Biomimetic synthesis of *Sinularia* meroterpenoids and photochemical reactivity of capillobenzopyranol

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Supporting Information

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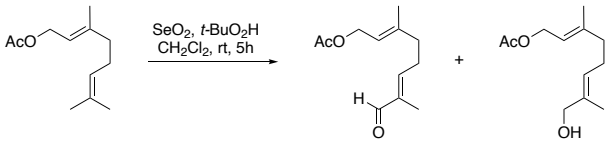
1. General Methods

All chemicals used were purchased from commercial suppliers and used as received unless specified otherwise. All reactions using dried solvents were performed under an inert atmosphere of N_2. All organic extracts were dried over anhydrous magnesium sulfate or sodium sulfate. Thin layer chromatography was performed using aluminium sheets coated with silica gel F254. Visualization was aided by viewing under a UV lamp and staining with ceric ammonium molybdate (CAM), $KMnO_4$ or vanillin followed by heating. The TLC stain solutions were prepared as follows. CAM stain: to a mixture of $Ce(SO_4)_2$ (1.2 g), $(NH_4)_6Mo_7O_{24}.4H_2O$ (6.2 g) in H_2O (90 mL) was added conc. sulfuric acid (10 mL) and the mixture was stirred until homogeneous. Vanillin stain: vanillin (6 g) was dissolved in EtOH (95 mL) followed by addition of conc. sulfuric acid (1.5 mL). $KMnO_4$ stain: $KMnO_4$ (0.75 g) and K_2CO_3 (5 g) were dissolved in H_2O (100 mL) and aq. NaOH (10%, 1 mL) was added. All R_f values were measured to the nearest 0.05. Flash column chromatography was performed using 40-63 micron grade silica gel. High field NMR spectra were recorded using either a 500 MHz spectrometer (^1H at 500 MHz, ^{13}C at 125 MHz) or 600 MHz spectrometer (^1H at 600 MHz, ^{13}C at 150 MHz). The solvent used for NMR spectra was $CDCl_3$ unless otherwise specified. ^1H chemical shifts are reported in ppm on the δ-scale relative to $CDCl_3$ (δ 7.26), $(CH_3)_2CO$ (2.050) and C_6D_6 (7.610) and ^{13}C NMR chemical shifts are reported in ppm relative to $CDCl_3$ (δ 77.16), $(CH_3)_2CO$ (29.840) and C_6D_6 (128.060). Multiplicities are reported as (br) broad, (s) singlet, (d) doublet, (t) triplet, (q) quartet, (quin) quintet, (sext) sextet, (hept) heptet and (m) multiplet. All *J*-values were rounded to the nearest 0.1 Hz. ESI high resolution mass spectra were recorded on an Agilent 6230 TOF LC/MS mass spectrometer. Infrared spectra were recorded as the neat compounds using an FT-IR Shimadzu IRSpirit spectrometer fitted with an ATR head. Melting points were recorded on a digital melting point apparatus and are uncorrected.

2. Synthetic Procedures



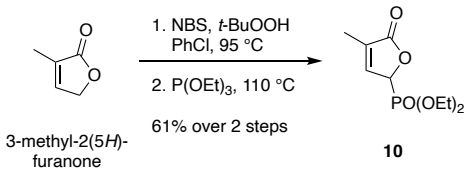
geranyl acetate **9** **SI-1**

To a solution of geranyl acetate (70%, 102 mmol, 31.4 mL, 1 equiv.) in CH_2Cl_2 (500 mL) was added SeO_2 (4.52 g, 40.7 mmol, 0.4 equiv.) and *t*-BuO_2H (57.4 mL, 316 mmol, 5.50 M in decane, 3.1 equiv.). The mixture was stirred for 5 hours at room temperature then quenched with a saturated aqueous solution of $Na_2S_2O_3$ (500 mL). The organic layer was separated, and the aqueous layer was further extracted with CH_2Cl_2 (2 x 150 mL). The combined organic extracts were washed with brine (400 mL) then dried with $MgSO_4$, filtered and concentrated *in vacuo*. The crude residue was purified by flash chromatography on SiO_2 using hexanes/EtOAc (10:1 → 2:1, gradient elution) to provide aldehyde **9** (7.07 g, 33%) followed by the allylic alcohol **SI-1** (6.15 g, 28%) both observed as colourless oils. Data for **9** and **SI-1** matched those previously reported in the literature.[1]

Data for aldehyde **9**:
R_f: 0.70 (2:1 hexanes/EtOAc)
^{1}H NMR (500 MHz, $CDCl_3$): δ 9.39 (s, 1H), 6.44 (t, *J* = 6.9 Hz, 1H), 5.38 (t, *J* = 7.5 Hz, 1H), 4.59 (d, *J* = 7.0 Hz, 2H), 2.49 (q, *J* = 7.5 Hz, 2H), 2.23 (t, *J* = 7.6 Hz, 2H), 2.05 (s, 3H), 1.75 (s, 3H), 1.74 (s, 3H) ppm.

Partial data for **SI-1**:
R_f: 0.45 (2:1 hexanes/EtOAc).
^{1}H NMR (500 MHz, $CDCl_3$): δ 5.47 – 5.32 (m, 2H), 4.58 (d, *J* = 7.1 Hz, 2H), 3.99 (s, 2H), 2.18 (q, *J* = 7.3 Hz, 2H), 2.11 – 2.07 (m, 2H), 2.05 (d, *J* = 0.9 Hz, 3H), 1.71 (s, 3H), 1.67 (s, 3H) ppm.

[1] F. M. Ippoliti, J. S. Barber, Y. Tang and N. K. Garg, *J. Org. Chem.*, 2018, **83**, 11323.



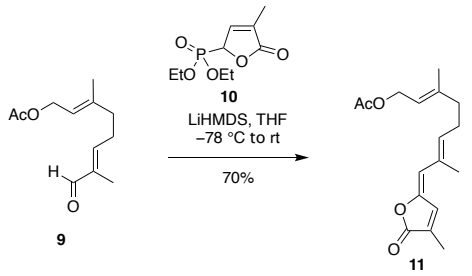
3-methyl-2(5*H*)-furanone

10

To a solution of 5-methyl-(2H)-furanone (4.40 mL, 50.97 mmol, 1 equiv.) in chlorobenzene (175 mL) was added NBS (9.97 g, 56.07 mmol, 1.1 equiv.) and *t*-BuOOH (0.46 mL, 2.54 mmol, 5.5 M in decane, 0.05 equiv.). The mixture was heated to 95 °C using a metal heating mantle for 3 hours, after which time starting material consumption was observed by TLC (visualised with $KMnO_4$ stain). The solution was cooled to room temperature and concentrated *in vacuo*. The residue was redissolved with EtOAc (200 mL) and washed with a saturated aqueous Na_2SO_3 solution (2 x 100 mL) then brine (100 mL). The organic layer was dried with $MgSO_4$, filtered and concentrated *in vacuo*. The orange oil was diluted with triethyl phosphite (8.3 mL, 48.4 mmol, 1 equiv.) and heated to 110 °C for 1 hour. The solution was cooled to room temperature and directly purified by flash chromatography on SiO_2 using hexanes/EtOAc (1:1 → 1:3, gradient elution) to provide phosphonate **10** as a pale-yellow oil (6.95 g, 61% over two steps). Data for **10** matched that previously reported in the literature.[2]

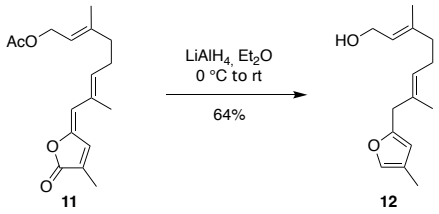
Partial data for phosphonate **10**:
R_f: 0.30 (1:3 hexanes/EtOAc, visualise with CAM stain and gentle heating).
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.19 (q, *J* = 1.9 Hz, 1H), 5.16 (dt, *J* = 15.2, 2.2 Hz, 1H), 4.27 – 4.21 (m, 2H), 4.21 – 4.14 (m, 2H), 1.98 (ddd, *J* = 4.7, 2.2, 1.6 Hz, 3H), 1.37 (t, *J* = 7.1 Hz, 3H), 1.31 (td, *J* = 7.1, 0.6 Hz, 3H) ppm.

[2] P. Yang, M. Yao, J. Li, Y. Li and A. Li, *Angew. Chem. Int. Ed.*, 2016, **55**, 6964.



To phosphonate **10** (1.86 g, 7.94 mmol, 1.1 equiv.) was added anhydrous THF (40 mL) and the solution was cooled to –78 °C. LiHMDS (8.65 mL, 1M in THF, 8.85 mmol, 1.2 equiv.) was added before the solution was warmed to room temperature and stirring continued for 15 minutes. A solution of aldehyde **9** (1.52 g, 7.21 mmol, 1 equiv.) in anhydrous THF (15 mL) was then added at this temperature. The mixture was stirred for a further 2 hours before 1M HCl (50 mL) was added. The organic layer was separated, and the aqueous layer was extracted with Et_2O (3 x 50 mL). The combined organic extracts were washed with brine (100 mL), dried with $MgSO_4$ then filtered and concentrated *in vacuo*. The orange oil residue was purified by flash chromatography on SiO_2 using hexanes/EtOAc (8:1 → 4:1, gradient elution) to provide butenolide **11** (1.47 g, 70%) as a pale yellow wax.

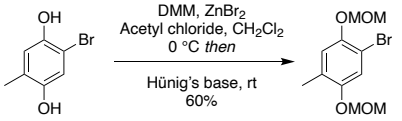
Data for butenolide **11**:
R_f: 0.50 (4:1 hexanes/EtOAc).
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.44 (s, 1H), 6.22 (s, 1H), 5.71 (t, *J* = 7.1 Hz, 1H), 5.36 (tt, *J* = 5.6, 2.8 Hz, 1H), 4.59 (d, *J* = 7.0 Hz, 2H), 2.34 (q, *J* = 7.6 Hz, 2H), 2.15 (t, *J* = 7.6 Hz, 2H), 2.05 (s, 3H), 2.04 (s, 3H), 1.92 (s, 3H), 1.72 (s, 3H) ppm.
^{13}C NMR (125 MHz, $CDCl_3$): δ 171.2, 170.6, 147.1, 141.2, 138.6, 135.0, 131.1, 130.3, 119.3, 119.2, 61.4, 38.8, 26.9, 21.2, 16.6, 15.6, 11.0 ppm.
HRMS (ESI): calculated for $C_{17}H_{23}O_4$ $[M+H]^+$, 291.1518, found 291.1519.
IR (neat): 2928, 1751, 1650, 1002, 954 cm^{-1}.



A solution of butenolide **11** (2.88 g, 9.93 mmol, 1 equiv.) in Et_2O (150 mL) was cooled to 0 °C then $LiAlH_4$ (14.9 mL, 29.8 mmol, 2 M in THF, 3 equiv.) was added at a dropwise rate. The solution was allowed to warm to room temperature. After 1.5 hours the solution was cooled in an ice bath and a saturated aqueous solution of Rochelle's salt (150 mL) was added – initially at a dropwise rate. Once added, the mixture was vigorously stirred for 1.5 hours for two distinct layers to form. The aqueous layer was then extracted with Et_2O (3 x 75 mL). The combined organic extracts were washed with brine (100 mL), dried with $MgSO_4$ then filtered and concentrated *in vacuo*. The residue was purified by flash chromatography on SiO_2 using hexanes/EtOAc (4:1) to provide alcohol **12** (1.59 g, 64%) as a colourless oil. ^{1}H NMR was consistent with that previously reported.[3]

Partial data for alcohol **12**:
R_f: 0.25 (4:1 hexanes/EtOAc).
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.09 – 7.05 (m, 1H), 5.87 (s, 1H), 5.41 (ddd, *J* = 8.2, 5.6, 1.3 Hz, 1H), 5.24 – 5.17 (m, 1H), 4.14 (d, *J* = 6.9 Hz, 2H), 3.23 (s, 2H), 2.16 (q, *J* = 7.3 Hz, 2H), 2.10 – 2.03 (m, 2H), 1.99 (s, 3H), 1.68 (s, 3H), 1.60 (s, 3H) ppm.

[3] C. W. Jefford, J.-C. Rossier, J. Boukouvalas, A. W. Sledeski and P.-Z Huang, *J. Nat. Prod.*, 2004, **67**, 1383.



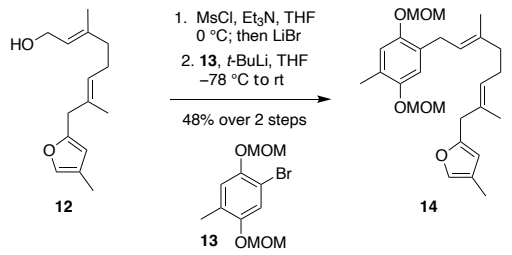
2-bromo-5-methyl hydroquinone

13

Procedure adapted from Berliner.[4] To a solution of dimethoxymethane (8.1 mL, 91.15 mmol, 4 equiv.) in CH_2Cl_2 (45 mL) was added $ZnBr_2$ (51 mg, 0.23 mmol, 0.01 equiv.) at room temperature under N_2. Acetyl chloride (6.5 mL, 91.15 mmol, 4 equiv.) was added dropwise and the solution was stirred for 1 hour before cooling to 0 °C. Solid 2-bromo-5-methyl hydroquinone (4.6 g, 22.7 mmol, 1 equiv.) was added neat in 2 portions with stirring between each addition until dissolved. Hünig's base (16 mL, 91.15 mmol, 4 equiv.) was then added slowly, initially at a rate of 1 mL over 5 minutes [CAUTION: gas evolution] while a bleed needle was inserted through the septum. Once the addition was complete, the solution was brought to room temperature and stirred for 24 hours. H_2O (10 mL) was added to the reaction mixture followed by aqueous 1M HCl (60 mL) and stirring continued for 15 minutes. The aqueous layer was extracted with CH_2Cl_2 (3 x 50 mL) and the combined organic extracts were washed with brine (75 mL), dried with $MgSO_4$ then filtered and concentrated *in vacuo*. The yellow solid was recrystallised from 95% EtOH to provide aryl bromide **13** (3.96 g, 60%) as pale brown needles. ^{1}H NMR was consistent with that previously reported.[5]

Partial data for aryl bromide **13**:
R_f: 0.45 (8:1 hexanes/EtOAc).
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.25 (s, 1H), 6.96 (s, 1H), 5.16 (s, 2H), 5.12 (s, 2H), 3.53 (s, 3H), 3.48 (s, 3H), 2.19 (s, 3H) ppm.

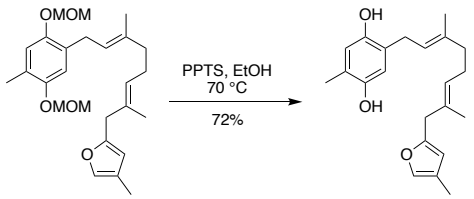
[4] M. Berliner and K. Belecki. *J. Org. Chem.* **2005**, *70*, 9618.
[5] J. R. Vyvyan, C. Loitz, R. E. Looper, C. S. Mattingly, E. A. Peterson and S. T. Staben. *J. Org. Chem.* **2004**, *69*, 2461.



A solution of alcohol **12** (1.00 g, 4.27 mmol, 1 equiv.) in anhydrous THF (16 mL) was cooled to 0 °C under N_2 and protected from light. MsCl (0.50 mL, 6.41 mmol, 1.5 equiv.) was added dropwise followed by Et_3N (1.18 mL, 8.54 mmol, 2 equiv.). The solution was stirred for 45 minutes at this temperature. Meanwhile, LiBr was dried with a heat gun under high vacuum for 5 minutes. Once cooled, the solid was dissolved in anhydrous THF to provide a 1.5 M stock solution. To the reaction mixture was added freshly prepared 1.5 M LiBr solution in THF (5.7 mL, 17.09 mmol, 4 equiv.) and stirring continued for a further 45 minutes. The solution was then diluted with H_2O (10 mL) and the aqueous layer was extracted with Et_2O (3 x 30 mL). The organic extracts were washed with a saturated aqueous $NaHCO_3$ solution (2 x 20 mL) then brine (2 x 20 mL), dried with $MgSO_4$ then filtered and concentrated *in vacuo* at 25 °C while protected from light. The resulting alkyl bromide intermediate was further dried under vacuum for 15 minutes then used immediately.

Aryl bromide **13** (1.62 g, 5.55 mmol, 1.3 equiv.) was dissolved in anhydrous THF (25 mL) in an oven dried flask then cooled to –78 °C. *t*-BuLi (6.5 mL, 5.56 mmol, 1.7 M in pentane, 3.6 equiv.) was added dropwise over 5 minutes. After stirring for 15 minutes, a solution of freshly prepared alkyl bromide in anhydrous THF (6 mL) and added at this temperature. Following the addition, the reaction warmed to room temperature to stir for 3 hours before a saturated aqueous NH_4Cl solution (30 mL) was added. The aqueous layer was extracted with EtOAc (3 x 15 mL). The combined organic extracts were then washed with brine (50 mL), dried with $MgSO_4$ then filtered and concentrated *in vacuo*. The brown residue was purified by flash chromatography on SiO_2 using CH_2Cl_2/hexanes (2:3 → 1:1, gradient elution) to provide hydroquinone **14** (882 mg, 48% over two steps) as a light brown oil.

