material was recombined with the rest of the crude mixture and used in the next step without further purification.

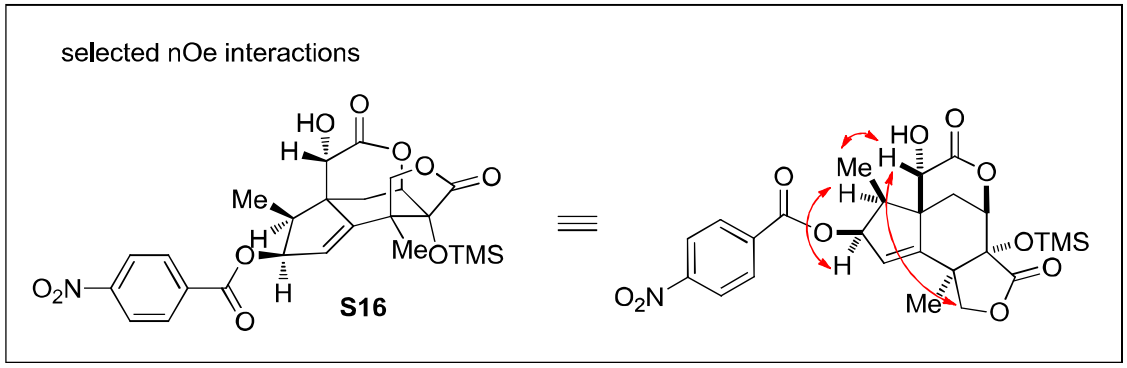
Crude **S16** was dissolved in CH_2Cl_2 (1.5 mL) and Dess-Martin periodinane (136 mg, 0.3198 mmol) was added at rt. The resulting reaction mixture was stirred at rt for 24 h. After sequential addition of saturated $Na_2S_2O_3$ and Na_2CO_3, the mixture was stirred for 5 min at rt. The reaction mixture was then extracted with CH_2Cl_2 (four times) and the combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo* to provide a crude α-ketolactone (19.6 mg) which was used immediately.

To a solution of above crude material in MeOH (2 mL) at –78 °C was added $NaBH_4$ (12 mg, 0.3198 mmol). The reaction mixture was stirred at –78 °C for 2 h. After quenching the reaction with saturated aqueous NH_4Cl and warming to rt, the MeOH was removed *in vacuo*. The resulting mixture was extracted with CH_2Cl_2 (four times) and the combined organic extracts were dried over Na_2SO_4 and concentrated *in vacuo* to provide the crude α-hydroxylactone[14] which was used without further purification for the next step.

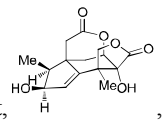
[14] Partial transesterification was observed between the resulting alkoxide from this reduction and the nitrobenzoate of the allylic alcohol.

The above crude material was dissolved in MeOH (1 mL) and K_2CO_3 (4.4 mg, 0.032 mmol) was added at rt. After 12 h at rt, the reaction mixture was filtered through a pad of Celite and silica gel mixture. The resulting clear solution was concentrated *in vacuo* and the crude material was purified by flash chromatography (silica gel, 95:5 CH_2Cl_2:MeOH) to afford **2** (2.1 mg, contaminated with a C10 non-hydroxyated compound[15], containing 1.7 mg pure **2** based on ^{1}H NMR, 14% over four steps) as a an amorphous white solid. In order to acquire **2** of higher purity, 0.4 mg of the above sample of **2** was purified by flash chromatography using a 10 mm ID glass column (silica gel, 20–45 μm mesh, 98:2 to 95:5 CH_2Cl_2:MeOH).

Data for **S16**: R_f = 0.8 (1:1 hexanes:EtOAc); $[\alpha]_D^{23}$ = –252.5° (*c* 0.04, $CHCl_3$); IR (thin film) 3469, 2956, 2932, 2879, 1787, 1747, 1529, 1368, 1346, 1269, 1254, 1183, 1140, 1100, 1006, 893, 847, 719 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33–8.30 (m, 2H), 8.18–8.15 (m, 2H), 6.42 (d, *J* = 3.2 Hz, 1H), 5.61 (dd, *J* = 5.3, 3.4 Hz, 1H), 4.78 (dd, *J* = 4.7, 0.7 Hz, 1H), 4.38 (d, *J* = 0.9 Hz, 1H), 3.99 (app. d, *J* = 10.1 Hz, 1H), 3.79 (app. d, *J* = 10.1 Hz, 1H), 2.89 (dd, *J* = 14.0, 4.8 Hz, 1H), 2.71 (brs, 1H), 2.37 (dq, *J* = 7.5, 5.5 Hz, 1H), 1.82 (d, *J* = 14.0, 1H), 1.36 (d, *J* = 7.6 Hz, 3H), 1.34 (s, 3H), 0.23 (s, 9H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 175.1, 174.4, 164.5, 153.5, 150.9, 135.5, 131.7, 130.9 (2C), 124.0 (2C), 79.6, 79.4, 79.2, 75.2, 74.7, 50.2, 43.3, 24.4, 23.83, 23.80, 12.6, 2.0 (3C); HRMS (ESI-TOF) calculated for $C_{25}H_{29}NO_{10}NaSi$ $[M+Na]^+$ 554.1458, found 554.1455.

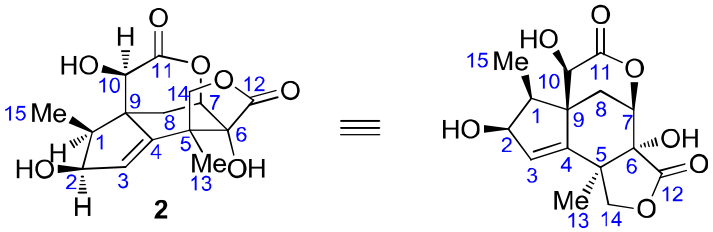


Data for **2**: R_f = 0.14 (95:5 CH_2Cl_2:MeOH); $[\alpha]_D^{23}$ = –82.4° (*c* 0.09, dioxane); IR (thin film) 3372, 2957, 2926, 2875, 2855, 1782, 1749, 1368, 1225, 1199, 1168, 1117, 1092, 1058, 1001, 967, 883 cm^{-1}; ^{1}H NMR (500 MHz, CD_3OD) δ 6.27 (d, *J* = 3.1 Hz, 1H), 4.64 (dd, *J* = 4.3, 1.6 Hz, 1H), 4.24 (dd, *J* = 5.8, 3.2 Hz, 1H), 4.06 (s, 1H), 3.99 (app. d, *J* = 10.4 Hz, 1H), 3.89 (app. dd, *J* =

[15] This contaminant,  , inseparable from **2**, was formed as a result of the impurity **S15** in starting material **17**.

10.4, 0.4 Hz, 1H), 2.46 (dd, J = 14.4, 4.3 Hz, 1H), 2.03 (dq, J = 7.3, 5.9 Hz, 1H), 1.94 (dd, 14.4, 1.6 Hz, 1H), 1.37 (s, 3H), 1.07 (d, J = 7.3 Hz, 3H); ^{1}H NMR (600 MHz, C_5D_5N-TMS) δ 9.71 (d, J = 3.5 Hz, 1H), 9.11 (brs, 1H), 6.49 (d, J = 3.1 Hz, 1H), 5.12 (dd, J = 4.1, 1.5 Hz, 1H), 4.72 (d, J = 11.1 Hz, 1H), 4.51 (ddd, J = 11.1, 5.9, 3.1 Hz, 1H), 4.50 (app. d, J = 10.3 Hz, 1H), 4.38 (d, J = 3.2 Hz, 1H), 4.11 (app. d, J = 10.3 Hz, 1H), 2.45 (dd, J = 14.2, 4.2 Hz, 1H), 2.26 (dd, J = 14.2, 1.5 Hz, 1H), 2.09 (dq, J = 7.2, 6.3 Hz, 1H), 1.59 (s, 3H), 1.23 (d, J = 7.3 Hz, 3H); ^{13}C NMR (150 MHz, C_5D_5N-TMS) δ 178.0, 173.4, 146.0, 135.4, 79.8, 78.6, 74.7, 74.2, 68.5, 50.2, 48.9, 42.8, 30.9, 22.7, 9.3; HRMS (ESI-TOF) calculated for $C_{15}H_{18}O_7Na$ $[M+Na]^+$ 333.0950, found 333.0952.

Full structural assignments of **2** based on 2D NMR and comparison with data for natural **2**[11, 16]:

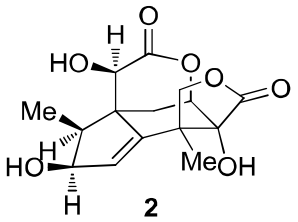


position	^{1}H shifts (C_5D_5N-TMS, ppm; J (Hz) in parentheses)	
	synthetic **2**	natural **2**
1	**2.09** (dq, 7.2, 6.3)	**2.08** (dq, 7.3, 5.9)
2	**4.51** (ddd, 11.1, 5.9, 3.1)	**4.50** (dd, 5.9, 2.9)
2-OH	**4.72** (d, 11.1)	—
3	**6.49** (d, 3.1)	**6.47** (d, 2.9)
6-OH	**9.11** (brs)	—
7	**5.12** (dd, 4.1, 1.5)	**5.10** (dd, 4.0, 1.5)
8	**2.45** (dd, 14.2, 4.2)	**2.45** (dd, 14.3, 4.0)
	2.26 (dd, 14.2, 1.5)	**2.25** (dd, 14.3, 1.5)
10	**4.38** (d, 3.2)	**4.36** (s)
10-OH	**9.71** (d, 3.5)	—
13	**1.59** (s)	**1.58** (s)
14	**4.50** (app. d, 11.1)	**4.46** (d, 10.3)
	4.11 (app. d, 11.1)	**4.09** (d, 10.3)
15	**1.23** (d, 7.3)	**1.22** (d, 7.3)

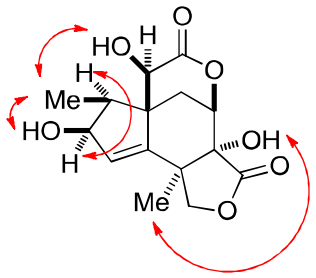
[16] Kouno *et al.* have reported detailed NMR data of **2** in C_5D_5N-TMS (reference **11**). Therefore, our comprehensive NMR analyses were based on the synthetic sample of **2** in C_5D_5N-TMS. There have been no published NMR spectra of **2**, but we were able to obtain an NMR spectrum of natural **2** in CD_3OD from Prof. Yoshiyasu Fukuyama. See page S43 for details.

	^{13}C shifts (C_5D_5N-TMS, ppm)	
position	synthetic **2**	natural **2**
1	**48.9**	**48.8**
2	**74.2**	**74.2**
3	**135.4**	**135.4**
4	**146.0**	**146.0**
5	**42.8**	**42.8**
6	**78.6**	**78.5**
7	**79.8**	**79.8**
8	**30.9**	**30.8**
9	**50.2**	**50.2**
10	**68.5**	**68.5**
11	**173.4**	**173.3**
12	**178.0**	**177.9**
13	**22.7**	**22.7**
14	**74.7**	**74.7**
15	**9.3**	**9.2**

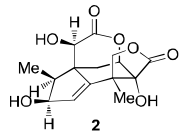
selected nOe interactions



2

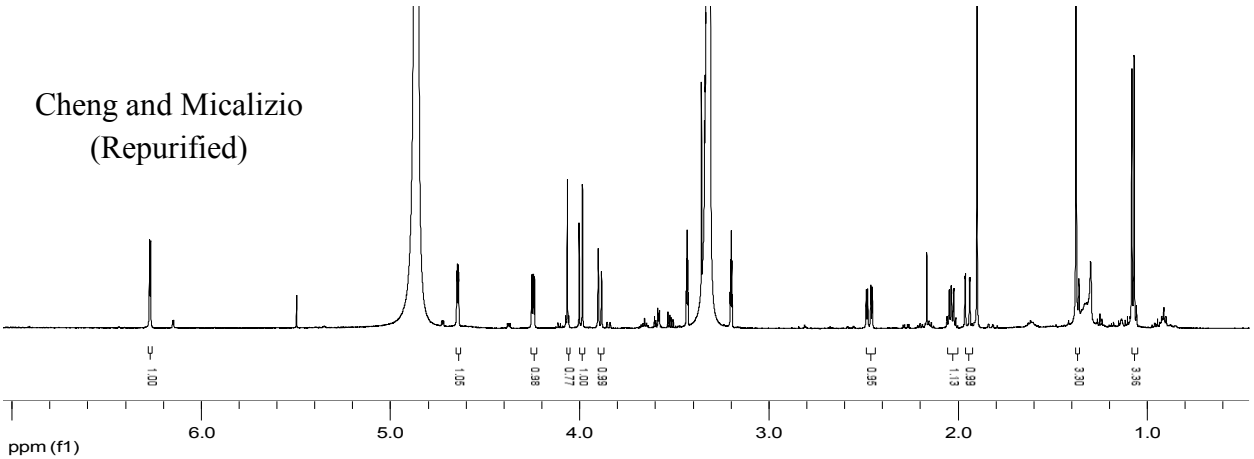


Comparison of ^{1}H NMR of **2** with ^{1}H NMR spectra of natural **2** (CD_3OD):[17]

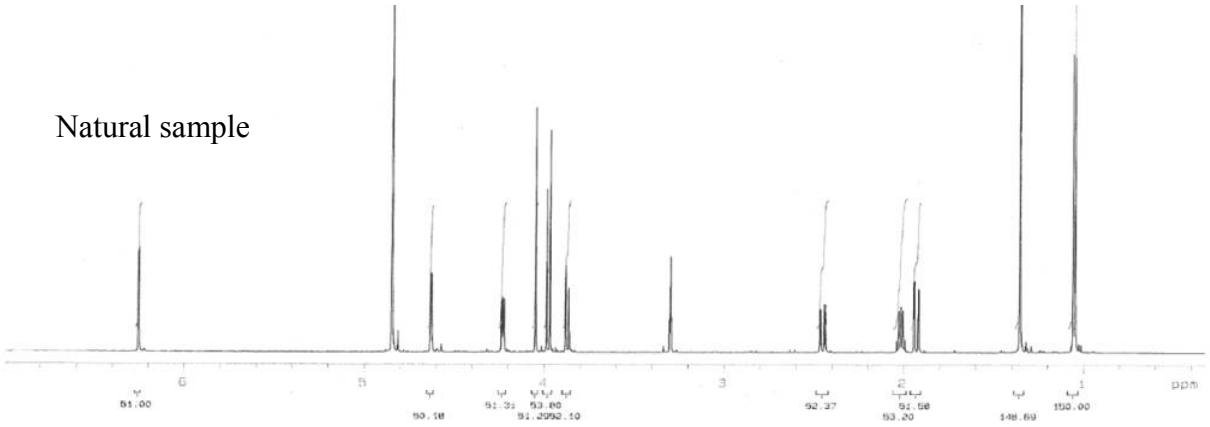


Cheng and Micalizio
(Initial sample)

Cheng and Micalizio
(Repurified)



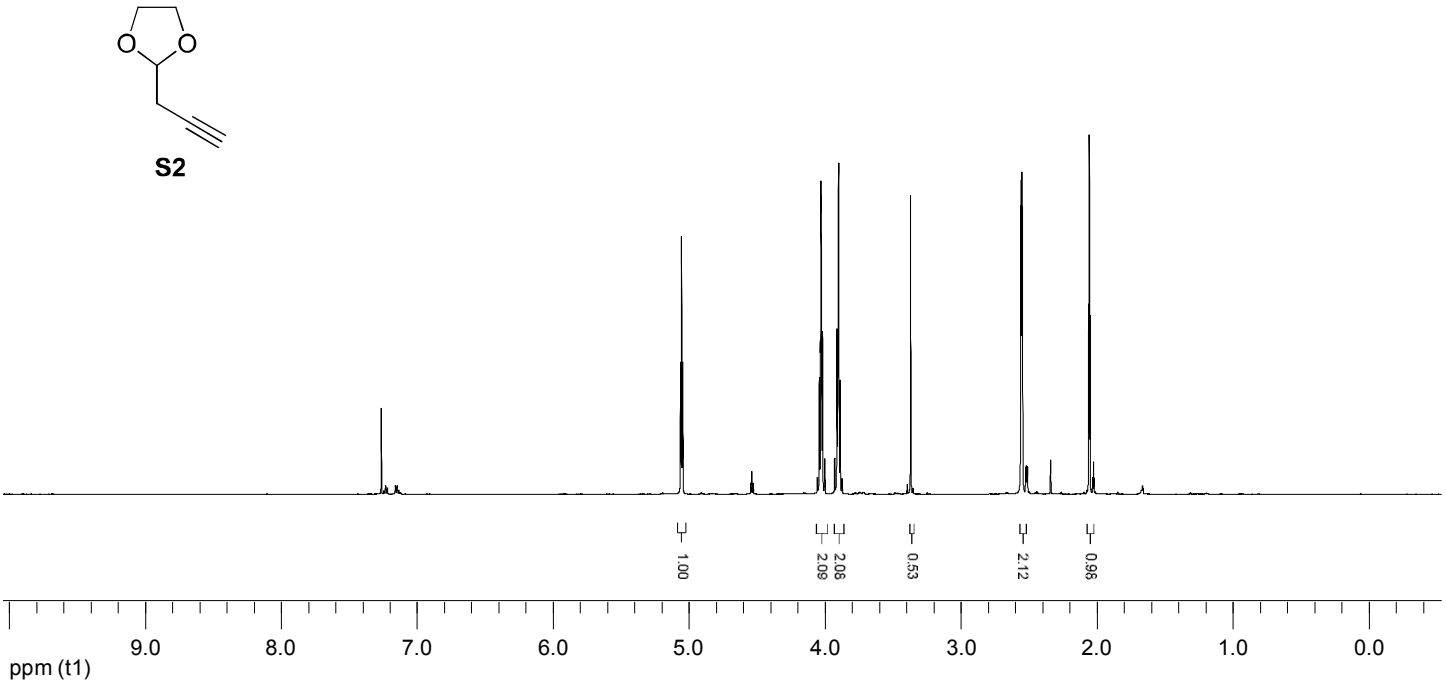
Natural sample



[17] This spectrum was kindly provided by Prof. Yoshiyasu Fukuyama.

3. Spectral Data

Figure S1: ^{1}H NMR (600 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S2** (purified by distillation).



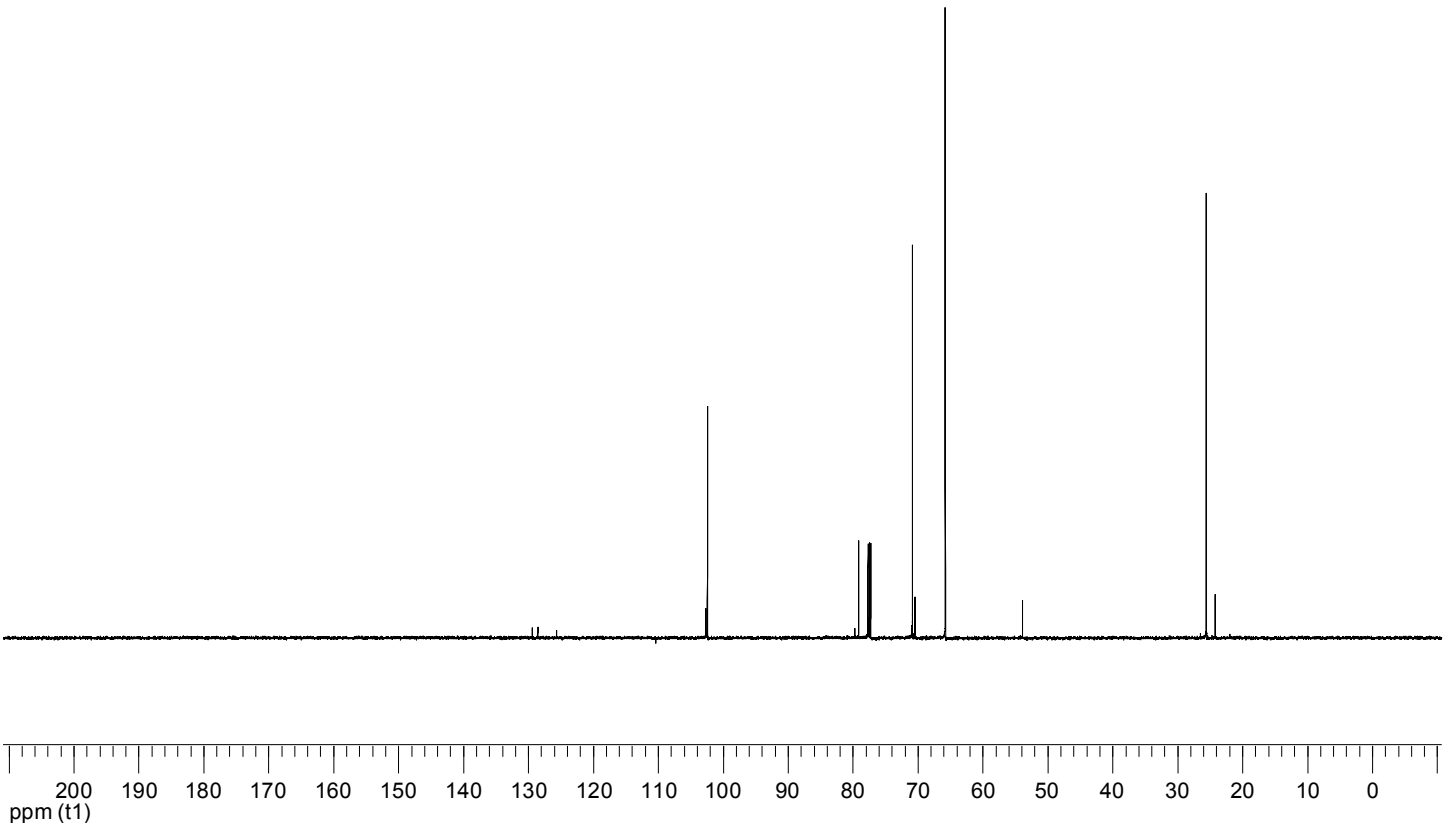


Figure S2: ^{1}H NMR (600 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S2** (purified by column chromatography).

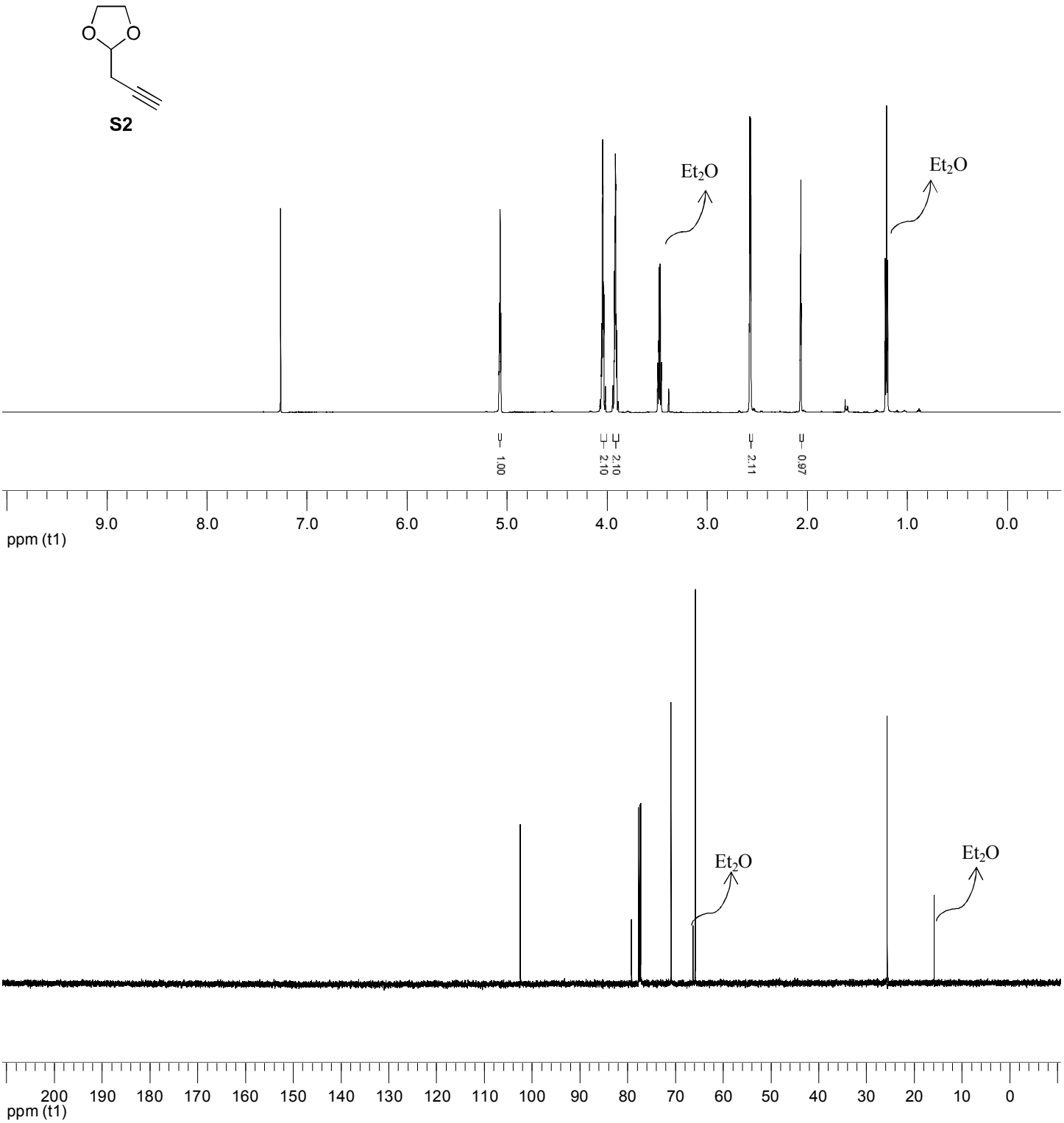


Figure S3: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **9** (contaminated with a small amount of the β-brominated regioisomer.

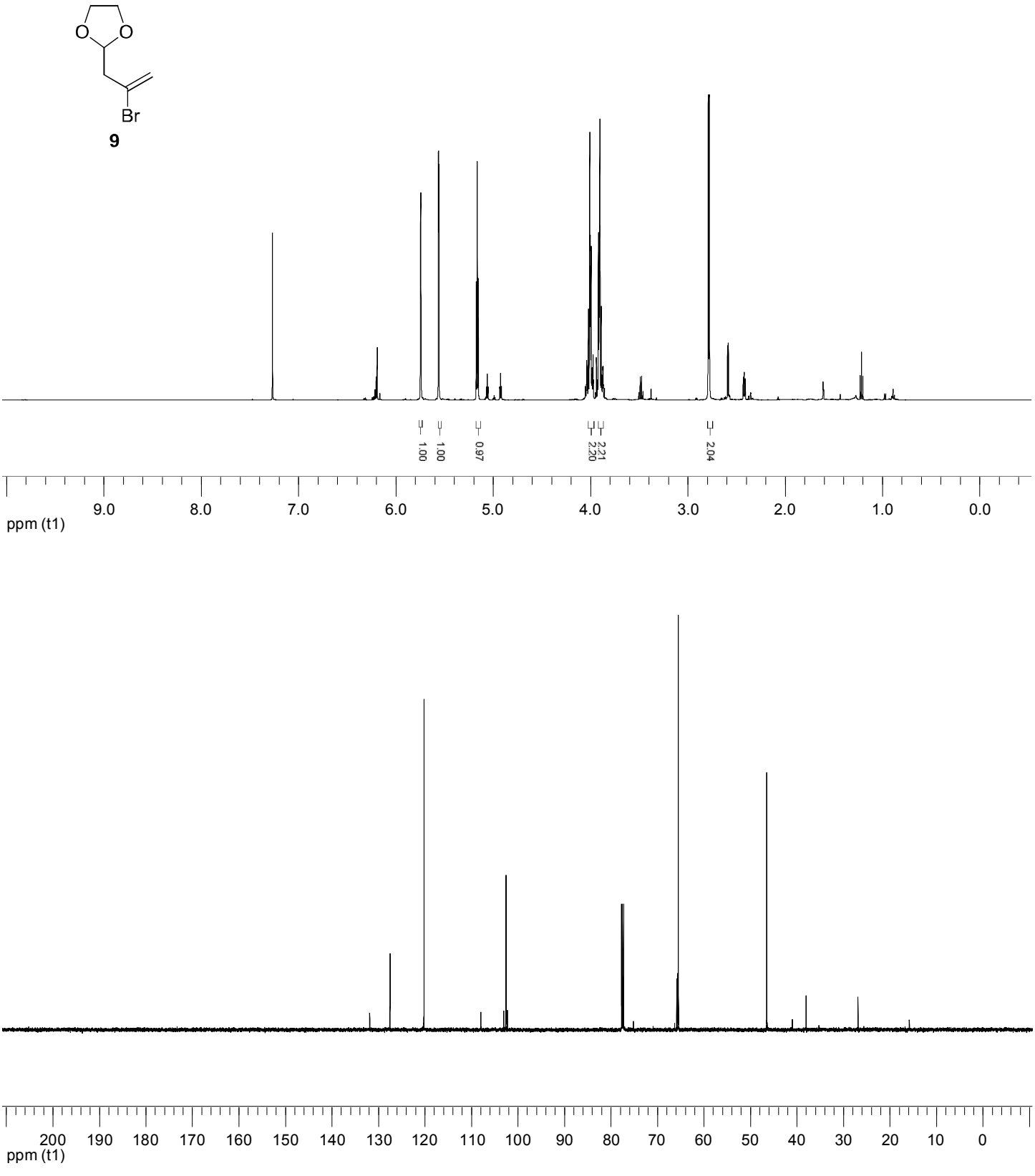


Figure S4: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **10**.

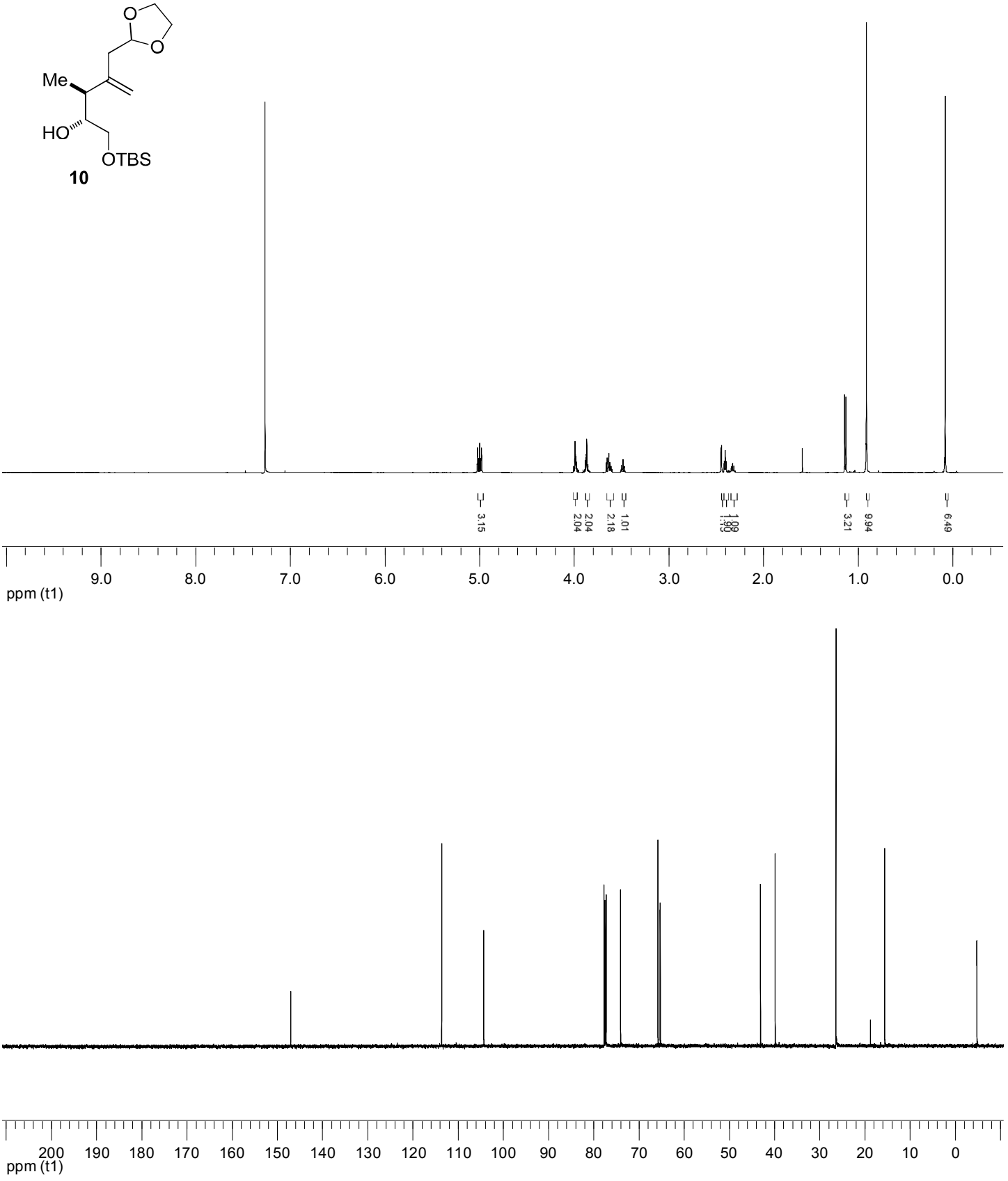
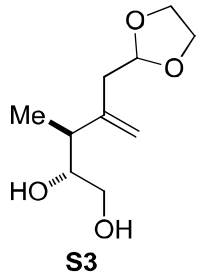


Figure S5: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S3**.



S3

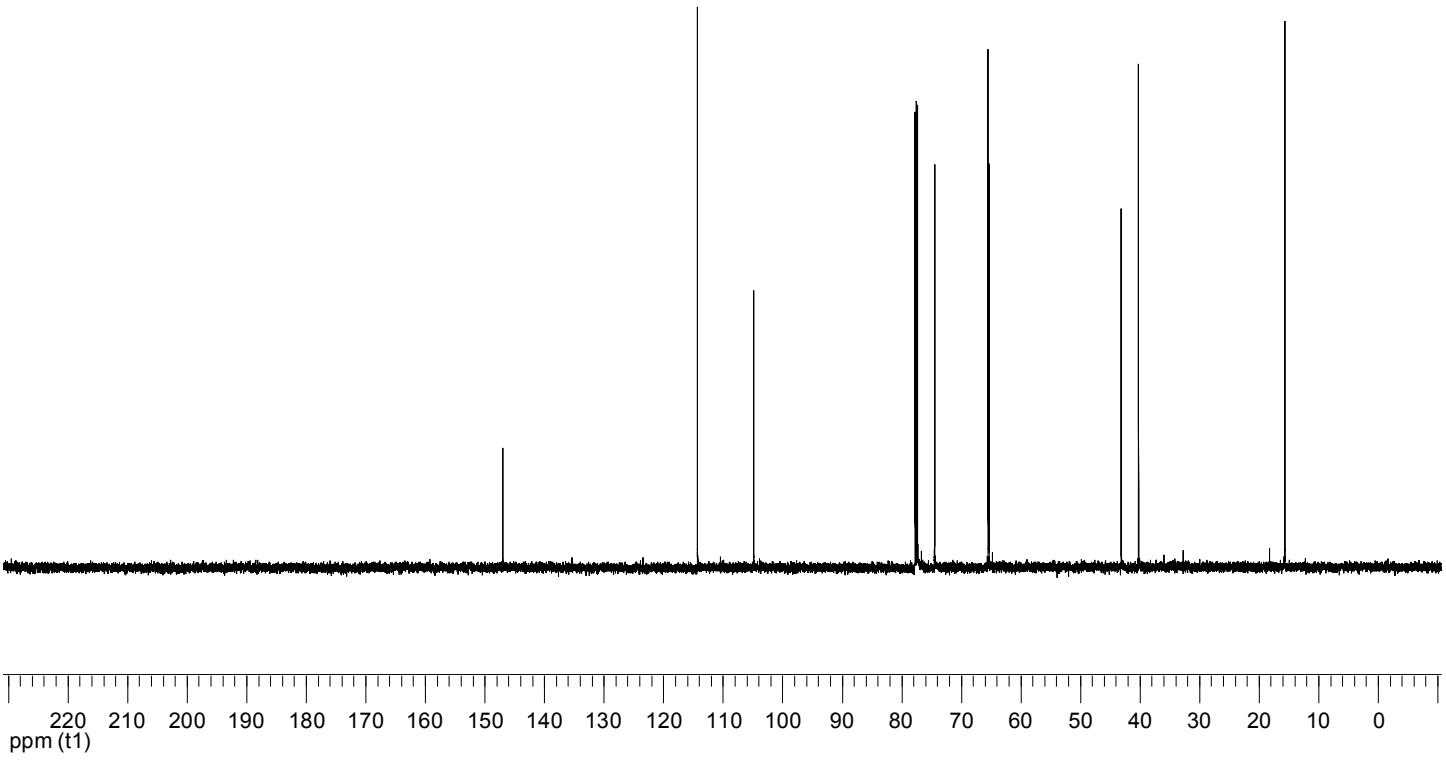


Figure S6: ^{1}H NMR (600 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S4**.

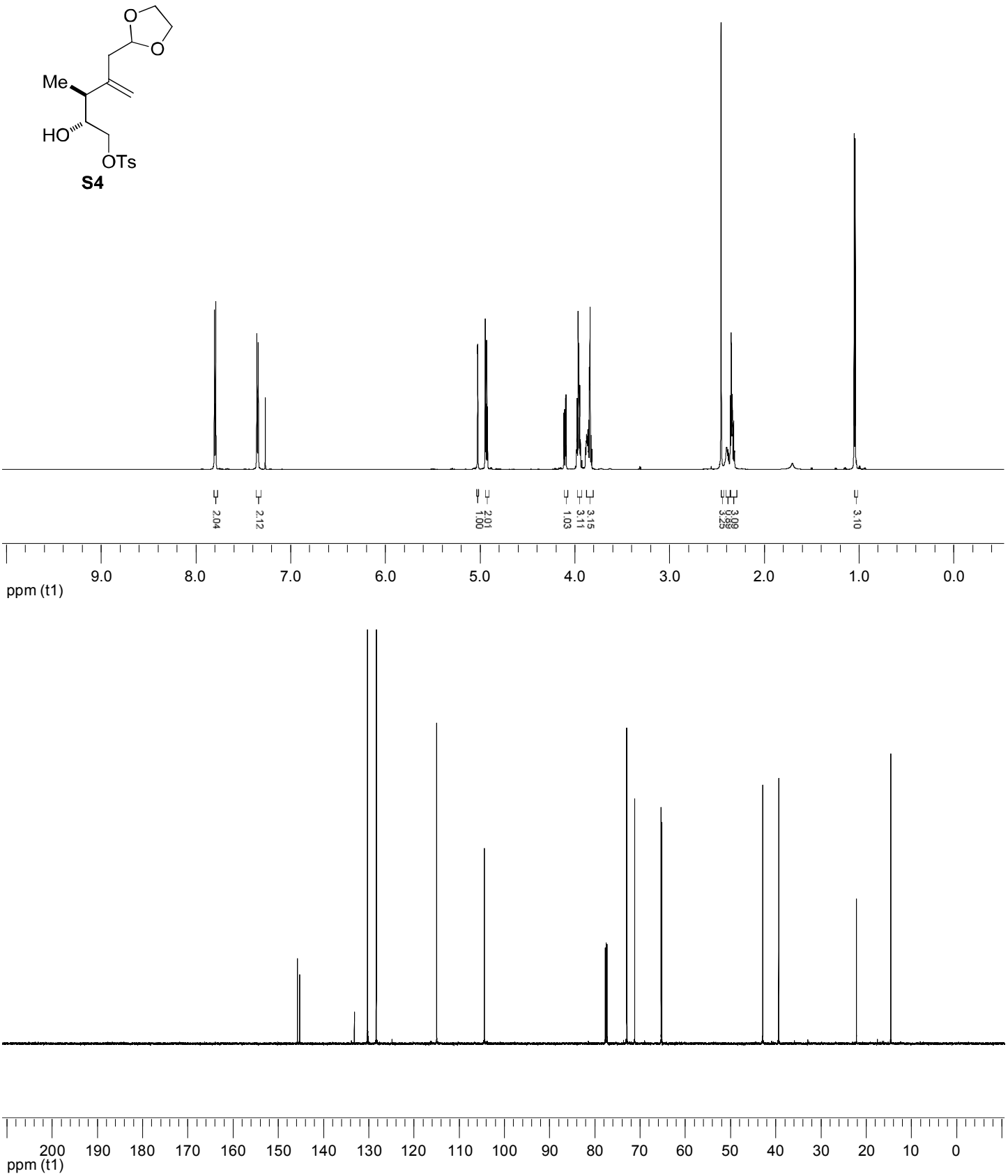


Figure S7: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **6**.

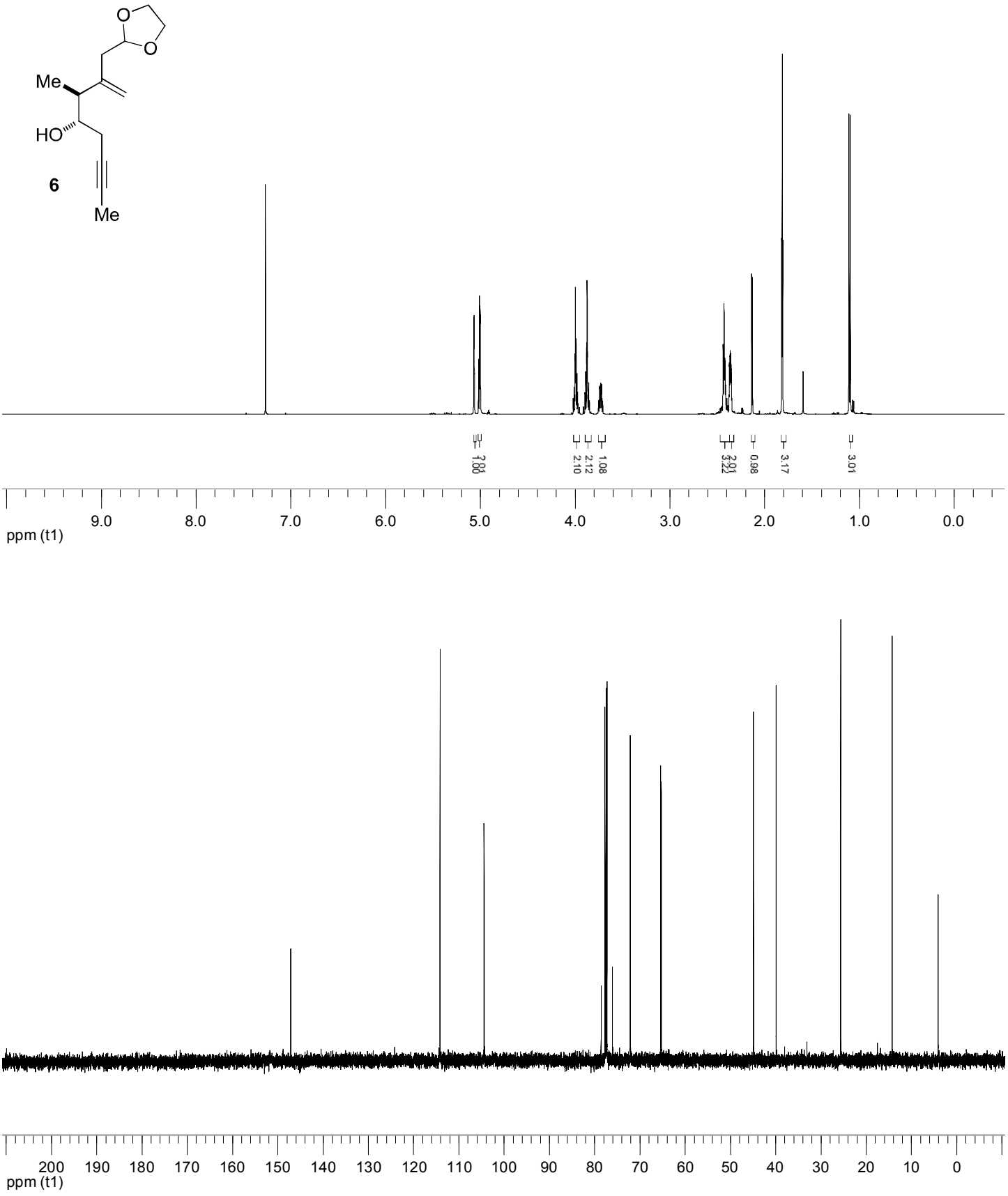


Figure S8: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **5**.

