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Supplementary Information

$Bi(OTf)_3$-promoted cascade annulation of hydroxy-pyranones and unsaturated γ-ketoesters for the construction of polycyclic bridged pyrano-furopyranones

Akshay B. Rathod,[a,b] Balasaheb R. Borade,[a,b] Pooja I. Sambherao [a,b] and Ravindar Kontham[*,a,b]

[a]*Organic Chemistry Division, CSIR-National Chemical Laboratory, Dr. Homi Bhabha Road, Pune-411008, India.*
[b]*Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India*

[*]E-mail: k.ravindar@ncl.res.in; konthamravindar@gmail.com

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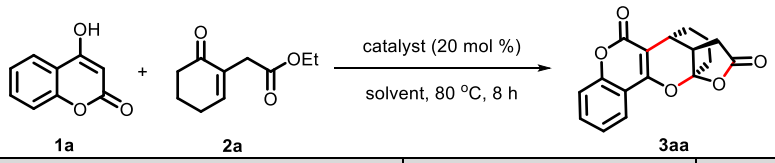
1. General Information

All reactions were performed under an argon atmosphere with an oven (90 °C) or flame-dried glassware with a septum seal. Anhydrous dichloromethane, dichloroethane, acetonitrile, toluene, fluorobenzene, chlorobenzene, DMF, and methanol were purchased from commercial sources and used as such. Tetrahydrofuran was dried over sodium before use. Reaction temperatures are reported as the bath temperature surrounding the reaction vessel. Analytical thin layer chromatography (TLC) was performed on TLC Silica gel 60 F254. Visualization was accomplished with short-wave UV light, anisaldehyde, or $KMnO_4$ staining solutions, followed by heating. Chromatography was performed on silica gel (100-200, 230-400 mesh) by standard techniques eluting with solvents as indicated. As indicated, in solvents, 1H and 13C NMR spectra were recorded on Bruker AV 200, 400, and 500 spectrometers. Chemical shifts (δ) are given in ppm. The residual solvent signals were used as references. The chemical shifts converted to the TMS scale ($CDCl_3$: δ H = 7.27 ppm, δ C = 77.16 ppm), the following abbreviations were used: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; dd, doublet of doublet; td, triplet doublet; and br, broad. HRMS data were recorded on a Thermo Scientific Q-Exactive, Accela 1250 pump. Experimental procedures for all new and known compounds without published experimental procedures are described below. Compounds that are not presented in the main text (manuscript) are numbered starting from **S1**.

Note: Compounds **1a**, **1h**, **1f**, **1i**, **2g** were purchased from commercial sources.

2. Table S1. Optimization studies[a]

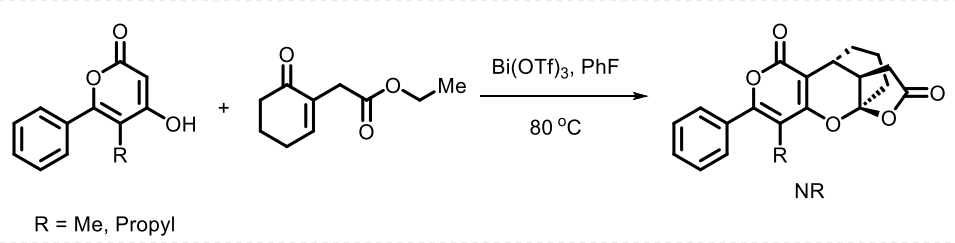


1a 2a 3aa

Entry	Catalyst	Solvent	Yield (%)[b]
1	$Bi(OTf)_3$	PhCl	41
2	$Bi(OTf)_3$	THF	18
3	$Bi(OTf)_3$	CH_3CN	trace
4	$Bi(OTf)_3$	DMF	-[c]
5	$Bi(OTf)_3$	Toluene	-[c]
6	$Bi(OTf)_3$	MeOH	-[c]
7	$Bi(OTf)_3$	EtOH	-[c]
8	$Bi(OTf)_3$ (10 mol %)	PhF	56
9	$Bi(OTf)_3$ (5 mol %)	PhF	30

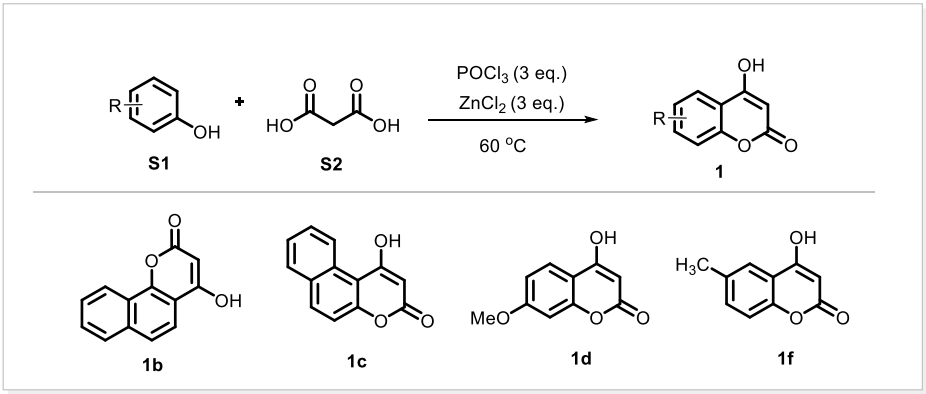
[a]Unless otherwise specified, the reaction was performed with **1a** (0.55 mmol), **2a** (0.55 mmol), catalyst (20 mol %), and in indicated solvent (anhydrous, 2 mL) at 80 °C. [b]Isolated yield of **3aa**. [c]No conversion was observed.

3. List of unsuccessful examples:



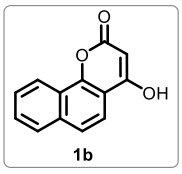
4. Synthesis of 4-hydroxy-2*H*-chromen-2-ones (1):[1]

3.a. General Procedure A:



To a flame-dried (100 mL) two-neck round bottom flask, substituted phenol **S1** (9.60 mmol), malonic acid **S2** (9.60 mmol), anhydrous $ZnCl_2$ (28.82 mmol), and $POCl_3$ (28.82 mmol) was added sequentially under an argon atmosphere at rt, and stirred at 60 °C. Then, the reaction progress was monitored by TLC, after completion of the reaction (~18 h), the reaction mixture was cooled to room temperature and poured to ice-cold water (50 mL), resulting in precipitation of reaction mixture into dark brown solid. The precipitate is further stirred for 30 min in water, filtered and washed with water (4 times). Then, the solid was trated with saturated aqueous $NaHCO_3$ solution (20 mL) and filtered using whatmann filter paper and washed with water (2 times). Then this crude product was further purified by silica-gel column chromatography to afford the desired product **1**.

4-Hydroxy-2*H*-benzo[*h*]chromen-2-one (1b):

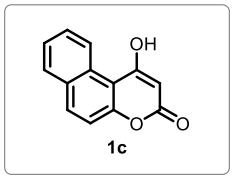


Following General Procedure A, **1b** was obtained from 1-naphthol (**S1**) (1 g, 9.60 mmol), malonic acid (**S2**) (1.38 g, 9.60 mmol), anhydrous $ZnCl_2$ (4.42 g, 28.82 mmol), and $POCl_3$ (3.9 mL, 28.82 mmol). Purification of crude product by column

[1] S. K.Mishra, S. N.Singh and R. K. Paliwal, *J. Chemtracks*, 2016, **18**, 309-310, and references cited therein.

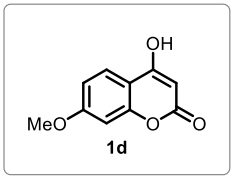
chromatography afforded 4-hydroxy-2*H*-benzo[*h*]chromen-2-one (**1b**) (1.1 g, 54%) as a brown solid. TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.34-8.32 (m, 1H), 7.97-7.94 (m, 2H), 7.68 (d, *J* = 8.5 Hz, 1H), 7.64-7.62 (m, 2H), 5.11 (s, 1H); ^{13}C{^{1}H} NMR (101 MHz, DMSO-d_6) 172.85, 163.79, 150.59, 134.43, 127.84, 127.59, 126.38, 122.90, 121.80, 121.98, 116.09, 87.53.

1-Hydroxy-3*H*-benzo[*f*]chromen-3-one (1c)[2]:



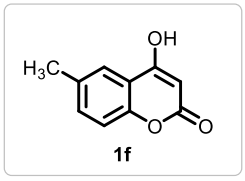
Following General Procedure A, **1c** was obtained from *β*-naphthol (**S3**) (1.38 g, 9.60 mmol), malonic acid (**S2**) (1 g, 9.60 mmol), anhydrous $ZnCl_2$ (3.9 g, 28.82 mmol), and $POCl_3$ (2.7 mL, 28.82 mmol). Purification of crude product by column chromatography afforded 1-hydroxy-3*H*-benzo[*f*]chromen-3-one (**1c**) (1.38 g, 67%) as a brown solid. TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.29 (d, *J* = 8.6 Hz, 1H), 8.20 (d, *J* = 9.0 Hz, 1H), 8.04 (d, *J* = 8.0 Hz, 1H), 7.71-7.67 (m, 1H), 7.60 (t, *J* = 7.4 Hz, 1H), 7.53 (d, *J* = 9.0 Hz, 1H), 5.76 (s, 1H); ^{13}C{^{1}H} NMR (101 MHz, DMSO-d_6) δ 169.39, 161.34, 154.88, 134.24, 130.31, 128.93, 128.87, 128.32, 125.99, 125.58, 117.19, 108.61, 91.70.

4-Hydroxy-7-methoxy-2*H*-chromen-2-one (1d)[3]:



Following General Procedure A, **1d** was obtained from 3-methoxyphenol (**S4**) (1.0 g, 8.06 mmol), malonic acid (**S2**) (0.83 g, 8.06 mmol), anhydrous $ZnCl_2$ (3.29 g, 24.18 mmol), and $POCl_3$ (3.69 mL, 24.18 mmol). Purification of crude product by column chromatography afforded 4-hydroxy-7-methoxy-2*H*-chromen-2-one (**1d**) (0.82 g, 35%) as a white solid. TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.60 (s, 1H), 7.43 (d, *J* = 8.4 Hz, 1H), 7.25 (d, *J* = 8.4 Hz, 1 H), 5.62 (s, 1H), 2.38 (s, 3H); ^{13}C{^{1}H} NMR (101MHz , DMSO-d_6) δ 165.61, 162.08, 151.68, 133.39, 133.07, 122.76, 116.08, 115.48, 91.0, 20.32.

4-Hydroxy-6-methyl-2*H*-chromen-2-one (1f)[4]:



Following General Procedure A, **1f** was obtained from *p*-cresol (**S5**) (1.0 g, 6.66 mmol), malonic acid (**S2**) (0.69 g, 6.66 mmol), anhydrous $ZnCl_2$ (3.06 g, 20 mmol), and $POCl_3$ (2.72 mL, 20 mmol). Purification of crude product by column

[2] L. Bin, X. L. Guan, X. X. Hua and L. Y. Hong, *Chin. J. Org. Chem*, 2011, **31**, 2067-2073.

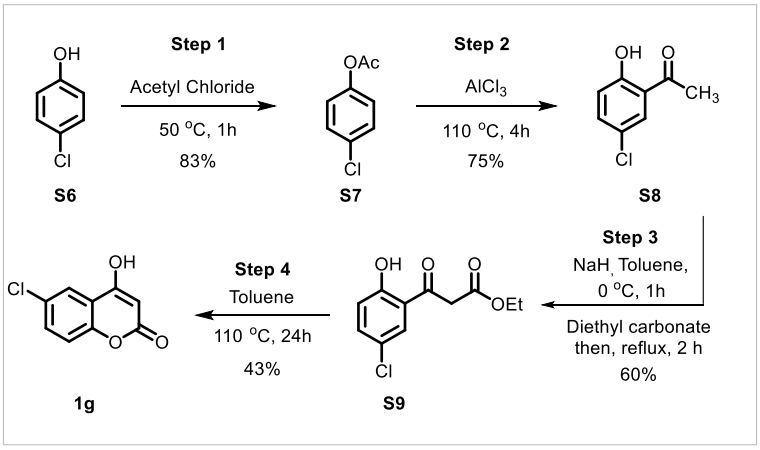
[3] Q. Shen, J. Shao, Q. Peng, W. Zhang, L. Ma, A. S, C. Chan, and L. Gu, *J. Med. Chem*. ,2010, **53**, 8252-8259.

[4] Q. Li, Z. Ge, Z. Ge, K. Chen, H Wu, X. Liu, Y. Huang, L. Yuan and F. Liao., *E. Jor. Med. Chem.* 2016, **108**, 166–176.

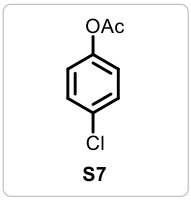
chromatography afforded 4-hydroxy-6-methyl-2*H*-chromen-2-one (**1f**) (0.46 g, 31%) as a white solid. TLC: R_f = 0.3 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6,) δ 12.33 (br. s., 1H), 7.70 (d, *J* = 8.5 Hz, 1H), 6.92-6.89 (m, 2H), 5.44 (s, 1H), 3.84 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, DMSO-d_6) δ 166.01, 162.93, 162.28, 155.41, 124.30, 111.81, 108.90, 100.49, 88.50, 55.85.

3.b. General Procedure B:[5]

***Synthesis of 6-chloro-4-hydroxy-2H-chromen-2-one (1g)*:**

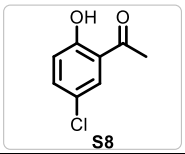


4-Chlorophenyl acetate (S7):



Step-1: To a flame-dried (100 mL) two-neck round bottom flask, 4-chlorophenol (**S6**, 1 g, 7.77 mmol), and acetyl chloride (0.91 mL, 9.33 mmol) were added under an argon atmosphere and stirred at 50 °C. Then, the reaction progress was monitored by TLC; after completion of the reaction (1 h) the reaction mixture was cooled to room temperature and it was quenched with saturated aqueous $NaHCO_3$ solution (20 mL), and the aqueous layer was extracted with EtOAc (3 × 50 mL), dried over Na_2SO_4, and filtered, the solvent was evaporated under reduced pressure to afford 4-chlorophenyl acetate **S7** (1.1 g, 83%) as a colorless liquid. TLC: R_f = 0.7 (SiO_2, 10% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 7.5 Hz, 2H), 7.03 (d, *J* = 7.5 Hz, 2H), 2.29 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.15, 149.10, 131.15, 129.43, 122.91, 21.00.

1-(5-Chloro-2-hydroxyphenyl)ethan-1-one (S8):

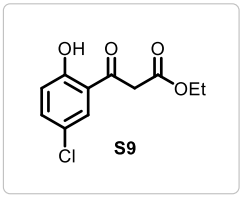


Step-2: To a flame-dried (100 mL) two-neck round bottom flask, a mixture of 4-chlorophenyl acetate (**S7,** 1 g, 5.88 mmol), and anhydrous $AlCl_3$ (1.56 g, 11.76 mmol)

[5] S. H. Kurma, S. Karri, M. Kuncha, R. Sistla and C. R. Bhimapaka, *Bioorganic Med. Chem. Lett*, 2020, **30**, 127341.

were added under an argon atmosphere and stirred at 110 °C. Then, the reaction progress was monitored by TLC; after completion of the reaction (4 h) the reaction mixture was cooled to room temperature and it was poured to ice-cold water (50 mL). Then, it was quenched with saturated aqueous $NaHCO_3$ solution (20 mL), and the aqueous layer was extracted with EtOAc (3 × 50 mL), dried over Na_2SO_4, and filtered, the solvent was evaporated under reduced pressure, and the resulting crude product was purified by silica gel column chromatography to afford 1-(5-chloro-2-hydroxyphenyl)ethan-1-one **S8** (0.75 g, 75%) as a colorless solid. TLC: R_f = 0.6 (SiO_2, 20% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 12.14 (s, 1H), 7.69 (s, 1H), 7.41 (d, *J* = 8.9 Hz, 1H), 6.94 (d, *J* = 8.9 Hz, 1H), 2.63 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 203.57, 160.84, 136.29, 129.83, 123.51, 120.22, 120.06, 26.66.

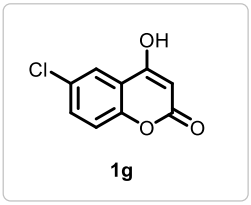
Ethyl 3-(5-chloro-2-hydroxyphenyl)-3-oxopropanoate (S9):



S9

Step-3: To a flame-dried (100 mL) two-neck round bottom flask, acetophenone (**S8**, 0.75 g, 4.41 mmol) in toluene (10 mL), sodium hydride (60% w/w suspension, 1.05 g, 44.11 mmol) in toluene (10 mL), under an argon atmosphere was stirred for 30 min at 0 °C. Then, diethyl carbonate (0.78 mL, 6.62 mmol) was added dropwise. Then, the reaction was slowly warmed to room temperature and stirred for 30 min. Further, the reaction mixture was refluxed for 2 h and the reaction progress was monitored by TLC; after completion of the reaction, the reaction mixture was cooled to room temperature. Then, it was quenched with 2N HCl (5 mL) and the aqueous layer was extracted with EtOAc (3 × 50 mL), dried over Na_2SO_4, and filtered, the solvent was evaporated under reduced pressure, and the resulting crude product was purified by silica gel column chromatography to afford ethyl 3-(5-chloro-2-hydroxyphenyl)-3-oxopropanoate **S9** (0.64 g, 60%) as a colorless liquid. TLC: R_f = 0.5 (SiO_2, 20% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.76 (s, 1H), 7.64 (s, 1H), 7.45 (d, *J* = 8.9 Hz, 1H), 6.98 (d, *J* = 9.0 Hz, 1H), 4.25 (q, *J* = 7.1 Hz, 2H), 3.98 (s, 2H), 1.29 (t, *J* = 7.1 Hz, 3H) ; ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 197.64, 166.40, 161.22, 136.97, 129.42, 123.92, 120.35, 119.52, 61.89, 45.79, 14.02.

6-Chloro-4-hydroxy-2*H*-chromen-2-one (1g):



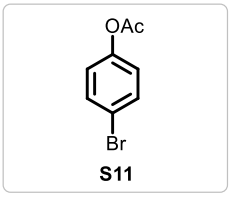
1g

Step-4: To ethyl 3-(5-chloro-2-hydroxyphenyl)-3-oxopropanoate (**S9**, 0.6 g, 2.47 mmol) was added toluene (15 mL) under an argon atmosphere and refluxed at 110 °C for 2 h. Then cooled the reaction mixture to room temperature to form a precipitate. Filtered off the resulting precipitate and washed with hexane (4–5 times) to afford 6-chloro-4-hydroxy-2*H*-chromen-2-one **1g** (0.21 g, 43%) as a

colorless solid. TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.76-7.67 (m, 2H), 7.43-7.41- (d, *J* = 8.8 Hz, 1H), 5.63 (s, 1H); ^{13}C{^{1}H} NMR (101 MHz, DMSO-d_6) δ 164.55, 161.41, 152.11, 132.33, 127.95, 122.35, 118.51, 117.35.

Synthesis of 6-bromo-4-hydroxy-2H-chromen-2-one (1h)[6]:

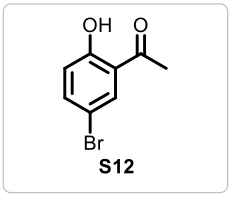
4-Bromo phenyl acetate (S11):



S11

Following General Procedure B, **S11** (2.56 g, 67%) as a colorless liquid) was obtained from 4-bromophenol (**S10,** 3 g, 17.34 mmol), and acetyl chloride (1.62 mL, 20.80 mmol). TLC: R_f = 0.6 (SiO_2, 20% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 7.4 Hz, 2H), 6.96 (d, *J* = 7.4 Hz 2H), 2.30 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 169.05, 149.63, 132.40, 123.32, 118.84, 21.00.

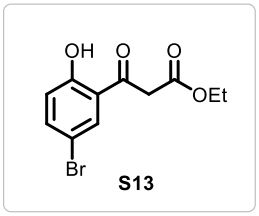
1-(5-Bromo-2-hydroxyphenyl)ethan-1-one (S12):



S12

Following General Procedure, **S12** was obtained from 4-bromophenyl acetate (**S11**, 3 g, 13.95 mmol), and anhydrous $AlCl_3$ (3.7 g, 27.90 mmol). The crude product was purified by silica gel column chromatography to afford 1-(5-bromo-2-hydroxyphenyl)ethan-1-one **S12** (2.06 g, 68%) as a colorless solid. TLC: R_f = 0.7 (SiO_2, 10% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 12.16 (s, 1H), 7.84 (s, 1H), 7.55 (d, *J* = 8.8 Hz, 1H), 6.90 (d, *J* = 8.8 Hz, 1H), 2.63 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 203.52, 161.30, 139.09, 132.89, 120.88, 120.48, 110.40, 26.69.

Ethyl 3-(5-bromo-2-hydroxyphenyl)-3-oxopropanoate (S13):

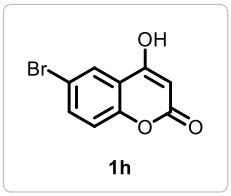


S13

Following General Procedure B, **S13** was obtained from acetophenone (**S12**, 1 g, 4.67 mmol) in toluene (10 mL), sodium hydride (60% w/w suspension, 1.12 g, 46.73 mmol) in toluene (10 mL), and diethyl carbonate (0.82 mL, 7.04 mmol). Purification of the product by silica gel column chromatography afforded ethyl 3-(5-bromo-2-hydroxyphenyl)-3-oxopropanoate **S13** (1.13 g, 84%) as a white solid. TLC: R_f = 0.4 (SiO_2, 20% EtOAc/hexane);); ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.77 (s, 1H), 7.77 (s, 1H), 7.57 (d, *J* = 8.9 Hz, 1H), 6.92 (d, *J* = 8.9 Hz, 1H), 4.25 (q, *J* = 7.0 Hz, 2H), 3.98 (s, 2H), 1.31-1.27 (m, 3H); ^{13}C{^{1}H} NMR (101 MHz ,$CDCl_3$) δ 197.57, 166.37, 161.63, 139.70, 132.48, 120.71, 120.15, 110.72, 61.88, 45.77, 14.02.

[6]M. L.N. Rao and A. Kumar. *Tetrahedron,* 2014, 70, 6995−7005.

6-Bromo-4-hydroxy-2*H*-chromen-2-one (1h):



Following General Procedure B, **1h** (0.92 g, 74%, as a colorless solid) was obtained from ethyl 3-(5-bromo-2-hydroxyphenyl)-3-oxopropanoate (**S13**, 1.13 g, 5.25 mmol). TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.89 (s, 1H), 7.79 (d, *J* = 8.8 Hz, 1H), 7.35 (d, *J* = 8.8 Hz, 1H), 5.61 (s, 1H); ^{13}C{^{1}H} NMR (101 MHz, DMSO-d_6) δ 165.08, 161.88, 153.01, 135.55, 125.82, 119.25, 118.35, 116.12, 92.04.

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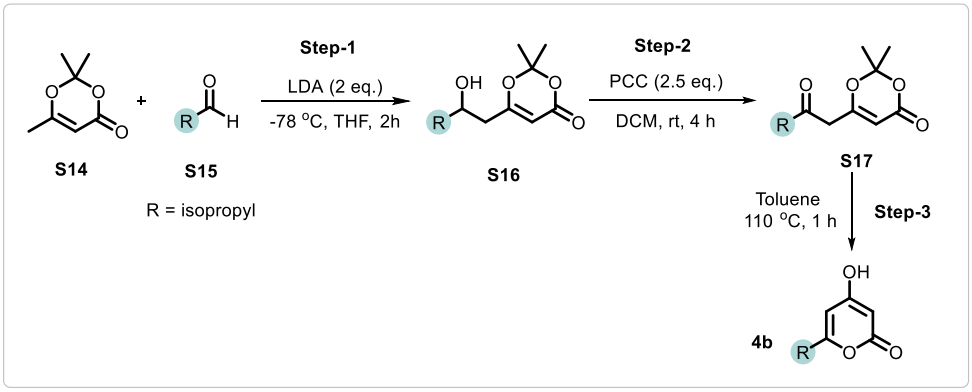
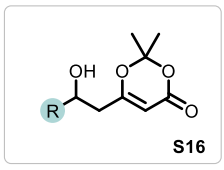
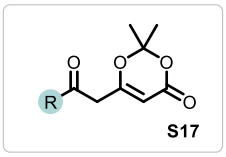
5. Synthesis of 4-hydroxy-2*H*-pyran-2-ones (4): General Procedure C:[7]



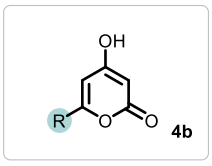


Step-1: To a flame-dried (100 mL) two-neck round bottom flask, was added anhydrous THF (50 mL) under an argon atmosphere and was cooled to 0 °C. To this, diisopropylamine (37.77 mmol) followed by *n*-butyl lithium (1.6 M in hexane, 45.55 mmol) was added dropwise at 0 °C and stirred for 45 min at 0 °C to generate LDA solution. This LDA solution was added dropwise to 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 32.72 mmol) in THF (30 mL) at −78 °C under argon atmosphere. The resulting mixture was stirred for 1.5 h at −78 °C, and then aldehyde (**S15**, 27.73 mmol) in THF was added dropwise. Then, the resulting reaction mixtures was stirred for 2 h at same temperature. The reaction progress was monitored by TLC; after completion of the reaction, it was quenched with saturated NH_4Cl (50 mL), and the aqueous layer was extracted with EtOAc (3 × 50 mL), dried over Na_2SO_4, and filtered, the solvent was evaporated under reduced pressure, and the resulting crude product was purified by silica gel column chromatography (SiO_2, 20% EtOAc/hexane) to afford hydroxy product **S16**.

[7] A. R. Katritzky, Z. Wang, M. Wang, C. D. Hall and K. Suzuki, *J. Org. Chem*, 2005, **70**, 4854–4856.



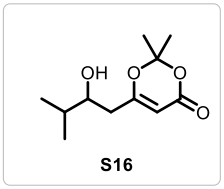
Step-2: To a solution of hydroxy compound (**S16**, 1 eq.) in anhydrous CH_2Cl_2 (20 mL) was added grinded PCC powder (2.5 eq.) at 0 ^oC and stirred for 4 h. The reaction progress was monitored by TLC; after completion of the reaction, the reaction mixture was filtered through celite pad and washed with CH_2Cl_2. Then, the solvent was evaporated under reduced pressure, and the resulting crude product was purified by silica gel column chromatography (SiO_2, 20% EtOAc/hexane) to afford the ketone product **S17**.



Step-3: To a solution of ketone (**S17**, 3.77 mmol) and toluene (15 mL) was refluxed at 110 °C for 1 h under an argon atmosphere. Then the reaction mixture was cooled to rt and the formed solid filtered off and washed with hexane (4–5 times) to afford **4b** as a colorless solid. TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane). These pyrones were used in the annulation reaction without further purification.

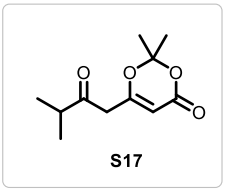
Synthesis of 4-hydroxy-6-isopropyl-2H-pyran-2-one (4b):

6-(2-Hydroxy-3-methylbutyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S16)*:*



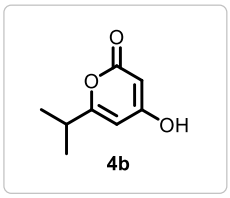
Following General Procedure C, **S16** (1 g, 17%, as a colorless liquid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 4.65 g, 32.72 mmol) and isobutyraldehyde (**S15**, 2 g, 27.73 mmol). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.33 (s, 1H), 3.72-3.63 (m, 1H), 2.42-2.38 (d, *J* = 14.15 Hz,, 1H), 2.30 (d, *J* = 9.5 Hz, 1H), 1.70 (s, 6H), 0.95 (d, *J* = 6.8 Hz, 6H); ^{13}C{^{1}H} NMR (101MHz ,$CDCl_3$) δ 169.94, 161.17, 106.56, 94.93, 73.38, 38.70, 33.78, 25.33, 24.68, 18.51, 17.09; HRMS (ESI): m/z calcd for $C_{11}H_{19}O_4$ $[M+H]^+$ 215.1283, found 215.1278.

2,2-Dimethyl-6-(3-methyl-2-oxobutyl)-4*H*-1,3-dioxin-4-one (S17)*:*



Following General Procedure C, **S17** (0.85 g, 86%, as a colorless solid) was obtained from 6-(2-hydroxy-3-methylbutyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (**S16**, 1 g, 46.67 mmol) and PCC powder (2.51 g, 11.66 mmol). TLC: R_f = 0.5 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.33 (s, 1H), 3.38 (s, 2H), 2.71-2.64 (m, 1H), 1.71 (s, 6H), 1.15 (d, J = 6.6 Hz, 6H) ; ^{13}C{^{1}H} NMR (101 MHz,$CDCl_3$) δ 207.02, 164.91, 160.74, 107.17, 96.66, 44.66, 41.38, 24.98, 17.88; HRMS (ESI): m/z calcd for $C_{11}H_{17}O_4$ $[M+H]^+$ 213.1127, found 213.1108.

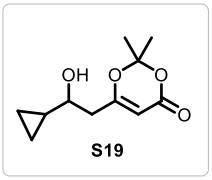
4-Hydroxy-6-isopropyl-2*H*-pyran-2-one (4b):



Following General Procedure C, **4b** (0.55 g, 95%, as a colorless solid) was obtained from 2,2-dimethyl-6-(3-methyl-2-oxobutyl)-4*H*-1,3-dioxin-4-one (**S17**, 0.8 g, 3.77 mmol). TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.99 (s, 1H), 5.58 (s, 1H), 2.77-2.71 (m, 1H), 1.24-1.22 (d, J = 6.9 Hz, 6H) ; $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 172.76, 171.87, 168.25, 99.25, 89.82, 32.62, 19.94; HRMS (ESI): m/z calcd for $C_8H_{11}O_3$ $[M+H]^+$ 155.0708, found 155.0704.

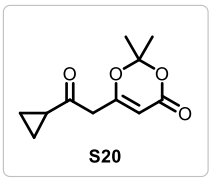
Synthesis of 6-cyclopropyl-4-hydroxy-2H-pyran-2-one (4c):

6-(2-Cyclopropyl-2-hydroxyethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S19):



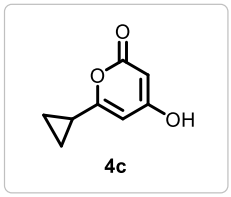
Following General Procedure C, **S19** (4 g, 66%, as a colorless liquid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one, cyclopropane carbaldehyde (**S18**, 2 g, 28.53 mmol). (4 g, 66%) as a colorless liquid. TLC: R_f = 0.4 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.30 (s, 1H), 3.17 (d, *J* = 4.1 Hz, 1H), 2.49-2.45 (m, 2H), 1.65 (s, 6H), 0.92-0.91 (m, 1H), 0.51 (d, *J* = 7.8 Hz, 2H), 0.32 (br. s., 1H), 0.22 (br. s., 1H) ; $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 169.33, 161.34, 106.44, 94.73, 72.96, 41.35, 25.30, 24.47, 17.68, 2.91, 2.50; HRMS (ESI): m/z calcd for $C_{11}H_{17}O_4$ $[M+H]^+$ 213.1126, found 213.1121.

6-(2-Cyclopropyl-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S20):



Following General Procedure C, **S20** (2.51 g, 63%, as a colorless solid) was obtained from 6-(2-cyclopropyl-2-hydroxyethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (**S19**, 4 g, 18.86 mmol), and PCC powder (8.1 g, 37.73 mmol). TLC: R_f = 0.6 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.38 (s, 1H), 3.48 (s, 2H), 2.00-1.98 (m, 1H), 1.72 (s, 6H), 1.12 (d, *J* = 3.13, 2H), 1.01-0.98 (q, *J* = 3.1, 7.3 Hz, 2H); $^{13}C\{^1H\}$ NMR (101 MHz ,$CDCl_3$) δ 203.23, 164.64, 160.72, 107.12, 96.50, 47.86, 25.0, 20.95, 11.84; HRMS (ESI): m/z calcd for $C_{11}H_{15}O_4$ $[M+H]^+$ 211.0970, found 211.0964.

6-Cyclopropyl-4-hydroxy-2*H*-pyran-2-one (4c):

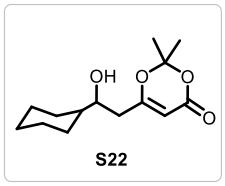


Following General Procedure C, **4c** (1.3 g, 72%, as a colorless solid) was obtained from 6-(2-cyclopropyl-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (**S20**, 2.5 g, 11.95 mmol). TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 6.02 (d, *J* = 2.1 Hz, 1H), 5.16 (d, *J* = 2.1 Hz, 1H), 1.91-1.87 (m, 1H),

0.94.0.92 (m, 2H), 0.89-0.86 (m, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, DMSO-d_6) δ 170.84, 167.15, 163.68, 97.97, 87.75,13.73, 7.76; HRMS (ESI): m/z calcd for $C_8H_9O_3$ $[M+H]^+$ 153.0551, found 153.0546.

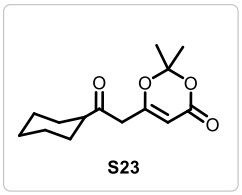
Synthesis of 6-cyclohexyl-4-hydroxy-2H-pyran-2-one (4d):

6-(2-Cyclohexyl-2-hydroxyethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S22):



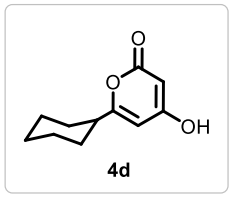
Following General Procedure C, **S22** (1.48 g, 54%, as a colorless liquid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 2 g, 13.5 mmol), cyclohexanecarbaldehyde (**S21**, 1.26 g, 11.25 mmol). TLC: R_f = 0.4 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.34 (s, 1H), 3.68 (br. s., 1H), 2.44 (d, *J* = 14.5 Hz, 1H), 2.33-2.30 (dd, *J* = 9.6, 14.5 Hz, 1H), 1.84-1.71 (m, 4H), 1.71 (s, 6H), 1.38 (br. s., 1H), 1.26-1.10 (m., 6H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 169.93, 161.09, 106.57, 95.02, 72.97, 43.75, 38.80, 29.02, 27.67, 26.29, 26.10, 25.95, 25.39, 24.71; HRMS (ESI): *m/z* calcd for $C_{14}H_{23}O_4$ $[M+H]^+$ 255.1591, found 255.1586.

6-(2-Cyclohexyl-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S23):



Following General Procedure C, **S23** (0.97 g, 66%, as a colorless liquid) was obtained from 6-(2-cyclohexyl-2-hydroxyethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (**S22**, 1.48 g, 5.87 mmol), and PCC powder (3.15 g, 14.68 mmol). TLC: R_f = 0.5 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.31 (s, 1H), 3.35 (s, 2H), 2.42-2.36 (m, 1H), 1.88-1.78 (m, 4H), 1.70 (s, 6H), 1.39-1.18 (m, 6H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 206.33, 165.02, 160.71, 107.10, 96.59, 51.05, 44.87, 28.13, 25.60, 25.38, 24.96; HRMS (ESI): *m/z* calcd for $C_{14}H_{23}O_4$ $[M+H]^+$ 253.1434, found 253.1429.

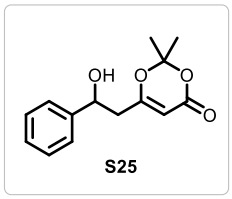
6-Cyclohexyl-4-hydroxy-2*H*-pyran-2-one (4d):



Following General Procedure C, **4d** (0.51 g, 60%, as a off white solid) was obtained from 6-(2-cyclohexyl-2-oxoethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (**S23**, 1.12 g, 4.40 mmol). TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.59 (br. s., 1H), 5.87 (s, 1H), 5.21 (s, 1H), 2.37 (br. s., 1H), 1.82-1.63 (m, 5H), 1.635-1.16 (m, 5H); $^{13}C\{^{1}H\}$ NMR (101 MHz, DMSO-d_6) δ 170.56, 170.05, 163.82, 97.75, 88.44, 41.28, 29.82, 25.29, 25.24.

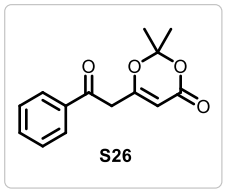
Synthesis of 4-hydroxy-6-phenyl-2H-pyran-2-one (4e):

6-(2-Hydroxy-2-phenylethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S25):



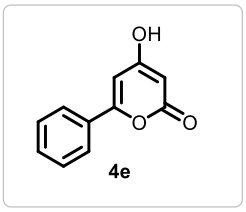
Following General Procedure C, **S25** (2 g, 96%, as a colorless solid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 1.38 g, 11.11 mmol), benzaldehyde (**S24** 1g, 95.23 mmol). TLC: R_f = 0.4 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36-7.31 (m, 4H), 7.31-7.26 (m, 1H), 5.23 (s, 1H), 4.92-4.90 (m, 1H), 3.23 (br. s., 1H), 2.67-2.53 (m, 2H), 1.61 (d, J = 5.8 Hz, 6H) ; ^{13}C{^{1}H} NMR (101 MHz ,$CDCl_3$) δ 168.87, 161.56, 143.01, 128.61, 128.05, 125.77, 106.71, 95.12, 70.89, 43.14, 25.28, 24.59; HRMS (ESI): m/z calcd for $C_{14}H_{17}O_4$ $[M+H]^+$ 249.1126, found 249.1121.

2,2-Dimethyl-6-(2-oxo-2-phenylethyl)-4*H*-1,3-dioxin-4-one (S26):



Following General Procedure C, **S26** (1.29 g, 65%, as a colorless solid) was obtained from 6-(2-hydroxy-2-phenylethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (**S25**, 2 g, 80.55 mmol), and PCC powder (4.34 g, 20.13 mmol). TLC: R_f = 0.5 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 7.4 Hz, 2H), 7.64 (t, *J* = 7.3 Hz, 1H), 7.51 (t, *J* = 7.4 Hz, 2H), 5.43 (s, 1 H), 3.91 (s, 2H), 1.71 (s, 6H) ; ^{13}C{^{1}H} NMR (101 MHz ,$CDCl_3$) δ 193.00, 165.10, 160.71, 135.84, 133.99, 128.88, 128.29, 107.29, 96.97, 43.27, 24.96; HRMS (ESI): m/z calcd for $C_{14}H_{15}O_4$ $[M+H]^+$ 247.0970, found 247.0963.

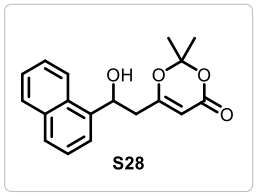
4-Hydroxy-6-phenyl-2*H*-pyran-2-one (4e):



Following General Procedure C, **4e** (0.50 g, 65%, as a colorless solid) was obtained from 2,2-dimethyl-6-(2-oxo-2-phenylethyl)-4*H*-1,3-dioxin-4-one (**S26**, 0.6 g, 11.76 mmol). TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.85 (s, 1H), 7.85-7.83 (m, 2H), 7.54-7.52 (t, *J* = 3.0 Hz 3H), 6.75 (d, *J* = 1.88 Hz, 1H), 5.41-5.40 (d, *J* = 1.9 Hz, 1H); ^{13}C{^{1}H} NMR (101 MHz , DMSO-d_6) δ 170.53, 163.03, 160.05, 131.05, 130.94, 129.06, 125.45, 98.38, 89.63; HRMS (ESI): m/z calcd for $C_{11}H_9O_3$ $[M+H]^+$ 189.0551, found 189.0546

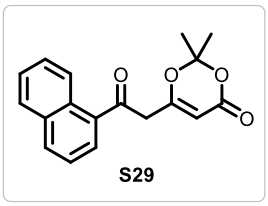
Synthesis of 4-hydroxy-6-(naphthalen-1-yl)-2H-pyran-2-one (4f):

6-(2-Hydroxy-2-(naphthalen-1-yl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (**S28**):



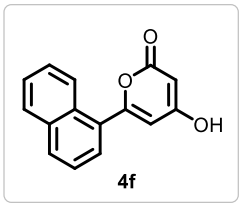
Following General Procedure C, **S28** (3 g, 79%, as a colorless liquid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 2.14 g, 15.11 mmol), 1-naphthaldehyde (**S27**, 2.0 g, 12.80 mmol). TLC: R_f = 0.4 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz,$CDCl_3$) δ 8.05 (d, *J* = 8.3 Hz, 1H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.82 (d, *J* = 8.1 Hz, 1H), 7.68 (d, *J* = 7.1 Hz, 1H), 7.58-7.47 (m, 3H), 5.76 (d, *J* = 7.0 Hz, 1H), 5.37 (s, 1H), 2.79 (m, 2H), 1.69 (d, *J* = 14.01 Hz 6H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.70, 161.18, 138.35, 133.79, 129.85, 129.12, 128.62, 126.45, 125.77, 125.42, 122.90, 122.42, 106.75, 95.27, 67.94, 42.47, 25.40, 24.63; HRMS (ESI): m/z calcd for $C_{18}H_{19}O_4$ $[M+H]^+$ 299.1283, found 299.1271.

2,2-Dimethyl-6-(2-(naphthalen-1-yl)-2-oxoethyl)-4H-1,3-dioxin-4-one (**S29**):



Following General Procedure C, **S29** (2.98 g, 40%, as a colorless liquid) was obtained from 6-(2-hydroxy-2-(naphthalen-1-yl)ethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (**S28**, 3 g, 10.05 mmol), and PCC powder (5.4 g, 25.13 mmol). TLC: R_f = 0.6 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz , $CDCl_3$) δ 8.66 (d, *J* = 8.63 Hz, 1H), 8.06 (d, *J* = 8.13 Hz, 1H), 7.90 (d, *J* = 7.63 Hz, 2H), 7.66-7.62 (t, *J* = 7.25 Hz, 1H), 7.59-7.51 (m, 2H), 5.47 (s, 1H), 4.00 (s, 2H), 1.62 (s, 6H); ^{13}C{^{1}H} NMR (101 MHz ,$CDCl_3$) δ 196.25, 165.16, 160.80, 133.98, 130.22, 128.61, 126.86, 125.52, 124.23, 107.31, 96.92, 46.34, 24.92; HRMS (ESI): m/z calcd for $C_{18}H_{17}O_4$ $[M+H]^+$ 297.1121, found 297.1118.

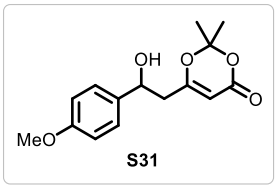
4-Hydroxy-6-(naphthalen-1-yl)-2*H*-pyran-2-one (4f):



Following General Procedure C, **4f** (0.7 g, 79%, as a colorless solid) was obtained from 2,2-dimethyl-6-(2-(naphthalen-1-yl)-2-oxoethyl)-4H-1,3-dioxin-4-one (**S29**, 1.1 g, 37.16 mmol). TLC: R_f = 0.6 (SiO_2, 20% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6): δ 8.12-8.10 (m, 3H), 7.73 (d, *J* = 7.0 Hz, 1H), 7.66-7.60 (m, 4H), 6.46 (s, 1H), 5.49 (s, 1H); ^{13}C{^{1}H} NMR (101 MHz, DMSO-d_6) δ 170.30, 163.51, 161.88, 133.27, 130.95, 129.72, 128.64, 127.71, 127.42, 126.55, 125.35, 124.60, 103.27, 89.59; HRMS (ESI): m/z calcd for $C_{15}H_{11}O_3$ $[M+H]^+$ 239.0708, found 239.0701

Synthesis of 4-hydroxy-6-(4-methoxyphenyl)-2H-pyran-2-one (4g):

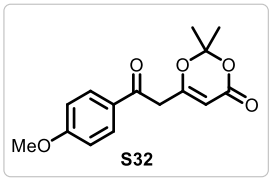
6-(2-Hydroxy-2-(4-methoxyphenyl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S31):



Following General Procedure C, **S31** (1.5 g, 37%, as a colorless liquid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 2.46 g, 17.33 mmol), 4-

methoxybenzaldehyde (**S30**, 2.0 g, 14.68 mmol). TLC: R_f = 0.4 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.40 (d, *J* = 8.0 Hz, 2H), 6.01 (d, *J* = 8.3 Hz, 2H), 4.39 (s, 1H), 4.04 (br. s., 1H), 2.93 (s, 3H), 1.72- 1.67 (m, 3H), 0.78 (d, *J* = 7.4 Hz, 6H); $^{13}C\{^1H\}$ NMR (101 MHz ,$CDCl_3$) δ 168.59, 161.23, 159.37, 134.90, 126.98, 113.94, 106.57, 95.08, 55.22, 43.01, 25.22, 24.59; HRMS (ESI): m/z calcd for $C_{15}H_{19}O_5$ $[M+H]^+$ 279.1232, found 279.1223.

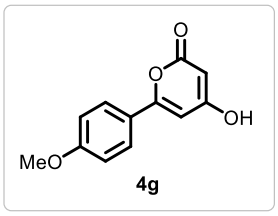
6-(2-(4-Methoxyphenyl)-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S32):



S32

Following General Procedure C, **S32** (1 g, 68%, as a colorless liquid) was obtained from 6-(2-Hydroxy-2-(4-methoxyphenyl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (**S31**, 1.5 g, 5.38 mmol), and PCC powder (2.90 g, 13.47 mmol). TLC: R_f = 0.6 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.6 Hz, 2H), 6.94 (d, *J* = 7.6 Hz, 2H), 5.38 (s, 1H), 3.84 (d, *J* = 11.76 Hz,, 5H), 1.67 (s, 6H); $^{13}C\{^1H\}$ NMR (101 MHz ,$CDCl_3$) δ 191.39, 165.50, 164.08, 160.71, 130.61, 128.78, 113.95, 107.10, 96.66, 55.47, 42.92, 24.87; HRMS (ESI): m/z calcd for $C_{15}H_{17}O_5$ $[M+H]^+$ 277.1071, found 277.1067.

4-Hydroxy-6-(4-methoxyphenyl)-2*H*-pyran-2-one (4g):

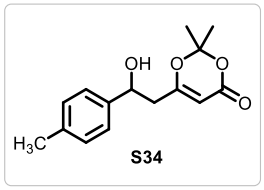


4g

Following General Procedure C, **4g** (0.75 g, 95%, as a colorless solid) was obtained from 6-(2-(4-methoxyphenyl)-2-oxoethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (**S32**, 1 g, 36.23 mmol). TLC: R_f = 0.3 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6): δ 7.79 (d, *J* = 8.8 Hz, 2H), 7.05 (d, *J* = 8.8 Hz, 2H), 6.63 (s, 1H), 5.33 (s, 1H), 3.82 (s, 3H); $^{13}C\{^1H\}$ NMR (101 MHz, DMSO-d_6) δ 175.99, 168.36, 166.62, 165.49, 132.44, 128.64, 119.69, 101.85, 93.91, 60.63; HRMS (ESI): m/z calcd for $C_{12}H_{11}O_4$ $[M+H]^+$ 219.0657, found 219.0656.

Synthesis of 4-hydroxy-6-(p-tolyl)-2H-pyran-2-one (4h):

6-(2-Hydroxy-2-(p-tolyl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S34):

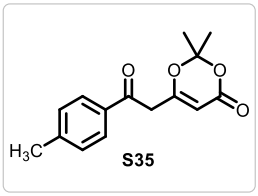


S34

Following General Procedure C, **S34** (3.75 g, 86%, as a colorless liquid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 2.79 g, 19.64 mmol), 4-methylbenzaldehyde (**S33**, 2.0 g, 16.64 mmol). TLC: R_f = 0.6 (SiO_2, 20% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (d, *J* = 7.3 Hz, 2H), 7.13 (d,

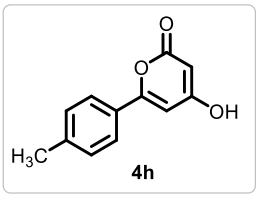
J = 7.5 Hz, 2H), 5.22 (s, 1H), 4.88 (t, *J* = 7.0, 1H), 2.66-2.60 (dd, *J* = 8.6, 14.6 Hz, 1H), 2.55-2.51 (dd, *J* = 4.7, 14.6 Hz, 1H), 2.32 (s, 3H), 1.62-1.60 (d, *J* = 7.0 Hz, 6H); $^{13}C\{^{1}H\}$ NMR (101 MHz ,$CDCl_3$) δ 168.74, 161.34, 139.85, 137.51, 129.04, 125.52, 106.46, 94.87, 42.89, 25.07, 24.37, 20.89; HRMS (ESI): m/z calcd for $C_{15}H_{19}O_4$ $[M+H]^+$ 263.1283, found 263.1280.