Data for hydroquinone **14**:
R_f: 0.40 (8:1 hexanes/EtOAc).
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.06 (s, 1H), 6.87 (s, 1H), 6.86 (s, 1H), 5.86 (s, 1H), 5.34 – 5.27 (m, 1H), 5.24 (t, J = 6.8 Hz, 1H), 5.12 (s, 2H), 5.11 (s, 2H), 3.48 (s, 6H), 3.30 (d, J = 7.2 Hz, 2H), 3.22 (s, 2H), 2.21 (s, 3H), 2.17 – 2.10 (m, 2H), 2.08 – 2.02 (m, 2H), 1.98 (s, 3H), 1.71 (s, 3H), 1.59 (s, 3H) ppm.
^{13}C NMR (125 MHz, $CDCl_3$): δ 154.6, 150.4, 149.8, 137.8, 136.0, 131.9, 129.3, 126.8, 126.0, 122.9, 120.6, 117.5, 116.5, 108.9, 95.6, 95.3, 56.1, 56.1, 39.7, 38.6, 28.6, 27.0, 16.3, 16.3, 16.0, 10.0 ppm.
HRMS (ESI): calculated for $C_{26}H_{37}O_5$ $[M+H]^+$ 429.2636, found 429.2640.
IR (neat): 2922, 1505, 1147, 1007 cm^{-1}.
*Note: Compound **14** was observed to be unstable overtime hence trace impurities are observed in the NMR spectra.*



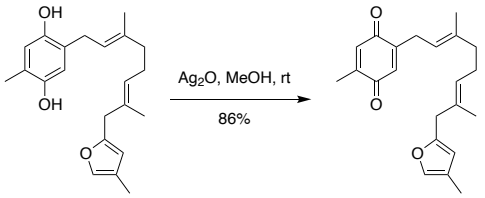
14 **3**: furanoquinol

To a solution containing **14** (523 mg, 1.22 mmol, 1 equiv.) in EtOH (20 mL) was added pyridinium *p*-toluenesulfonate (1.22 g, 4.88 mmol, 4 equiv.) at room temperature. The solution was heated to 70 °C using a metal heating mantle, under N_2 while protected from light. After refluxing for 8 hours starting material consumption was observed by TLC and the mixture was diluted with H_2O (20 mL), then EtOAc (25 mL) and brine (2 mL). The aqueous phase was extracted with EtOAc (3 x 20 mL), then the combined organic phases were washed with brine (2 x 50 mL), dried with Na_2SO_4 then filtered and concentrated at 25 °C *in vacuo*, while protected from light. The crude was recrystallised from a Et_2O/hexanes mixture twice to afford furanoquinol (**3**) (297 mg, 72%) as a yellow solid. Data matched that previously reported following the isolation of **3**.[6]

Data for furanoquinol (**3**):
R_f: 0.30 (4:1 hexanes/EtOAc).
^{1}H NMR (600 MHz, C_6D_6): δ 6.97 (t, *J* = 1.2 Hz, 1H), 6.32 (s, 1H), 6.28 (s, 1H), 5.83 (s, 1H), 5.37 (tq, *J* = 7.3, 1.4 Hz, 1H), 5.26 (tq, *J* = 7.0, 1.4 Hz, 1H), 4.10 (s, 1H), 3.76 (s, 1H), 3.28 (d, *J* = 7.2 Hz, 2H), 3.24 (s, 2H), 2.10 (q, *J* = 7.2 Hz, 2H), 2.04 (s, 3H), 2.03 – 2.01 (m, 2H), 1.81 (d, *J* = 1.2 Hz, 3H), 1.58 (s, 3H), 1.55 (s, 3H) ppm.
^{13}C NMR (150 MHz, C_6D_6): δ 154.9, 148.2, 148.1, 138.2, 136.9, 132.4, 126.7, 125.6, 123.0, 122.5, 120.8, 118.2, 116.4, 109.3, 39.8, 38.9, 29.2, 26.8, 16.1, 16.0, 15.6, 9.9 ppm.
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.07 (s, 1H), 6.59 (s, 1H), 6.54 (s, 1H), 5.87 (s, 1H), 5.29 (t, *J* = 7.1 Hz, 1H), 5.20 (t, *J* = 7.0 Hz, 1H), 4.51 (br s, 2H), 3.27 (d, *J* = 7.6 Hz, 2H), 3.23 (s, 2H), 2.17 (s, 3H), 2.16 (m, 1H), 2.12 – 2.09 (m, 2H), 1.98 (s, 3H), 1.74 (s, 3H), 1.60 (s, 3H) ppm.
^{13}C NMR (150 MHz, $CDCl_3$): δ 154.5, 147.9, 147.6, 138.1, 137.9, 132.4, 126.3, 125.4, 122.6, 122.0, 120.7, 118.2, 116.3, 109.0, 39.5, 38.6, 29.3, 26.5, 16.3, 16.1, 15.6, 10.0 ppm.
HRMS (ESI): calculated $C_{22}H_{29}O_3$ $[M+H]^+$ 341.2111, found 341.2112.
IR (neat): 3336, 2925, 2362, 1418, 1185 cm^{-1}.

*Note: Furanoquinol (**3**) was observed to be unstable on SiO_2, after prolonged periods under aerobic conditions or in some organic solvents (e.g. $CDCl_3$), hence trace impurities are present in the synthetic sample by NMR.*

[6] J. C. Coll, N. Liyanage, G. J. Stokie, I. Van Altena, J. N. E. Nemorin, S. Sternhell and R. Kazlauskas. *Aust. J. Chem.* **1978**, *31*, 157.

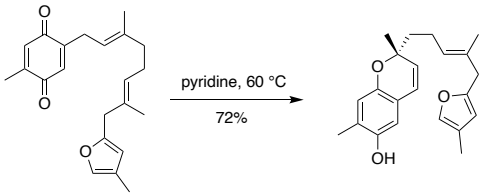


3: furanoquinol **4**: furanoquinone

Furanoquinol (**3**) (99 mg, 0.29 mmol, 1 equiv.) was dissolved in MeOH (2.5 mL) and left open to air at room temperature. Ag_2O (134.6 mg, 0.58 mmol, 2 equiv.) was added. After 10 minutes, TLC showed complete starting material consumption. The reaction mixture was diluted with H_2O (2 mL) and extracted with EtOAc (4 x 2 mL). The combined organic extracts were washed with brine (10 mL), dried with Na_2SO_4 then filtered and concentrated *in vacuo* to afford the furanoquinone (**4**) (85 mg, 86%) as a pale brown solid. Data matched that previously reported following the isolation of **4**.[6]

Data for furanoquinone (**4**):
R_f: 0.60 (4:1 hexanes/EtOAc).
^{1}H NMR (600 MHz, C_6D_6): δ 6.99 (q, *J* = 1.2 Hz, 1H), 6.35 (t, *J* = 1.7 Hz, 1H), 6.10 (q, *J* = 1.7 Hz, 1H), 5.86 (s, 1H), 5.25 (ddq, *J* = 7.1, 5.6, 1.4 Hz, 1H), 5.05 (tq, *J* = 7.4, 1.3 Hz, 1H), 3.29 (s, 2H), 3.00 (d, *J* = 7.3, 2H), 2.07 (q, *J* = 7.3 Hz, 2H), 1.96 (t, *J* = 7.4 Hz, 2H), 1.83 (d, *J* = 1.2 Hz, 3H), 1.58 – 1.57 (m, 3H), 1.57 (br s, 3H), 1.42 (s, 3H) ppm.
^{13}C NMR (150 MHz, C_6D_6): δ 187.8, 187.4, 154.8, 148.1, 145. 2, 139.2, 138.2, 133.4, 132.5, 132.3, 126.6, 120.7, 119.1, 109.3, 39.7, 38.9, 27.5, 26.8, 16.1, 15.9, 15.1, 9.9 ppm.
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.06 (s, 1H), 6.59 – 6.58 (m, 1H), 6.49 (t, *J* = 1.8 Hz, 1H), 5.87 (s, 1H), 5.20 (ddt, *J* = 7.0, 5.6, 1.4 Hz, 1H), 5.15 (tq, *J* = 7.3, 1.4 Hz, 1H), 3.24 (s, 2H), 3.11 (d, *J* = 7.2 Hz, 2H), 2.18 – 2.12 (m, 2H), 2.11 – 2.06 (m, 2H), 2.03 (d, *J* = 1.7 Hz, 3H), 1.98 (d, *J* = 1.2 Hz, 3H), 1.62 (s, 3H), 1.60 (s, 3H) ppm.
^{13}C NMR (125 MHz, $CDCl_3$): δ 188.5, 188.0, 154.5, 148.6, 145.8, 139.8, 137.8, 133.6, 132.5, 132.4, 126.3, 120.6, 118.2, 108.9, 39.7, 38.6, 27.2, 26.6, 16.3, 16.1, 15.6, 10.0 ppm.
HRMS (ESI): calculated for $C_{22}H_{27}O_3$ $[M+H]^+$ 339.1955, found 339.1952.
IR (neat): 2922, 2364, 1654, 1612 cm^{-1}.

*Note: Furanoquinone (**4**) was observed to be unstable over time or in some organic solvents (e.g. $CDCl_3$), hence trace impurities are observed in the NMR spectra.*

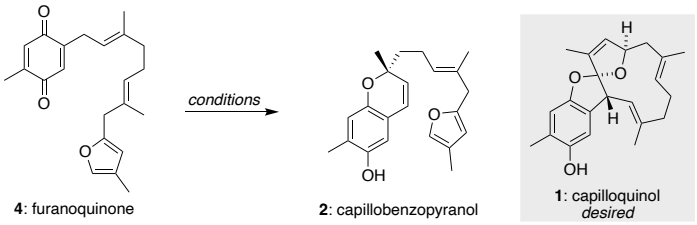


4: furanoquinone **2**: capillobenzopyranol

Furanoquinone (**4**) (10 mg, 0.027 mmol) was stirred in pyridine (1 mL) at 60 °C using a metal heating mantle for 1.5 hours. The reaction was then cooled and the solvent was removed *in vacuo.* The crude residue was purified by flash chromatography on SiO_2 using hexanes/EtOAc (9:1 → 4:1, gradient elution) to afford capillobenzopyranol (**2**) (7 mg, 72%) as a colourless oil. Data matched that previously reported following the isolation of **2**.[7]

Data for capillobenzopyranol (**2**):
R_f: 0.50 (4:1 hexanes/EtOAc).
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.06 (s, 1H), 6.56 (s, 1H), 6.41 (s, 1H), 6.25 (d, J = 9.8 Hz, 1H), 5.86 (s, 1H), 5.53 (d, J = 9.9 Hz, 1H), 5.21 (t, J = 7.2 Hz, 1H), 4.35 (s, 1H), 3.21 (s, 2H), 2.21 – 2.12 (m, 2H), 2.18 (s, 3H), 1.98 (s, 3H), 1.74 – 1.66 (m, 2H), 1.58 (s, 3H), 1.36 (s, 3H) ppm.
^{13}C NMR (125 MHz, $CDCl_3$) δ: 154.5, 147.5, 146.9, 137.8, 132.2, 129.9, 126.5, 124.6, 122.6, 120.6, 119.7, 118.3, 112.6, 108.9, 78.1, 40.9, 38.5, 26.2, 22.9, 16.0, 16.0, 10.0 ppm.
HRMS (ESI) *m/z*: Calculated for $C_{22}H_{27}O_3$ $[M+H]^+$ 339.1955, found 339.1944.
IR (neat) ν_{max}: 2924, 1771, 1456, 1197 cm^{-1}.

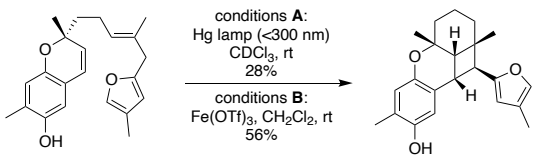
Condition screen for desired cascade reaction via tautomerisation of **4**:



4: furanoquinone **2**: capillobenzopyranol **1**: capilloquinol *desired*

Entry	Wavelength or Additive (equiv)	Solvent	Temp.	Time	Outcome
1	245 nm	$CDCl_3$	rt	1 h	Non specific decomposition
2	365 nm	$CDCl_3$	rt	1 h	Non specific decomposition
3	Sunlight	$CDCl_3$	rt	1 h	Non specific decomposition
4	$PhB(OH)_2$ (2)	PhMe	75 to 120 °C	17 h	trace **2**
5	–	1:4 AcOH/PhMe	75 to 120 °C	17 h	trace **2**
6	CSA (1.1)	CH_2Cl_2	0 to 23 °C	4 h	Trace SM and non specific decomposition
7	Et_3N (4)	CH_2Cl_2	0 to 23 °C	1.5 h	trace unknown compound
8	Et_3N (4)	CH_2Cl_2	0 °C	1.5 h	trace unknown compound
9	Et_3N (2)	CH_2Cl_2	-11 °C	1.5 h	Non specific decomposition
10	LDA (1.1)	THF	–78 °C to rt	3 h	Non specific decomposition
11	Piperidine (2)	CH_2Cl_2	rt	1 h	Non specific decomposition
12	–	pyridine	60 °C	1.5 h	**3** (72%)

[7] S.-Y. Cheng, K.-J. Huang, S.-K. Wang, Z.-H. Wen, P.-W. Chen and C.-Y. Duh, *J. Nat. Prod.*, 2010, **73**, 771.

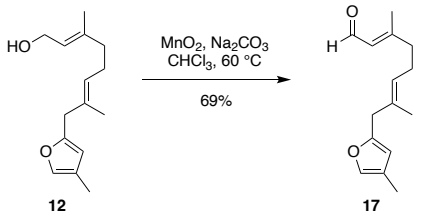


2: capillobenzopyranol **16**

Procedure A: A solution of capillobenzopyranol (**2**) (100 mg, 0.30 mmol) in $CDCl_3$ (4 mL) was degassed with N_2 in a quartz cuvette for 10 minutes. The cuvette was then capped and sealed with parafilm. The reaction vial was then placed 5 centimetres from a broad spectrum Hg lamp (<300 nm) and irradiated for 60 minutes when ^{1}H NMR showed complete starting material consumption. The crude was concentrated *in vacuo* onto SiO_2 then purified by flash chromatography on SiO_2 using a hexanes/EtOAc (9:1 → 4:1, gradient elution) to provide tetracycle **16** (28 mg, 28%) as a pale yellow oil.

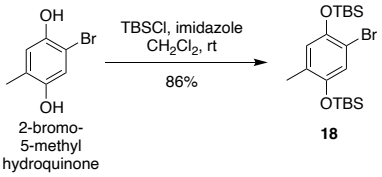
Procedure B: To a solution of chromene **2** (41 mg, 0.122 mmol) in dry CH_2Cl_2 (8 mL) at –40 °C was added $Fe(OTf)_3$ (18.5 mg, 0.037 mmol, 0.3 equiv.). The solution was allowed to slowly warm to room temperature. After 6 hours, brine (10 mL) was then added and the aqueous phase was extracted with CH_2Cl_2 (3 x 3 mL). The combined organic extracts were washed with brine (20 mL) then dried with $MgSO_4$, filtered and concentrated *in vacuo*. The crude was purified by flash chromatography on SiO_2 using hexanes/EtOAc (9:1) to provide tetracycle **16** (23 mg, 56%) as a yellow oil. Recrystallisation of **16** from Et_2O provided crystals for X-ray crystallography.

Data for tetracycle **16**:
R_f: 0.45 (4:1 hexanes/EtOAc).
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.05 (s, 1H), 6.66 (s, 1H), 6.54 (s, 1H), 5.91 (s, 1H), 4.26 (br s, 1H), 3.59 (t, *J* = 9.1 Hz, 1H), 3.40 (d, *J* = 9.7 Hz, 1H), 2.17 (s, 3H), 2.04 – 2.01 (m, 2H), 1.97 (s, 3H), 1.88 – 1.86 (m, 1H), 1.65 (d, *J* = 15.1, 1H), 1.60 – 1.57 (m, 1H), 1.35 – 1.29 (m, 1H), 1.15 – 1.13 (m, 1H), 1.02 (s, 3H), 1.01 (s, 3H) ppm.
^{13}C NMR (125 MHz, $CDCl_3$): δ 155.4, 148.3, 147.9, 138.1, 127.3, 122.7, 120.9, 120.3, 113.9, 108.9, 75.6, 47.5, 44.4, 38.7, 37.1, 34.9, 34.0, 28.9, 28.9, 26.2, 17.3, 15.8, 10.0 ppm.
HRMS (ESI): calculated for $C_{22}H_{27}O_3$ $[M+H]^+$ 339.1955, found 339.1944.
IR (neat): 3358, 2923, 1457, 1173, 1126, 951, 908 cm^{-1}.



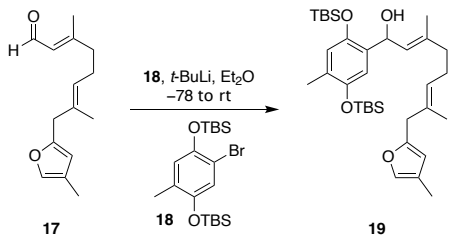
To a solution of alcohol **12** (1.01 g, 4.29 mmol, 1 equiv.) in $CHCl_3$ (50 mL) was added Na_2CO_3 (2.30 g, 21.45 mmol, 5 equiv.) and MnO_2 (1.86 g, 21.45 mmol, 5 equiv.). The mixture was heated to 60 °C using a metal heating mantle. After 24 hours another portion of MnO_2 was added (930 mg, 2.5 equiv.) and the mixture was stirred for a further 72 hours. The solution was cooled then filtered through celite which was washed with CH_2Cl_2 (250 mL) before the filtrate was concentrated *in vacuo*. The crude material was purified by flash chromatography on SiO_2 using hexanes/EtOAc (6:1 → 2:1, gradient elution) to afford the aldehyde **17** (680 mg, 69%) as a pale yellow oil and further elution provided the recovered starting material **12** (160 mg, 16%) as a colourless oil.

Data for aldehyde **17**:
R_f: 0.45 (4:1 hexanes/EtOAc).
^{1}H NMR (500 MHz, $CDCl_3$): δ 9.99 (d, *J* = 8.0 Hz, 1H), 7.06 (t, *J* = 1.2 Hz, 1H), 5.91 – 5.83 (m, 2H), 5.20 – 5.17 (m, 1H), 3.23 (s, 2H), 2.28 – 2.22 (m, 4H), 2.17 (d, *J* = 1.3 Hz, 3H), 1.98 (d, *J* = 1.2 Hz, 3H), 1.61 (s, 3H) ppm.
^{13}C NMR (150 MHz, $CDCl_3$): δ 191.4, 163.7, 154.0, 137.9, 133.5, 127.6, 124.9, 120.7, 109.1, 40.5, 38.5, 25.9, 17.7, 16.1, 9.9 ppm.
HRMS (ESI): calculated for $C_{15}H_{21}O_2$ $[M+H]^+$ 259.1329, found 259.1333.
IR (neat): 2926, 1671, 1116, 949, 805, 598 cm^{-1}.



To a solution of 2-bromo, 5-methyl hydroquinone (2.04 g, 10.05 mmol) in CH_2Cl_2 (80 mL) was added TBSCl (3.58 g, 23.6 mmol, 2.4 equiv.) and imidazole (1.64 g, 24.08 mmol, 2.4 equiv.) at room temperature. The solution was stirred for 6 hours then diluted with H_2O (100 mL) and extracted into CH_2Cl_2 (3 x 50 mL). The combined organic extracts were washed with brine (150 mL), dried with $MgSO_4$ then filtered and concentrated *in vacuo*. The crude was purified by flash chromatography on SiO_2 using hexanes/EtOAc (40:1) to afford silyl ether **18** (3.64 g, 86%) as white crystals.

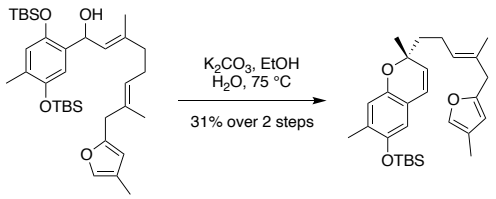
Data for **18**:
R_f: 0.80 (20:1 hexanes /EtOAc).
^{1}H NMR (500 MHz, $CDCl_3$): δ 6.90 (s, 1H), 6.65 (s, 1H), 2.11 (m, 3H), 1.03 (s, 9H), 1.00 (s, 9H), 0.21 (s, 6H), 0.19 (s, 6H) ppm.
^{13}C NMR (125 MHz, $CDCl_3$): δ 148.4, 146.6, 129.1, 122.9, 122.2, 111.2, 26.0, 25.9, 18.5, 18.4, 17.0, -4.1, -4.2 ppm.
HRMS (ESI): Ions corresponding to $[M+H/Na/K]^+$ or resulting from decomposition were not found despite substantial effort.
IR (neat): 2928, 1470, 1251, 1206, 915, 837, 777 cm^{-1}.
MP: 95.7 °C.



Aryl bromide **18** (773 mg, 1.79 mmol, 1.5 equiv.) was dissolved in dry Et_2O (15 mL) then cooled to –78 °C. *t*-BuLi (1.7 M in pentane, 2.10 mL, 3.58 mmol, 3 equiv.) was added dropwise. After stirring for 20 minutes, a solution of aldehyde **17** (275 mg, 1.16 mmol, 1 equiv.) in Et_2O (3 mL) was added before the solution was allowed to warm to room temperature. After stirring for 90 minutes, H_2O (20 mL) was added and the aqueous layer was extracted with Et_2O (3 x 10 mL). The combined organic extracts were washed with brine (30 mL), dried with $MgSO_4$, then filtered and concentrated *in vacuo*. The crude material was used immediately.

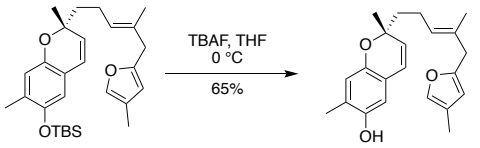
For analytical purposes, a portion of the crude reaction mixture was purified by flash chromatography on phosphate-buffered SiO_2 using hexanes/EtOAc (40:1 → 20:1, gradient elution) to provide an analytical sample of alcohol **19,** which was found to be unstable.