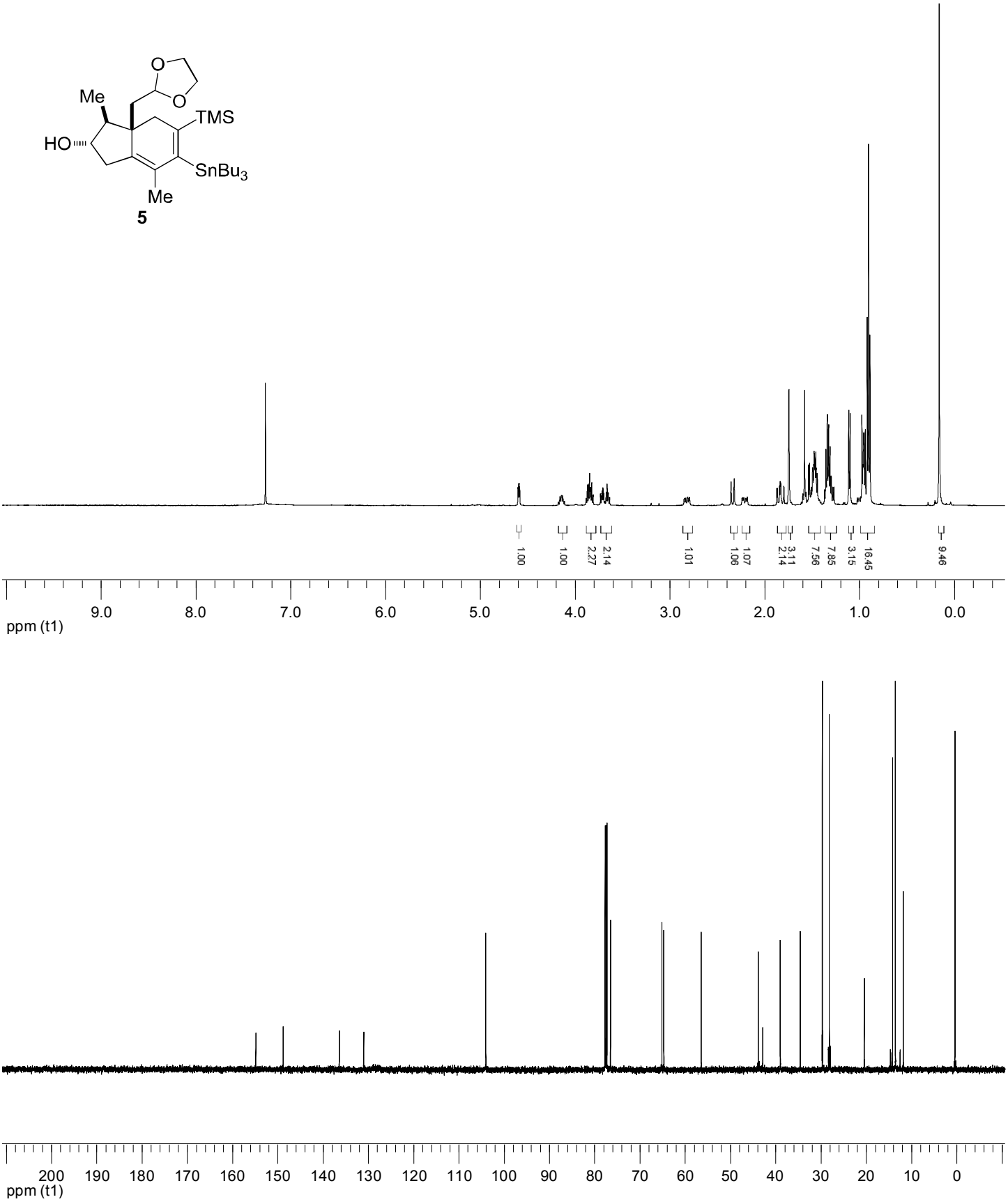
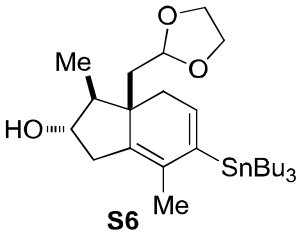


Figure S9: ^{1}H NMR (600 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S6**.



S6

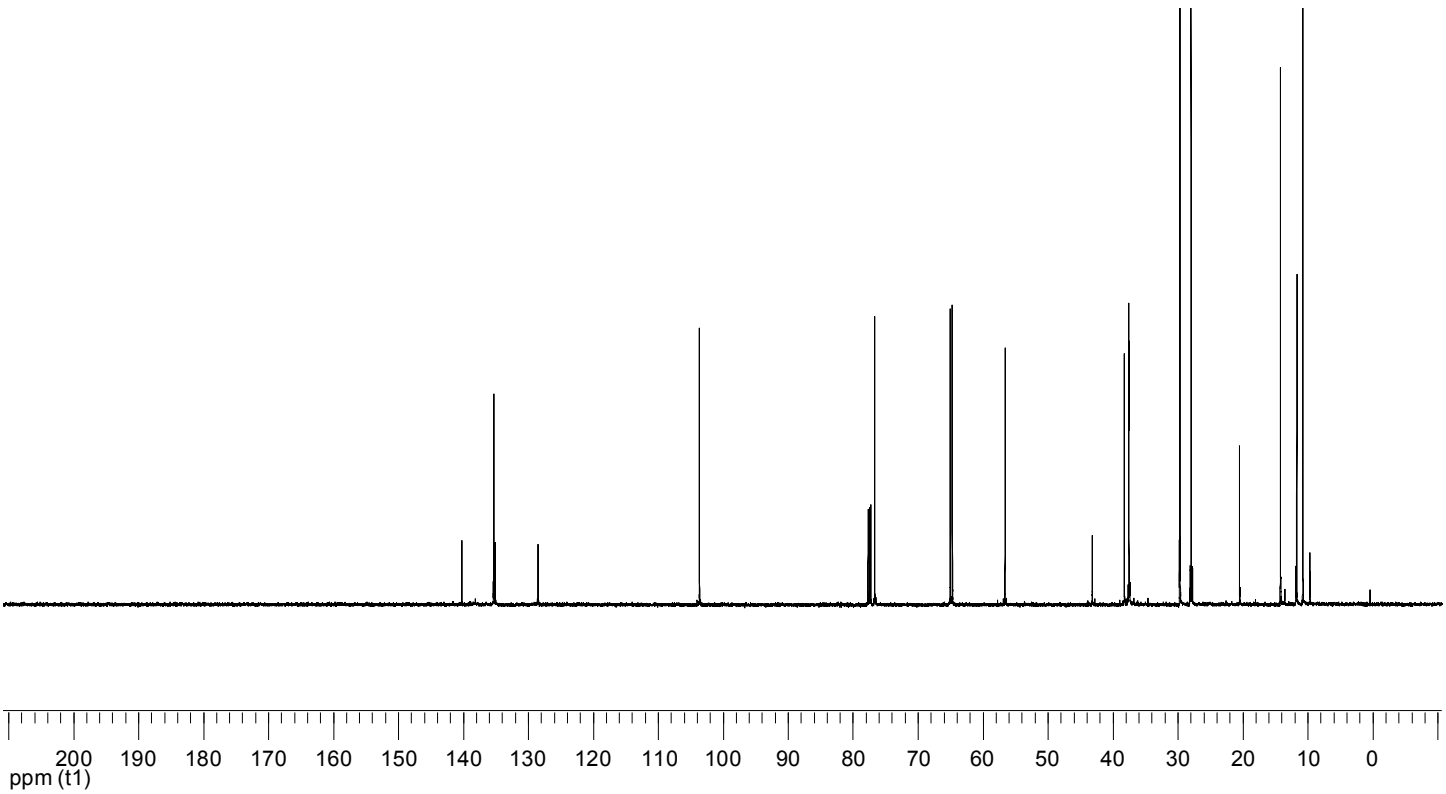
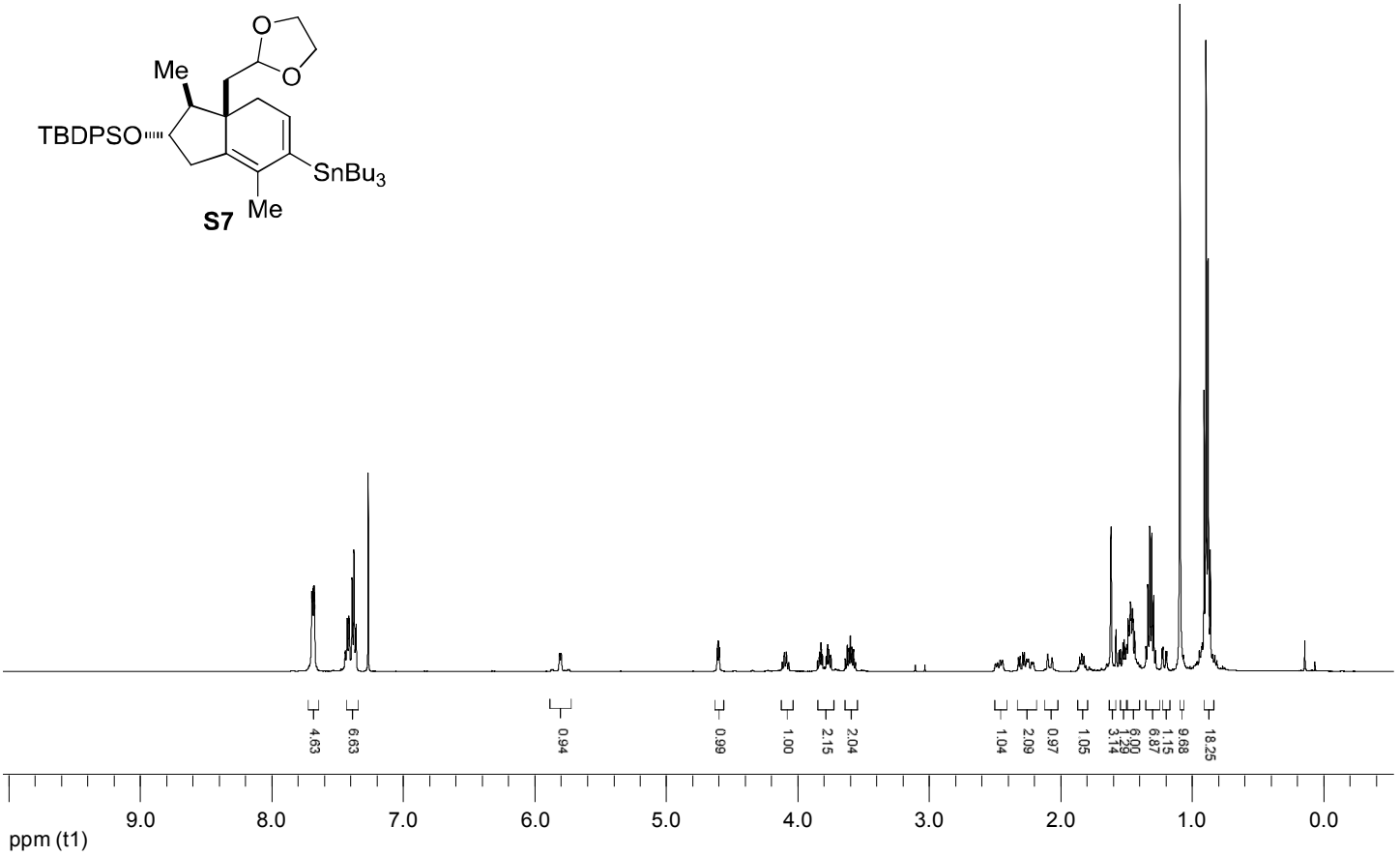


Figure S10: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S7**.



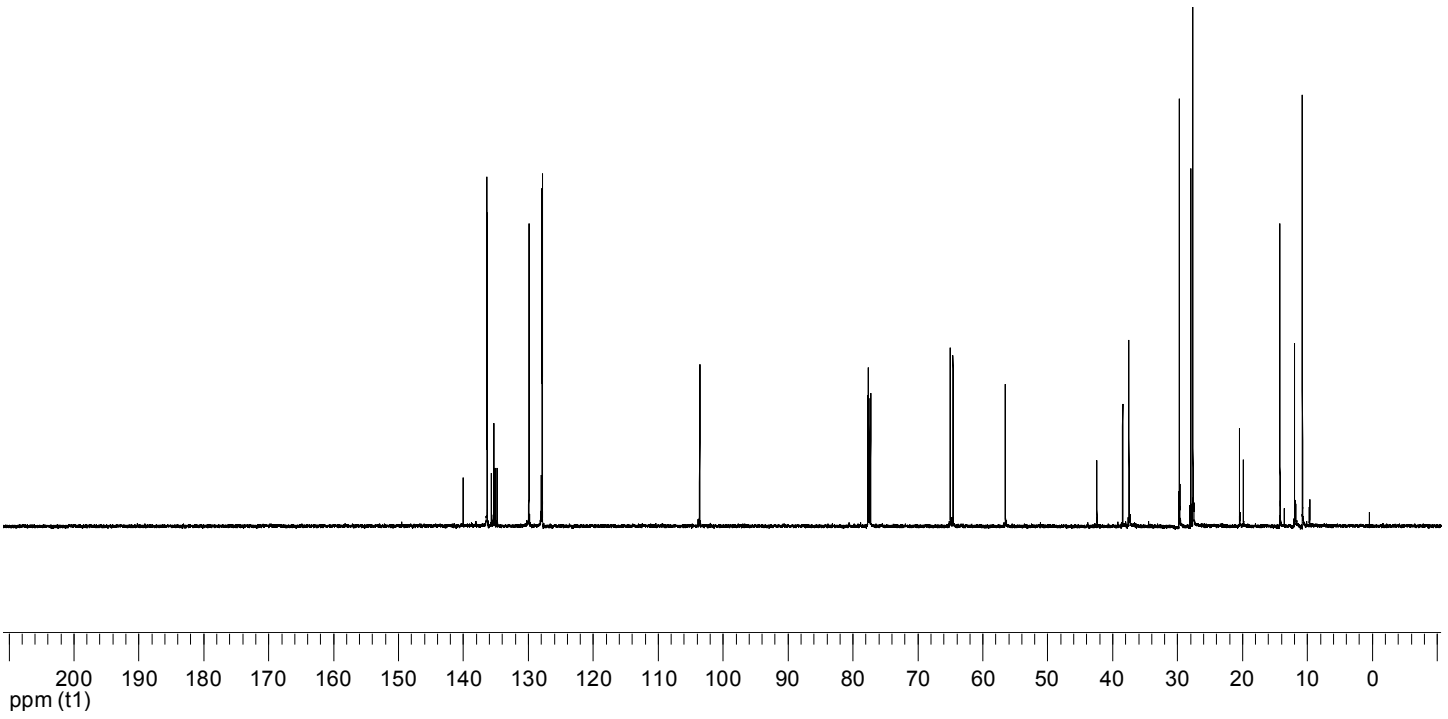


Figure S11: ^{1}H NMR (600 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **4**.

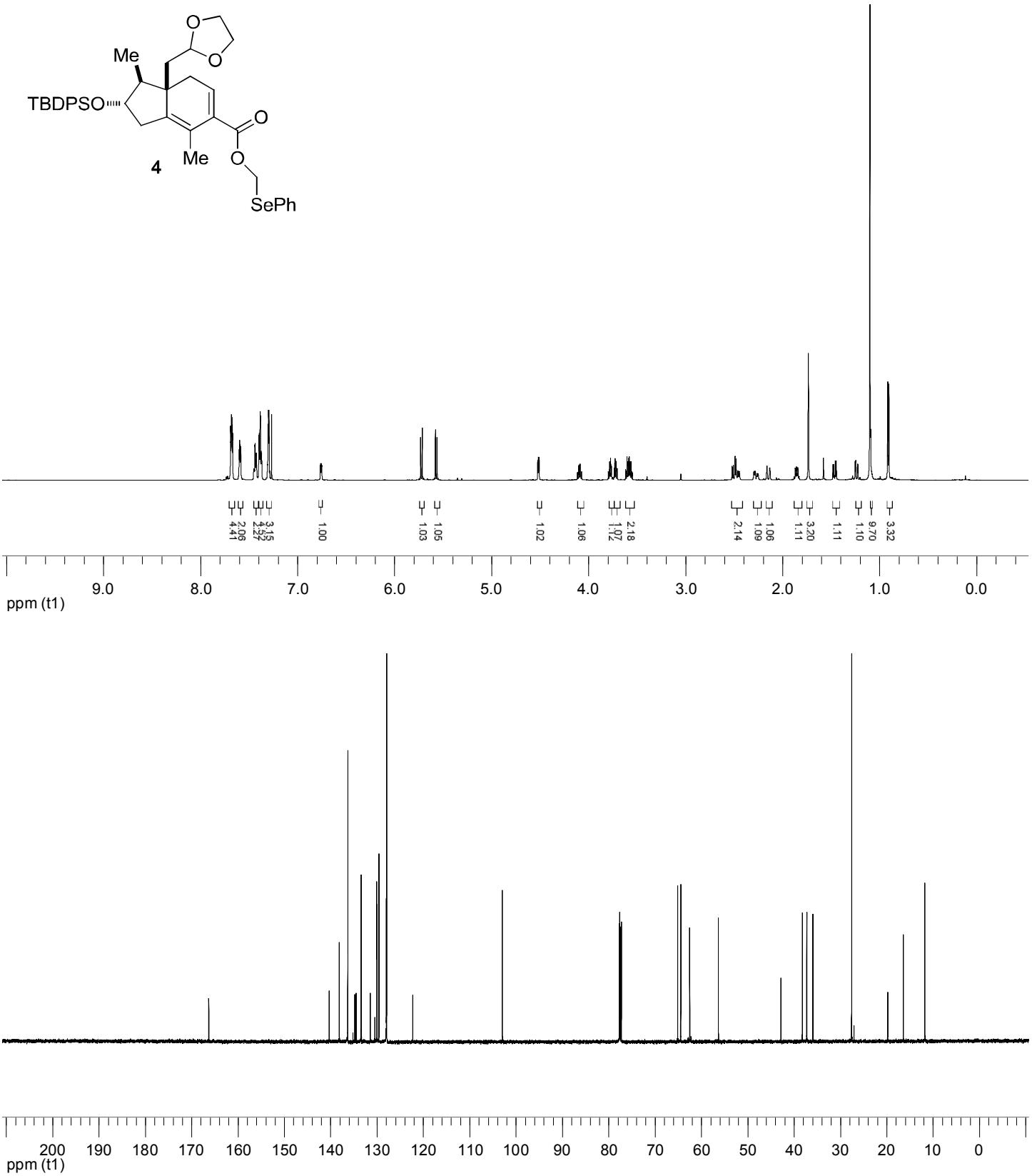


Figure S12: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **11**.

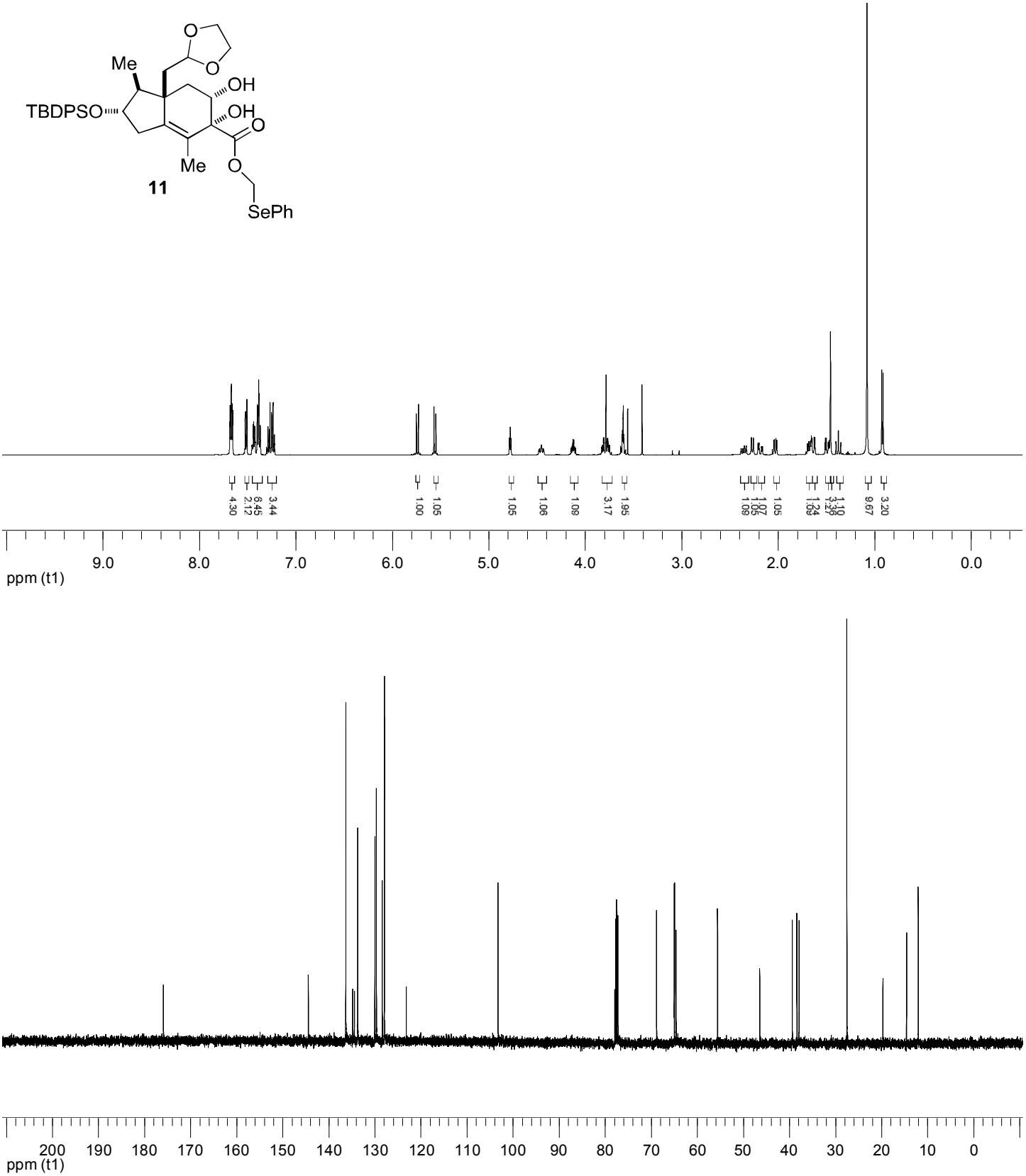
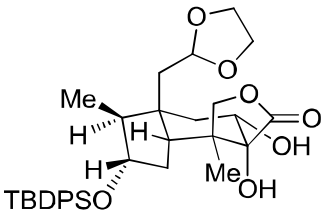


Figure S13: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **12**.



12

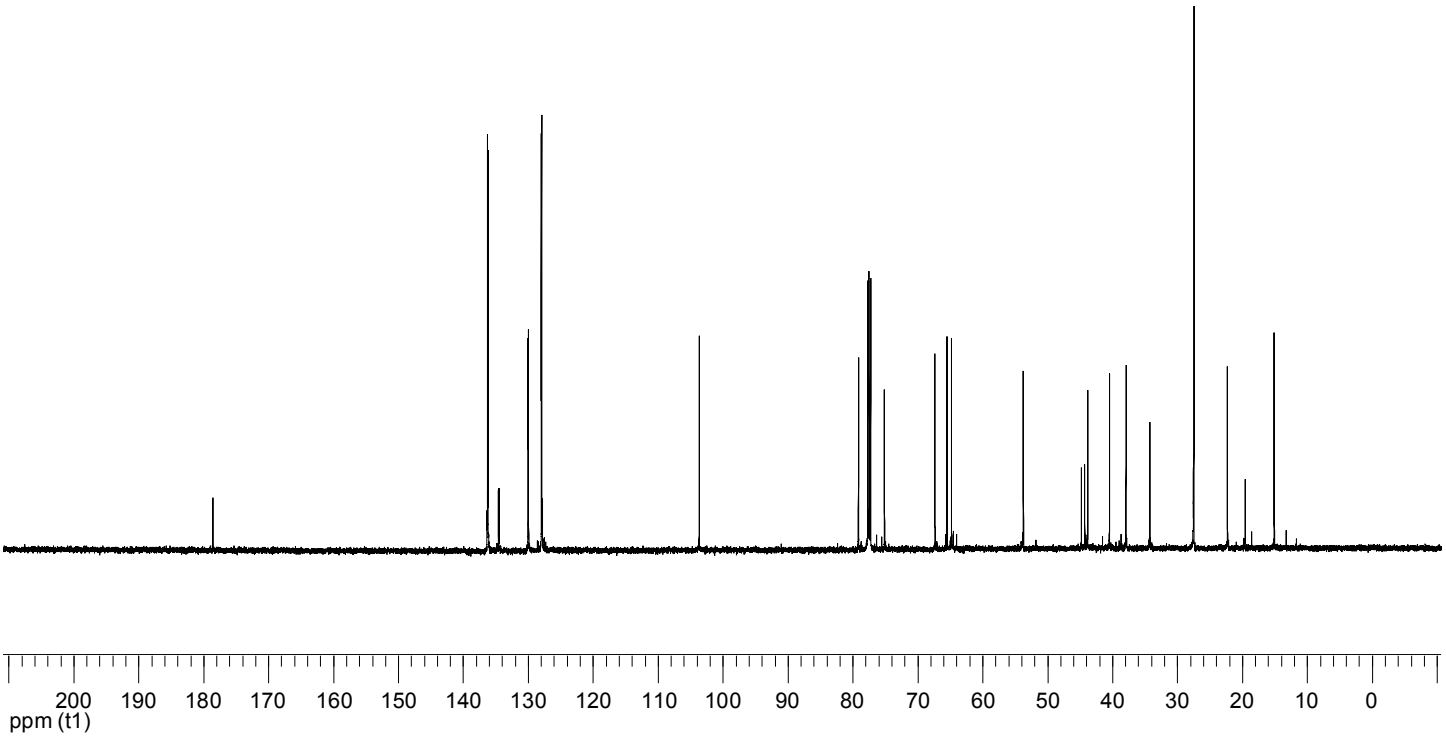


Figure S14: COSY (600 MHz, $CDCl_3$) of **12**.

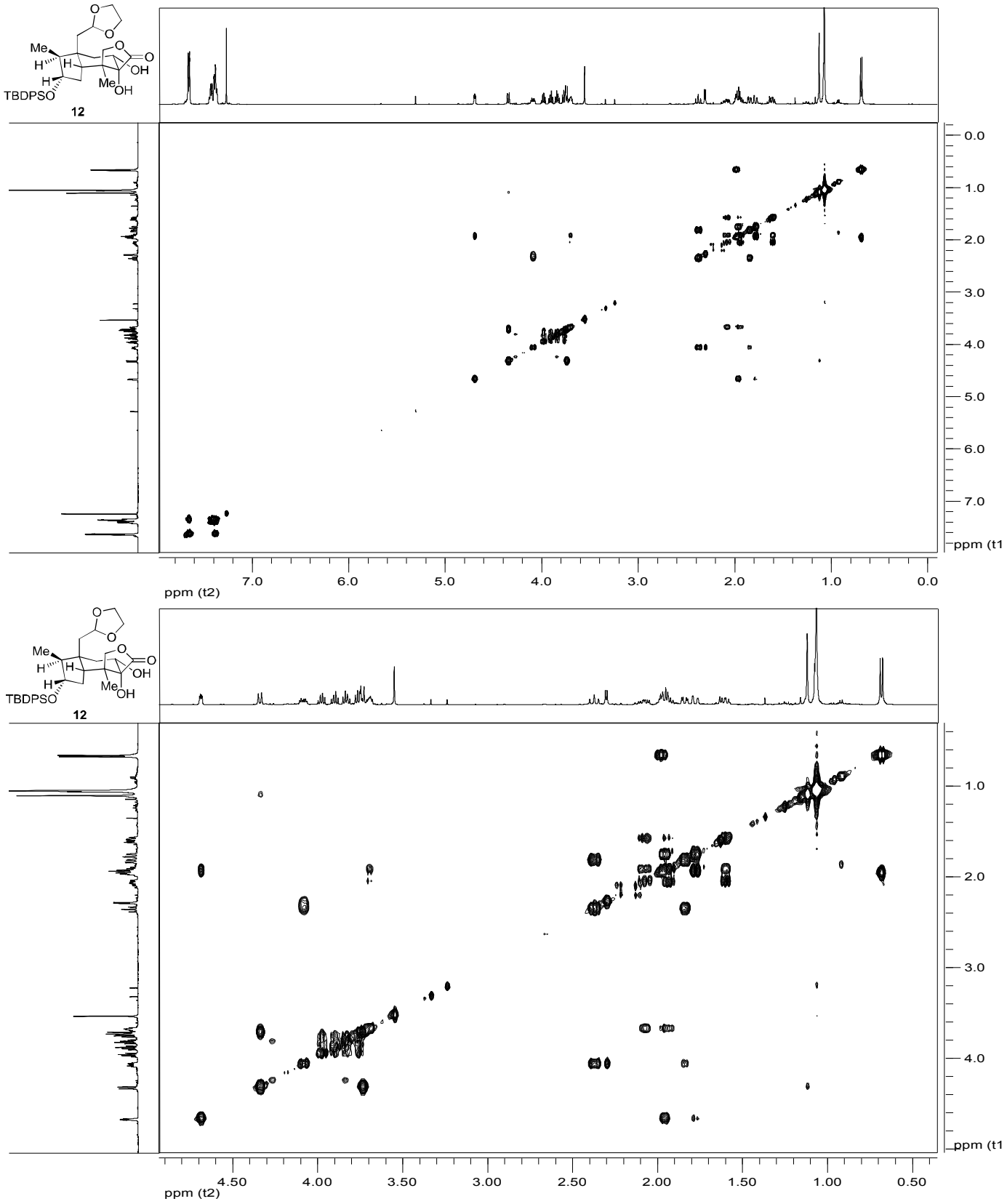


Figure S15: HMQC (600 MHz and 150 MHz, $CDCl_3$) of **12**.

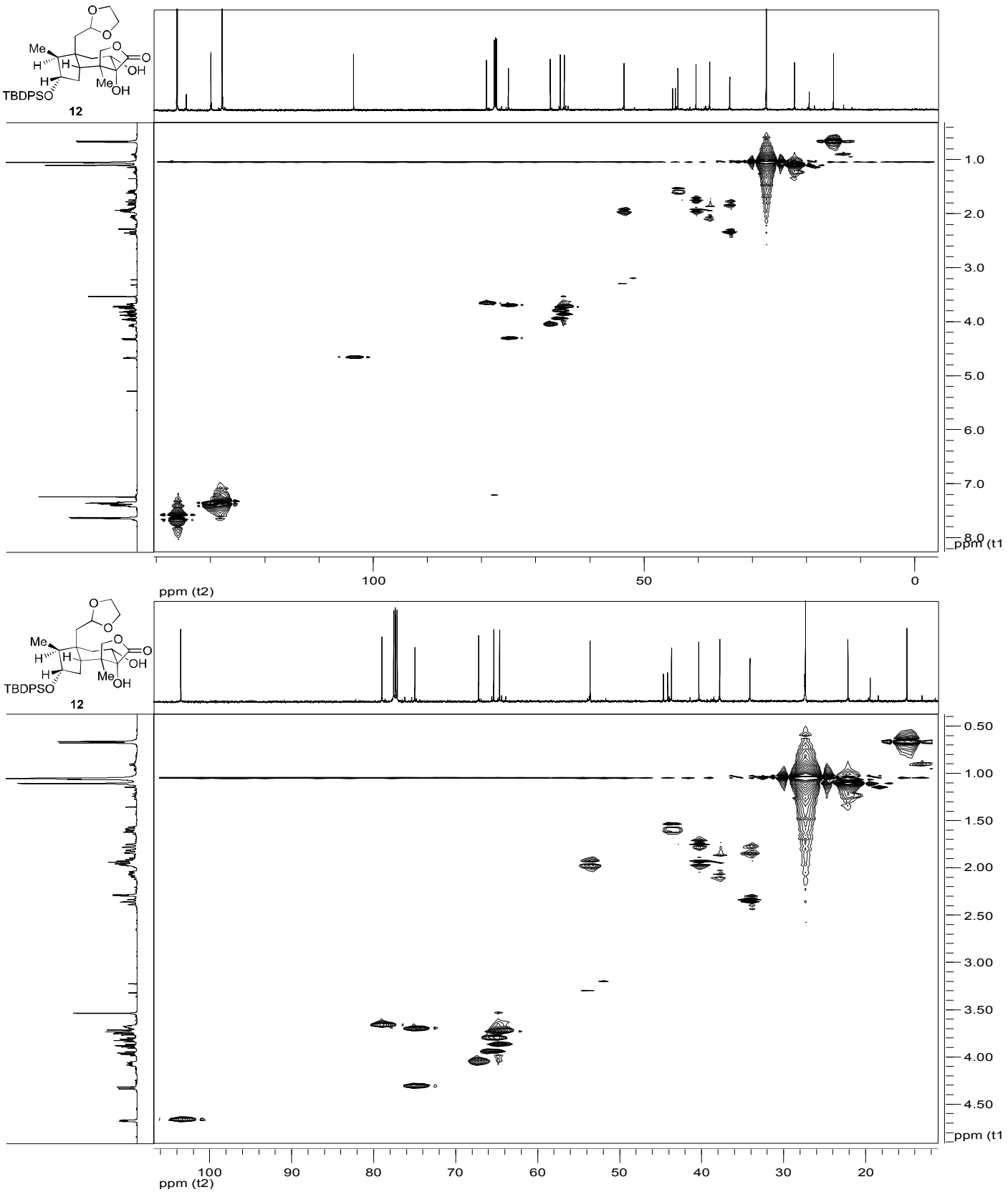


Figure S16: TOCSY (600 MHz, $CDCl_3$) of **12**.

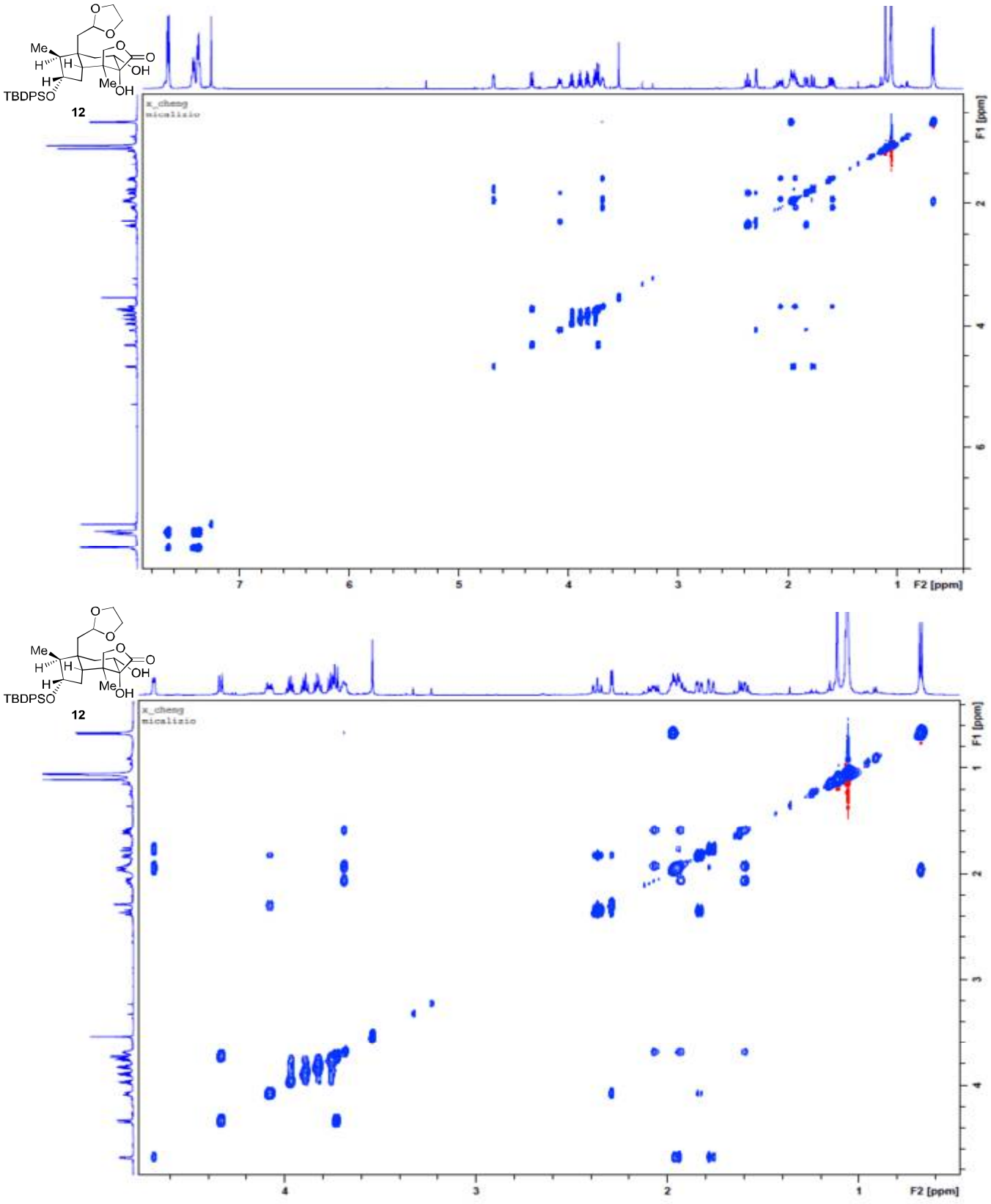


Figure S17: NOESY (600 MHz, $CDCl_3$) of **12**.

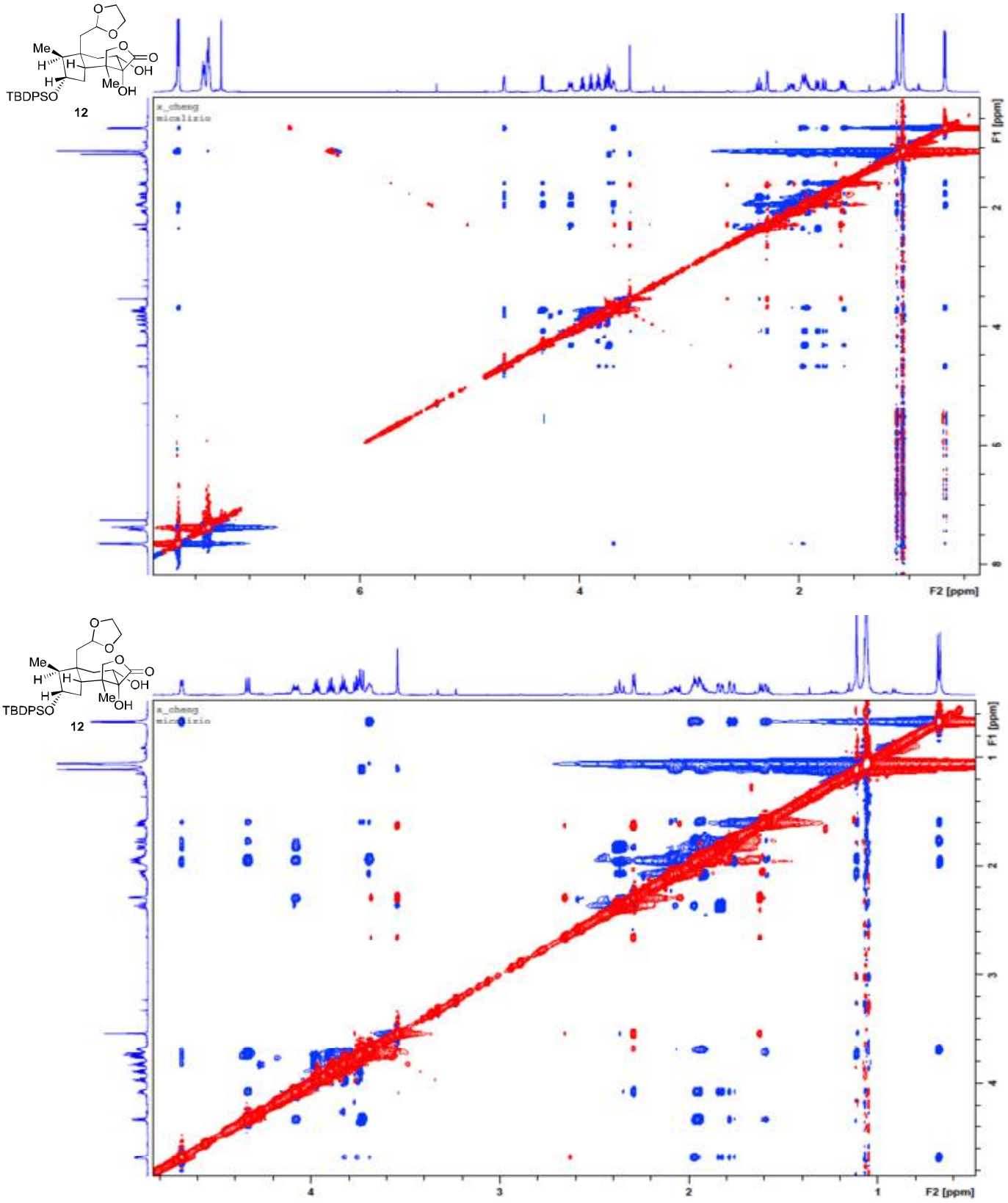


Figure S18: HMBC (600 MHz and 150 MHz, $CDCl_3$) of **12**.