2,2-Dimethyl-6-(2-oxo-2-(*p*-tolyl)ethyl)-4*H*-1,3-dioxin-4-one (S35):



Following General Procedure C, **S35** (1.6 g, 43%, as a colorless liquid) was obtained from 6-(2-hydroxy-2-(p-tolyl)ethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (**S34**, 3.75 g, 14.29 mmol) and PCC powder. TLC: R_f = 0.6 (SiO_2, 20% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 7.5 Hz, 2H), 7.29 (d, *J* = 7.5 Hz, 2H), 5.41 (s, 1H), 3.88 (s, 2H), 2.43 (s, 3H), 1.70 (s, 6H); $^{13}C\{^{1}H\}$ NMR (101 MHz ,$CDCl_3$) δ 192.57, 165.33, 160.68, 144.95, 133.33, 129.48, 128.36, 107.14, 96.77, 43.11, 24.88, 21.61; HRMS (ESI): m/z calcd for $C_{15}H_{17}O_4$ $[M+H]^+$ 261.1121, found 261.1118 .

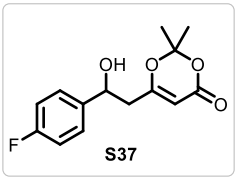
4-Hydroxy-6-(p-tolyl)-2*H*-pyran-2-one (4h):



Following General Procedure C, **4h** (1.1 g, 79%, as a colorless solid) was obtained from 2,2-Dimethyl-6-(2-oxo-2-(p-tolyl)ethyl)-4*H*-1,3-dioxin-4-one (**S35**, 1.8 g, 6.92 mmol). TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.79 (br. s., 1H), 7.73 (d, *J* = 7.8 Hz, 2H), 7.31 (d, *J* = 7.9 Hz, 2H), 6.69 (s, 1H), 5.37 (s, 1H), 2.35 (s, 3H); $^{13}C\{^{1}H\}$ NMR (101 MHz, DMSO-d_6) δ 170.61, 163.07, 160.25, 140.97, 129.62, 128.31, 125.38, 97.60, 89.27, 20.94; HRMS (ESI): m/z calcd for $C_{12}H_{11}O_3$ $[M+H]^+$ 203.0703, found 203.0701.

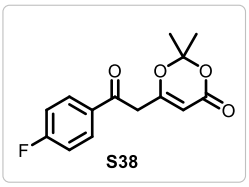
Synthesis of 6-(4-fluorophenyl)-4-hydroxy-2H-pyran-2-one (4i):

6-(2-(4-Fluorophenyl)-2-hydroxyethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S37):

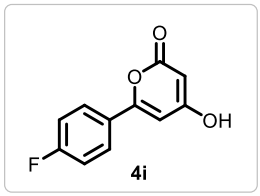


Following General Procedure C, **S37** (1.2 g, 60%, as a colorless solid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 2.74 g, 19.3 mmol) and 4-fluorobenzaldehyde (**S36**, 2.0 g, 16.11 mmol). TLC: R_f = 0.4 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz , $CDCl_3$) δ 7.98 (t, *J* = 6.1 Hz, 2H), 7.19-7.15 (t, *J* = 7.9 Hz, 2H), 5.41 (s, 1H), 3.87 (s, 2H), 1.69 (s, 6H); $^{13}C\{^{1}H\}$ NMR (101 MHz ,$CDCl_3$) δ 168.22, 163.64, 161.19, 161.14, 138.62, 138.62, 127.45, 127.37, 115.63, 115.42, 106.70, 95.29, 43.23, 25.28, 24.63; HRMS (ESI): m/z calcd for $C_{14}H_{16}O_4F$ $[M+H]^+$ 267.1027, found 267.1021.

6-(2-(4-Fluorophenyl)-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S38)



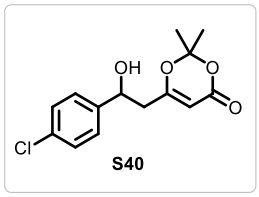
Following General Procedure C, **S38** (0.85 g, 71%, as a colorless liquid) was obtained from 6-(2-(4-fluorophenyl)-2-hydroxyethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (**S37**, 1.2 g, 45.11 mmol) and PCC (1.93 g, 9.02 mmol). TLC: R_f = 0.6 (SiO_2, 20% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.98 (t, *J* = 6.1 Hz, 2H), 7.19-7.15 (t, *J* = 7.9 Hz, 2H), 5.41 (s, 1H), 3.87 (s, 2H), 1.69 (s, 6H); $^{13}C\{^1H\}$ NMR (101 MHz ,$CDCl_3$) δ 191.40, 167.42, 164.86, 160.58, 132.26, 132.23, 131.04, 130.95, 116.16, 115.94, 107.27, 96.97, 43.13, 24.91; HRMS (ESI): m/z calcd for $C_{14}H_{14}O_4F$ $[M+H]^+$ 265.0871, found 265.0866.



6-(4-Fluorophenyl)-4-hydroxy-2H-pyran-2-one (4i): Following General Procedure C, **4i** (0.32 g, 69%, as a faint yellow solid) was obtained from 6-(2-(4-Fluorophenyl)-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (**S38**, 0.6 g, 2.25 mmol). TLC: R_f = 0.6 (SiO_2, 20% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.85 (br. s., 1H), 7.90 (t, *J* = 6.2 Hz, 2H), 7.33 (t, *J* = 8.1 Hz, 2H), 6.73 (s, 1H), 5.39 (s, 1H); $^{13}C\{^1H\}$ NMR (101 MHz, DMSO-d_6) δ 170.54, 164.78, 162.89, 162.30, 159.12, 128.08, 127.99, 127.68, 127.65, 116.22, 116.00, 98.29, 89.46; HRMS (ESI): m/z calcd for $C_{11}H_8O_3F$ $[M+H]^+$ 207.0452, found 207.0452.

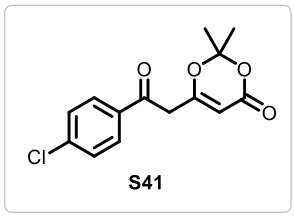
Synthesis of 6-(4-chlorophenyl)-4-hydroxy-2H-pyran-2-one (4j):

6-(2-(4-Chlorophenyl)-2-hydroxyethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S40):



Following General Procedure C, **S40** (1.6 g, 40%, as a colorless solid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 2.38 g, 16.85 mmol) and 4-chlorobenzaldehyde (**S39**, 2.0 g, 14.22 mmol). TLC: R_f = 0.4 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (q, *J* = 8.88, 11.76 Hz, 4H), 5.16 (s, 1H), 4.85-4.82 (m, 1H), 3.37 (br. s., 1H), 2.56-2.43 (m, 2H), 1.55 (d, *J* = 4.1 Hz, 6H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 168.50, 161.42, 141.49, 133.43, 128.53, 127.02, 106.64, 94.99, 42.98, 25.11, 24.42; HRMS (ESI): m/z calcd for $C_{14}H_{16}ClO_4$ $[M+H]^+$ 283.0737, found 283.0732.

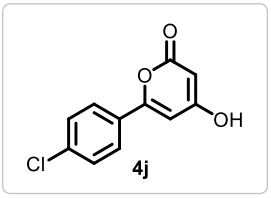
6-(2-(4-Chlorophenyl)-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S41):



Following General Procedure C, **S41** (1.2 g, 76%, as a colorless solid) was obtained from 6-(2-(4-chlorophenyl)-2-hydroxyethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (**S40**, 1.6 g, 56.59 mmol) and PCC (3.04 g, 14.14 mmol). TLC:

R_f = 0.5 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.88 (d, *J* =7.4 Hz, 2H), 7.48 (d, *J* = 7.4 Hz, 2H), 5.42 (s, 1H), 3.87 (s, 2H), 1.71 (s, 6H); $^{13}C\{^1H\}$ NMR (101 MHz ,$CDCl_3$) δ 191.81, 164.68, 160.61, 140.62, 134.14, 129.25, 107.36, 97.08, 43.20, 24.97; HRMS (ESI): m/z calcd for $C_{14}H_{14}O_4Cl$ $[M+H]^+$ 281.0580, found 281.0575.

6-(4-Chlorophenyl)-4-hydroxy-2*H*-pyran-2-one (4j):

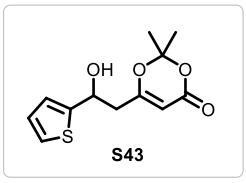


4j

Following General Procedure C, **4j** (1.1 g, 99%, as a colorless solid) was obtained from 6-(2-(4-chlorophenyl)-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (**S41**, 1.2 g, 4.28 mmol). TLC: R_f = 0.6 (SiO_2, 20% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.90 (br. s., 1H), 7.87 (d, *J* = 8.25 Hz, 2H), 7.58 (d, *J* = 8.38 Hz, 2H), 6.80 (s, 1H), 5.41 (s, 1H); $^{13}C\{^1H\}$ NMR (101 MHz ,DMSO-d_6) δ 170.42, 162.76, 158.80, 135.58, 129.89, 129.13, 127.27, 98.87, 89.82,; HRMS (ESI): m/z calcd for $C_{11}H_8ClO_3$ $[M+H]^+$ 223.0162, found 223.0159.

Synthesis of 4-hydroxy-6-(thiophen-2-yl)-2H-pyran-2-one (4k):

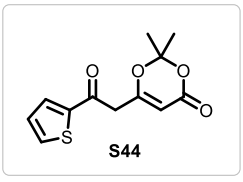
6-(2-Hydroxy-2-(thiophen-2-yl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S43):



S43

Following General Procedure C, **S43** (1.9 g, 42%, as a colorless liquid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 3.04 TLC: R_f = 0.4 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (s, 1H), 6.33-6.28 (m., 1H), 6.28 (br. s., 1H), 5.30 (s, 1H), 4.98 (br. s., 1H), 2.77 (d, *J* = 6.4 Hz, 2H), 1.66-1.62 (d, *J* = Add Hz, 6H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 167.96, 161.26, 154.76, 142.26, 110.24, 106.69, 106.57, 95.28, 64.34, 39.76, 25.03, 24.68.

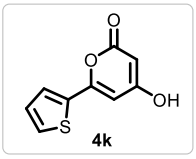
2,2-Dimethyl-6-(2-oxo-2-(thiophen-2-yl)ethyl)-4*H*-1,3-dioxin-4-one (S44):



S44

Following General Procedure C, **S44** (1.12 g, 62%, as a colorless liquid) was obtained from 6-(2-hydroxy-2-(thiophen-2-yl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (**S43**, 1.8 g, 7.08 mmol) and PCC (3.8 g, 17.71 mmol). TLC: R_f = 0.5 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74-7.73 (d, *J* = 2H), 7.18 (br. s., 1H), 5.45 (s, 1H), 3.84 (s, 2H), 1.71 (s, 6H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 185.47, 164.45, 160.65, 142.89, 135.15, 132.98, 128.42, 107.35, 97.03, 43.89, 24.96. ; HRMS (ESI): m/z calcd for $C_{12}H_3O_4S$ $[M+H]^+$ 253.0529, found 253.0524.

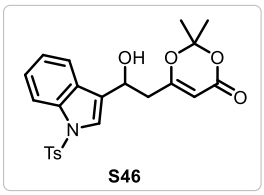
4-Hydroxy-6-(thiophen-2-yl)-2*H*-pyran-2-one (4k):



Following General Procedure C, **4k** (0.49 g, 64%, as a colorless solid) was obtained from 2,2-dimethyl-6-(2-oxo-2-(thiophen-2-yl)ethyl)-4*H*-1,3-dioxin-4-one (**S44**, 1 g, 3.96 mmol) and toluene (15 mL). TLC: R_f = 0.3 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.86 (br. s., 1H), 7.82-7.76 (m, 1H), 7.76 (br. s., 1H), 7.21 (br. s., 1H), 6.63 (s, 1H), 5.33 (s, 1H) ; ^{13}C{^{1}H} NMR (101 MHz, DMSO-d_6) δ 170.47, 162.41, 156.08, 134.49, 130.20, 128.75, 127.73, 96.75, 89.00; HRMS (ESI): m/z calcd for $C_9H_7O_3S$ $[M+H]^+$ 195.0110 found 195.0112.

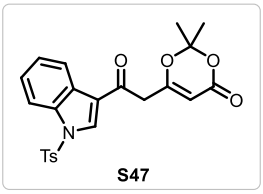
Synthesis of 4-hydroxy-6-(1-tosyl-1H-indol-2-yl)-2H-pyran-2-one (4l):

6-(2-Hydroxy-2-(1-tosyl-1*H*-indol-3-yl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S46):



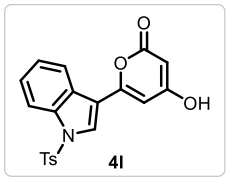
Following General Procedure C, **S46** (1.89 g, 64%, as a colorless liquid) was obtained from 2,2,6-trimethyl-1,3-dioxin 4-one (**S14**, 3.04 g, 7.8 mmol) and 1-tosyl-1*H*-indole-3-carbaldehyde (**S45**, 2 g, 6.6 mmol). TLC: R_f = 0.5 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.4 Hz, 1H), 7.74 (d, *J* = 8.4 Hz, 2H), 7.62 (d, *J* = 7.8 Hz, 1H), 7.55 (s, 1H), 7.35-7.31 (m, 1H), 7.27-7.25 (m, 1H), 7.22 (d, *J* = 8.4 Hz, 2H), 5.27 (s, 1H), 5.23 (t, *J* = 6.6 Hz, 1H), 2.80-2.78 (m, 2H), 2.33 (s, 3H), 1.64 (s, 3H), 1.59 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 168.32, 161.18, 145.29, 135.39, 134.97, 130.12, 130.04, 128.36, 126.79,125.13, 124.30, 123.40, 123.01, 120.11, 113.80, 106.81, 95.36, 64.65, 41.44, 25.23, 24.67, 21.56; HRMS (ESI): m/z calcd for $C_{23}H_{24}NO_6S$ $[M+H]^+$ 442.1324, found 442.1319.

2,2-Dimethyl-6-(2-oxo-2-(1-tosyl-1*H*-indol-3-yl)ethyl)-4*H*-1,3-dioxin-4-one (S47):



Following General Procedure C, **S47** (1.45 g, 77%, as a colorless liquid) was obtained from 6-(2-hydroxy-2-(1-tosyl-1*H*-indol-3-yl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (**S46**, 1.89 g, 4.28 mmol) and PCC (2.30 g, 10.7 mmol). TLC: R_f = 0.6 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.30 (d, *J* = 7.1 Hz, 1H), 8.27 (s, 1H), 7.95 (d, *J* = 7.6 Hz, 1H), 7.85 (d, *J* = 8.4 Hz, 2H), 7.43-7.35 (m, 2H), 7.31 (m, *J* = 8.4 Hz, 2H), 5.47 (s, 1H), 3.83 (s, 2H), 2.39 (s, 3H), 1.71 (s, 6H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 187.89, 164.77, 160.75, 146.29, 134.83, 134.27, 132.37, 130.37, 127.18, 127.10, 126.19, 125.14, 122.95, 120.32, 113.14, 107.34, 96.89, 44.68, 25.0, 21.65; HRMS (ESI): m/z calcd for $C_{23}H_{21}NO_6S$ $[M+H]^+$ 440.1167, found 440.1162.

4-Hydroxy-6-(1-tosyl-1*H*-indol-3-yl)-2*H*-pyran-2-one (4l):

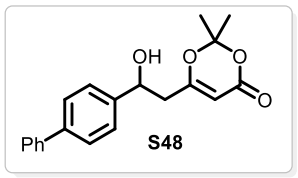


4l

Following General Procedure C, **4l** (0.437 g, 34%, as a colorless solid) was obtained 2,2-Dimethyl-6-(2-oxo-2-(1-tosyl-1*H*-indol-3-yl)ethyl)-4*H*-1,3-dioxin-4-one (**S47**, 1.45 g). TLC: R_f = 0.7 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.92 (br. s., 1H), 8.49 (s, 1H), 7.99 (t, *J* = 8.3 Hz, 4H), 7.47-7.43 (m, 1H), 7.40 (d, *J* = 8.1 Hz, 3H), 6.78 (d, *J* = 1.9 Hz, 1H), 5.39 (d, *J* = 1.9 Hz, 1H), 2.31 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, DMSO-d_6) δ 170.61, 163.96, 156.34, 146.25, 134.41, 133.55, 130.52, 127.28, 127.18, 126.01, 125.82, 124.59, 121.34, 114.49, 113.53, 99.02, 89.28, 21.11; HRMS (ESI): m/z calcd for $C_{20}H_{16}O_5NS$ $[M+H]^+$ 382.0744, found 382.0738.

Synthesis of 6-([1,1'-biphenyl]-4-yl)-4-hydroxy-2H-pyran-2-one (4m):

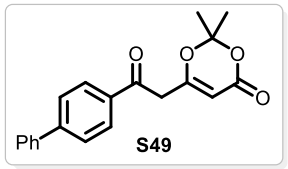
6-(2-([1,1'-biphenyl]-4-yl)-2-hydroxyethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (S48):



S48

Following the general procedure, **S48** was prepared from 4-phenylbenzaldehyde (2.0 g, 10.97 mmol) and 2,2,6-trimethyl-1,3-dioxin4-one (1.84 g, 12.95 mmol) in 71% yield (2.53 g) as a colourless solid. TLC: R_f = 0.4 (SiO_2, 40% EtOAc/hexane); ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 7.62-7.58 (m, 4 H), 7.47-7.44 (m, 4 H), 7.39-7.35 (m, 1 H), 5.35 (s, 1 H), 5.05 (br. s., 1 H), 2.77-2.64 (m, 2 H), 2.30 (br. s., 1 H), 1.69 (br. s., 6 H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 168.3, 161.1, 141.7, 141.3, 140.5, 128.9, 127.5, 127.5, 127.1, 126.2, 106.7, 95.4, 71.0, 43.2, 25.4, 24.7; HRMS (ESI): m/z calcd for $C_{20}H_{21}O_4$ $[M+H]^+$ 325.1439, found 325.1434.

6-(2-([1,1'-biphenyl]-4-yl)-2-oxoethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (S49):

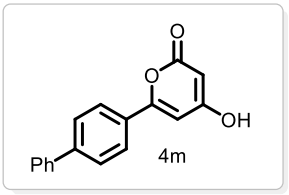


S49

Following the general procedure, **S48** was prepared from 6-(2-([1,1'-biphenyl]-4-yl)-2-hydroxyethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (2.53 g, 81.61 mmol) and PCC (4.39 g, 20.40 mmol) in 75% yield (1.98 g) as a colorless liquid. TLC: R_f = 0.5 (SiO_2, 40% EtOAc/hexane); ^{1}H NMR ($CDCl_3$, 400 MHz): δ = 8.02 (d, *J* = 8.5 Hz, 2 H), 7.73 (d, *J* = 8.5 Hz, 2 H), 7.64 (d, *J* = 8.0 Hz, 3 H), 7.50-7.48 (m, 2 H), 6.23 (s, 1 H), 5.46 (s, 1 H), 3.94 (s, 2 H), 1.73 (s, 6 H); ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$): δ = 193.8, 192.6, 182.9, 165.2, 160.8, 146.8, 145.1, 140.0, 139.5, 134.5,

129.1, 129.0, 129.0, 128.6, 128.1, 127.8, 127.6, 127.5, 127.4, 127.3, 127.2, 107.4, 97.0, 96.7, 96.6, 43.3, 25.9, 25.0; HRMS (ESI): m/z calcd for $C_{20}H_{19}O_4$ $[M+H]^+$ 323.1283, found 323.1278.

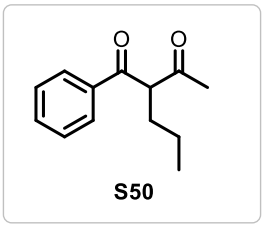
6-([1,1'-biphenyl]-4-yl)-4-hydroxy-2H-pyran-2-one (4m):



Following the general procedure, **4m** was prepared from 6-(2-([1,1'-biphenyl]-4-yl)-2-oxoethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (1.98 g, 20.38 mmol) in 48 % yield (0.780 g) as an off white solid. TLC: R_f = 0.4 (SiO_2, 10% MeOH/DCM); ^{1}H NMR (400 MHz, DMSO-d_6): δ = 7.94 (d, *J* = 8.5 Hz, 2 H), 7.82 (d, *J* = 8.5 Hz, 2 H), 7.74 (d, *J* = 7.4 Hz, 2 H), 7.51-7.48 (m, 2 H), 7.42-7.39 (m, 1 H), 6.81 (d, *J* = 2.0 Hz, 1 H), 5.42 (d, *J* = 2.0 Hz, 1 H); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6): δ = 171.1, 163.7, 160.3, 142.9, 139.3, 130.4, 129.6, 128.7, 127.7, 127.2, 126.6, 98.8, 90.1; HRMS (ESI): m/z calcd for $C_{17}H_{13}O_3$ $[M+H]^+$ 265.0859, found 265.0857.

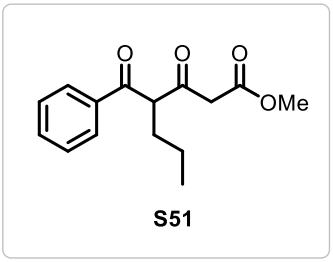
Synthesis of 4-hydroxy-6-phenyl-5-propyl-2H-pyran-2-one (4m):

1-Phenyl-2-propylbutane-1,3-dione (S50):



Under a nitrogen atmosphere, 1-phenylbutane-1,3-dione (18.4 mmol) were dissolved in anhydrous acetone (30 mL) and pre-dried potassium carbonate (17.2 mmol) was added. After stirring the solution at room temperature for 5 min, the propyl iodide (22.7 mmol) was added dropwise over a period of 2 min and the reaction mixture was refluxed overnight. Complete reaction was observed by thin layer chromatography analysis of reaction aliquots. After condensation of the reaction mixture, diethyl ether (30 mL) was added, the mixture was filtered and the organic layer was evaporated to dryness. Pure products were obtained using silica gel chromatography (hexane/EtOAc, 95:05), 53% isolated yield of **S50** (2 g, 53%, as a colorless liquid); TLC: R_f = 0.6 (SiO_2, 10% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ = 8.02-7.92 (m, 2 H), 7.60-7.54 (m, 1 H), 7.50-7.43 (m, 2 H), 4.44 (t, *J* = 7.1 Hz, 1 H), 2.12 (s, 3 H), 2.06-1.85 (m, 2 H), 1.31 (sex, *J* = 7.5 Hz, 2 H), 0.91 (t, *J* = 7.4 Hz, 3 H); ^{13}C{^{1}H} NMR (100MHz, $CDCl_3$) δ = 204.3, 196.4, 136.5, 133.6, 128.8, 128.6, 63.2, 31.0, 27.7, 20.9, 13.9.

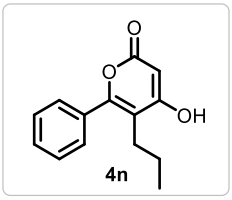
Methyl 4-benzoyl-3-oxoheptanoate (S51):



S51

To a stirred solution of 1.0 M solution of NaHMDS in THF (29.3 mmol) was added dropwise 1-phenyl-2-propylbutane-1,3-dione (**S50**) (9.7 mmol) in THF (20 mL) at −78 °C. Stirring was continued for 2 h at rt, and dimethyl carbonate (9.7 mmol) was added dropwise to the reaction mixture at −78 °C; stirring continued for another 10 h at rt. The reaction mixture was quenched with 10% HCl and extracted with AcOEt. The combined extracts were washed with brine and then dried to obtain crude products **S51** for direct use in the next step, **S51** (2.5 g, 98%, as a colorless solid).

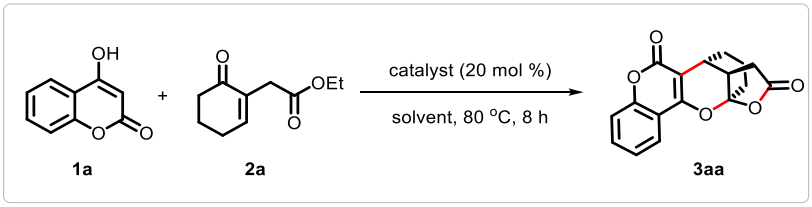
4-Hydroxy-6-phenyl-5-propyl-2*H*-pyran-2-one (4n):



4n

To a stirred solution of β,δ-diketo ester **S51** in benzene (30 mL) was added DBU (19.4 mmol) at rt, and stirring was continued for 2.5 h under refluxing conditions. The reaction mixture was quenched with 10% HCl and extracted with AcOEt. The combined extracts were washed with brine, and the residue upon workup was chromatographed on silica gel with hexane-AcOEt (40:60) as eluent to give the 4-hydroxy-6-phenyl-5-propyl-2*H*-pyran-2-one (**4n**, 1.12 g, 50%, 2 steps) as an orange solid. TLC: R_f = 0.2 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, DMSO-d_6) δ = 12.02 (br. s., 1 H), 7.50 (s, 5 H), 5.47 (s, 1 H), 2.31-2.22 (m, 2 H), 1.53-1.40 (m, 2 H), 0.77 (t, *J* = 7.3 Hz, 3 H); ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ = 170.3, 162.7, 158.3, 132.7, 129.8, 128.5, 128.4, 112.3, 89.9, 26.6, 22.4, 13.8; HRMS (ESI): m/z calcd for $C_{14}H_{15}O_3$ [M+H]+ 231.1016, found 231.1016.

6. <u>General Procedure D for the synthesis of chromano(pyrano)-furopyranones (3, 5, 7 and 8) from hydroxy-chromen(pyran)-ones (1 and 4) and unsaturated γ-ketoesters</u>:



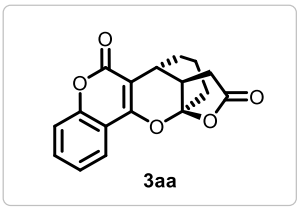
1a **2a** **3aa**

To the mixture of keto-ester **2a** (0.55 mmol) and 4-hydroxy-2*H*-chromen-2-one **1a** (0.55 mmol) in 2.0 mL of anhydrous fluorobenzene (PhF) in a dry 25 mL single neck round bottom flask equipped with a

reflux condenser, was added $Bi(OTf)_3$ (0.110 mmol) under argon atmosphere at room temperature. The resulting mixture was stirred at 80 °C for 8 h. After completion of the reaction (monitored by TLC, visualized using UV, anisaldehyde and $KMnO_4$ staining solutions), the reaction mixture was quenched with saturated aqueous $NaHCO_3$ solution then extracted with EtOAc (2 × 20 mL). The combined organic layers were dried over anhydrous Na_2SO_4, and filtered. The solvent was evaporated under reduced pressure, and the resulting crude product was purified by silica gel column chromatography (SiO_2, 25% EtOAc/hexane) to afford the desired product pyrano-chromane **3aa**.

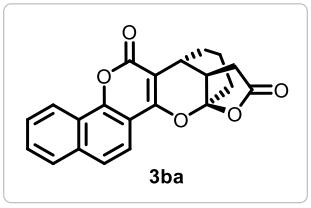
7. Synthesis of chromano-furopyranones:

7a,8-Dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione (3aa):



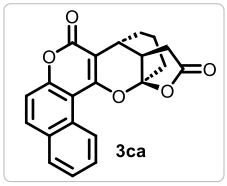
Following General Procedure D, **3aa** (0.112 g, 76%, as a white solid) was obtained from 4-hydroxy-2*H*-chromen-2-one (**1a**) (0.081 g, 0.5 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50%EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.82 (dd, *J* = 1.38, 7.88 Hz, 1H), 7.61-7.55 (m, 1H), 7.34 (q, *J* = 8.25, 15.51 Hz, 2H), 3.54 (d, *J* = 2.8 Hz, 1H), 2.78-2.73 (m, 1H), 2.58-2.51 (m, 2H), 2.29 (dd, *J* = 12.76, 17.13 Hz, 1H), 2.08-2.00 (m, 2H), 1.93-1.83 (m, 2H), 1.61-1.50 (m, 1H); ^{13}C{^{1}H} NMR ($CDCl_3$, 101MHz) δ 173.86, 161.99, 160.23, 152.78, 132.42, 124.23, 122.73, 116.75, 113.64, 107.82, 99.25, 41.58, 34.32, 30.20, 29.91, 29.58, 18.39.; HRMS (ESI): *m/z* calcd for $C_{17}H_{15}O_5$ $[M+H]^+$ 299.0914, found 299.0927, M.P: 216-218 ^{o}C.

7a,8-Dihydro-6*H*-7,10a-propanobenzo[h]furo[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione (3ba):



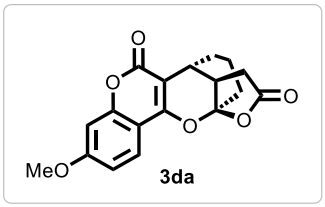
Following General Procedure D, **3ba** (0.107 g, 61%, as a white solid) was obtained from 4-hydroxy-2*H*-benzo[h]chromen-2-one (**1b**) (0.0791 g, 0.549 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.57 (t, *J* = 5.38, 8.88 Hz, 1H), 7.91 (t, *J* = 3.75, 9.01 Hz, 1H), 7.82 (d, *J* = 8.63 Hz, 1H), 7.74 (d, *J* = 8.63 Hz, 1H), 7.71-7.63 (m, 2H), 3.61 (br. s., 1H), 2.78 (ddd, *J* = 1.0, 6.88, 11.38 Hz, 1H), 2.58 (dd, *J* = 7.0, 16.51 Hz, 2H), 2.34 (dd, *J* = 12.76, 17.13 Hz, 1H), 2.15 - 2.01 (m, 2H), 1.98-1.85 (m, 2H), 1.62-1.56 (m,1H); ^{13}C{^{1}H} NMR (101MHz, $CDCl_3$) δ 173.87, 162.04, 161.24, 150.36, 135.15, 128.90, 127.93, 127.27, 124.28, 122.89, 122.49, 118.14, 108.98, 107.93, 98.78, 41.72, 34.44, 30.33, 30.0, 29.68, 18.49, HRMS (ESI): *m/z* calcd for $C_{21}H_{17}O_5$ $[M+H]^+$ 349.1071, found 349.1069; M.P: 204-205 ^{o}C.

9a,10-Dihydro-8*H*-9,12a-propanobenzo[f]furo[3',2':5,6]pyrano[3,2-c]chromene-8,11(9*H*)-dione (3ca):



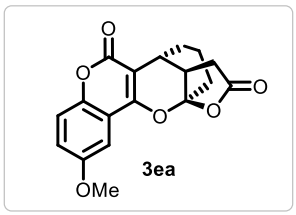
Following General Procedure D, **3ca** (0.13 g, 74%, as a white solid) was obtaibed from 1-hydroxy-3*H*-benzo[f]chromen-3-one (**1c**) (0.106 g, 0.5 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.15 (d, *J* = 8.88 Hz, 1H), 8.03 (d, *J* = 9.1 Hz, 1H), 7.91 (d, *J* = 7.8 Hz, 1H), 7.69 (t, *J* = 7.75 Hz, 1H), 7.59 (t, *J* = 7.25, 14.15 Hz, 1H), 7.59 (t, *J* = 7.38, 15.01 Hz, 1H),), 7.49 (d, *J* = 9.01 Hz, 1H), 3.66 (d, *J* = 2.63 Hz, 1H), 2.85-2.79 (ddd, *J* = 2.38, 7.50, 12.38 Hz, 1H), 2.69-2.58 (q, *J* = 12.63, 17.13 Hz, 2H), 2.16-2.09 (m, 1H), 1.95-1.87 (m, 2H), 1.71-1.63 (m, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.87, 163.82, 153.90, 134.34, 130.84, 129.03, 128.88, 126.33, 126.06, 117.11, 108.38, 107.28, 99.33, 41.07, 34.66, 30.96, 30.34, 30.19, 18.55.; HRMS (ESI): *m/z* calcd for $C_{21}H_{17}O_5$ $[M+H]^+$ 349.1071, found 349.1056, M.P: 208-209 ^{o}C.

3-Methoxy-7a,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione (3da):



Following General Procedure D, **3da** (0.097 g, 59%, as a white solid) was obtained from 4-hydroxy-7-methoxy-2*H*-chromen-2-one (**1d**) (0.096 g, 0.5 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 8.9 Hz, 1H), 6.89 (d, *J* = 8.9 Hz, 1H), 6.83 (s, 1H), 3.89 (s, 3 H), 3.51 (br. s., 1H), 2.78-2.68 (m, 1H), 2.58-2.47 (m, 2H), 2.30 (dd, *J* = 12.8, 17.1 Hz, 1H), 2.07-1.97 (m, 2H), 1.92-1.79 (m, 2H), 1.54 (br. s., 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.98, 163.27, 162.43, 160.69, 154.64, 123.88, 123.81, 112.40, 107.76, 106.89, 100.63, 96.38, 77.25, 77.00, 76.75, 55.79, 41.76, 34.32, 30.28, 29.80, 29.63, 18.43., HRMS (ESI): *m/z* calcd for $C_{18}H_{17}O_6$ $[M+H]^+$ 329.1020, found 329.1014, M.P.: 169-171 ^{o}C.

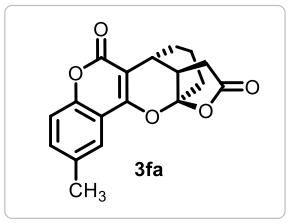
2-Methoxy-7a,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione



(3ea): Following General Procedure D, **3ea** (0.10 g, 61%, as a white solid) was obtained from 4-hydroxy-7-methoxy-2*H*-chromen-2-one (**1e**) (0.096 g, 0.5 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 8.9 Hz, 1H), 6.89 (d, *J* = 8.9 Hz, 1H), 6.83 (s, 1H), 3.89 (s, 3 H), 3.51 (br. s., 1H), 2.78-2.68 (m, 1H), 2.58-2.47 (m, 2H), 2.30 (dd, *J* = 12.8, 17.1 Hz, 1H), 2.07-1.97 (m, 2H), 1.92-1.79 (m, 2H), 1.54 (br. s., 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 174.02, 163.21,

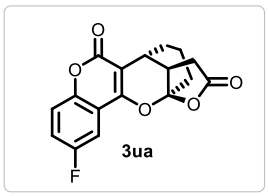
162.42, 160.65, 154.58, 123.78, 112.37, 107.74, 106.83, 100.57, 96.33, 55.78, 41.69, 34.27, 30.23, 29.75, 29.60, 18.39, HRMS (ESI): *m/z* calcd for $C_{18}H_{17}O_6$ $[M+H]^+$ 329.1020, found 329.1004, M.P: 168-170 ^oC.

2-Methyl-7a,8-dihydro-6H-7,10a-propanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7H)-dione (3fa):



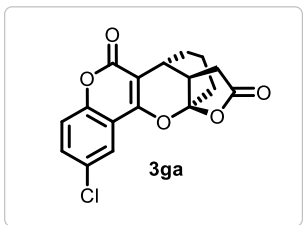
Following General Procedure D, **3fa** (0.10 g, 58%, as a white solid) was obtained from 4-hydroxy-6-methyl-2*H*-chromen-2-one (**1f**) (0.1 g, 0.56 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.1 g, 0.85 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (s, 1H), 7.38 (dd, *J* = 1.63, 8.50 Hz, 1H), 7.26 (t, *J* = 7.13, 15.63 Hz, 1H), 3.53 (d, *J* = 2.63 Hz, 1H), 2.75 (ddd, *J* = 2.25, 7.38, 12.63 Hz, 1H), 2.58- 2.51 (m, 2H), 2.43 (s, 3H), 2.29 (q, *J* = 12.76, 17.13 Hz, 1H), 2.08-2.00 (m, 2H), 1.91-1.82 (m, 2H), 1.60-1.51 (m, 1H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 173.92, 162.19, 160.24, 150.93, 134.09, 133.40, 122.38, 116.48, 113.25, 107.77, 99.09, 41.58, 34.32, 30.20, 29.91, 29.59, 20.84, 18.39.; HRMS (ESI): *m/z* calcd for $C_{18}H_{17}O_5$ $[M+H]^+$ 313.1071, found 313.1069, M.P: 198-200 ^oC.

2-Fluoro-7a,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione (3ua):



Following General Procedure D, **3ua** (0.080 g, 57%, as a white solid) was obtained from 6-fluro-4-hydroxy-2*H*-chromen-2-one (**1u**) (0.0791 g, 0.549 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51-7.49 (dd, *J* = 2.9, 8.1 Hz, 1H), 7.36-7.30 (m, 2H), 3.55-3.54 (d, *J* = 2.4 Hz, 1H), 2.78-2.74 (ddd, *J* = 2.3, 7.6, 12.7 Hz, 1H), 2.59- 2.52 (m, 2H), 2.30-2.24 (dd, *J* = 12.8, 17.1 Hz, 1H), 2.08-2.03 (m, 2H), 1.93-1.85 (m, 2H), 1.58-1.50 (m, 1H); $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 173.59, 161.67, 159.77, 159.51, 157.82, 148.95, 120.12, 119.92, 118.54, 118.48, 114.63, 114.56, 108.75, 108.54, 108.03, 100.21, 41.58, 34.35, 30.21, 30.02, 29.58, 18.43, ^{19}F NMR (400 MHz, $CDCl_3$) – 116.29; HRMS (ESI): *m/z* calcd for $C_{17}H_{14}FO_5$ $[M+H]^+$ 317.0820, found 317.0814.

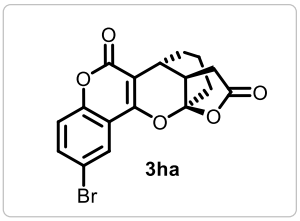
2-Chloro-7a,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione (3ga):



Following General Procedure D, **3ga** (0.088 g, 53%, as a white solid) was obtained from 6-chloro-4-hydroxy-2*H*-chromen-2-one (**1g**) (0.098 g, 0.5 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane) TLC: R_f = 0.6 (SiO_2, 50%

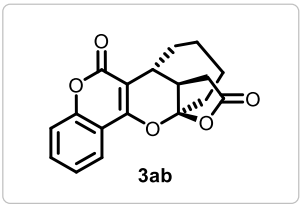
EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 (d, *J* = 2.50 Hz, 1H), 7.53 (dd, *J* = 2.50, 8.88 Hz, 1H), 7.30 (d, *J* = 8.88 Hz, 1H), 3.54 (d, *J* = 2.8 Hz, 1H), 2.75 (ddd, *J* = 2.38, 7.50, 12.63 Hz, 1H), 2.61-2.50 (m, 2H), 2.27 (dd, *J* = 12.63, 17.3 Hz, 1H), 2.09-2.01 (m, 2 H), 1.93-1.85 (m, 2H), 1.56-1.47 (m, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.46, 161.40, 159.20, 151.18, 132.44, 129.96, 122.37, 118.27, 114.79, 108.04, 100.23, 41.56, 34.32, 30.19, 30.03, 29.54, 18.40. HRMS (ESI): *m/z* calcd for $C_{17}H_{14}ClO_5$ $[M+H]^+$ 333.0524, found 333.0524, M.P: 228-227 ^{o}C.

2-Bromo-7a,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione (3ha):



Following General Procedure D, **3ha** (0.089 g, 47%, as a white solid) was obtained from 6-bromo-4-hydroxy-2*H*-chromen-2-one (**1h**) (0.119 g, 0.5 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (s, 1H), 7.67 (d, *J* = 8.85 Hz, 1H), 7.25 (d, *J* = 8.85 Hz, 1H), 3.54 (br. s., 1H), 2.75 (ddd, *J* = 8.24, 9.46, 10.68 Hz, 1H), 2.62-2.49 (m, 2H), 2.27 (q, *J* = 12.50, 16.78 Hz, 1H), 2.08-2.03 (m, 2H), 1.93-1.86 (m, 2H), 1.55-1.51 (m, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.49, 159.09, 151.64, 135.27, 125.39, 118.54, 117.18, 115.20, 108.05, 100.22, 41.54, 34.30, 30.19, 30.01, 29.54, 18.39.; HRMS (ESI): *m/z* calcd for $C_{17}H_{14}BrO_5$ $[M+H]^+$ 378.9999, found 379.0000, M.P: 195-197 ^{o}C.

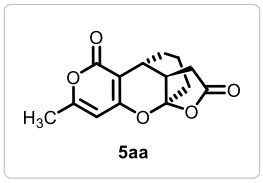
7a,8-Dihydro-6*H*-7,10a-butanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione (3ab):



Following General Procedure D, **3ab** (0.115 g, 73%, as a white solid) was obtained from 4-hydroxy-2*H*-chromen-2-one (**1a**) (0.081 g, 0.5 mmol), ethyl 2-(7-oxocyclohept-1-en-1-yl)acetate (**2b**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (dd, *J* = 1.13, 7.88 Hz, 1H), 7.62-7.55 (m, 1H), 7.34 (q, *J* = 7.88, 13.88 Hz 2H), 3.33 (d, *J* = 5.75 Hz, 1H), 3.09 (dd, *J* = 8.50, 12.26 Hz, 1H), 2.72 (q, *J* = 8.25, 17.64 Hz, 1H), 2.58-2.51 (m, 1H), 2.44 (q, *J* = 12.13, 17.64 Hz, 1H), 2.15-2.06 (m, 1H), 1.92-1.83 (m, 1H), 1.77-1.68 (m, 2H), 1.46-1.42 (m, 1H), 0.90-0.86 (m, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.73, 162.16, 158.08, 152.68, 132.31, 124.22, 122.85, 116.67, 114.19, 109.83, 100.76, 39.90, 38.08, 32.60, 31.92, 29.90, 23.57, 22.35, 22.30, 14.03; HRMS (ESI): *m/z* calcd for $C_{18}H_{17}O_5$ $[M+H]^+$ 313.1071, found 313.1072, M.P: 207-209 ^{o}C.

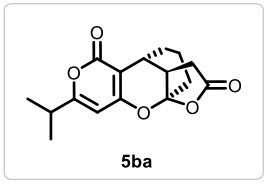
8. Synthesis of pyrano-furopyranones:

7-Methyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5aa):



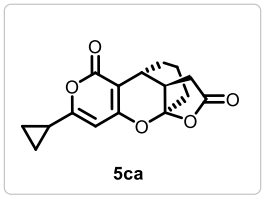
Following General Procedure D, **5aa** (0.12 g, 57%, as a white solid) was obtained from 4-hydroxy-6-methyl-2*H*-pyran-2-one (**4a**) (0.100 g, 0.79 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.5 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz , $CDCl_3$) δ 5.84 (s, 1H), 3.36 (br. s., 1H), 2.63 (t, *J* = 7.75, 20.26 Hz 1H), 2.52-2.38 (m, 2H), 2.26-2.19 (m, 4H), 1.98- 1.90 (m, 2H), 1.87-1.74 (m, 3H), 1.54-1.42 (m, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.90, 165.02, 163.76, 162.06, 107.34, 98.59, 96.43, 41.63, 34.22, 30.16, 29.68, 29.61, 29.27, 19.98, 18.36; HRMS (ESI): *m/z* calcd for $C_{14}H_{15}O_5$ $[M+H]^+$ 263.0914, found 263.0916, M.P: 228-229 ^{o}C.

7-Isopropyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ba):



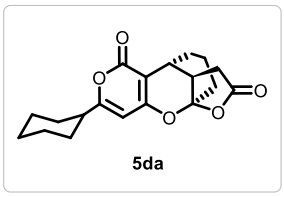
Following General Procedure D, **5ba** (0.154 g, 81%, as a white solid) was obtained from 4-hydroxy-6-isopropyl-2*H*-pyran-2-one (**4b**) (0.1 g, 0.64 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.5 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$,) δ 5.84 (s, 1H), 3.38 (br. s., 1H), 2.77-2.70 (m, 1H), 2.67-2.62 (m, 2H), 2.53-2.39 (m, 2H), 2.29-2.21 (m, 2H), 2.00-1.91 (m, 2H), 1.88-1.84 (m, 2H), 1.26 (s, 3H), 1.24 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 173.97, 170.46, 165.15, 163.85, 107.35, 96.59, 95.77, 41.69, 34.26, 32.69, 30.15, 29.65, 29.30, 19.95, 18.41; HRMS (ESI): *m/z* calcd for $C_{16}H_{19}O_5$ [M+H]+ 291.1232, found 291.1228

7-Cyclopropyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ca):



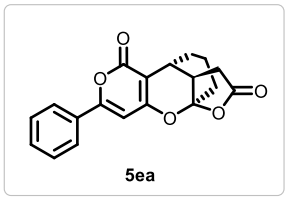
Following General Procedure D, **5ca** (0.149 g, 78%, as a white solid) was obtained from 6-cyclopropyl-4-hydroxy-2*H*-pyran-2-one (**4c**) (0.1 g, 0.64 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.89 (s, 1H), 3.34 (br. s., 1H), 2.67-2.57 (m, 1H), 2.51-2.37 (m, 2H), 2.23 (dd, *J* = 13.4, 16.3 Hz, 1H), 2.00-1.88 (m, 2H), 1.84 (d, *J* = 14.4 Hz, 1H), 1.80-1.69 (m, 3H), 1.50 (dd, *J* = 5.9, 12.7 Hz, 2H), 1.10 (br. s., 2H), 0.98 (d, *J* = 5.3 Hz, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 173.99, 166.30, 165.28, 163.42, 107.29, 96.14, 95.67, 41.68, 34.20, 30.19, 29.61, 29.30, 18.37, 14.34, 8.31, 8.22; HRMS (ESI): *m/z* calcd for $C_{16}H_{17}O_5$ [M+H]+ 289.1076, found 289.1075, M.P: 142-144 ^{o}C.

7-Cyclohexyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5da):



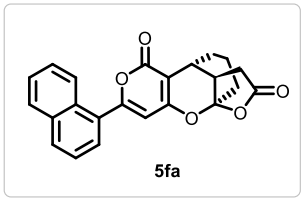
Following General Procedure D, **5da** (0.077 g, 45%, as a white solid) was obtained from 6-cyclohexyl-4-hydroxy-2*H*-pyran-2-one (**4d**) (0.100 g, 0.51 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.80 (s, 1 H), 3.36 (br. s., 1 H), 2.68 - 2.59 (m, 1 H), 2.53-2.45 (m, 1 H), 2.44-2.35 (m, 2 H), 2.25 (dd, *J* = 12.8, 16.9 Hz, 1 H), 2.03-1.91 (m, 4 H), 1.84 (d, *J* = 8.4 Hz, 4 H), 1.79-1.69 (m, 2 H), 1.59 (s, 1 H), 1.42-1.31 (m, 4 H) ; ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 173.99, 169.75, 165.17, 163.88, 107.32, 96.55, 95.93, 42.15, 41.67, 34.24, 30.29, 30.15, 29.65, 29.29, 25.73, 25.66, 18.41; HRMS (ESI): *m/z* calcd for $C_{19}H_{23}O_5$ $[M+H]^+$ 331.1540, found 331.1534, M.P: 205-206 ^{o}C.

7-Phenyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ea):



Following General Procedure D, **5ea** (0.101 g, 73%, as a white solid) was obtained from 4-hydroxy-6-phenyl-2*H*-pyran-2-one **(4e)** (0.080 g, 0.388 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.091 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane);^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83-7.76 (m, 2H), 7.48-7.43 (m, 3H), 6.48 (s, 1H), 3.43 (d, *J* = 2.63 Hz, 1H), 2.71-2.65 (m, 1H), 2.55-2.49 (m, 1H), 2.44 (dd, *J* = 4.6, 13.1 Hz, 1H), 2.32-2.24 (m, 1H), 2.03-1.88 (m, 2H), 1.90-1.77 (m, 2H), 1.61-1.50 (m, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 173.86, 165.04, 162.98, 160.03, 131.12, 130.87, 128.95, 125.55, 107.45, 97.79, 95.96, 41.60, 34.23, 30.21, 29.61, 29.48, 18.39; HRMS (ESI): *m/z* calcd for $C_{19}H_{17}O_5$ [M+H]+ 325.1071, found 325.1062, M.P: 196-198 ^{o}C.