Data for alcohol **19**:
R_f: 0.20 (40:1 hexanes/EtOAc).
^{1}H NMR (600 MHz, $(CD_3)_2CO$): δ 7.12 (s, 1H), 6.94 (s, 1H), 6.64 (d, *J* = 0.8 Hz, 1H), 5.91 (s, 1H), 5.66 (dd, *J* = 7.9, 4.4 Hz, 1H), 5.45 (dq, *J* = 7.9, 1.3 Hz, 1H), 5.28 – 5.22 (m, 1H), 3.73 (dd, *J* = 4.4, 1.2 Hz, 1H), 3.19 (s, 2H), 2.14 (m, 5H), 2.05 – 2.00 (m, 2H), 1.94 (d, *J* = 1.3 Hz, 3H), 1.74 (d, *J* = 1.4 Hz, 3H), 1.57 (d, *J* = 1.4 Hz, 3H), 1.03 (s, 9H), 1.02 (s, 9H), 0.27 (s, 3H), 0.24 (s, 3H), 0.21 (s, 3H), 0.21 (s, 3H) ppm.
^{13}C NMR (150 MHz, $(CD_3)_2CO$): δ 155.1, 148.7, 147.0, 138.6, 137.1, 134.8, 132.7, 129.9, 128.1, 127.0, 121.6, 121.2, 118.5, 109.6, 65.1, 40.1, 38.9, 27.3, 26.3, 26.2, 18.9, 18.8, 17.2, 16.9, 16.0, 9.8, -3.9, -3.9, -4.0, -4.0 ppm.
HRMS (ESI): calculated for $C_{34}H_{56}O_4Si_2Na$ $[M+Na]^+$ 607.3609, found 607.3604.
IR (neat): 3349, 2973, 1406, 1162, 1130, 949, 839, 818 cm^{-1}.



The dried reaction crude containing **19** (assumed 1.16 mmol) was diluted with EtOH (20 mL) and H_2O (100 mL) before K_2CO_3 (336 mg, 2.43 mmol, 2 equiv.) was added. The solution was heated to 75 °C using a metal heating mantle. After 4 hours, the crude mixture was cooled and filtered through celite which was washed with EtOAc (60 mL) and the filtrate was concentrated *in vacuo*. The crude was purified by flash chromatography on SiO_2 using hexanes/EtOAc (40:1 → 4:1, gradient elution) to provide **20** (162 mg, 31% over two steps) as a pale yellow oil.

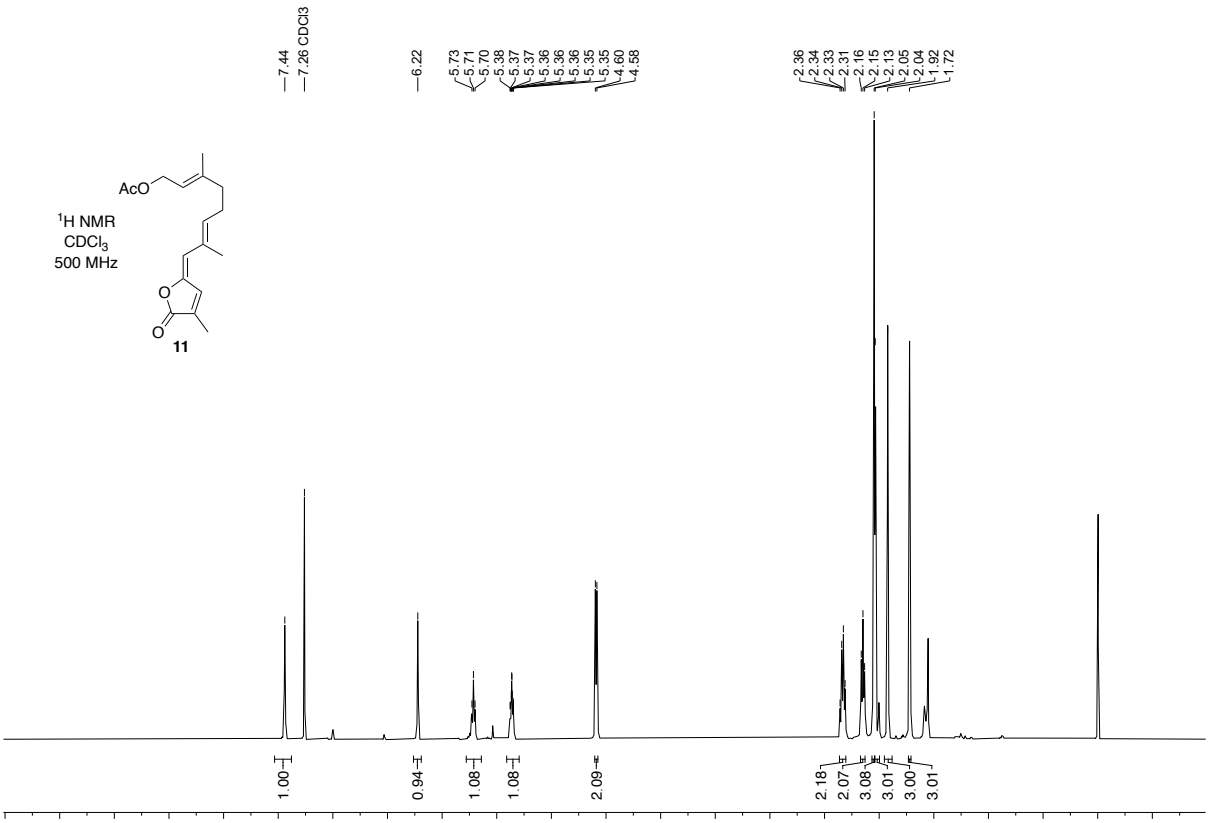
Data for **20:**
R_f: 0.70 (40:1 hexanes/EtOAc).
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.06 (s, 1H), 6.56 (s, 1H), 6.38 (s, 1H), 6.25 (d, J = 9.8 Hz, 1H), 5.86 (s, 1H), 5.50 (d, J = 9.8 Hz, 1H), 5.21 (t, J = 7.2 Hz, 1H), 3.21 (s, 2H), 2.15 (m, 2H), 2.13 (s, 3H), 1.98 (s, 3H), 1.76 – 1.70 (m, 1H), 1.68 – 1.64 (m, 1H), 1.58 (s, 3H), 1.36 (s, 3H), 1.01 (s, 9H), 0.18 (s, 6H) ppm.
^{13}C NMR (125 MHz, $CDCl_3$): δ 154.5, 147.4, 147.0, 137.8, 132.2, 129.7, 129.3, 129.3, 126.7, 126.6, 123.0, 119.2, 118.3, 116.1, 109.0, 78.1, 40.9, 38.6, 26.3, 26.0, 22.9, 18.4, 17.1, 16.0, 10.0, -4.1 ppm.
HRMS (ESI): calculated for $C_{28}H_{41}O_3Si$ $[M+H]^+$ 453.2810, found 453.2819.
IR (neat): 2928, 1496, 1174, 934, 837, 777 cm^{-1}.

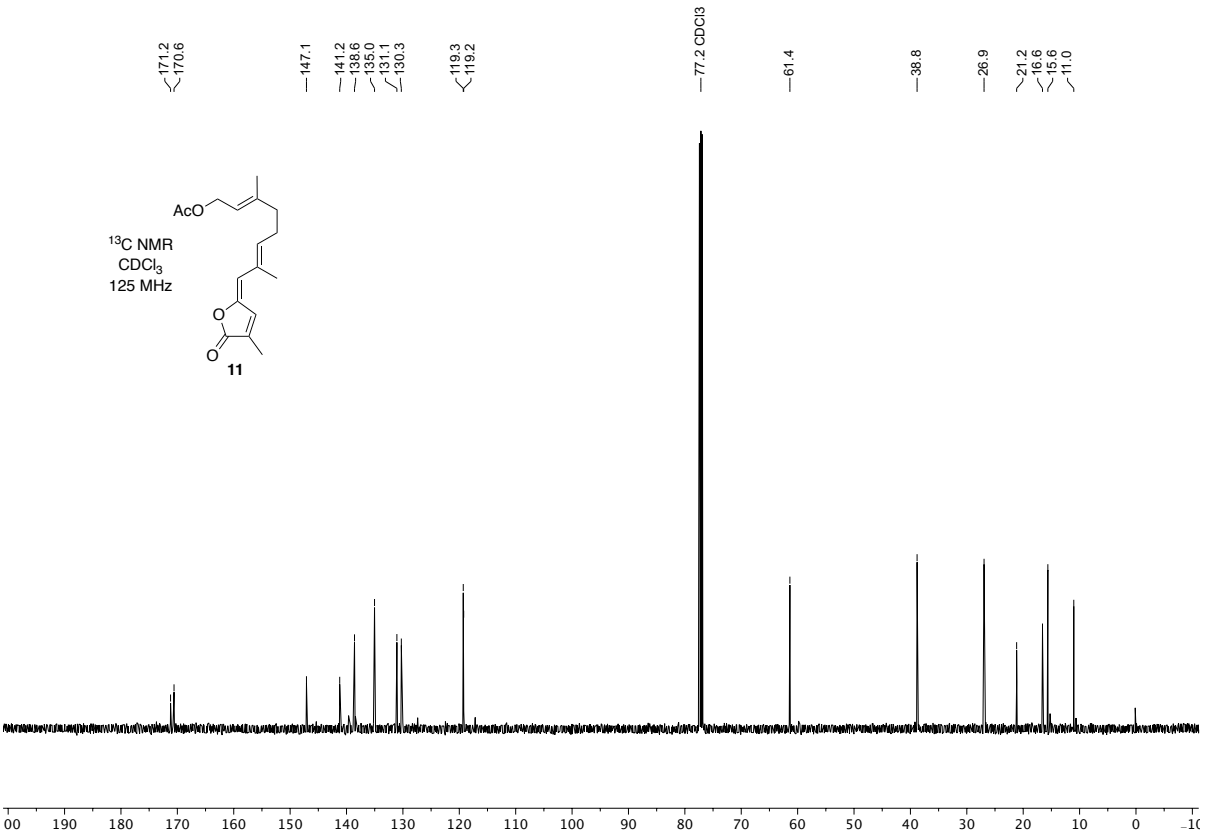


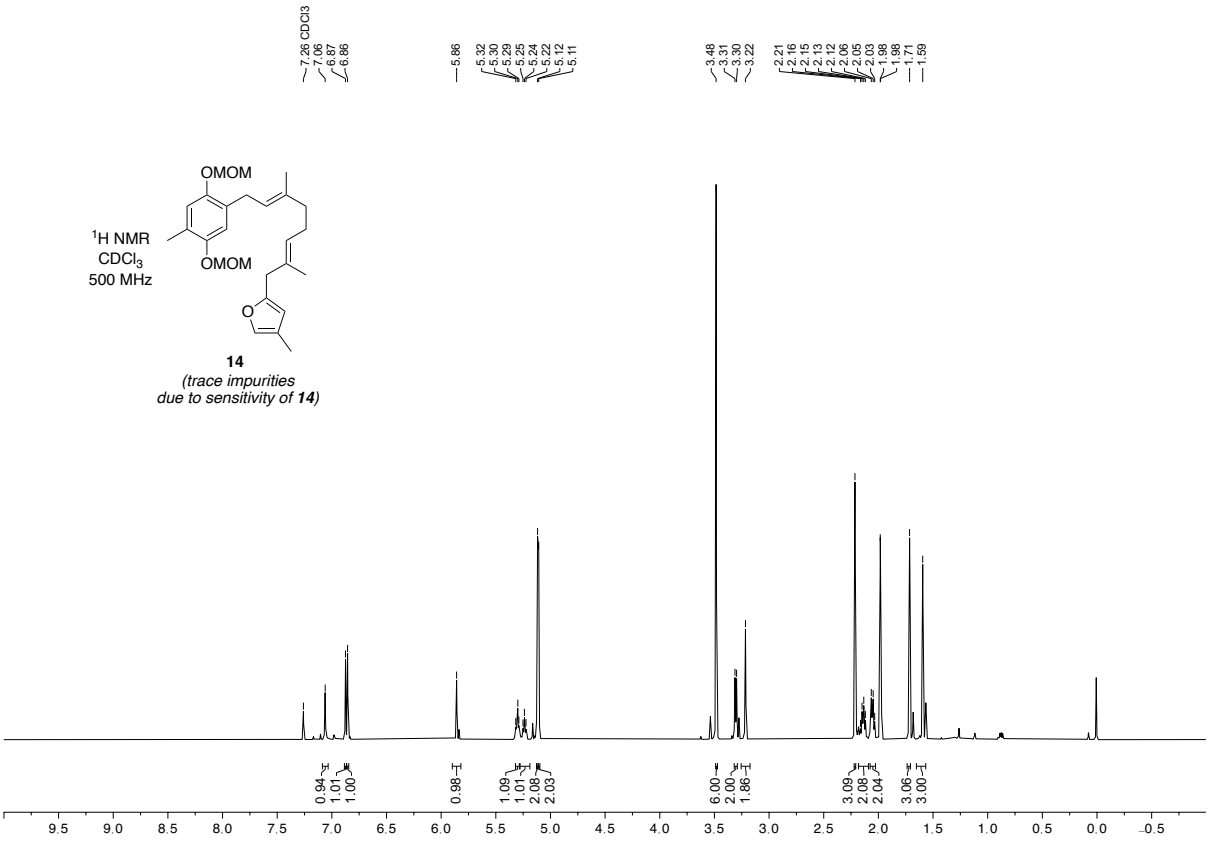
20 **2**: capillobenzopyranol

To a solution of **20** (59 mg, 0.13 mmol, 1 equiv.) in THF (5 mL) was added TBAF (1M in THF, 0.156 mL, 0.16 mmol, 1.2 equiv.) at 0 °C. The solution was stirred for 15 minutes before the solution was diluted with H_2O (4 mL), and the aqueous layer was extracted with EtOAc (3 x 6 mL). The combined organic extracts were washed with brine (15 mL), dried with $MgSO_4$, filtered then concentrated *in vacuo*. The crude was purified by flash chromatography on SiO_2 using hexanes/EtOAc (6:1) to provide the capillobenzopyranol (**2**) (28.6 mg, 65%) as a pale yellow oil. Data was consistent with that previously reported.