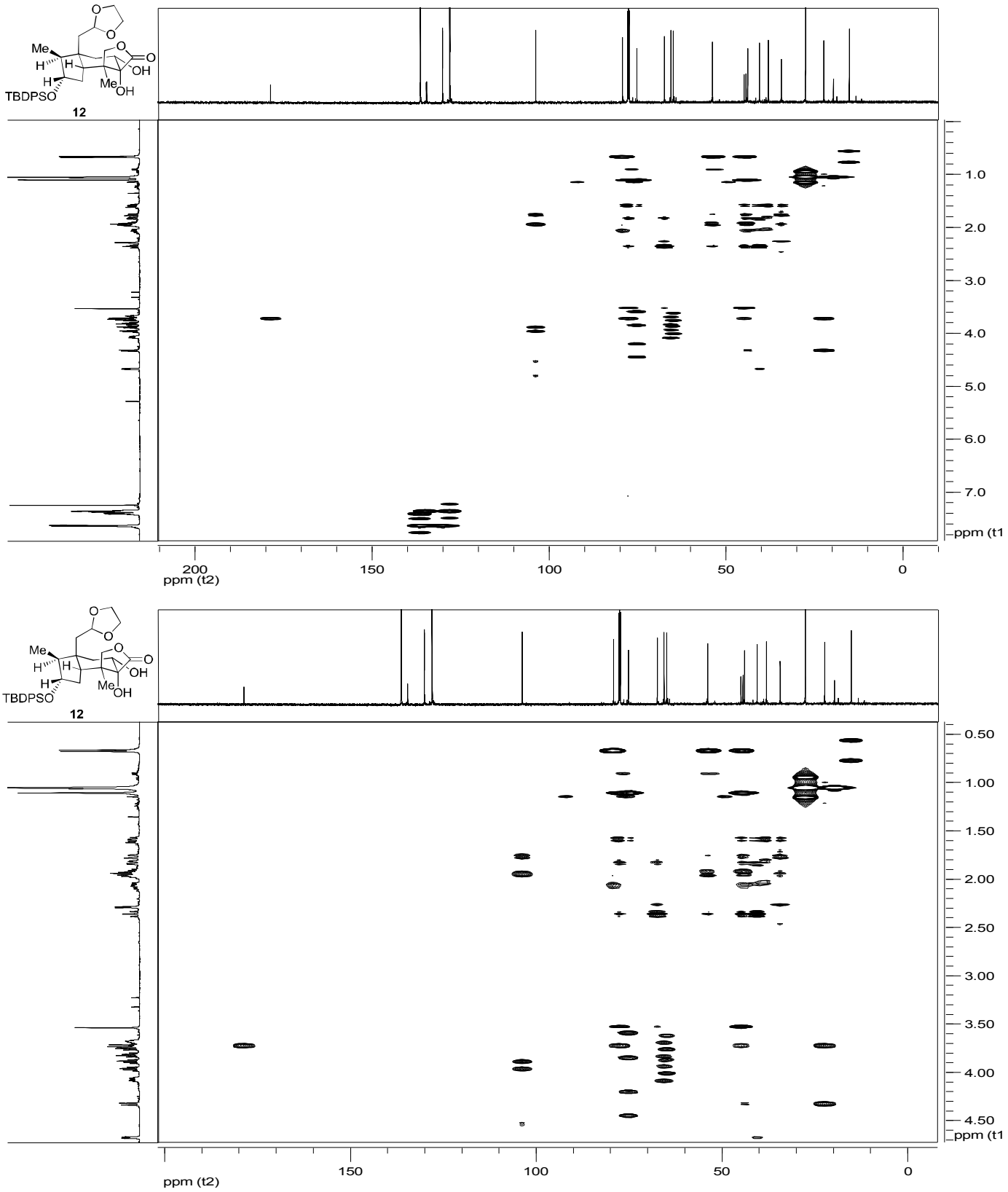


Figure S19: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **13** (contaminated with a small amount of **S11**).

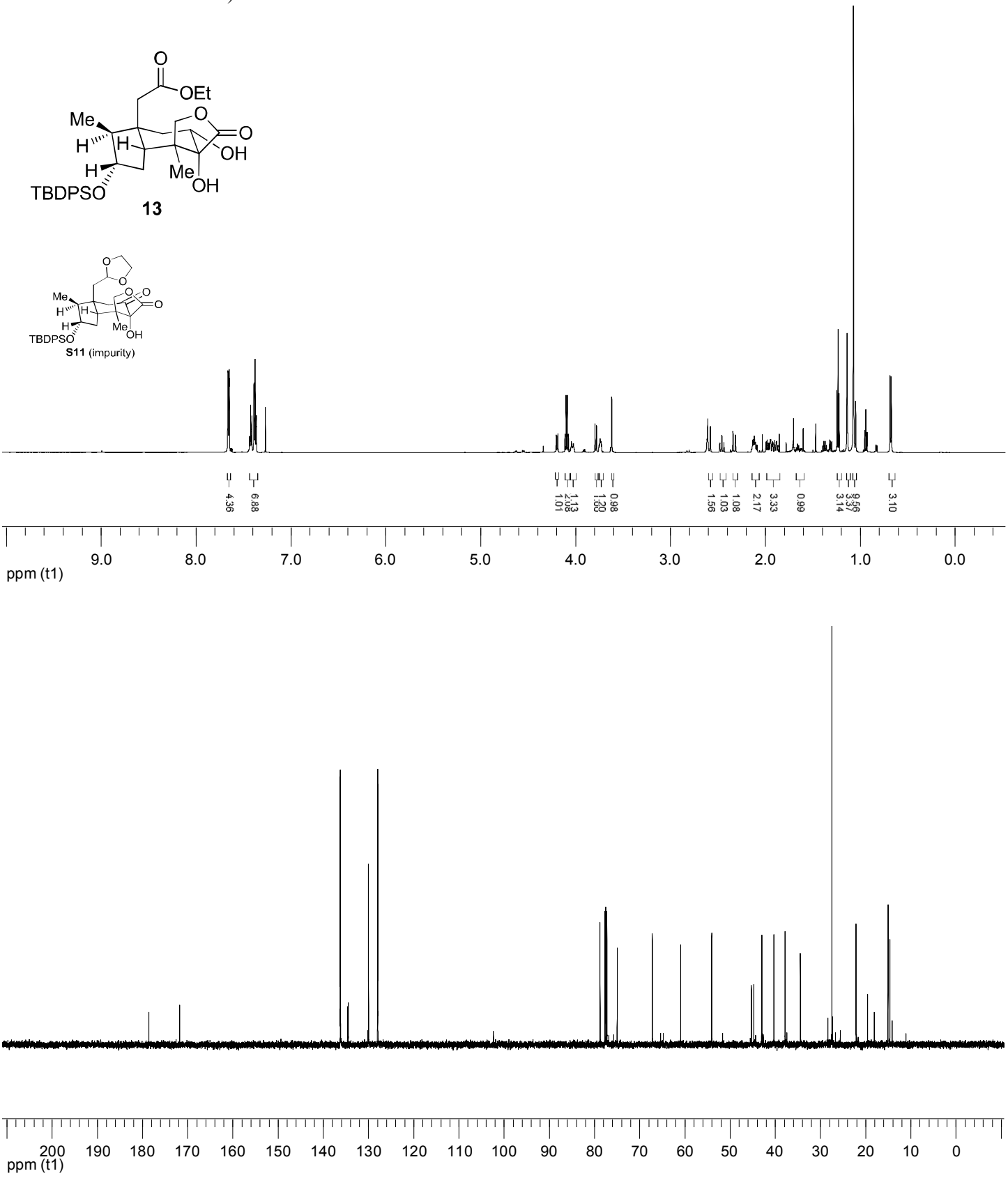


Figure S20: COSY (600 MHz, $CDCl_3$) of **13**.

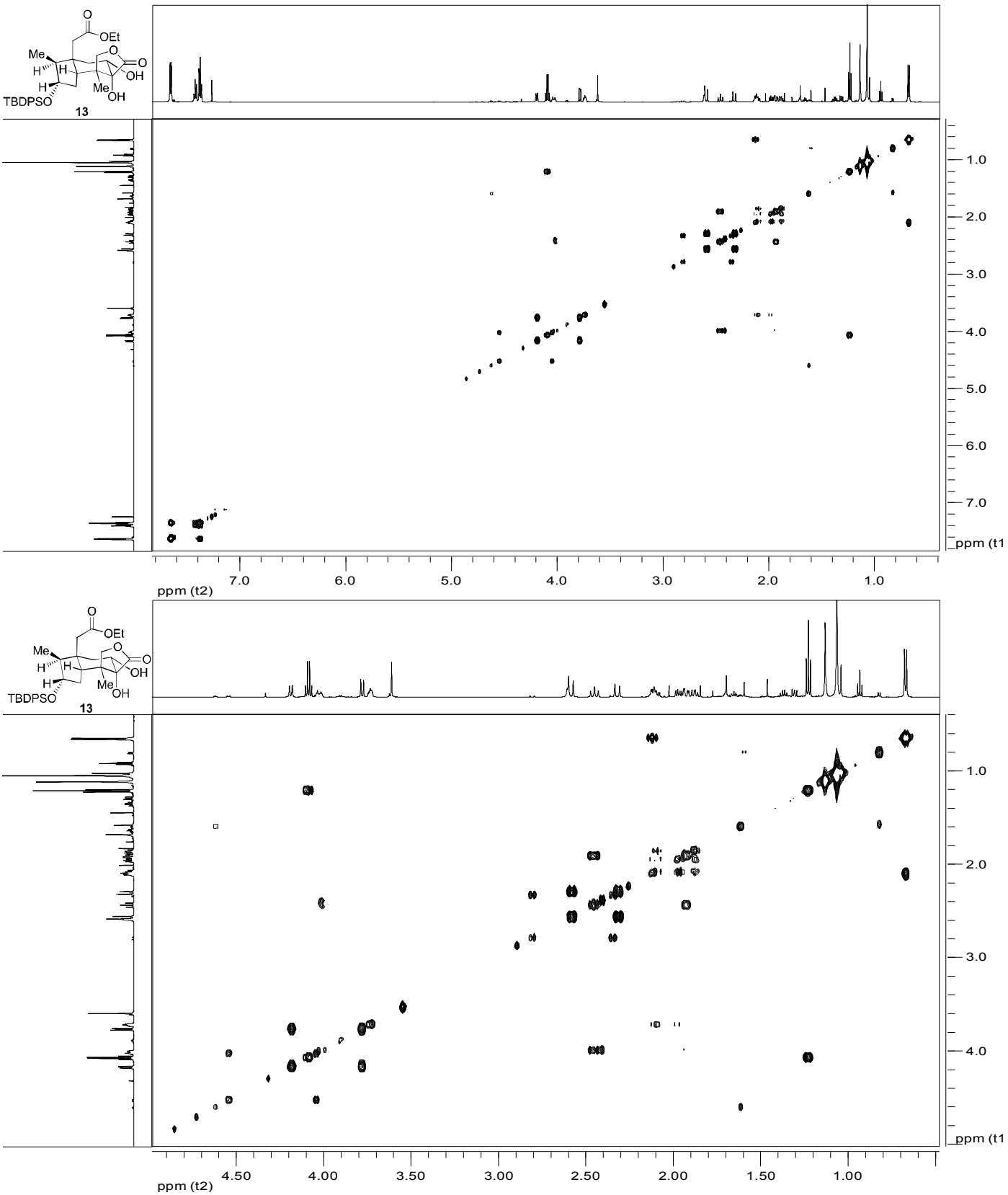


Figure S21: HMQC (600 MHz and 150 MHz, $CDCl_3$) of **13**.

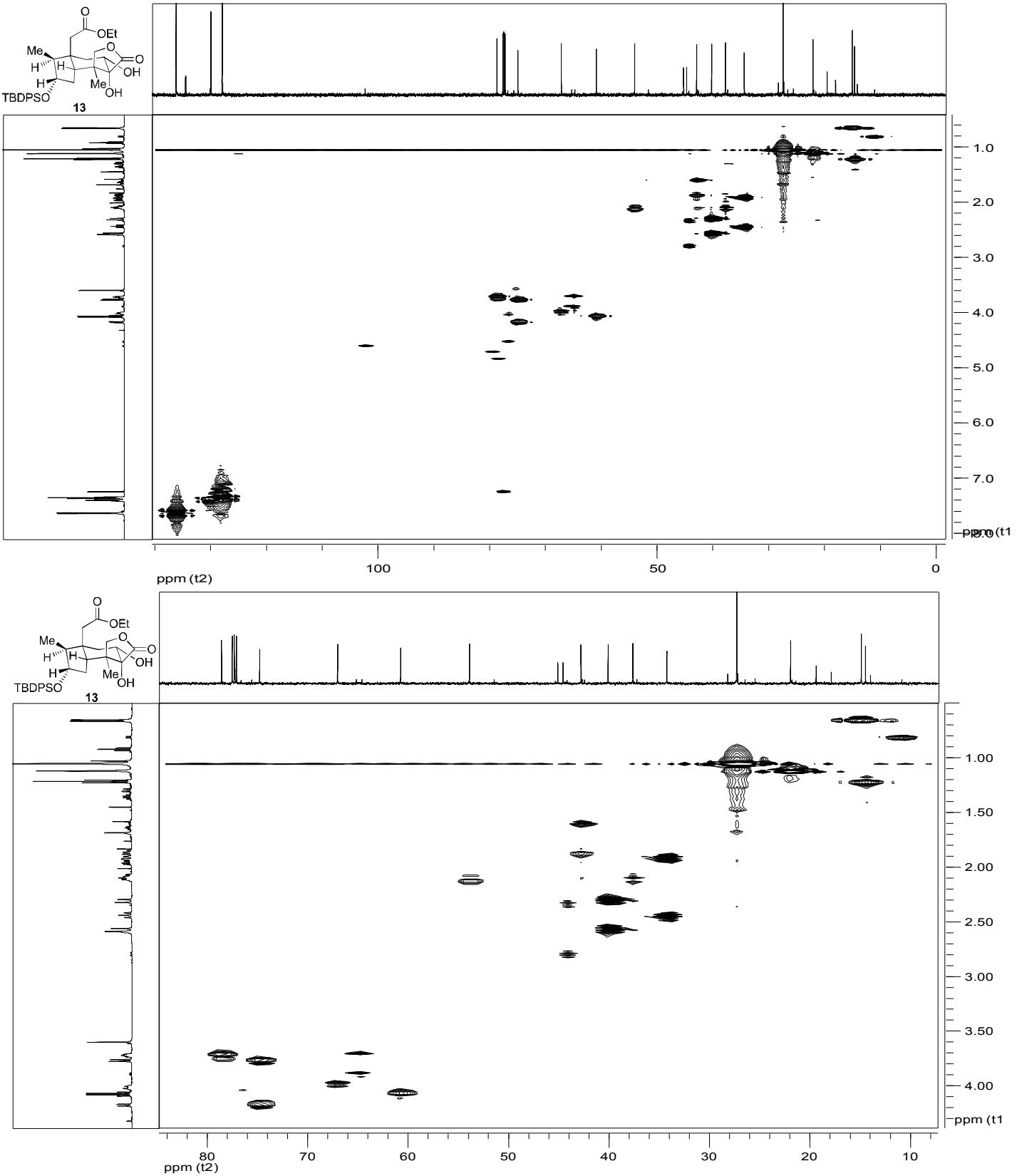


Figure S22: TOCSY (600 MHz, $CDCl_3$) of **13**.

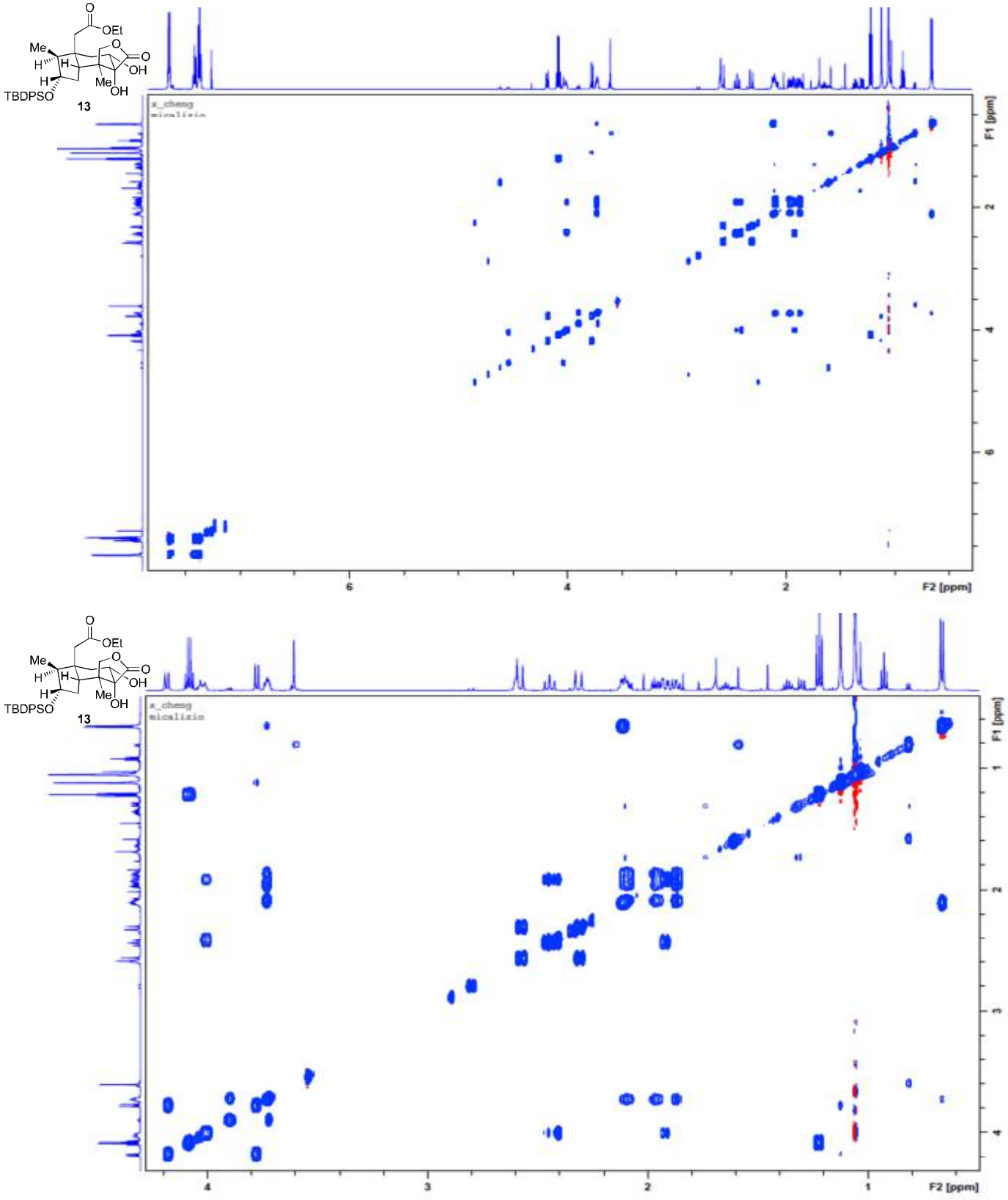


Figure S23: NOESY (600 MHz, $CDCl_3$) of **13**.

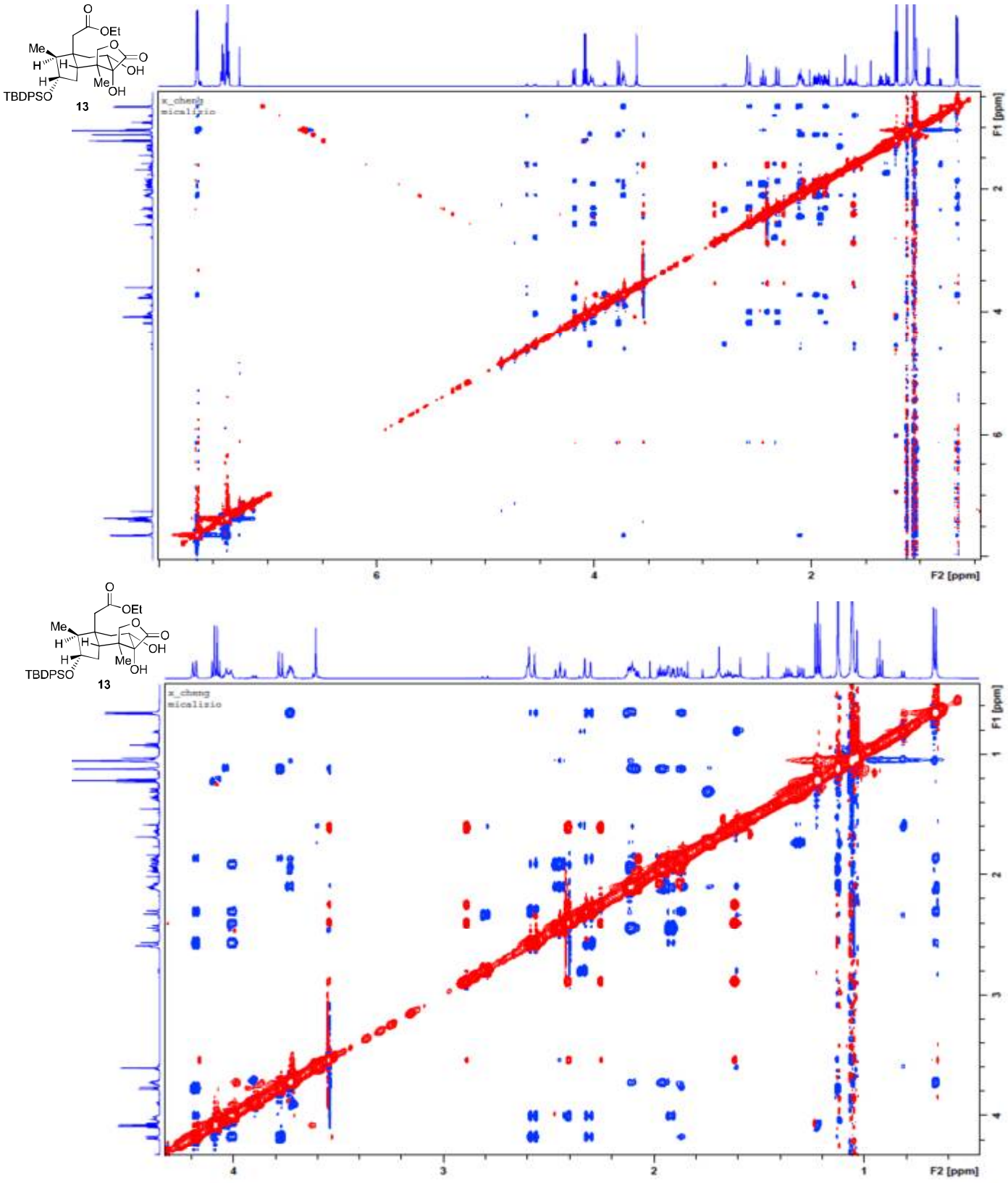
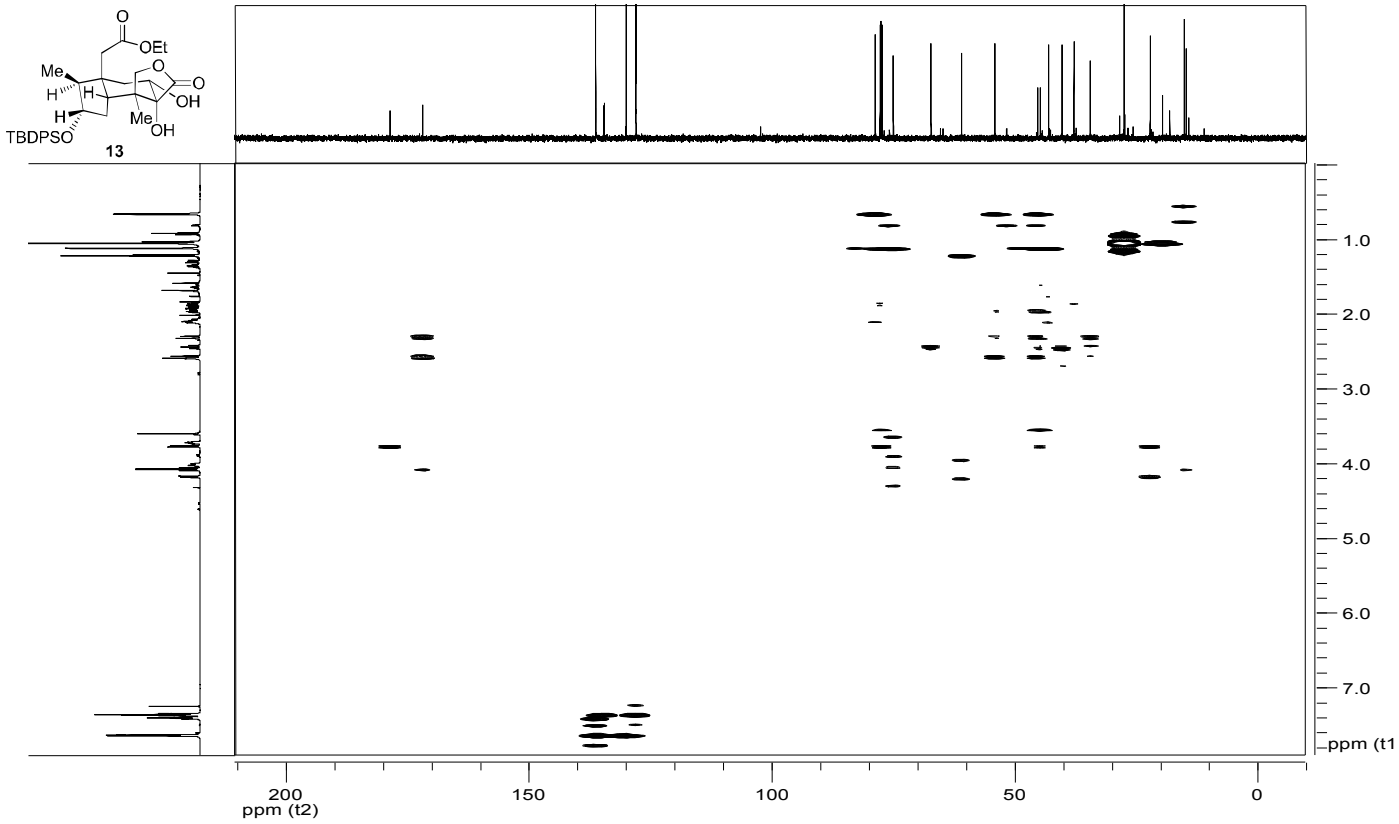


Figure S24: HMBC (600 MHz and 150MHz, $CDCl_3$) of **13.**



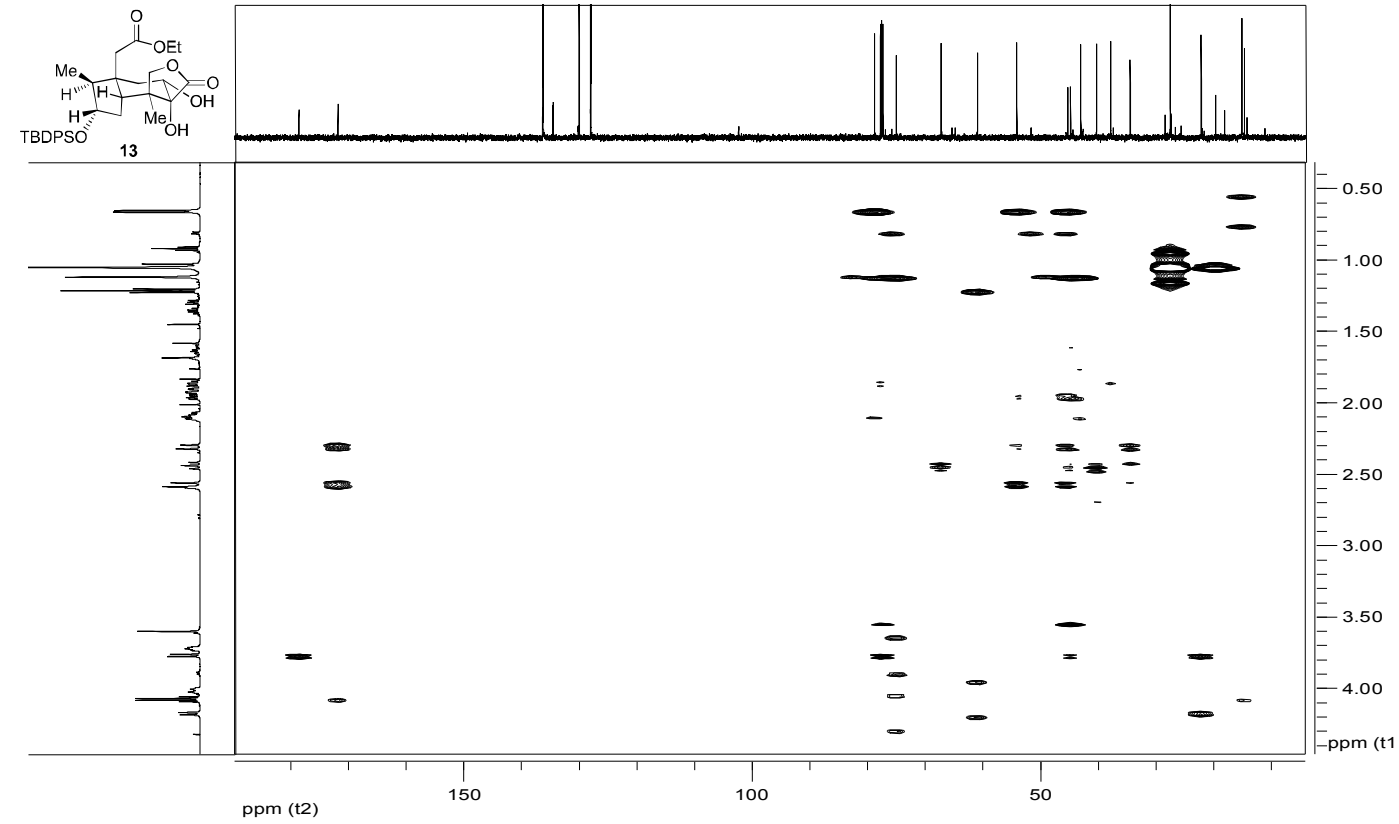


Figure S25: ^{1}H NMR (600 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S8**.

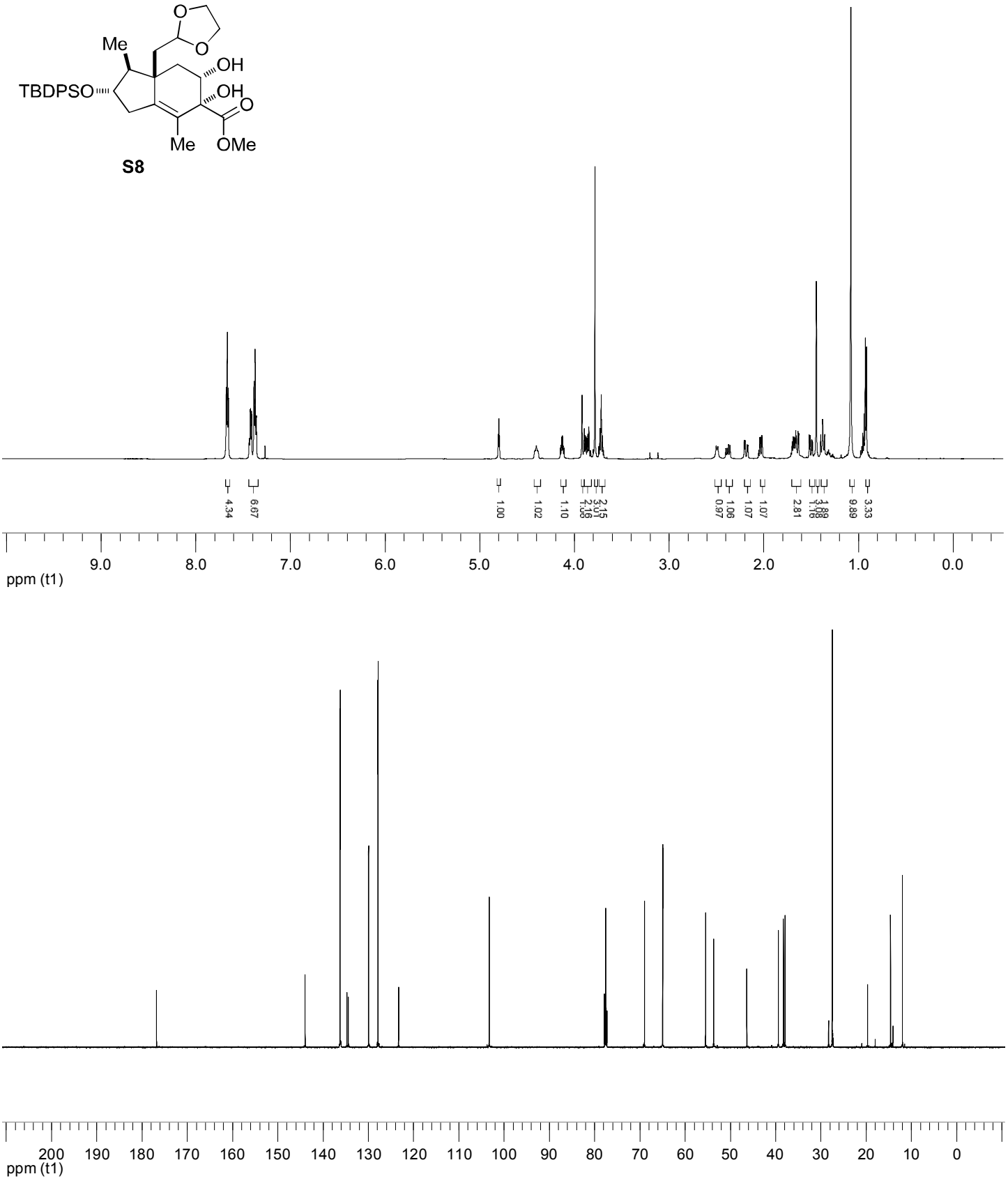


Figure S26: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **12D**.

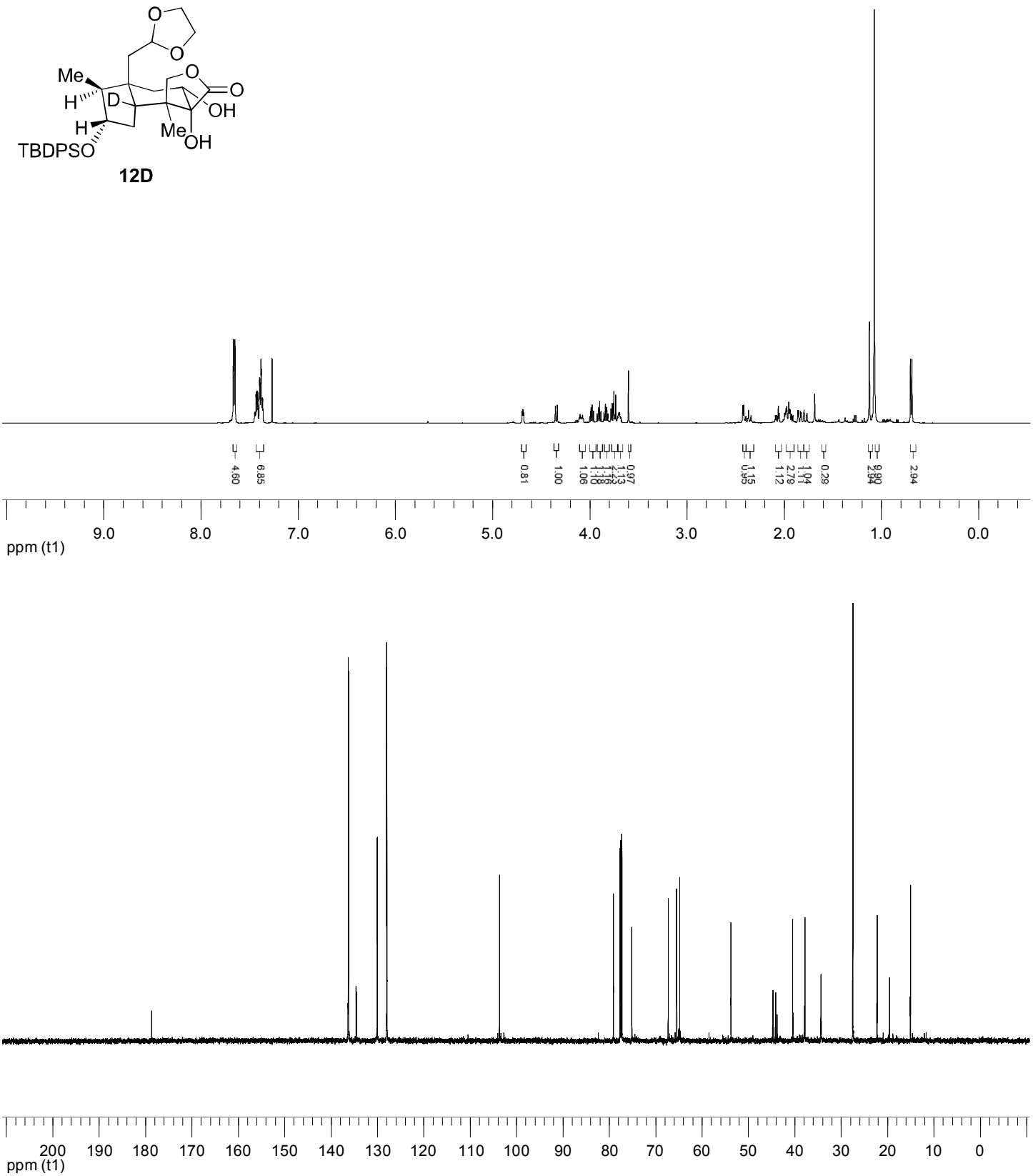
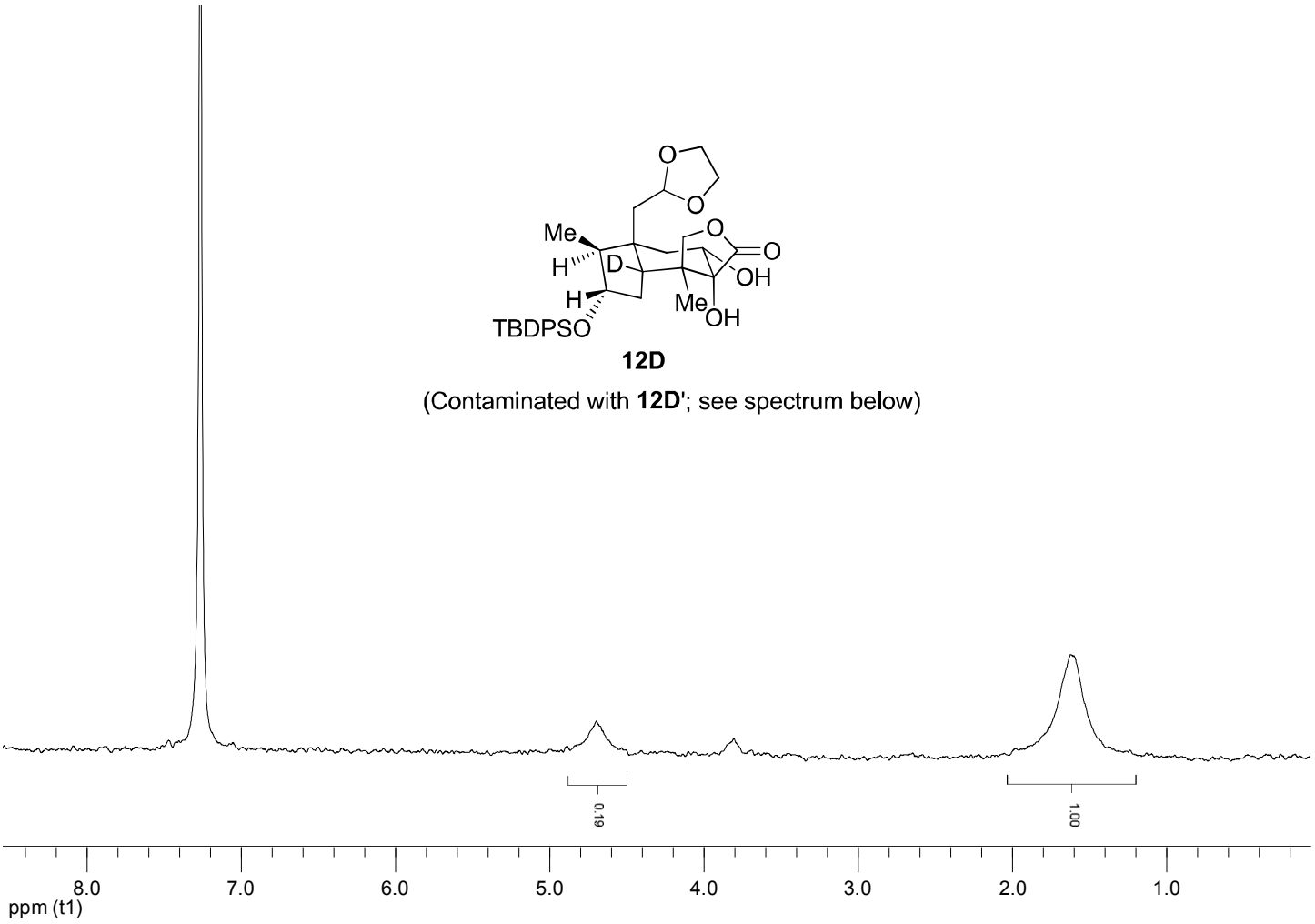


Figure S27: ^{2}H NMR (77 MHz, $CHCl_3$) of **12D**.



12D

(Contaminated with **12D'**; see spectrum below)

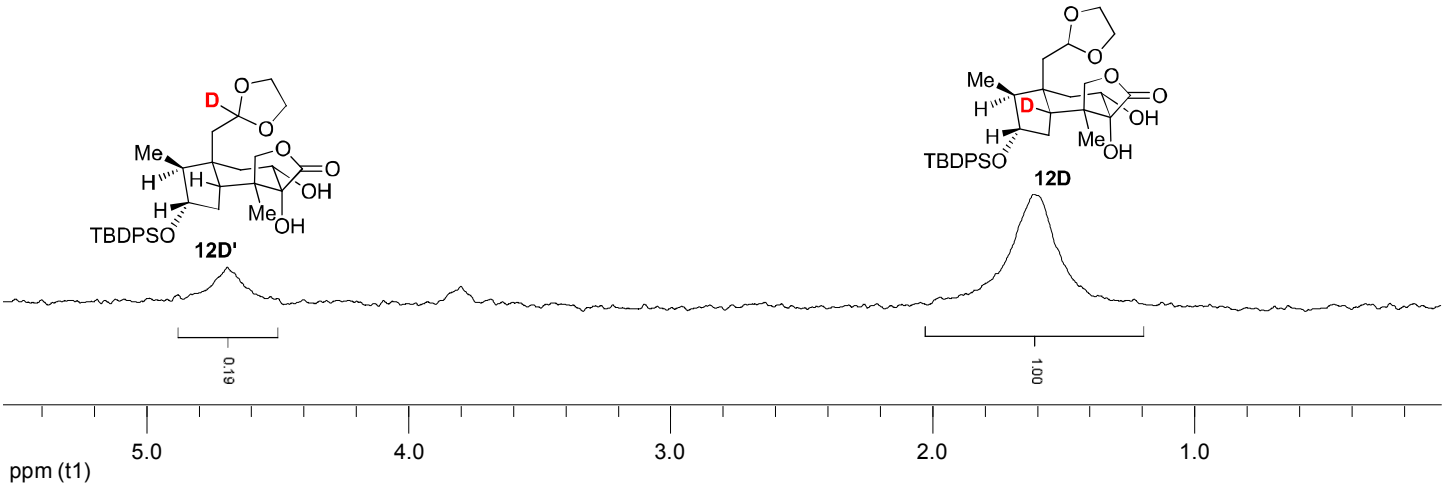


Figure S28: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of 1**3D**.