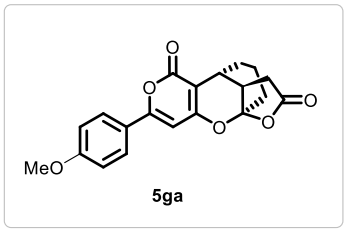
7-(Naphthalen-1-yl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5fa):



Following General Procedure D, **5fa** (0.099 g, 63%, as a white solid) was obtained from 4-hydroxy-6-(naphthalen-1-yl)-2*H*-pyran-2-one (**4f**) (0.1 g, 0.41 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.092 g, 0.5 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.21 (d, *J* = 8.25 Hz, 1H), 7.97 (d, *J* = 8.25 Hz, 1H), 7.92 (d, *J* = 8.88 Hz, 1H), 7.72 (d, *J* = 6.50 Hz, 1H), 7.61-7.51 (m, 3H), 6.39 (s, 1H), 3.50 (d, *J* = 2.5 Hz, 1H), 2.75-2.69 (m, 1H), 2.61-2.47 (m, 2H), 2.42-2.35 (m, 1H), 2.10 (d, *J* = 13.6 Hz, 1H), 2.05-1.83 (m, 3H), 1.70-1.62 (m, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.91, 164.83, 163.41, 161.51, 133.76, 131.43, 130.15, 129.67,

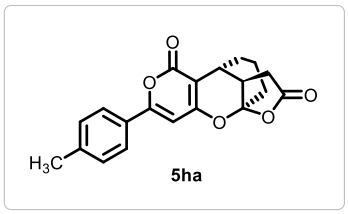
128.76, 127.75, 127.50, 126.51, 124.96, 124.70, 107.6, 101.2, 97.85, 41.71, 34.32, 30.26, 29.74, 29.54, 18.53; HRMS (ESI): *m/z* calcd for $C_{23}H_{19}O_5$ [M+H]+ 375.1227, found 375.1217.

7-(4-Methoxyphenyl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ga):



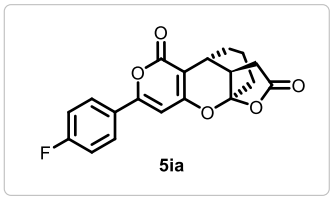
Following General Procedure D, **5ga** (0.056 g, 69%, as a white solid) was obtained from 4-hydroxy-6-(4-methoxyphenyl)-2*H*-pyran-2-one (**4g**) (0.050 g, 0.22 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.63 Hz, 2H), 6.97 (d, *J* = 7.75 Hz, 2H), 6.38 (s, 1H), 3.87 (s, 3H), 3.44 (br. s., 1H), 2.70-2.65 (m, 1H), 2.55-2.43 (m, 2H), 2.34 -2.26(m, 1H), 2.04-1.93 (m, 2H), 1.90-1.78 (m, 2H), 1.60 (d, *J* = 12.8 Hz, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.97, 165.37, 163.20, 162.00, 160.22, 127.31, 123.42, 114.38, 107.42, 96.72, 94.36, 55.44, 41.73, 34.29, 30.29, 29.67, 29.47, 18.44; HRMS (ESI): m/z calcd for $C_{20}H_{19}O_6$ [M+H]+ 355.1181, found 355.1181, M.P: 210-212 ^{o}C.

7-(p-Tolyl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ha):



Following General Procedure D, **5ha** (0.143 g, 85%, as a white solid) was obtained from 4-hydroxy-6-(p-tolyl)-2*H*-pyran-2-one (**4h**) (0.1 g, 0.49 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 7.8 Hz, 2H), 7.27 (d, *J* = 5.38 Hz, 2H), 6.45 (s, 1H), 3.45 (br. s., 1H), 2.71-2.66 (m, 1H), 2.56-2.47 (m, 2H), 2.42 (s, 3H), 2.37-2.25 (m, 2H), 2.05-1.99 (m, 2H), 1.95-1.82 (m, 2H), 1.60 (t, *J* = 6.50 Hz, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.93, 165.23, 163.16, 160.35, 141.74, 129.71, 128.15, 125.54, 107.45, 97.37, 95.25, 41.71, 34.29, 30.28, 29.67, 29.50, 21.47, 18.44; HRMS (ESI): *m/z* calcd for $C_{20}H_{19}O_5$ [M+H]+ 339.1232, found 339.1235.

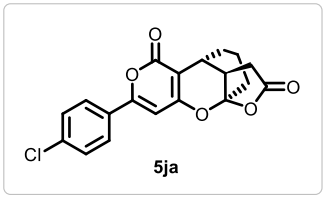
7-(4-Fluorophenyl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ia):



Following General Procedure D, **5ia** (0.044 g, 33%, as a white solid) was obtained from 6-(4-fluorophenyl)-4-hydroxy-2*H*-pyran-2-one (**4i**) (0.080 g, 0.388 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); TLC: R_f = 0.6 (SiO_2,

50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 7.88 Hz, 1H), 7.59 (t, *J* = 7.38 Hz, 1H), 7.39-7.30 (m, 2H), 7.27 (s, 1H), 3.55 (d, *J* = 2.0 Hz 1H), 2.78-2.73 (m, 1H), 2.58-2.52 (m, 2 H), 2.34-2.26 (m, 1H), 2.08-2.01 (m, 2H), 1.92-1.84 (m, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 173.83, 165.69 (*J*= 252.41 Hz) 165.06, 163.17, 162.86, 159.13, 127.84, 127.76, 127.22, 127.19, 116.36, 116.14, 107.54, 97.71, 95.78, 95.76, 41.64, 34.27, 30.25, 29.64, 29.51, 18.43, ^{19}F NMR (400 MHz, $CDCl_3$) – 108.00; HRMS (ESI): *m/z* calcd for $C_{19}H_{16}O_5F$ $[M+H]^+$ 343.0976, found 343.0977.

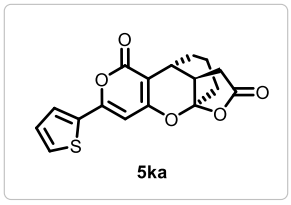
7-(4-Chlorophenyl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ja):



5ja

Following General Procedure D, **5ja** (0.066 g, 82%, as a white solid) was obtained from 6-(4-chlorophenyl)-4-hydroxy-2H-pyran-2-one (**4j**) (0.050 g, 0.22 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 8.1 Hz, 2H), 7.45 (d, *J* = 8.1 Hz, 2H), 6.47 (s, 1H), 3.45 (s., 1H), 2.72-2.67 (m, 1H), 2.57-2.51 (m, 1H), 2.48-2.43 (dd, *J* = 4.50, 13.13 Hz, 1H), 2.32-2.25 (m, 1H), 2.04-1.95 (m, 1H), 1.87-1.80 (m, 2H), 1.62-1.54 (m, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.76, 164.91, 162.73, 158.89, 137.35, 129.32, 126.84, 107.53, 98.13, 96.21, 41.60, 34.25, 30.22, 29.61, 29.53, 18.41; HRMS (ESI): *m/z* calcd for $C_{19}H_{16}ClO_5$ [M+H]+ 359.0686, found 359.0684, M.P: 219-220 ^{o}C.

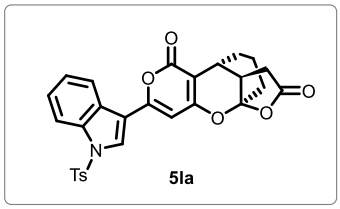
7-(Thiophen-2-yl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ka):



5ka

Following General Procedure D, **5ka** (0.089 g, 54%, as a white solid) was obtained from 4-hydroxy-6-(thiophen-2-yl)-2*H*-pyran-2-one (**4k**) (0.100 g, 0.51 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 3.6 Hz, 1H), 7.48 (d, *J* = 5.0 Hz, 1H), 7.12 (t, *J* = 4.3 Hz, 1H), 6.33 (s, 1H), 3.43 (br. s., 1H), 2.70-2.65 (m, 1H), 2.56-2.42 (m, 2H), 2.37-2.18 (m, 1H), 2.08-1.94 (m, 2H), 1.94-1.75 (m, 2H), 1.65-1.48 (m, 2H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.82, 164.92, 162.38, 155.66, 134.61, 129.21, 128.36, 127.64, 107.48, 97.32, 94.80, 41.66, 34.25, 30.27, 29.63, 29.58, 18.41; HRMS (ESI): *m/z* calcd for $C_{17}H_{15}O_5S$ $[M+H]^+$ 331.0635, found 331.0629, M.P: 220-222 ^{o}C.

7-(1-Tosyl-1*H*-indol-3-yl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5la):



Following General Procedure D, **5la** (0.091 g, 67%, as a white solid) was obtained from 4-hydroxy-6-(1-tosyl-1*H*-indol-3-yl)-2*H*-pyran-2-one (**4l**) (0.100 g, 0.26 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**2a**) (0.071 g, 0.39 mmol). TLC: R_f = 0.3 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (s, 1H), 8.05 (d, *J* = 8.13 Hz, 1H), 7.88 (d, *J* = 7.8 Hz, 1H), 7.83 (d, *J* = 8.4 Hz, 2H), 7.43-7.34 (m, 2H), 7.27-7.25 (m, 2 H), 6.48 (s, 1H), 3.45 (d, *J* = 2.5 Hz, 1H), 2.72-2.66 (m, 1H), 2.57-2.51 (m, 1H), 2.45 (dd, *J* = 4.4, 13.38 Hz, 1H), 2.36 (s, 3H), 2.34-2.28 (m, 1H), 2.07-1.94 (m, 2H), 1.91-1.78 (m, 2H), 1.62-1.54 (m, 1H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.85, 164.94, 162.73, 155.65, 145.75, 135.31, 134.57, 130.15, 127.29, 127.09, 125.95, 125.64, 124.41, 120.62, 114.31, 113.94, 107.52, 97.60, 96.77, 41.64, 34.24, 30.27, 29.64, 29.52, 21.60, 18.41

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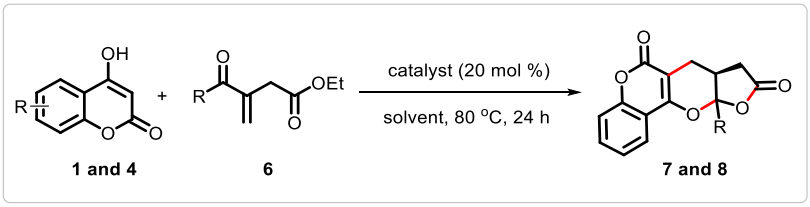
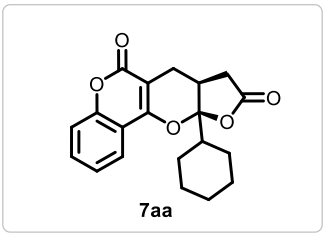
9. Synthesis of fused furopyranones:



To the mixture of keto-ester **6** (0.55 mmol) and 4-hydroxy-2*H*-chromen-2-one **1** and **4** (0.55 mmol) in 2.0 mL of anhydrous fluorobenzene (PhF) in a dry 25 mL single neck round bottom flask equipped with a reflux condenser, was added $Bi(OTf)_3$ (0.110 mmol) under argon atmosphere at room temperature. The resulting mixture was stirred at 80 °C for 24 h. After completion of the reaction (monitored by TLC, visualized using UV, anisaldehyde and $KMnO_4$ staining solutions), the reaction mixture was quenched with saturated aqueous $NaHCO_3$ solution then extracted with EtOAc (2 × 20 mL). The combined organic layers were dried over anhydrous Na_2SO_4, and filtered. The solvent was evaporated under reduced pressure, and the resulting crude product was purified by silica gel column chromatography (SiO_2, 25% EtOAc/hexane) to afford the desired product pyrano-chromane **7** and **8**.

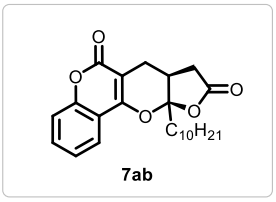
10a-Cyclohexyl-7a,10a-dihydro-6*H*,7*H*-furo[3',2':5,6]pyrano[3,2-c]chromene-6,9(8*H*)-dione (7aa):



Following General Procedure D, **7aa** (0.110 g, 52%, as a white solid) was obtained from 4-hydroxy-2*H*-chromen-2-one **(1a)** (0.100 g, 0.61 mmol), ethyl 3-(cyclohexanecarbonyl)but-3-enoate (**6a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.84 (d, *J* = 7.8 Hz, 1H), 7.58 (t, *J* = 7.8 Hz, 1H), 7.40-7.30 (m, 2H), 3.25-

3.14 (m, 1H), 2.90-2.82 (m, 1H), 2.81-2.68 (m, 2H), 2.46 (dd, *J* = 11.9, 17.6 Hz, 1H), 2.07-1.93 (m, 2H), 1.90-1.83 (m, 2H), 1.71 (d, *J* = 9.9 Hz, 1H), 1.37-1.17 (m, 6H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 173.45, 162.57, 158.27, 152.62, 132.27, 124.33, 122.59, 116.76, 114.52, 110.27, 97.0, 43.80, 33.13, 32.94, 26.61, 26.18, 25.78, 25.70, 20.51; HRMS (ESI): *m/z* calcd for $C_{20}H_{21}O_5$ $[M+H]^+$ 341.1389, found 341.1381, M.P: 160-162 ^{o}C.

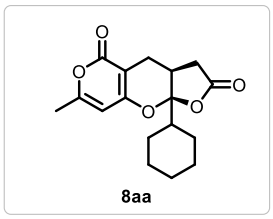
10a-Cyclohexyl-7a,10a-dihydro-6*H*,7*H*-furo[3',2':5,6]pyrano[3,2-c]chromene-6,9(8*H*)-dione (7ab):



7ab

Following General Procedure D, **7ab** (0.070 g, 35%, as a white solid) was obtained from 4-hydroxy-2*H*-chromen-2-one (**1a**) (0.080 g, 0.388 mmol), ethyl 2-(6-oxocyclohex-1-en-yl)acetate (**6b**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (dd, *J* = 1.4, 7.9 Hz, 1H), 7.58 (ddd, *J* = 1.6, 7.2, 8.5 Hz, 1H), 7.38-7.30 (m, 2H), 3.10-3.00 (m, 1H), 2.93-2.80 (m, 2H), 2.79-2.68 (m, 1H), 2.46 (dd, *J* = 12.2, 17.4 Hz, 1H), 2.13-2.03 (m, 1H), 1.98 (t, *J* = 8.1 Hz, 1H), 1.68-1.57 (m, 4H), 1.31 (br. s., 10H), 0.93-0.89 (m, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 173.42, 162.54, 157.87, 152.59, 132.29, 124.31, 122.58, 116.74, 114.53, 108.68, 96.75, 77.3, 35.95, 35.65, 32.37, 31.84, 29.69, 29.49, 29.29, 29.25, 22.70, 22.65, 19.77, 14.08.

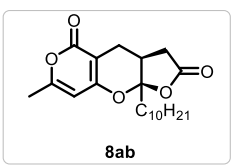
9a-Cyclohexyl-7-methyl-3a,9a-dihydro-4*H*,5*H*-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (8aa):



8aa

Following General Procedure D, **8aa** (0.176 g, 73%, as a white solid) was obtained from 4-hydroxy-6-methyl-2*H*-pyran-2-one (**4a**) (0.100 g, 0.79 mmol), ethyl 3-(cyclohexanecarbonyl)but-3-enoate (**6a**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.84 (s, 1H), 3.15-3.03 (m, 1H), 2.72-2.61 (m, 3H), 2.38 (dd, *J* = 11.9, 17.5 Hz, 1H), 2.24 (s, 3H), 1.96-1.85 (m, 3H), 1.82 (br. s., 3H), 1.71 (d, *J* = 10.3 Hz, 1H), 1.22 (s, 3H), 1.26 (s, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 173.52, 164.45, 163.15, 161.45, 109.90, 99.58, 94.01, 43.95, 33.06, 32.90, 26.47, 26.10, 25.83, 25.69, 19.76; HRMS (ESI): m/z calcd for $C_{17}H_{21}O_5$ $[M+H]^+$ 305.1389, found 305.0390, M.P: 189-190 ^{o}C.

9a-(Deca-1,3,5,7,9-pentayn-1-yl)-7-methyl-3a,9a-dihydro-4*H*,5*H*-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione--dihydrogen (1/9) (8ab):

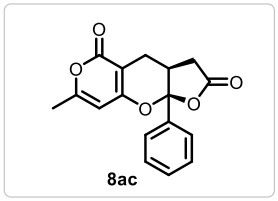


8ab

Following General Procedure D, **8ab** (0.07 g, 56%, as a white solid) was obtained from 4-hydroxy-6-methyl-2*H*-pyran-2-one (**4a**) (0.100 g, 0.35 mmol), ethyl 2-(6-

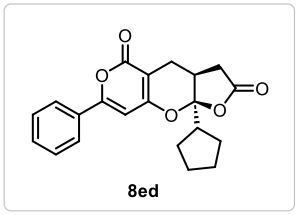
oxocyclohex-1-en-yl)acetate (**6b**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.82 (s, 1H), 3.00-2.82 (m, 1H), 2.77-2.58 (m, 3H), 2.54-2.34 (m, 2H), 2.31-2.20 (m, 3H), 2.04-1.93 (m, 1H), 1.92-1.80 (m, 1H), 1.63 (br. s., 1H), 1.57-1.39 (m, 2H), 1.33-1.25 (m, 9H), 0.88 (t, *J* = 6.8 Hz, 4H); ^{13}C{^{1}H} NMR (101 MHz $CDCl_3$) δ 174.78, 173.58, 164.42, 162.64, 161.43, 161.09, 160.78, 108.97, 108.29, 99.58, 99.53, 97.86, 93.70, 35.92, 35.48, 32.25, 31.84, 29.50, 29.26, 29.24, 22.65, 22,59, 19.83, 18.89, 14.10; HRMS (ESI): *m/z* calcd for $C_{21}H_{31}O_5$ $[M+H]^+$ 363.2171, found 363.2164.

7-Methyl-9a-phenyl-3a,9a-dihydro-4*H*,5*H*-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (8ac):



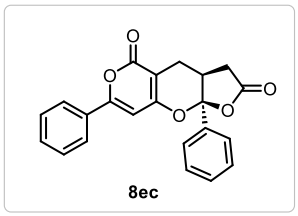
Following General Procedure D, **8ac** (0.077 g, 32%, as a white solid) was obtained from rom 4-hydroxy-6-methyl-2*H*-pyran-2-one (**4a**) (0.100 g, 0.79 mmol), ethyl 3-benzoylbut-3-enoate (**6c**) (0.136 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47-7.42 (m, 3H), 7.41-7.36 (m, 2H), 5.96 (s, 1H), 3.17 (dddd, *J* = 1.6, 6.2, 7.9, 12.2 Hz, 1H), 2.86-2.72 (m, 2H), 2.62-2.49 (m, 2H), 2.28 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 173.18, 164.23, 163.16, 161.85, 136.20, 130.10, 128.93, 124.90, 106.85, 99.26, 94.19, 39.20, 32.41, 19.92, 18.19; HRMS (ESI): *m/z* calcd for $C_{17}H_{15}O_5$ $[M+H]^+$ 299.0919, found 299.0912.

9a-cyclopentyl-7-phenyl-3a,9a-dihydro-4H,5H-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3H)-dione (8ed):



Following General Procedure D, **8ed** (0.083 g, 44%, as a white solid) was obtained from 4-hydroxy-6-phenyl-2H-pyran-2-one **(4e)** (0.100 g, 0.53 mmol), ethyl 3-(cyclopentanecarbonyl)but-3-enoate (**6c**) (0.167 g, 0.79 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): 7.84-7.79 (m, 2H), 7.50-7.45 (m, 3H), 6.48 (s, 1H), 3.05-3.02 (m, 1H), 2.82-2.68 (m, 3H), 2.50-2.41 (m, 2H), 1.87-1.84 (m, 2H), 1.74-1.68 (m, 3H), 1.61-1.58 (m, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 173.6, 163.7, 163.2, 159.6, 131.1, 130.9, 129.0, 125.5, 109.9, 97.0, 95.3, 45.3, 35.3, 32.7, 27.0, 26.5, 25.7, 25.4, 19.5; HRMS (ESI): *m/z* calcd for $C_{21}H_{21}O_5$ $[M+H]^+$ 353.1384, found 353.1382.

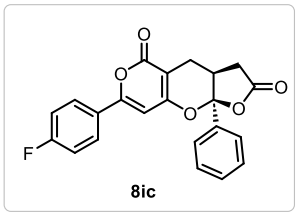
9a-Diphenyl-3a,9a-dihydro-4H,5H-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3H)-dione (8ec):



Following General Procedure D, **8ec** (0.160 g, 45%, as a white solid) was obtained from 4-hydroxy-2*H*-chromen-2-one **(4e)** (0.200 g, 1.06 mmol), ethyl 3-benzoylbut-3-enoate (**6c**) (0.27 g, 1.59 mmol). TLC: R_f = 0.5 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.87-7.82 (m, 2H), 7.52-7.47

(m, 3H), 7.47-7.42 (m, 5 H), 6.61 (s, 1H), 3.27-3.17 (m, 1H), 2.90-2.81 (m, 2H), 2.71-2.57 (m, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 173.17, 163.53, 163.30, 159.97, 136.24, 131.27, 130.81, 130.17, 129.05, 129.00, 125.64, 124.98, 107.02, 96.68, 95.58, 77.35, 77.03, 76.71, 39.27, 32.52, 18.52.; HRMS (ESI): *m/z* calcd for $C_{20}H_{21}O_5$ [M+H]+341.1389, found 341.1381.

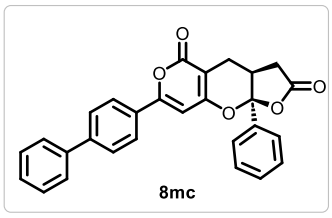
(4-Fluorophenyl)-9a-phenyl-3a,9a-dihydro-4H,5H-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3H)-dione (8ic):



8ic

Following General Procedure D, **8ic** (0.135 g, 42%, as a white solid) was obtained from 6-(4-fluorophenyl)-4-hydroxy-2H-pyran-2-one **(4i)** (0.200 g, 0.61 mmol), ethyl 3-benzoylbut-3-enoate (**6c**) (0.317 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.89-7.79 (m, 2H), 7.47-7.42 (m, 5H), 7.20-7.16 (m, 2H), 6.54 (s, 1H), 3.28-3.16 (m, 1H), 2.91-2.81 (m, 2H), 2.72-2.55 (m, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 173.08, 165.74, 163.32, 163.23, 158.99, 136.17, 130.18, 128.99, 127.87, 127.78, 127.08, 127.05, 124.93, 116.40, 116.18, 107.01, 96.42, 95.43, 77.32, 77.00, 76.68, 39.22, 32.48, 18.48.

7-([1,1'-Biphenyl]-4-yl)-9a-phenyl-3a,9a-dihydro-4H,5H-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3H)-dione (8mc):

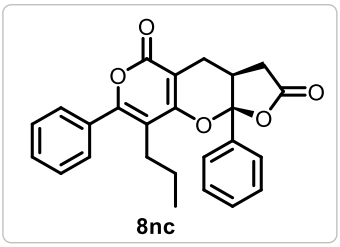


8mc

Following General Procedure D, **8mc** (0.163 g, 46%, as a white solid) was obtained from 6-([1,1'-biphenyl]-4-yl)-4-hydroxy-2H-pyran-2-one **(4m)** (0.200 g, 0.61 mmol), ethyl 3-benzoylbut-3-enoate (**6c**) (0.265 g, 0.75 mmol). TLC: R_f = 0.6 (SiO_2, 50% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93-7.90 (m, 2H), 7.73-7.69 (m, 3H), 7.67-7.61 (m, 3H), 7.50-7.43 (m, 8H), 6.64 (s, 1H), 3.22 (m, 1H), 2.90-2.81 (m, 2H), 2.73-2.57 (m, 2H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 173.19, 163.55, 163.34, 159.73, 144.01, 139.72, 136.25, 130.18, 129.56, 129.01, 129.00, 128.17, 127.68, 127.64, 127.17, 127.12, 126.10, 124.99, 107.04, 96.55, 95.55, 77.35, 77.04, 76.72, 39.28, 32.53, 18.55; HRMS (ESI): *m/z* calcd for $C_{28}H_{21}O_5$ $[M+H]^+$ 437.1384, found 437.1382.

7,9a-Diphenyl-8-propyl-3a,9a-dihydro-4H,5H-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3H)-dione (8nc):

Following General Procedure D, **8nc** (0.133 g, 38%, as a white solid) was obtained from 4-hydroxy-6-phenyl-5-propyl-2H-pyran-2-one (**4n**) (0.2 g, 0.9 mmol), ethyl 3-benzoylbut-3-enoate (**6c**) (0.189 g, 0.9 mmol). TLC: R_f = 0.4 (SiO_2, 30% EtOAc/hexane); ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.58-7.40 (m, 10 H), 3.25-3.16 (m, 1 H), 2.93-2.80 (m, 2 H), 2.72-2.55 (m, 2 H), 2.50 - 2.42 (m, 2 H), 1.55 (m, 2 H), 0.85 (t, *J*

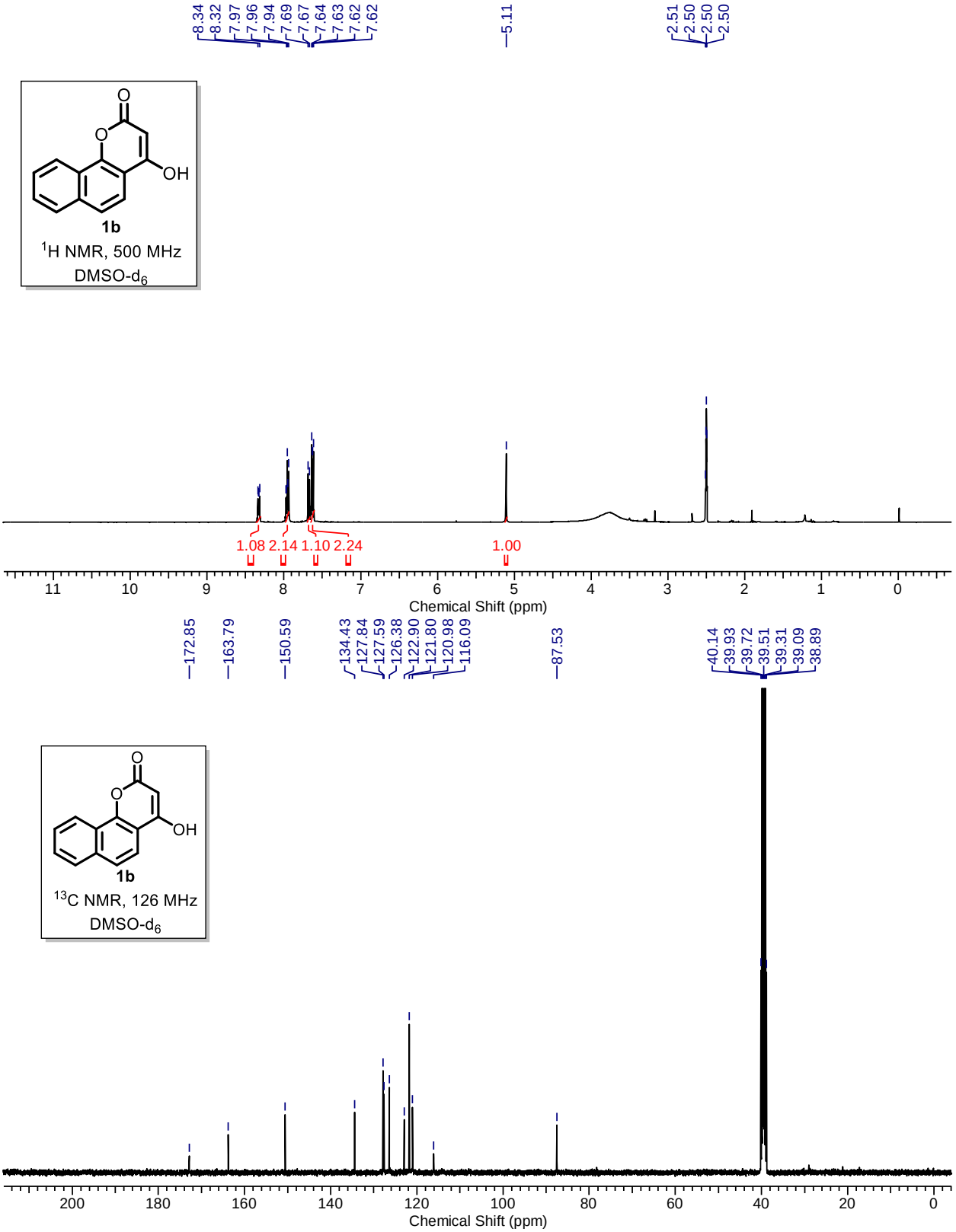


8nc

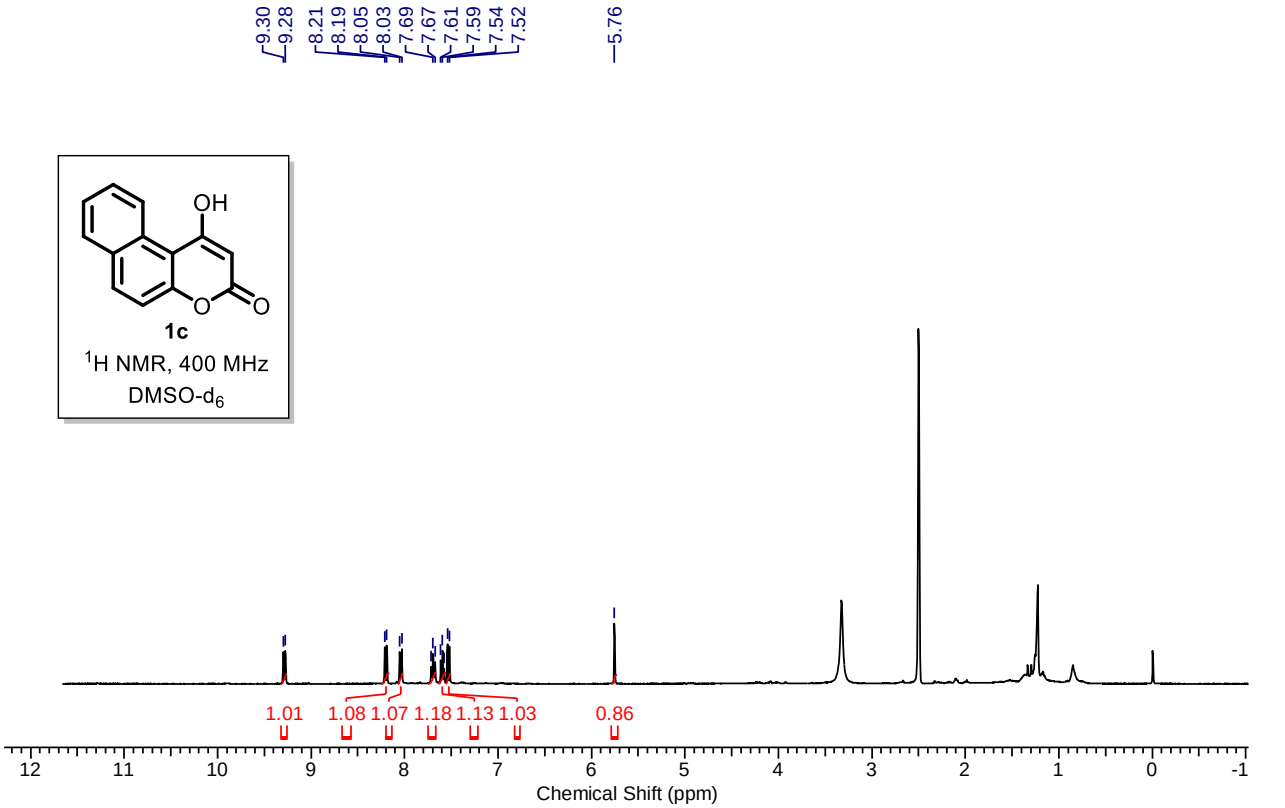
= 7.4 Hz, 3 H); $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$): δ = 173.3, 163.5, 163.1, 157.6, 136.5, 132.2, 130.0, 128.9, 128.6, 128.4, 124.9, 111.7, 107.3, 96.0, 39.0, 32.4, 27.0, 23.3, 18.6, 13.9; HRMS (ESI): *m/z* calcd for $C_{25}H_{23}O_5$ $[M+H]^+$ 403.1540, found 403.1540.

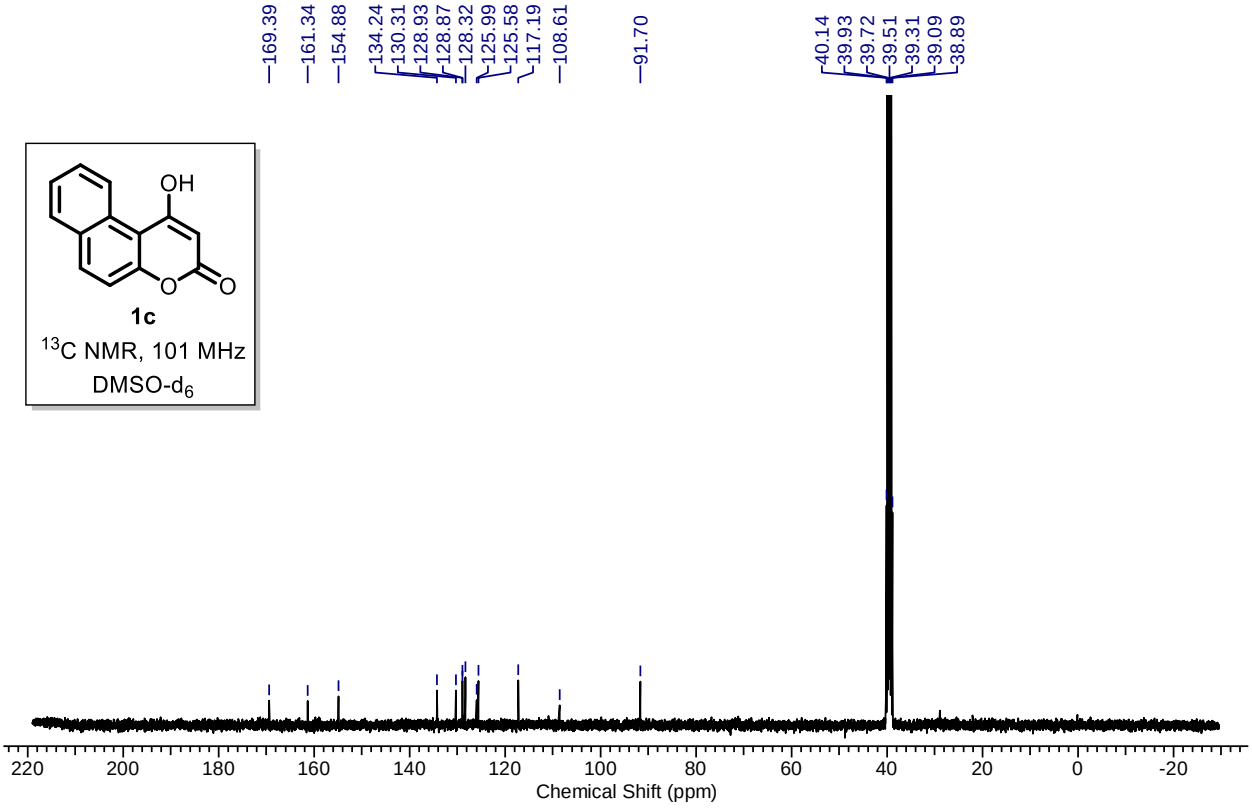
10. ^{1}H and ^{13}C NMR Data

4-Hydroxy-2*H*-benzo[*h*]chromen-2-one (1b)

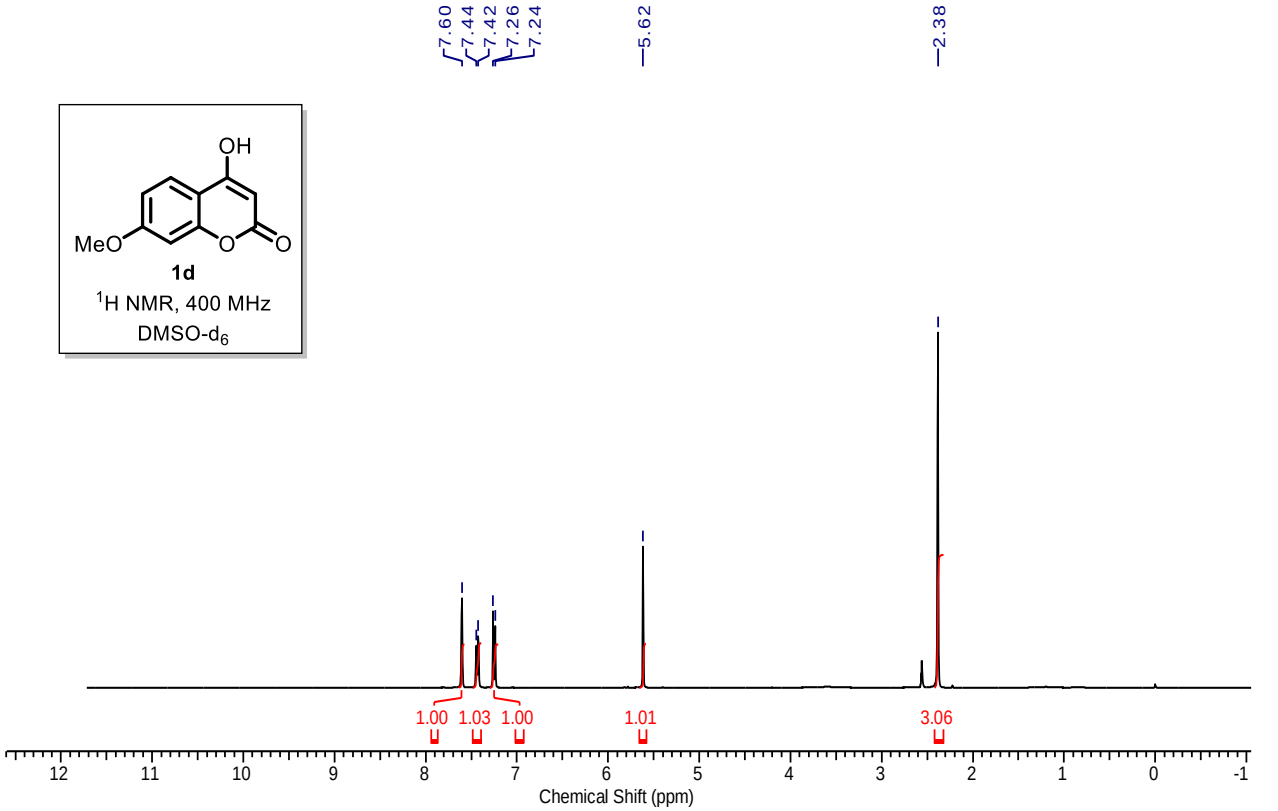


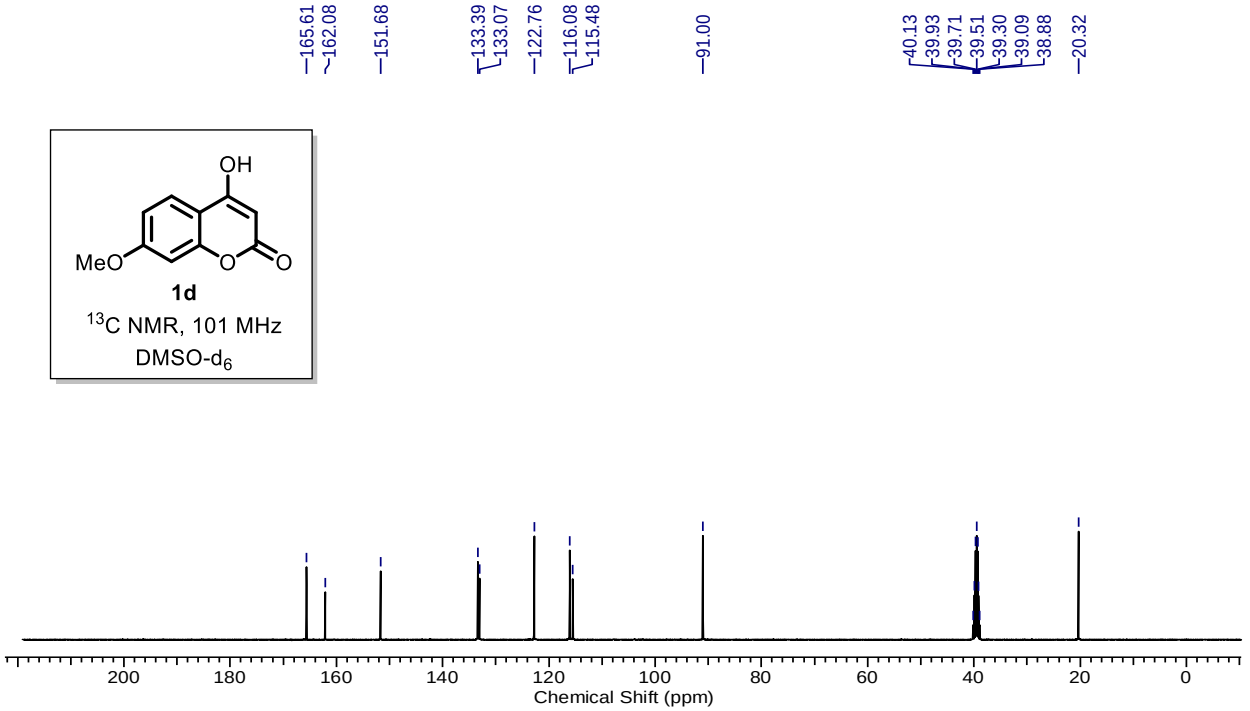
1-Hydroxy-3*H*-benzo[*f*]chromen-3-one (1c)



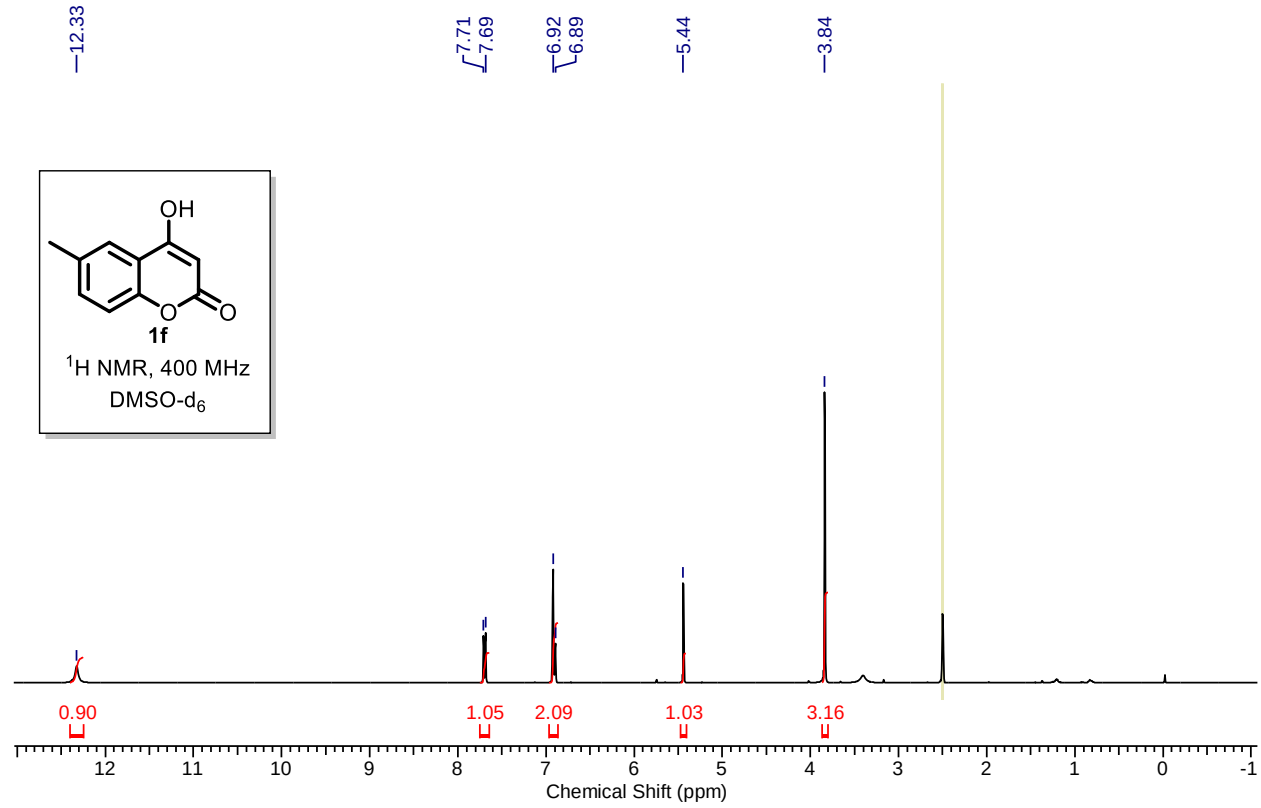


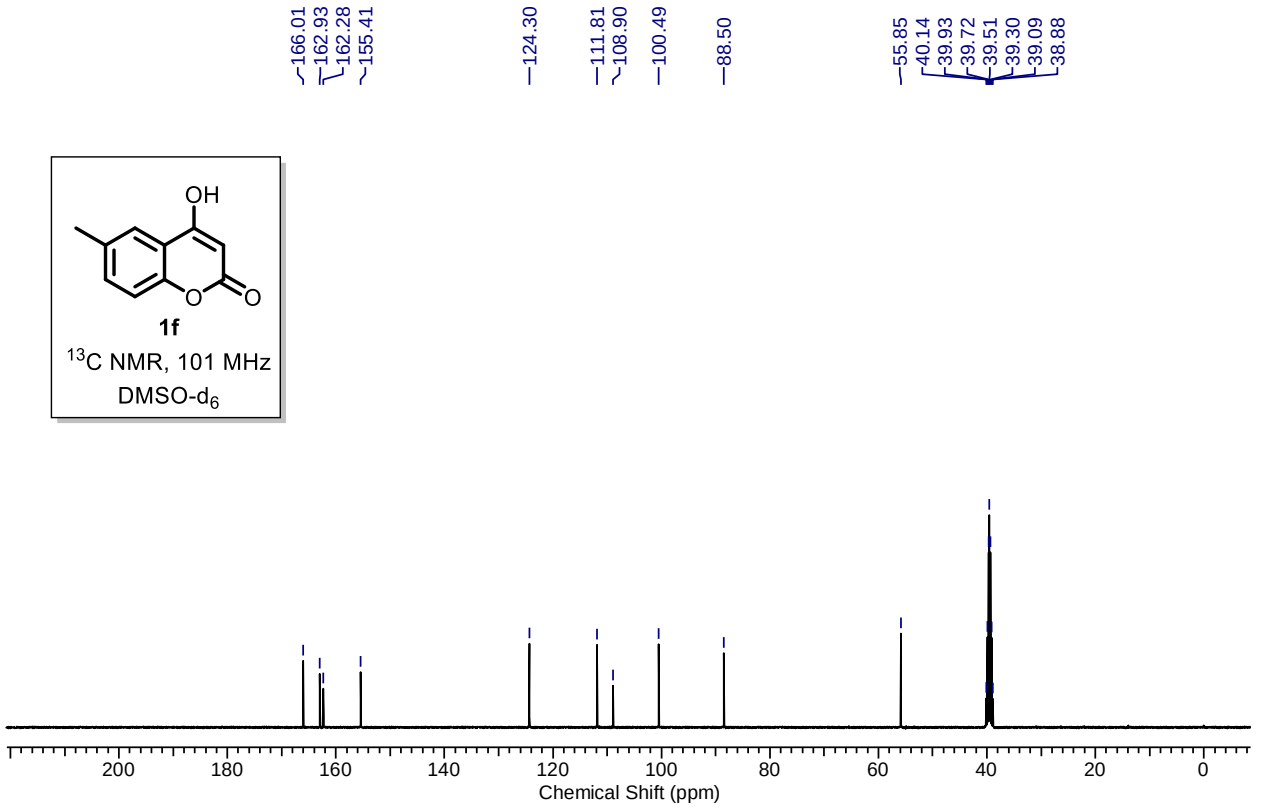
4-Hydroxy-7-methoxy-2*H*-chromen-2-one (1d):