3. NMR Spectra

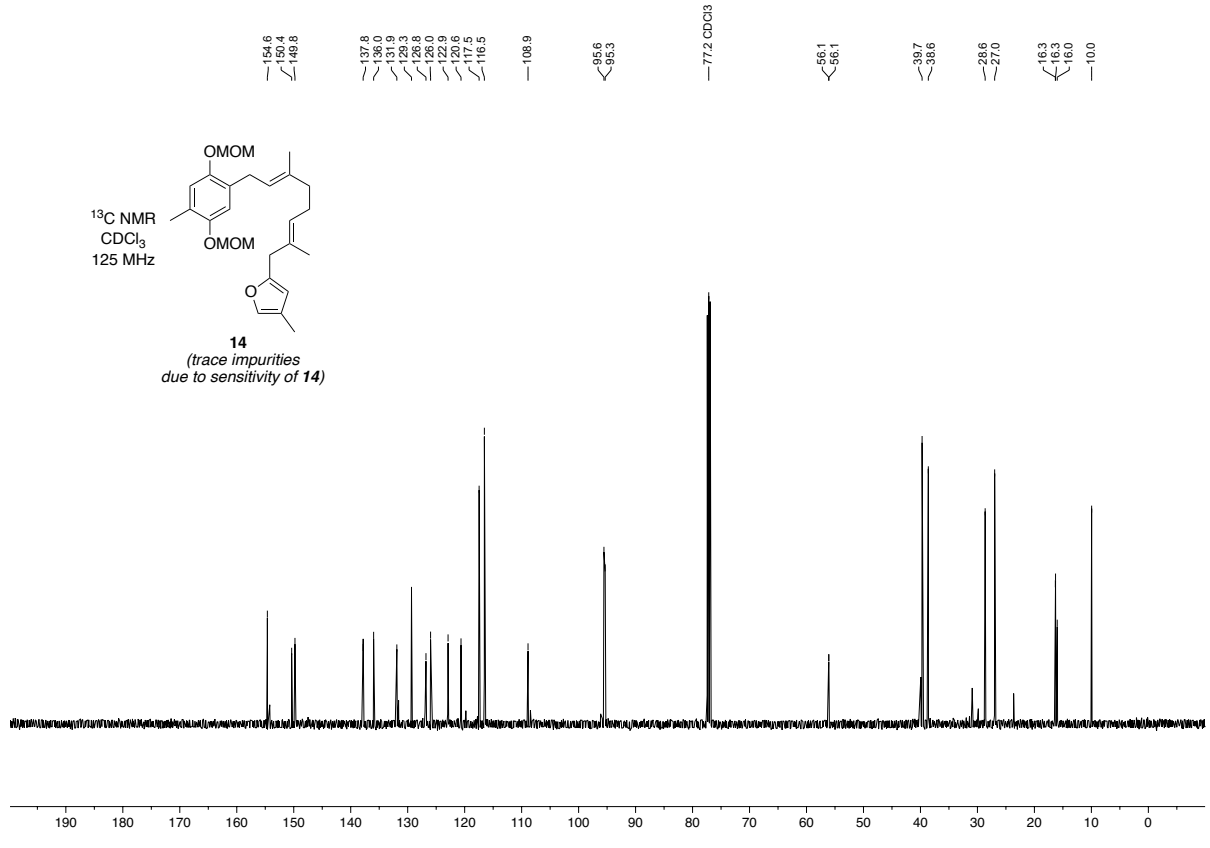






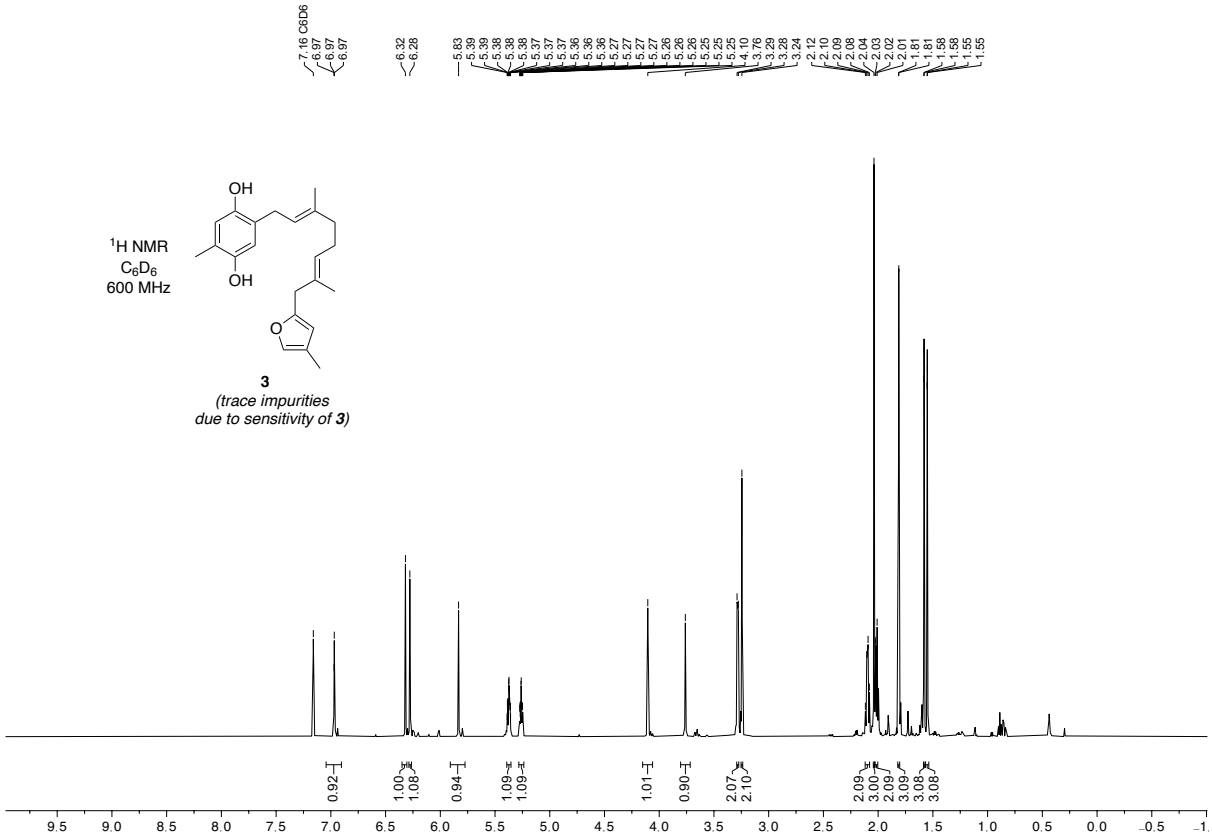
^{1}H NMR
$CDCl_3$
500 MHz

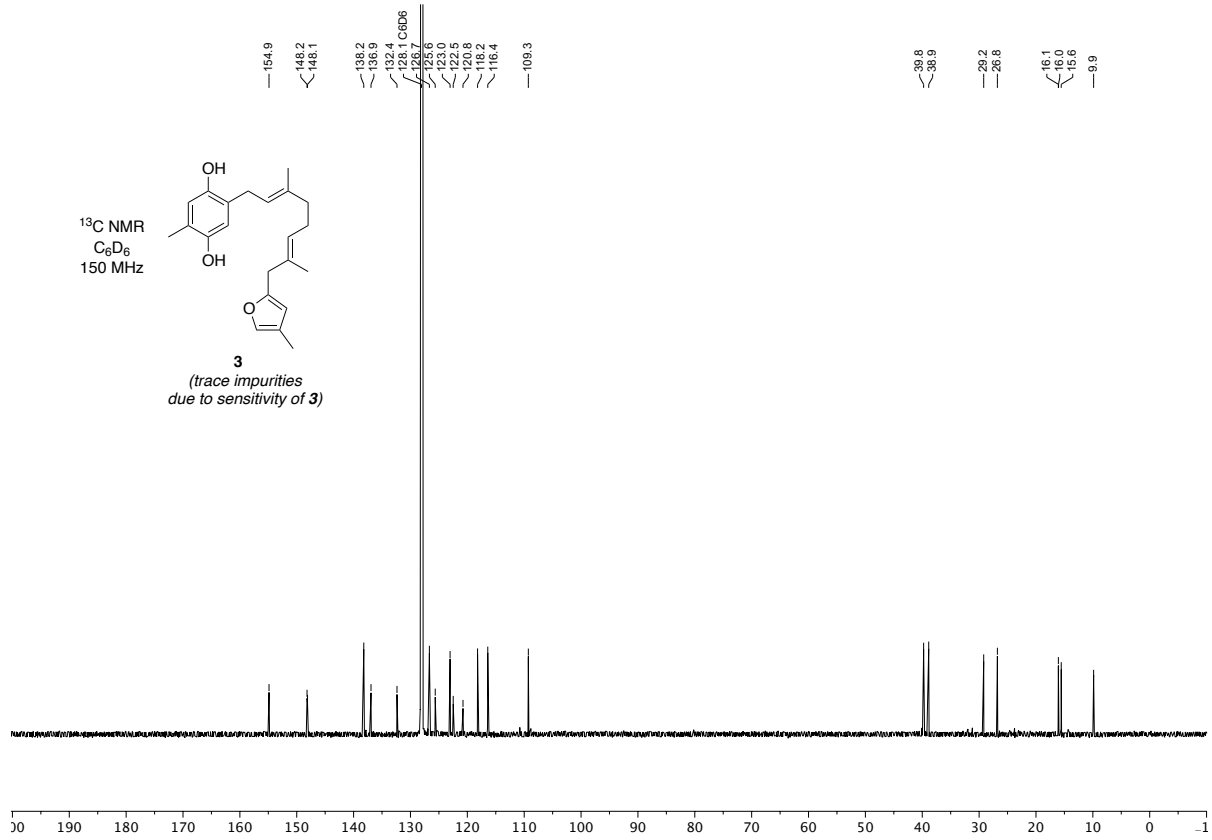
14
*(trace impurities due to sensitivity of **14**)*

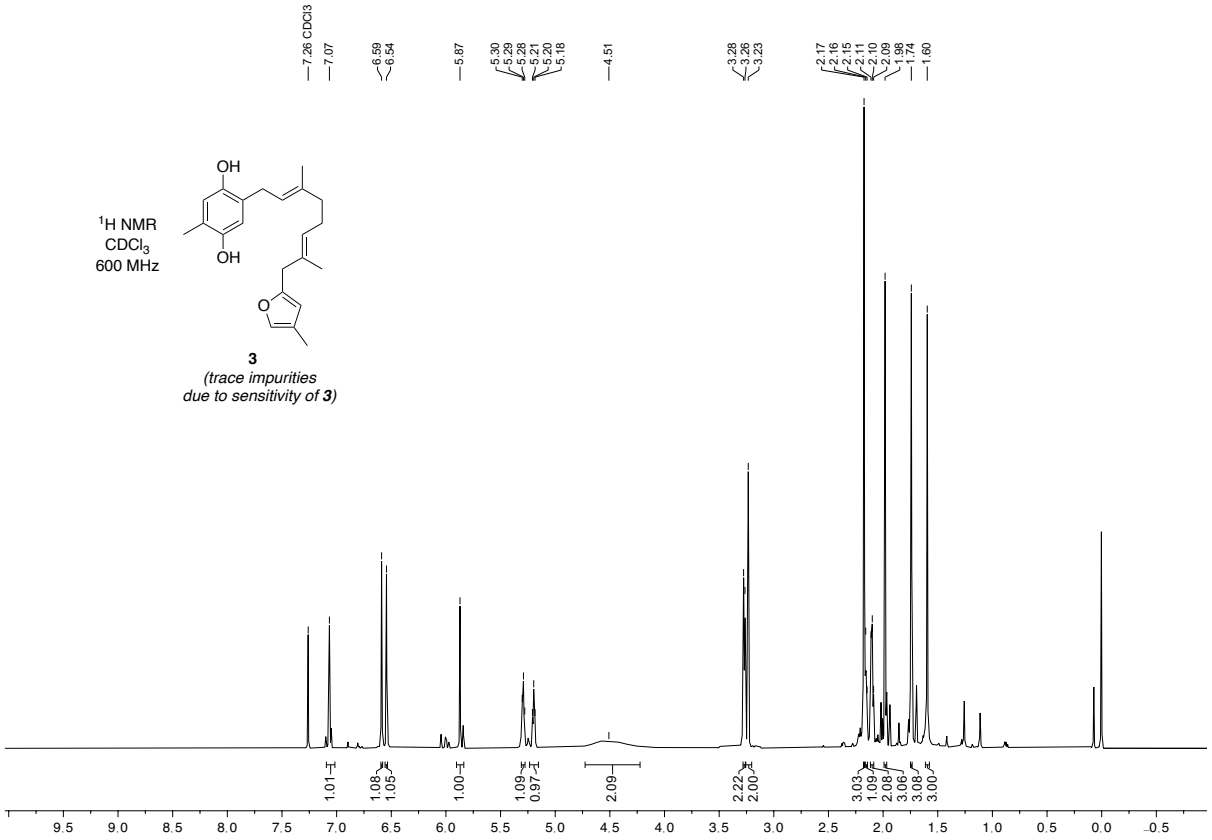


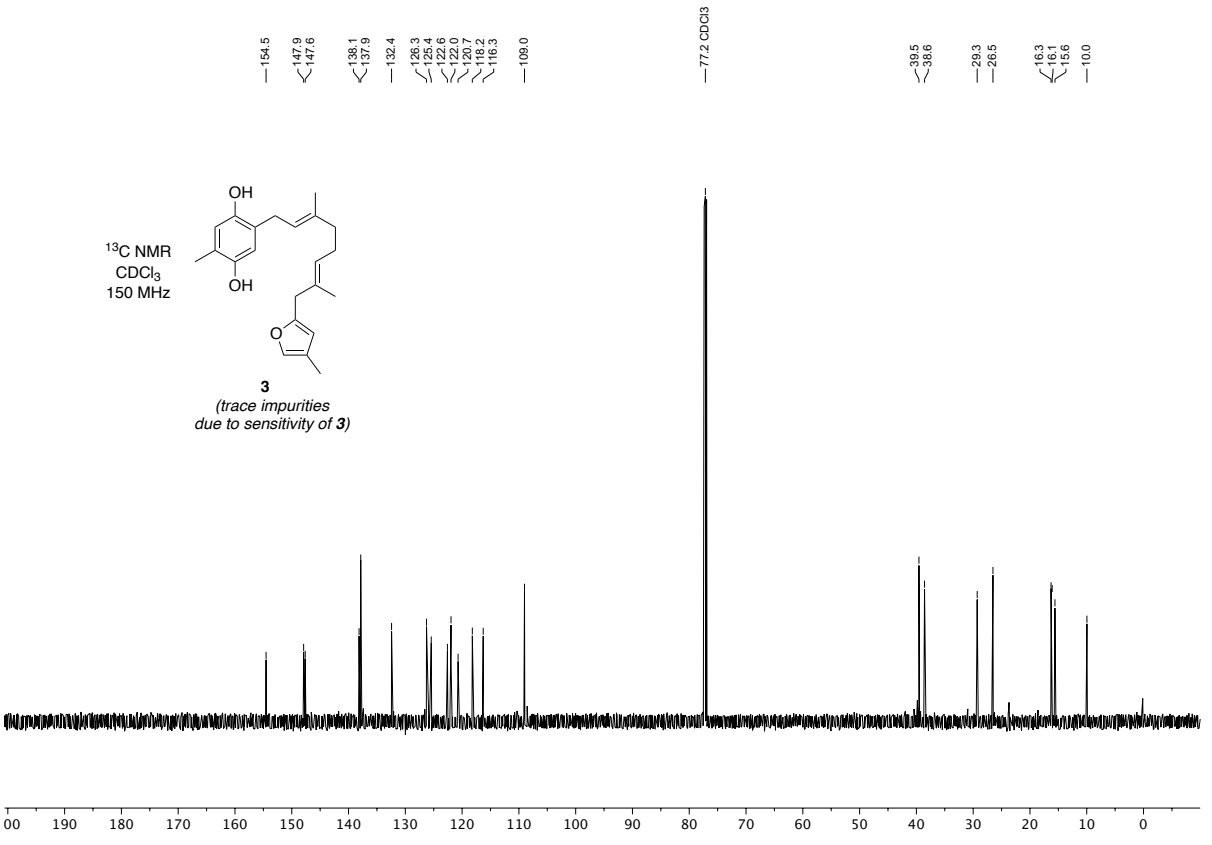
^{13}C NMR
$CDCl_3$
125 MHz

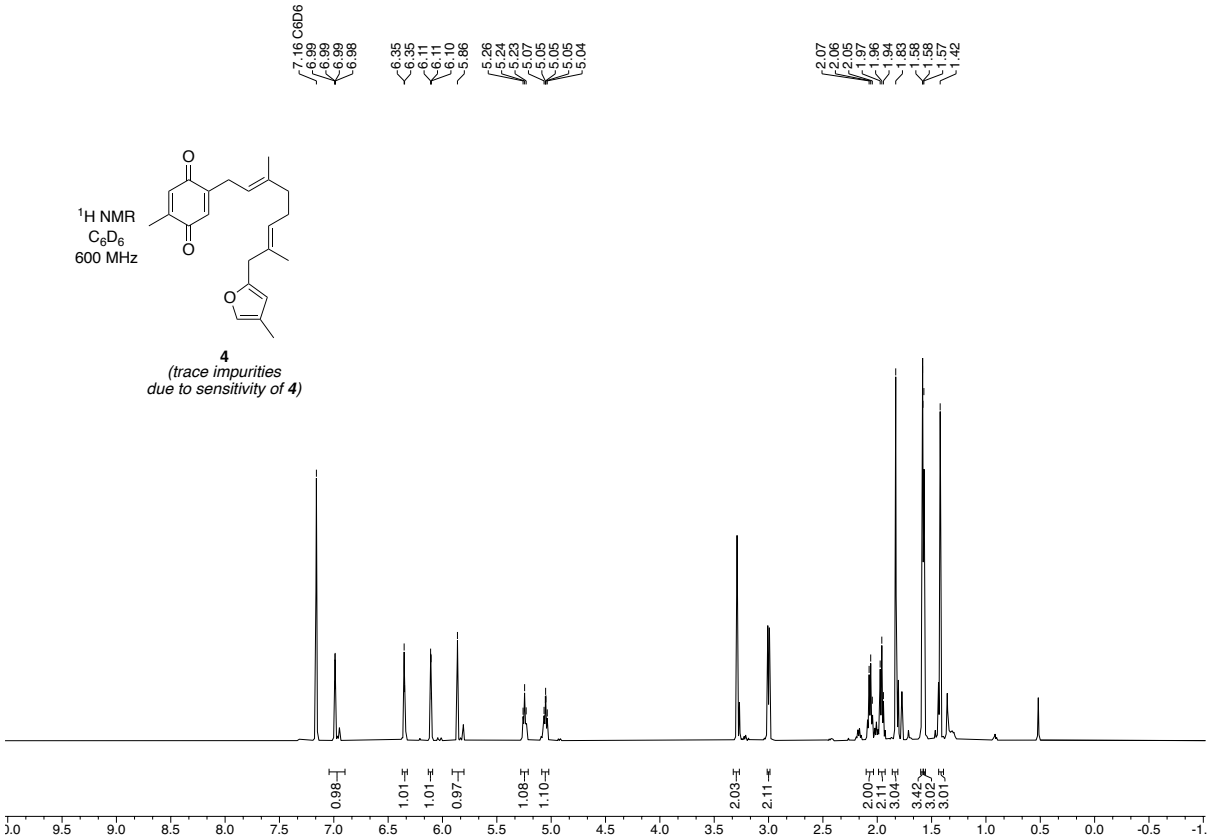
14
*(trace impurities due to sensitivity of **14**)*

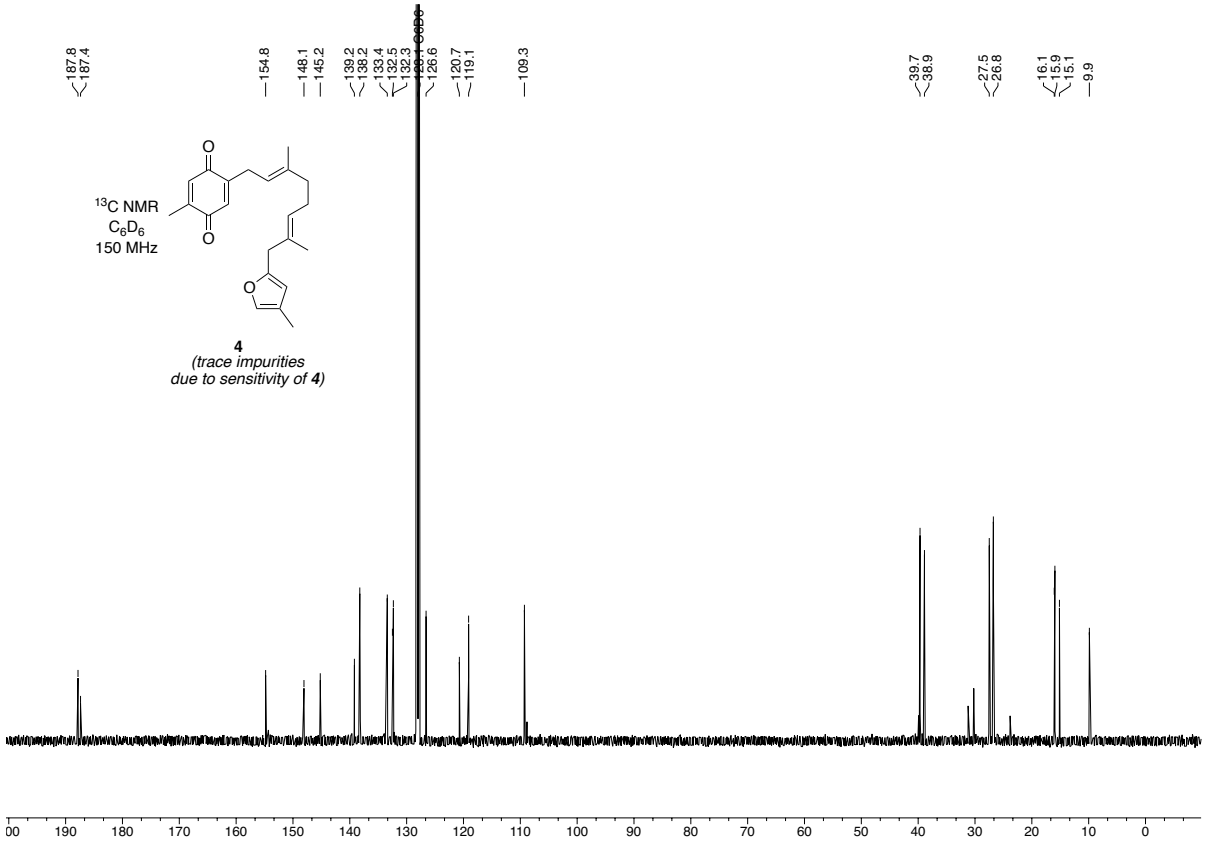

^{1}H NMR
C_6D_6
600 MHz
OH
OH
O
3
(trace impurities
due to sensitivity of 3)

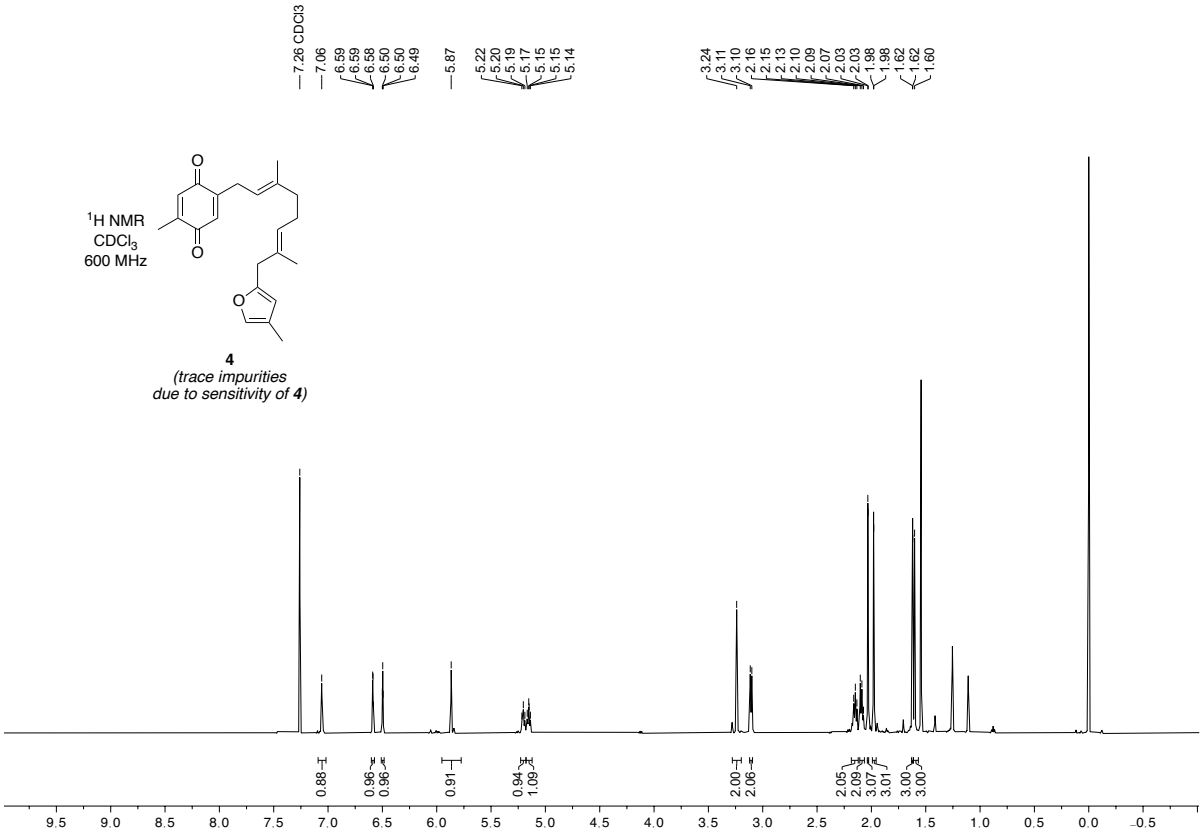

^{13}C NMR
C_6D_6
150 MHz
OH
OH
O
3
(trace impurities
due to sensitivity of 3)