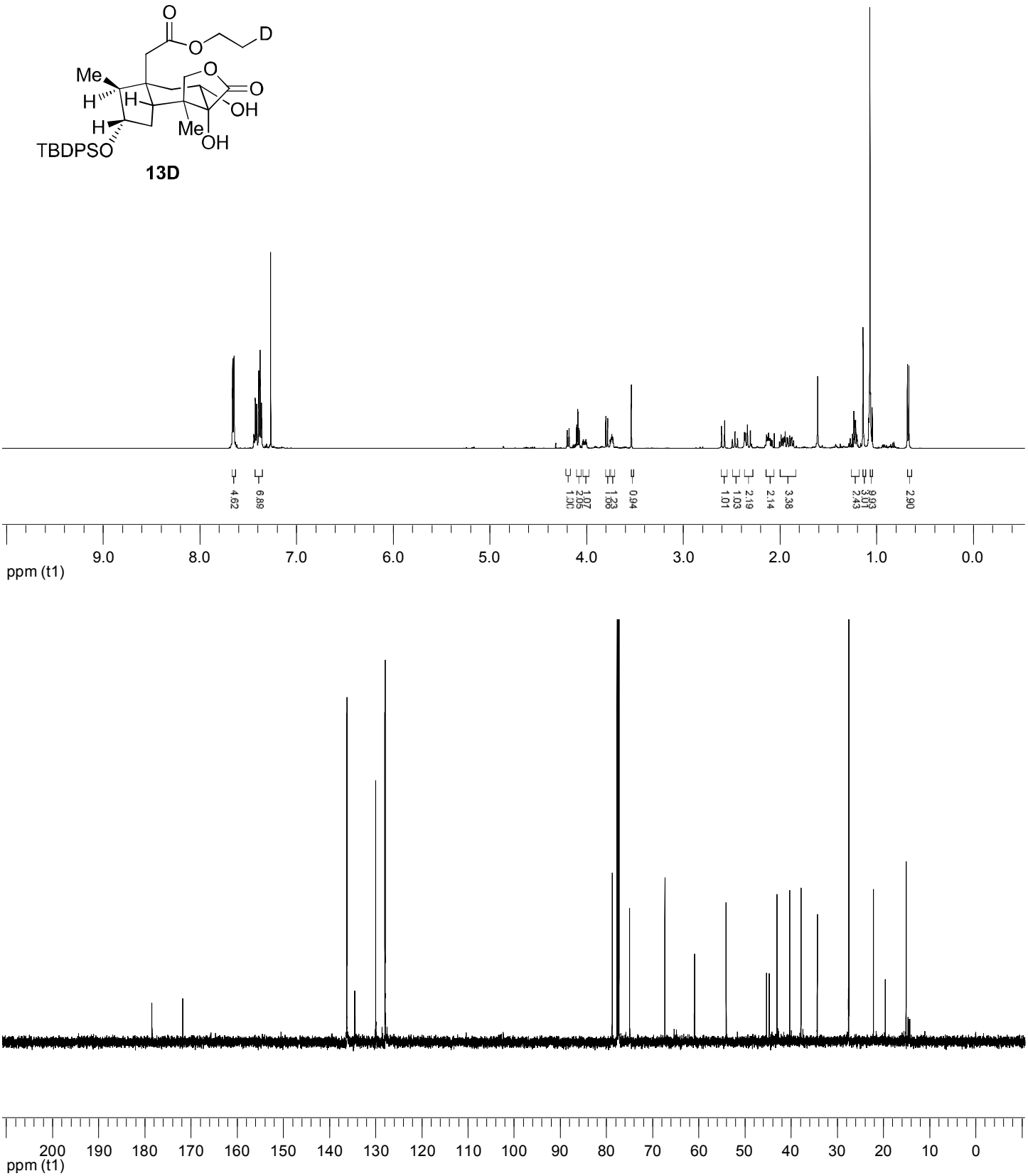


Figure S29: ^{2}H NMR (77 MHz, $CHCl_3$) of **13D**.

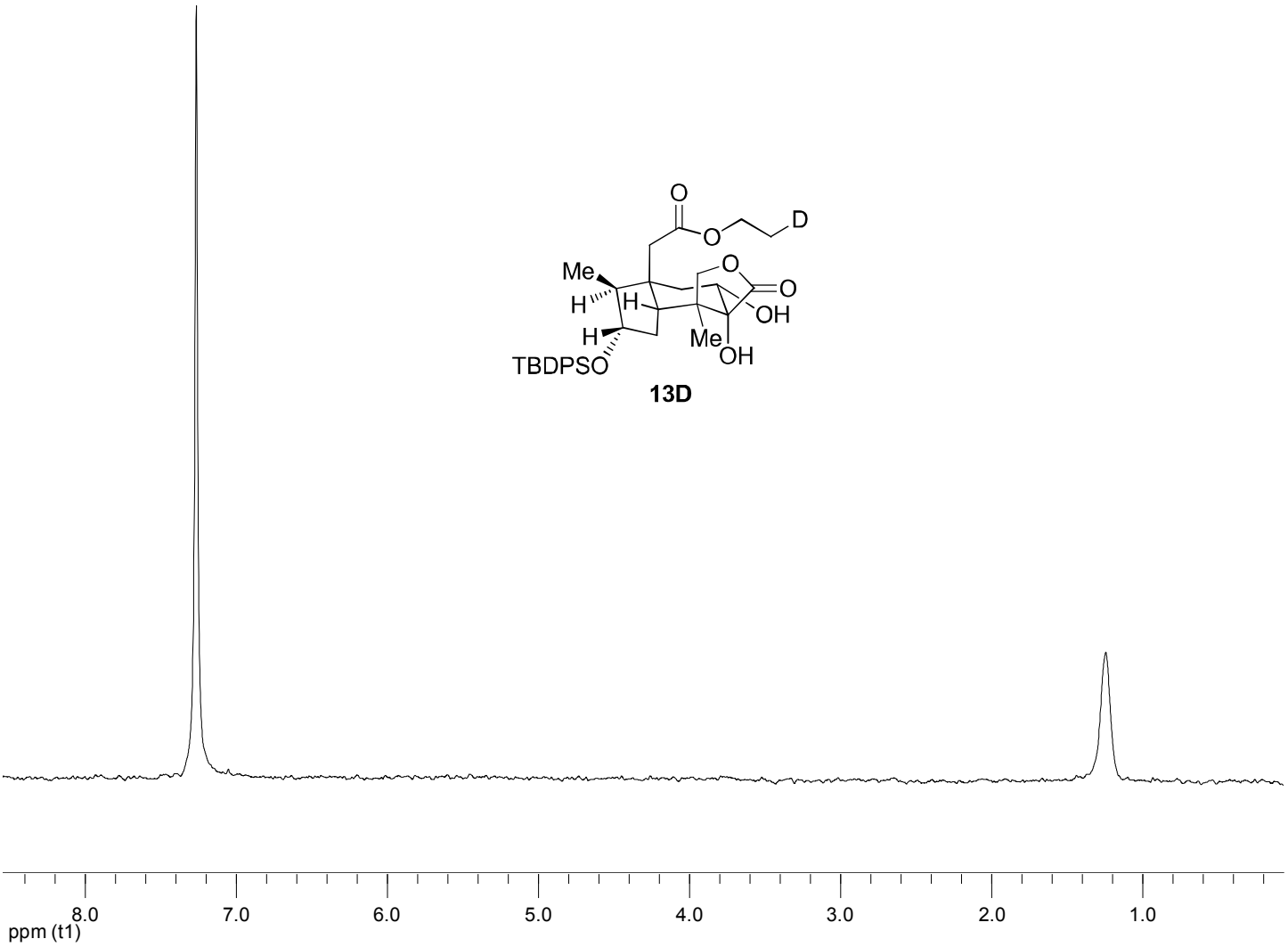


Figure S30: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S8D**.

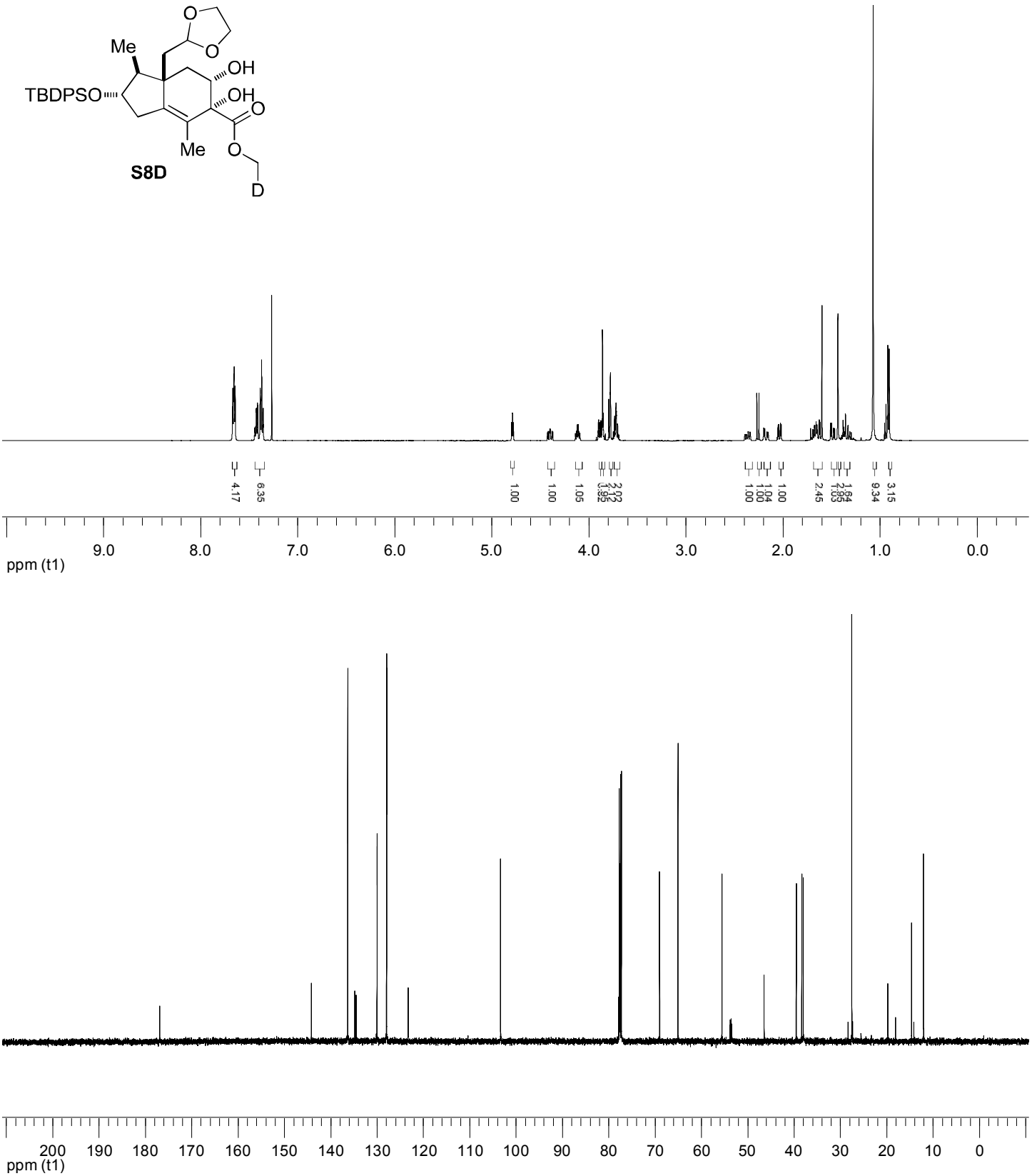


Figure S31: ^{2}H NMR (77 MHz, $CHCl_3$) of **S8D**.

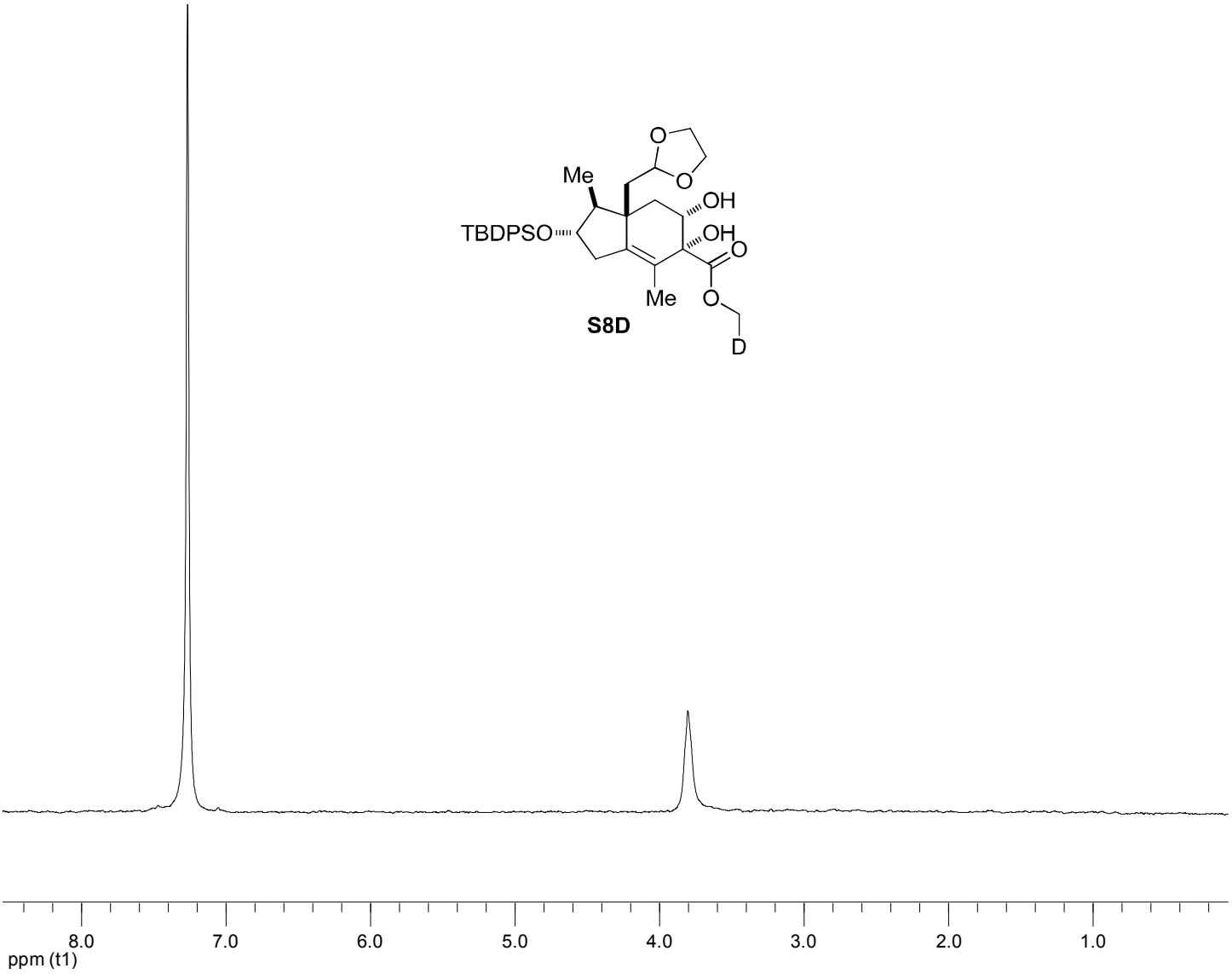
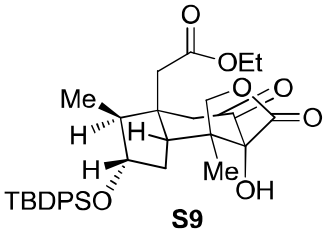


Figure S32: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S9**.



S9

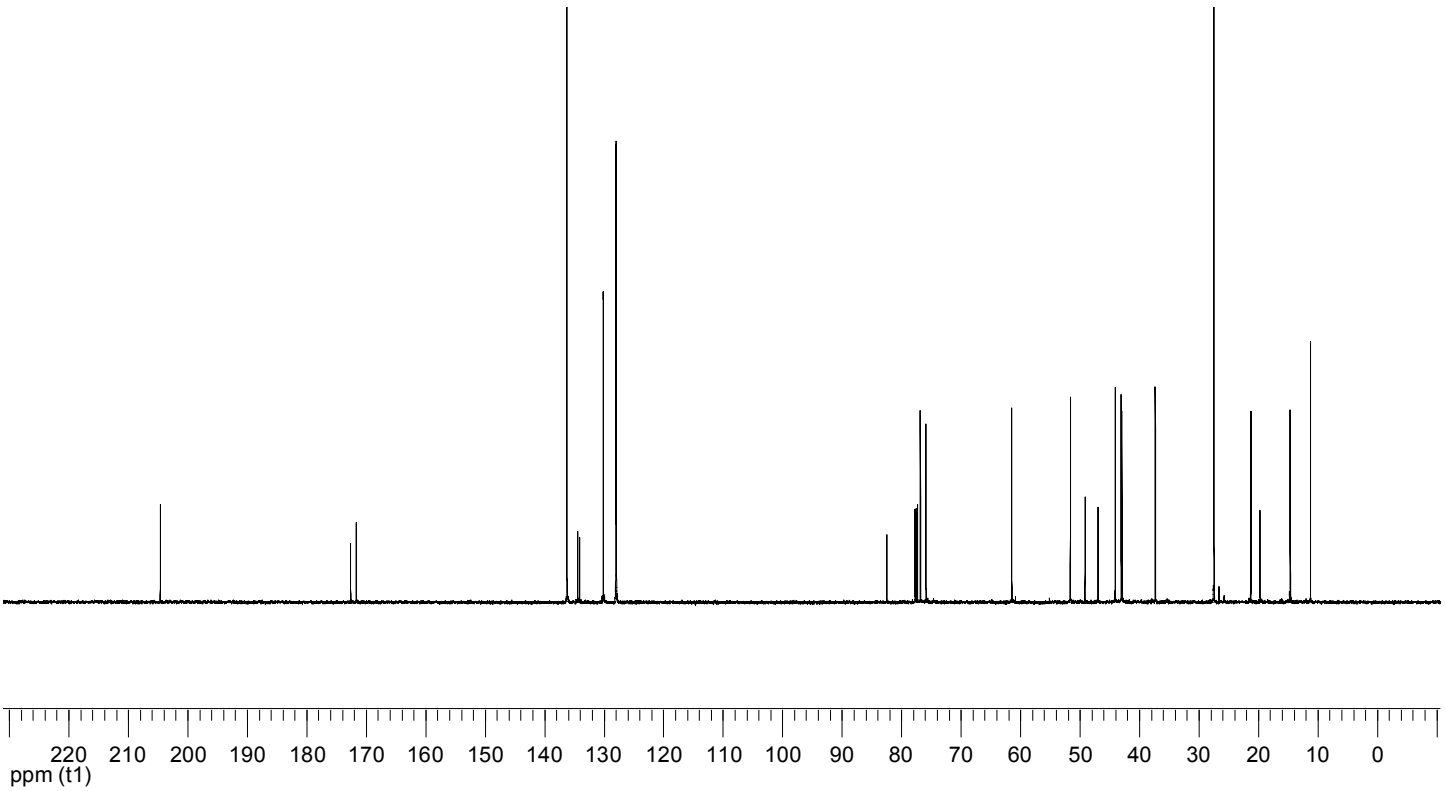


Figure S33: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S10**.

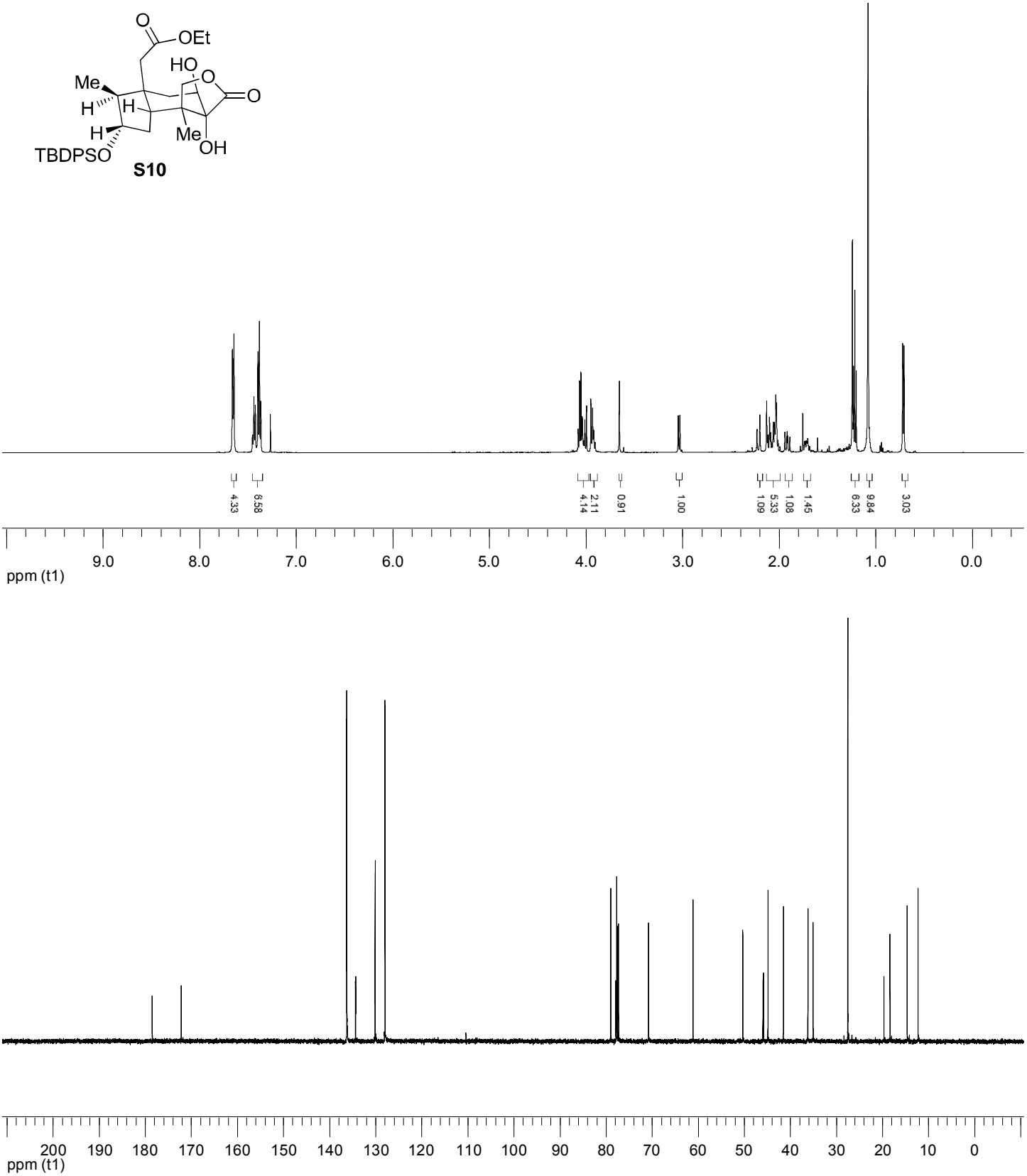


Figure S34: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S11**.

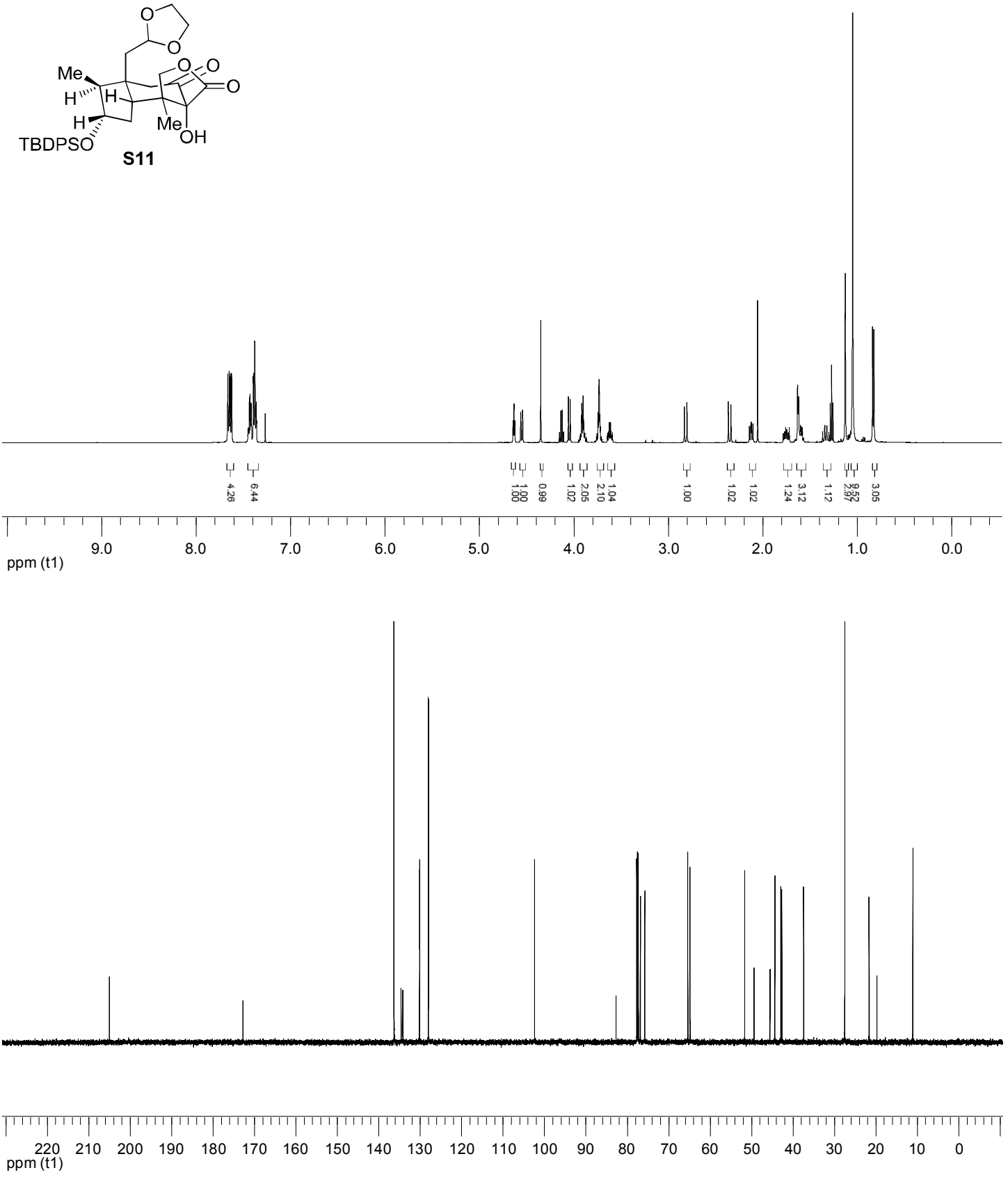
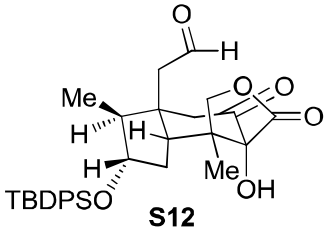


Figure S35: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S12**.



S12

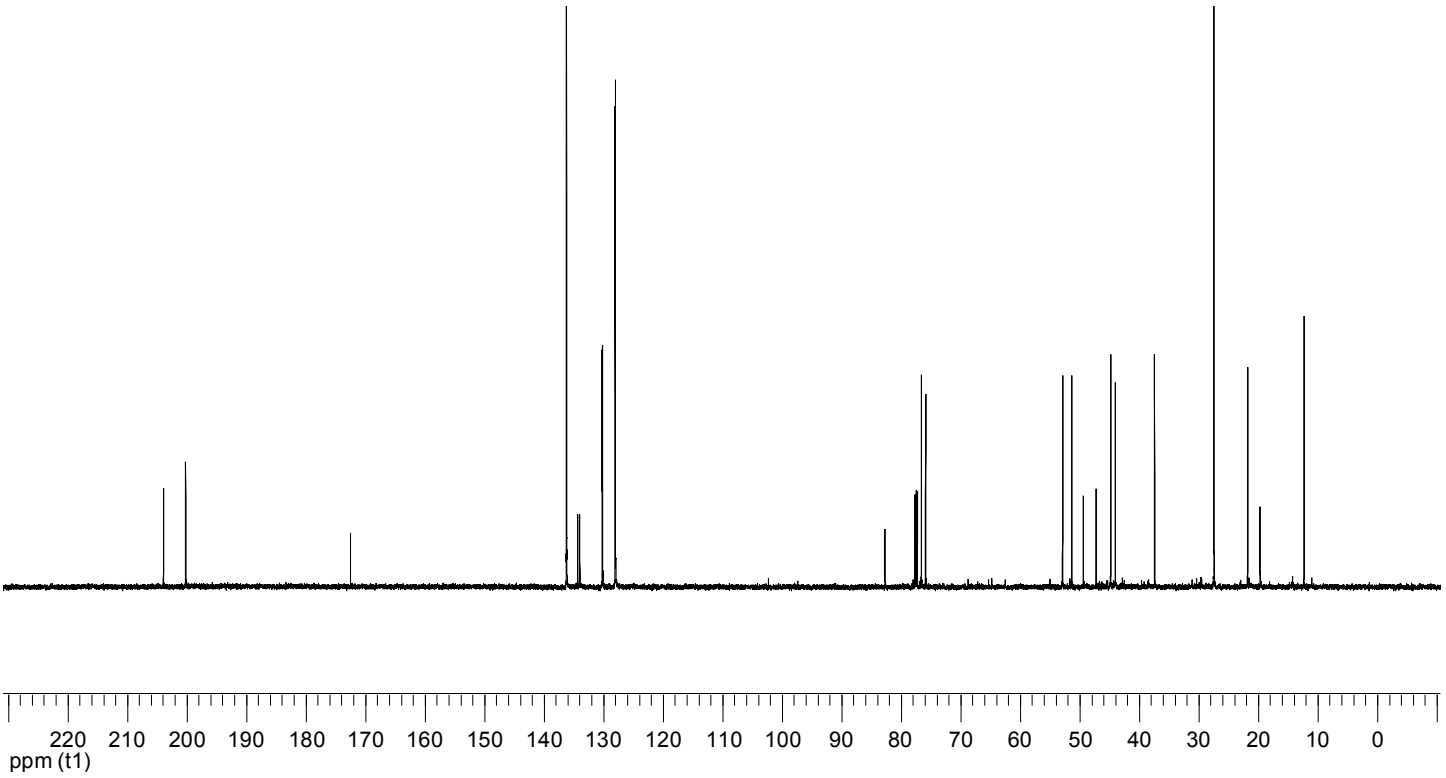
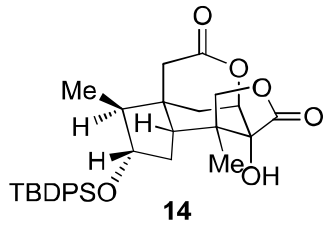


Figure S36: ^{1}H NMR (600 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **14**.



14

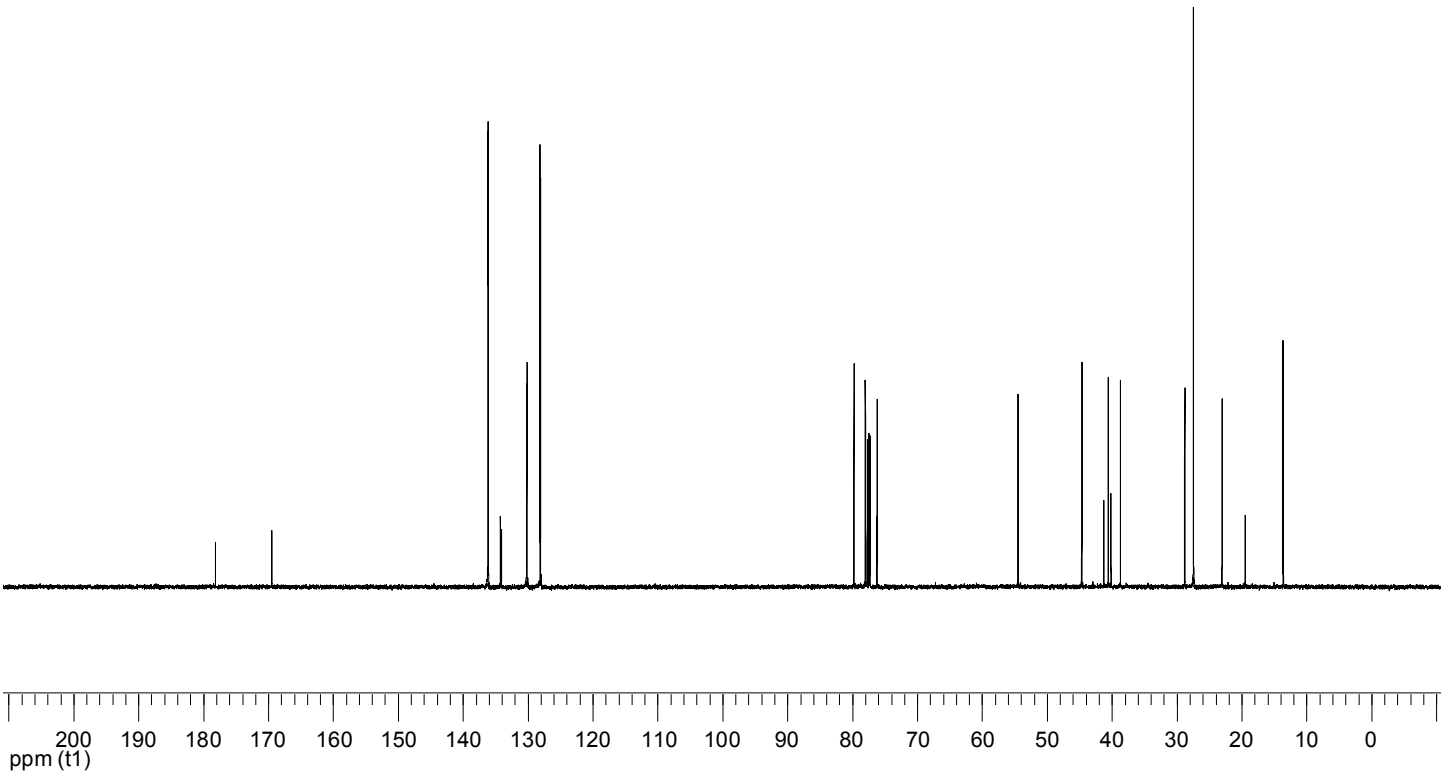


Figure S37: COSY (600 MHz, $CDCl_3$) of **14**.

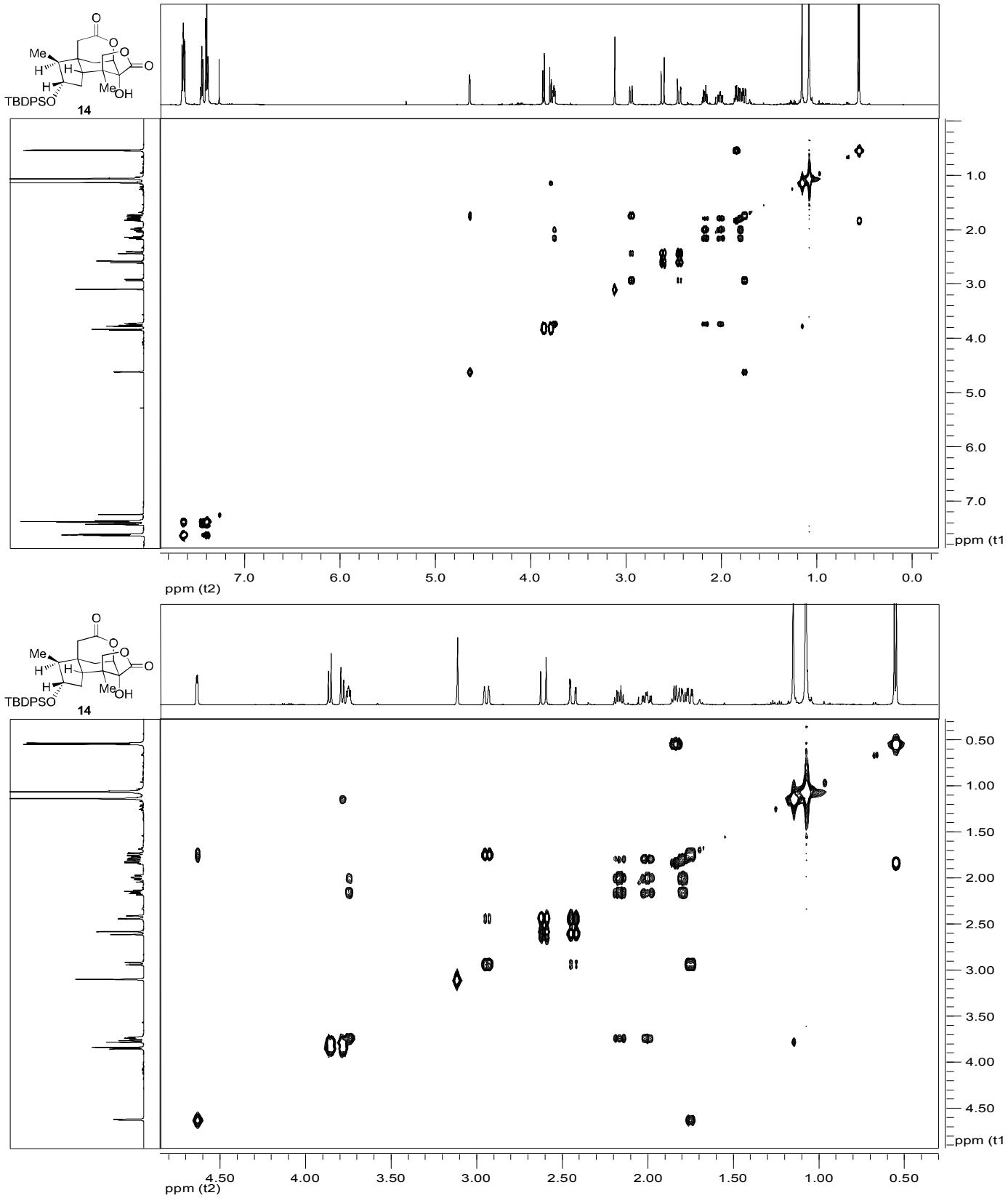


Figure S38: HMQC (600 MHz and 150 MHz, $CDCl_3$) of **14**.

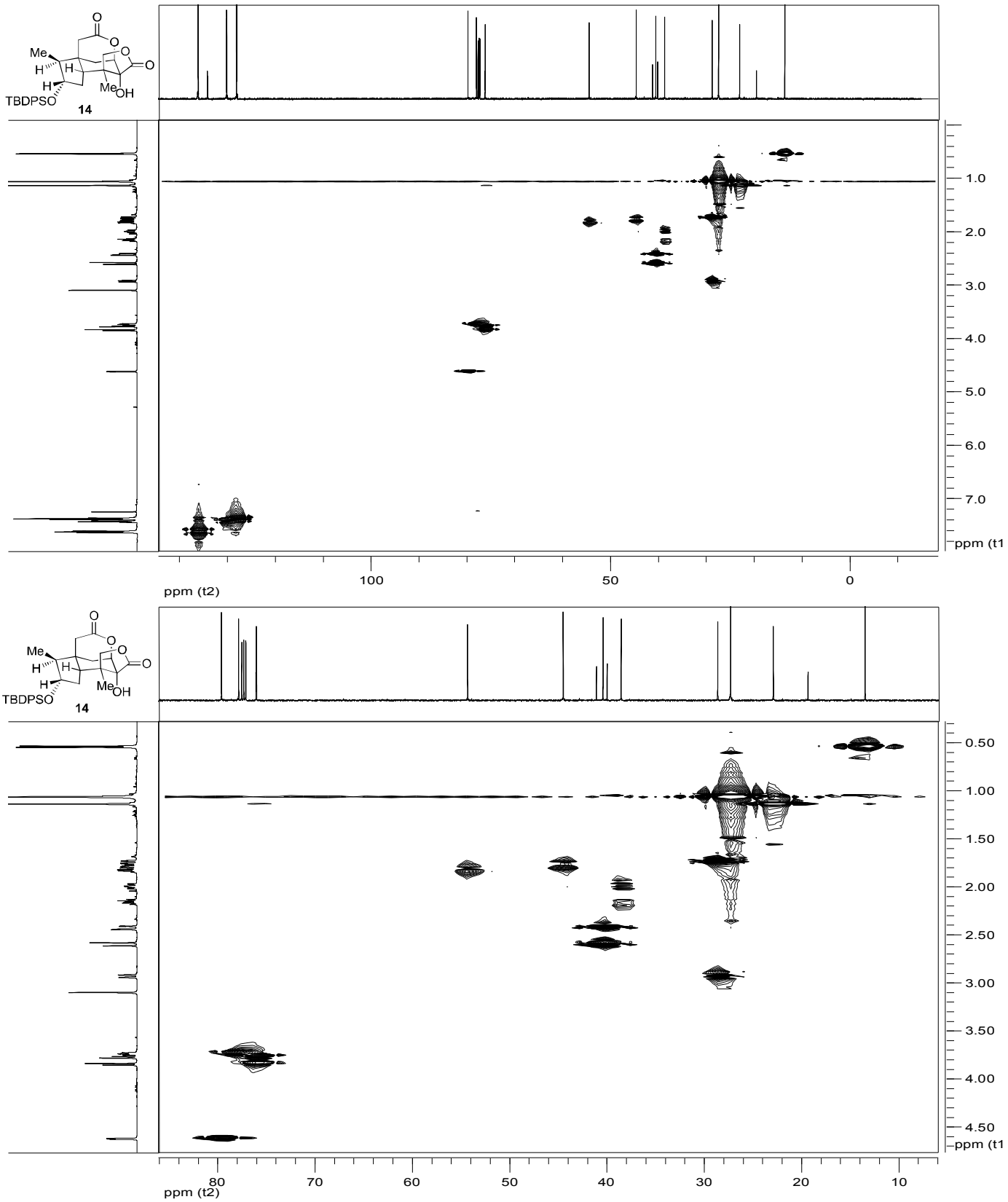


Figure S39: TOCSY (600 MHz, $CDCl_3$) of **14**.