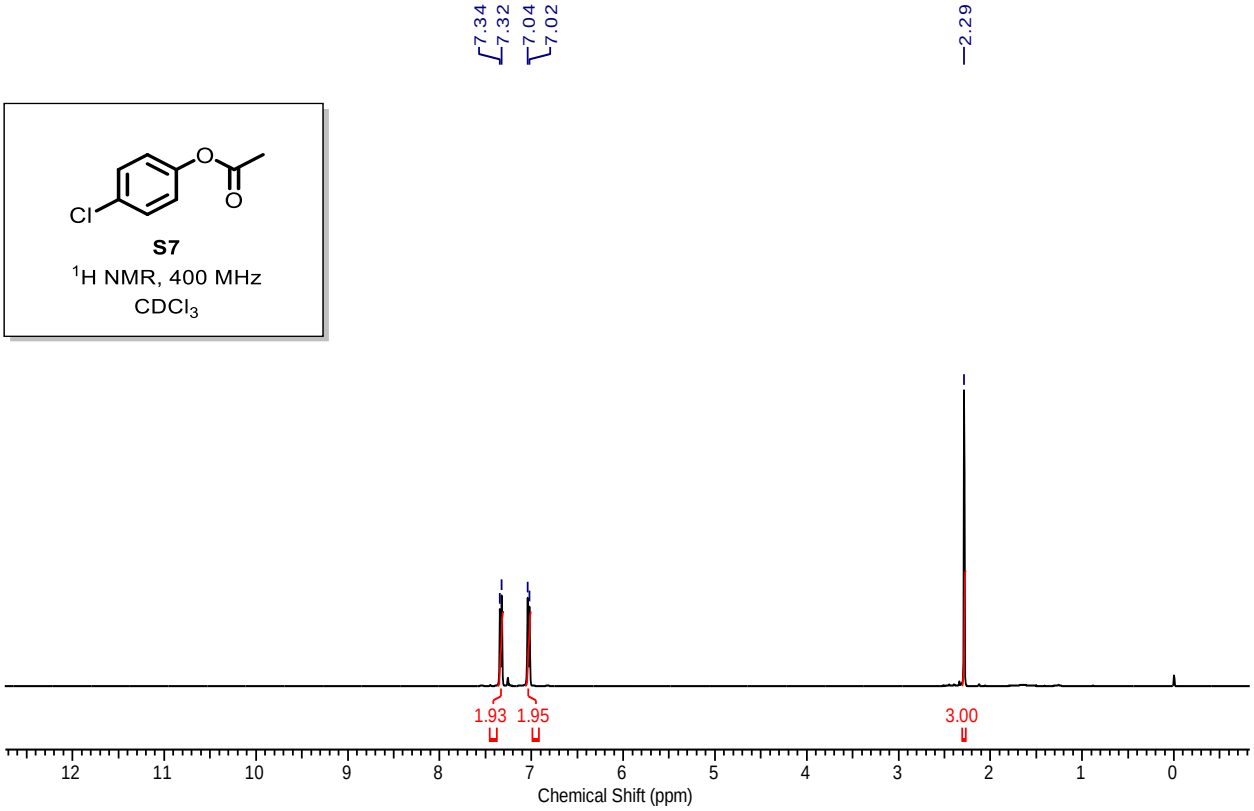


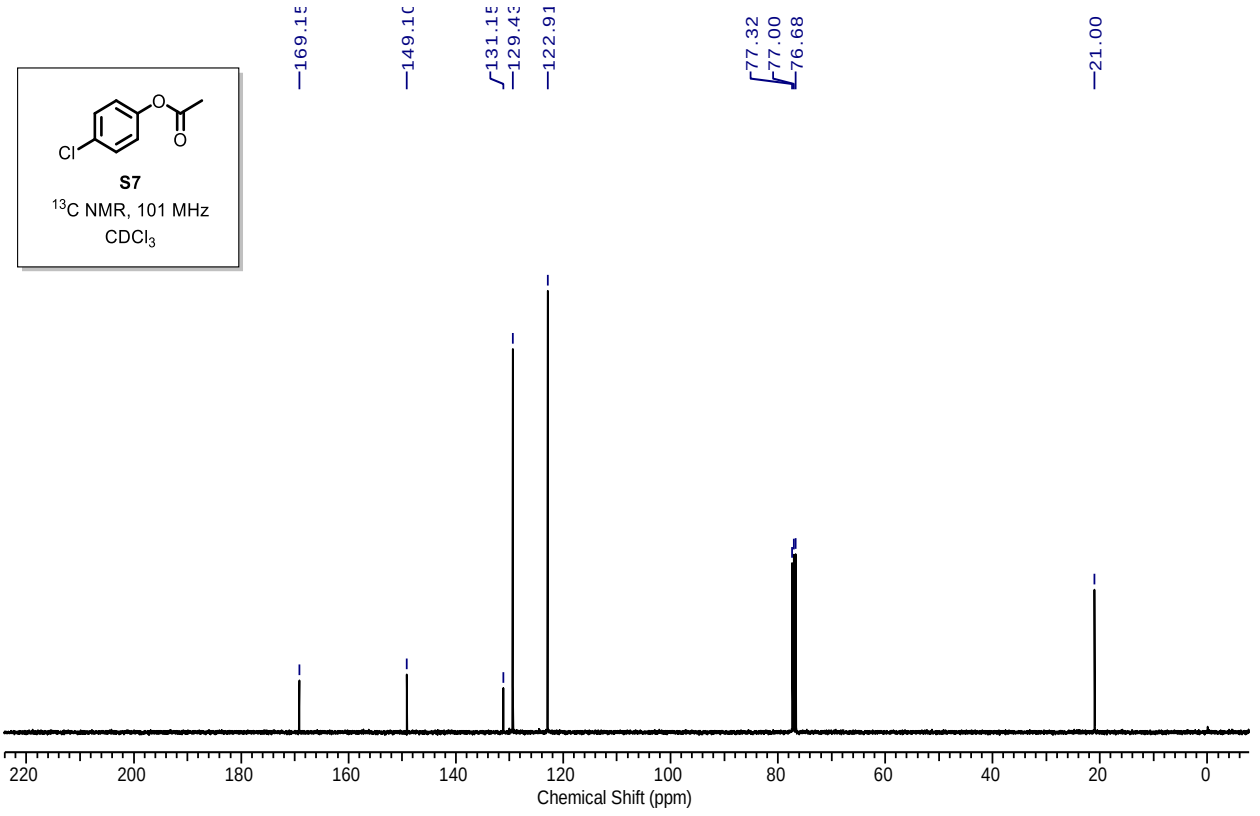
4-Hydroxy-6-methyl-2*H*-chromen-2-one (1f):



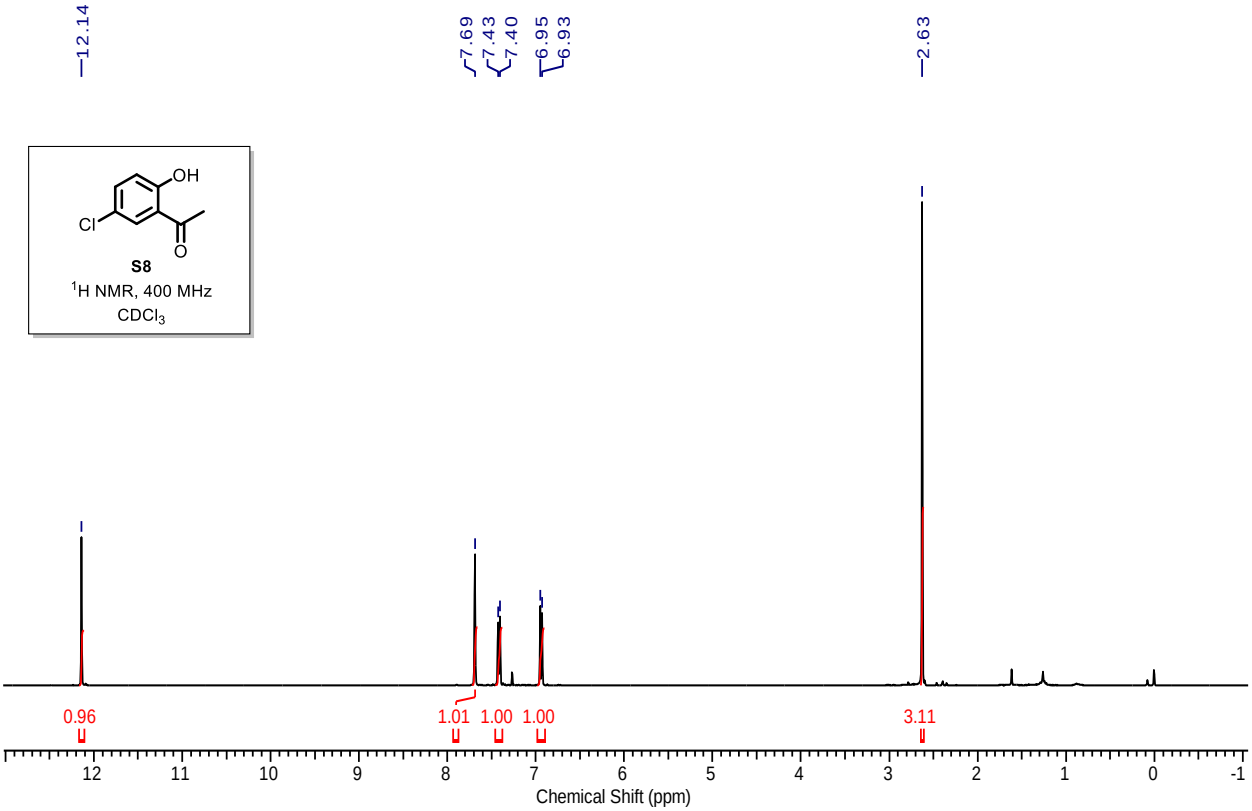


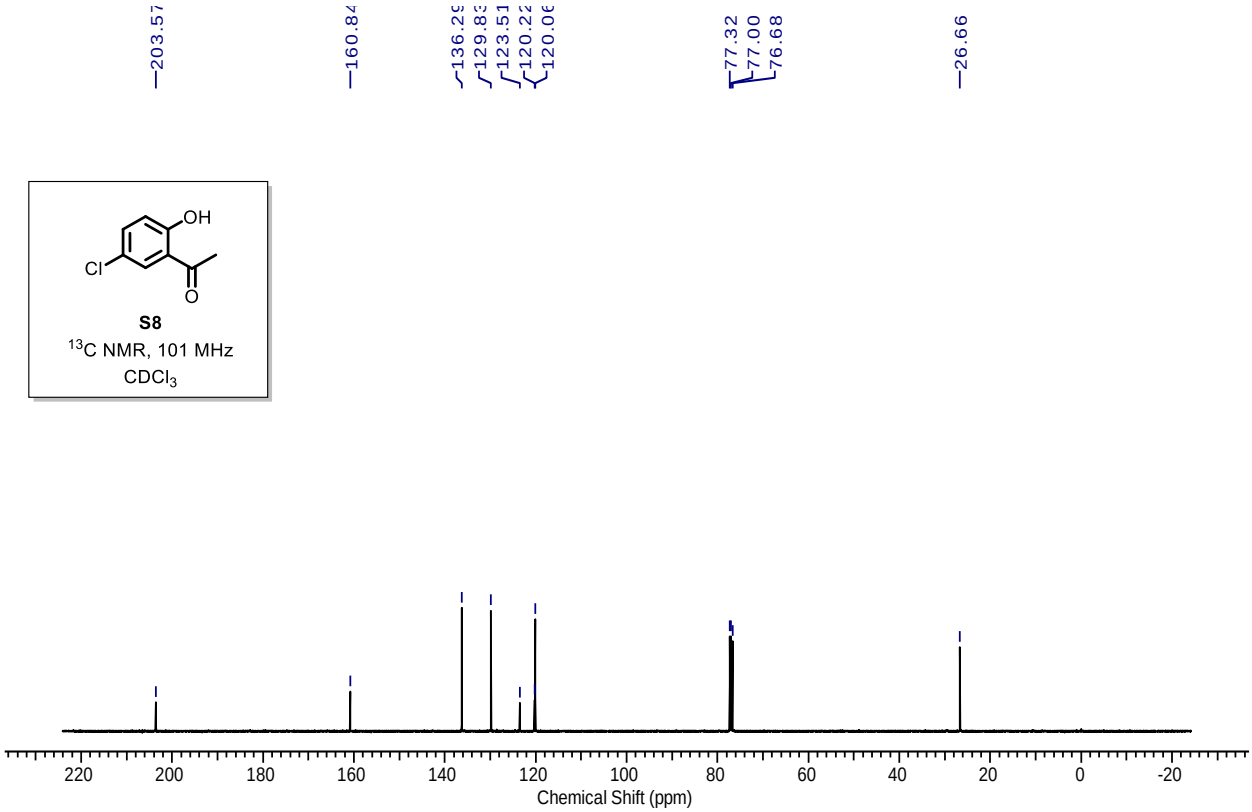
4-Chlorophenyl acetate (S7):



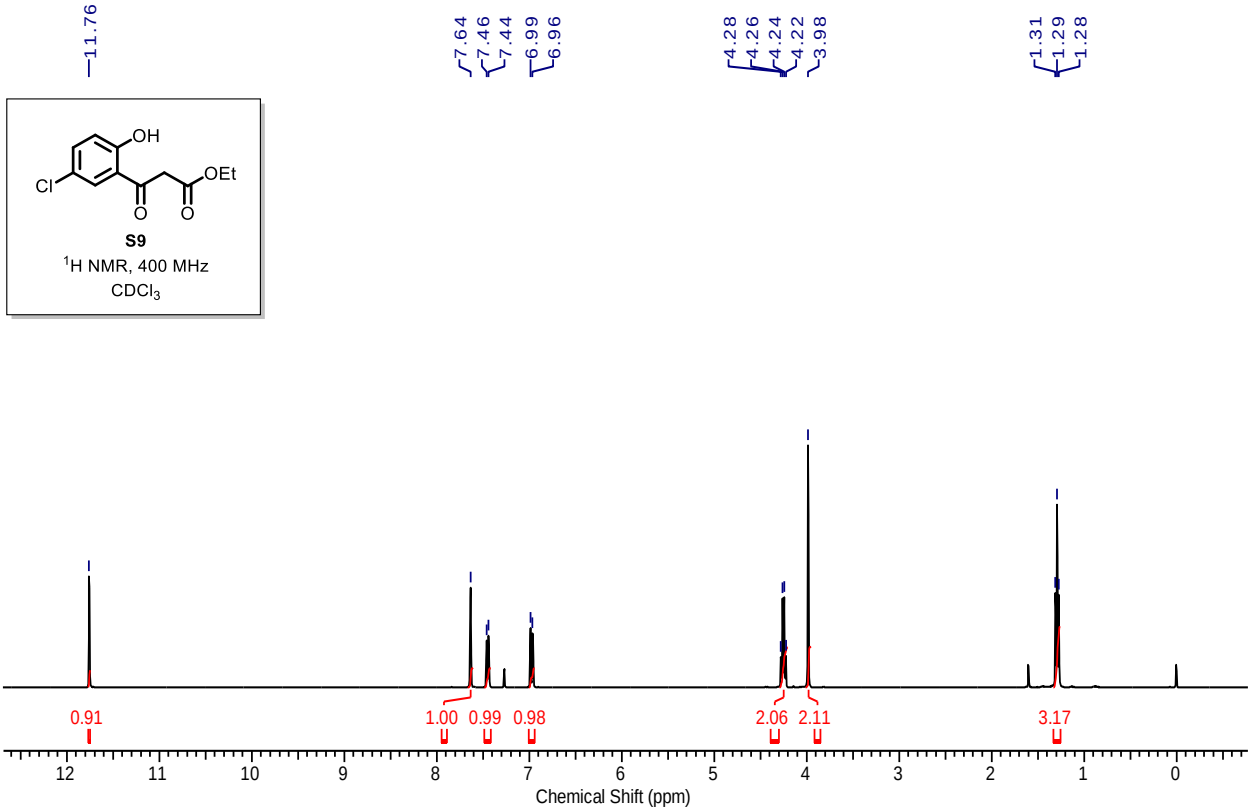


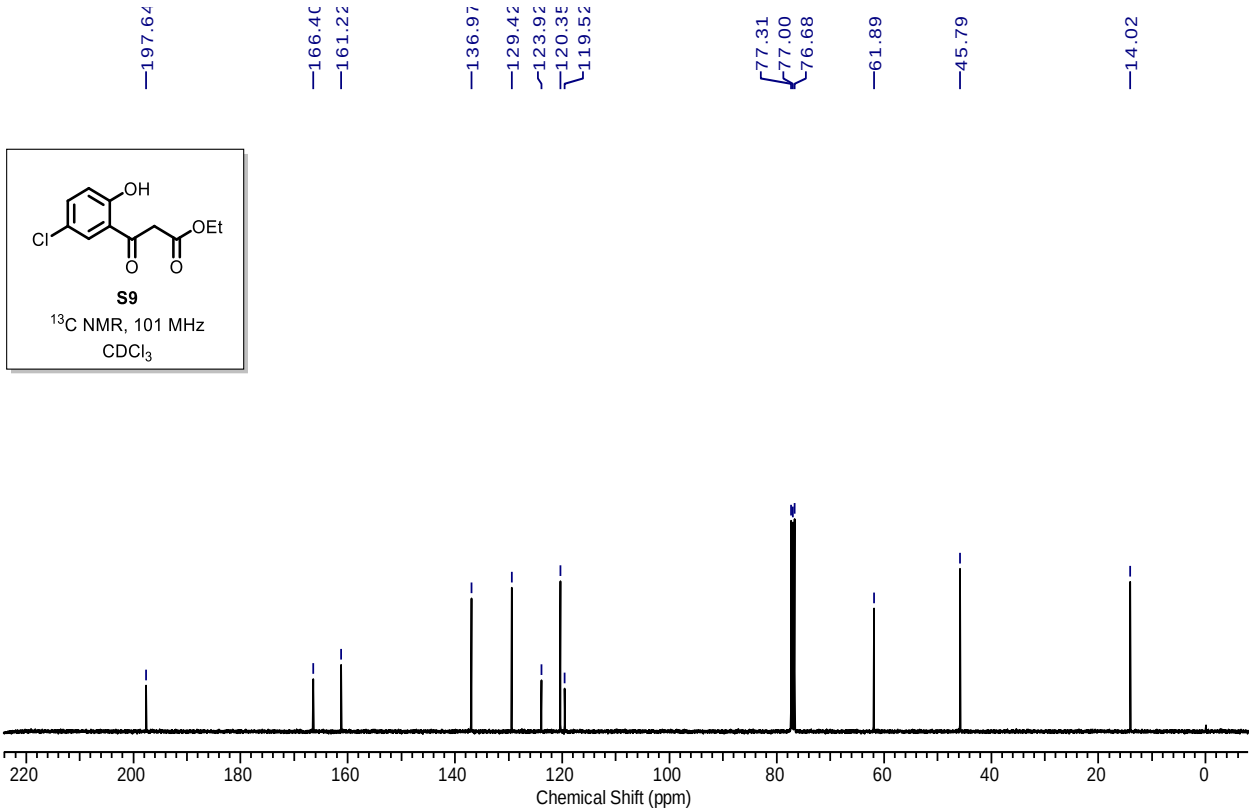
1-(5-Chloro-2-hydroxyphenyl)ethan-1-one (S8):



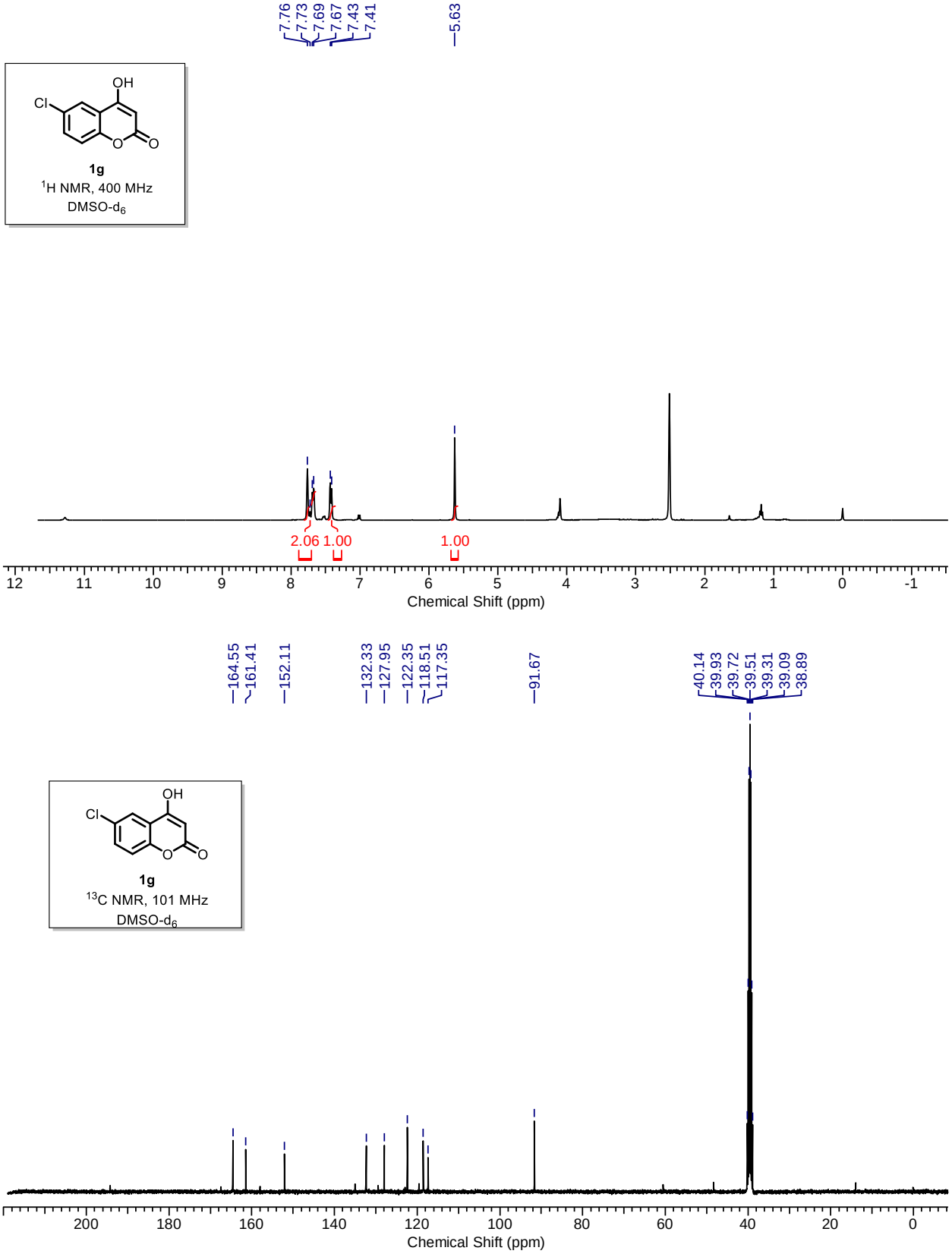


Ethyl 3-(5-chloro-2-hydroxyphenyl)-3-oxopropanoate (S9):

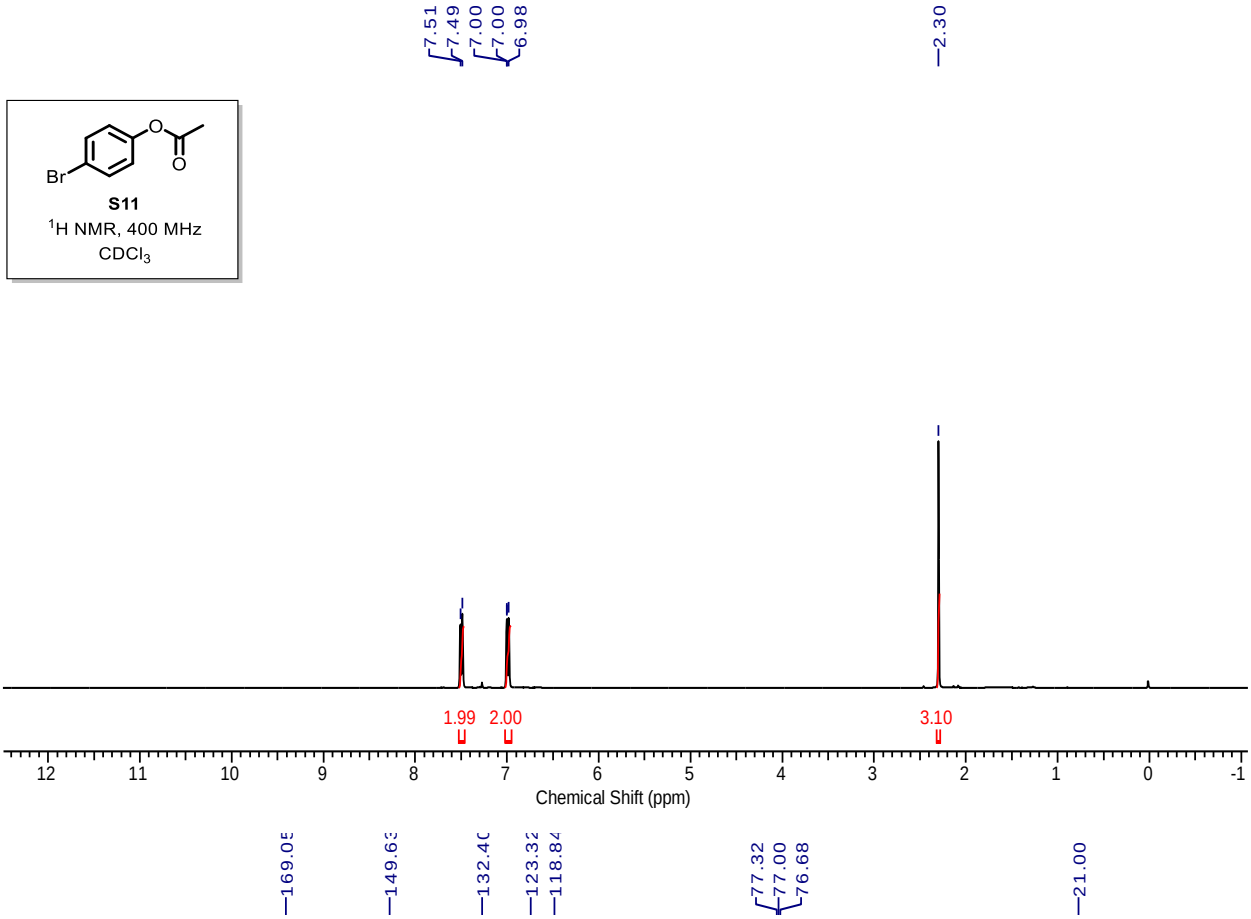


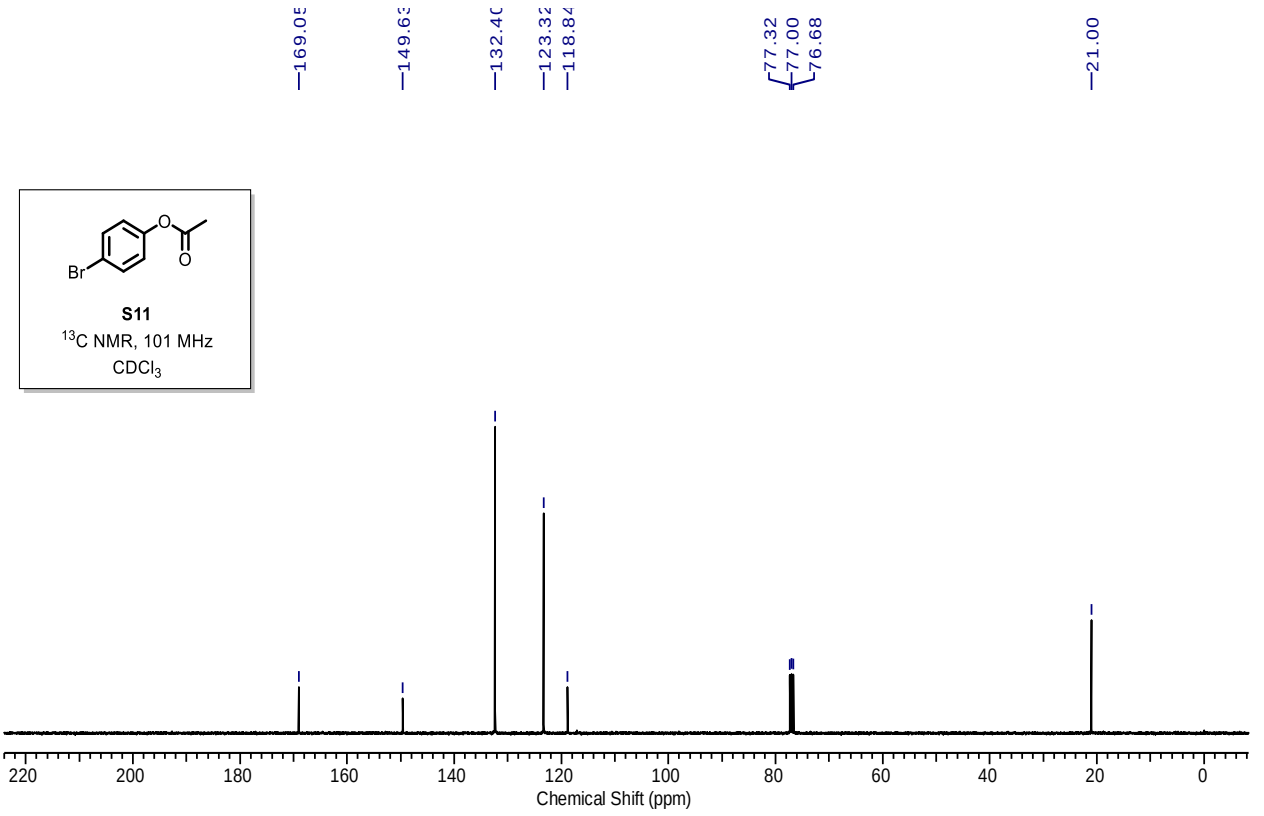


6-Chloro-4-hydroxy-2*H*-chromen-2-one (1g):

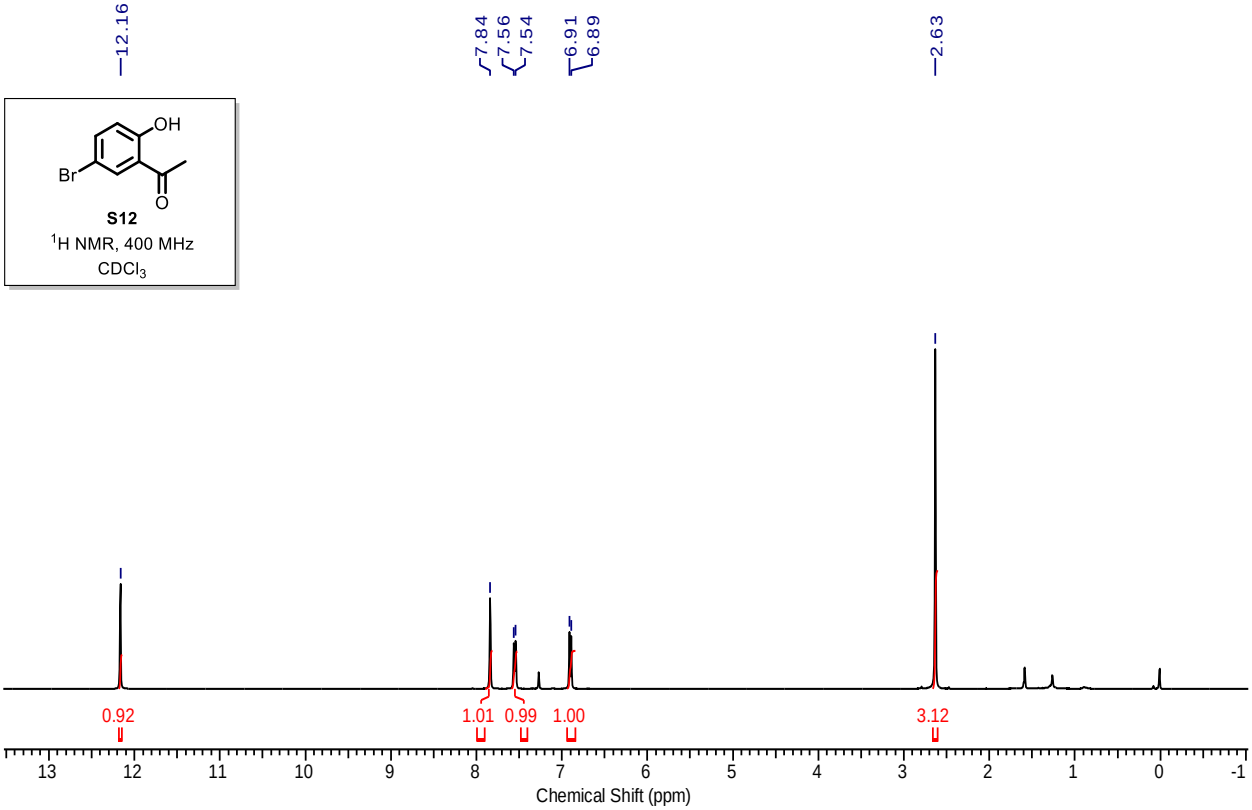


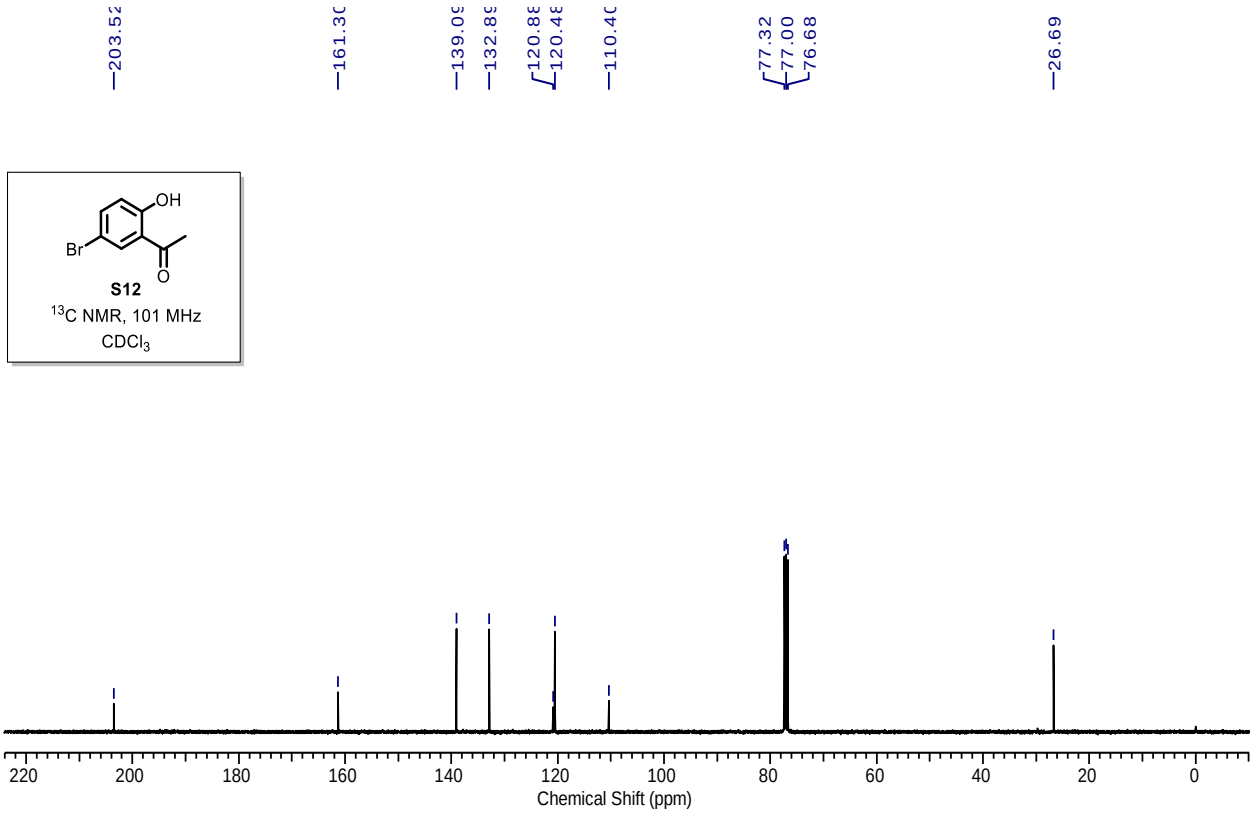
4-Bromophenyl acetate (S11):



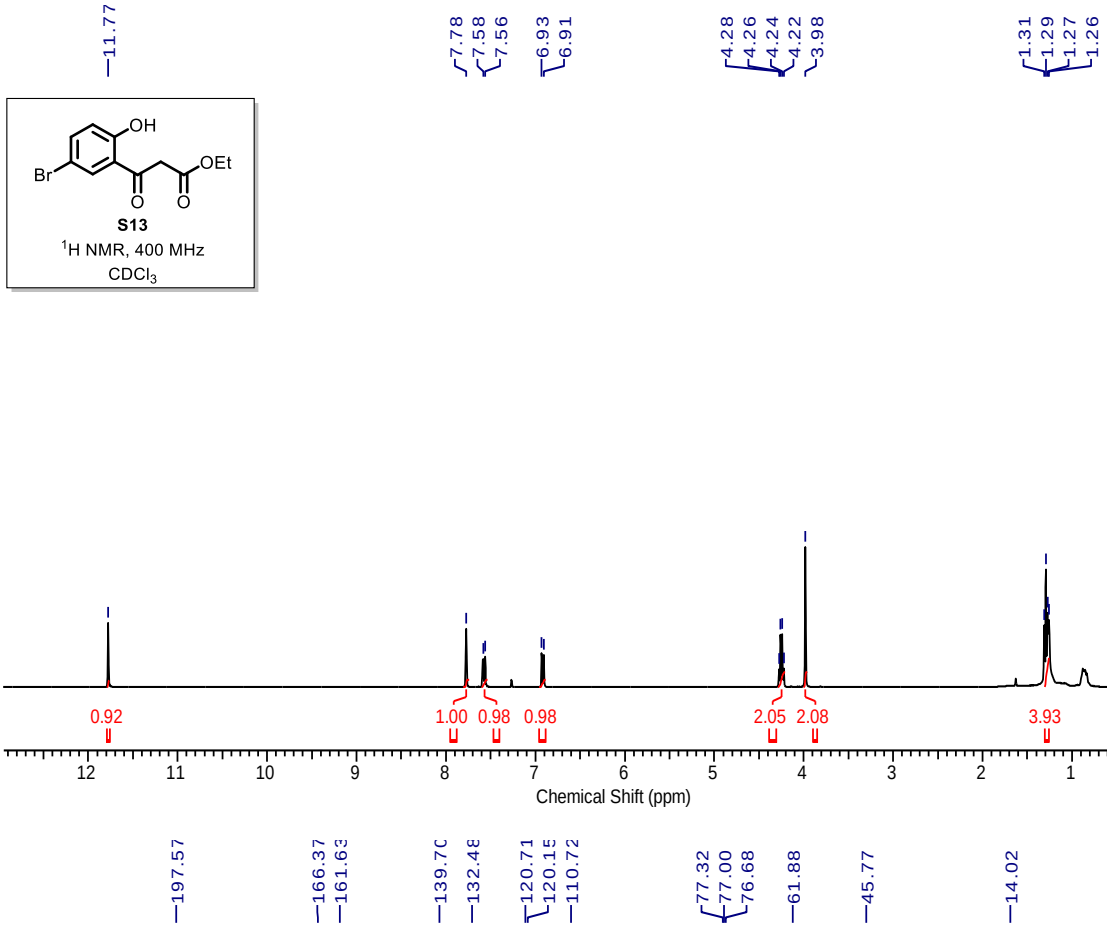


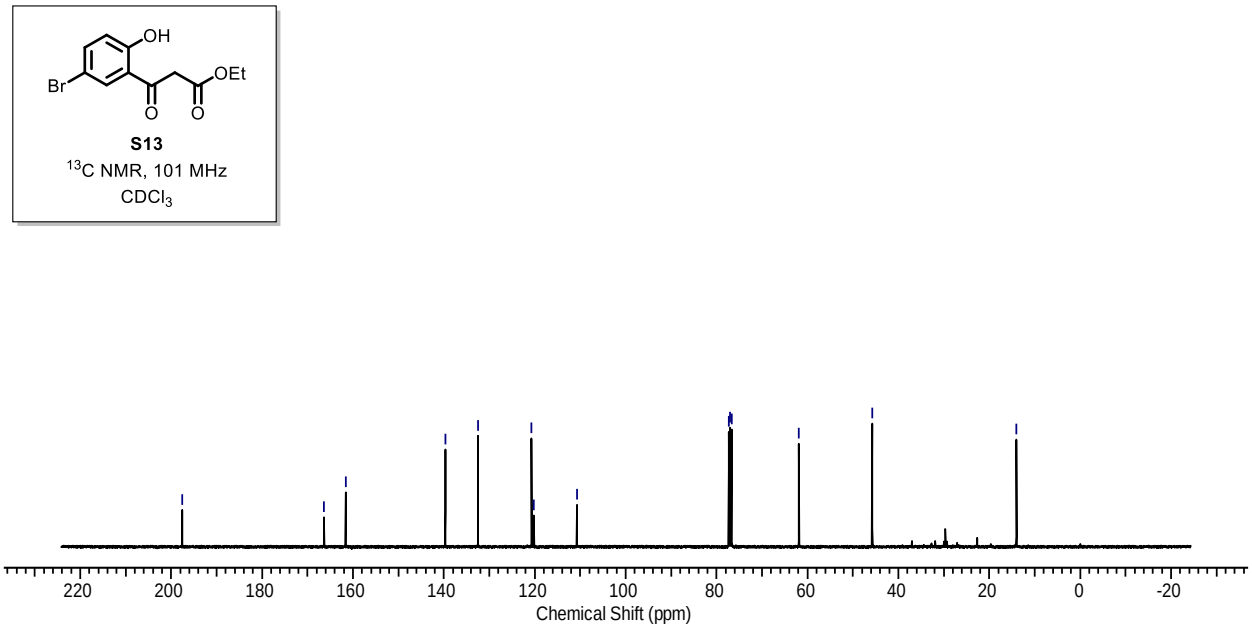
1-(5-Bromo-2-hydroxyphenyl)ethan-1-one (S12):



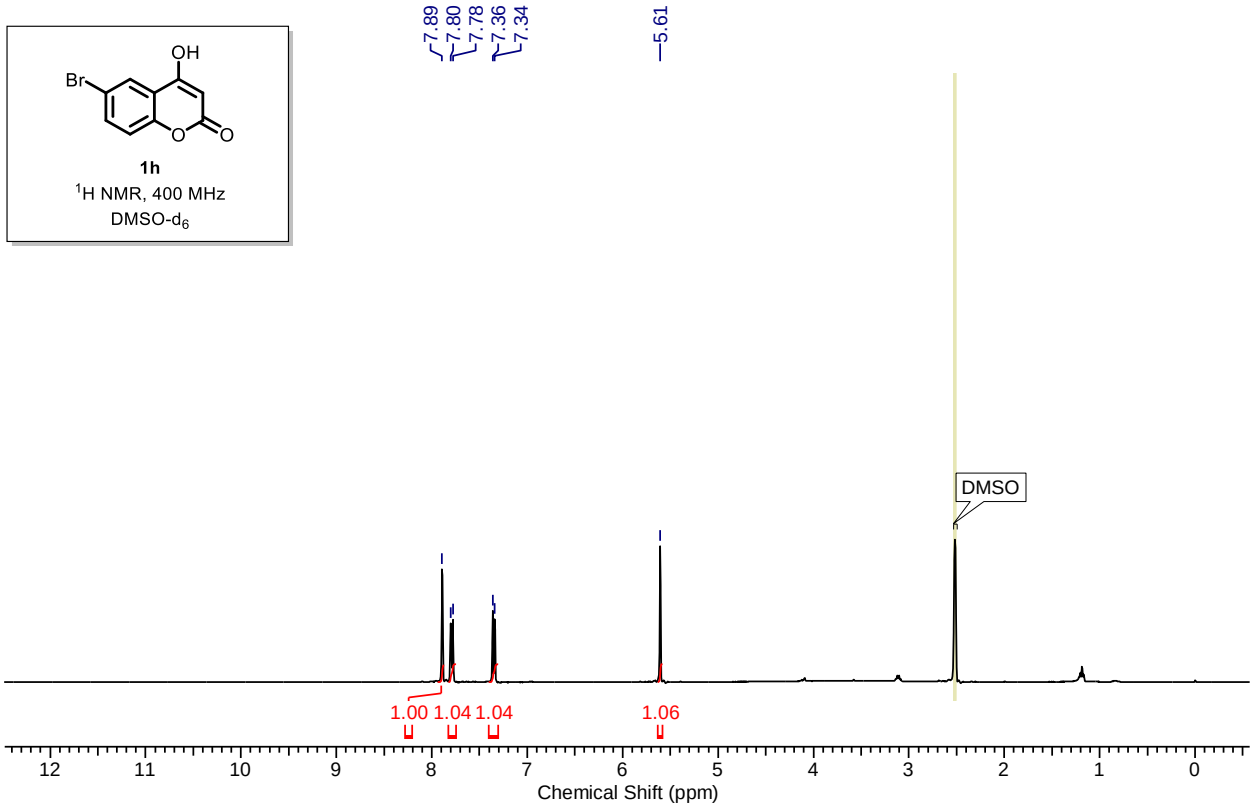


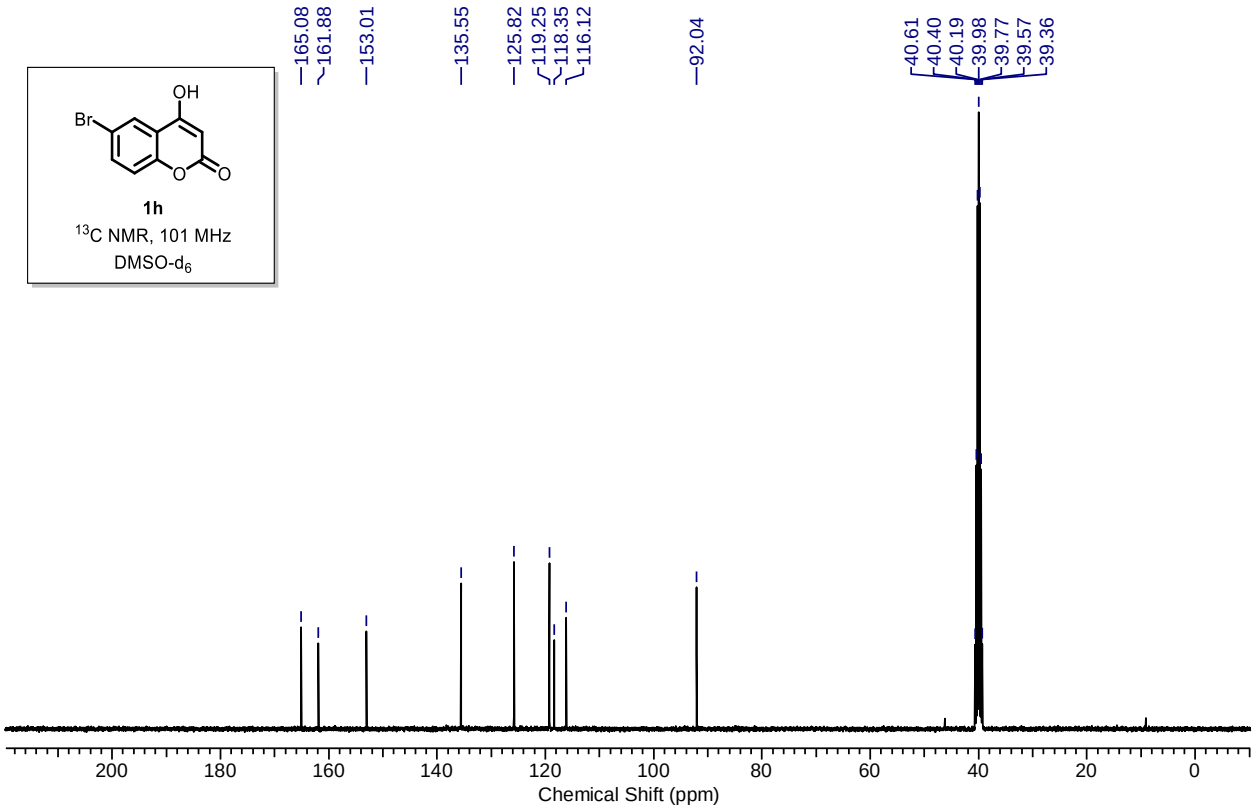
Ethyl 3-(5-bromo-2-hydroxyphenyl)-3-oxopropanoate (S13):