7.26 CDCl3
7.07
6.59
6.54
5.87
5.30
5.29
5.28
5.21
5.20
5.18
4.51
3.28
3.26
3.23
2.17
2.16
2.15
2.11
2.10
2.09
1.98
1.74
1.60
1H NMR
CDCl3
600 MHz
OH
OH
O
3
(trace impurities
due to sensitivity of 3)
1.01
1.08
1.05
1.00
1.09
0.97
2.09
2.22
2.00
3.03
1.09
2.08
3.06
3.08
3.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5

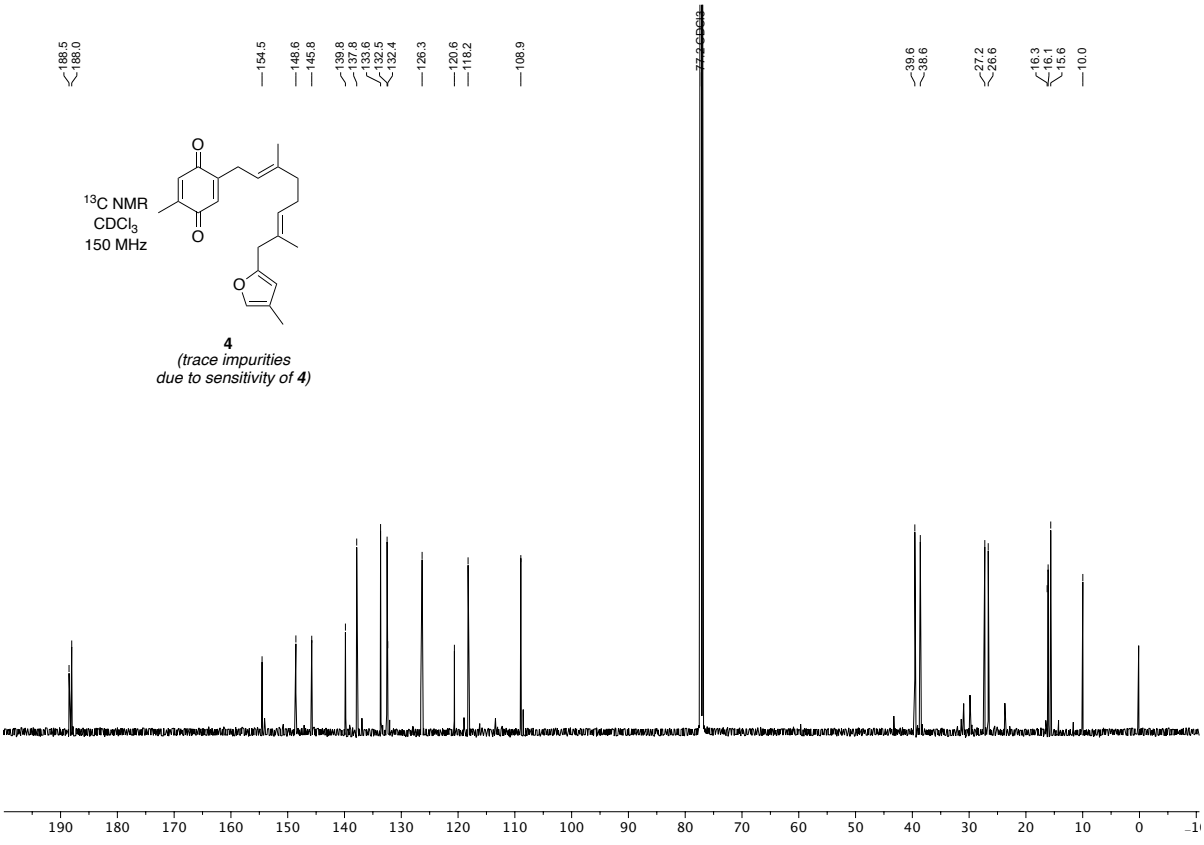

154.5
147.9
147.6
138.1
137.9
132.4
126.3
125.4
122.6
122.0
120.7
118.2
116.3
109.0
77.2 CDCl3
39.5
38.6
29.3
26.5
16.3
16.1
15.6
10.0
13C NMR
CDCl3
150 MHz
OH
OH
O
3
(trace impurities
due to sensitivity of 3)
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


7.16 C6D6
6.99
6.99
6.99
6.98
6.35
6.35
6.11
6.11
6.10
5.86
5.26
5.24
5.23
5.07
5.05
5.05
5.05
5.04
2.07
2.06
2.05
1.97
1.96
1.94
1.93
1.58
1.58
1.57
1.42
1H NMR
C6D6
600 MHz
O
O
O
4
(trace impurities
due to sensitivity of 4)
0.98
1.01
1.01
0.97
1.08
1.10
2.03
2.11
2.00
2.11
3.04
3.42
3.02
3.01
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5

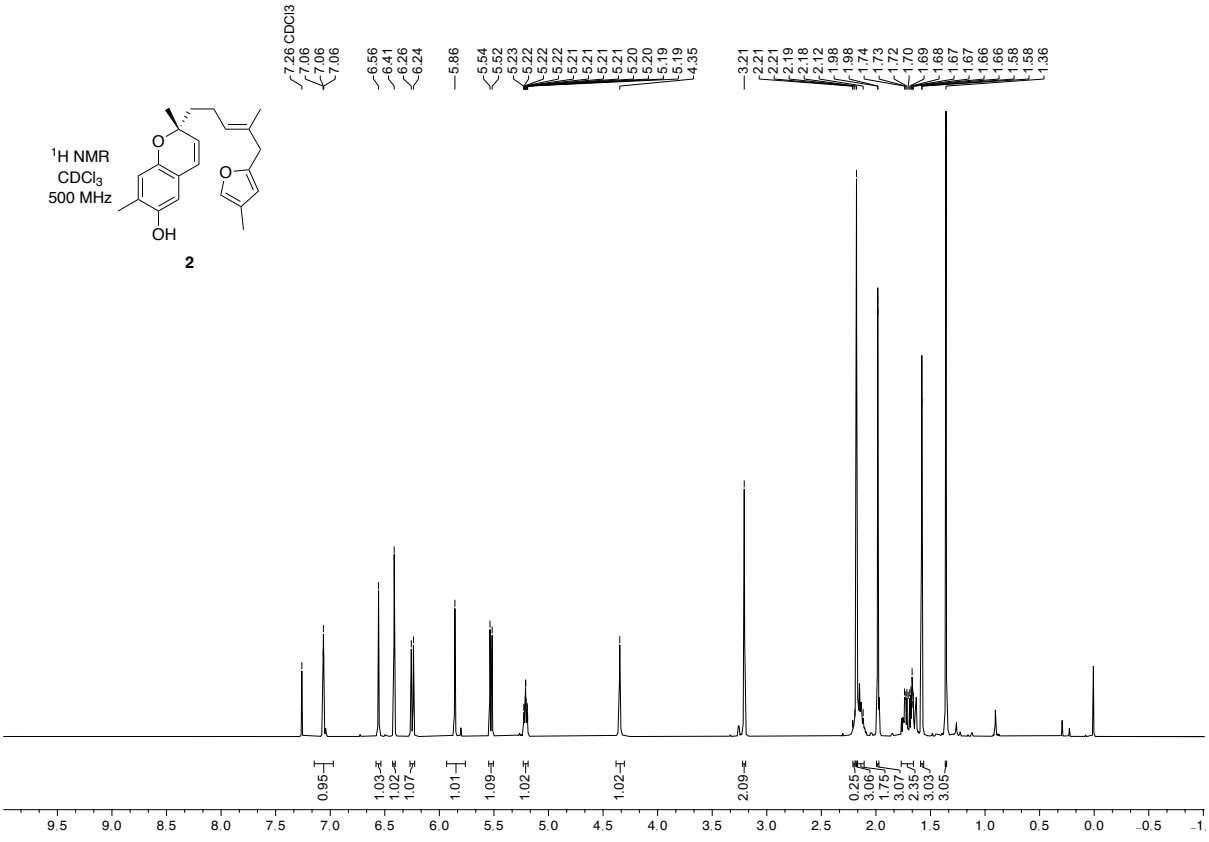

187.8
187.4
154.8
148.1
145.2
139.2
138.2
133.4
132.5
132.3
126.6
120.7
119.1
109.3
39.7
38.9
27.5
26.8
16.1
15.9
15.1
9.9
13C NMR
C6D6
150 MHz
O
O
O
4
(trace impurities
due to sensitivity of 4)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

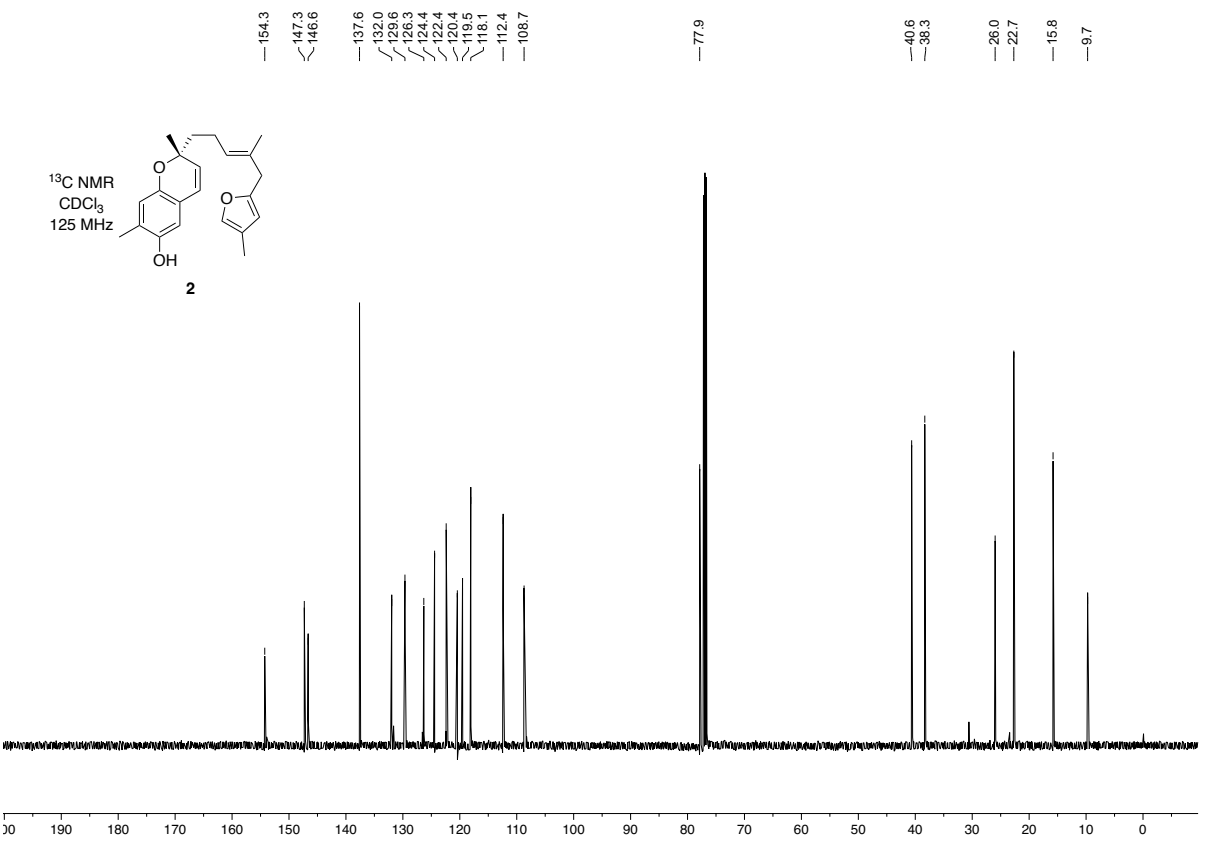


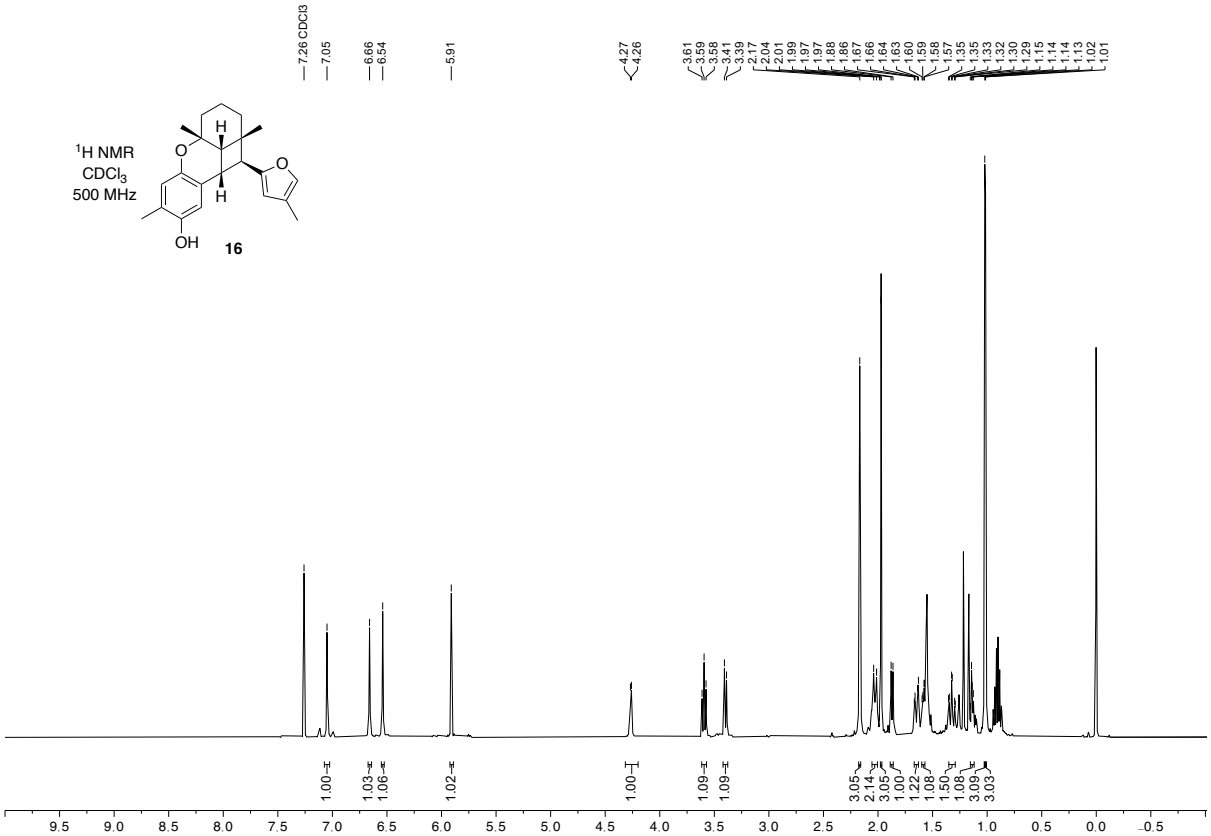
4
*(trace impurities due to sensitivity of **4**)*