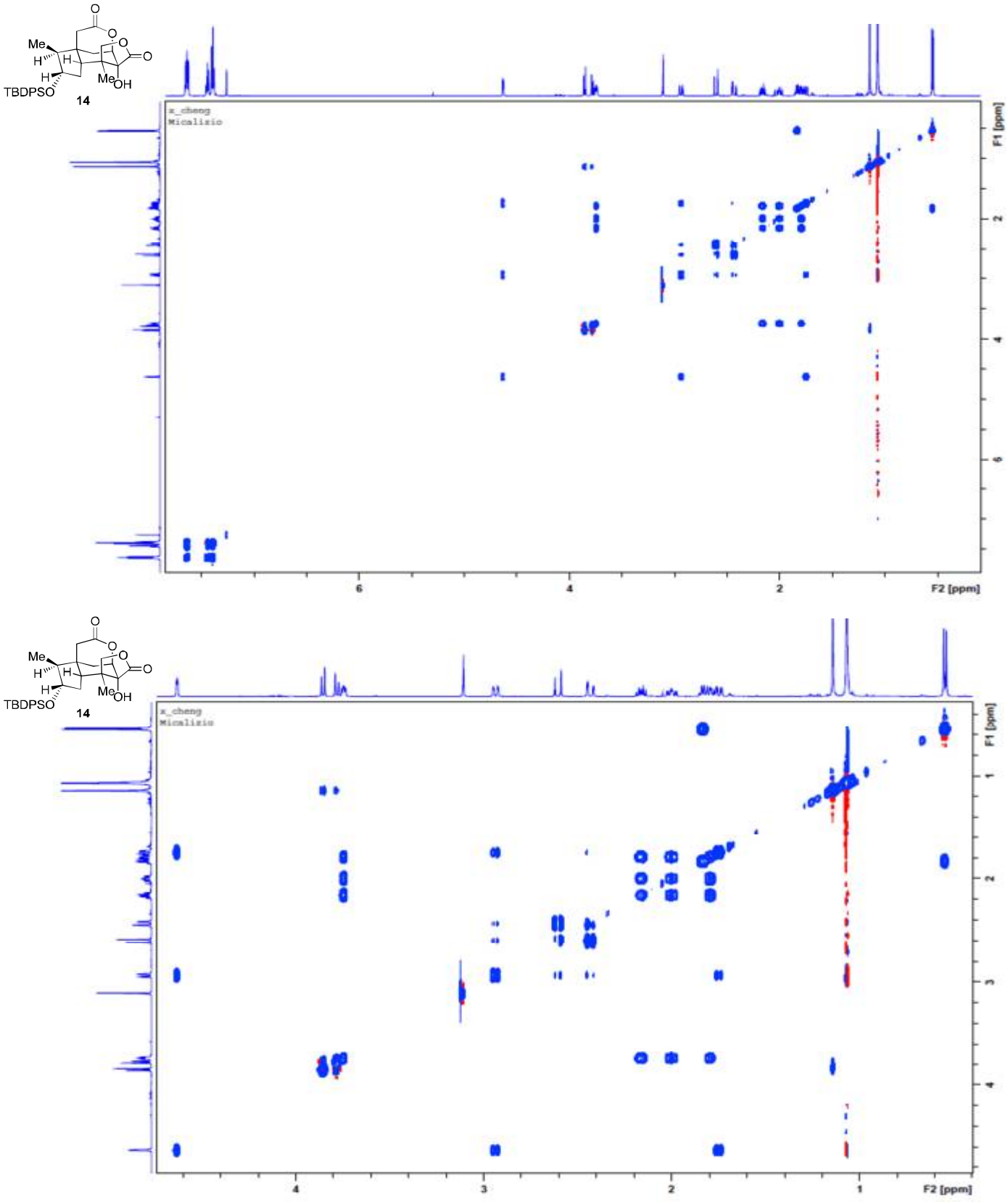


Figure S40: NOESY (600 MHz, $CDCl_3$) of **14**.

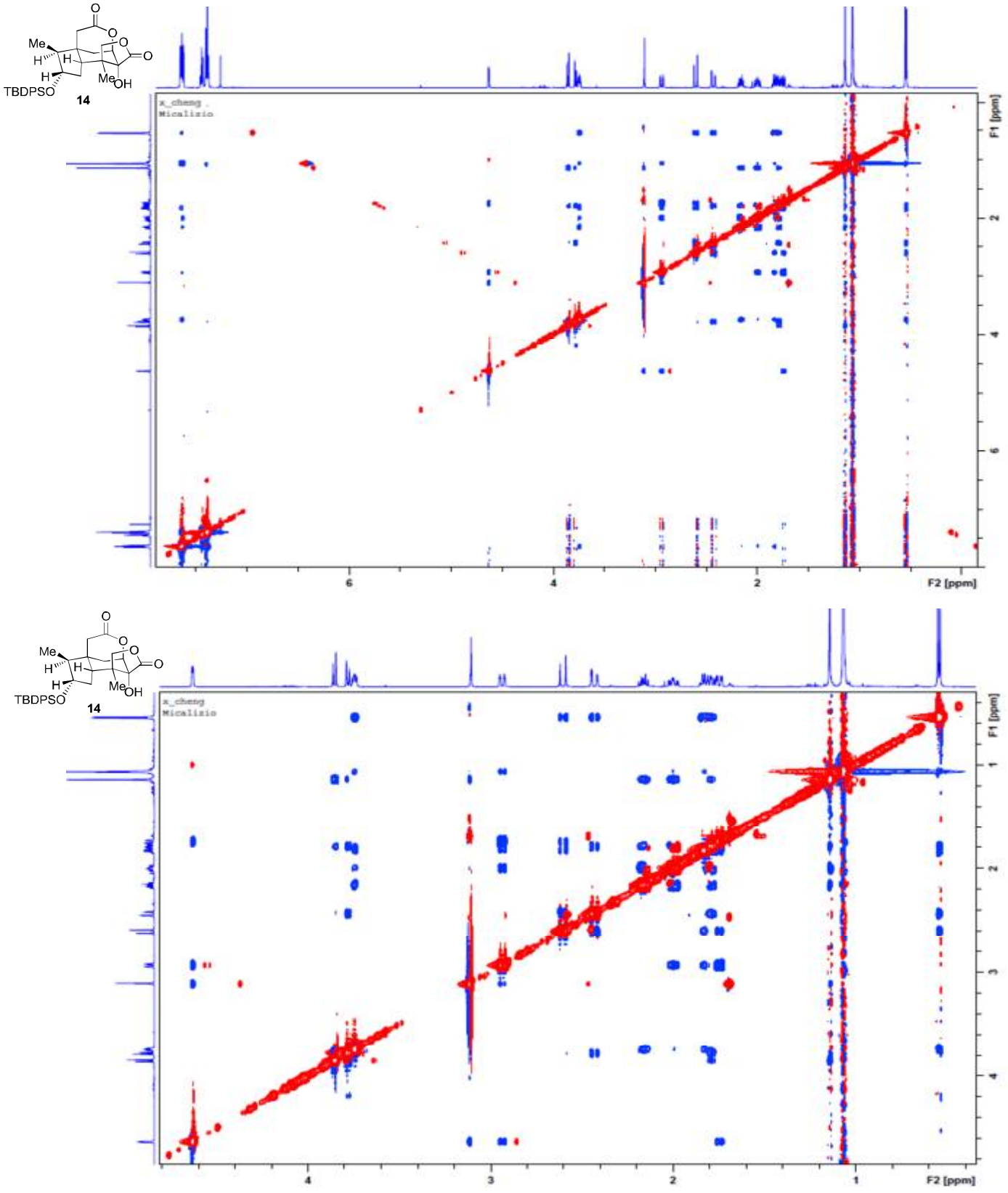


Figure S41: HMBC (600 MHz and 150 MHz, $CDCl_3$) of **14**.

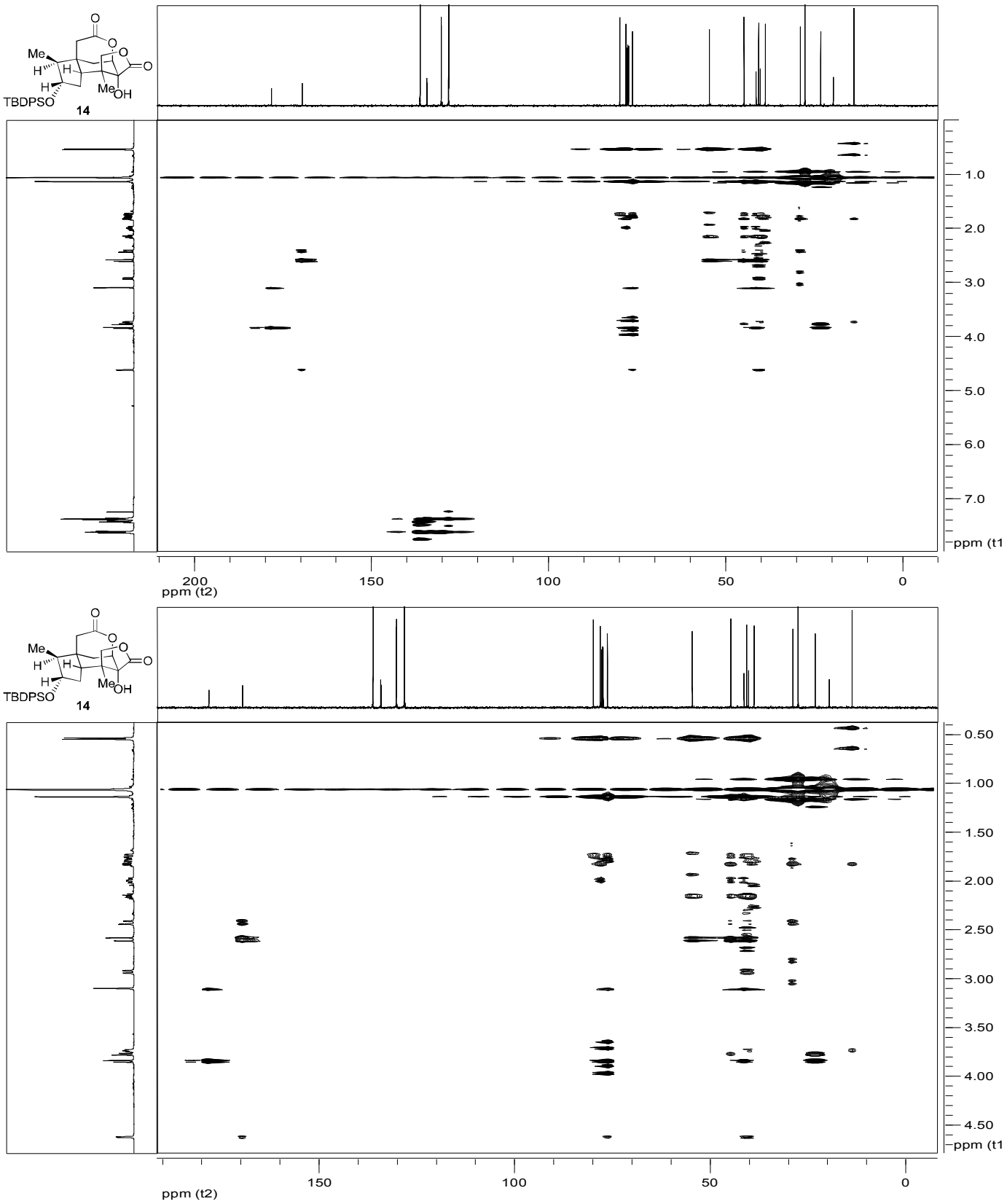
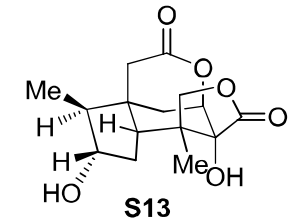


Figure S42: ^{1}H NMR (600 MHz, CD_3OD) and ^{13}C NMR (150 MHz, CD_3OD) of **S13**.



S13

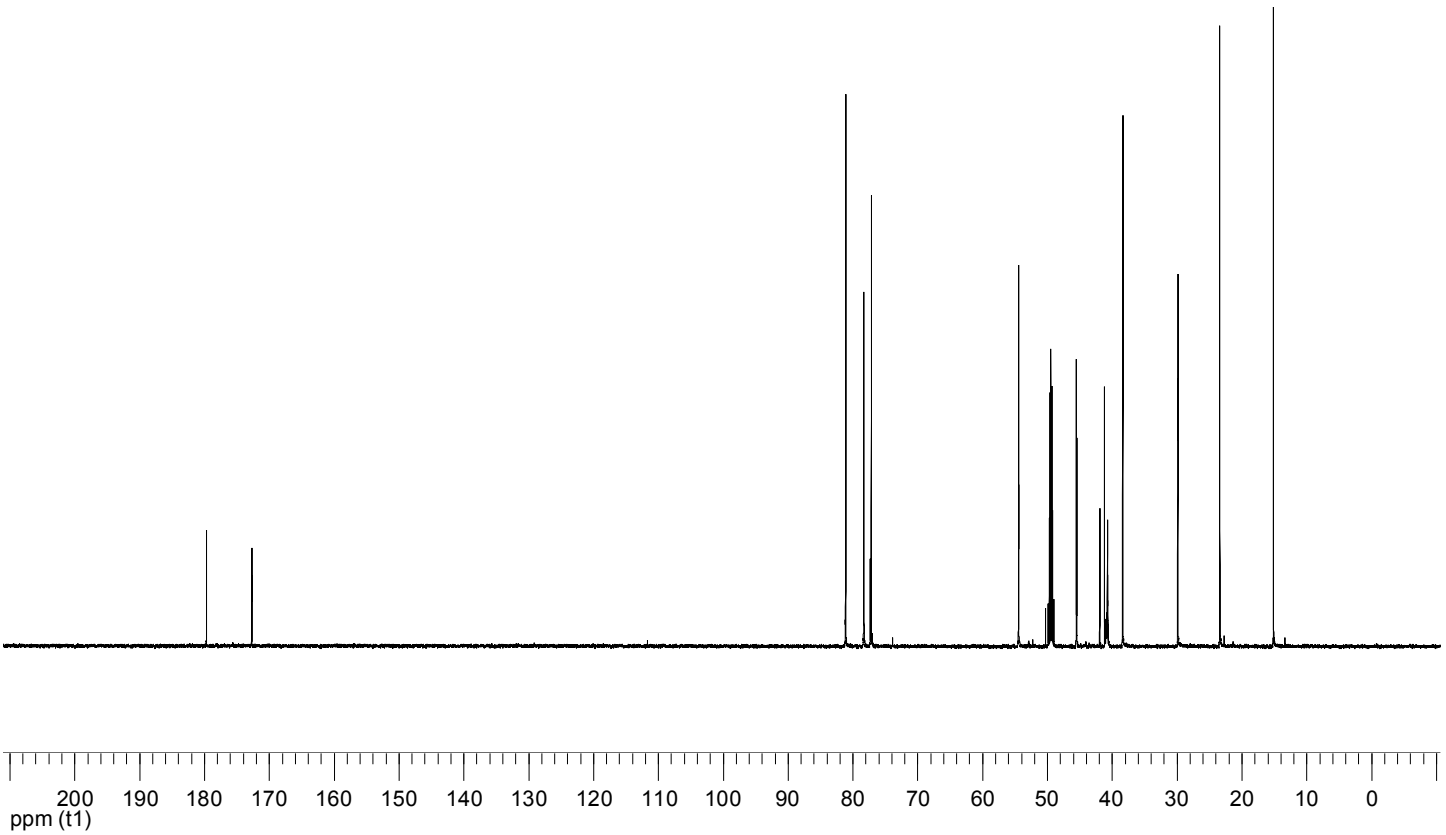


Figure S43: ^{1}H NMR (600 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $(CD_3)_2SO$) of **S14**.

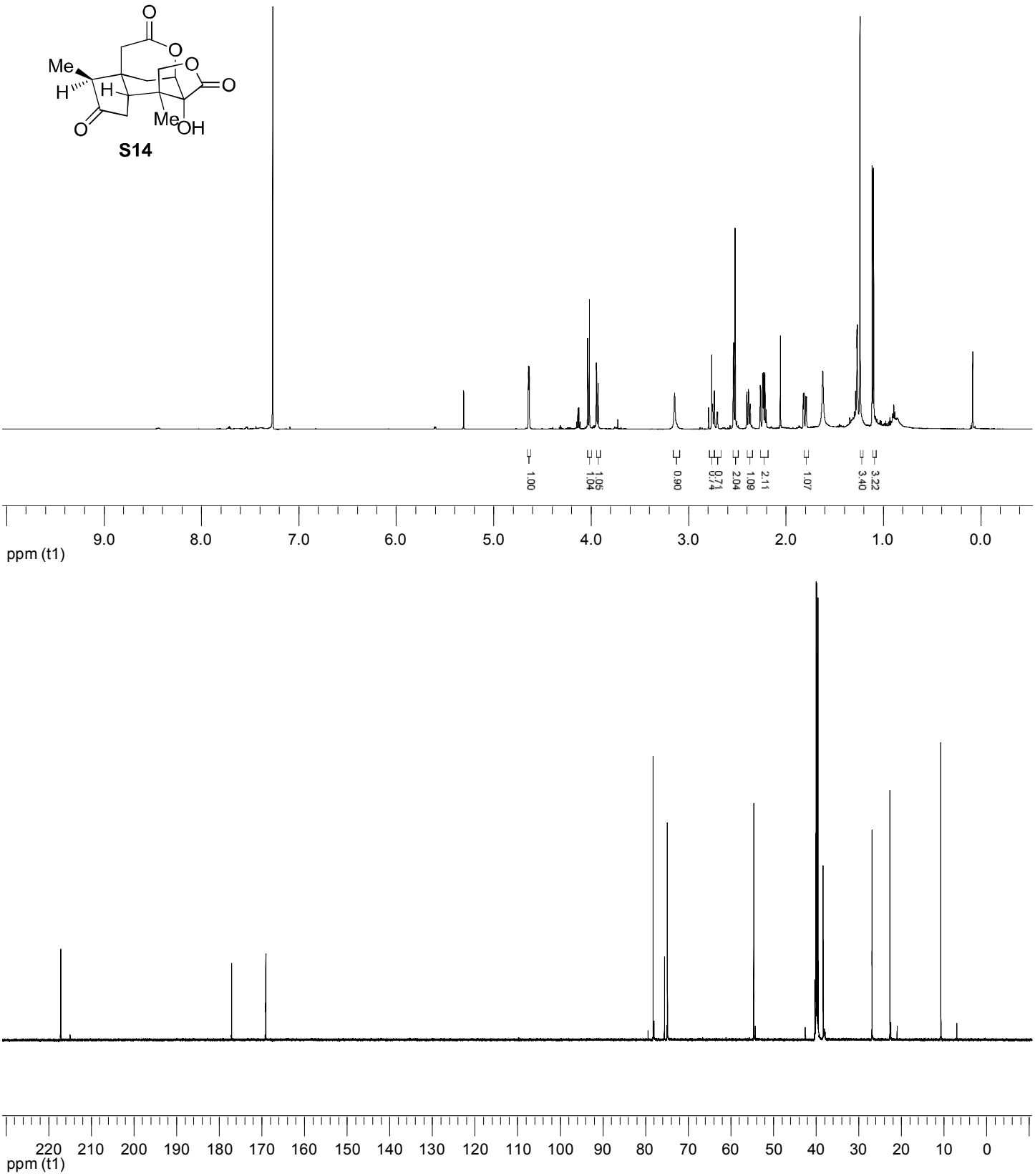
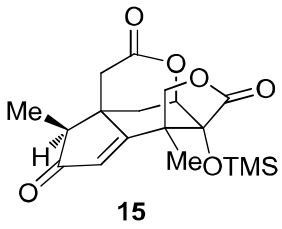


Figure S44: ^{1}H NMR (600 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **15**.



15

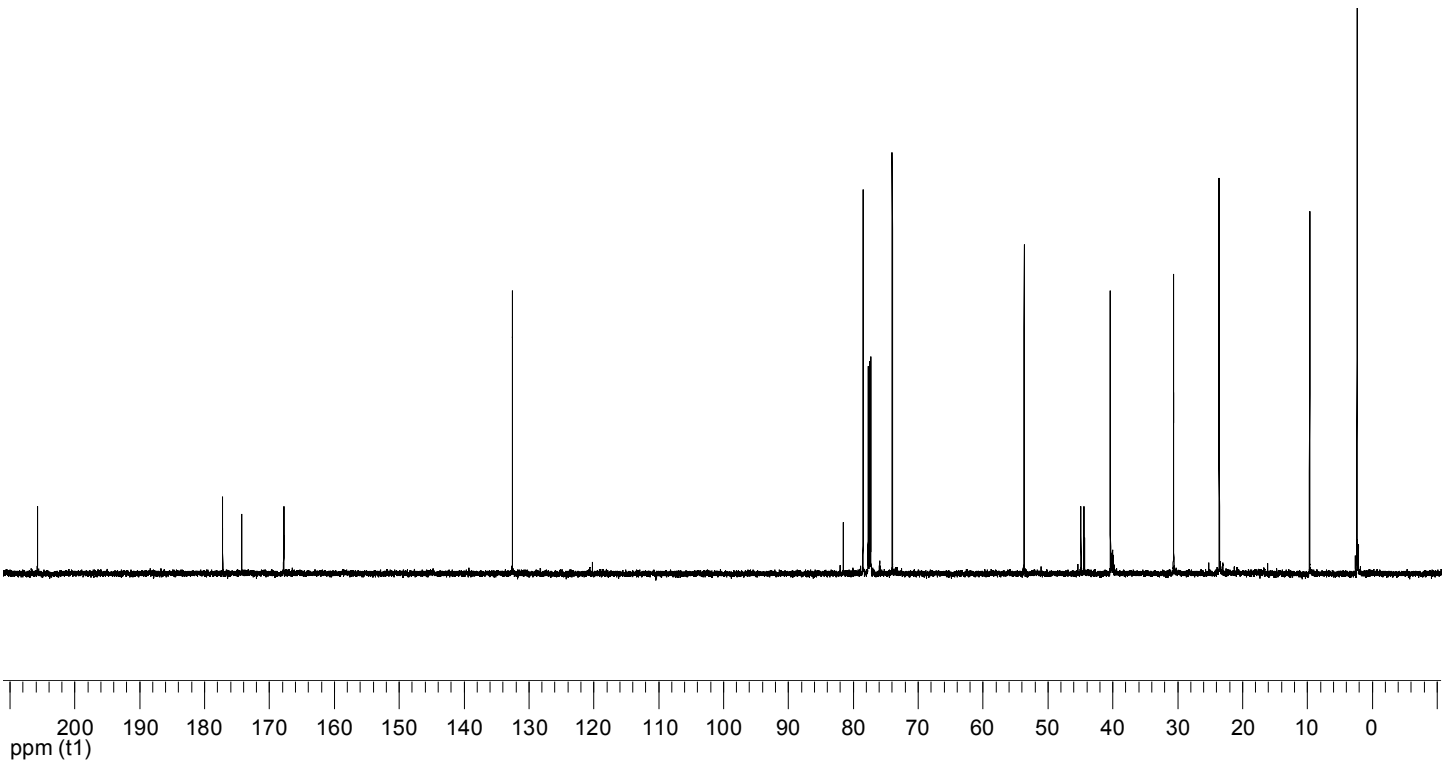


Figure S45: COSY (500 MHz, $CDCl_3$) of **15**.

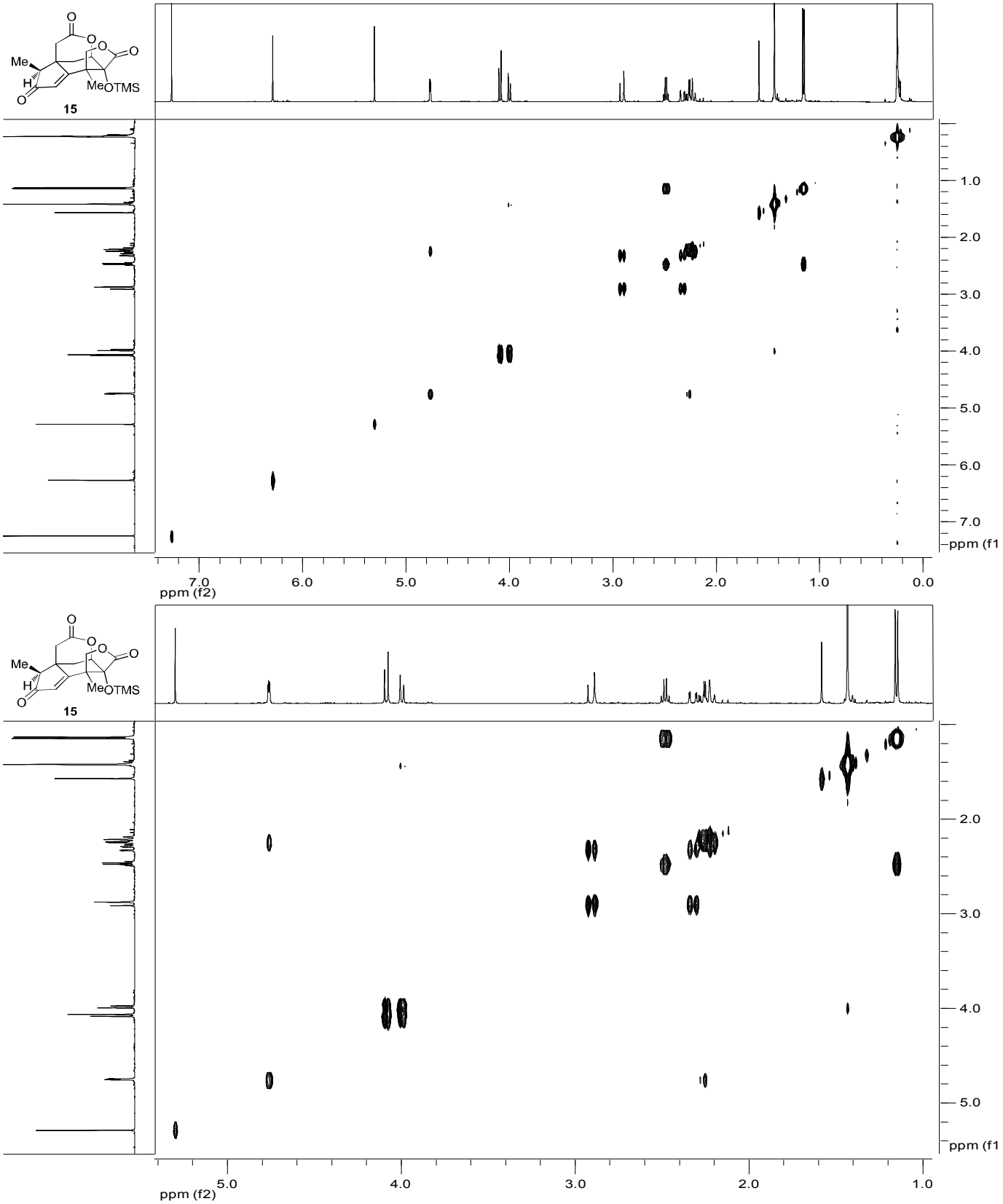


Figure S46: HMQC (600 MHz and 150 MHz, $CDCl_3$) of **15**.

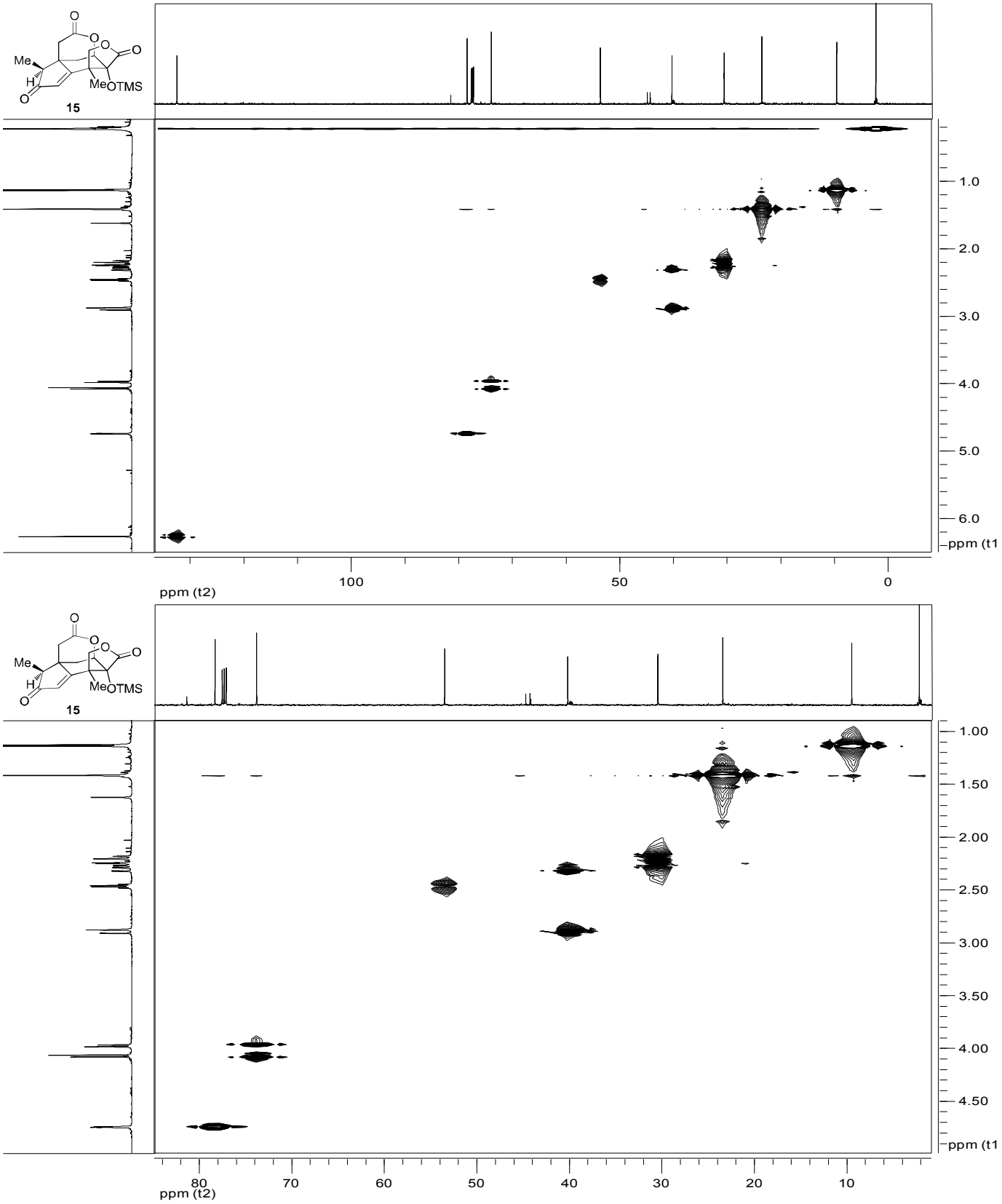


Figure S47: NOESY (500 MHz, $CDCl_3$) of **15**.

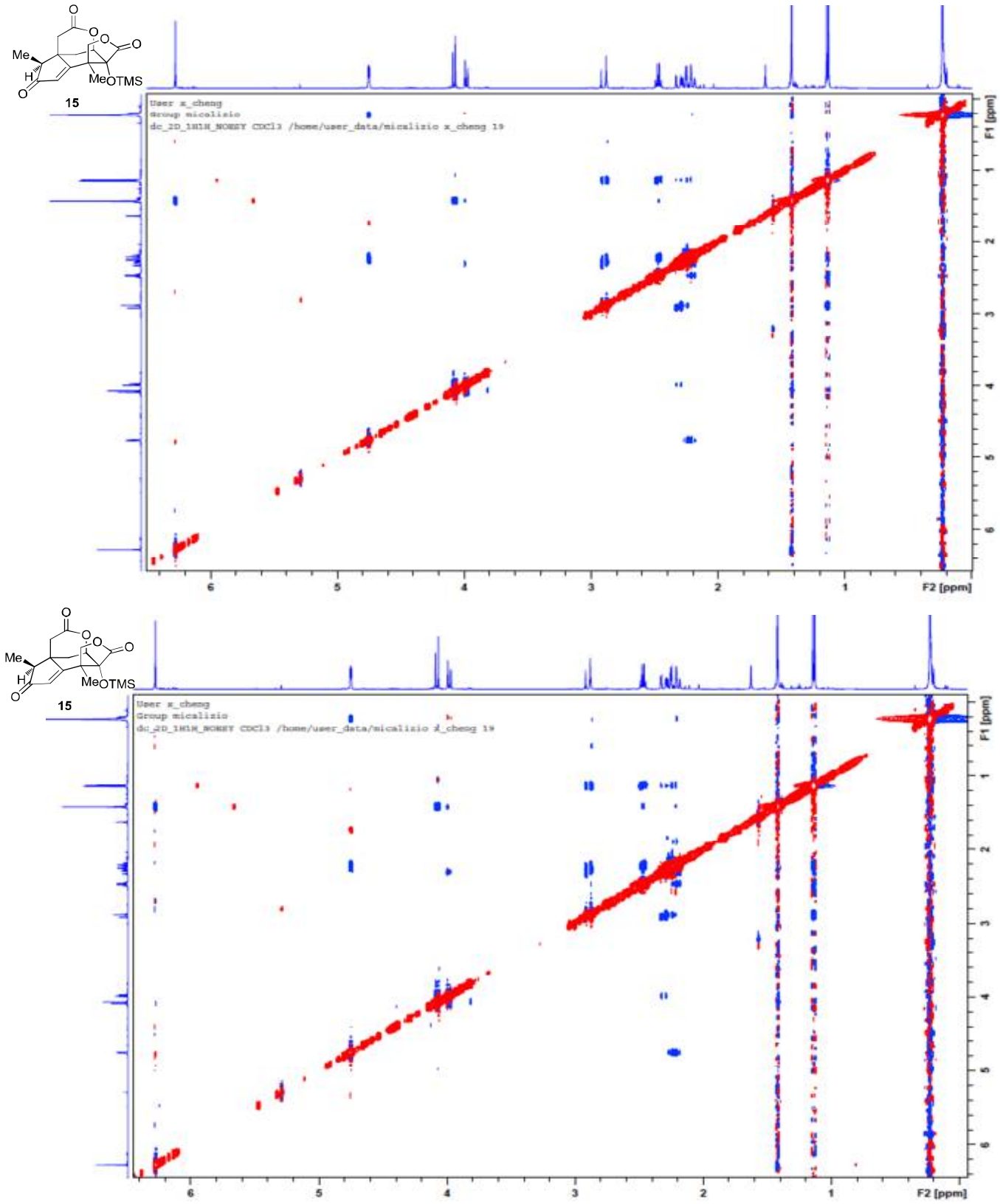


Figure S48: ^{1}H NMR (500 MHz, CD_3OD and 600 MHz, C_5D_5N-TMS) of **1** (contaminated with a very small amount of **16**).

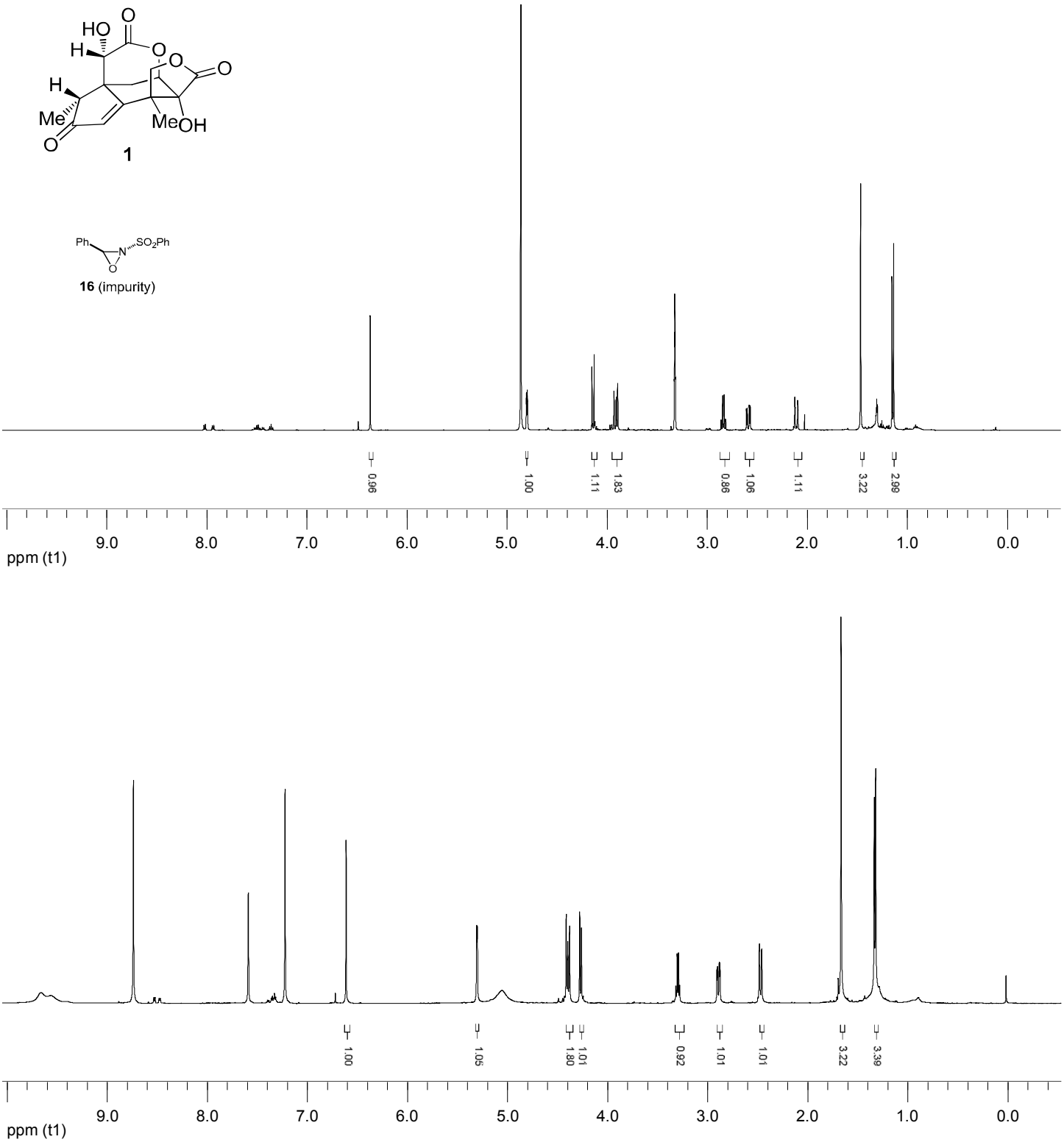


Figure S49: ^{13}C NMR (150 MHz, C_5D_5N-TMS) of **1** (contaminated with a very small amount of **16**).

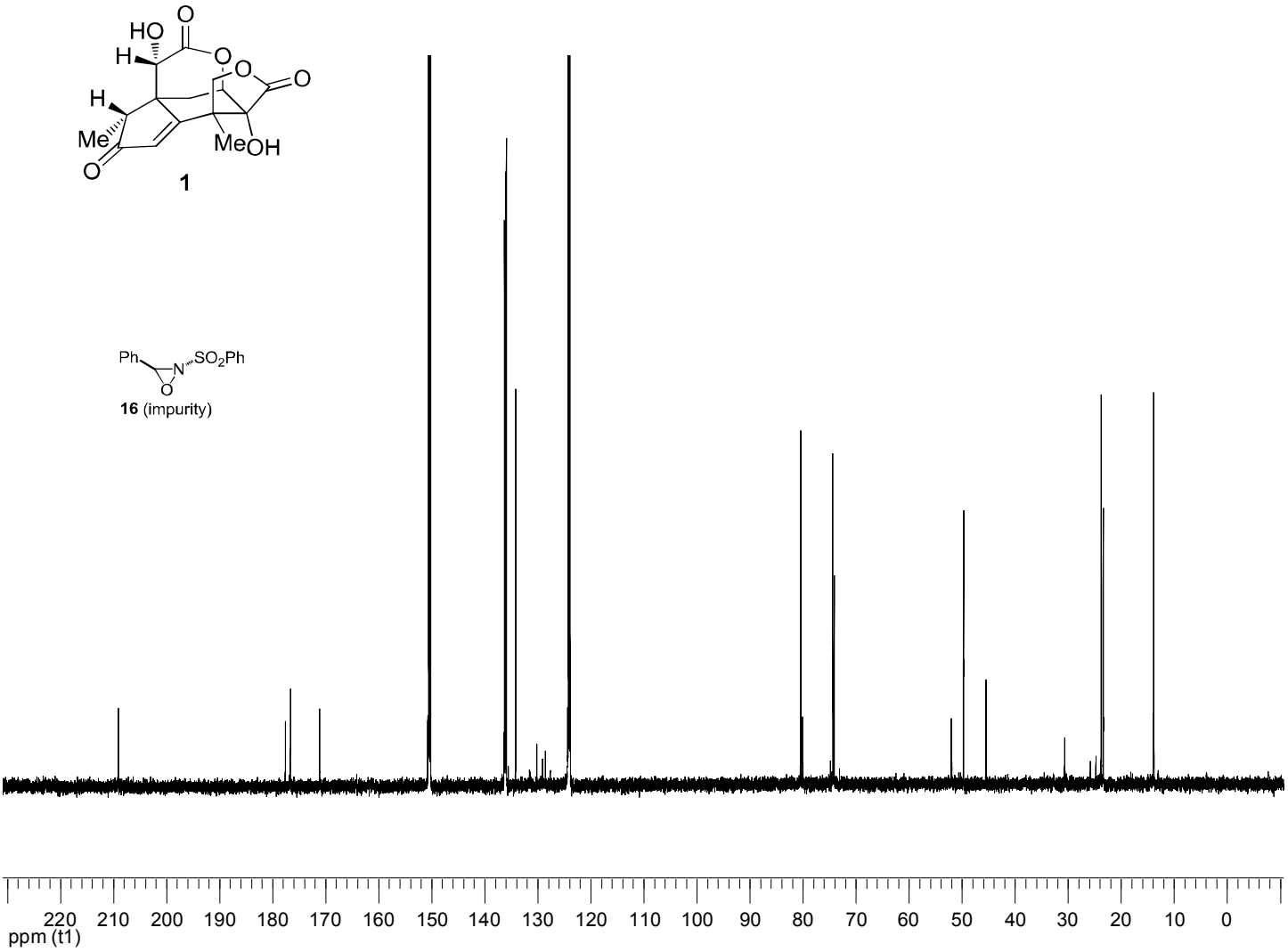
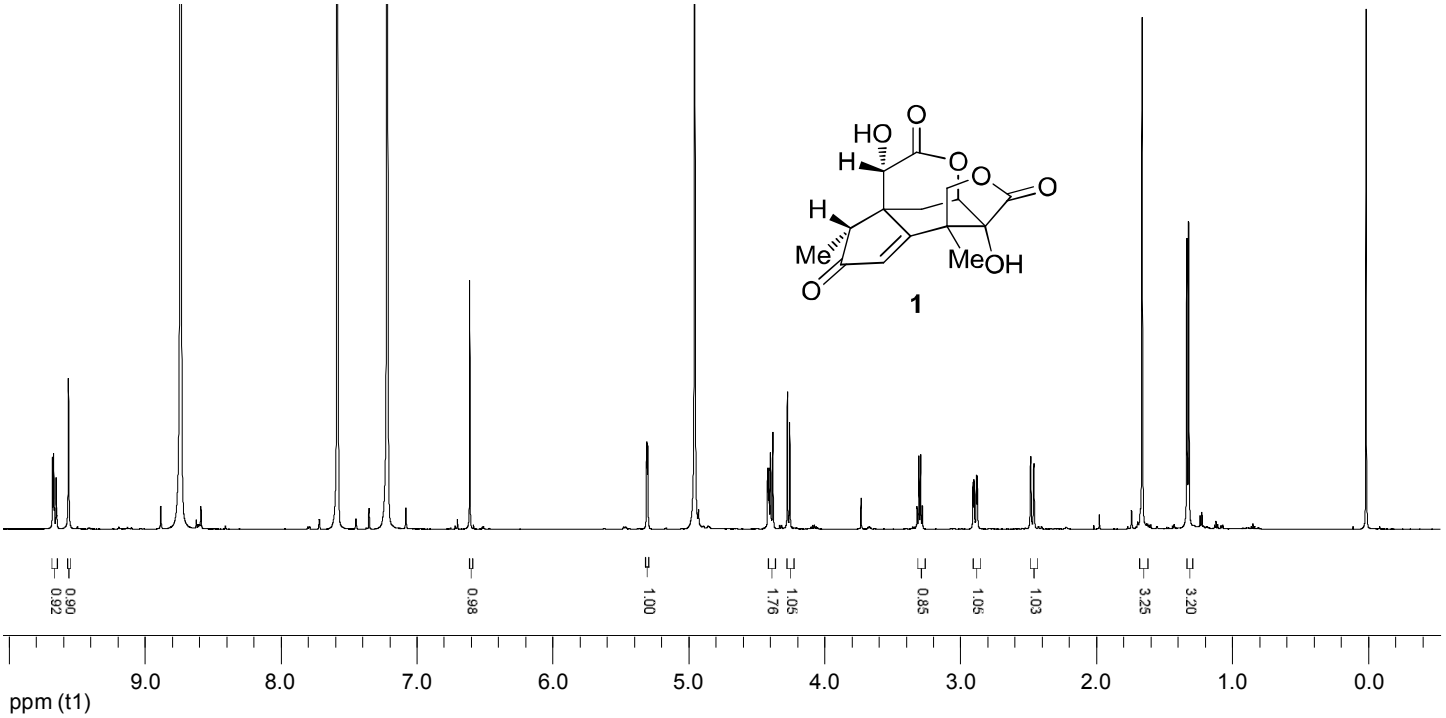


Figure S50: ^{1}H NMR (600 MHz, C_5D_5N-TMS) and ^{13}C NMR (150 MHz, C_5D_5N-TMS) repurified **1**.