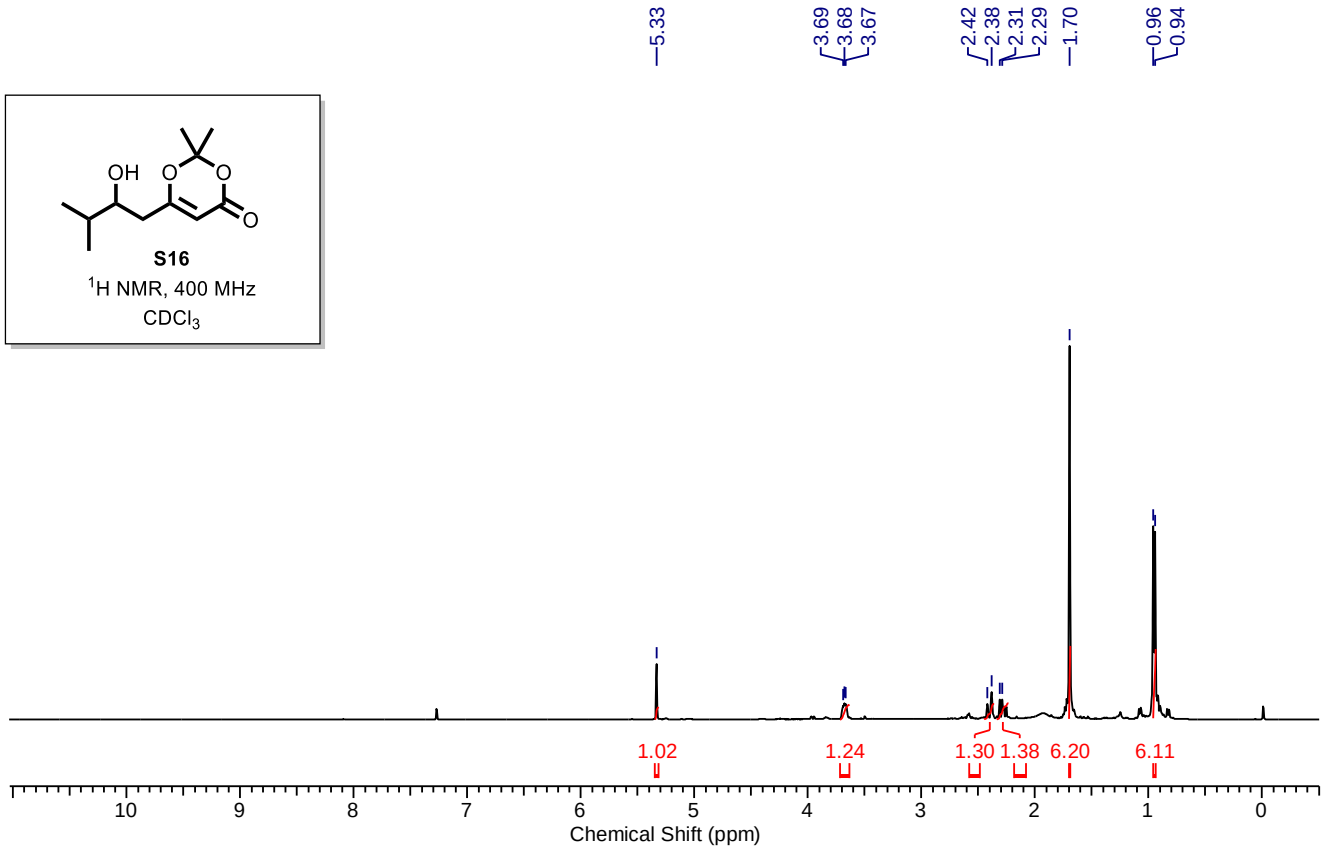


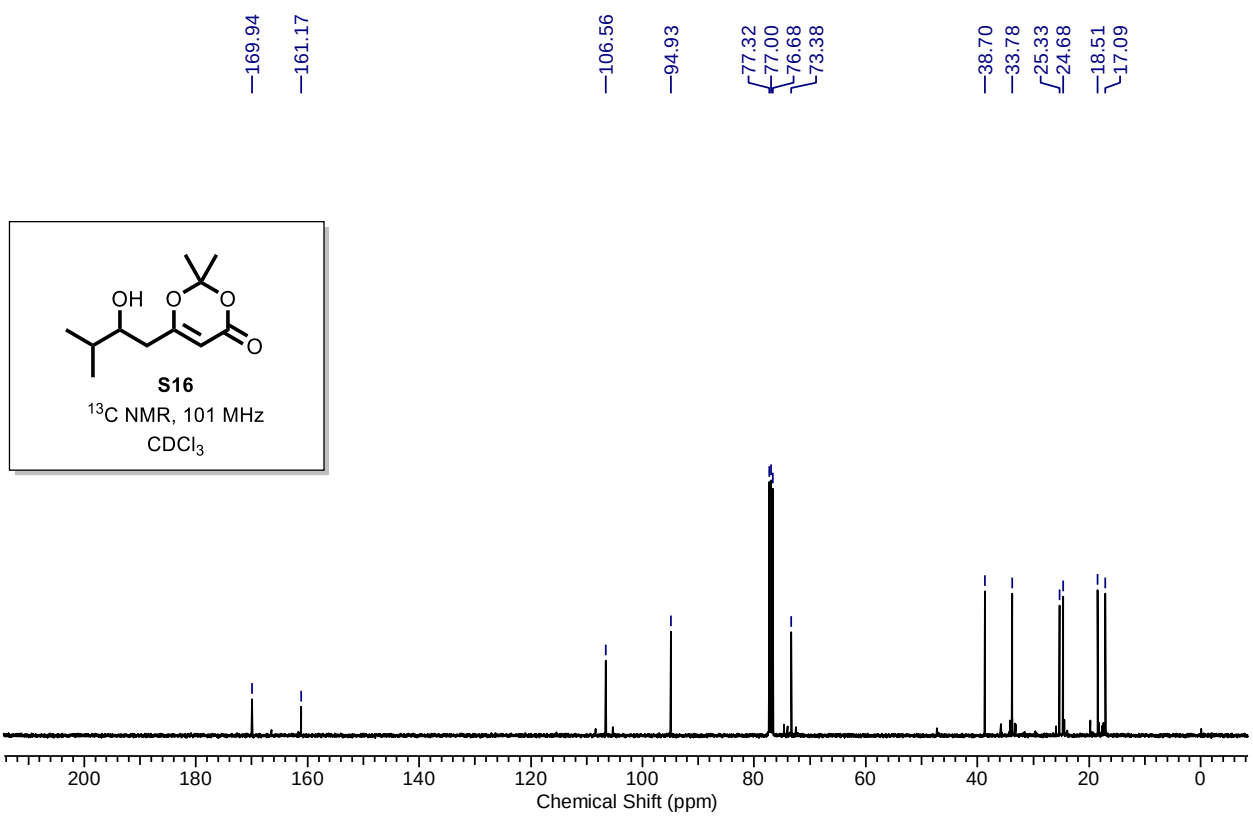
6-Bromo-4-hydroxy-2*H*-chromen-2-one (1h):



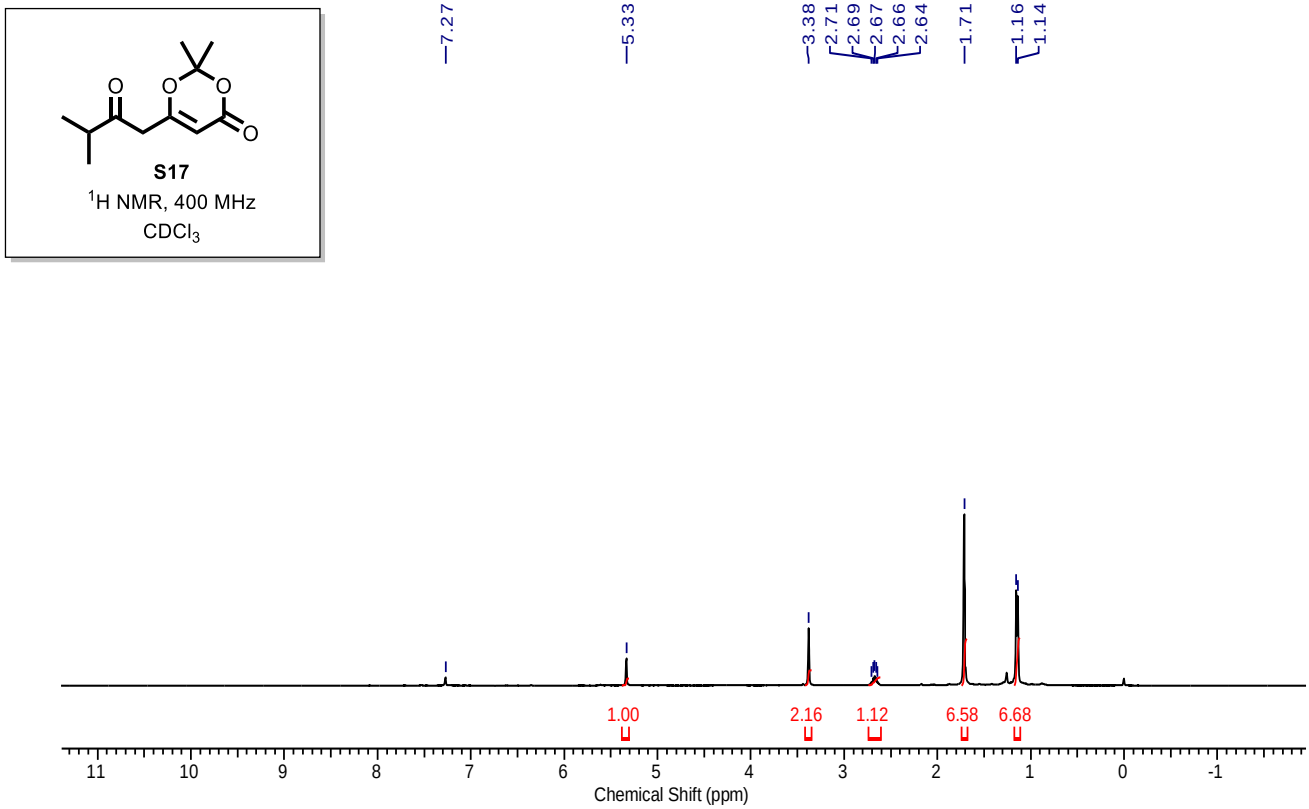


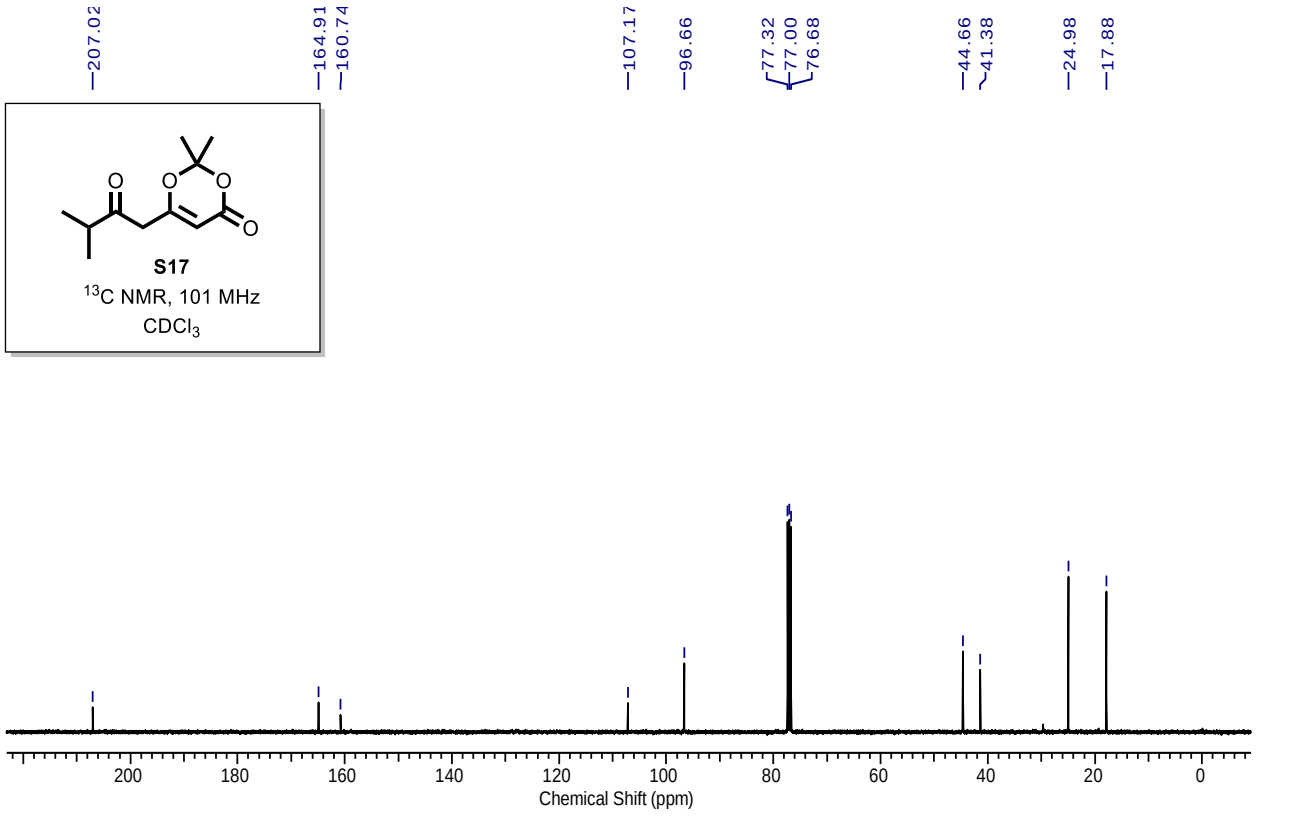
6-(2-Hydroxy-3-methylbutyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S16)



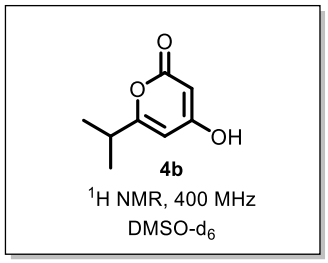


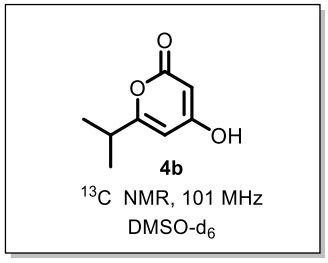
2,2-Dimethyl-6-(3-methyl-2-oxobutyl)-4*H*-1,3-dioxin-4-one (S17):

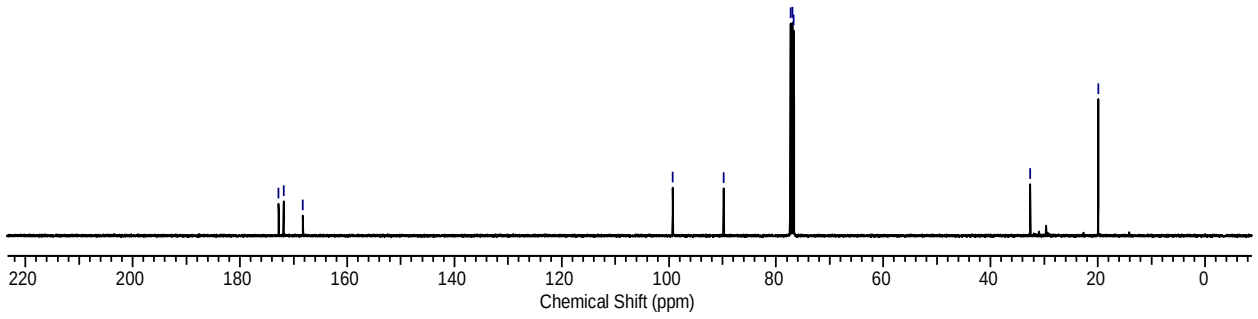




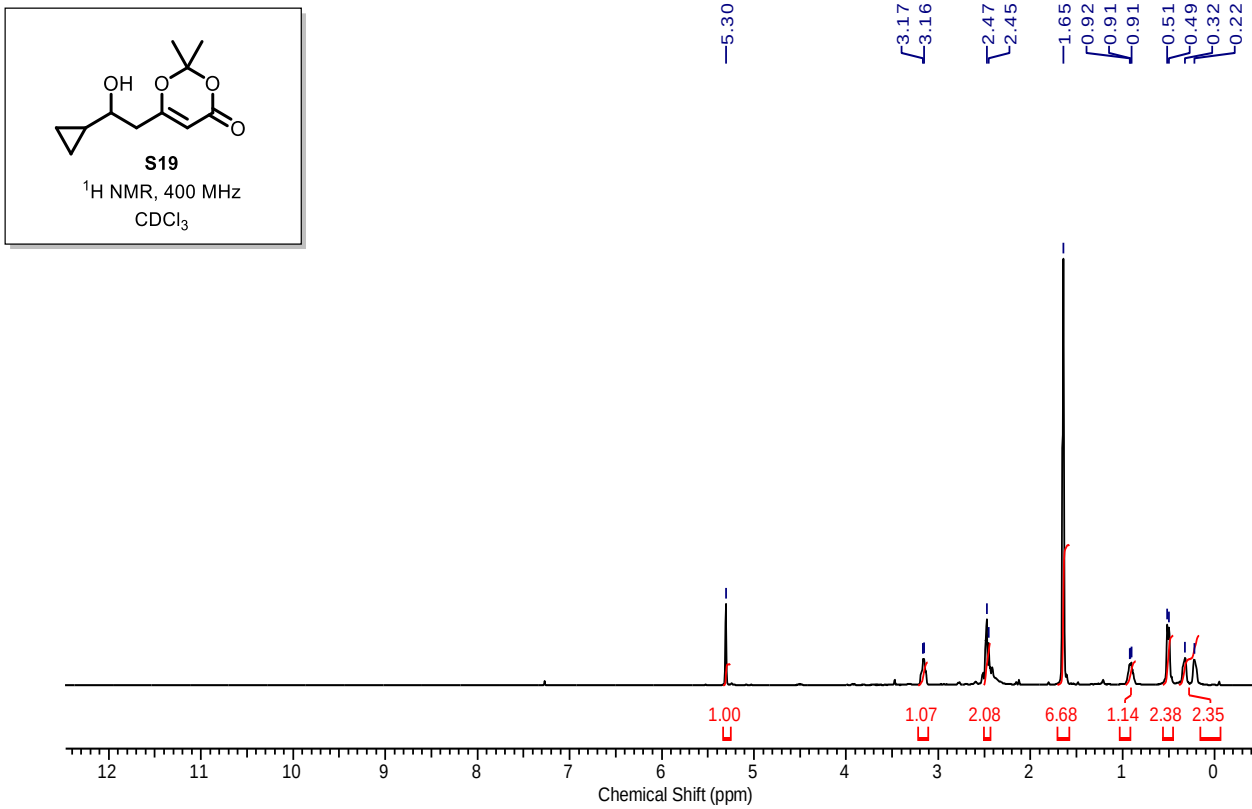
4-Hydroxy-6-isopropyl-2*H*-pyran-2-one (4b):

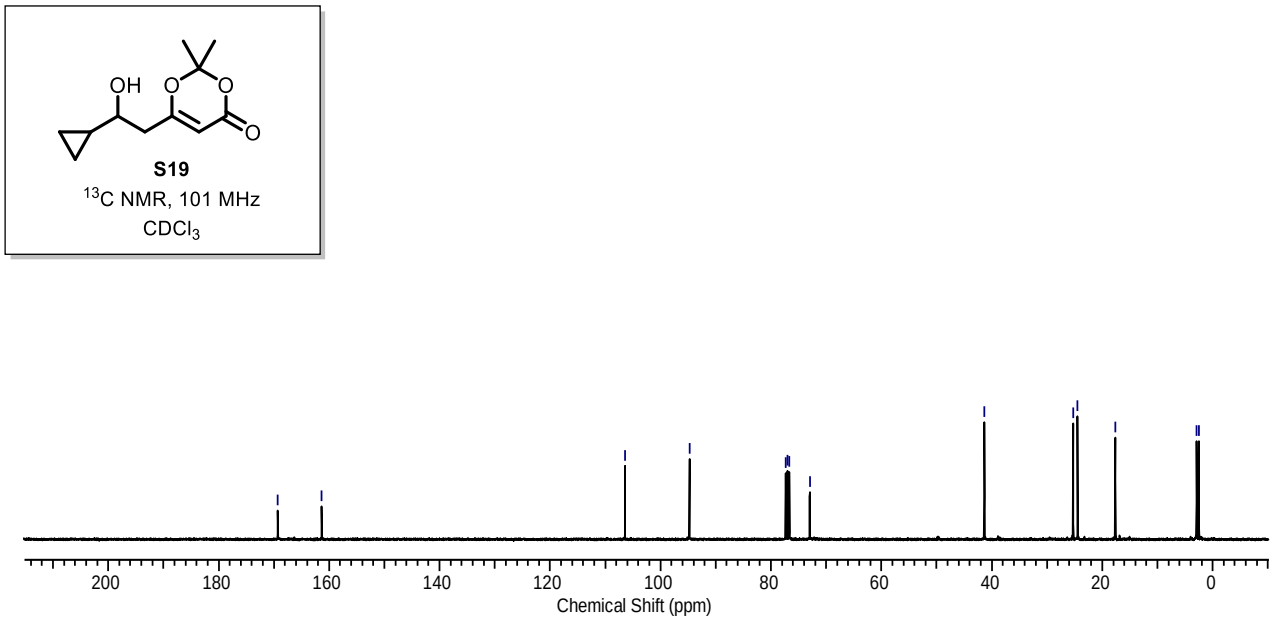




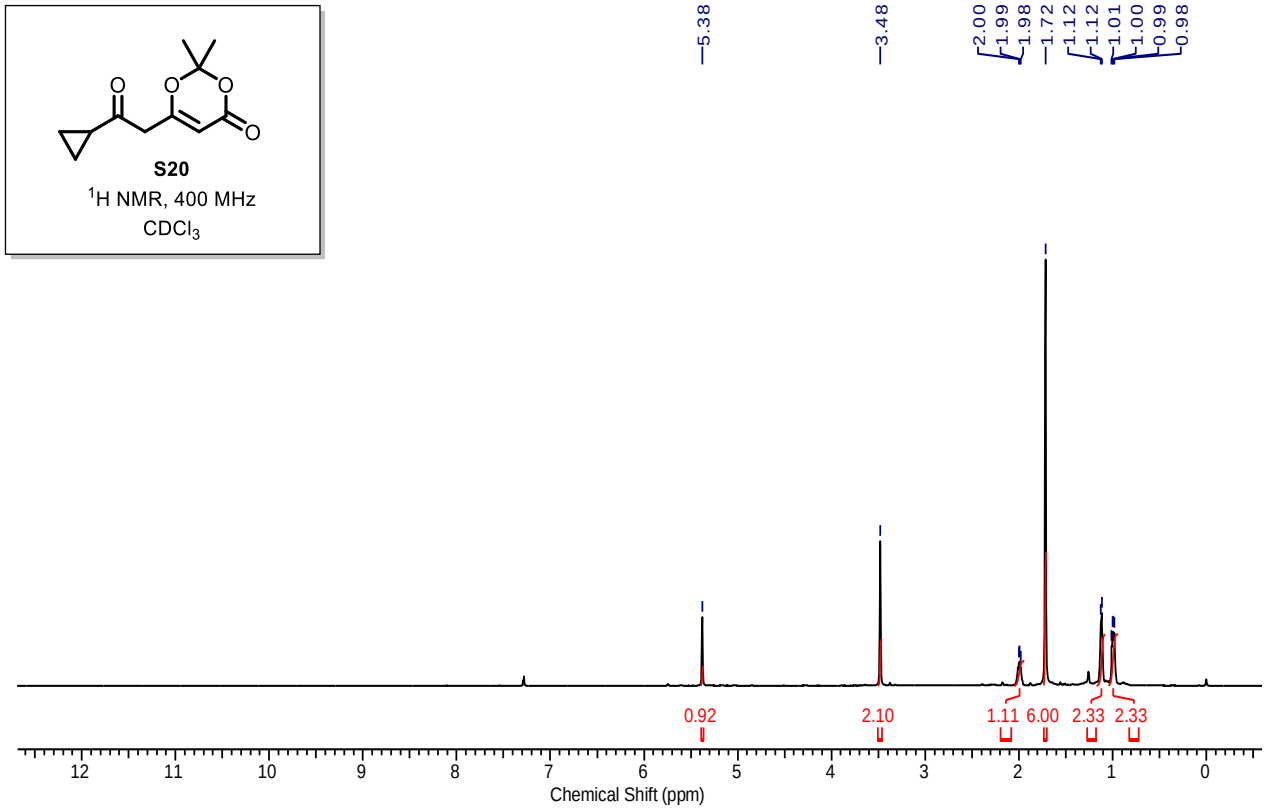


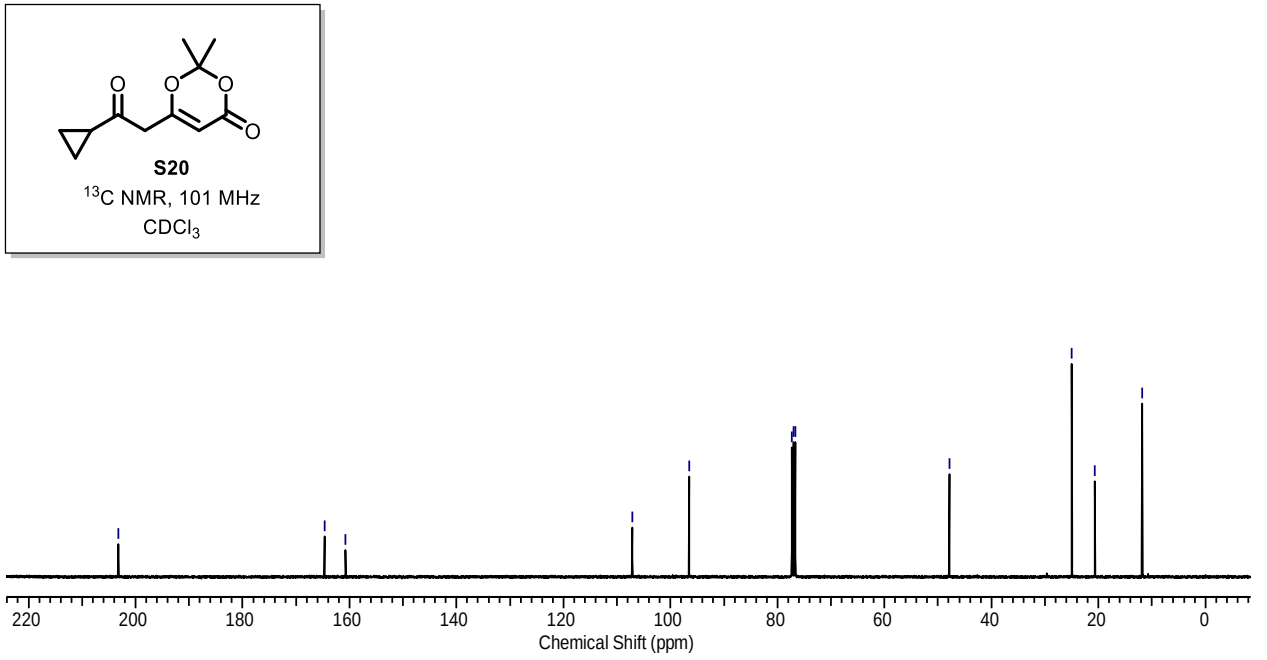
6-(2-Cyclopropyl-2-hydroxyethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S19):



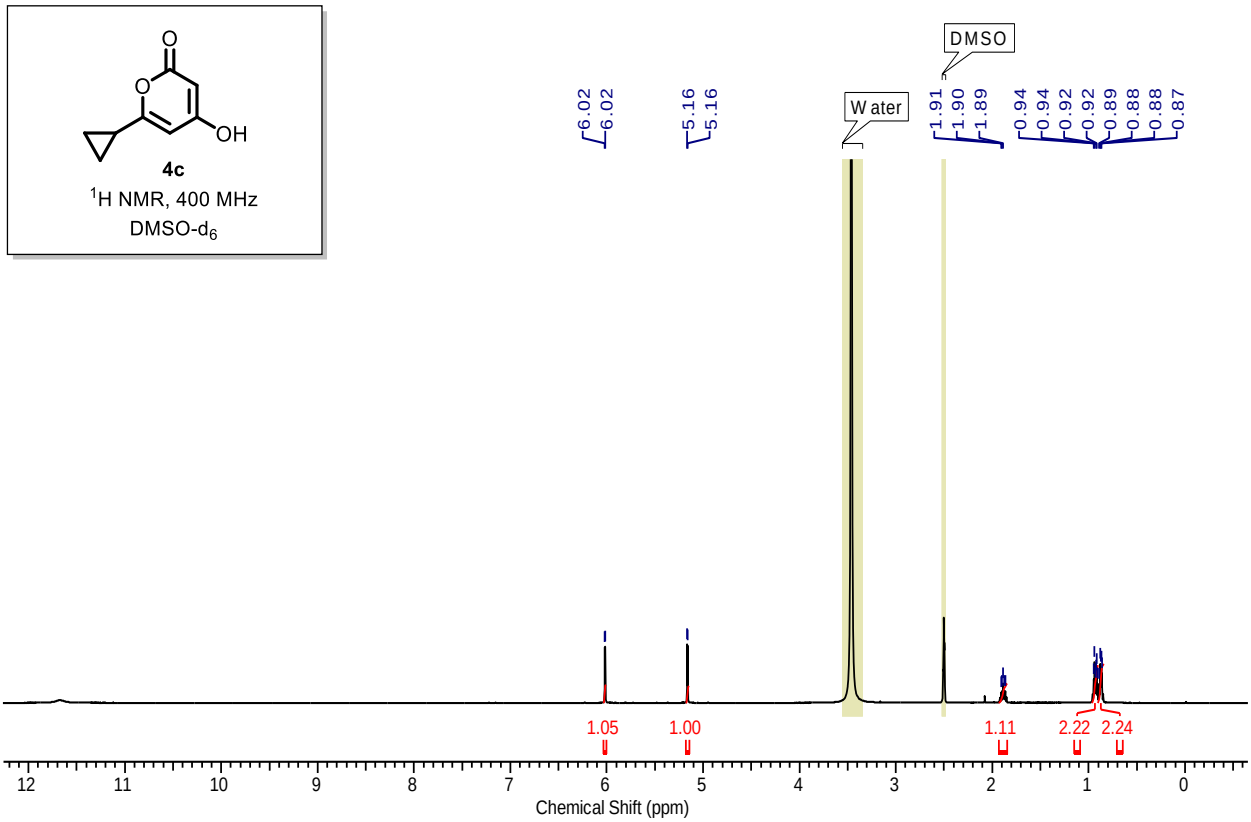


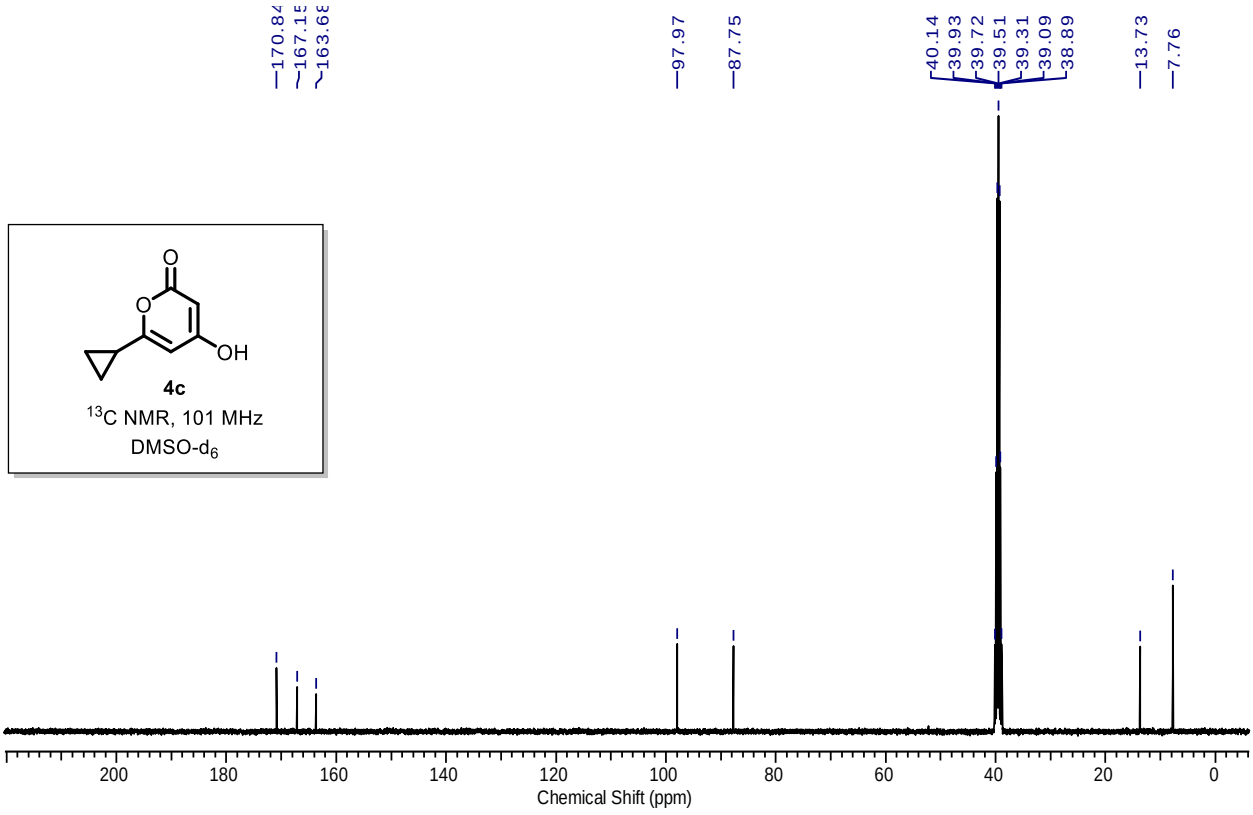
6-(2-Cyclopropyl-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S20):



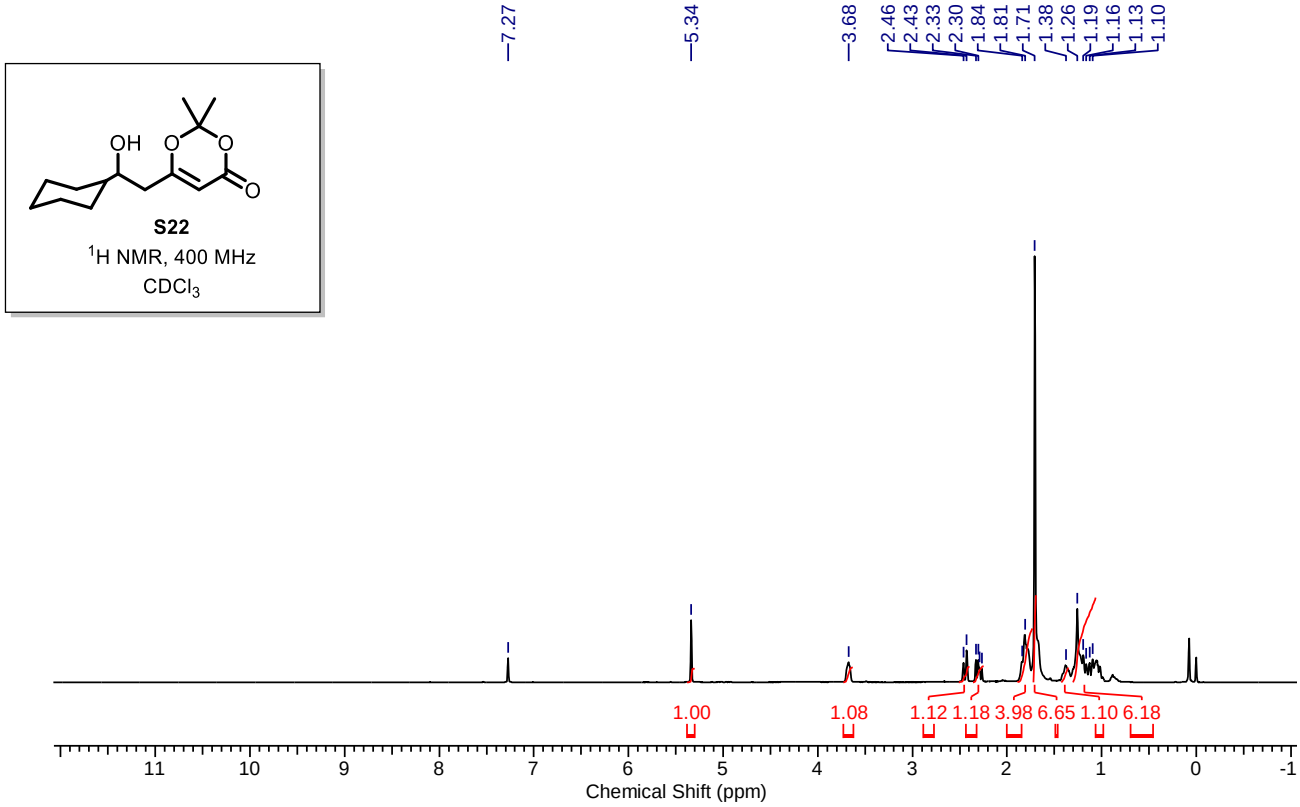


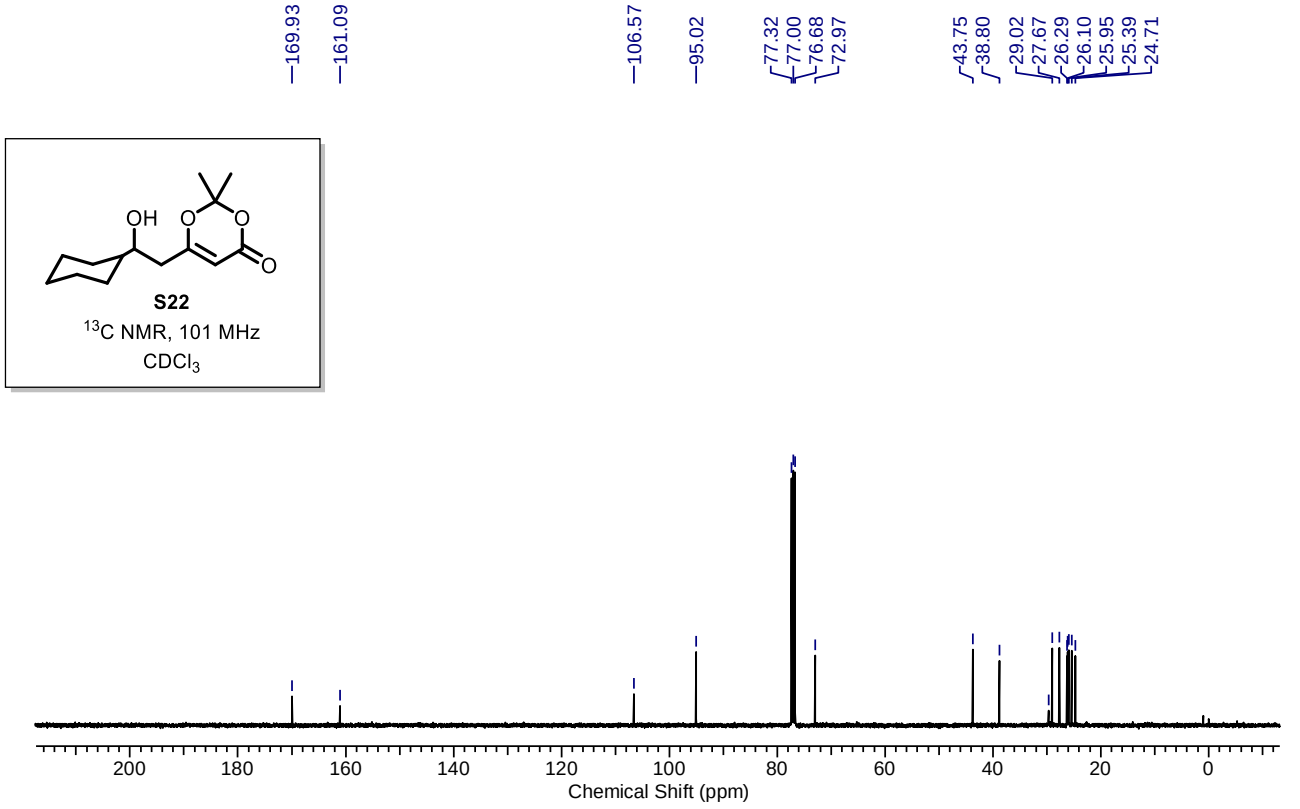
6-Cyclopropyl-4-hydroxy-2*H*-pyran-2-one (4c):



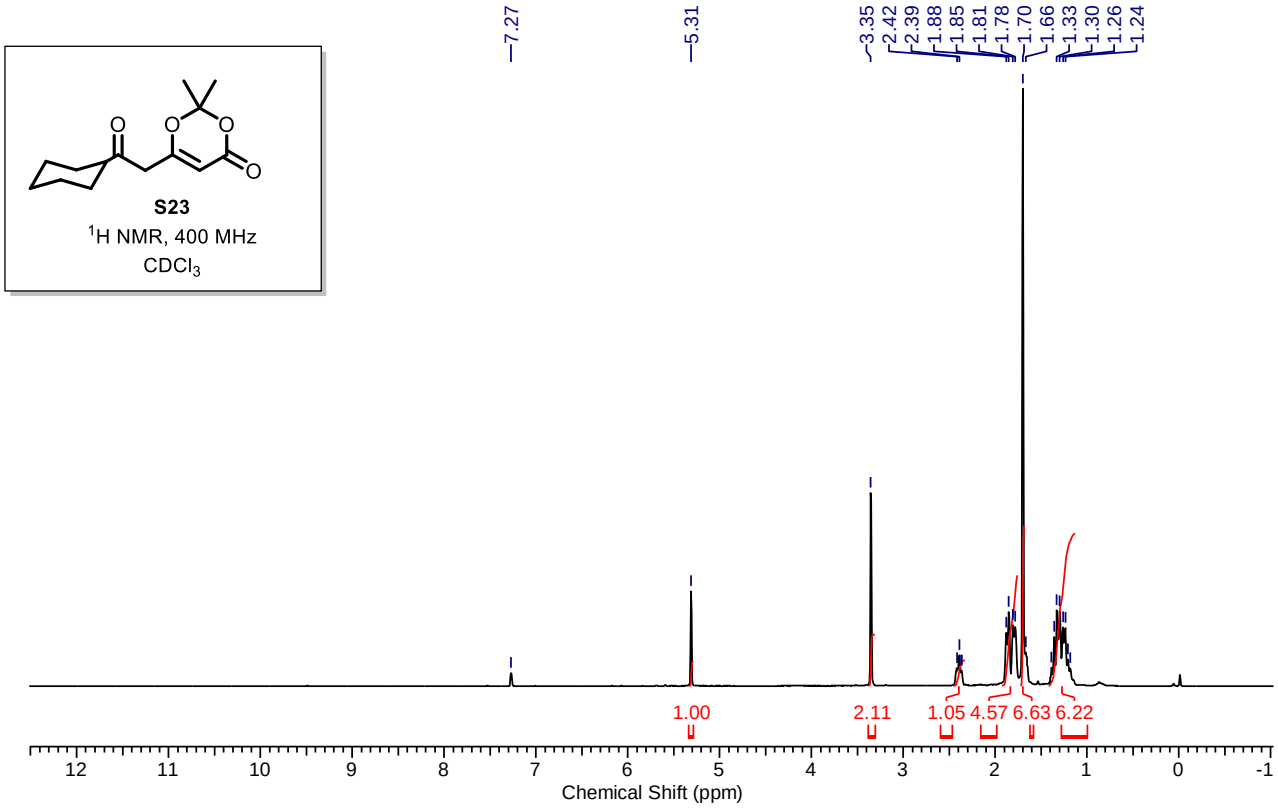


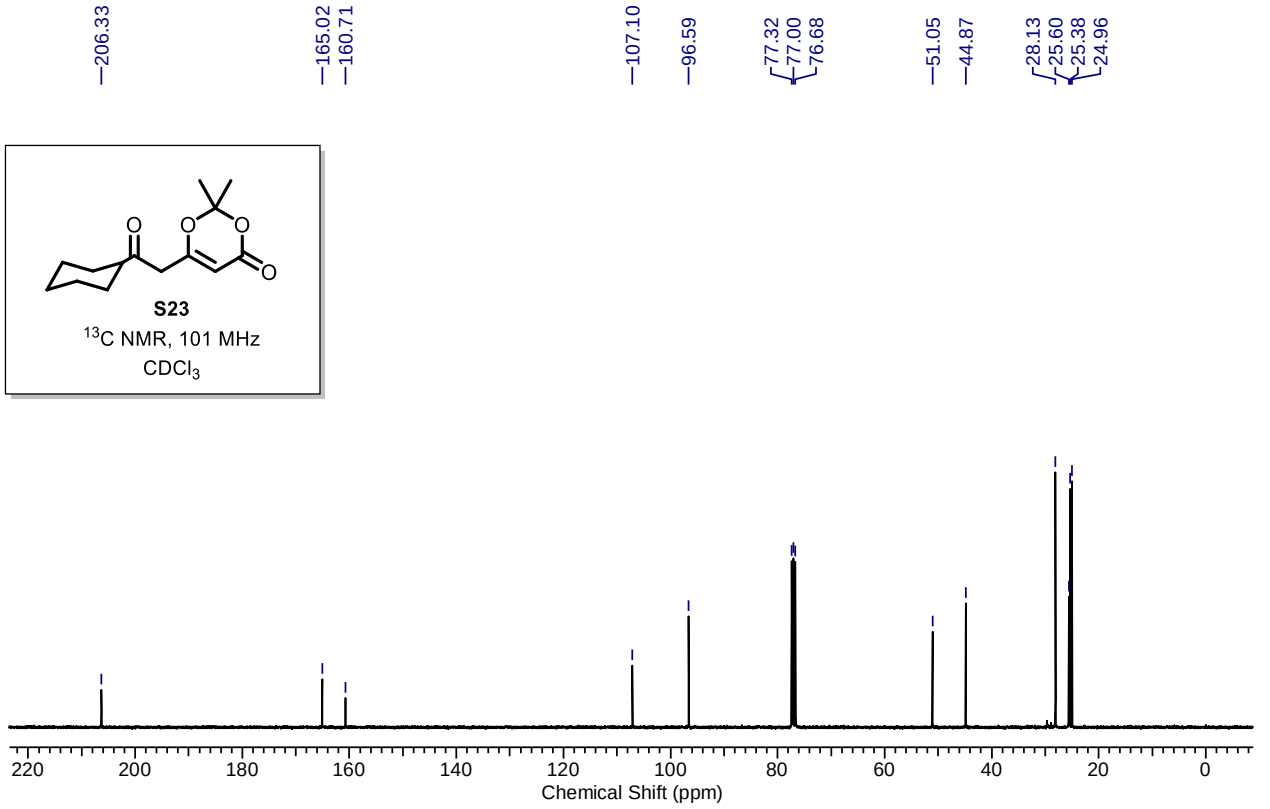
6-(2-Cyclohexyl-2-hydroxyethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S22):