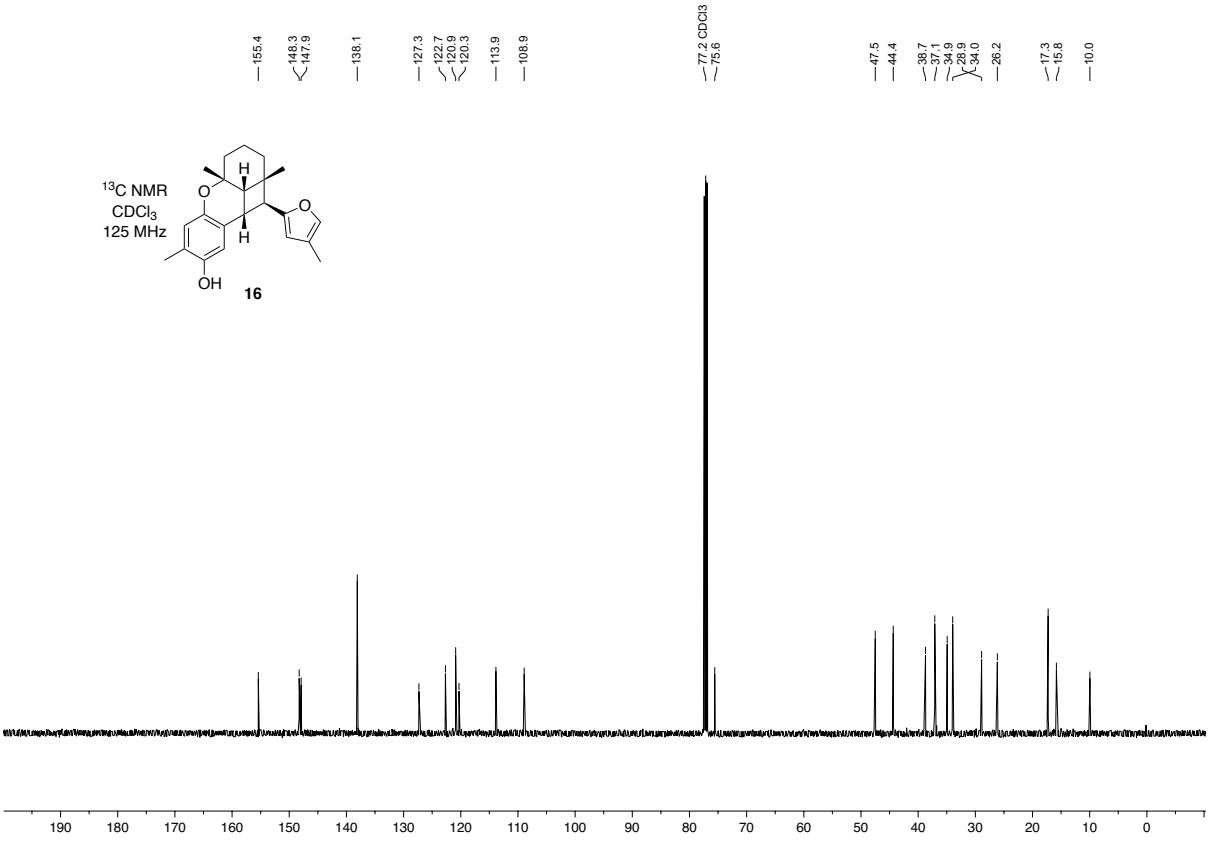


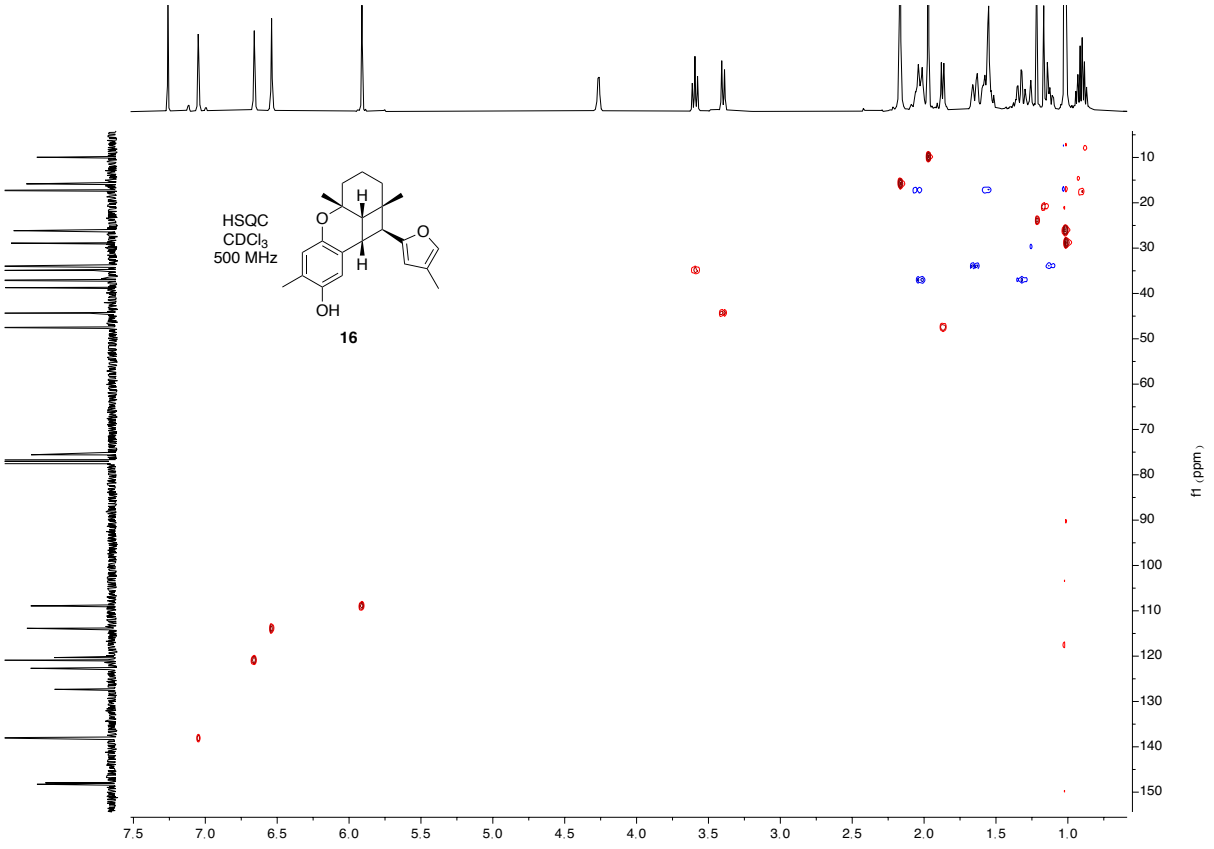
4
*(trace impurities due to sensitivity of **4**)*

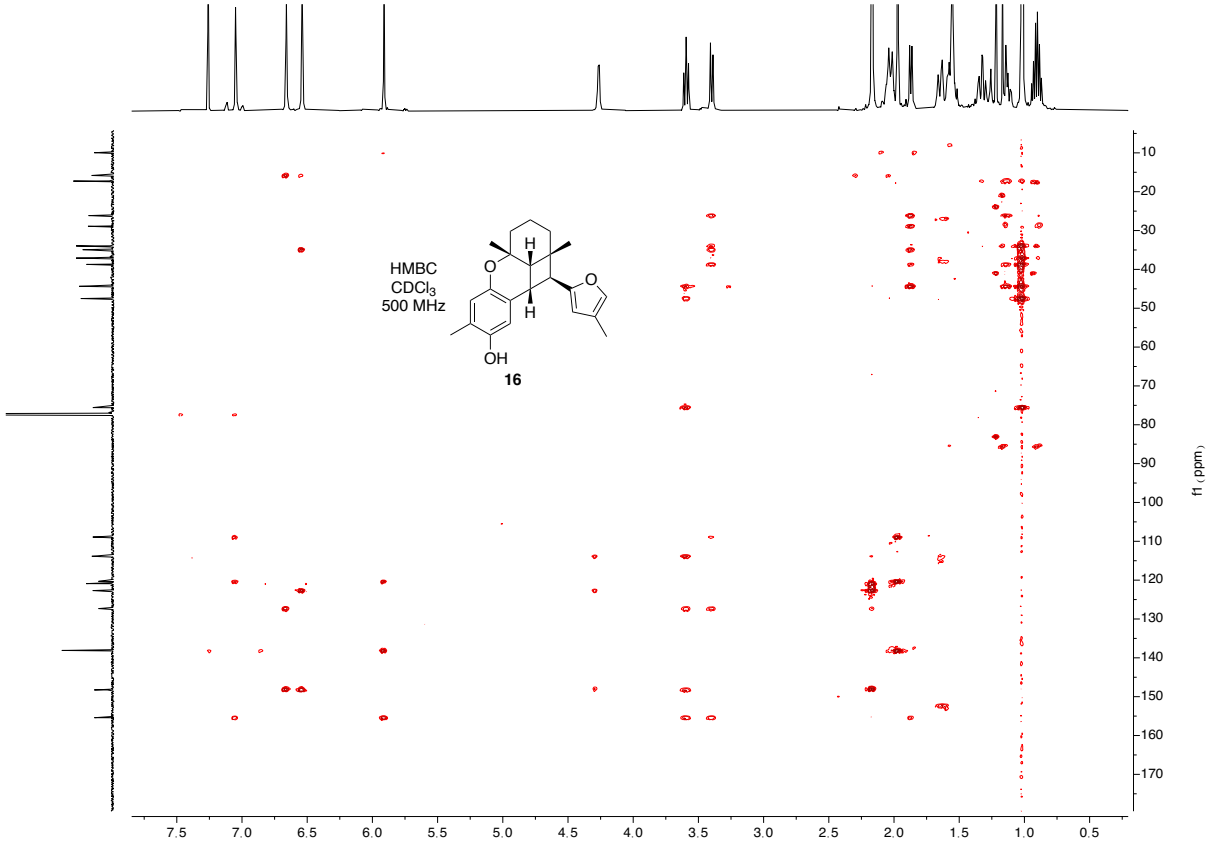

^{1}H NMR
$CDCl_3$
500 MHz
OH
2
7.26 CDCl3
7.06
7.06
7.06
6.56
6.41
6.26
6.24
5.86
5.54
5.52
5.23
5.22
5.22
5.22
5.21
5.21
5.21
5.21
5.20
5.20
5.19
5.19
4.35
3.21
2.21
2.21
2.19
2.18
2.12
1.98
1.98
1.74
1.73
1.72
1.70
1.69
1.68
1.67
1.67
1.66
1.66
1.58
1.58
1.36
0.95
1.03
1.02
1.07
1.01
1.09
1.02
1.02
2.09
0.25
3.06
1.75
3.07
2.35
3.03
3.05

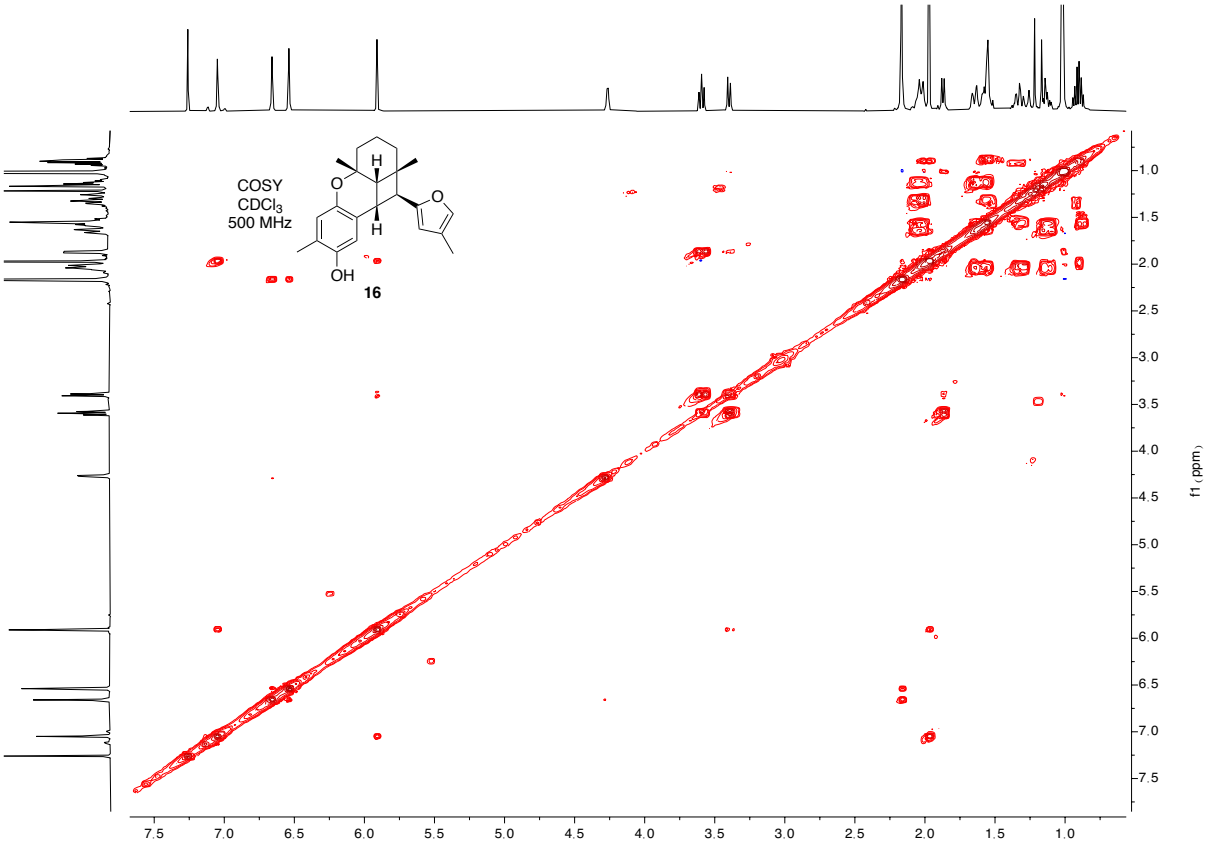

^{13}C NMR
$CDCl_3$
125 MHz
OH
2
154.3
147.3
146.6
137.6
132.0
129.6
126.3
124.4
122.4
120.4
119.5
118.1
112.4
108.7
77.9
40.6
38.3
26.0
22.7
15.8
9.7

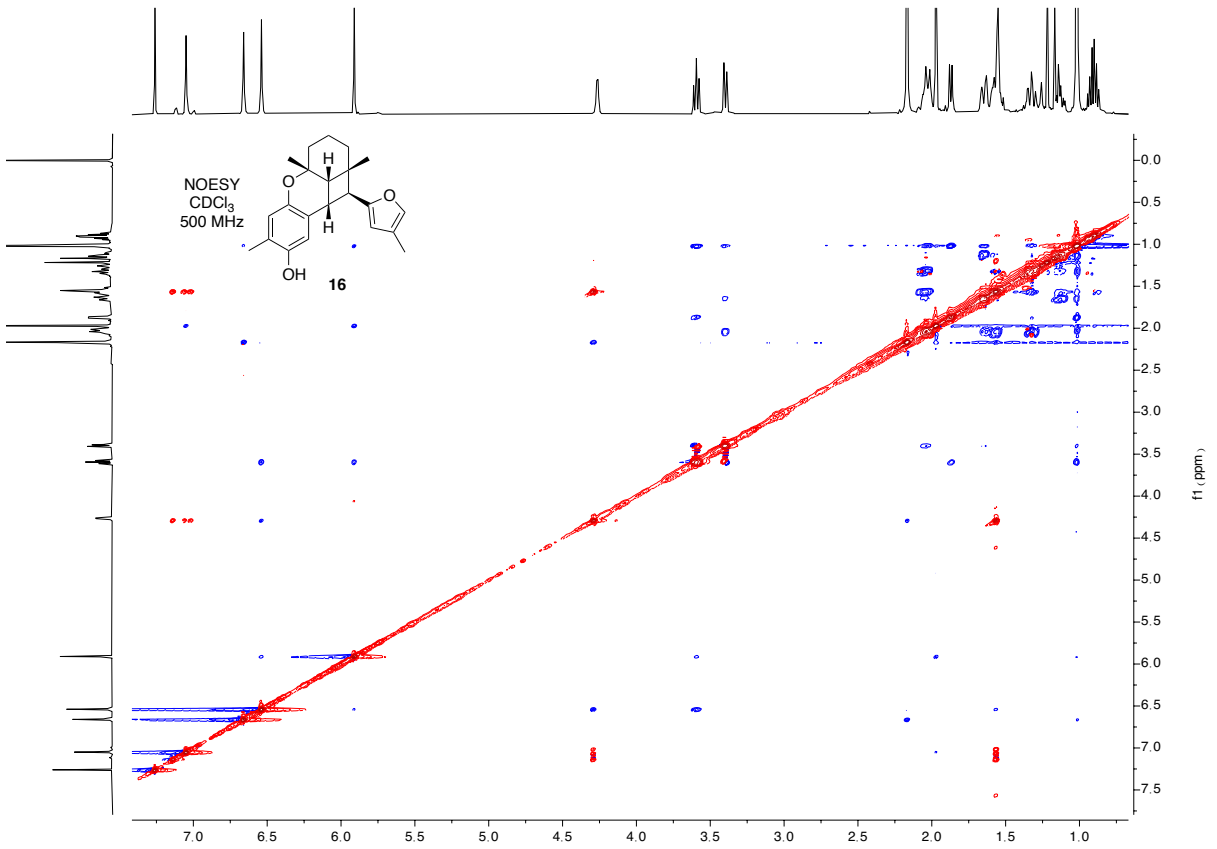

^{1}H NMR
$CDCl_3$
500 MHz
16
7.26 CDCl3
7.05
6.66
6.54
5.91
4.27
4.26
3.61
3.59
3.58
3.41
3.39
2.17
2.04
2.01
1.99
1.97
1.97
1.88
1.86
1.67
1.66
1.64
1.63
1.60
1.59
1.58
1.57
1.35
1.35
1.33
1.32
1.30
1.29
1.15
1.14
1.14
1.13
1.02
1.01
1.00
1.03
1.06
1.02
1.00
1.09
1.09
3.05
2.14
3.05
1.00
1.22
1.08
1.50
1.08
3.09
3.03

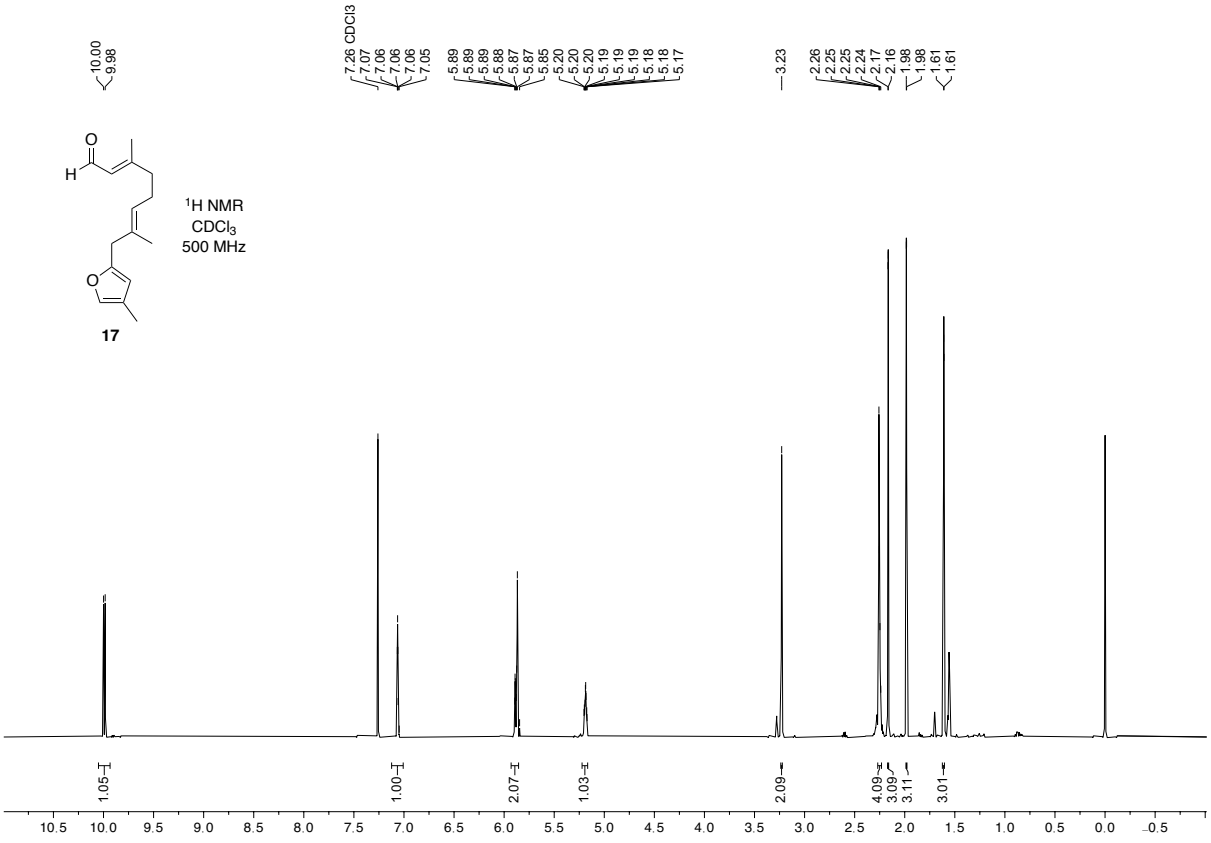

^{13}C NMR
$CDCl_3$
125 MHz
16
155.4
148.3
147.9
138.1
127.3
122.7
120.9
120.3
113.9
108.9
77.2 CDCl3
75.6
47.5
44.4
38.7
37.1
34.9
28.9
34.0
26.2
17.3
15.8
10.0