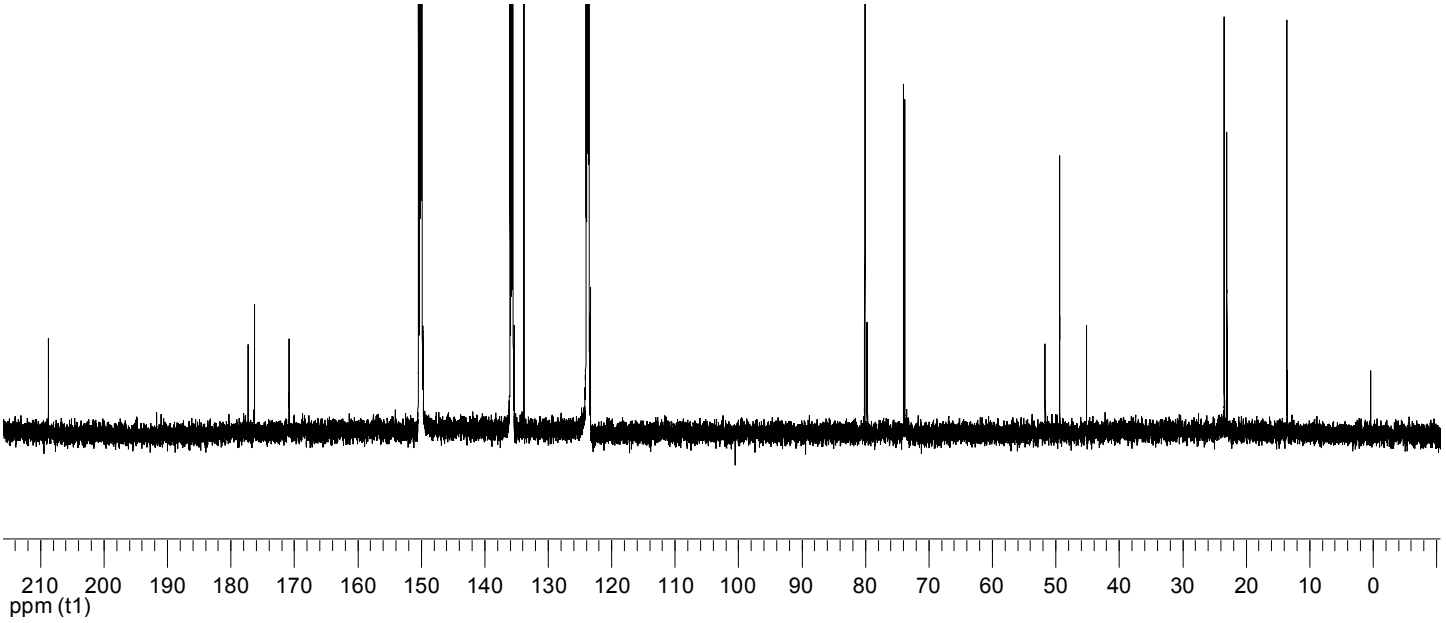


Figure S51: COSY (500 MHz, C_5D_5N-TMS-TMS) of **1**.

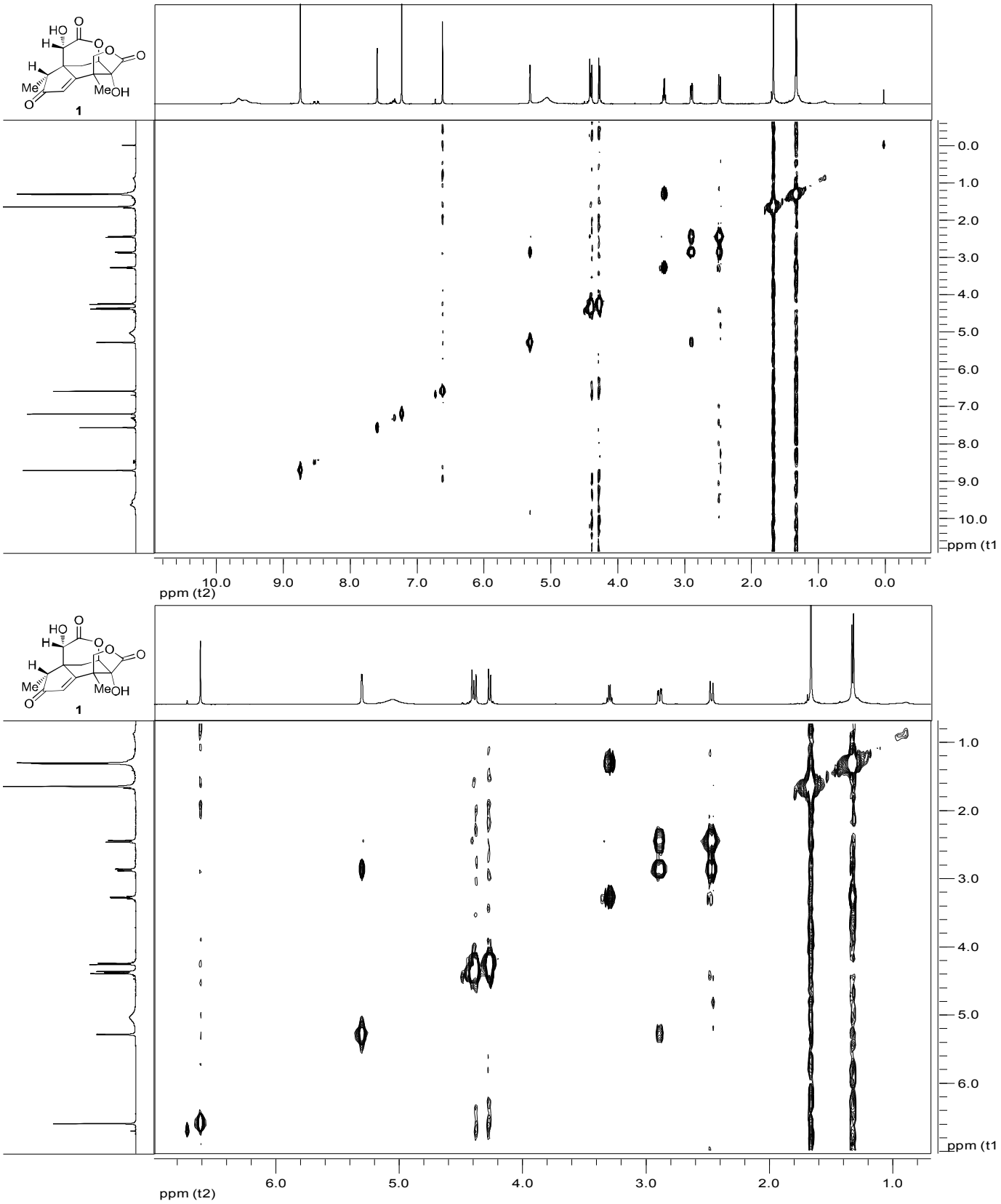


Figure S52: HMQC (500 MHz and 125 MHz, C_5D_5N-TMS) of **1**.

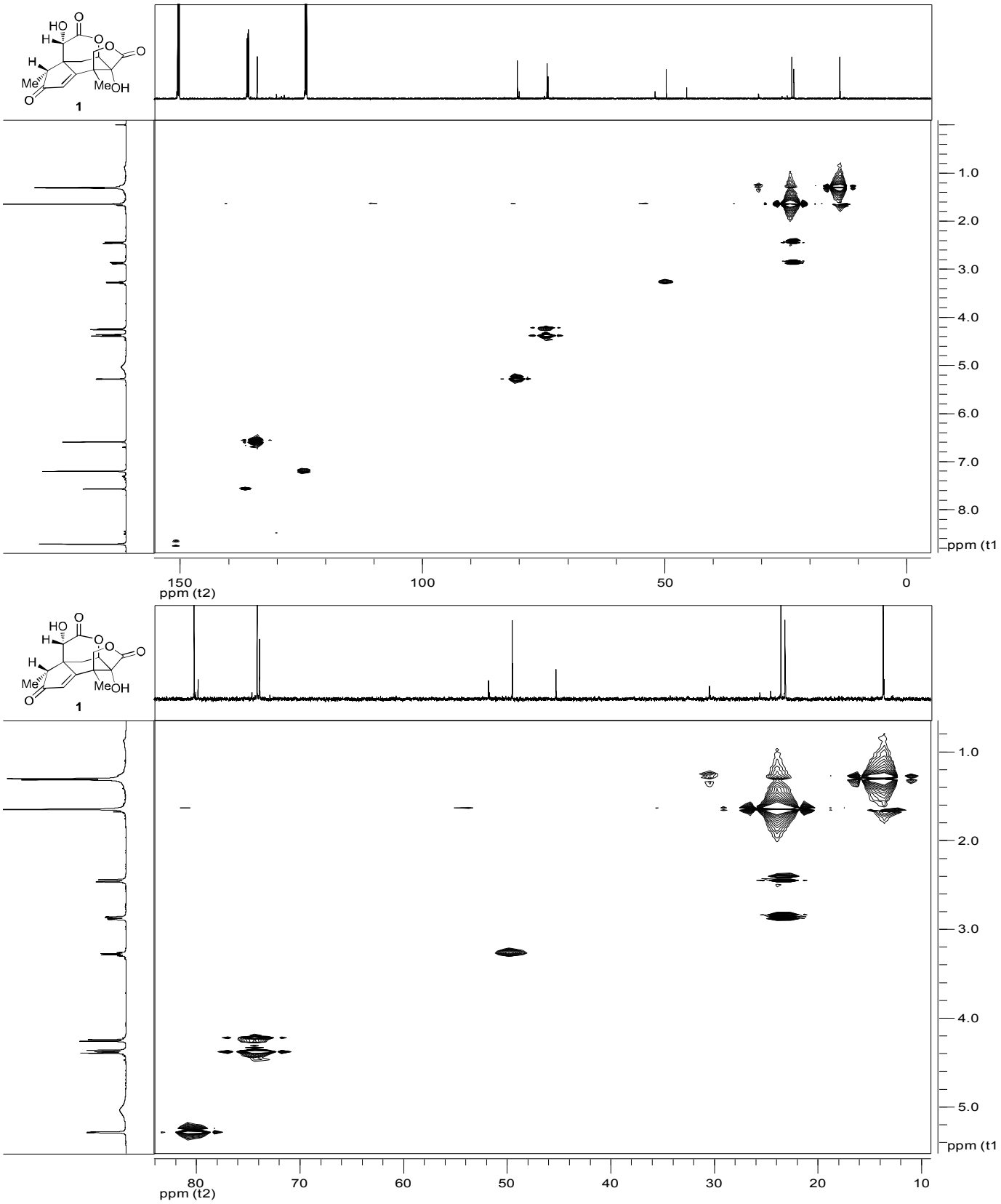


Figure S53: TOCSY (600 MHz, C_5D_5N-TMS) of **1**.

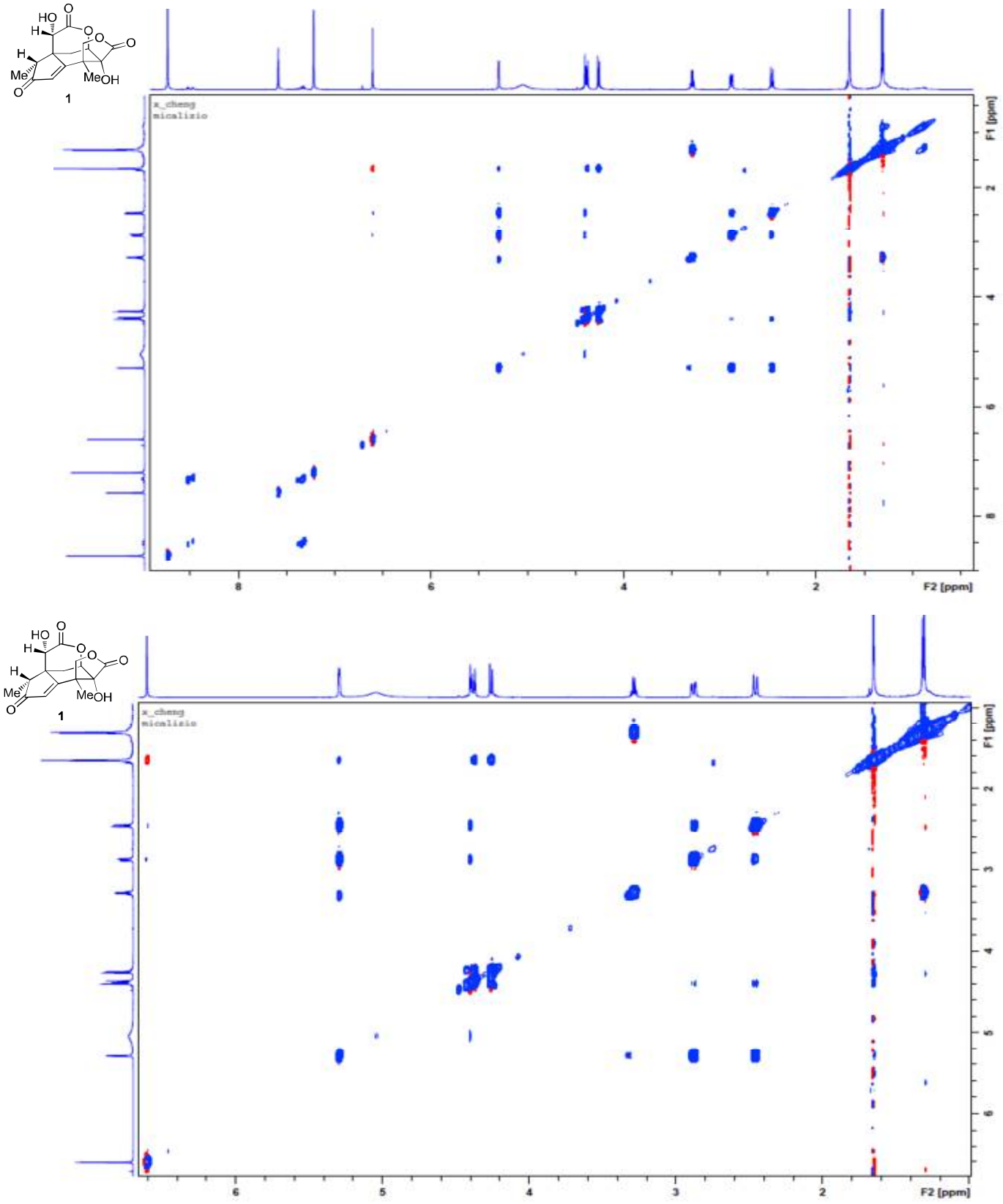


Figure S54: NOESY (600 MHz, C_5D_5N-TMS) of **1**.

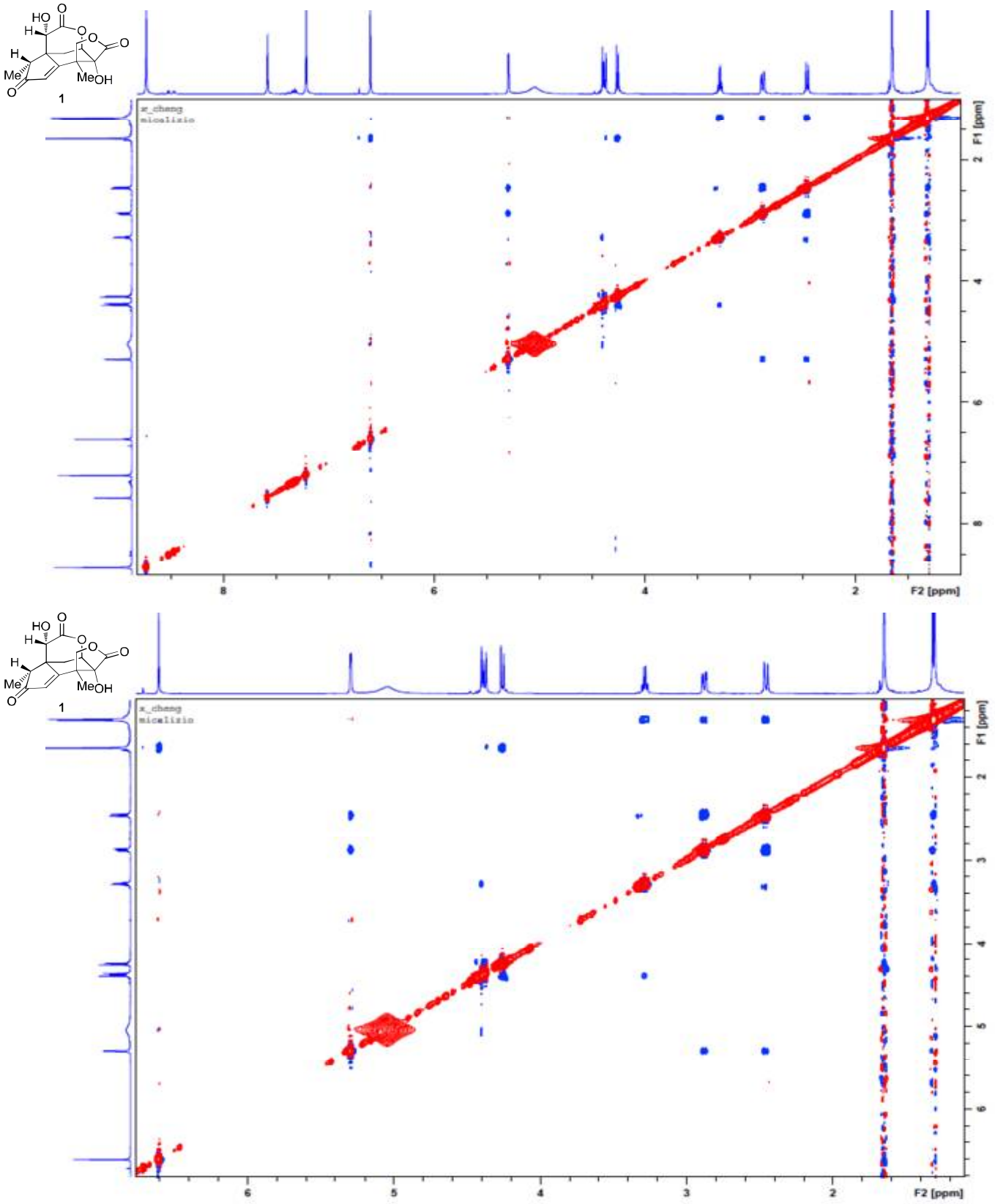


Figure S55: HMBC (600 MHz and 150 MHz, C_5D_5N-TMS) of **1**.

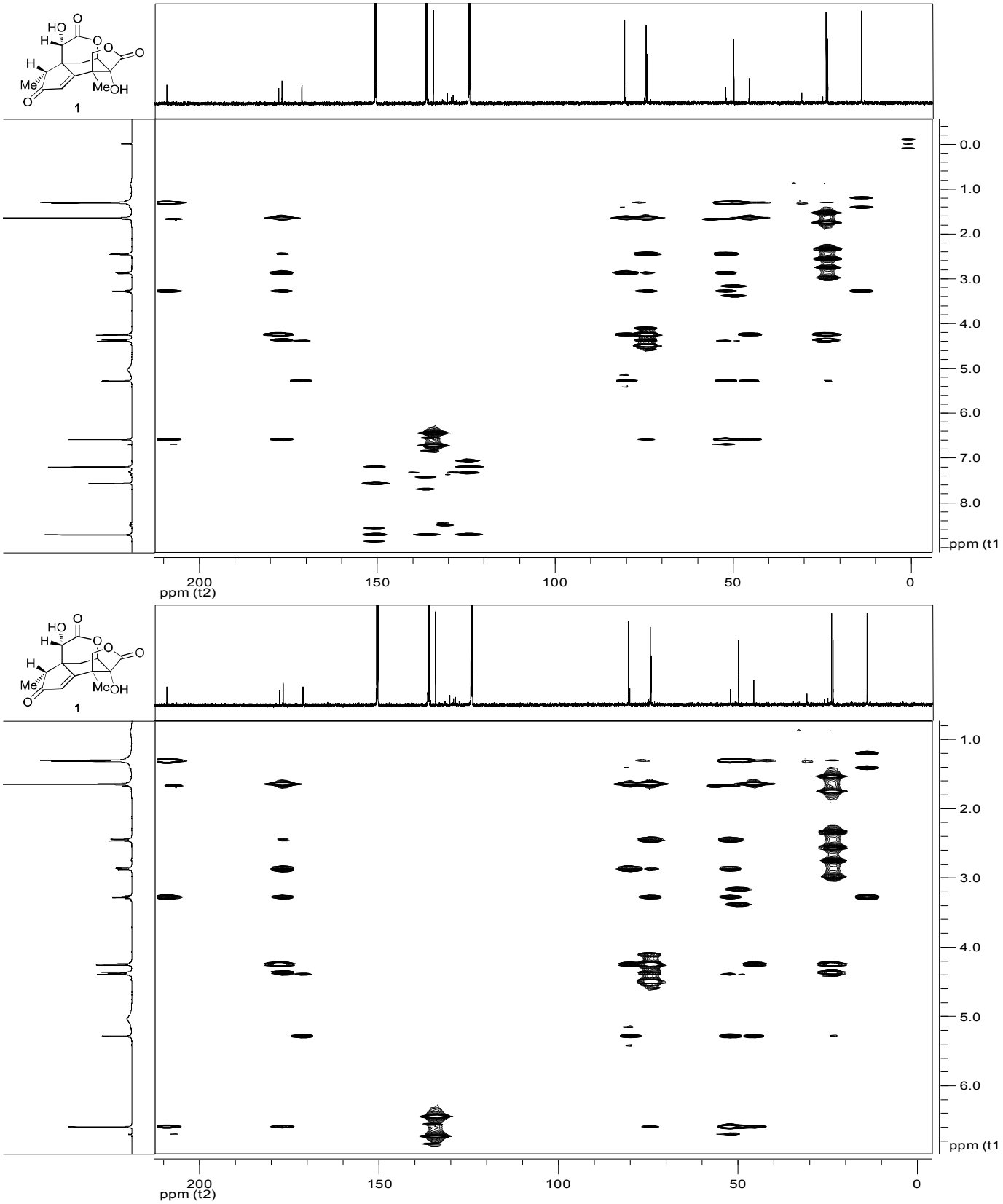
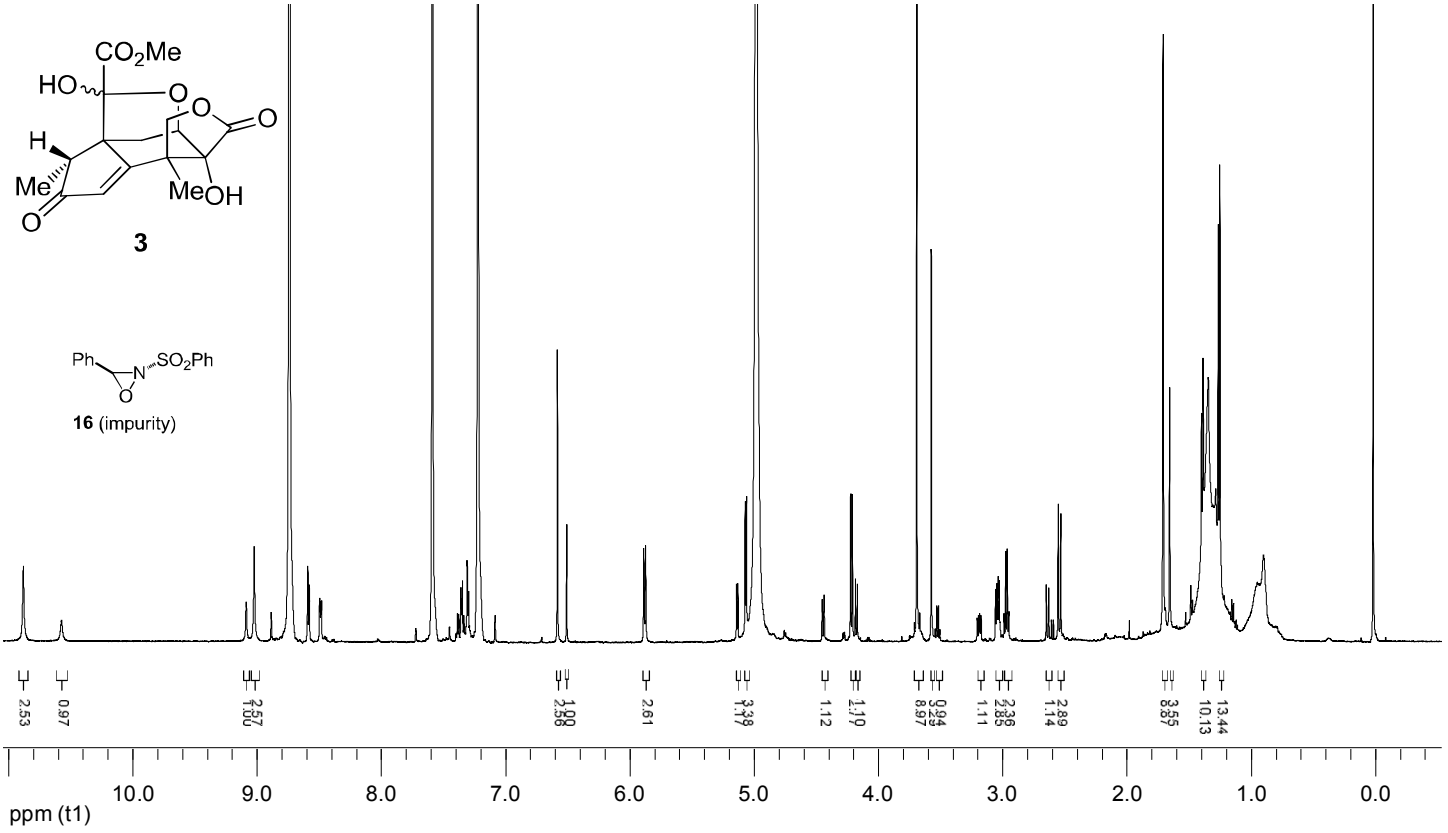


Figure S56: ^{1}H NMR (600 MHz, C_5D_5N-TMS) and ^{13}C NMR (150 MHz, C_5D_5N-TMS) of **3** (contaminated with a small amount of **16**).



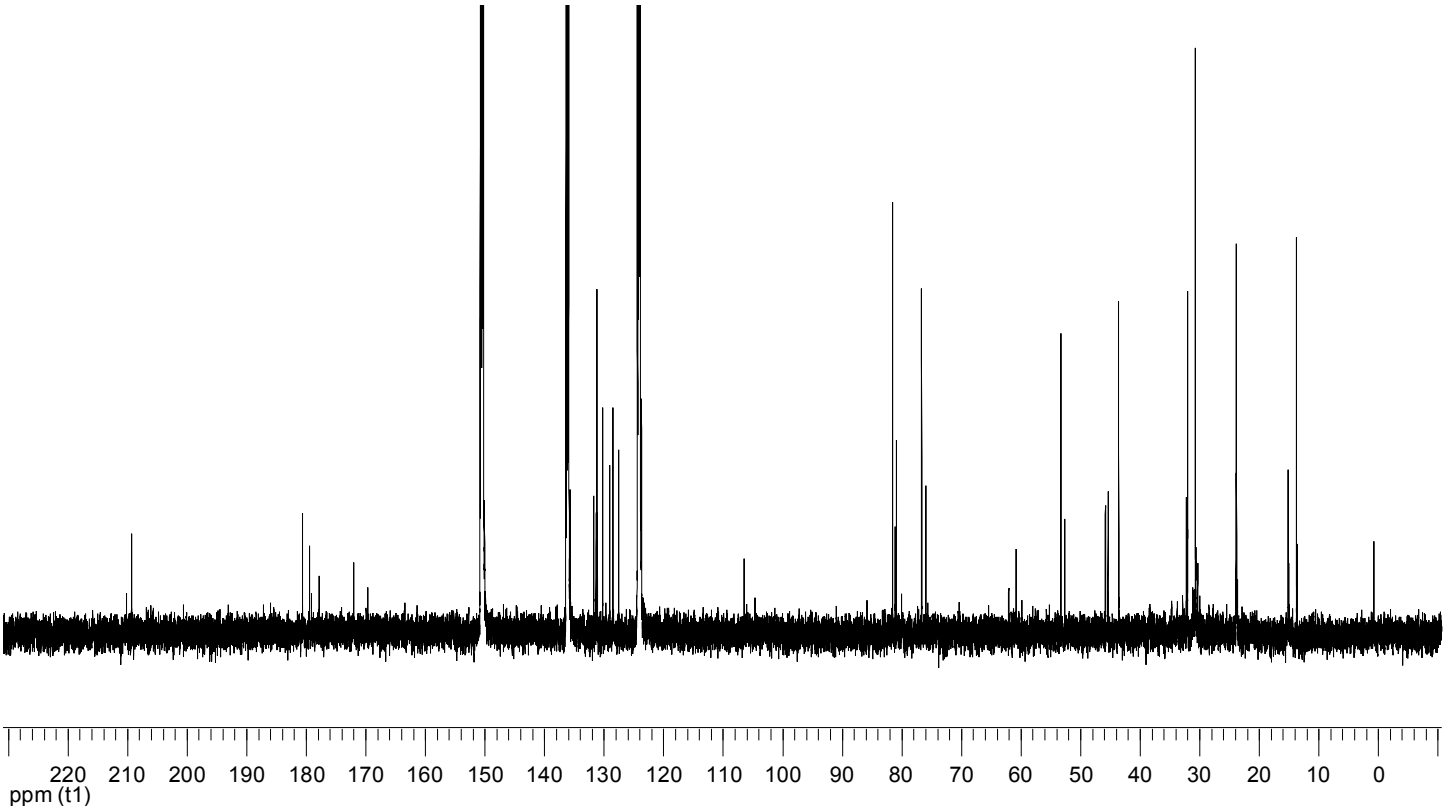


Figure S57: ^{1}H NMR (600 MHz, C_5D_5N-TMS) and ^{13}C NMR (150 MHz, C_5D_5N-TMS) of repurified **3**.

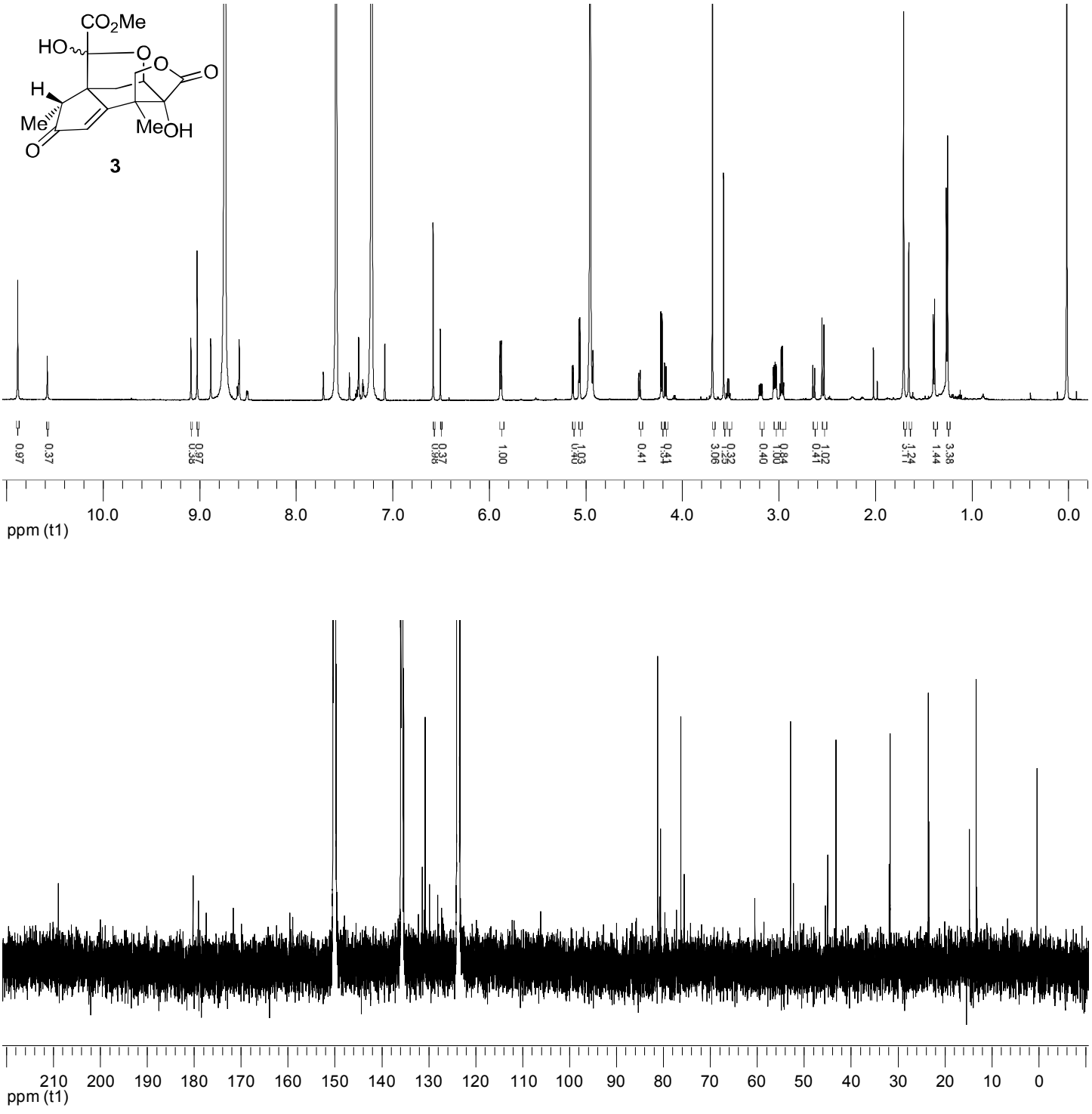


Figure S58: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S15**.

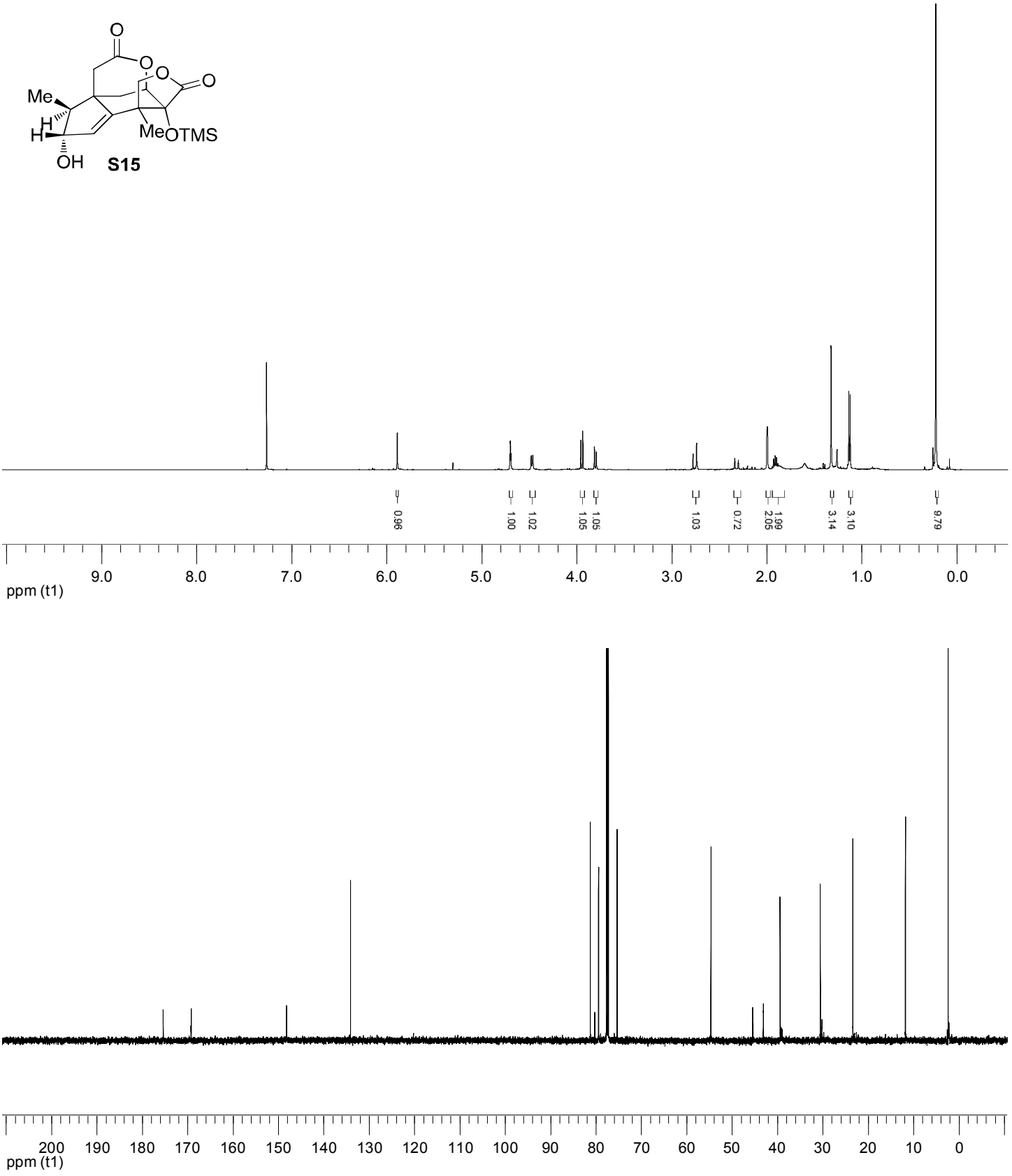


Figure S59: COSY (500 MHz, $CDCl_3$) of **S15**.

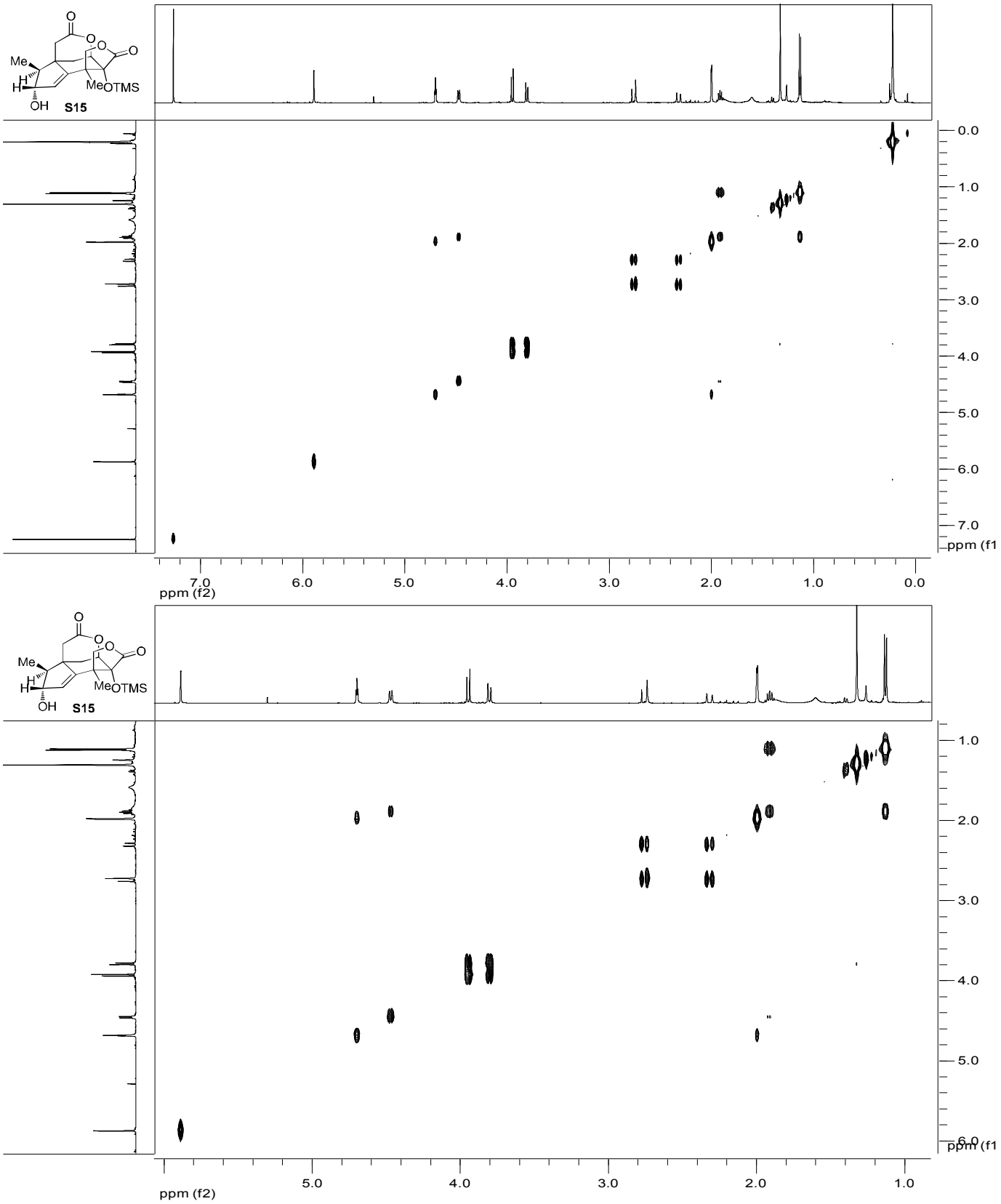


Figure S60: HMQC (500 MHz, $CDCl_3$ and 125 MHz) of **S15**.