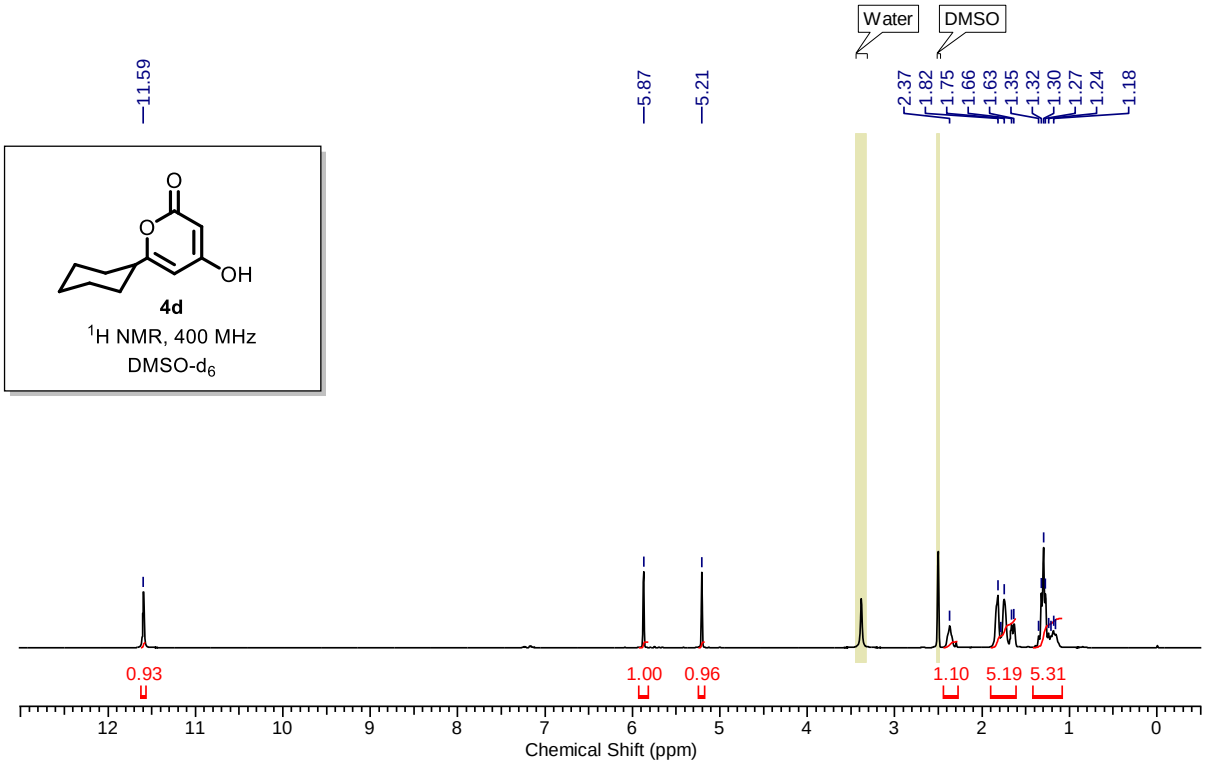


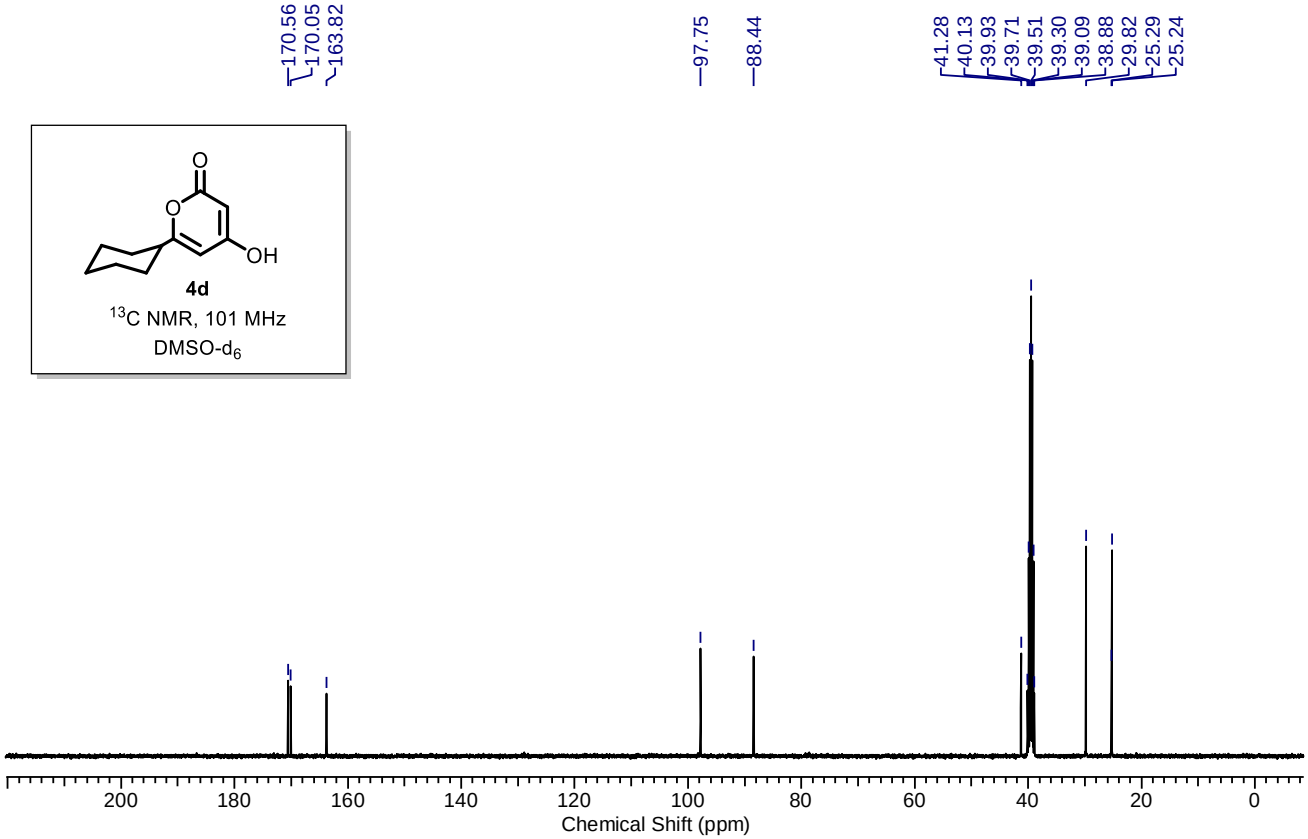
6-(2-Cyclohexyl-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S23):



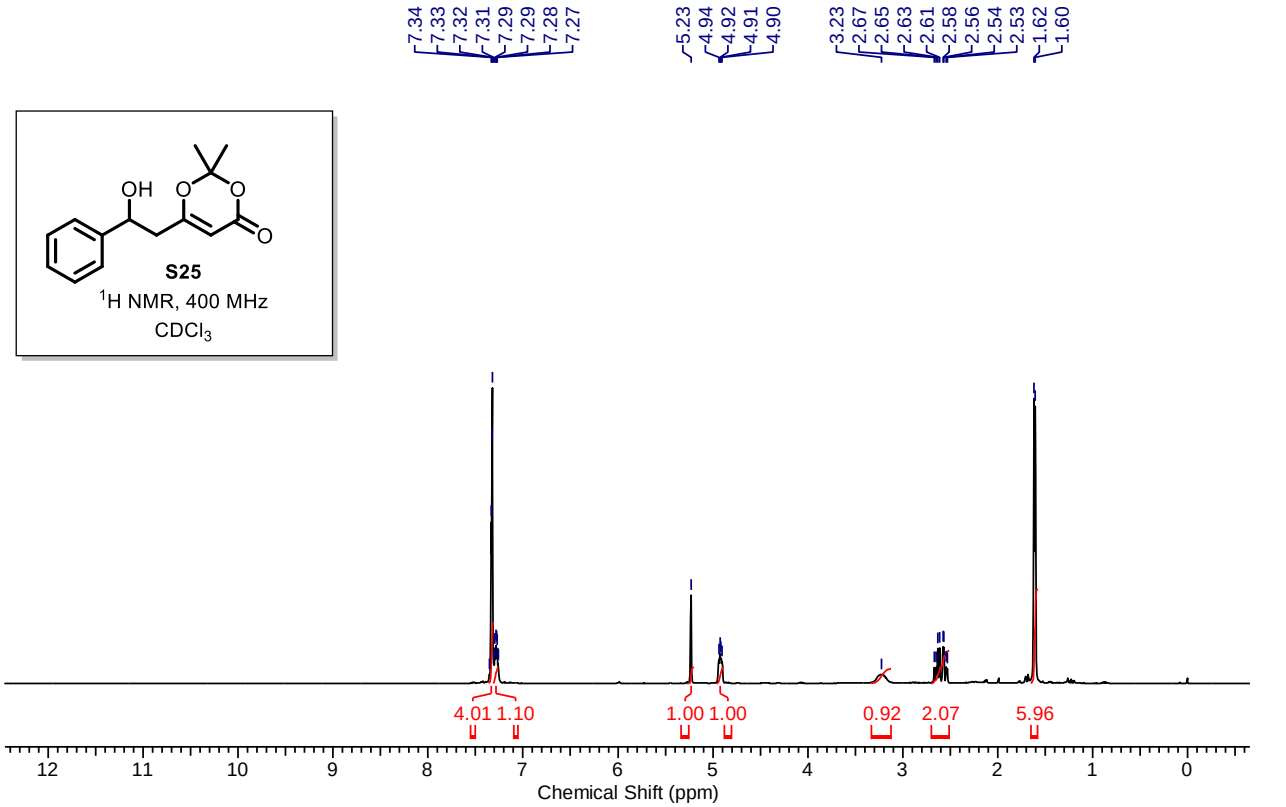


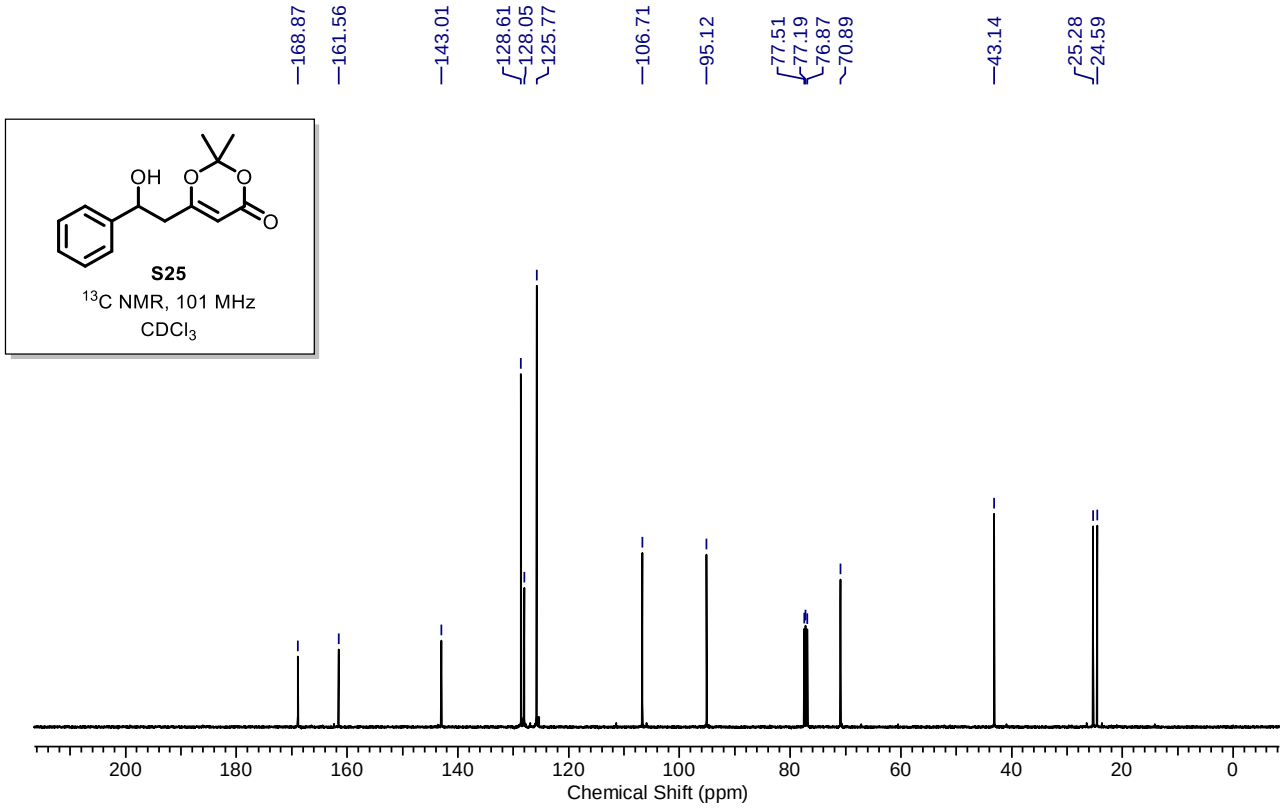
6-Cyclohexyl-4-hydroxy-2*H*-pyran-2-one (4d):



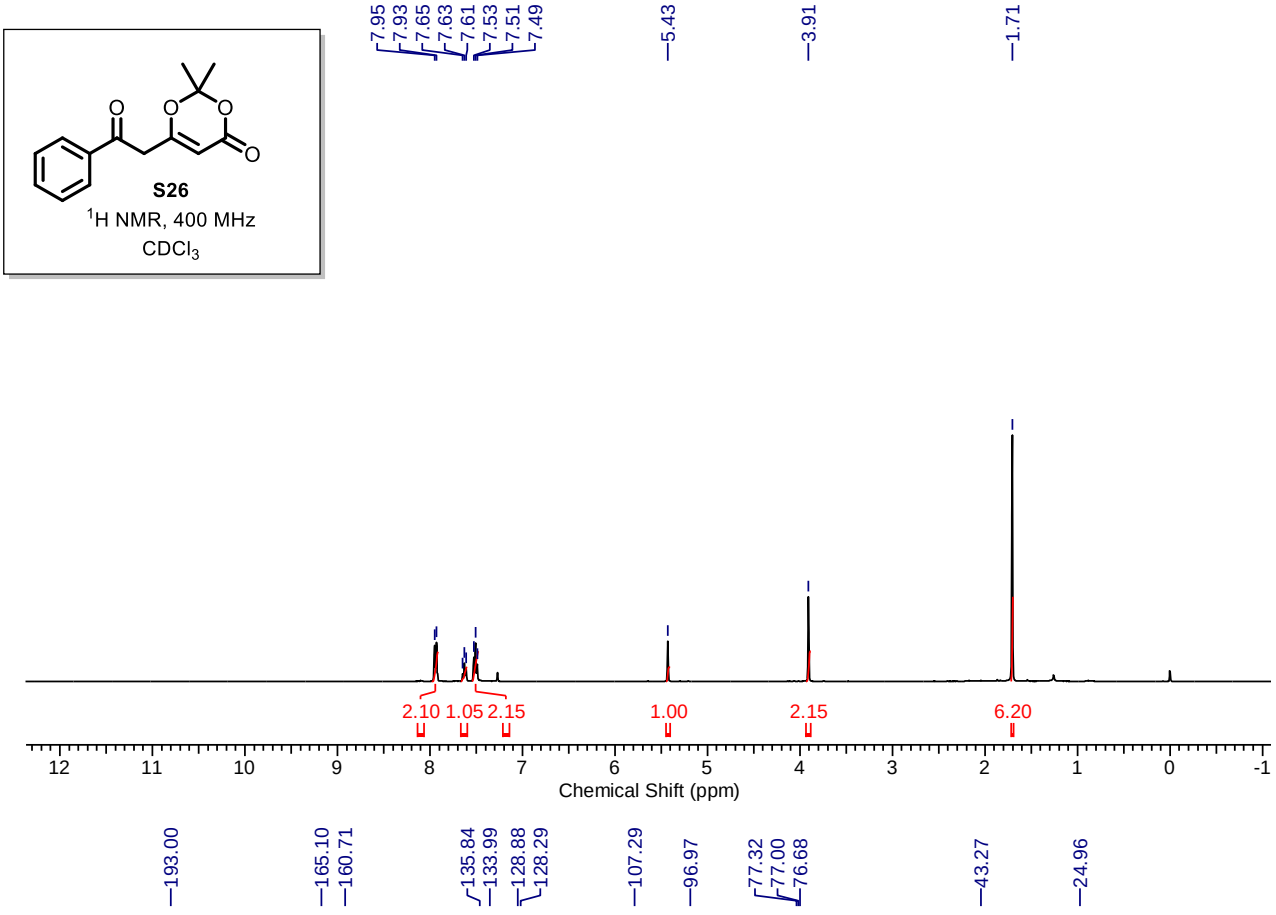


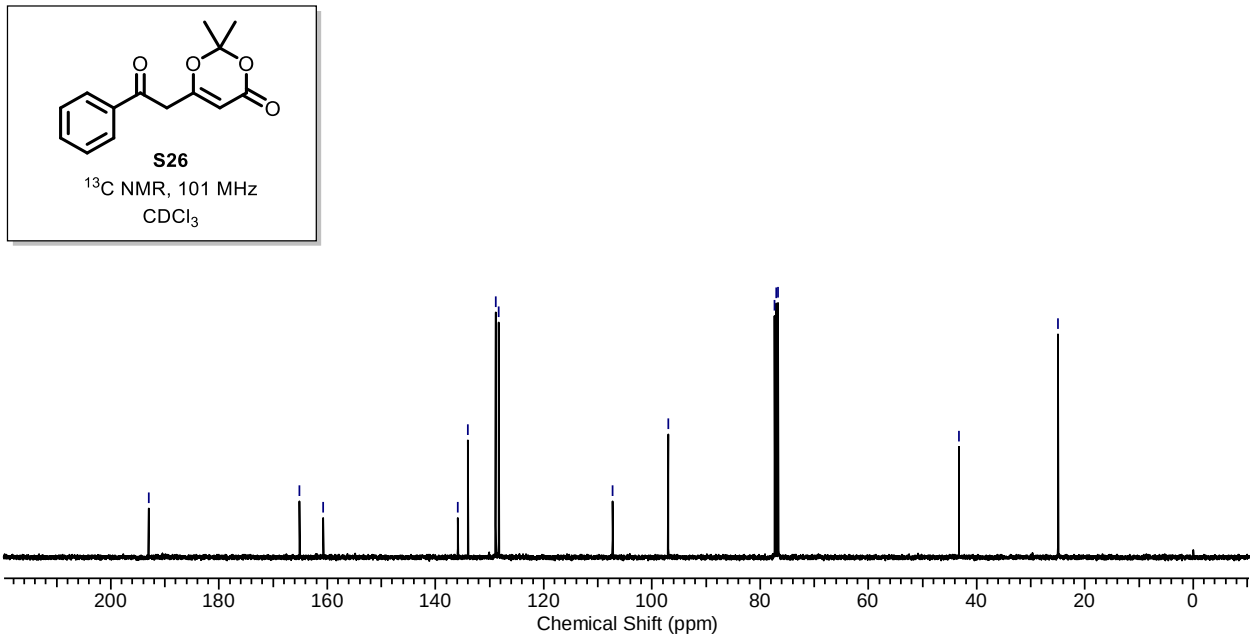
6-(2-Hydroxy-2-phenylethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S25):



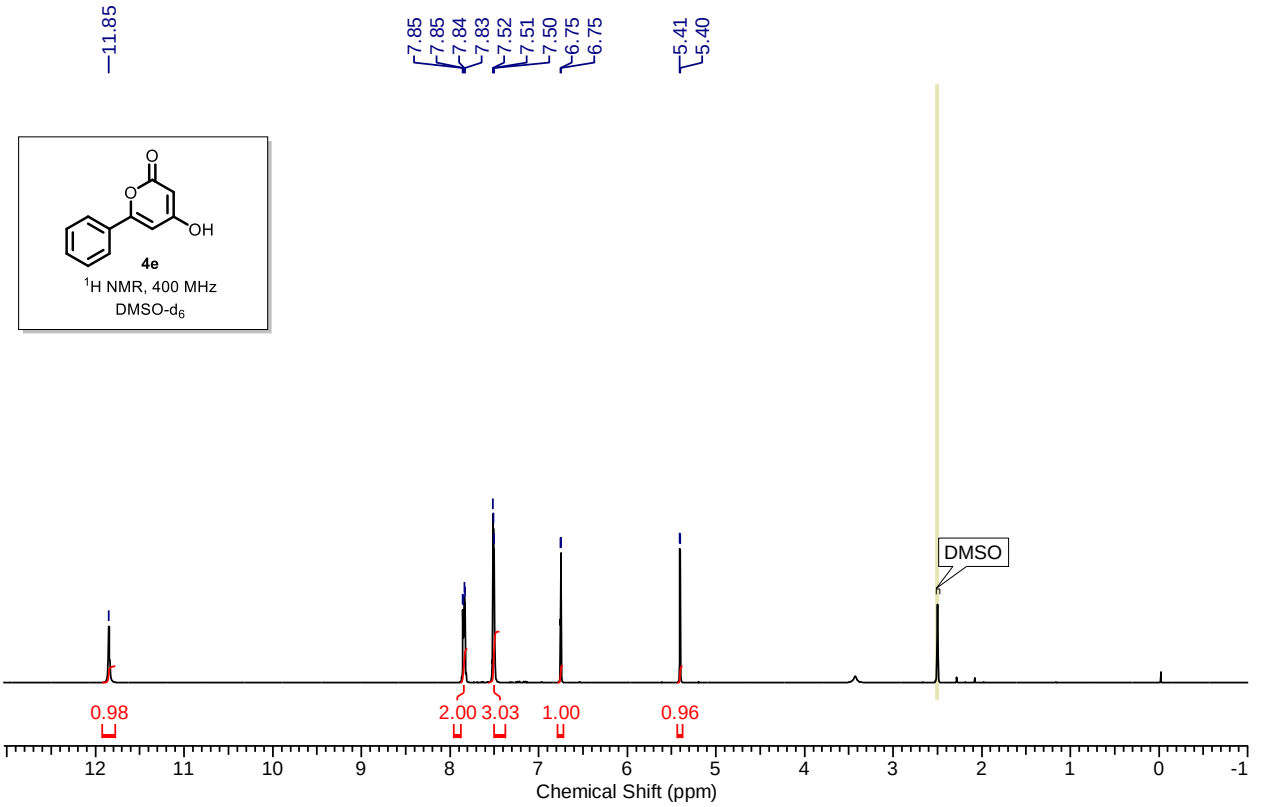


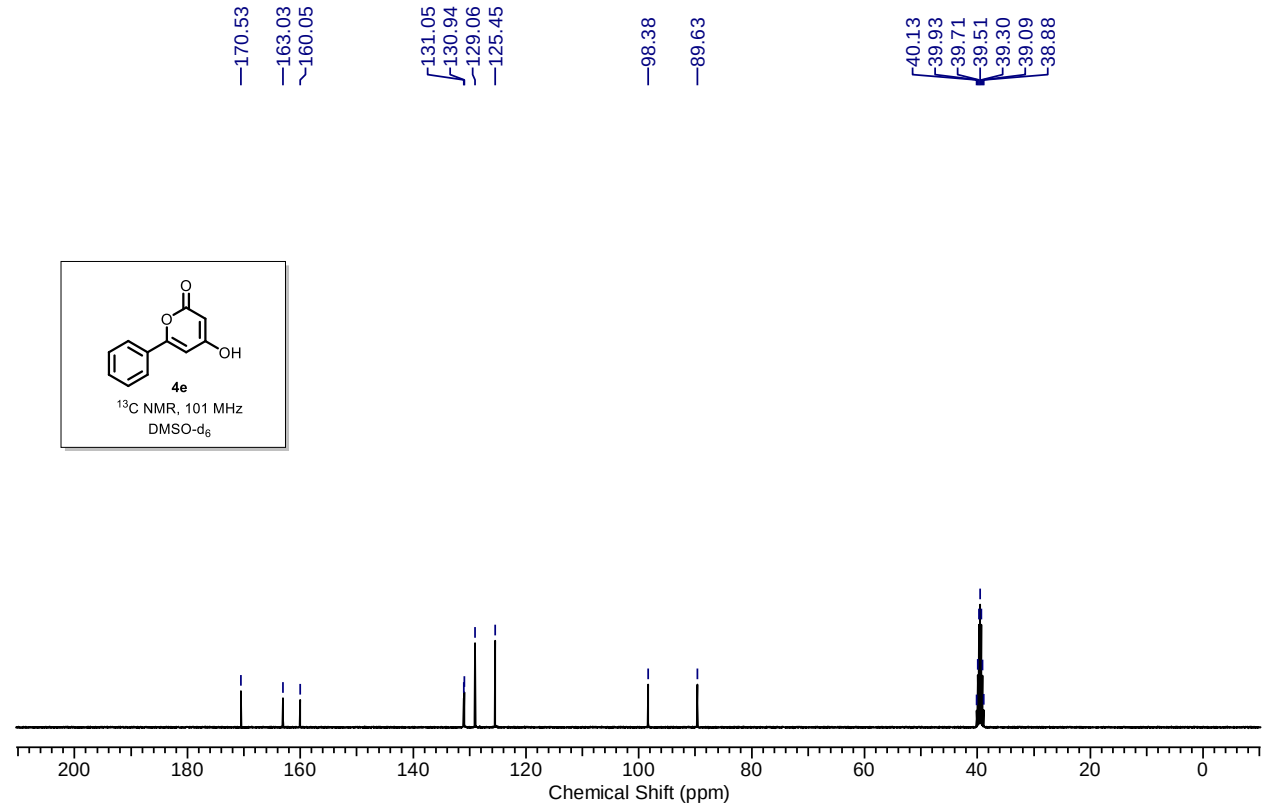
2,2-Dimethyl-6-(2-oxo-2-phenylethyl)-4*H*-1,3-dioxin-4-one (S26):



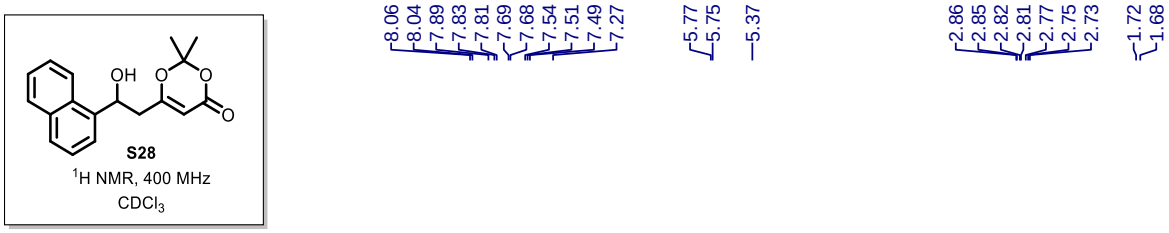


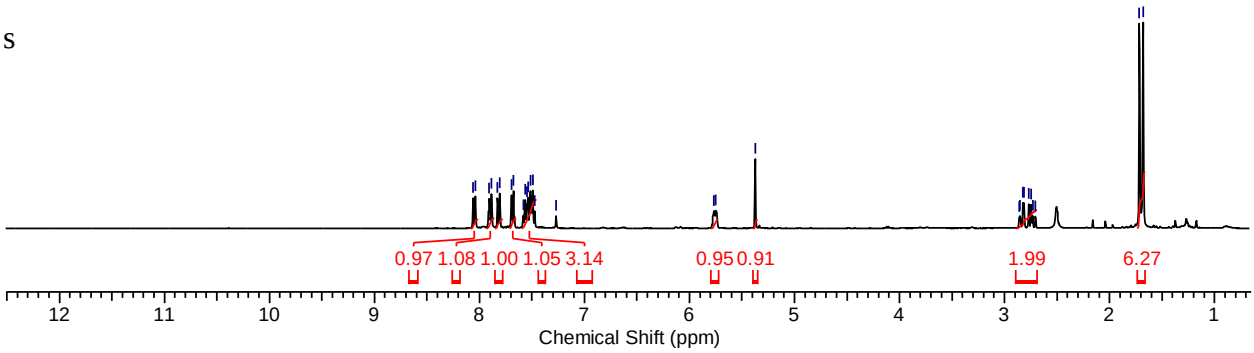
4-Hydroxy-6-phenyl-2*H*-pyran-2-one (4e):

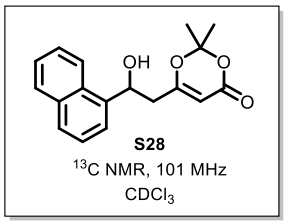


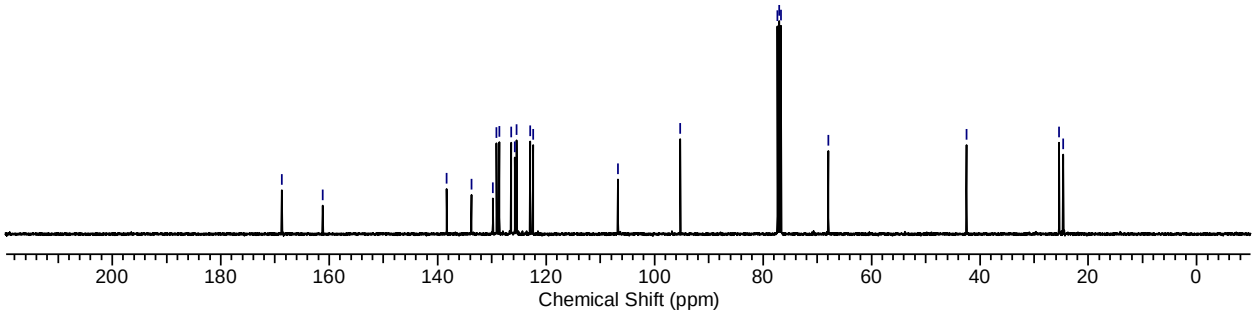


6-(2-Hydroxy-2-(naphthalen-1-yl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S28)

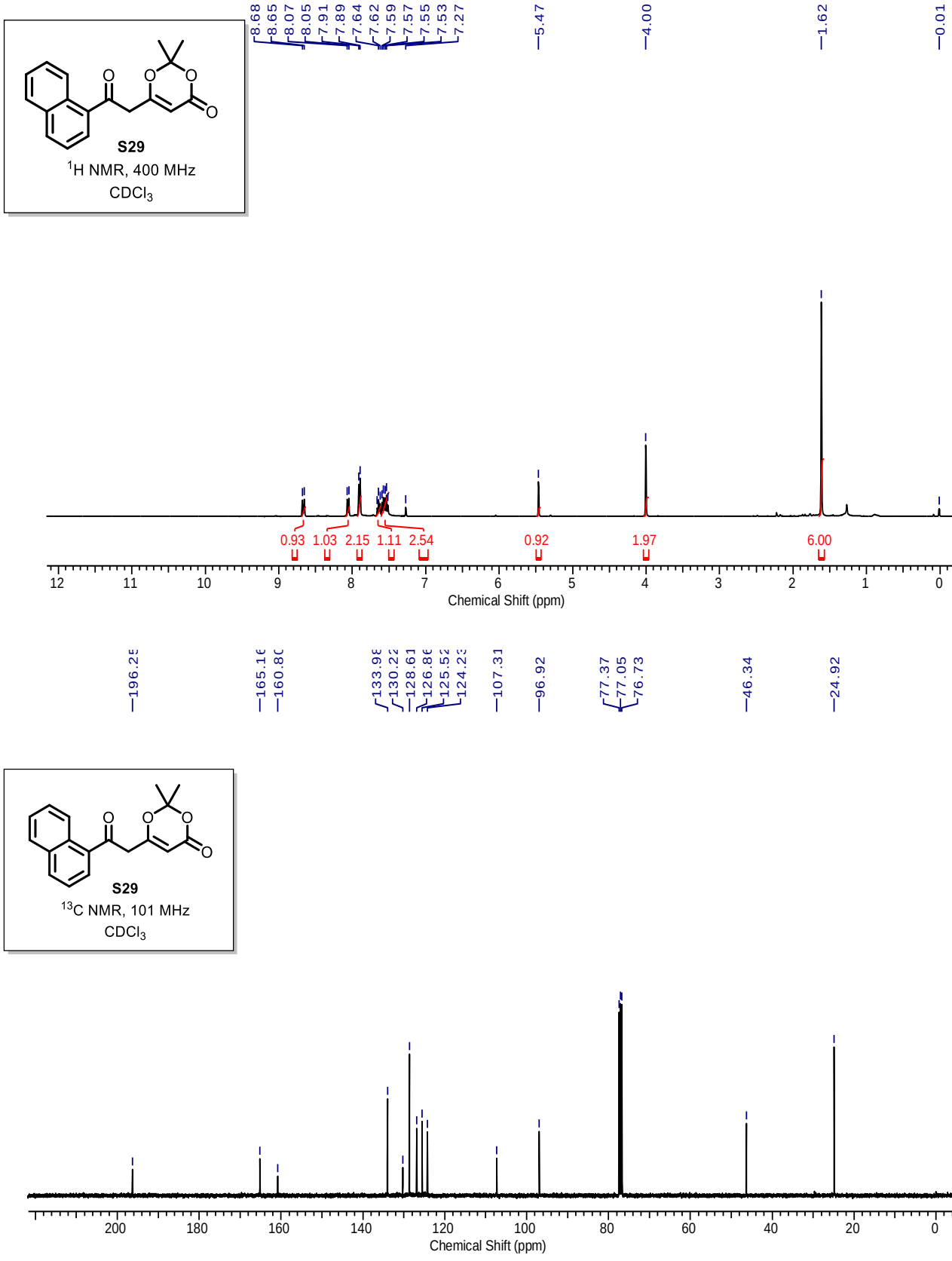




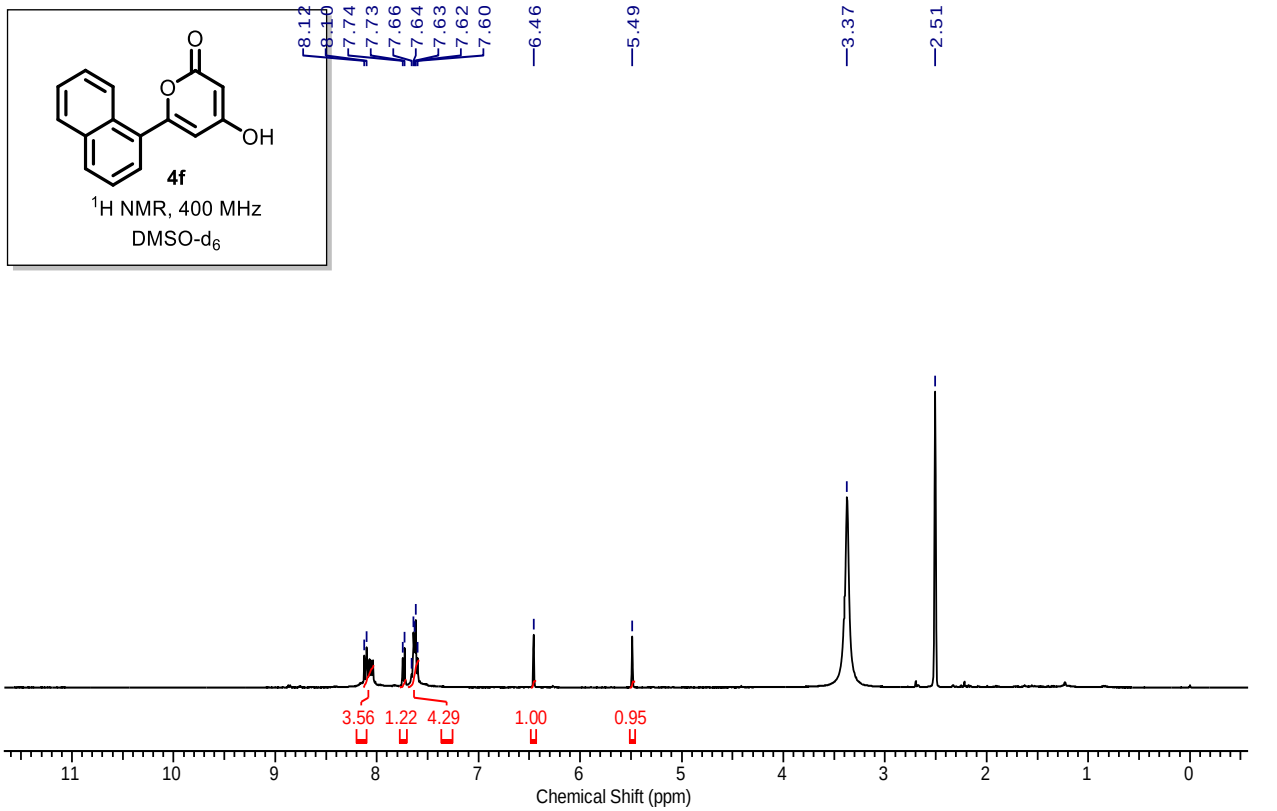


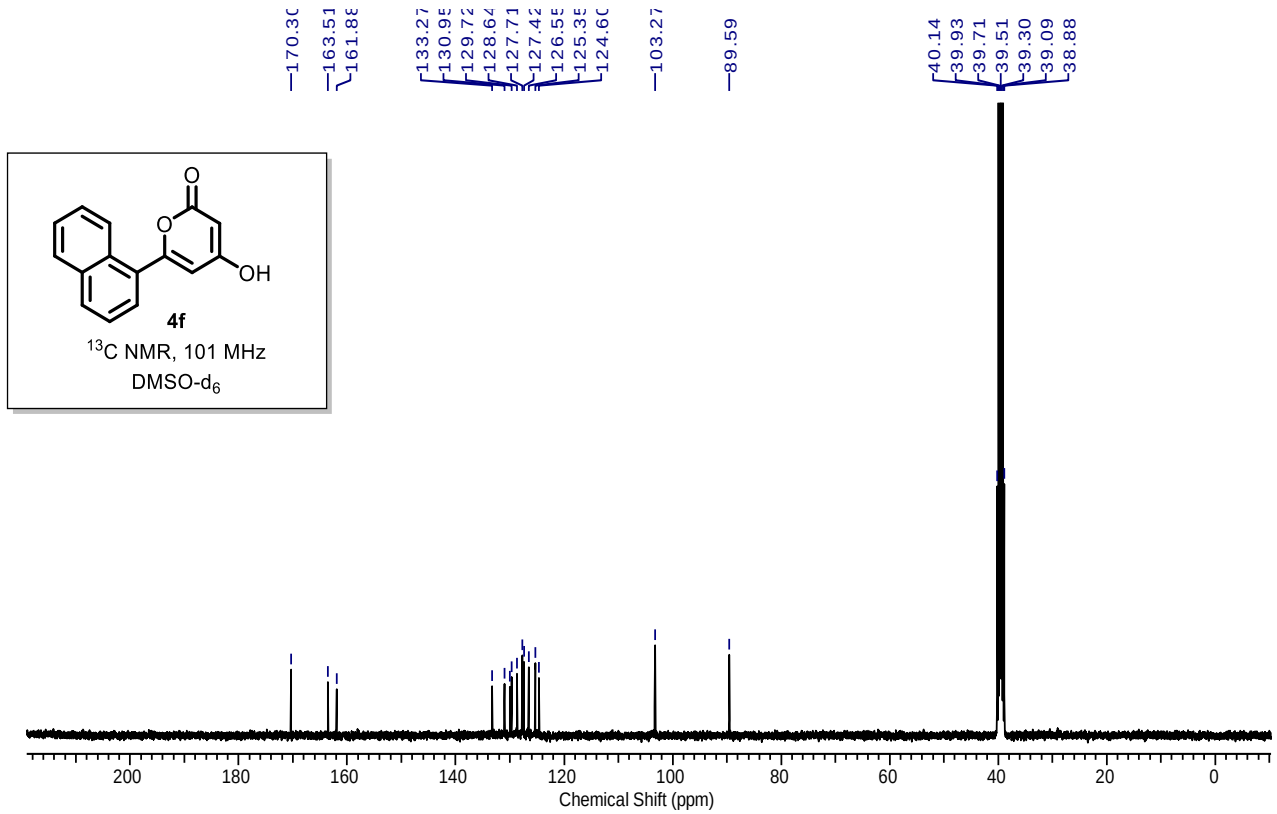


2,2-Dimethyl-6-(2-(naphthalen-1-yl)-2-oxoethyl)-4*H*-1,3-dioxin-4-one (S29):

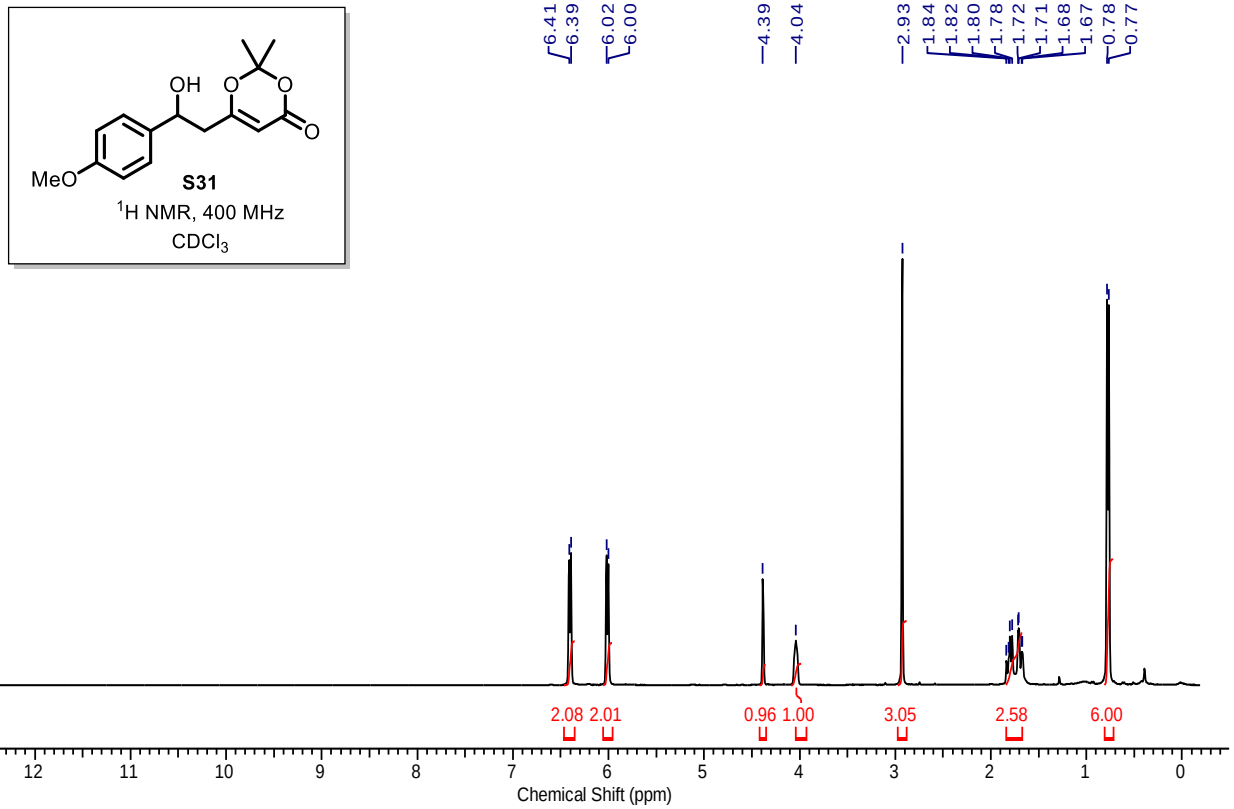


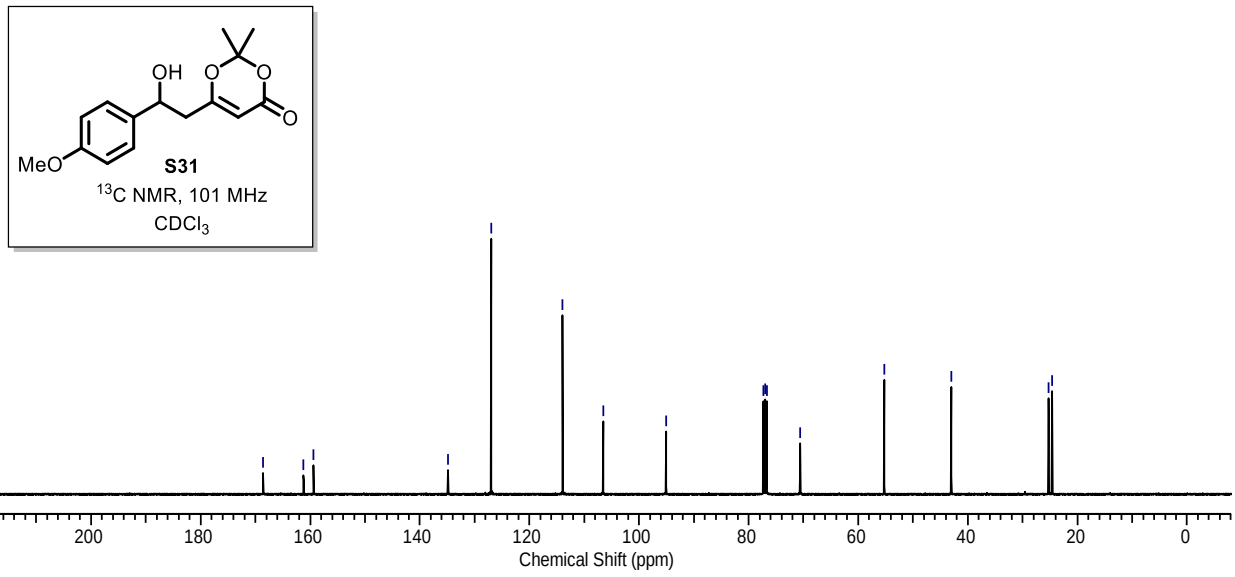
4-Hydroxy-6-(naphthalen-1-yl)-2*H*-pyran-2-one (4f):



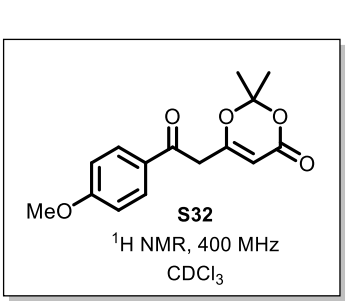


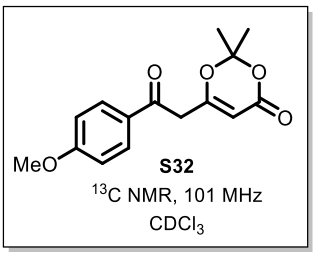
6-(2-Hydroxy-2-(4-methoxyphenyl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S31):