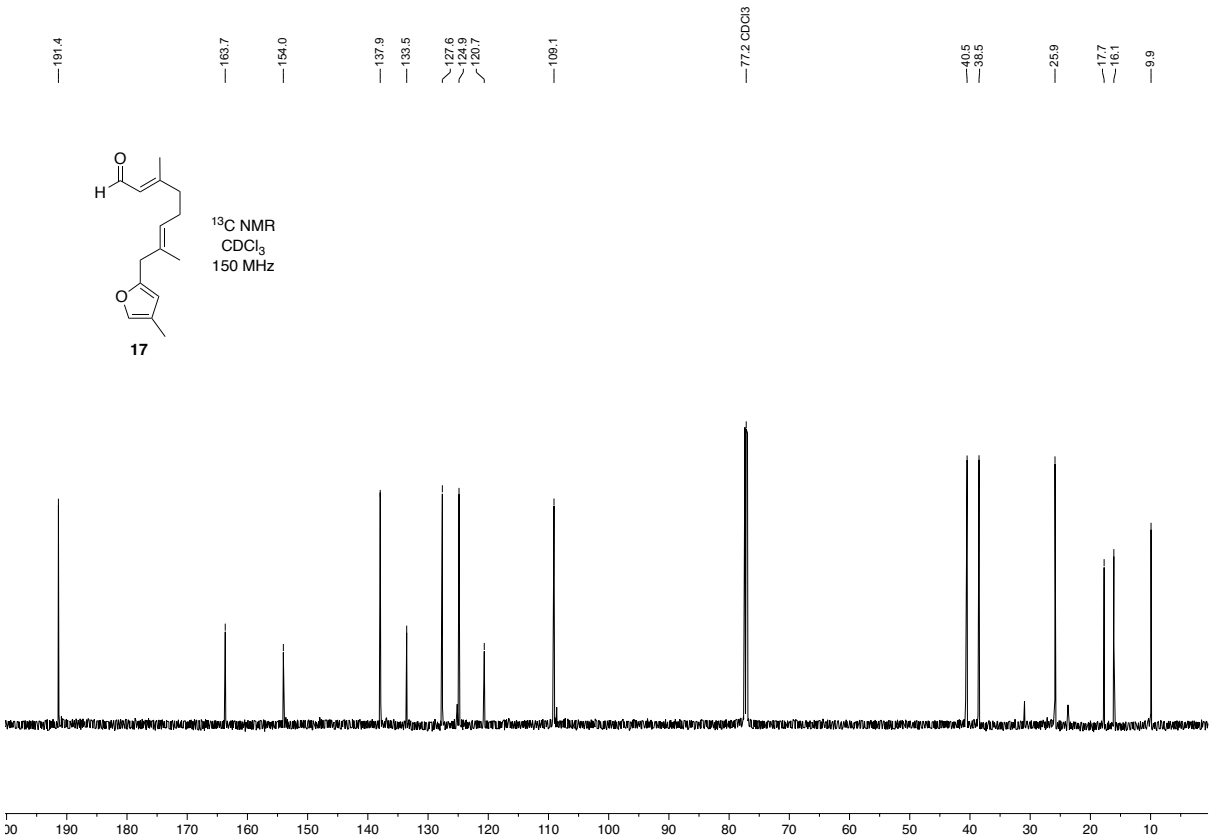

HSQC
CDCl3
500 MHz
H
O
O
H
OH
16
f1 (ppm)

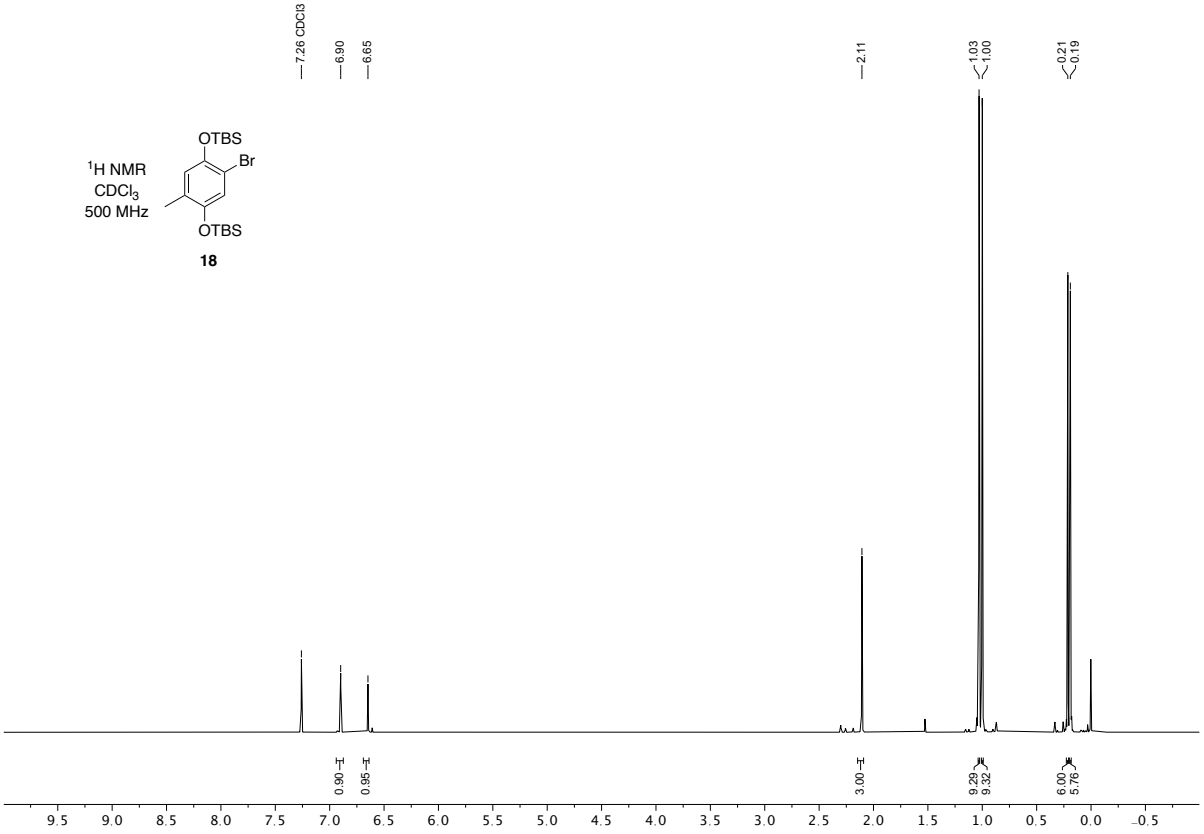

HMBC
CDCl3
500 MHz
H
O
O
H
OH
16
f1 (ppm)

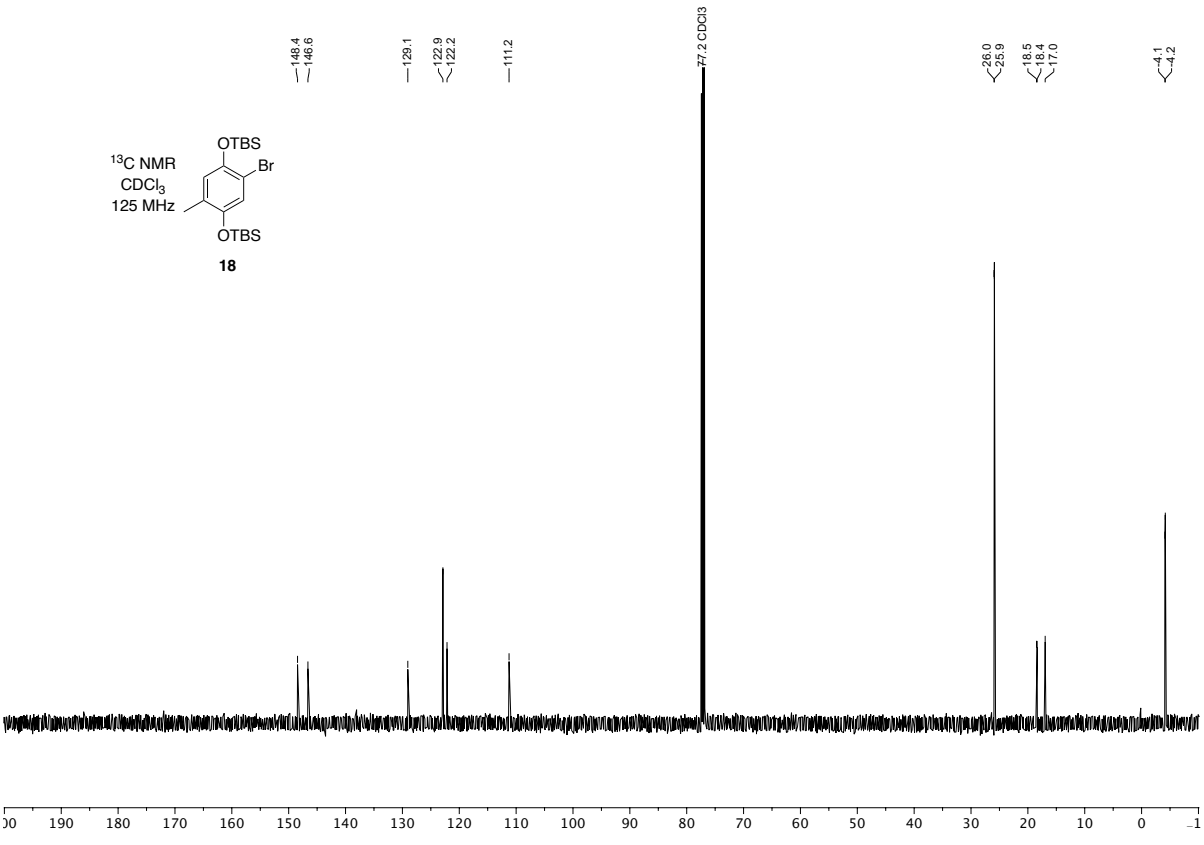

COSY
CDCl3
500 MHz
H
O
O
H
OH
16
f1 (ppm)

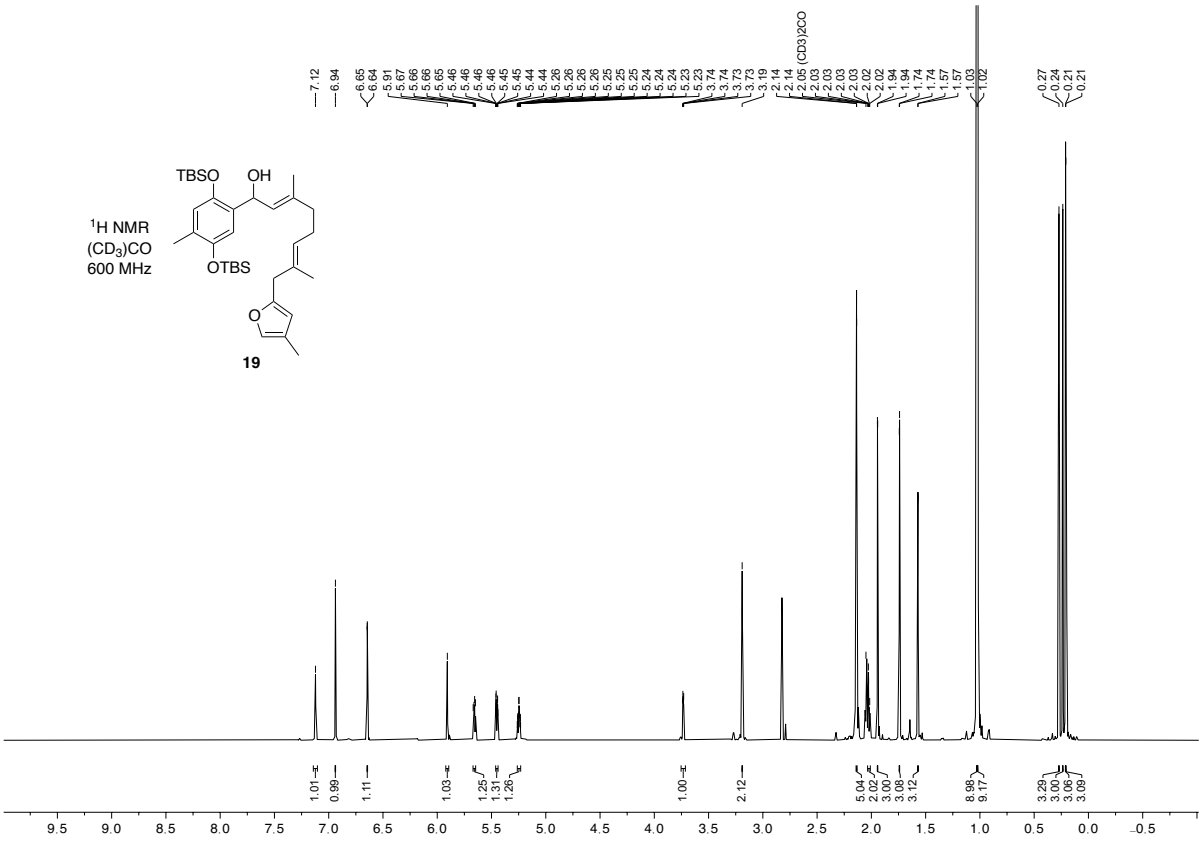

NOESY
CDCl3
500 MHz
H
O
O
H
OH
16
f1 (ppm)

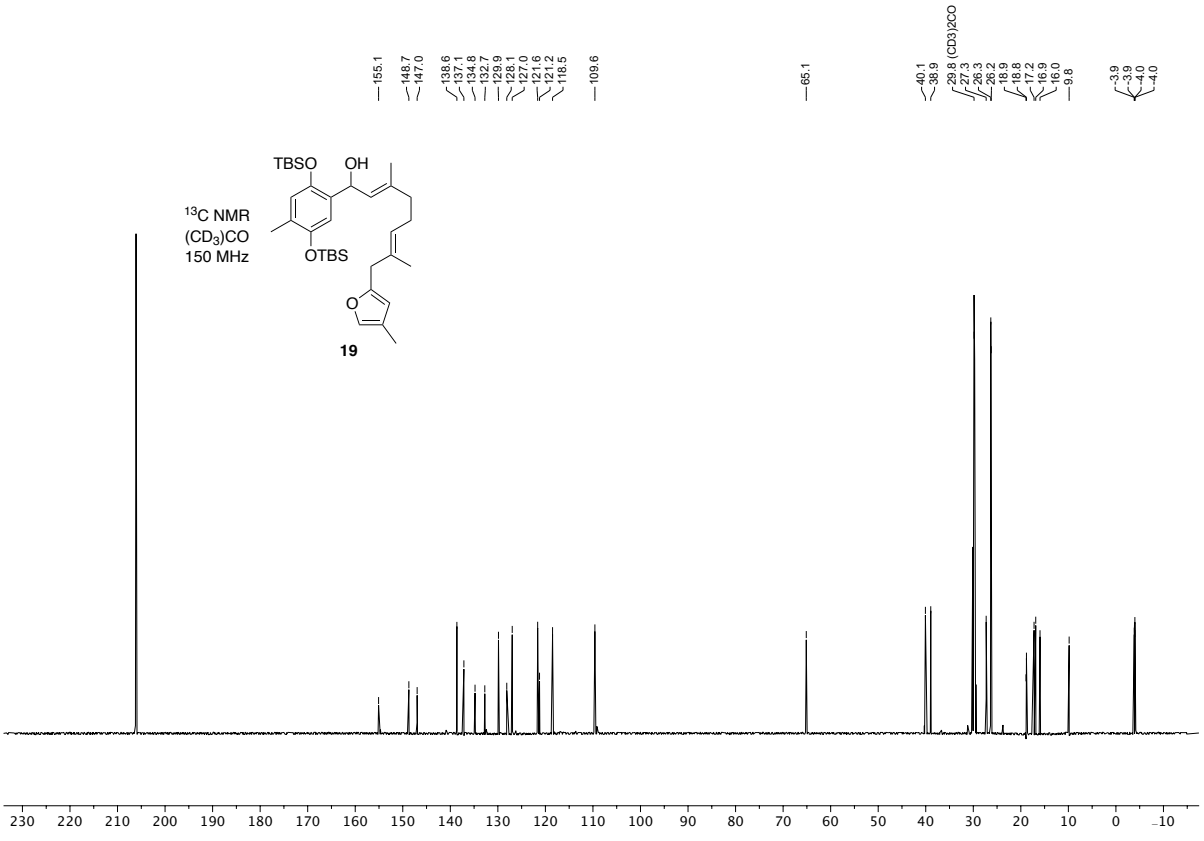

10.00
9.98
7.26 CDCl3
7.07
7.06
7.06
7.06
7.05
5.89
5.89
5.89
5.88
5.87
5.87
5.85
5.20
5.20
5.19
5.19
5.18
5.18
5.17
3.23
2.26
2.25
2.25
2.24
2.17
2.16
1.98
1.98
1.61
1.61
O
H
O
17
1H NMR
CDCl3
500 MHz
1.05
1.00
2.07
1.03
2.09
4.09
3.09
3.11
3.01
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5

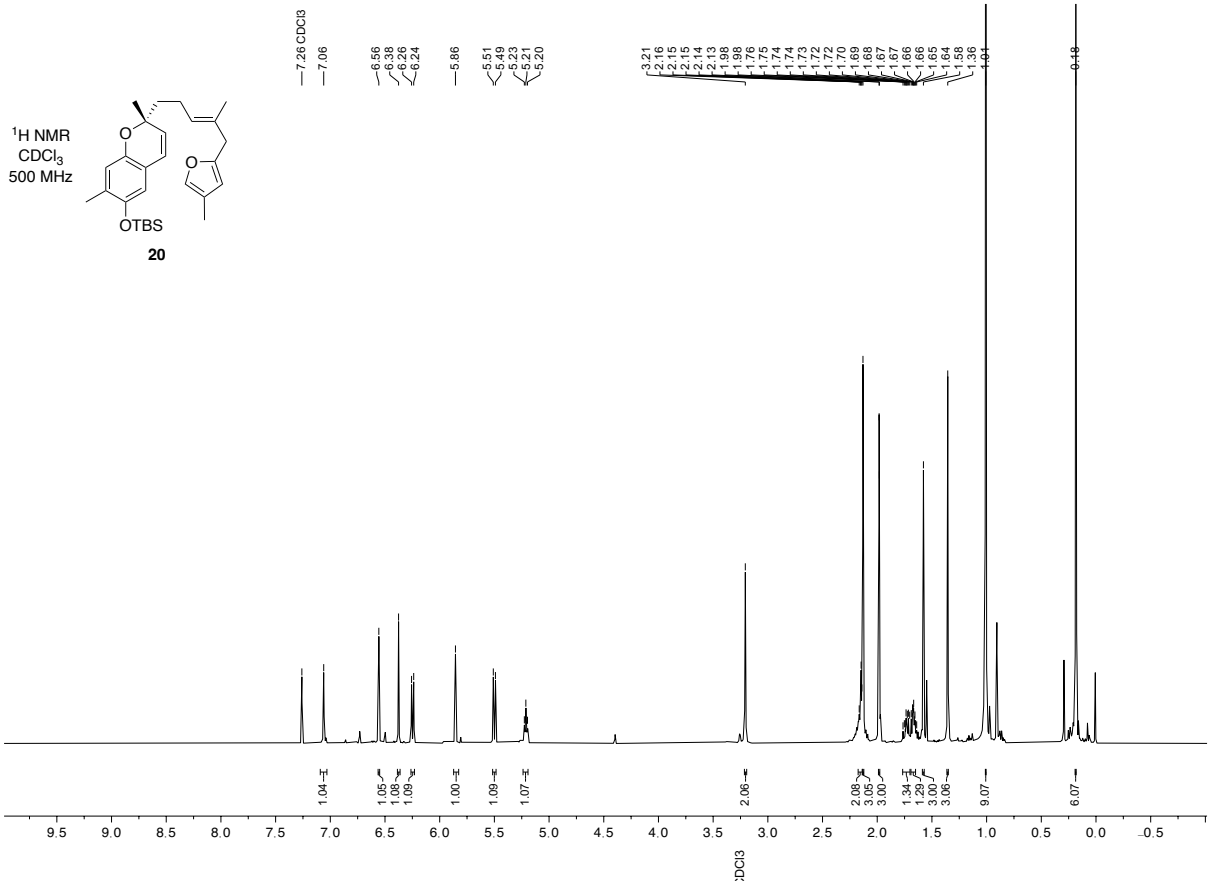

191.4
163.7
154.0
137.9
133.5
127.6
124.9
120.7
109.1
77.2 CDCl3
40.5
36.5
25.9
17.7
16.1
9.9
O
H
O
17
13C NMR
CDCl3
150 MHz
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