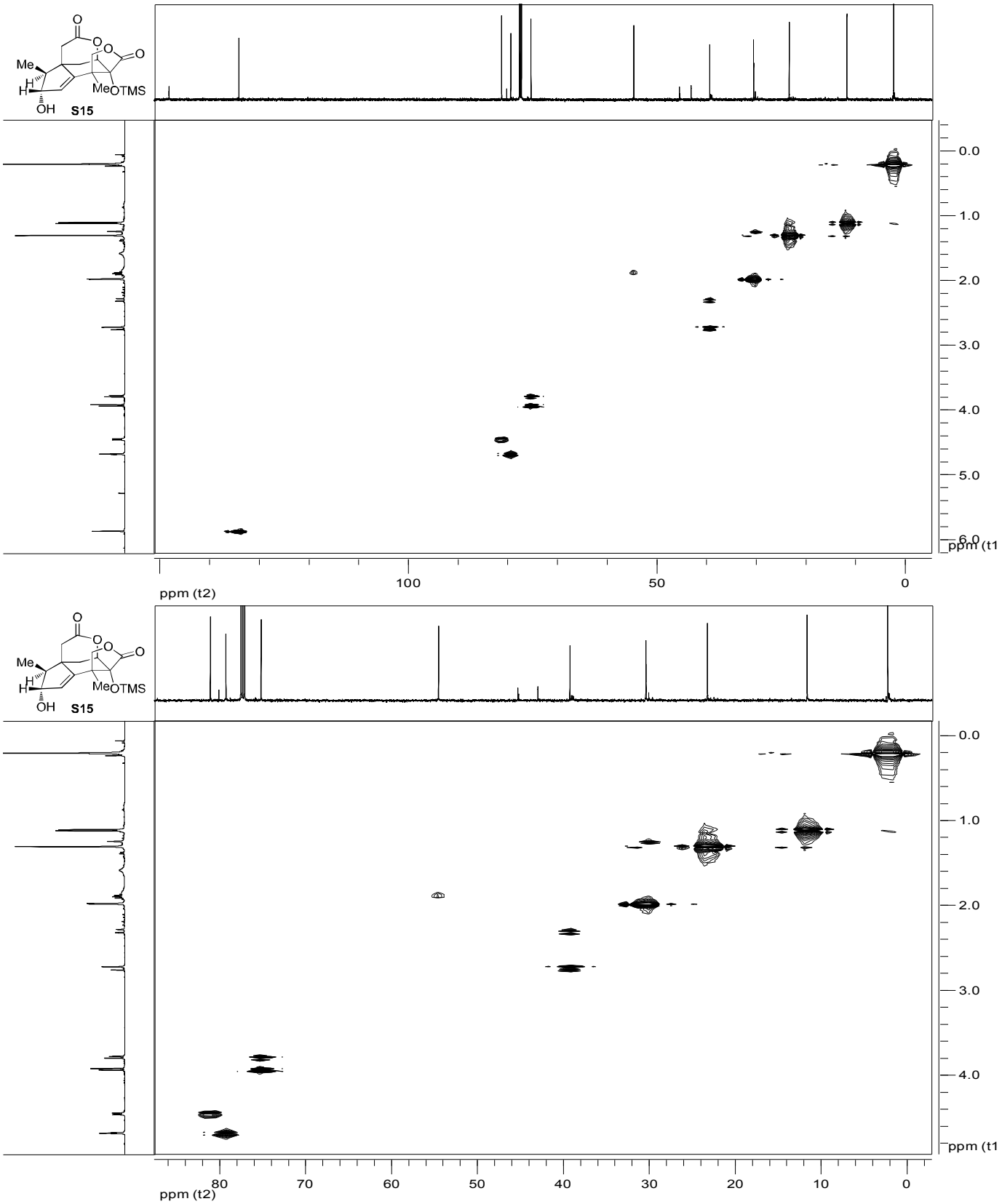


Figure S61: NOESY (500 MHz, $CDCl_3$) of **S15**.

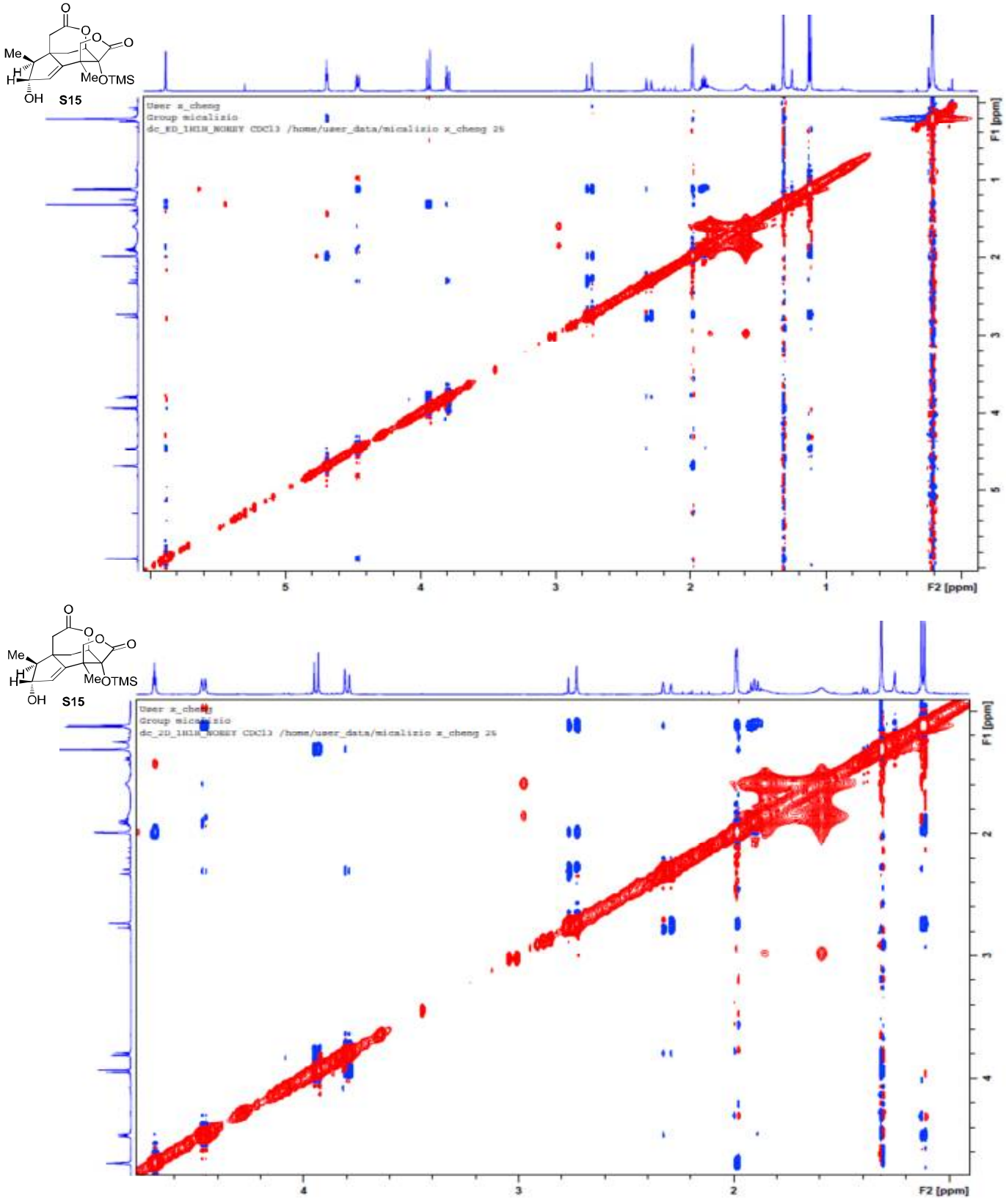
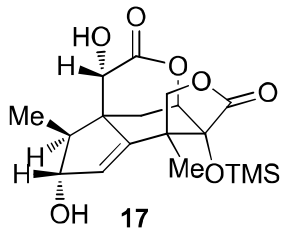


Figure S62: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of pure **17**.



17

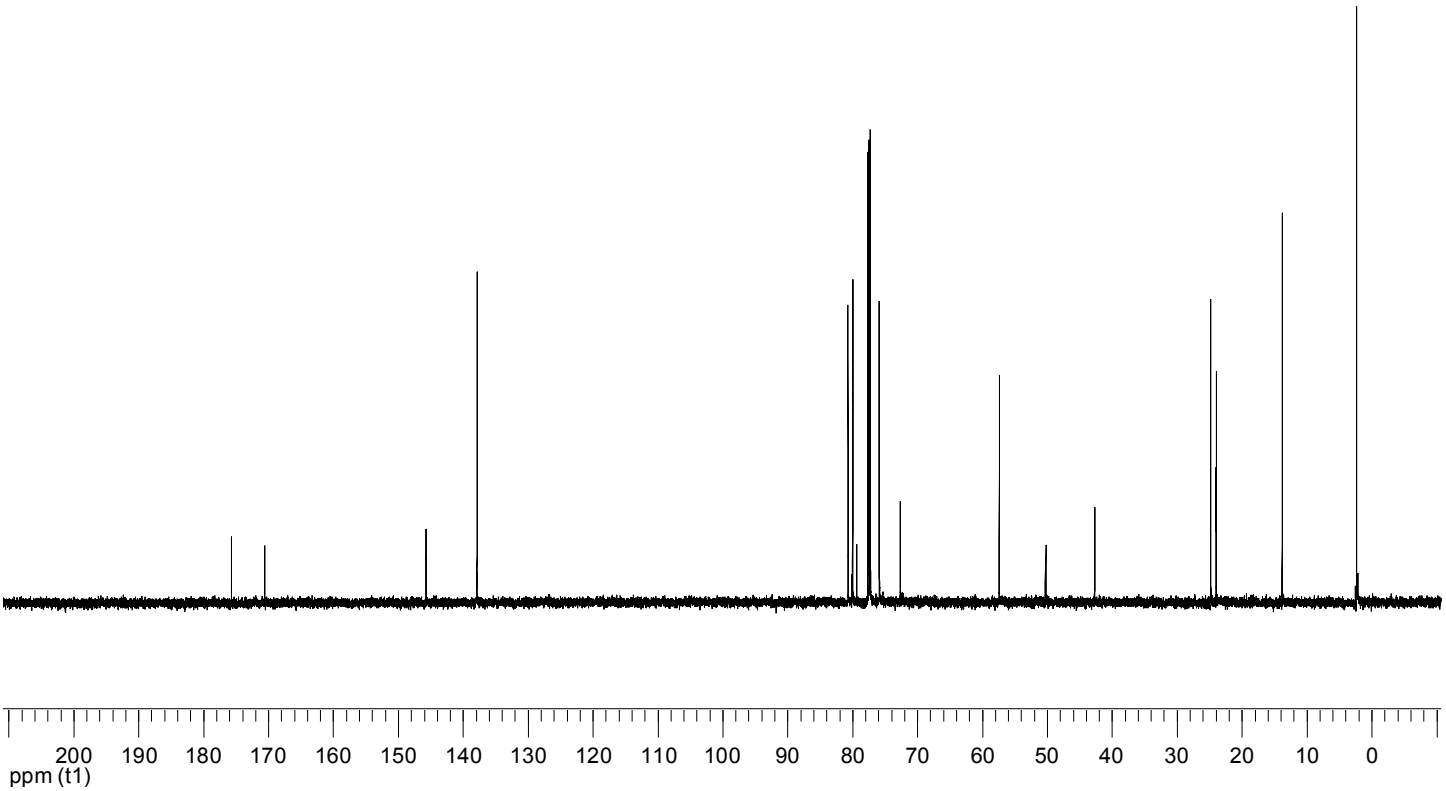


Figure S63: ^{1}H NMR (500 MHz, $CDCl_3$) of impure **17** (contaminated with a small amount of **S15** and **16** and used without further purification).

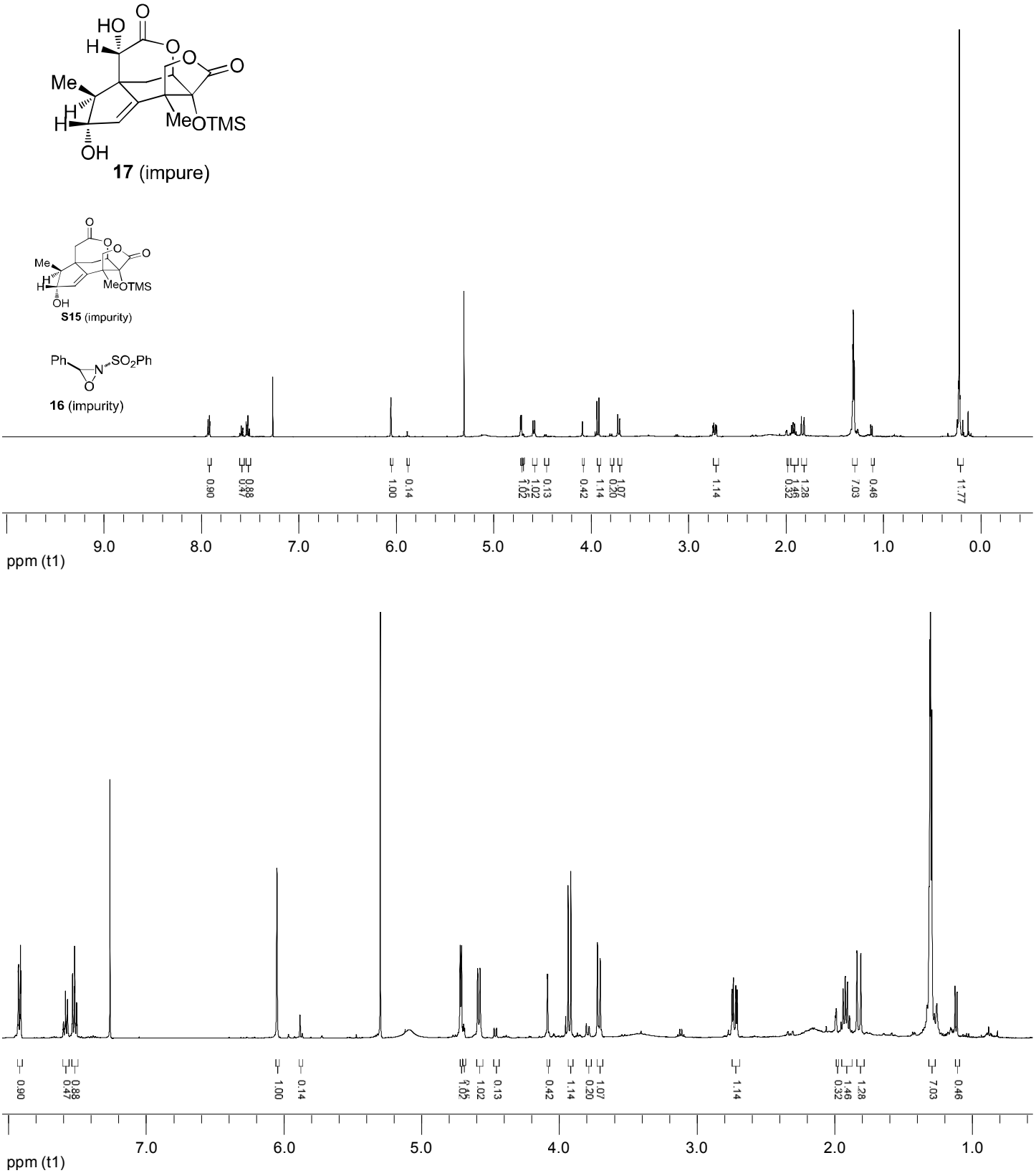


Figure S64: COSY (600 MHz, $CDCl_3$) of **17**.

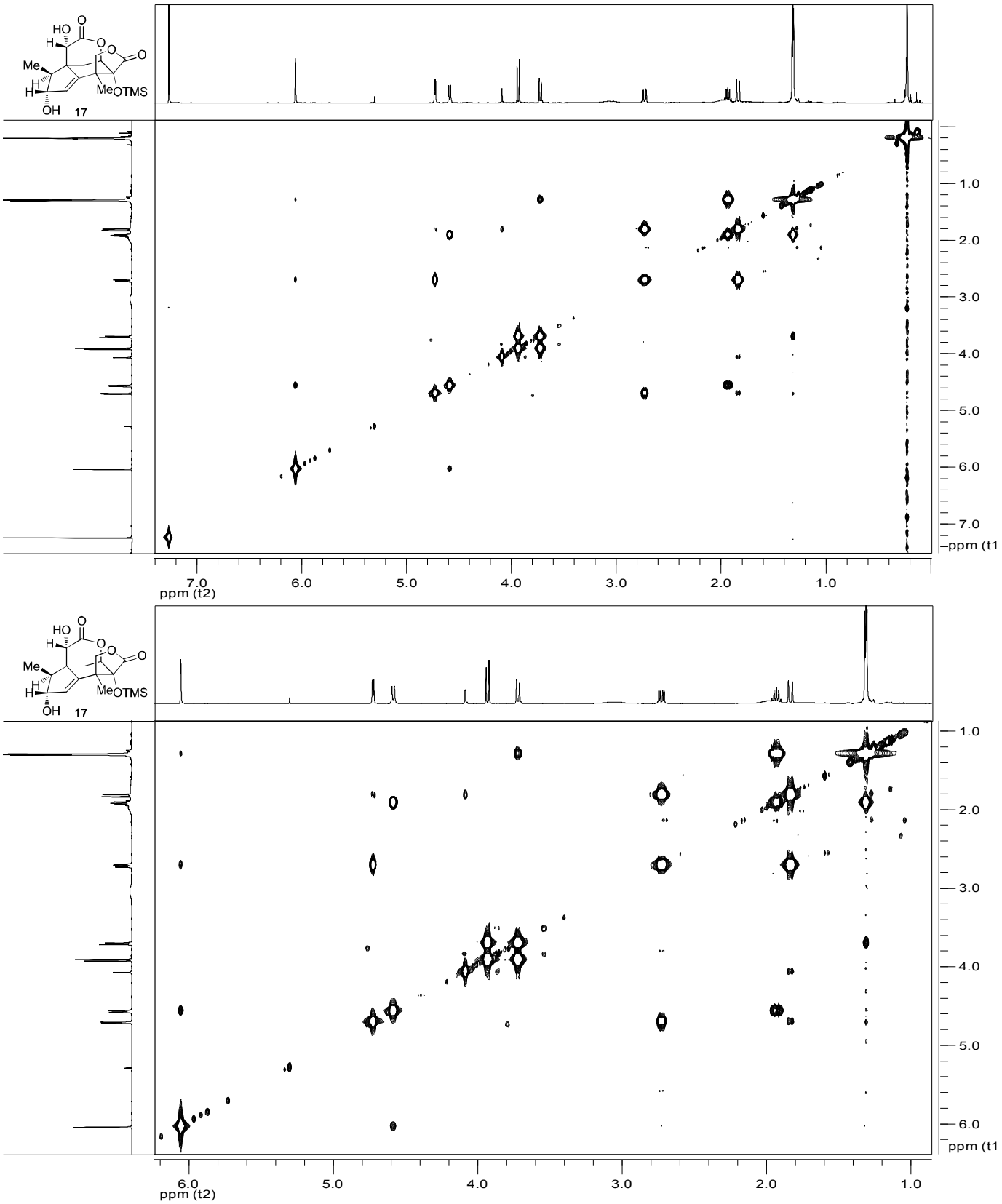


Figure S65: HMQC (600 MHz and 150MHz, $CDCl_3$) of **17**.

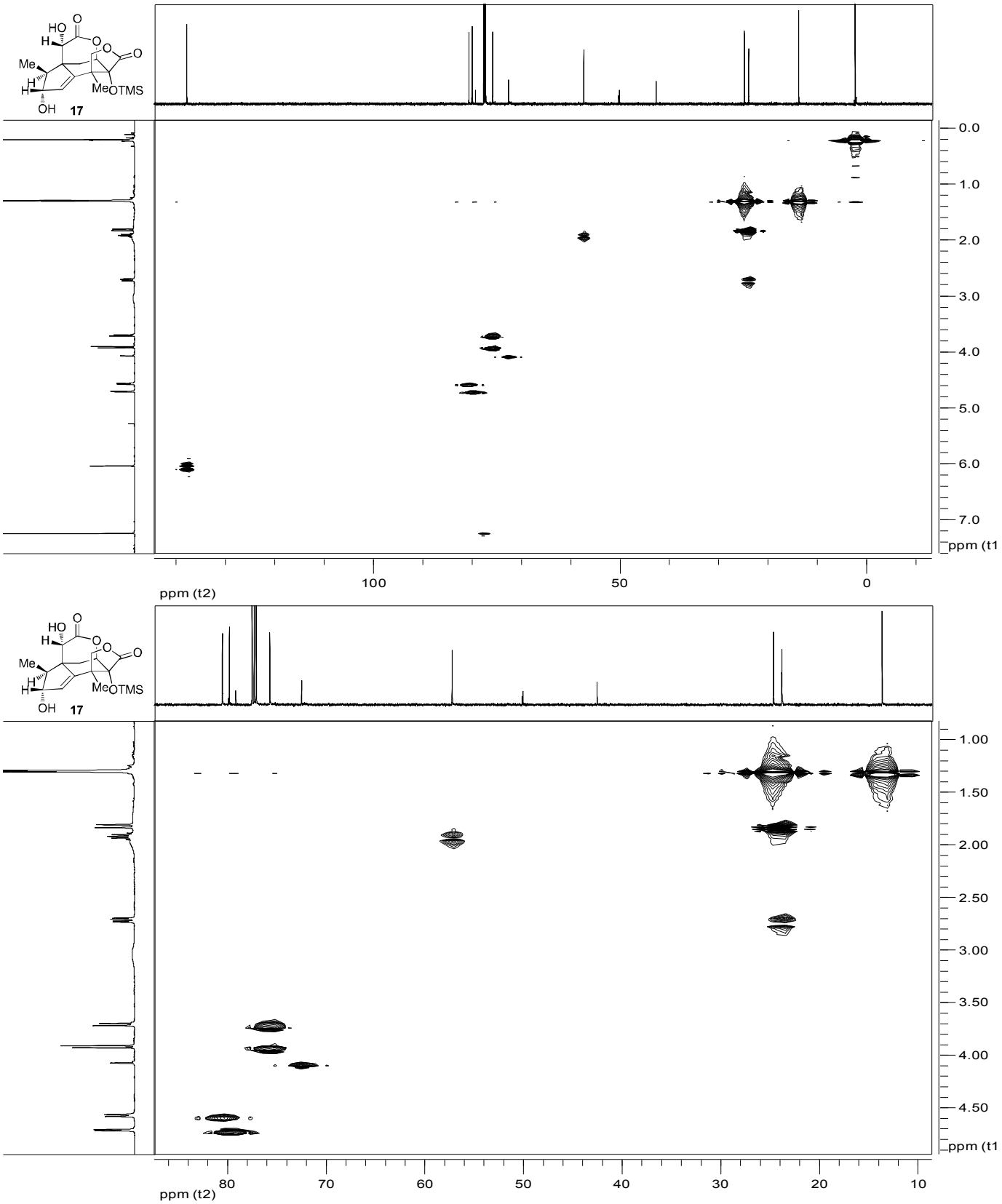


Figure S66: TOCSY (600 MHz, $CDCl_3$) of **17**.

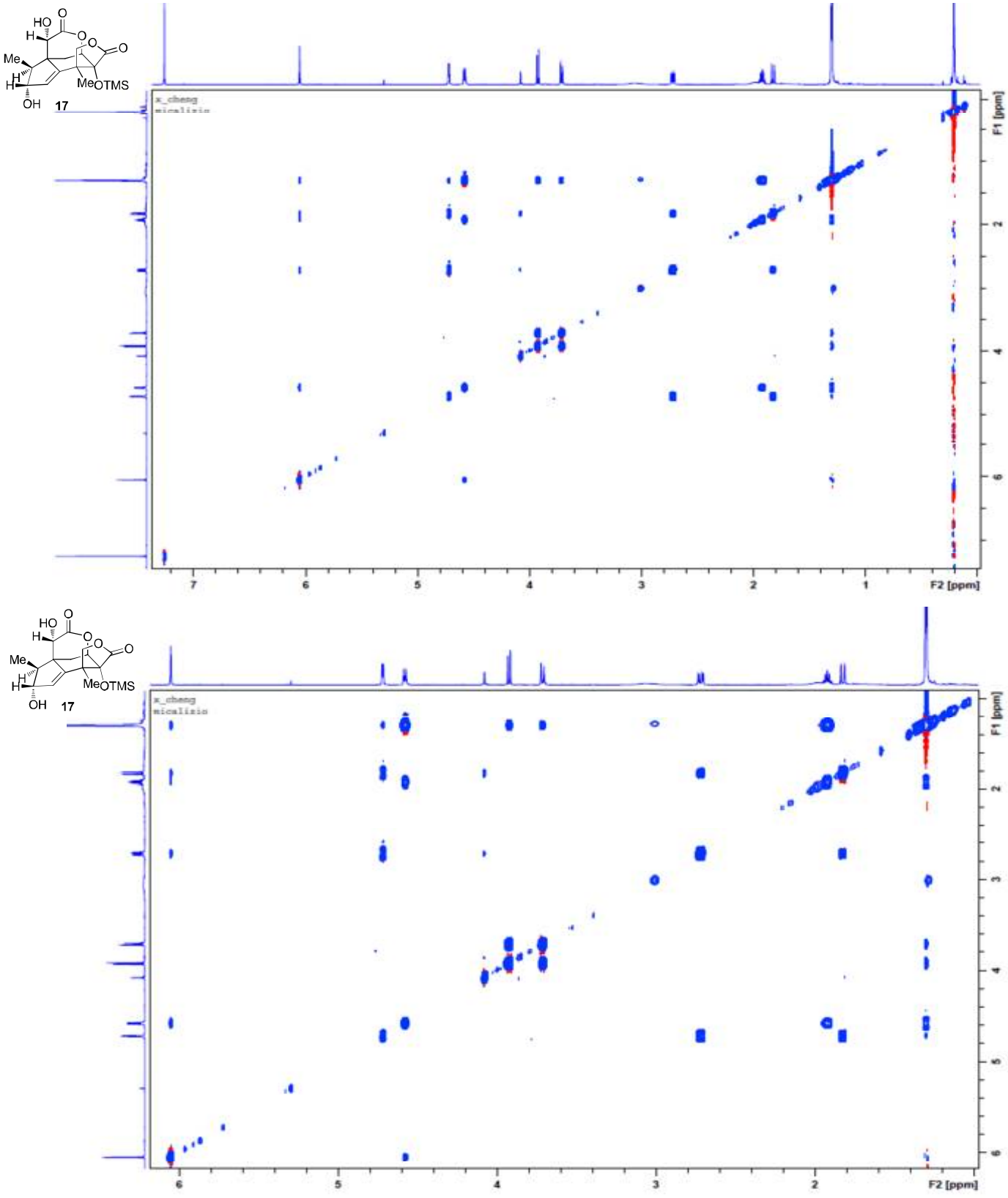


Figure S67: NOESY (600 MHz, $CDCl_3$) of **17**.

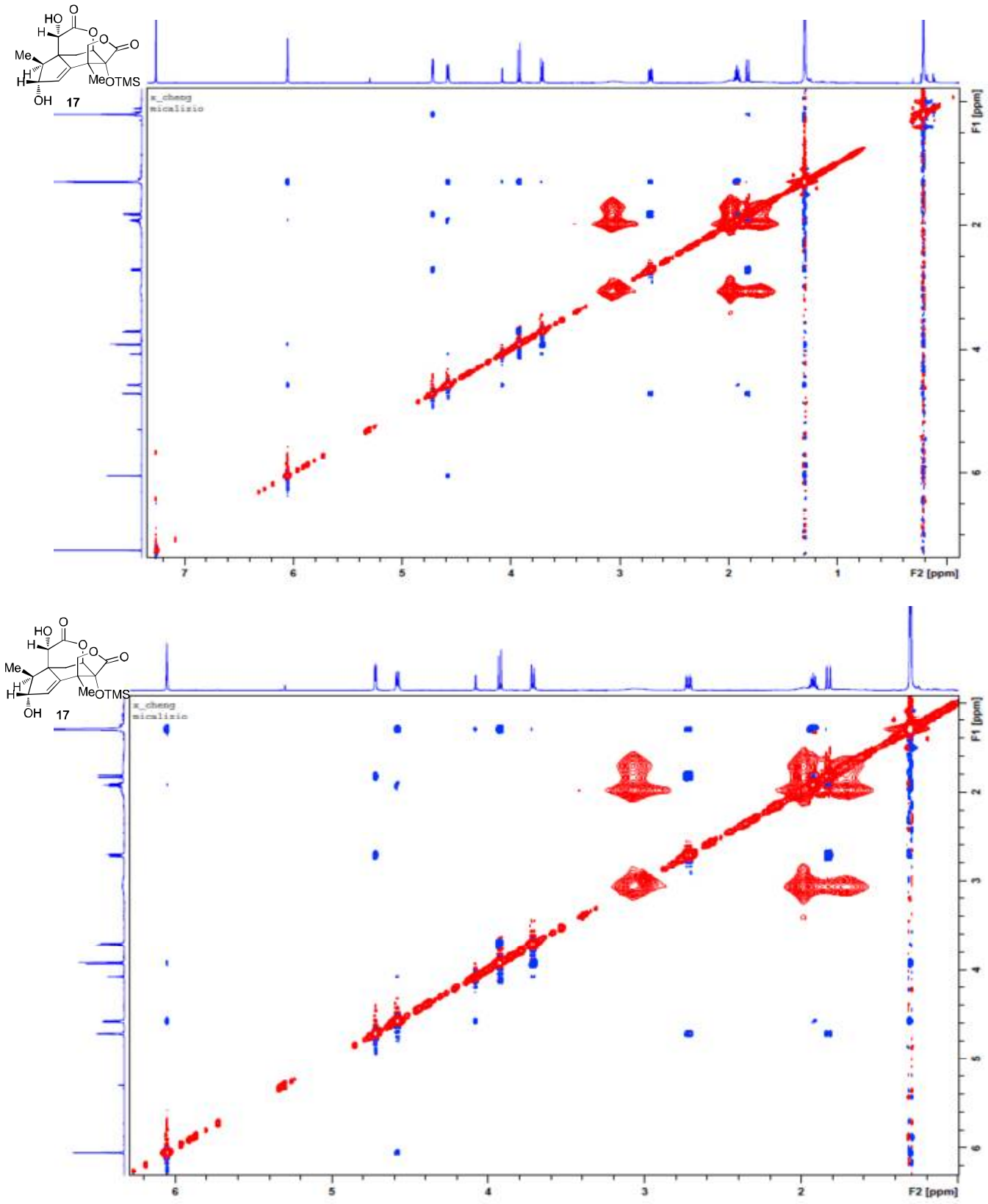


Figure S68: HMBC (600 MHz and 150 MHz, $CDCl_3$) of **17**.

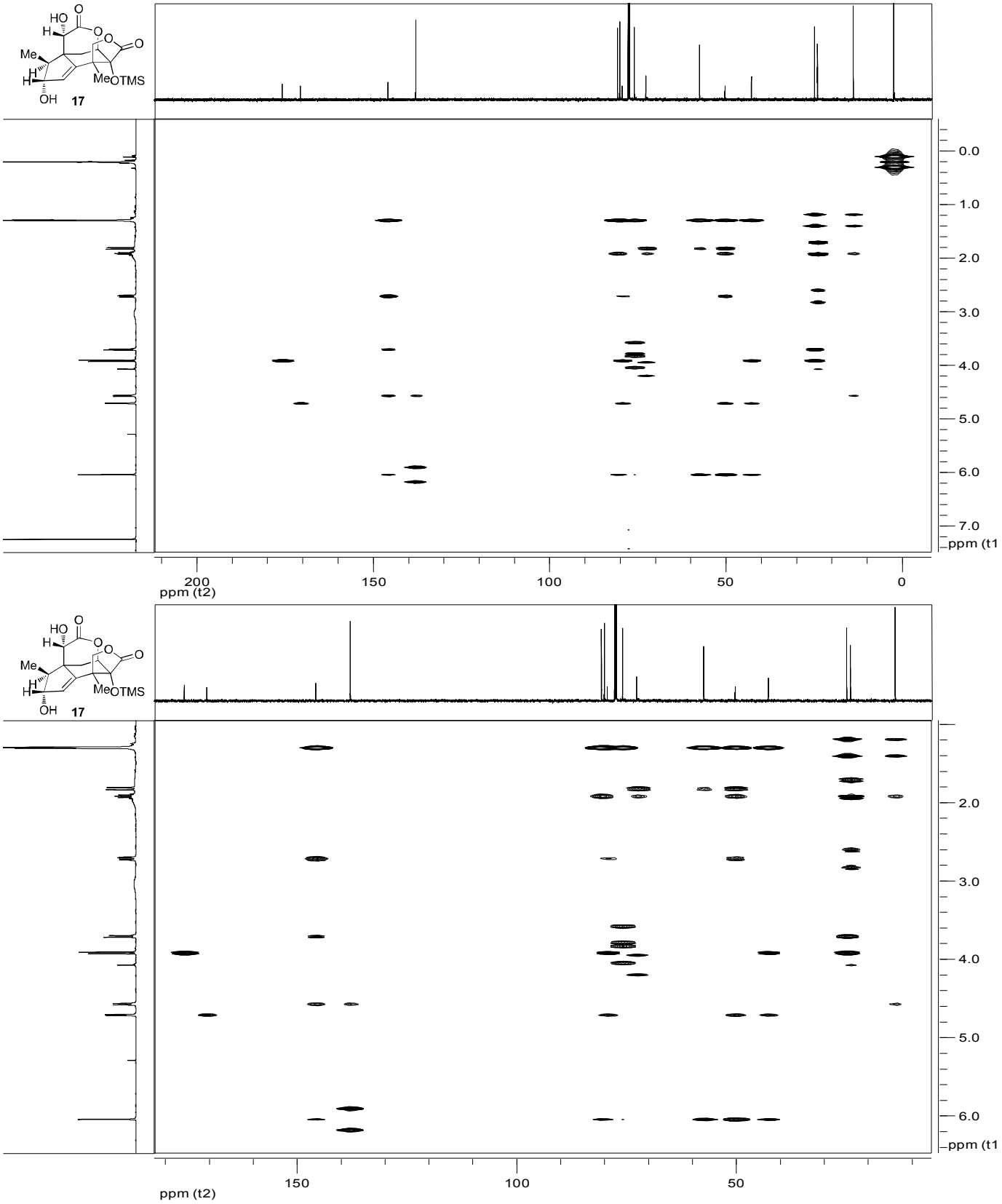
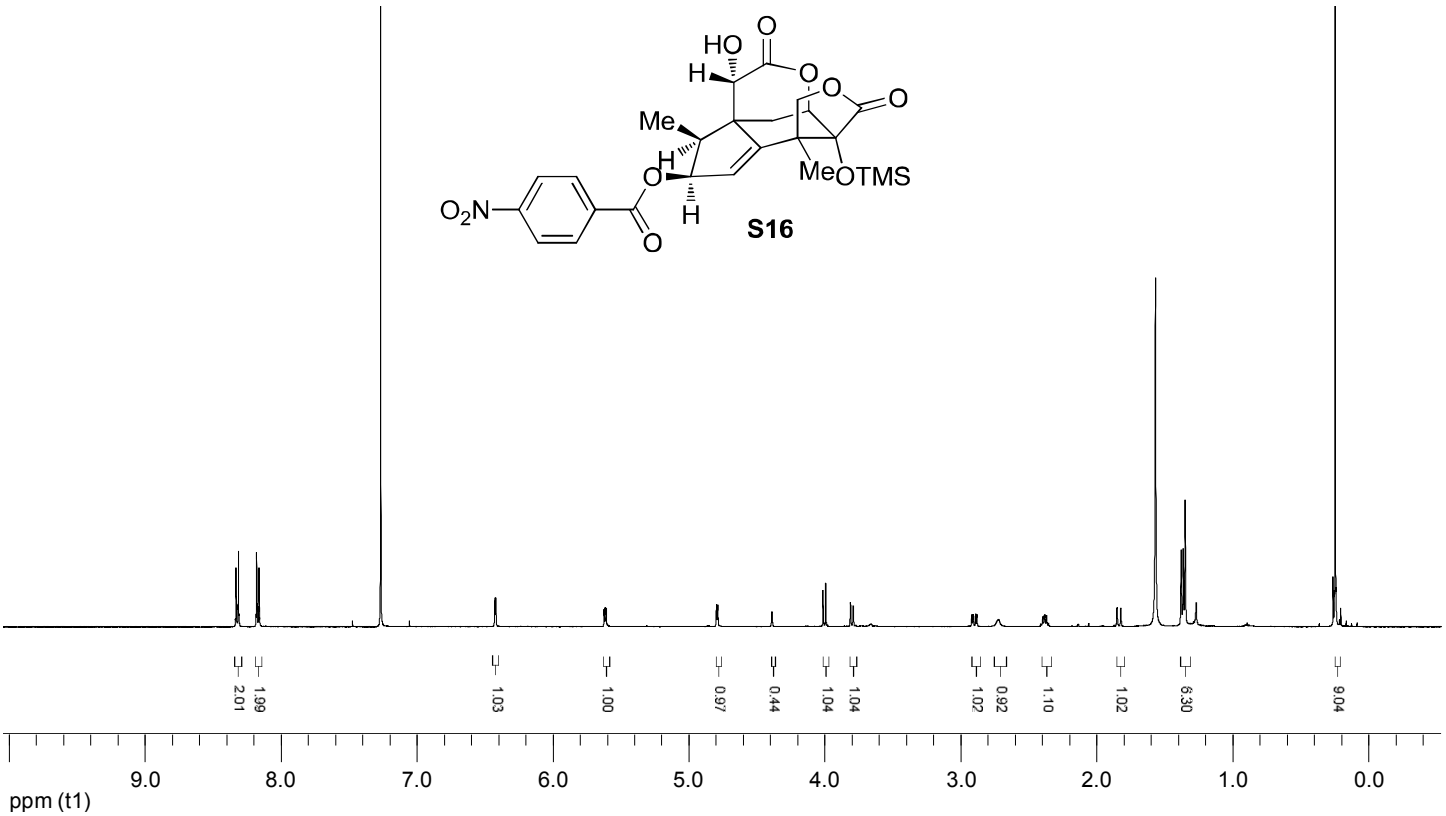


Figure S69: ^{1}H NMR (500 MHz, $CDCl_3$) and ^{13}C NMR (150 MHz, $CDCl_3$) of **S16**.



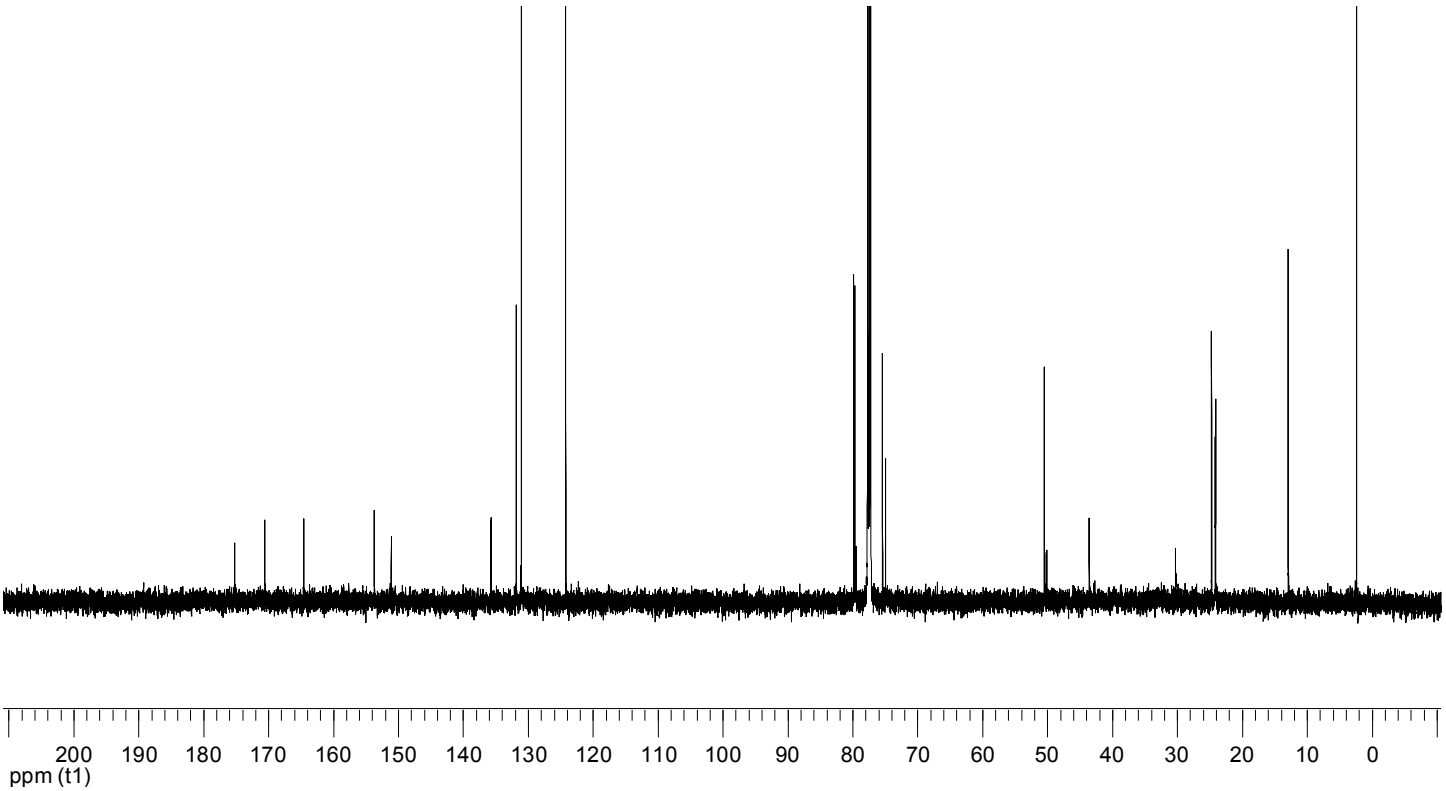


Figure S70: COSY (500 MHz, $CDCl_3$) of **S16**.