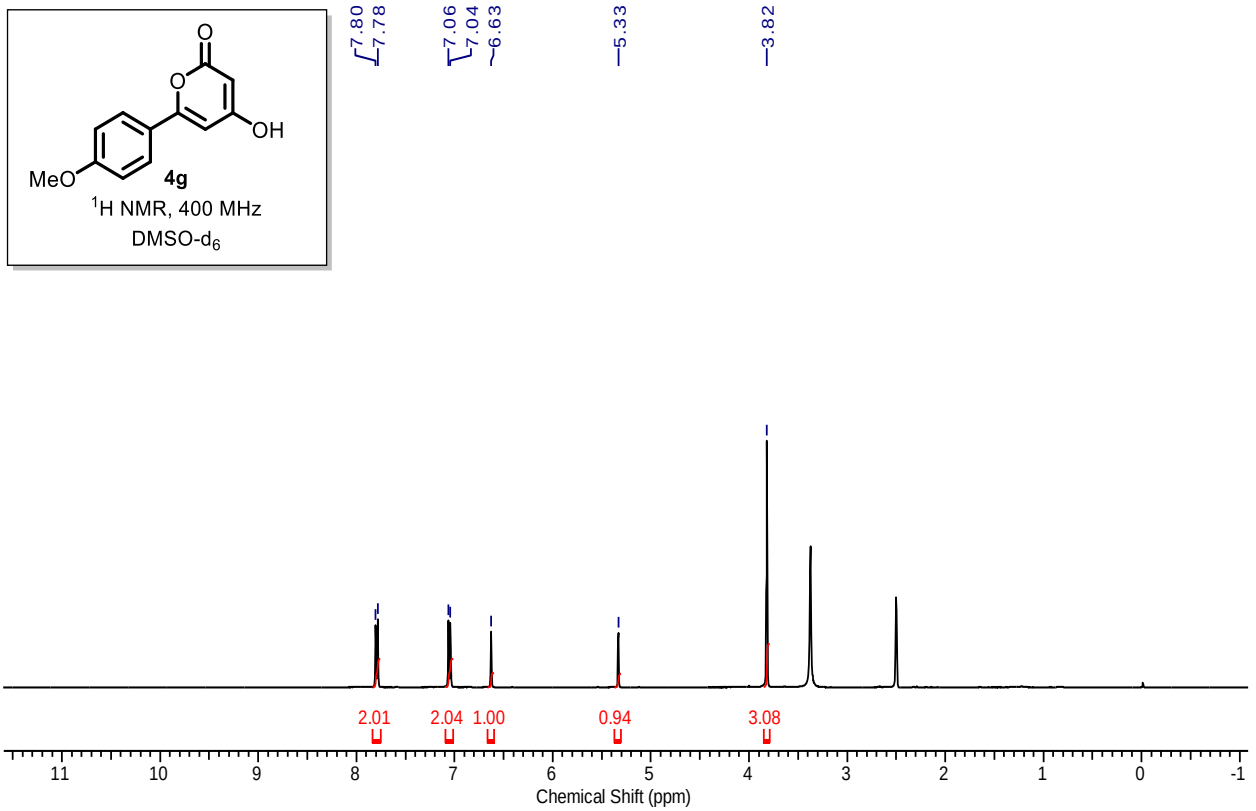


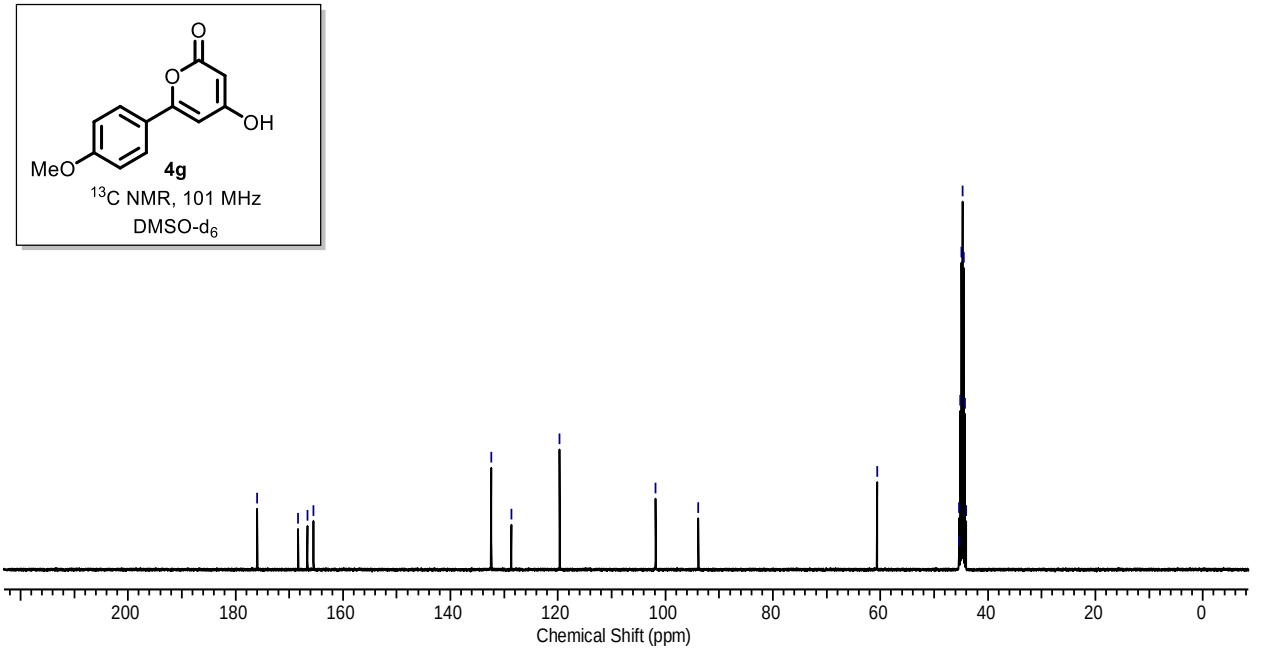
6-(2-(4-Methoxyphenyl)-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S32):



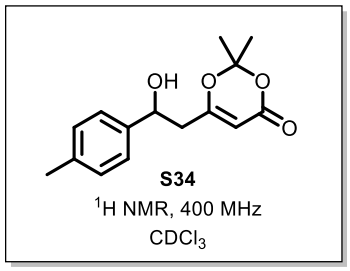


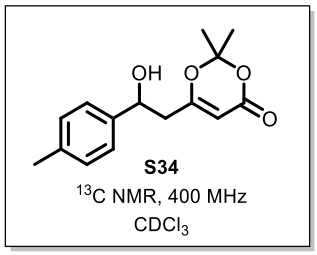
4-Hydroxy-6-(4-methoxyphenyl)-2*H*-pyran-2-one (4g):



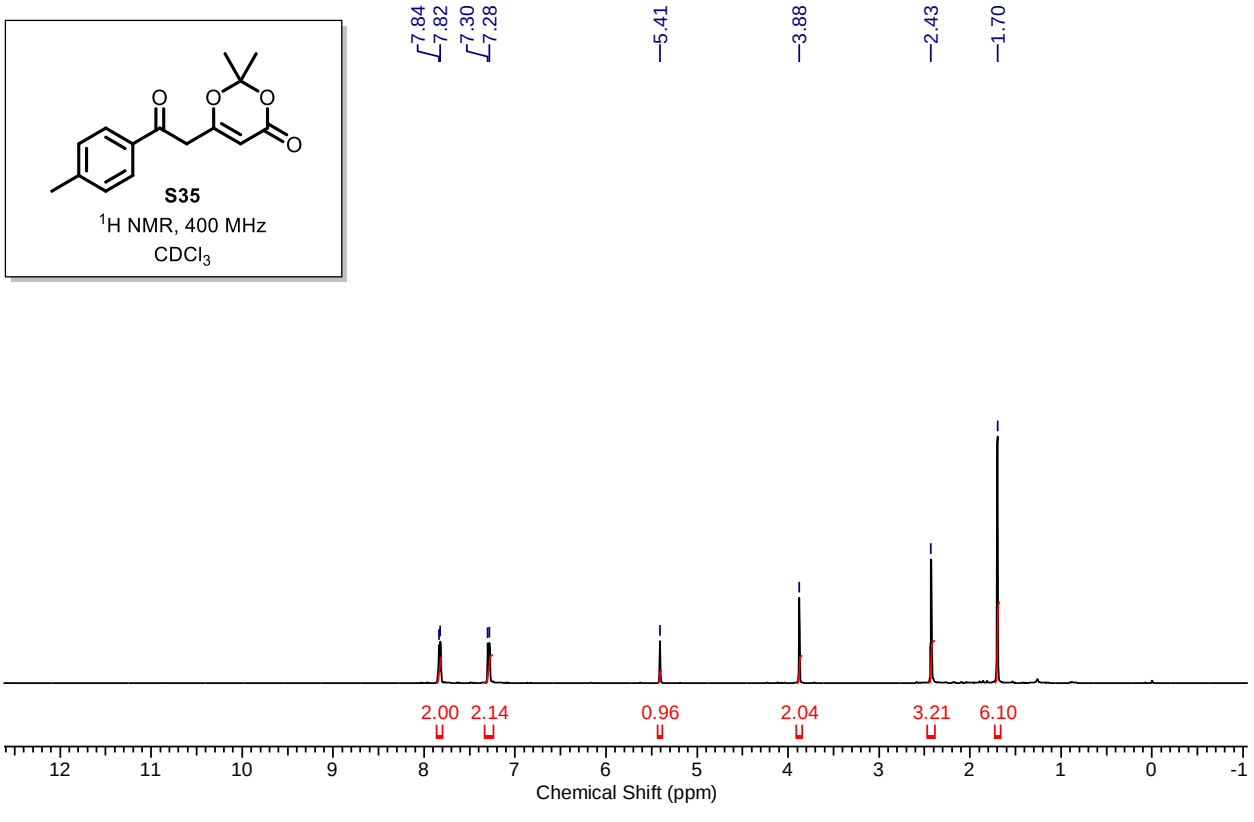


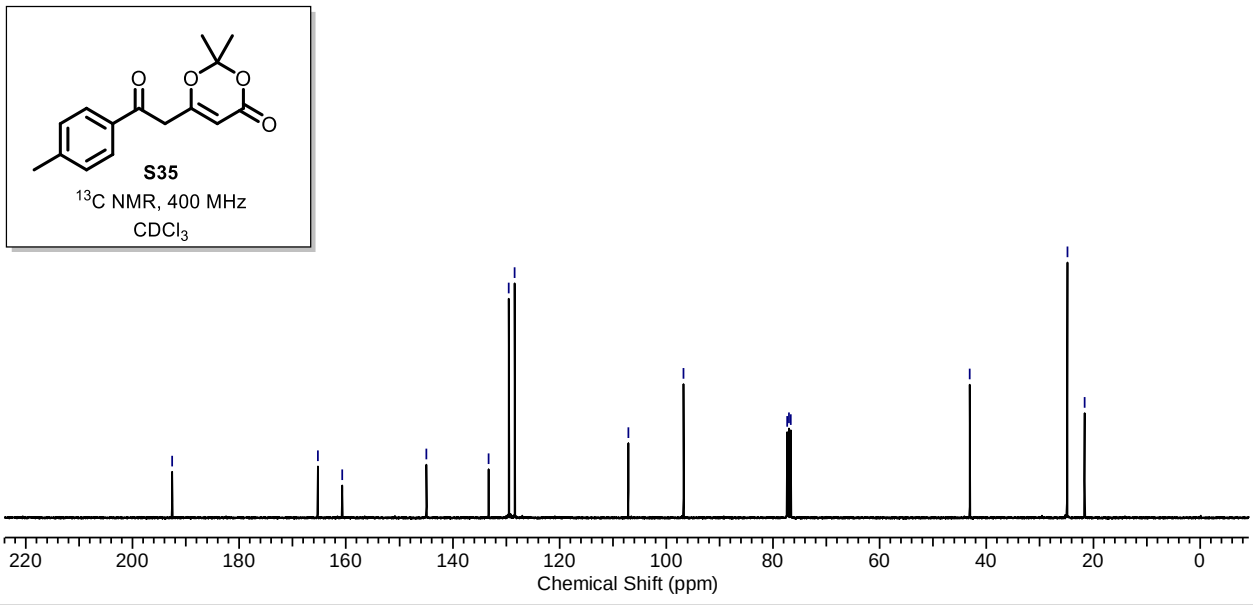
6-(2-Hydroxy-2-(*p*-tolyl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S34):



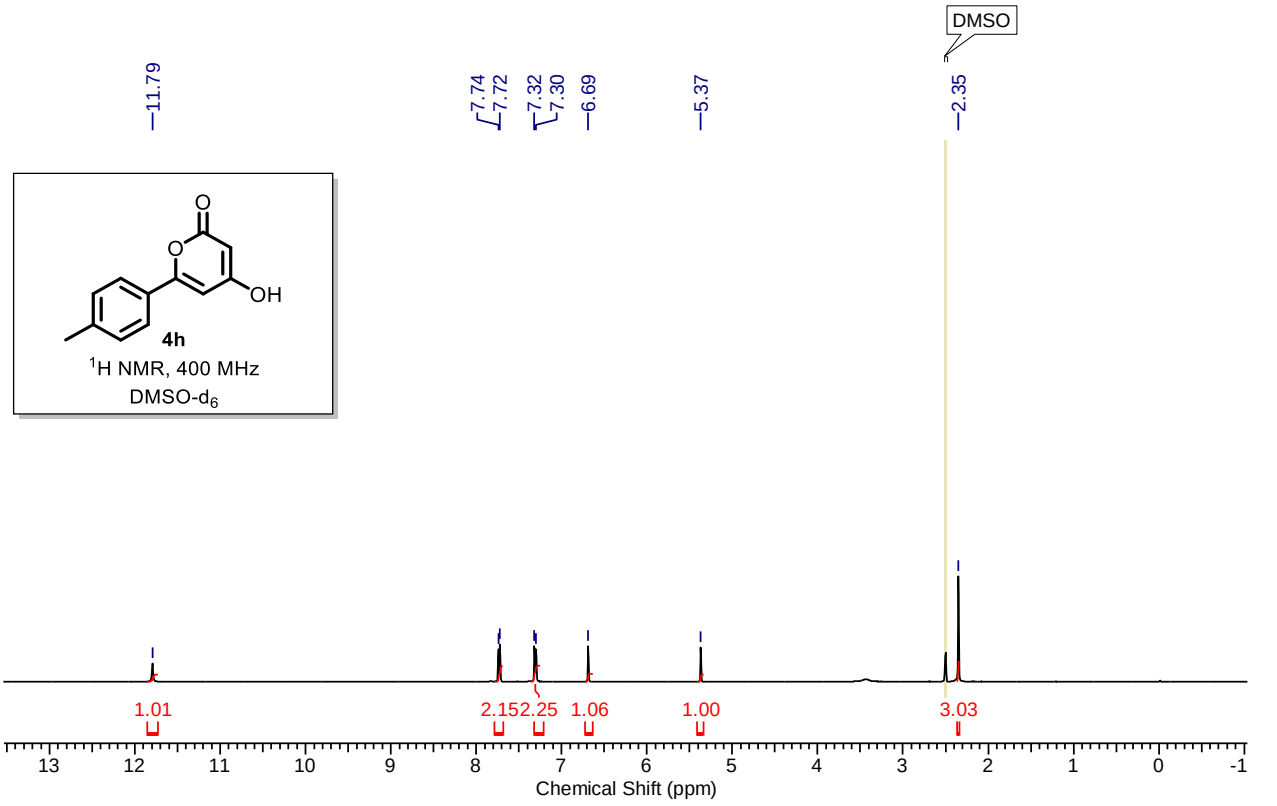


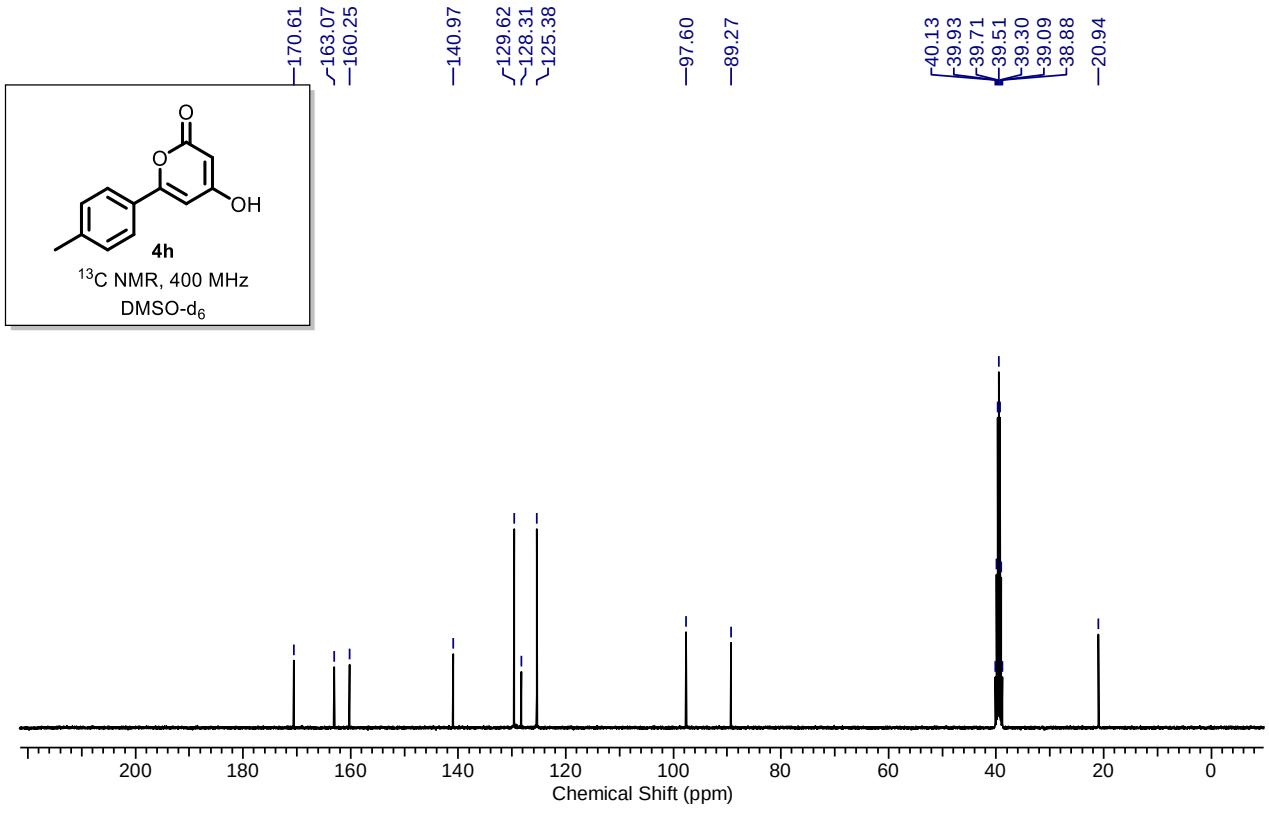
2,2-Dimethyl-6-(2-oxo-2-(p-tolyl)ethyl)-4*H*-1,3-dioxin-4-one (S35):



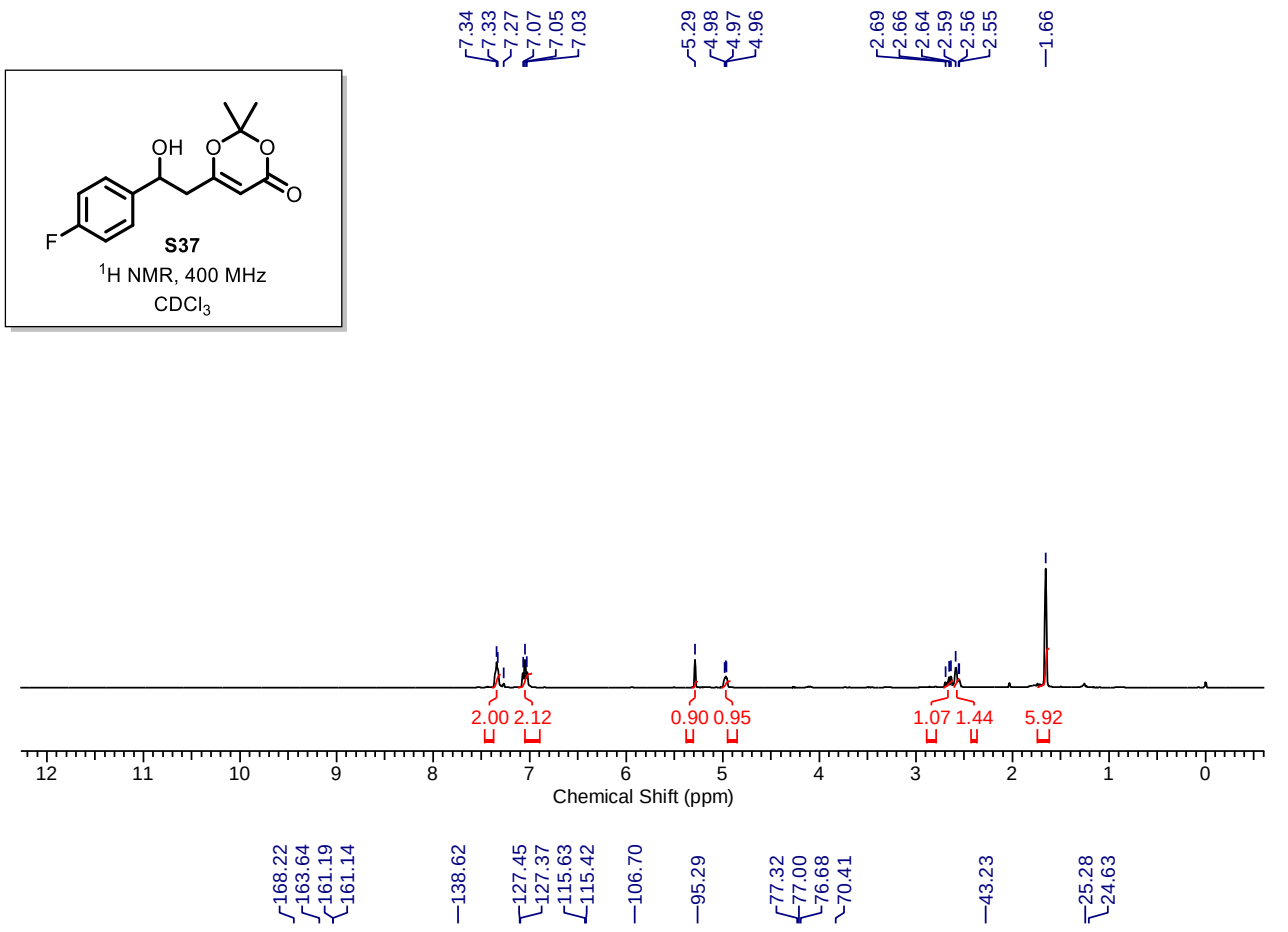


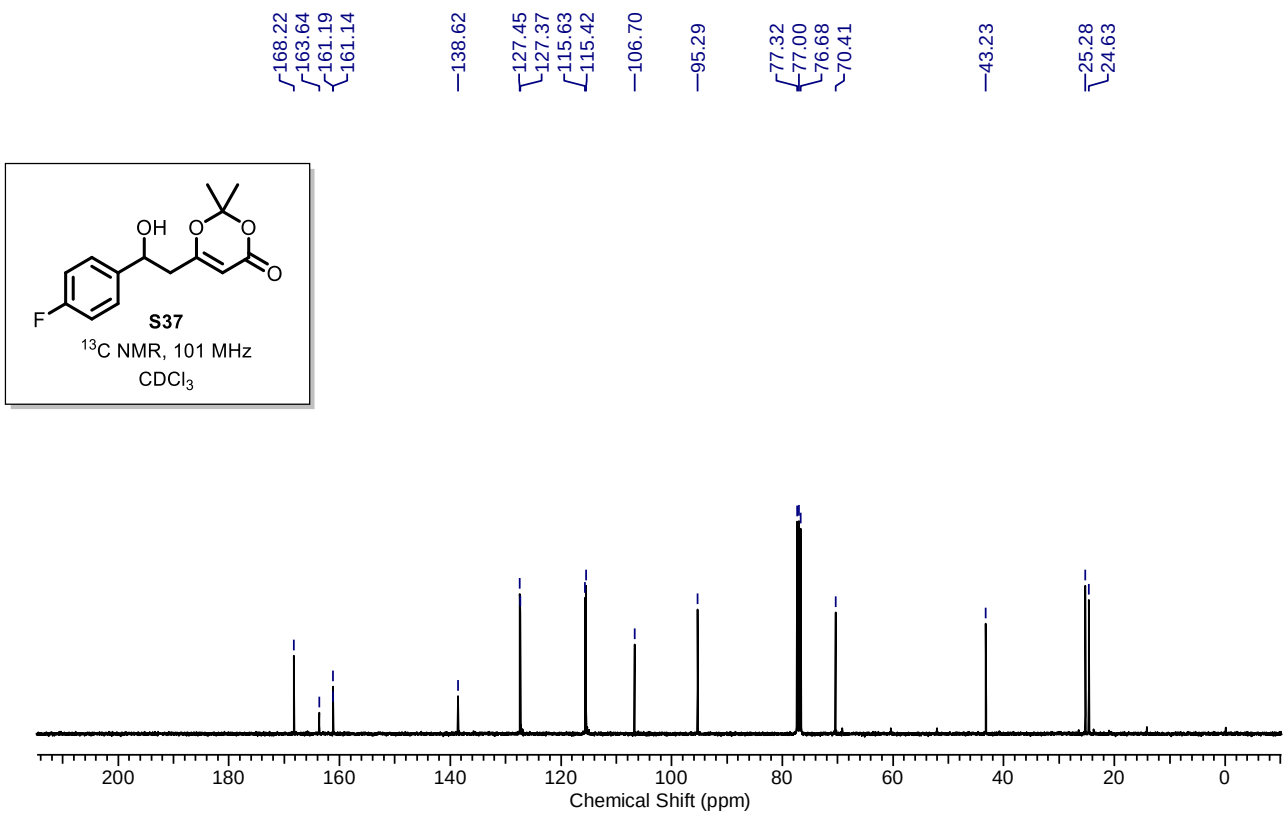
4-Hydroxy-6-(*p*-tolyl)-2*H*-pyran-2-one (4h):



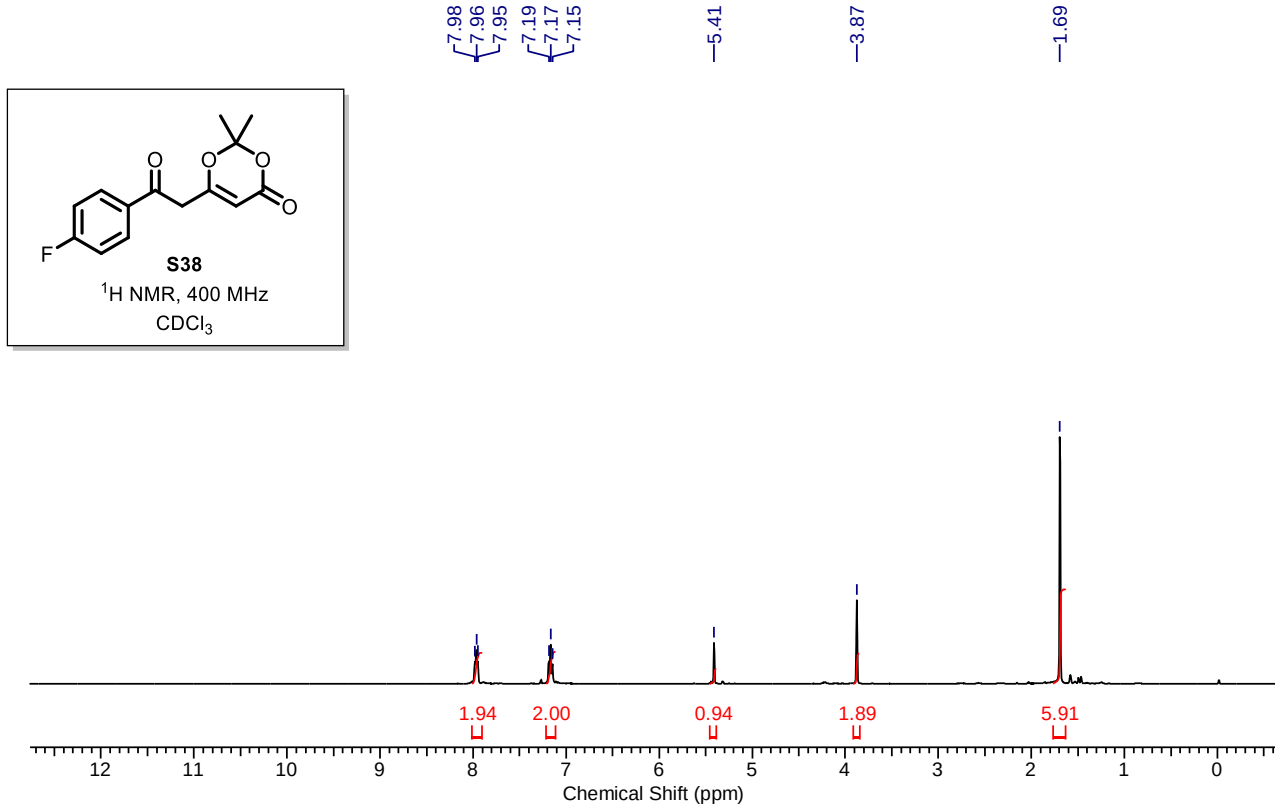


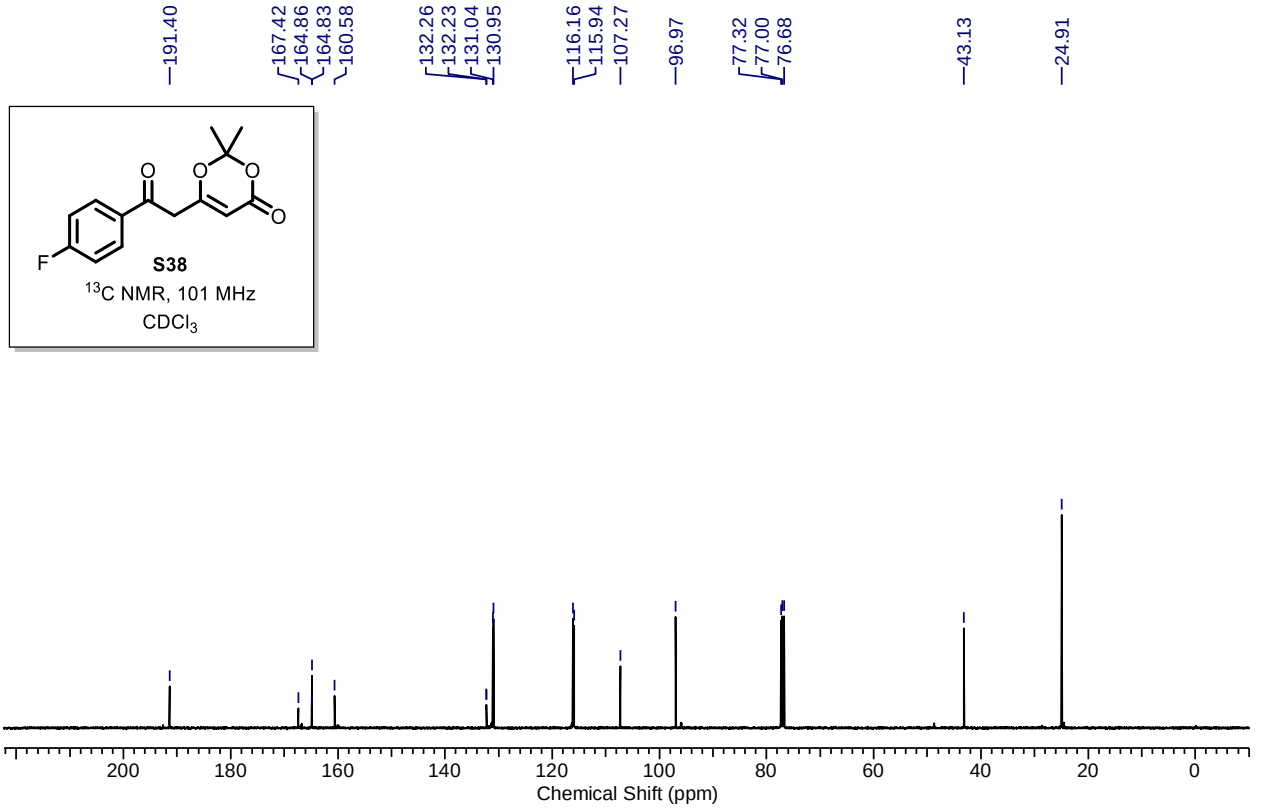
6-(2-(4-Fluorophenyl)-2-hydroxyethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S37):



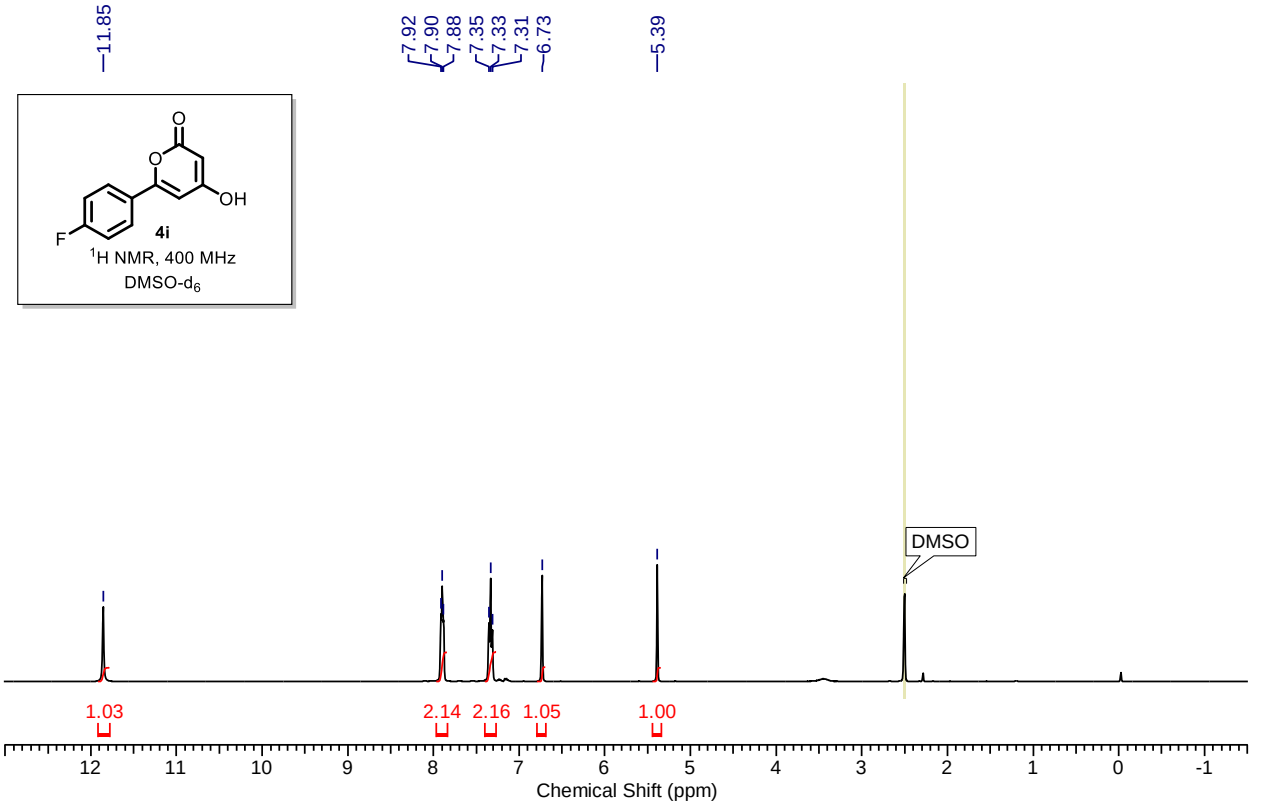


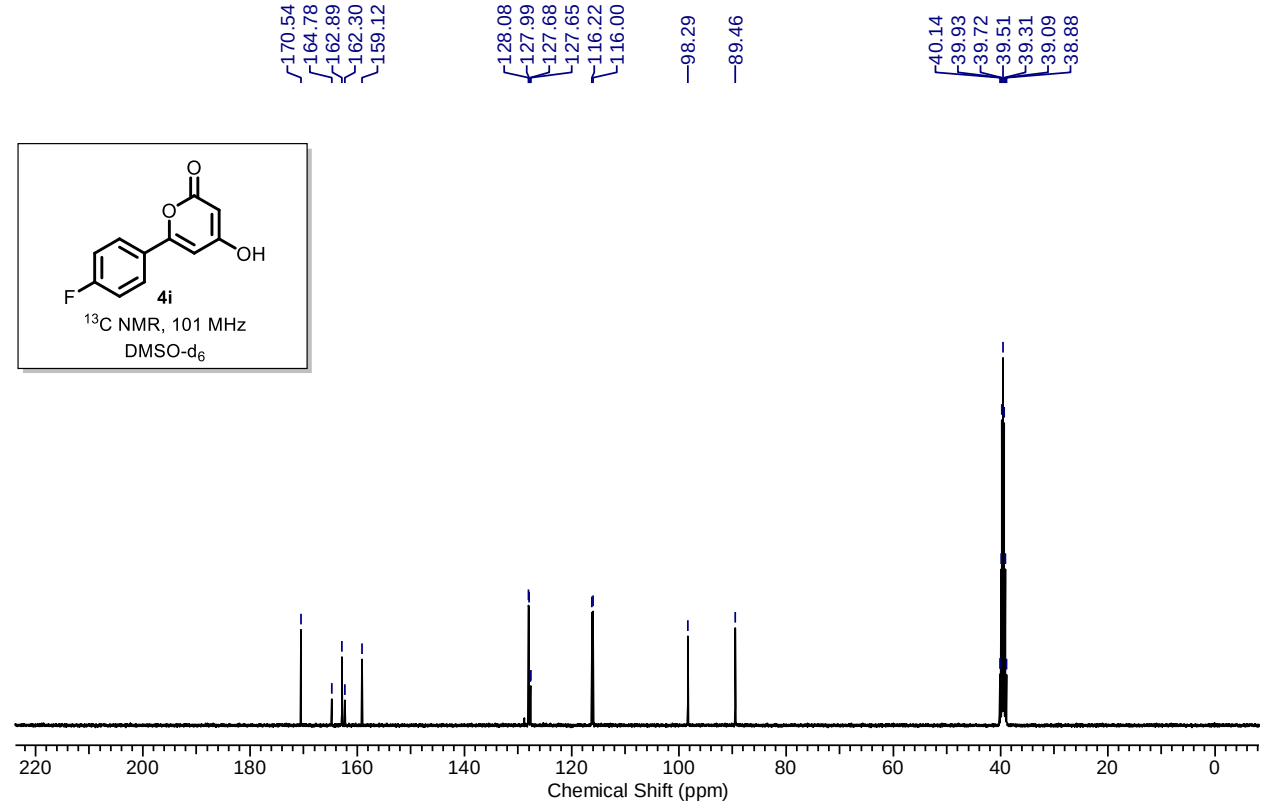
6-(2-(4-Fluorophenyl)-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S38):



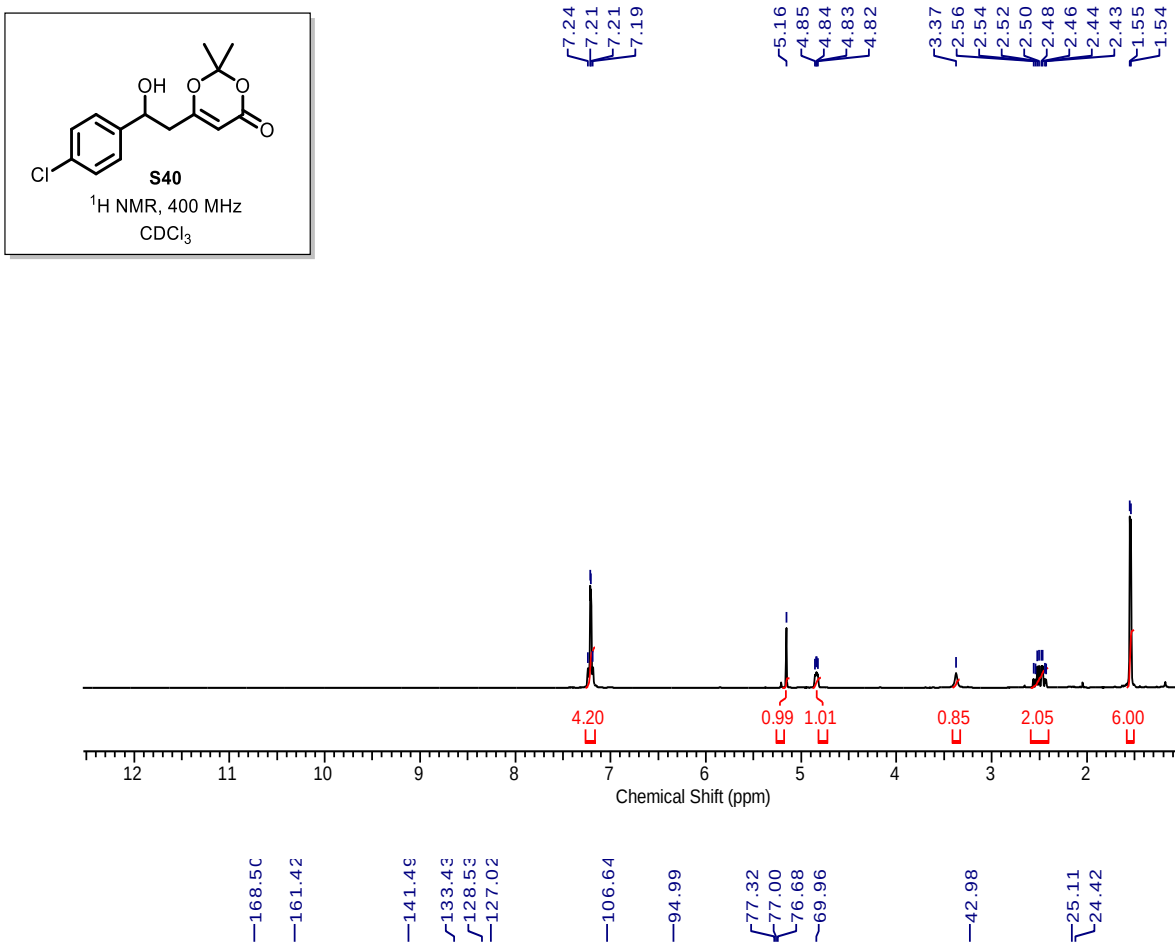


6-(4-Fluorophenyl)-4-hydroxy-2*H*-pyran-2-one (4i):

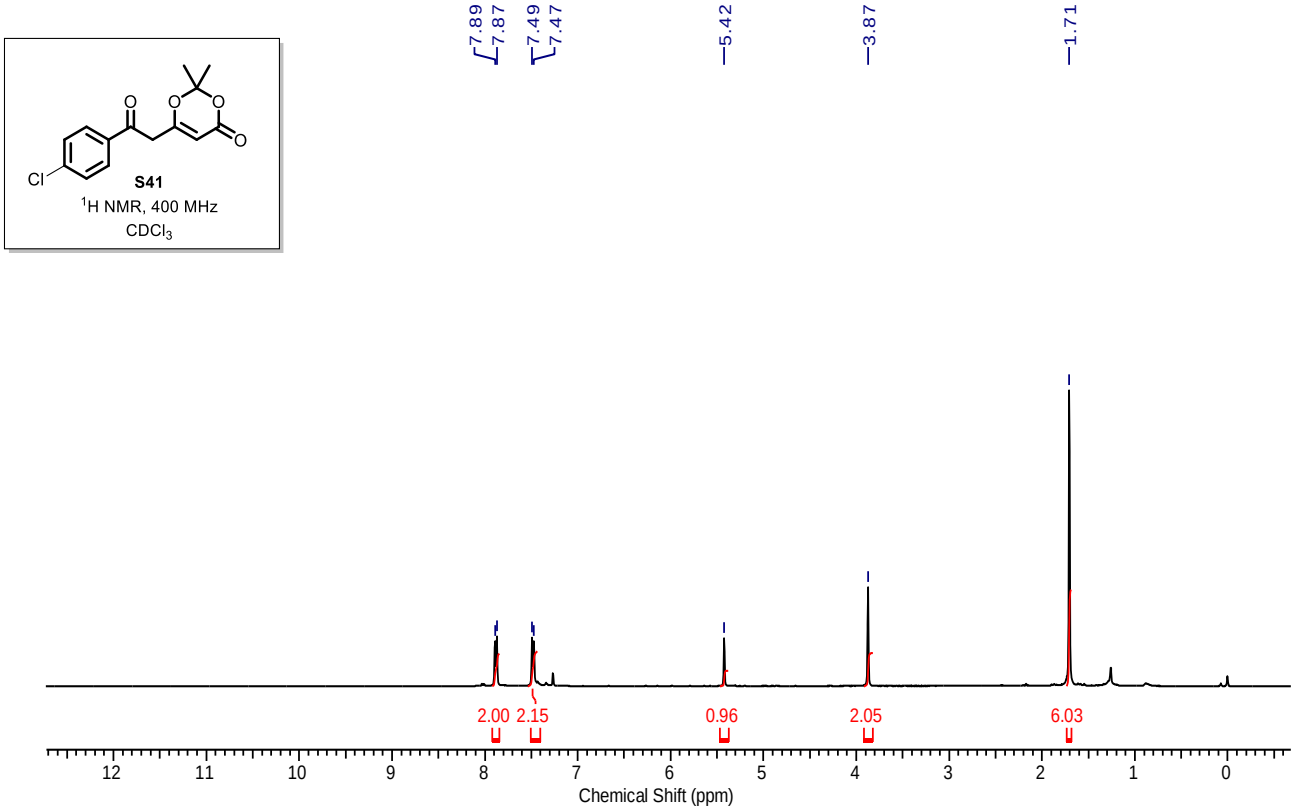


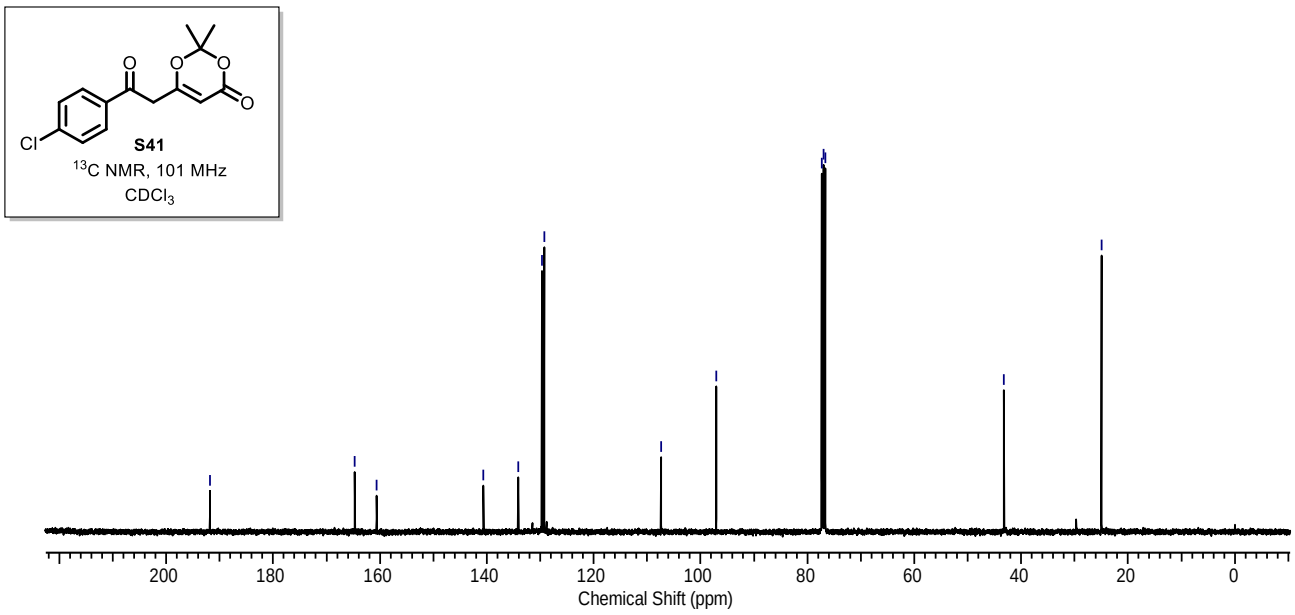


6-(2-(4-Chlorophenyl)-2-hydroxyethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S40):