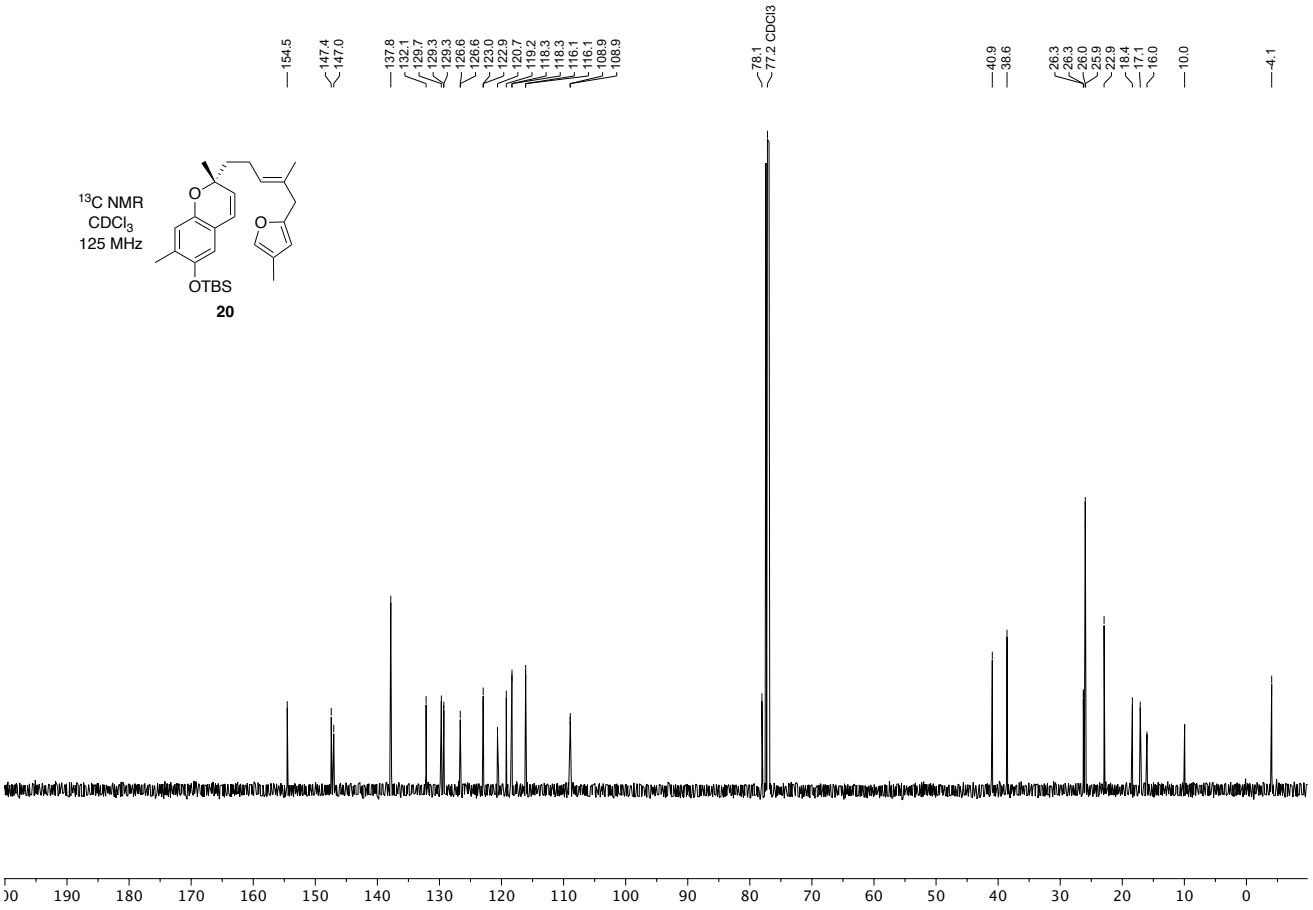

7.26 CDCl3
6.90
6.65
2.11
1.03
1.00
0.21
0.19
OTBS
Br
OTBS
1H NMR
CDCl3
500 MHz
18
0.90
0.95
3.00
9.29
9.32
6.00
5.76


148.4
146.6
129.1
122.9
122.2
111.2
77.2 CDCl3
26.0
25.9
18.5
18.4
17.0
-4.1
-4.2
OTBS
Br
OTBS
13C NMR
CDCl3
125 MHz
18

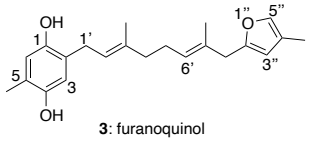

TBSO
OH
OTBS
O
19
^{1}H NMR
(CD$_3$)CO
600 MHz


TBSO
OH
OTBS
O
19
^{13}C NMR
(CD$_3$)CO
150 MHz


^{1}H NMR
$CDCl_3$
500 MHz
OTBS
20


^{13}C NMR
$CDCl_3$
125 MHz
OTBS
20

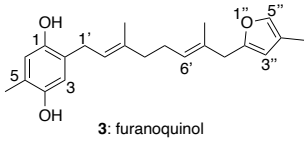
4. Tables of ^{1}H and ^{13}C NMR Data



3: furanoquinol

Assignment	^{1}H NMR (C_6D_6) δ_H ppm, mult., (J in Hz), int		^{13}C NMR (C_6D_6): δ_C ppm	
	Synthetic **3**[8]	Natural **3**[9]	Synthetic **3**[8]	Natural **3**[9]
1			148.1	147.4
2			125.6	125.5
3	6.32, s, 1H	6.329	116.4	116.2
4			148.2	147.4
5			123.0	122.6
5 CH_3	2.04, s, 3H	2.04	15.6	15.4
6	6.28, s, 1H	6.298	118.2	118.0
1’	3.28, d (*J* = 7.2) 1H	3.27	29.2	28.8
2’	5.37, tq (*J* = 7.3 & 1.4) 1H	5.36	126.7	126.2
3’			132.4	132.1
3’ CH_3	1.55, s, 3H	1.59	16.1	16.9
4’	2.03 – 2.01, m, 2H	2.1	39.8	39.6
5’	2.10, q (*J* = 7.2) 2H	2.1	26.8	26.5
6’	5.26, tq (*J* = 7.0 & 1.4) 1H	5.25	122.5	121.9
7’			138.2	137.6
7’ CH_3	1.58, s, 3H	1.65	16.0	16.0
8’	3.24, s, 2H	3.23	38.9	38.4
2’’			154.9	154.3
3’’	5.83, s, 1H	5.85	109.3	108.8
4’’			120.8	120.5
4’’ CH_3	1.81, d (*J* = 1.2) 3H	1.82	9.9	9.7
5’’	6.97, t, (*J* = 1.2) 1H	6.96	136.9	137.6

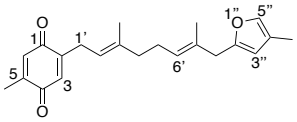
[8] ^{1}H and ^{13}C NMR spectroscopic data obtained at 600 MHz and 150 MHz, respectively.
[9] ^{1}H and ^{13}C NMR spectroscopic data obtained at 100 MHz and 20 MHz, respectively.
Isolation: J. C. Coll, N. Liyanage, G. J. Stokie, I. Van Altena, J. N. E. Nemorin, S. Sternhell and R. Kazlauskas, *Aust. J. Chem.* **1978**, *31*, 157.



3: furanoquinol

Assignment	^{1}H NMR ($CDCl_3$): δ_H ppm, mult., (J in Hz), int		^{13}C NMR ($CDCl_3$): δ_C ppm	
	Synthetic **3**[10]	Natural **3**[11]	Synthetic **3**[9]	Natural **3**[11]
1			147.9	147.4
2			125.4	125.5
3	6.54, s, 1H	6.65	116.3	116.2
4			147.6	147.4
5			122.6	122.6
5 CH_3	2.17, s, 3H	2.18	15.6	15.4
6	6.59, s, 1H	6.65	118.2	118.0
1’	3.27, d (J = 7.6) 2H	3.35	29.3	28.8
2’	5.29, t (J = 7.1) 1H	5.3	126.3	126.2
3’			132.4	132.1
3’ CH_3	1.74, s, 3H	1.75	16.3	16.9
4’	2.12 – 2.09, m, 2H	2.15	39.5	39.6
5’	2.16, m, 1H	2.15	26.5	26.5
6’	5.20, t (J = 7.0) 1H	5.3	122.0	121.9
7’			138.1	137.6
7’ CH_3	1.60, s, 3H	1.65	16.1	16.0
8’	3.23, s, 2H	3.3	38.6	38.4
2’’			154.5	154.3
3’’	5.87, s, 1H	5.95	109.0	108.8
4’’			120.7	120.5
4’’ CH_3	1.98, s, 3H	2.0	10.0	9.7
5’’	7.07, s, 1H	7.1	137.9	137.6

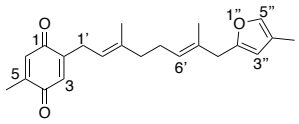
[10] ^{1}H and ^{13}C NMR spectroscopic data obtained at 600 MHz and 150 MHz respectively.
[11] ^{1}H and ^{13}C NMR spectroscopic data obtained at 100 MHz and 20 MHz respectively.
Isolation: J. C. Coll, N. Liyanage, G. J. Stokie, I. Van Altena, J. N. E. Nemorin, S. Sternhell and R. Kazlauskas, *Aust. J. Chem.* **1978**, *31*, 157.



4: furanoquinone

Assignment	^{1}H NMR (C_6D_6): δ_H ppm, mult. (J in Hz) int		^{13}C NMR (C_6D_6): δ_C ppm	
	Synthetic **4**[12]	Natural **4**[13]	Synthetic **4**[12]	Natural **4**[13]
1			187.4	187.3 or 187.7
2			148.1	148.1
3	6.35, t (*J* = 1.7) 1H	6.36	132.3	132.3
4			187.8	187.3 or 187.7
5			145.2	145.3
5 CH_3	1.58-1.57, m, 3H	1.70	15.1	15.2
6	6.10, q (*J* = 1.7) 1H	6.23	133.4	133.4
1’	3.00, d (*J* = 7.3) 2H	3.01	27.5	27.5
2’	5.05, tq (*J* = 7.4 & 1.3) 1H	5.08	126.6	126.6
3’			132.5	132.4
3’ CH_3	1.42, d (*J* = 1.3) 3H	1.62	15.9	15.93 or 15.98
4’	1.96, t (*J* = 7.4) 2H	1.9 – 2.2	39.7	39.7
5’	2.07, q (*J* = 7.3) 2H	1.9 – 2.2	26.8	26.7
6’	5.25, ddq (*J* = 7.1, 5.6 & 1.4) 1H	5.22	119.1	119.1
7’			139.2	139.1
7’ CH_3	1.57, br s, 3H	1.62	16.1	15.93 or 15.98
8’	3.29, s, 2H	3.25	38.9	38.8
2’’			154.8	154.7
3’’	5.86, s, 1H	5.83	109.3	109.2
4’’			120.7	120.6
4’’ CH_3	1.83, d (*J* = 1.2) 3H	1.86	9.9	9.9
5’’	6.99, q (*J* = 1.2) 1H	6.99	138.2	138.1

[12] ^{1}H and ^{13}C NMR spectroscopic data obtained at 600 MHz and 150 MHz respectively.
[13] ^{1}H and ^{13}C NMR spectroscopic data obtained at 100 MHz and 20 MHz respectively.
Isolation: J. C. Coll, N. Liyanage, G. J. Stokie, I. Van Altena, J. N. E. Nemorin, S. Sternhell and R. Kazlauskas, *Aust. J. Chem.* **1978**, *31*, 157.



4: furanoquinone

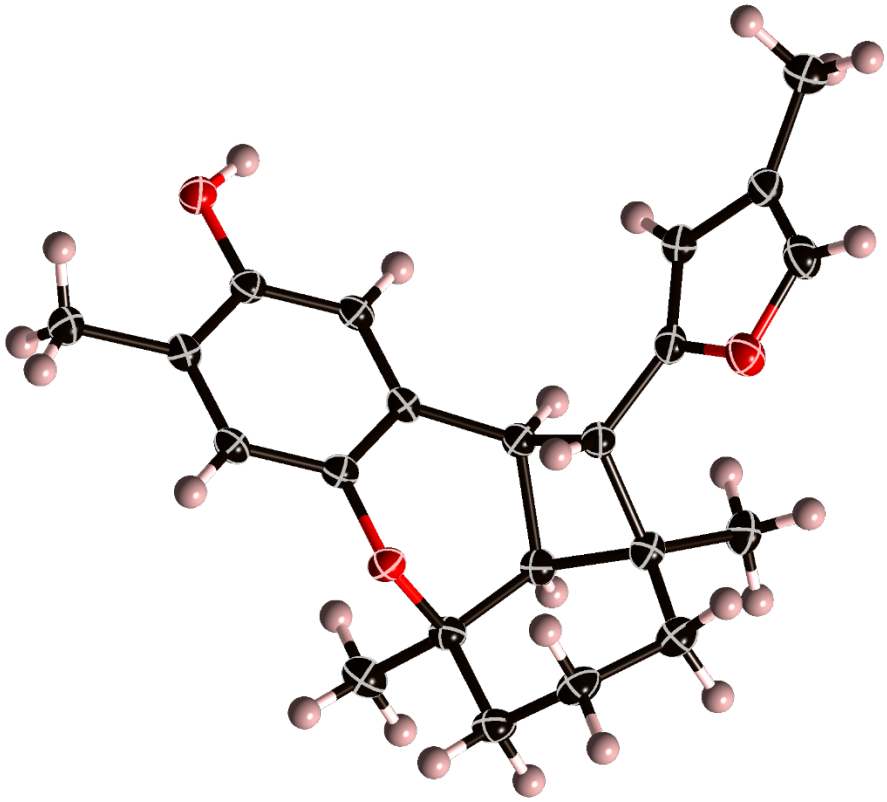
Assignment	^{1}H NMR ($CDCl_3$): δ_H ppm mult. (J in Hz) int		^{13}C NMR ($CDCl_3$): δ_C ppm
	Synthetic **4**[14]	Natural **4**[15]	Synthetic **4**[Error! Bookmark not defined.]
1			188.0
2			148.6
3	6.49, t (*J* = 1.8) 1H	6.45	132.5
4			188.5
5			145.8
5 CH_3	2.03, d (*J* = 1.7) 3H	1.97 or 2.03	15.6
6	6.59, m, 1H	6.50	133.6
1’	3.11, d (*J* = 7.2) 2H	3.11	27.2
2’	5.15, tq (*J* = 7.3 & 1.4) 1H	5.17	118.2
3’			132.4
3’ CH_3	1.60 or 1.62, s, 3H	1.62	16.3 or 16.1
4’	2.11 – 2.06, m, 2H	2.1	39.7
5’	2.18 – 2.12, m, 2H	2.1	26.6
6’	5.20, ddt (*J* = 7.0, 5.6 & 1.4) 1H	5.17	126.3
7’			139.8
7’ CH_3	1.60 or 1.62, s, 3H	1.60	16.3 or 16.1
8’	3.24, s, 2H	3.24	38.6
2’’			154.5
3’’	5.87, s, 1H	5.87	108.9
4’’			120.6
4’’ CH_3	1.98, d (*J* = 1.2) 3H	2.03 or 1.97	10.0
5’’	7.06, s, 1H	7.08	137.8

[14] ^{1}H and ^{13}C NMR spectroscopic data obtained at 600 MHz and 150 MHz respectively.
[15] ^{1}H spectroscopic data obtained at 100 MHz.
Isolation: J. C. Coll, N. Liyanage, G. J. Stokie, I. Van Altena, J. N. E. Nemorin, S. Sternhell and R. Kazlauskas, *Aust. J. Chem.* **1978**, *31*, 157.

5. Crystallography Data

Single crystals suitable for X-ray analysis of (1S,1aS,1a1S,4aR,9bR)-1a,4a,7-trimethyl-1-(4-methylfuran-2-yl)-1,1a,1a1,2,3,4,4a,9b-octahydrocyclobuta[kl]xanthen-8-ol (15 mg, 0.014 μmol) were recrystalized in Et_2O (5 mL) in a 15 mL vial and left at room temperature overnight to afford pale brown block crystals (7 mg, 50 %). A single crystal of (1S,1aS,1a1S,4aR,9bR)-1a,4a,7-trimethyl-1-(4-methylfuran-2-yl)-1,1a,1a1,2,3,4,4a,9b-octahydrocyclobuta[kl]xanthen-8-ol was mounted in paratone-N oil on a MiteGen crystal mount and X-ray diffraction was collected at 150(2) K on an Oxford X-calibur single crystal diffractometer using Mo Ka radiation. The data set was corrected for absorption and the structures solved by direct methods using SHELXS-97[1] and refined by full-matrix least squares on F2 by SHELXL-2015,[2] interfaced through the programs X-Seed[3] and Olex2.[4] In general, all nonhydrogen atoms were refined anisotropically and hydrogen atoms were included as invariants at geometrically estimated positions. Full data for the structure determination have been deposited with the Cambridge Crystallographic Data Centre as CCDC 2101324. Copies of this information may be obtained free of charge from The Director, CCDC, 12 Union Street, Cambridge CB2 1EZ, U.K. (fax, +44-1223-336-033; e-mail, deposit@ccdc.cam.ac.uk). The table below provides the crystal data and structure refinement details for (1S,1aS,1a1S,4aR,9bR)-1a,4a,7-trimethyl-1-(4-methylfuran-2-yl)-1,1a,1a1,2,3,4,4a,9b-octahydrocyclobuta[kl]xanthen-8-ol.

Crystal data and structure refinement for **16**.	
Identification code	P21c
Empirical formula	$C_{22}H_{26}O_3$
Formula weight	338.43
Temperature/K	150.00(14)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	11.6017(8)
b/Å	13.7639(6)
c/Å	12.7600(8)
α/°	90
β/°	114.935(8)
γ/°	90
Volume/Å^3	1847.6(2)
Z	4
ρ_{calcg}/cm^3	1.217
μ/mm^{-1}	0.079
F(000)	728.0
Crystal size/mm^3	0.3 × 0.26 × 0.051
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	6.888 to 58.742
Index ranges	$-15 \leq h \leq 15$, $-18 \leq k \leq 18$, $-17 \leq l \leq 16$
Reflections collected	80523
Independent reflections	4806 [R_{int} = 0.0846, R_{sigma} = 0.0427]
Data/restraints/parameters	4806/0/231
Goodness-of-fit on F^2	1.054
Final R indexes [I>=2σ (I)]	R_1 = 0.0518, wR_2 = 0.1408
Final R indexes [all data]	R_1 = 0.0816, wR_2 = 0.1586
Largest diff. peak/hole / e Å^{-3}	0.33/-0.20



A perspective view of one selected molecule of the asymmetric unit of **16**, with all non-hydrogen atoms represented by ellipsoids at the 50% probability level (Carbon, black; Hydrogen, white; Oxygen, red).

Crystallography References:

[1] G. M. Sheldrick, *Acta Crystallogr. Sect. A* **1990**, *46*, 467–473.
[2] G. M. Sheldrick, *Acta Crystallogr. Sect. A* **2008**, *64*, 112–122.
[3] L. J. Barbour, *J. Supramol. Chem.* **2001**, *1*, 189–191.
[4] L. J. Bourhis, O. V. Dolomanov, R. J. Gildea, J. A. K. Howardand and H. Puschmann, *Acta Crystallogr. Sect. A* **2015**, *71*, 59–75.