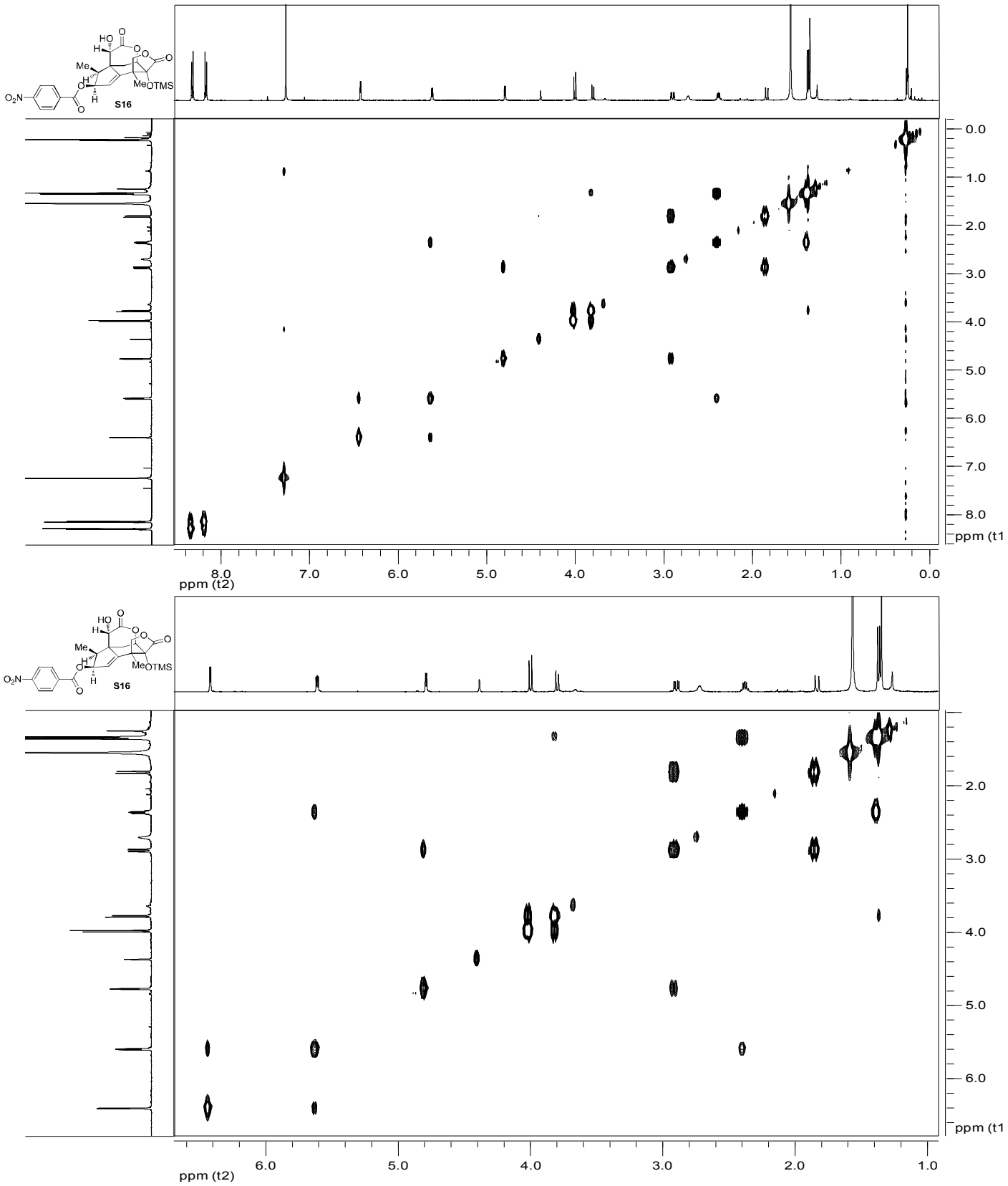


Figure S71: HMQC (500 MHz and 125 MHz, $CDCl_3$) of **S16**.

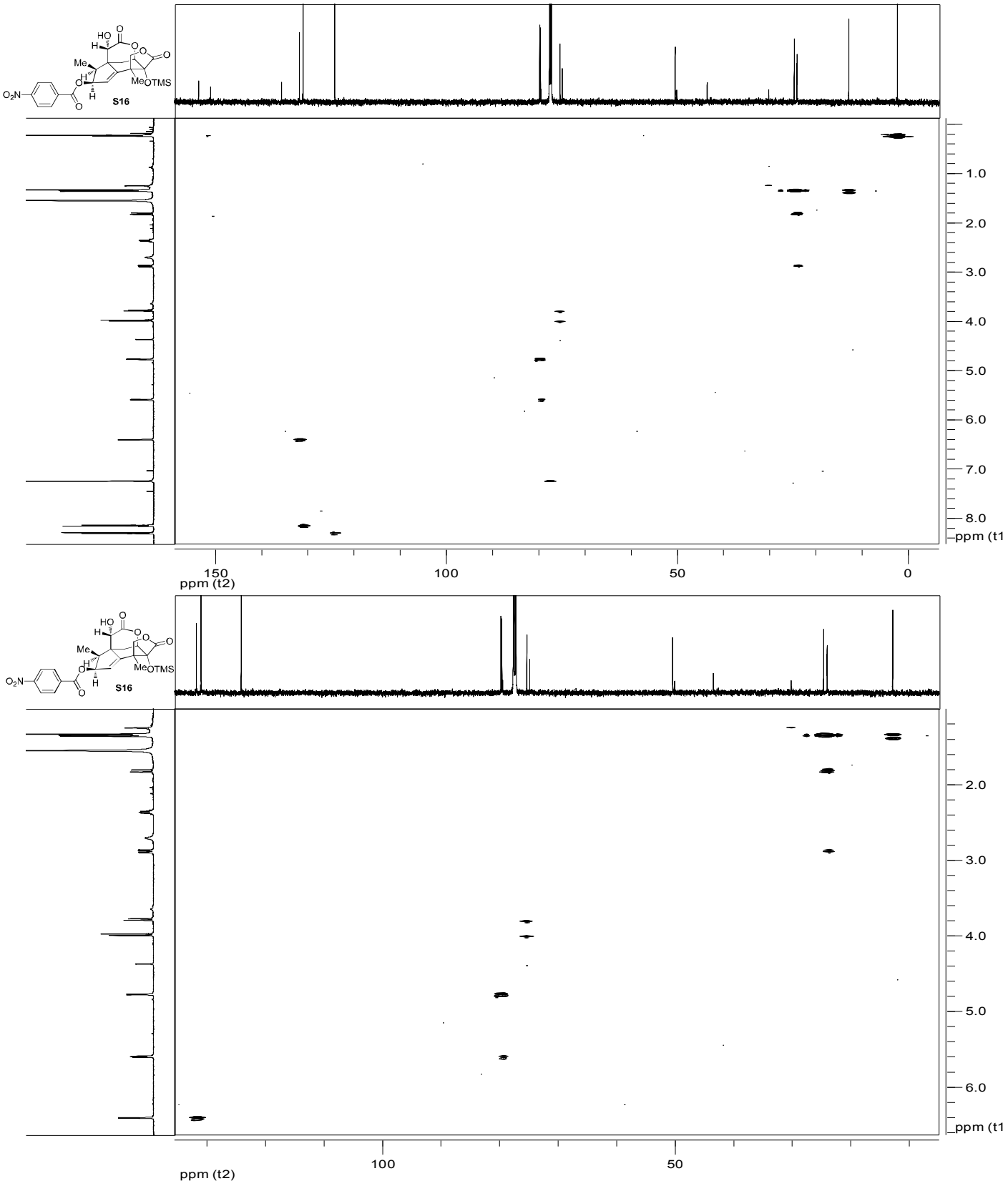


Figure S72: TOCSY (500 MHz, $CDCl_3$) of **S16**.

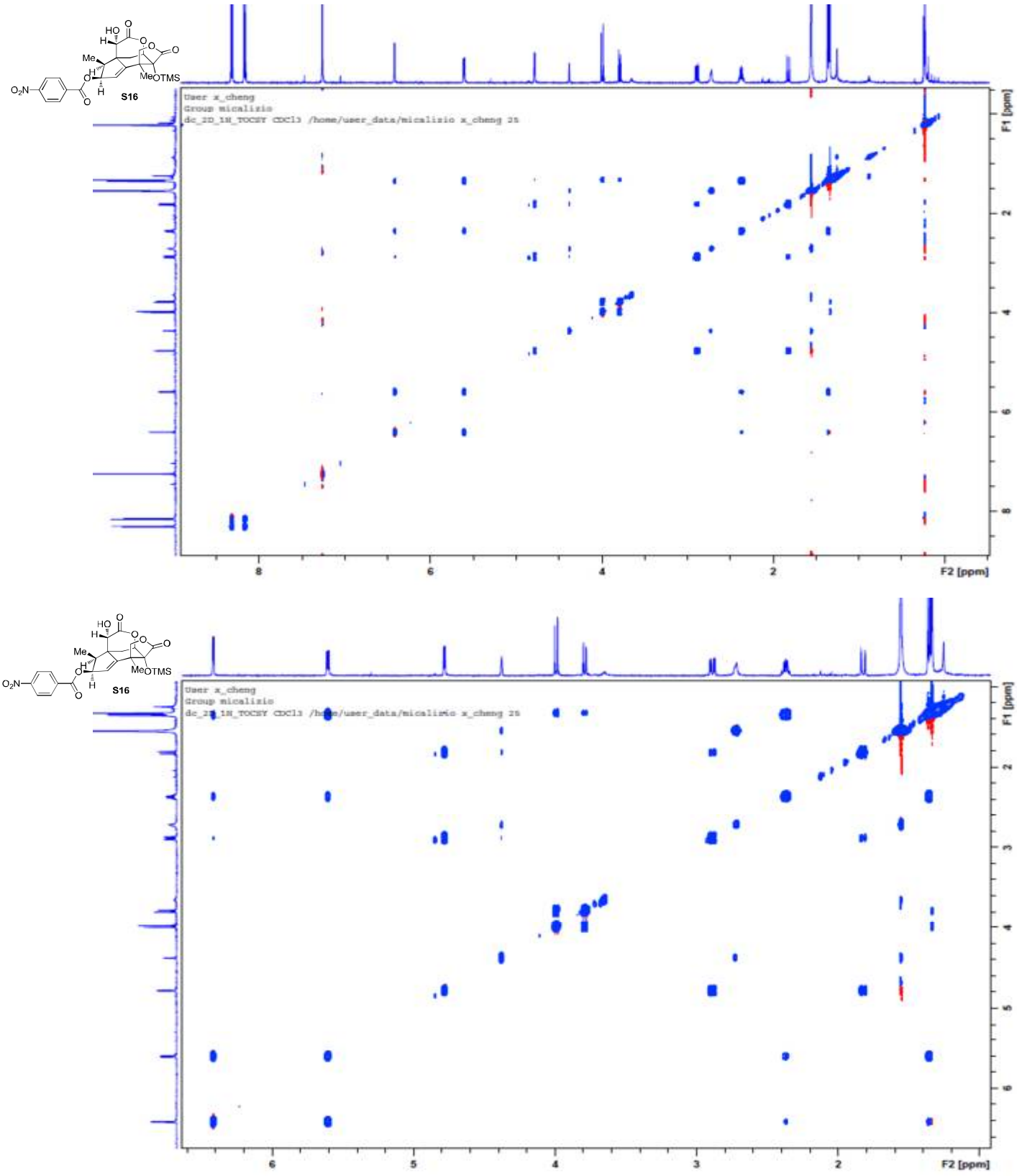


Figure S73: NOESY (600 MHz, $CDCl_3$) of **S16**.

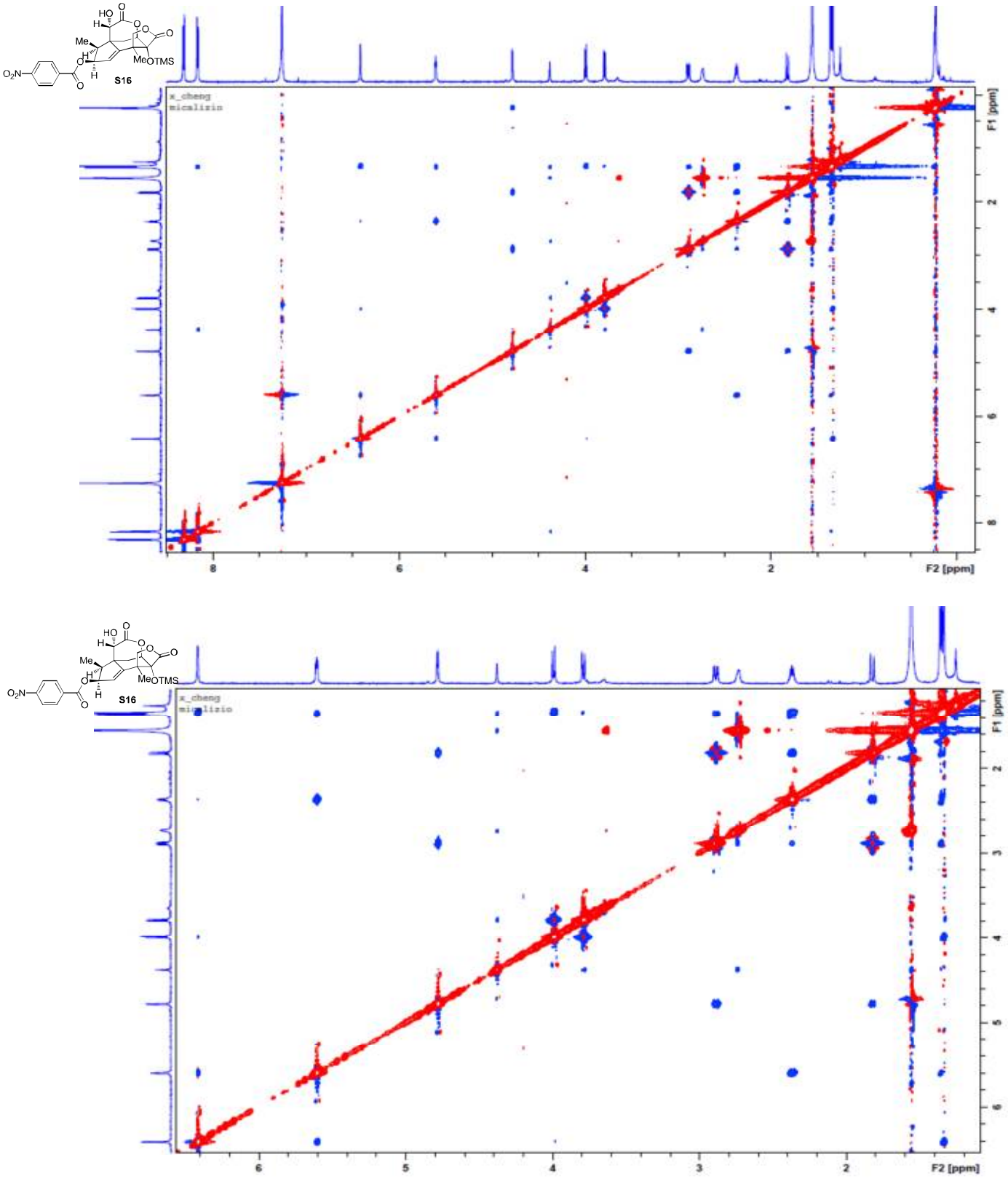


Figure S74: ^{1}H NMR (600 MHz, C_5D_5N-TMS and 500 MHz, CD_3OD) of **2** (contaminated with a C-10 nonhydroxylated compound, see below).

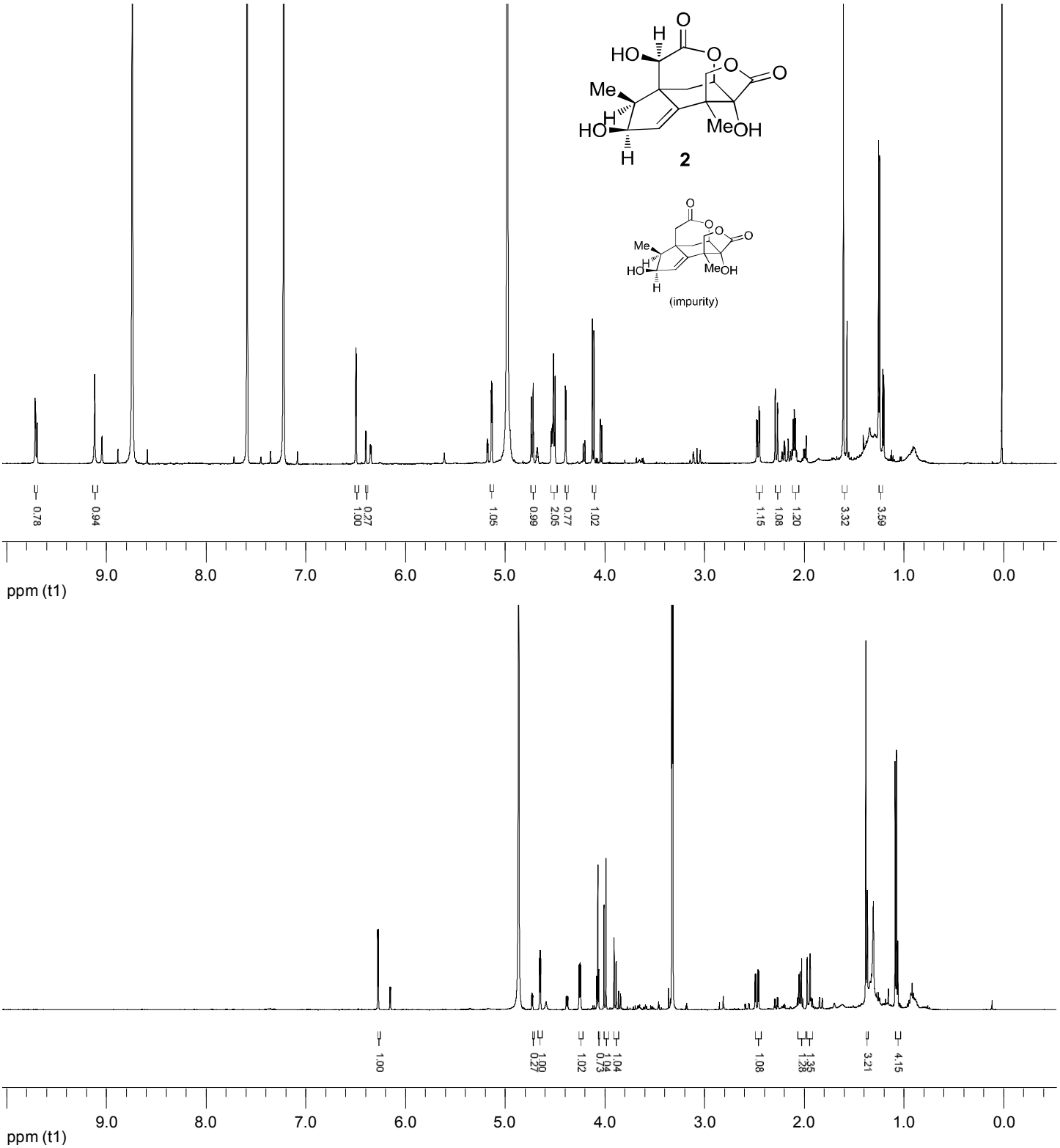
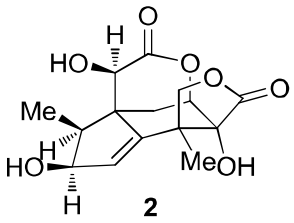


Figure S75: ^{13}C NMR (150 MHz, C_5D_5N-TMS) of **2**.



2

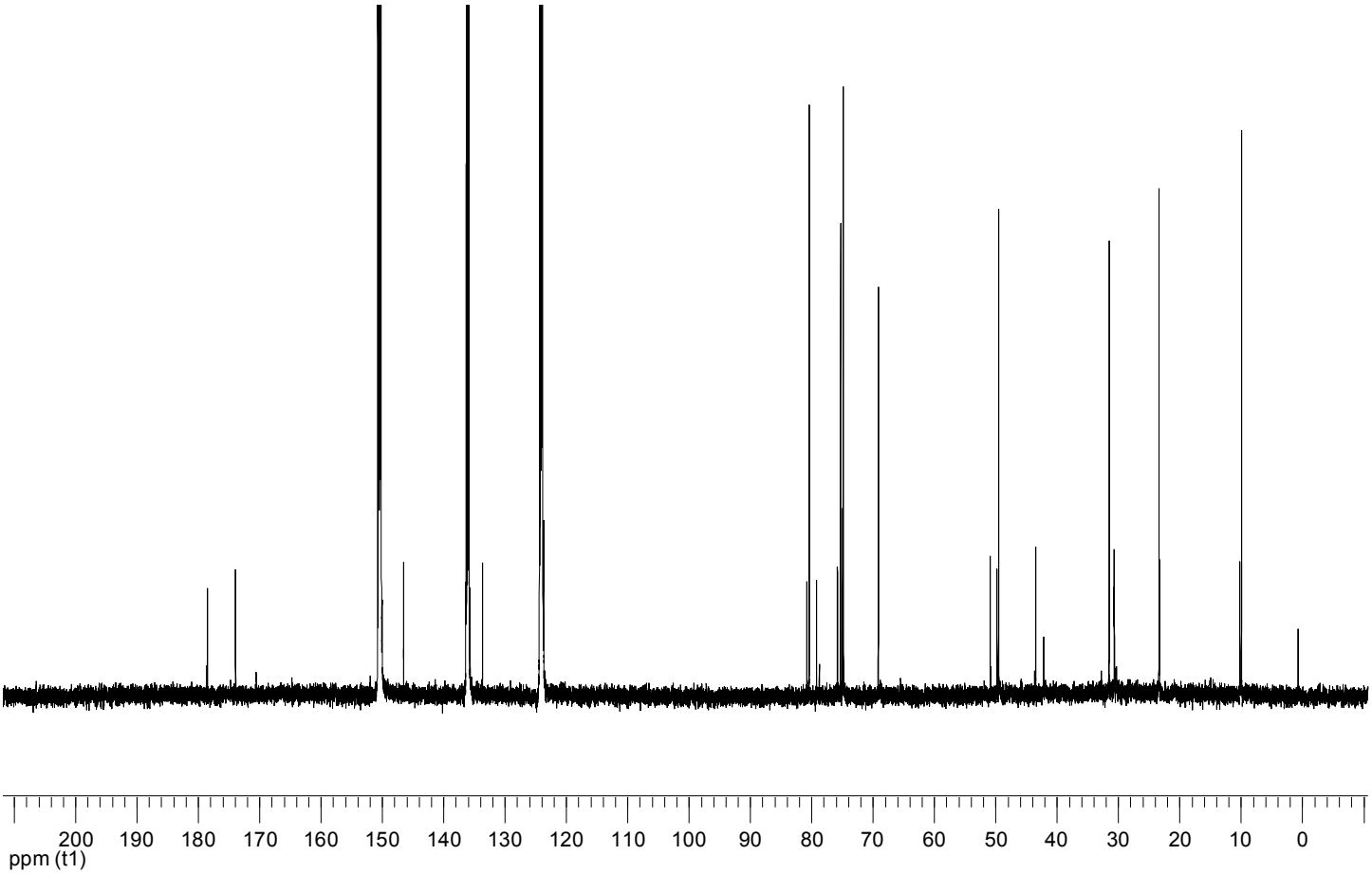


Figure S76: ^{1}H NMR (600 MHz, C_5D_5N-TMS and 600 MHz, CD_3OD) of repurified **2**.

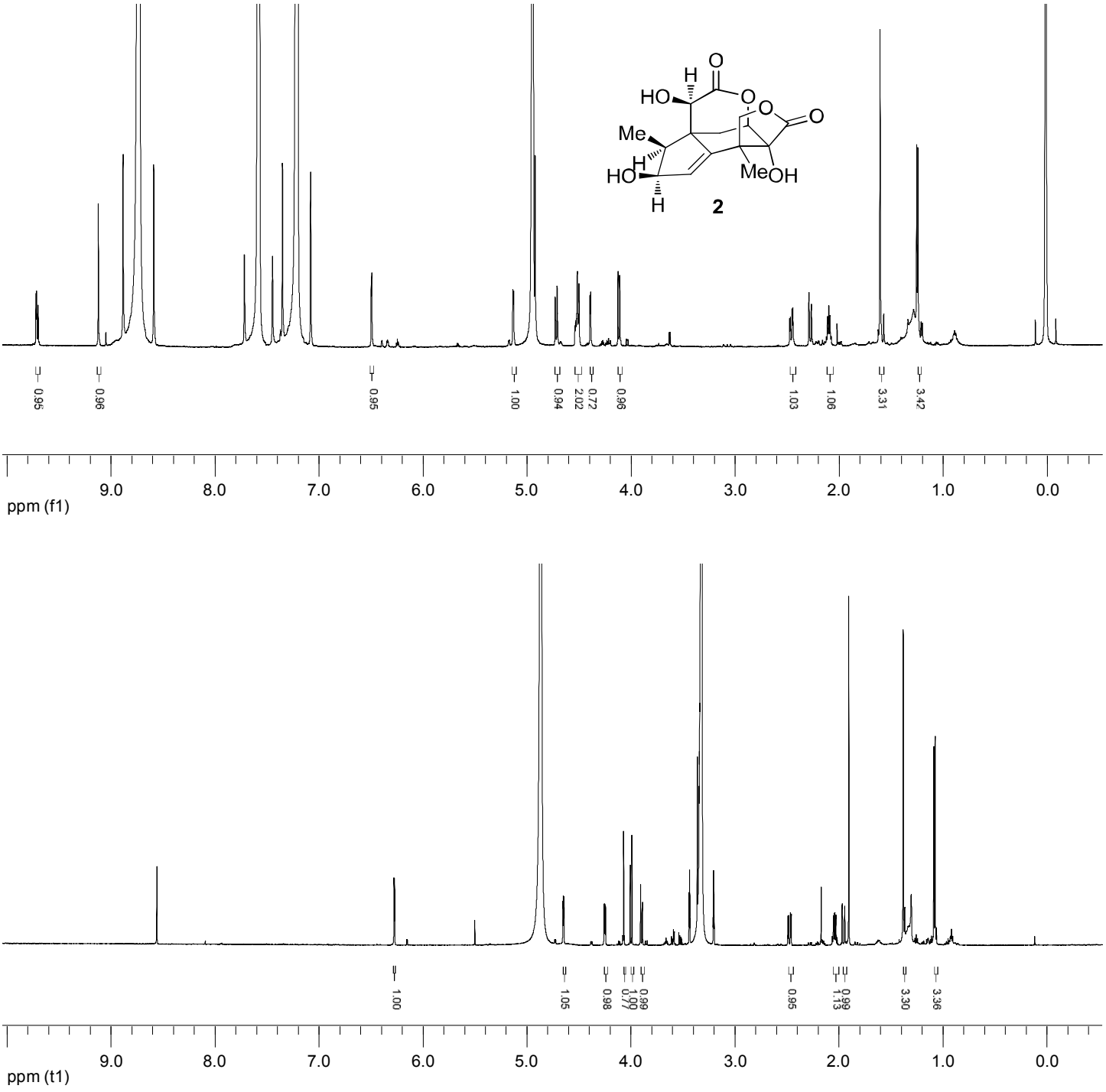


Figure S77: COSY (600 MHz, C_5D_5N-TMS) of **2**.

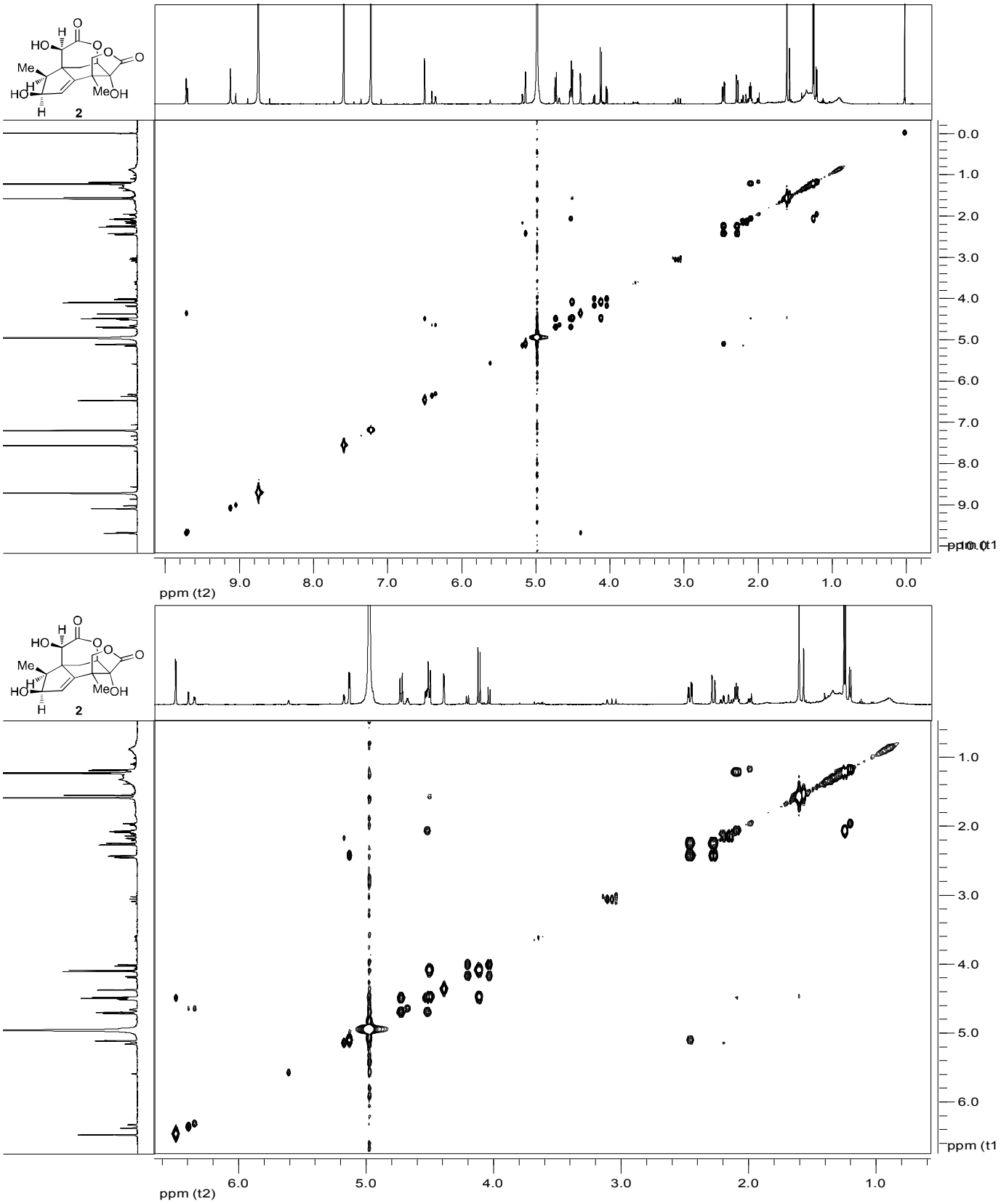


Figure S78: HMQC (600 MHz and 150 MHz, C_5D_5N-TMS) of **2**.

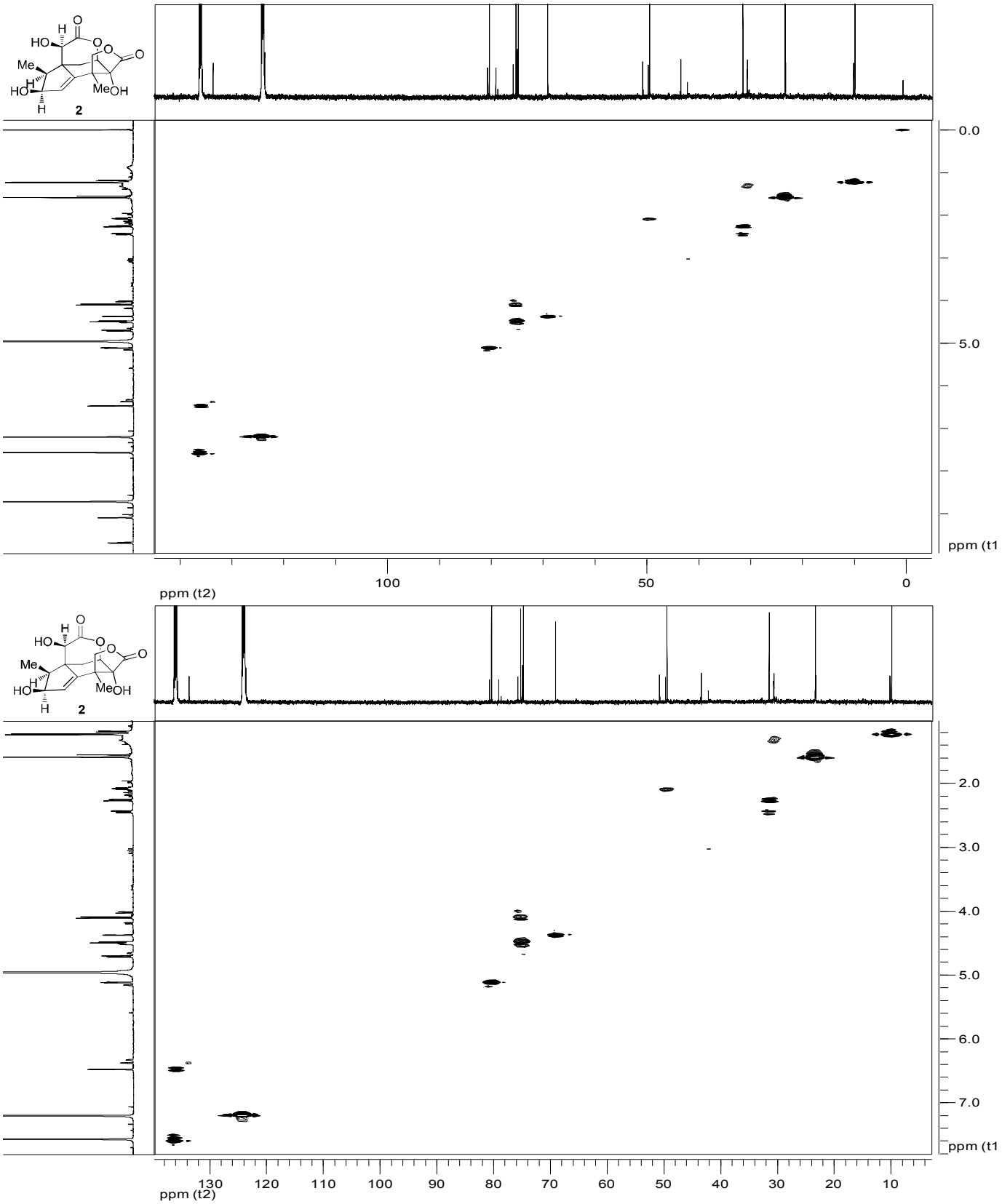


Figure S79: TOCSY (600 MHz, C_5D_5N-TMS) of **2**.

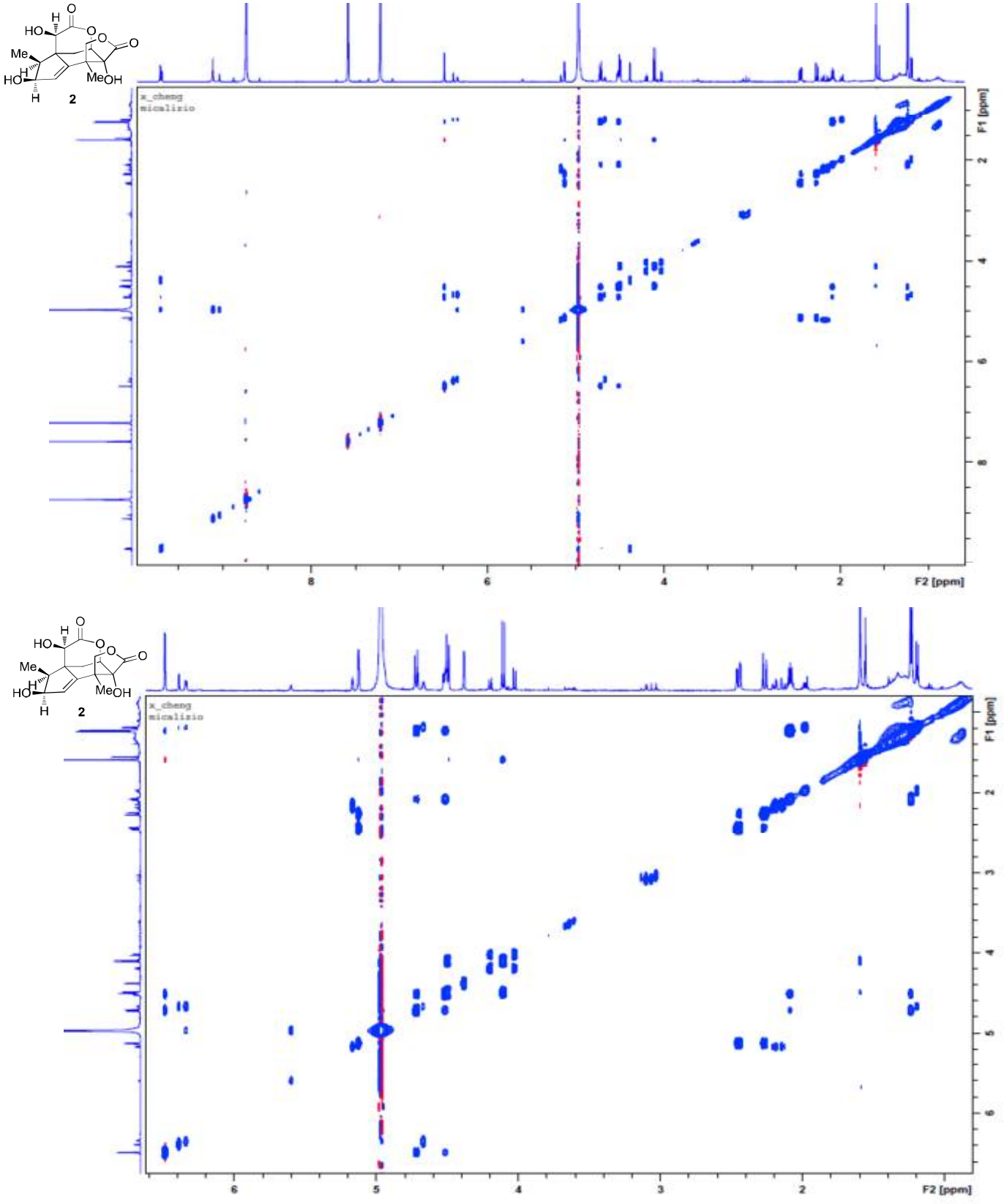


Figure S80: NOESY (600 MHz, C_5D_5N-TMS) of **2**.

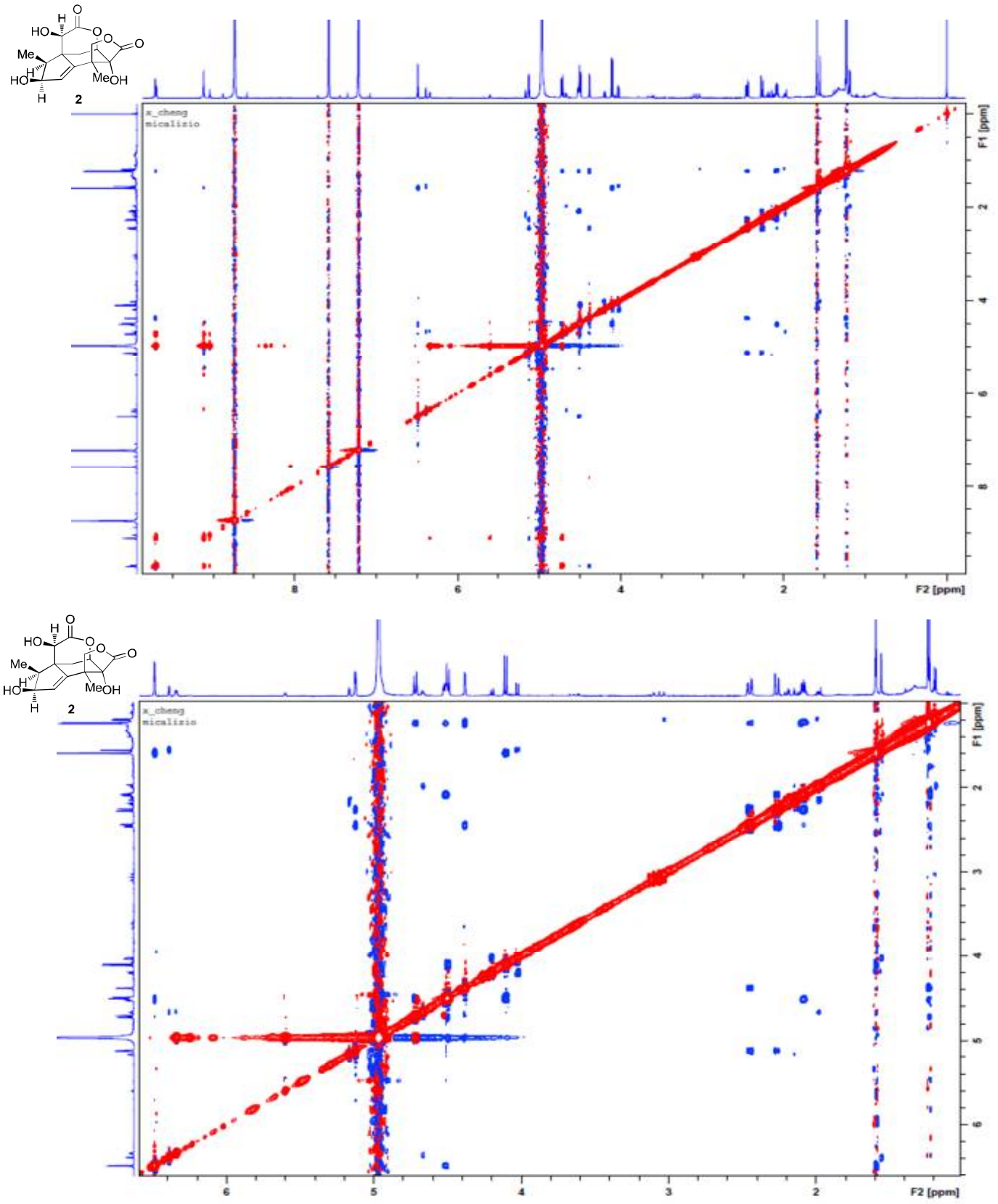


Figure S81: HMBC (600 MHz and 150 MHz, C_5D_5N-TMS) of **2**.