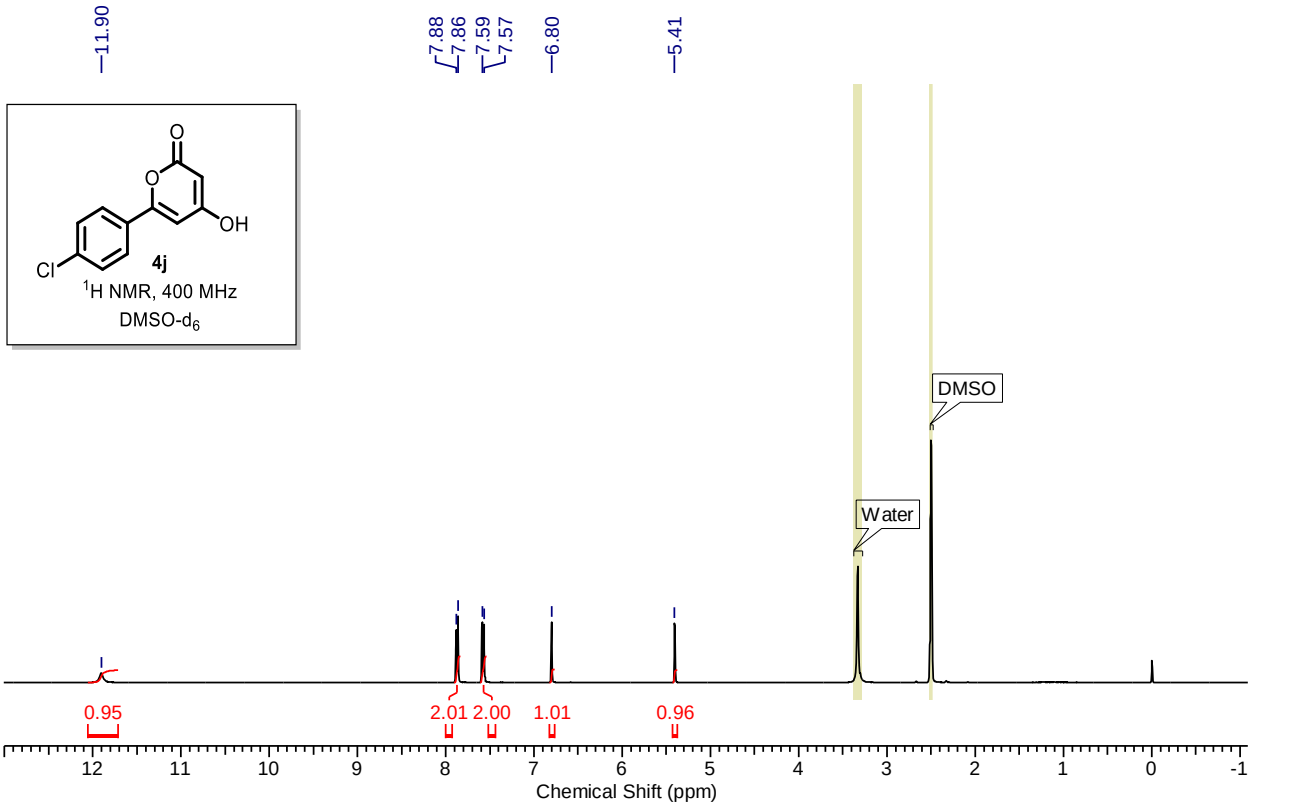


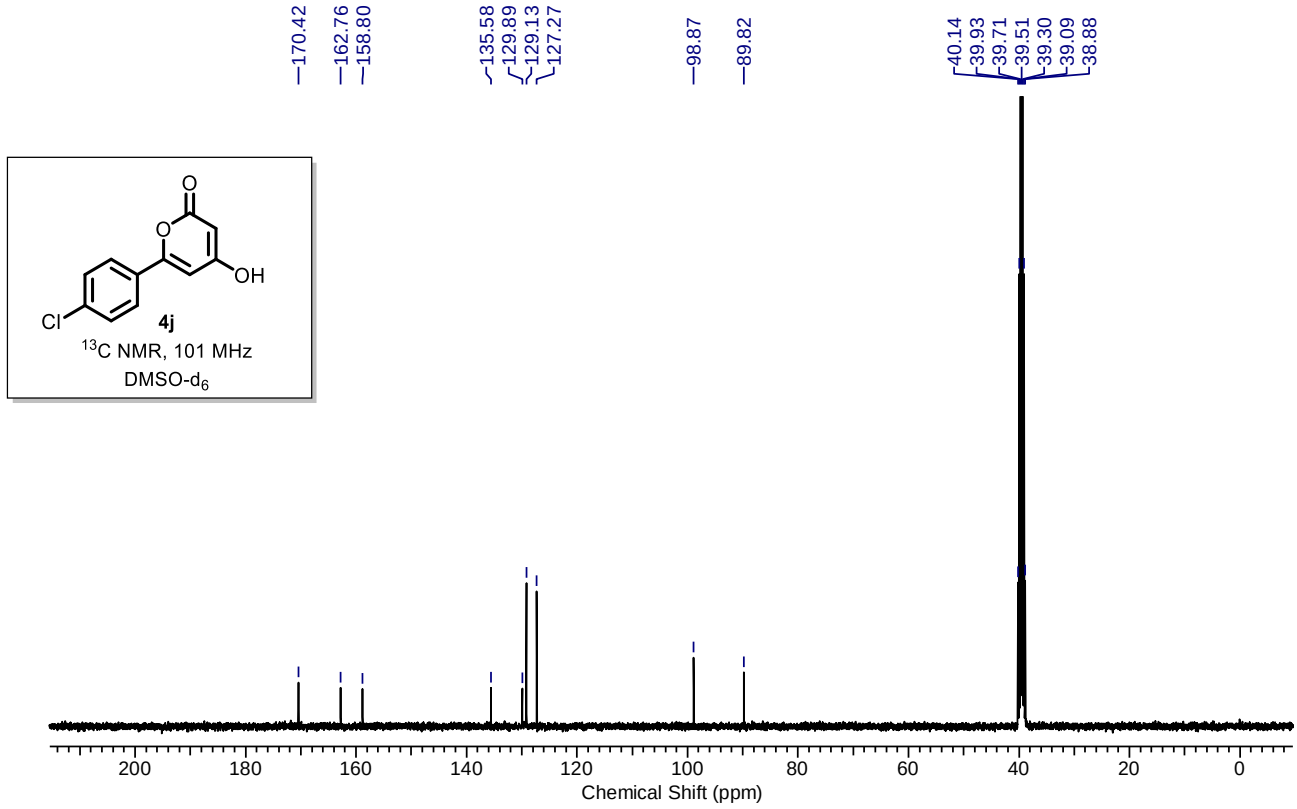
6-(2-(4-Chlorophenyl)-2-oxoethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S41):



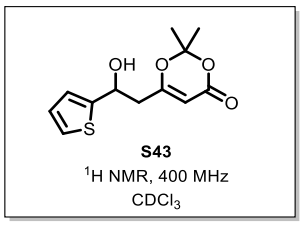


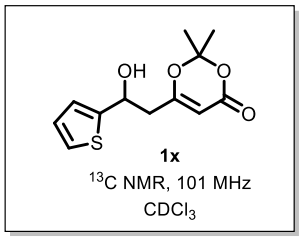
6-(4-Chlorophenyl)-4-hydroxy-2*H*-pyran-2-one (4j):



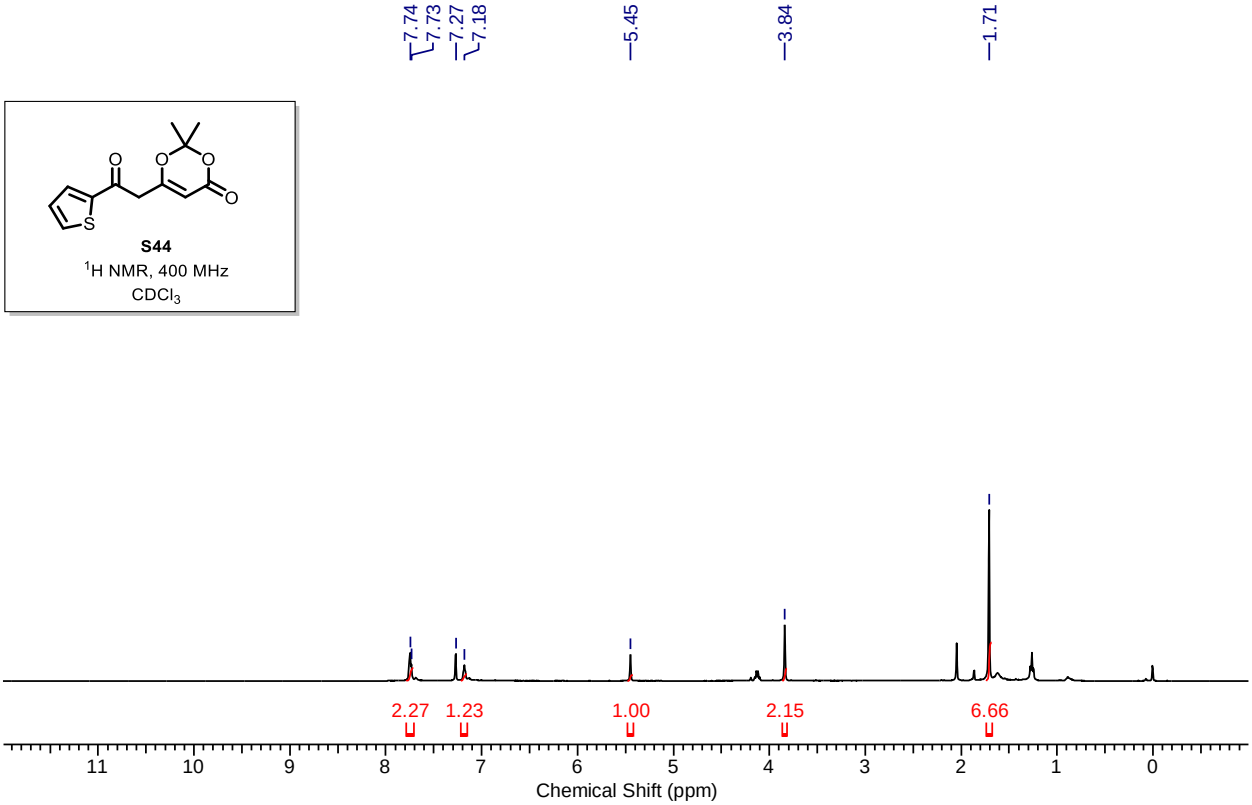


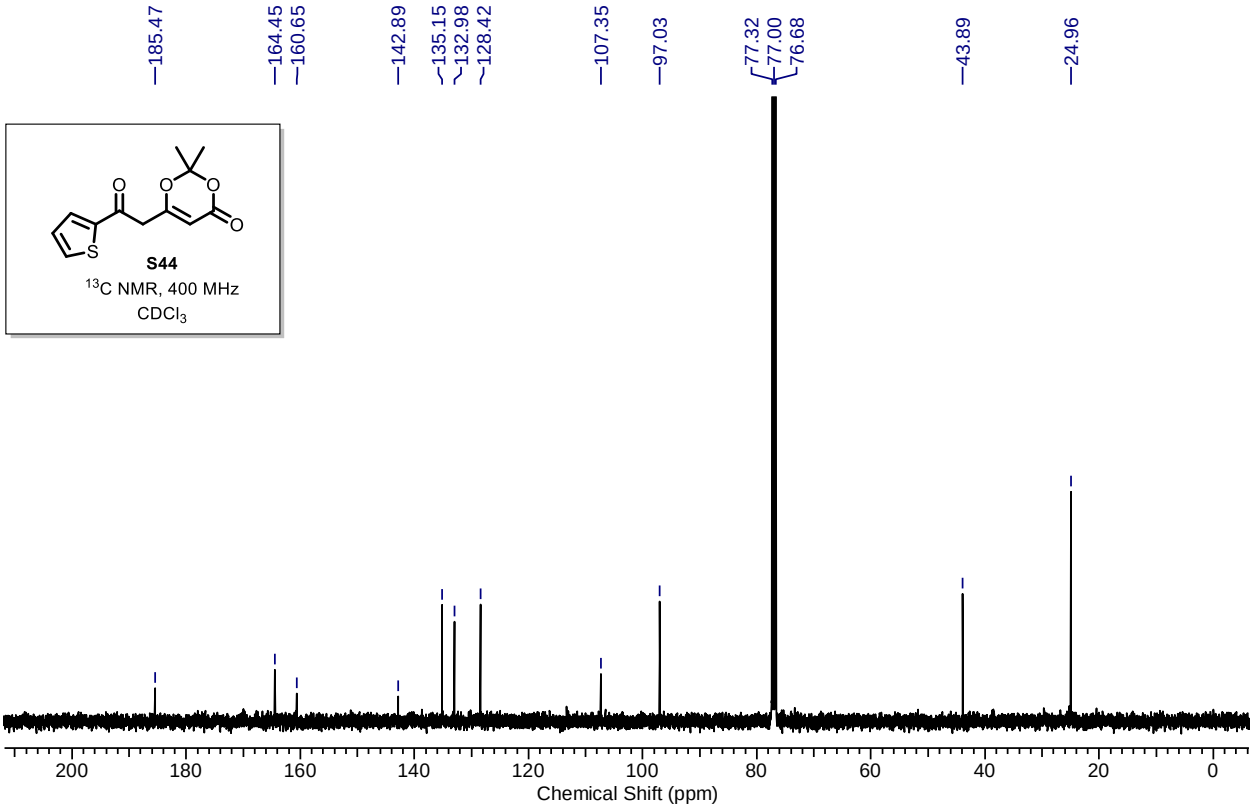
6-(2-Hydroxy-2-(thiophen-2-yl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S43)



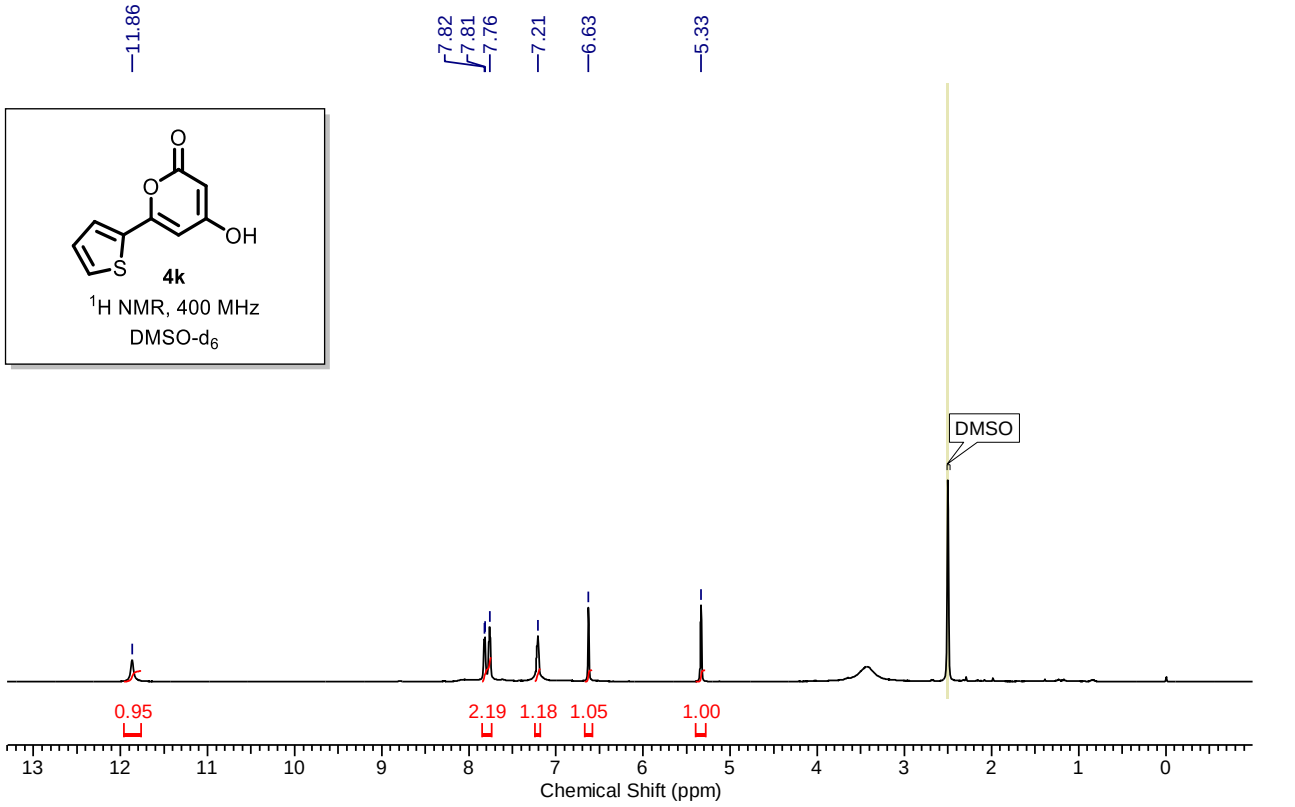


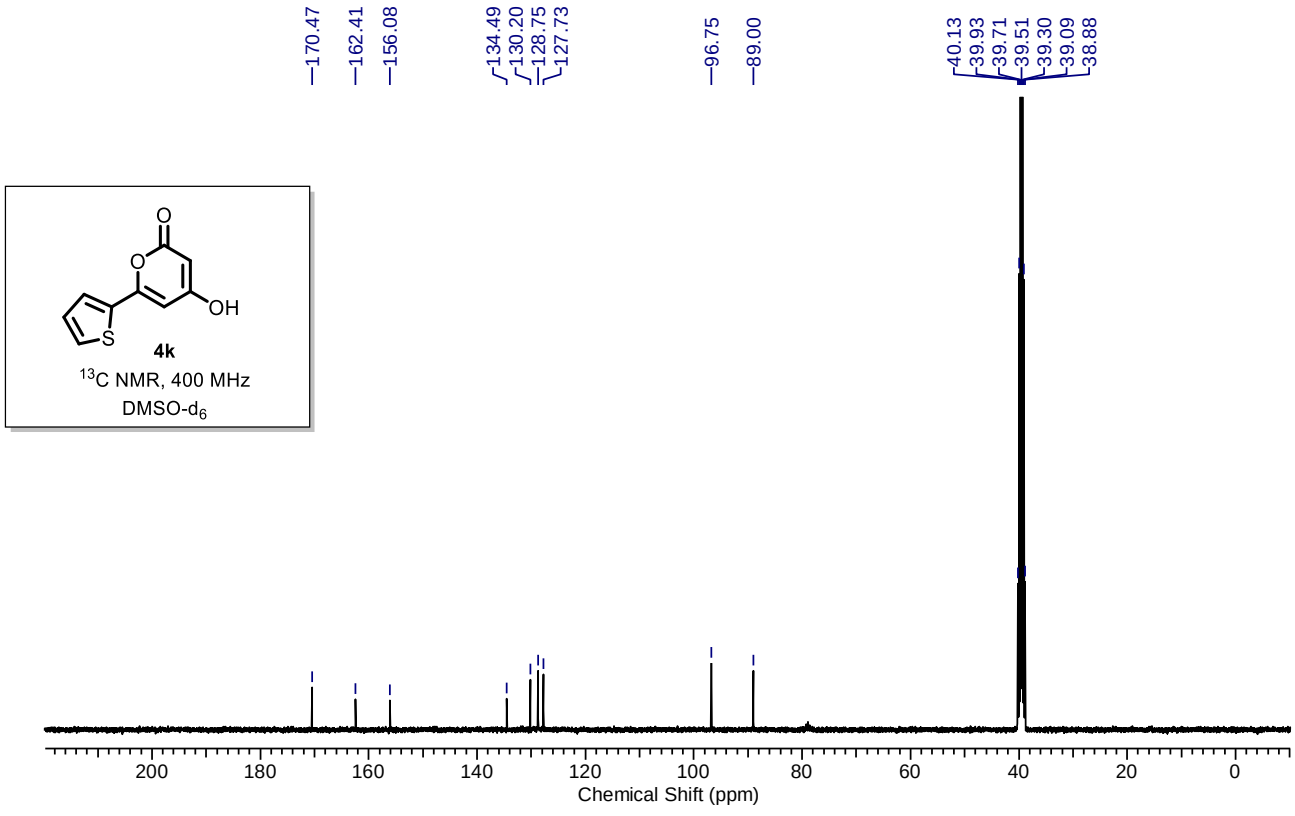
2,2-Dimethyl-6-(2-oxo-2-(thiophen-2-yl)ethyl)-4*H*-1,3-dioxin-4-one (S44):



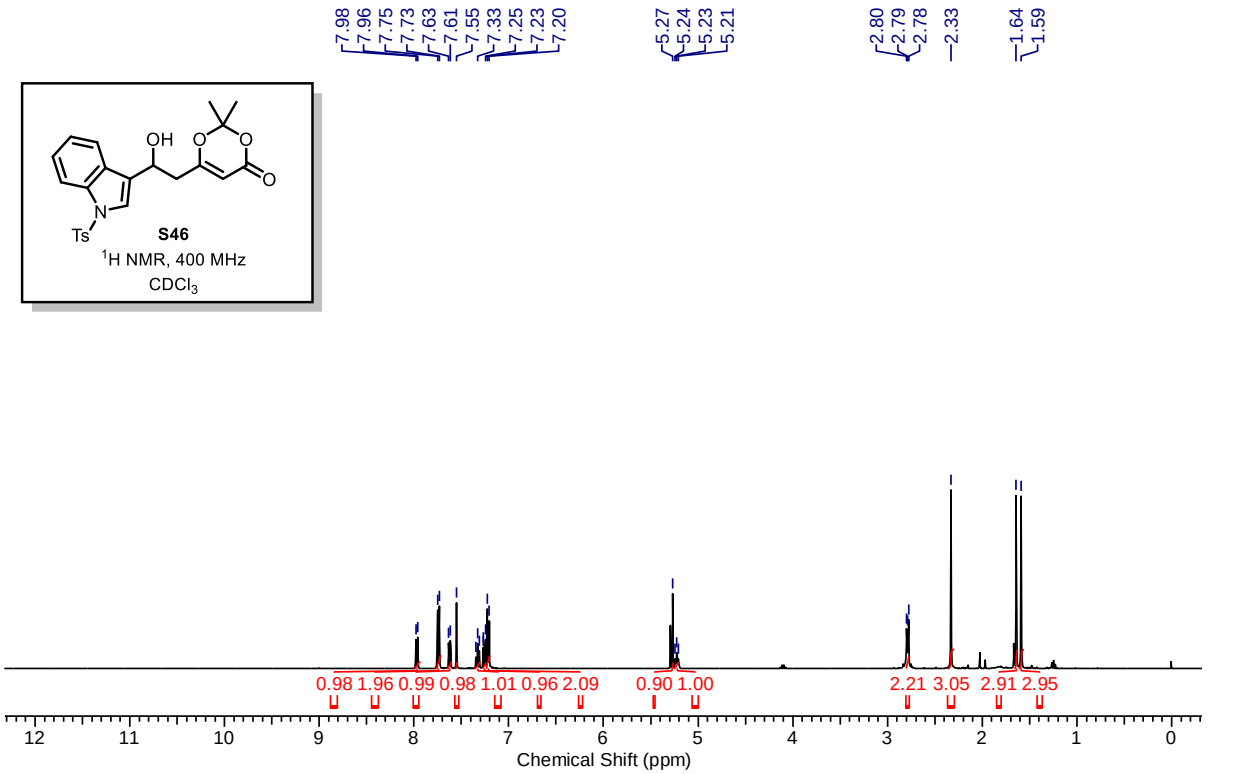


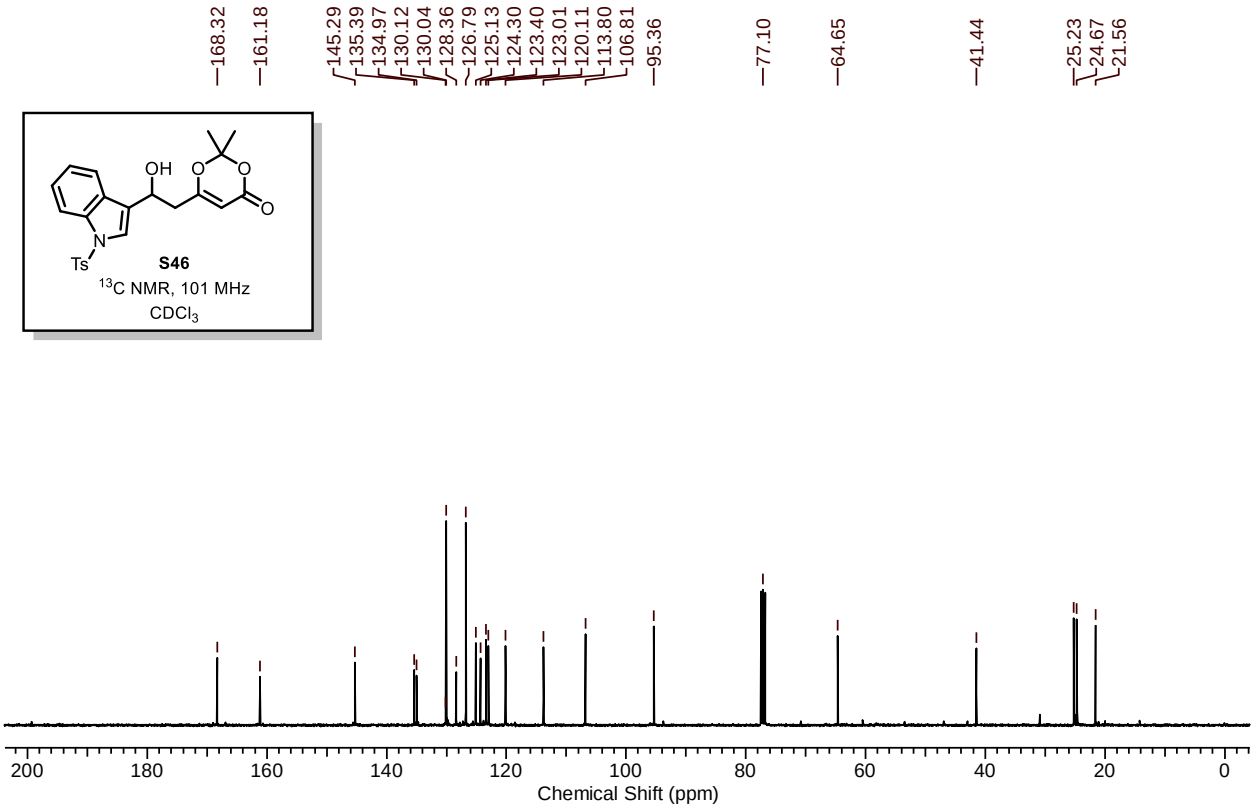
4-Hydroxy-6-(thiophen-2-yl)-2*H*-pyran-2-one (4k):



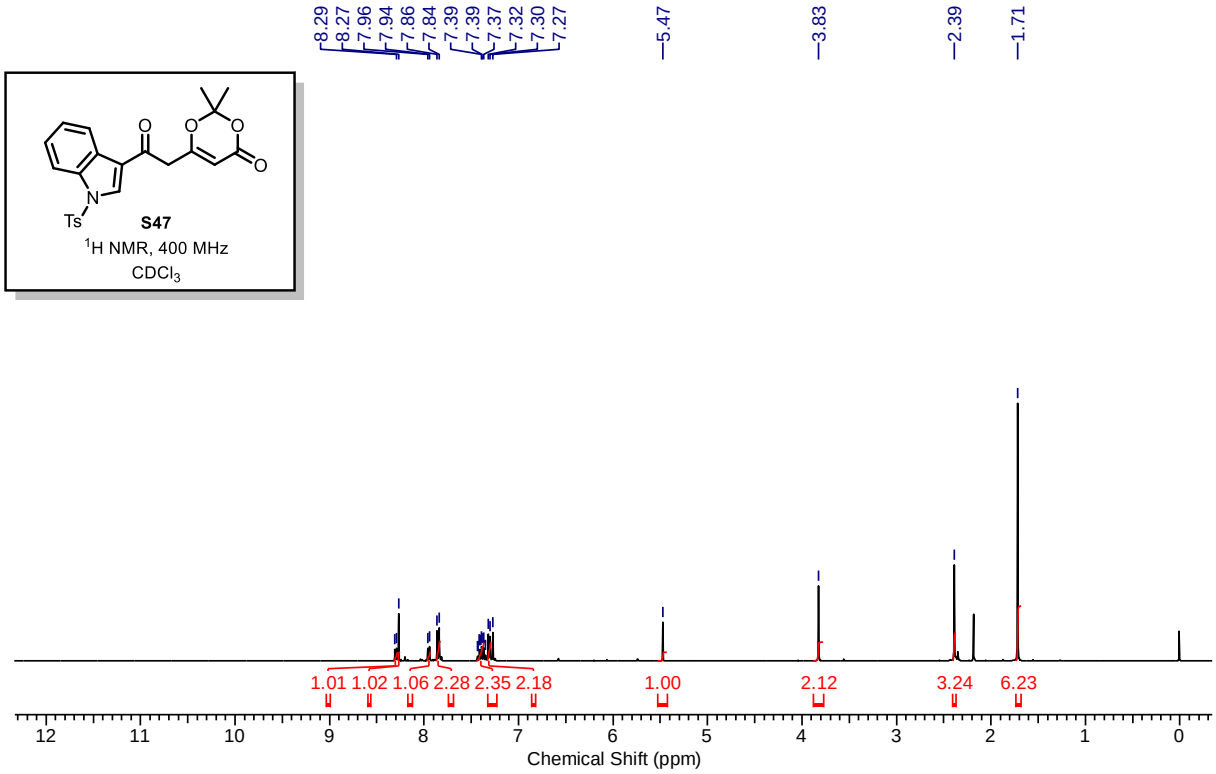


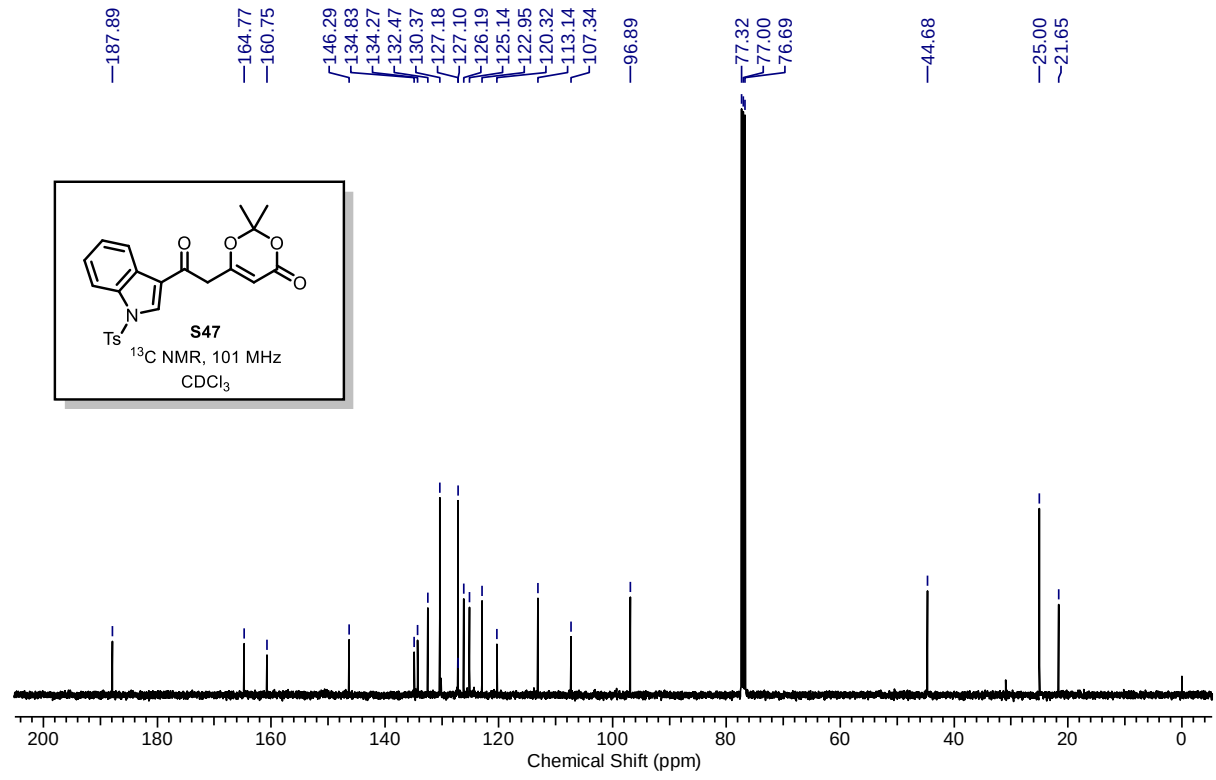
6-(2-Hydroxy-2-(1-tosyl-1*H*-indol-3-yl)ethyl)-2,2-dimethyl-4*H*-1,3-dioxin-4-one (S46):



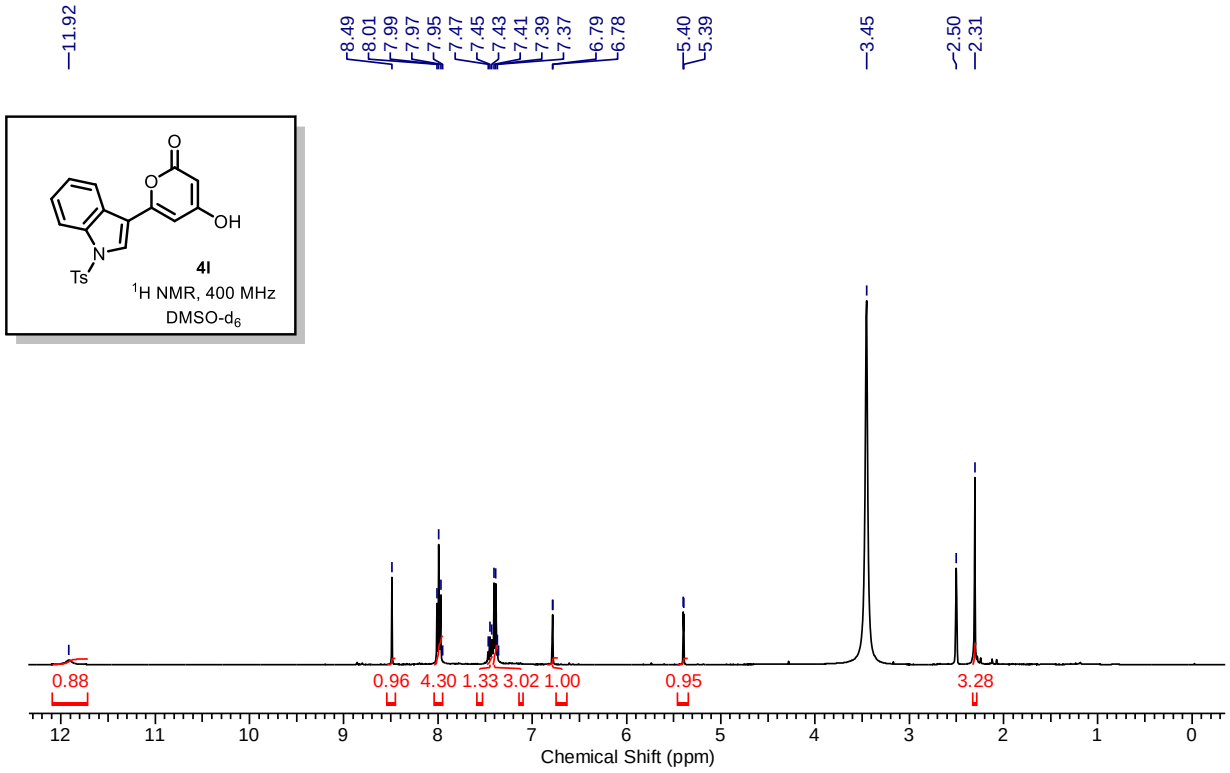


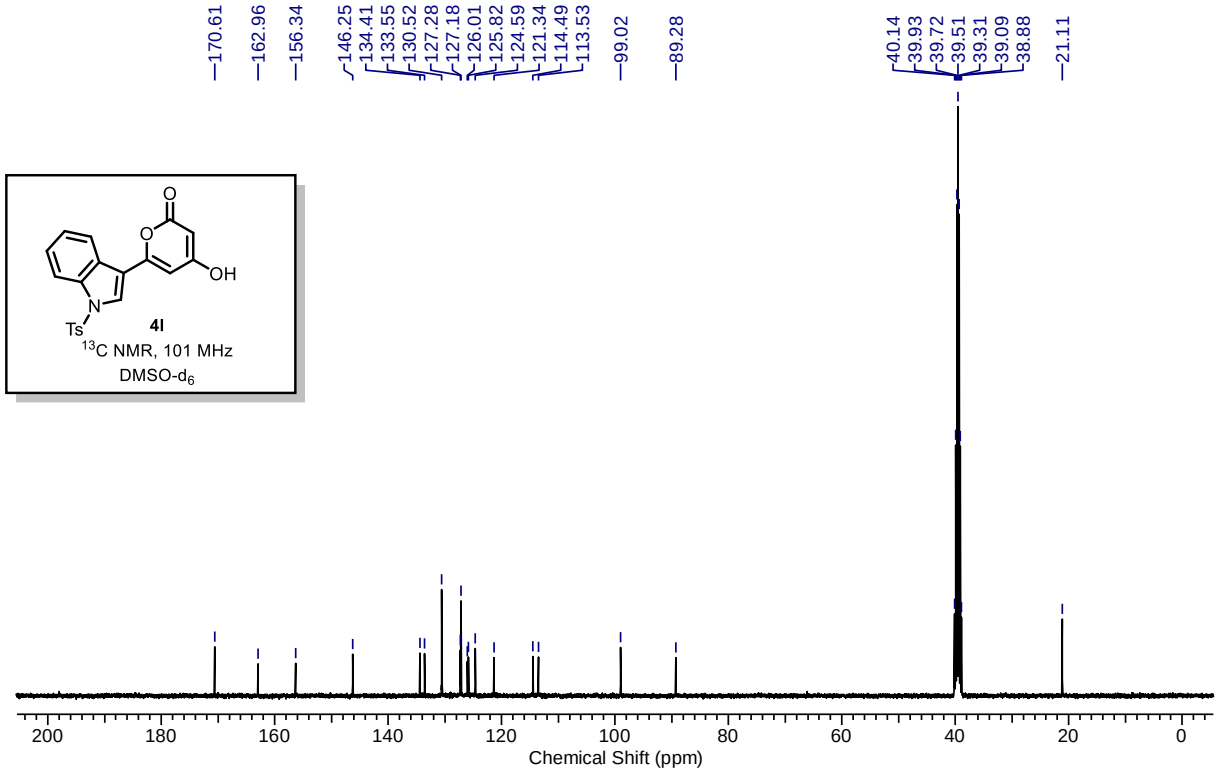
2,2-Dimethyl-6-(2-oxo-2-(1-tosyl-1*H*-indol-3-yl)ethyl)-4*H*-1,3-dioxin-4-one (S47):



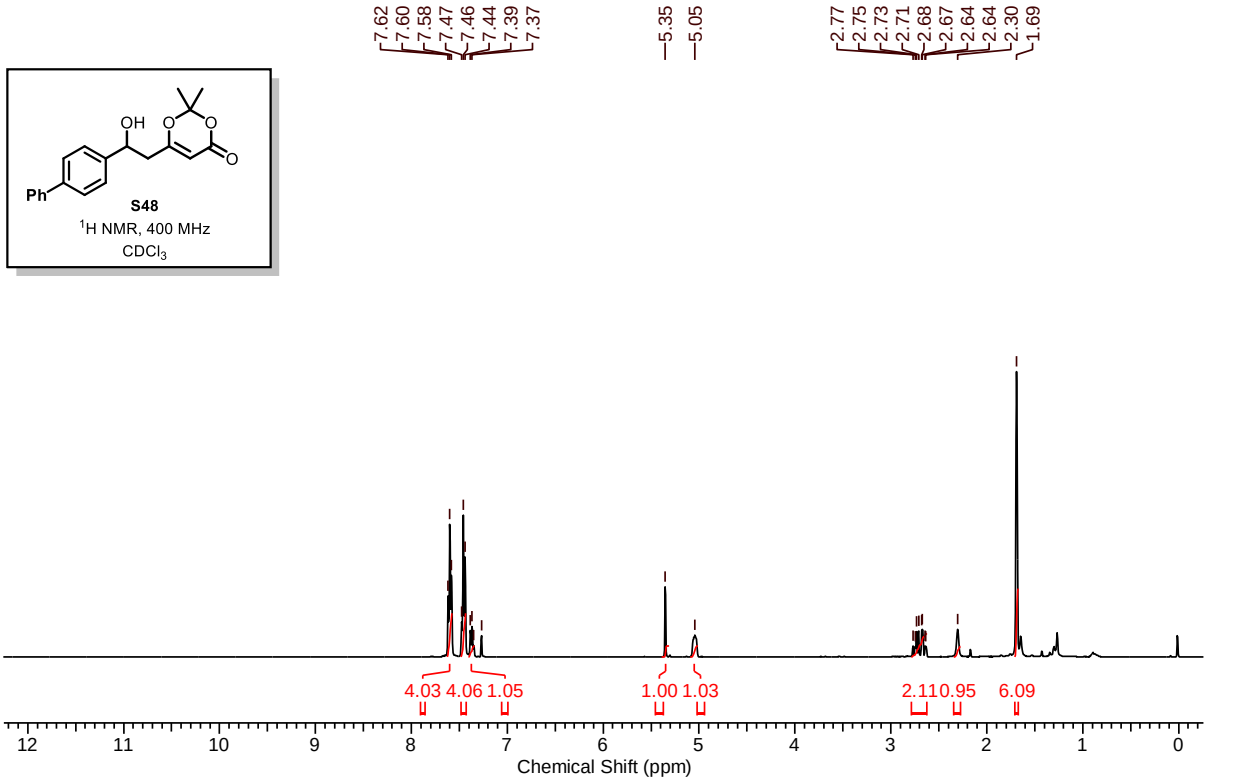


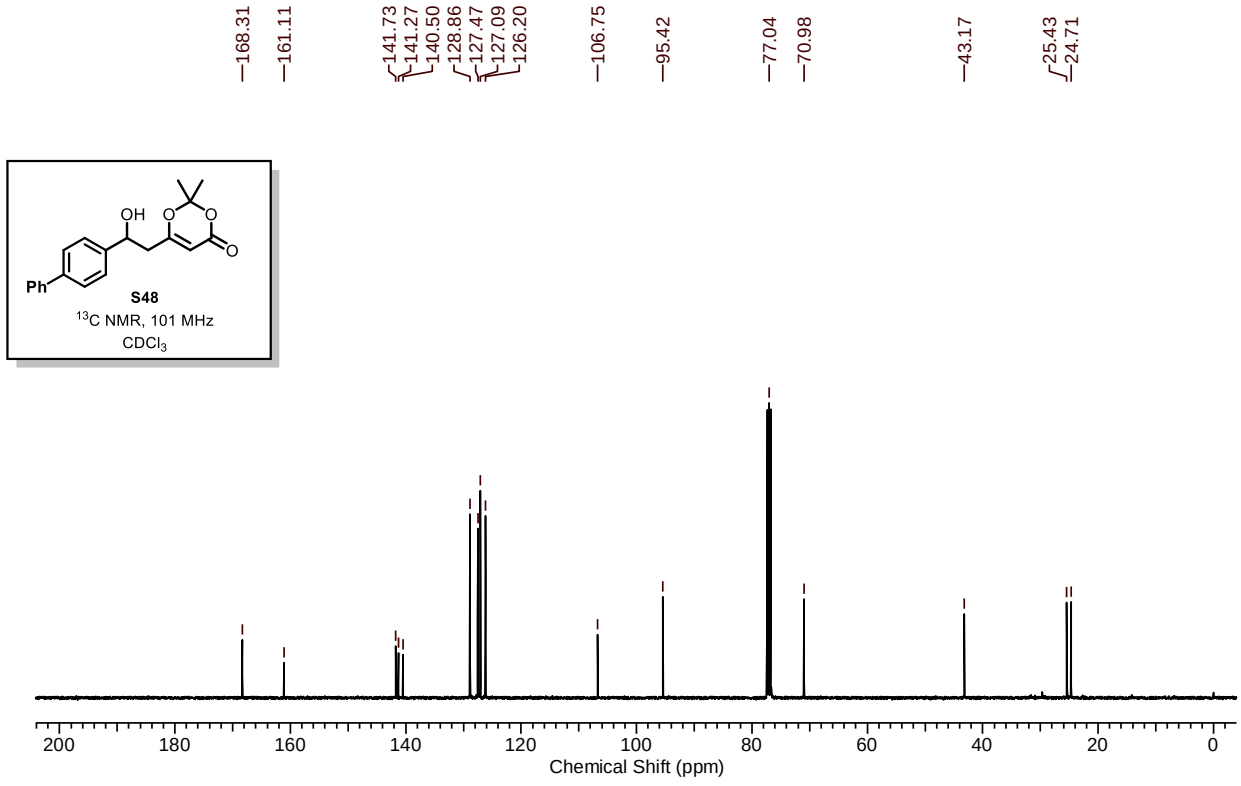
4-Hydroxy-6-(1-tosyl-1*H*-indol-3-yl)-2*H*-pyran-2-one (4l):



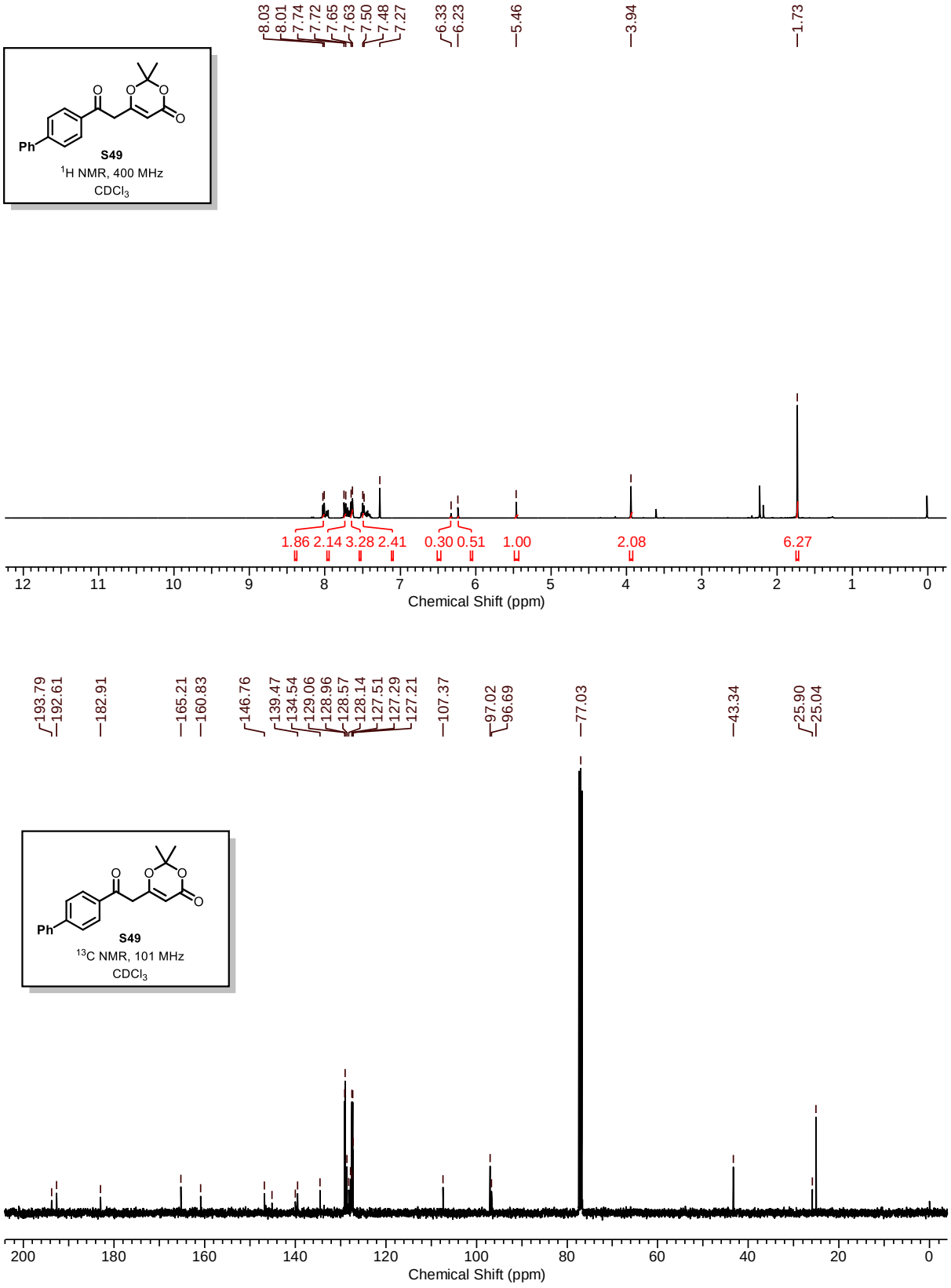


6-(2-([1,1'-Biphenyl]-4-yl)-2-hydroxyethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one(S48):

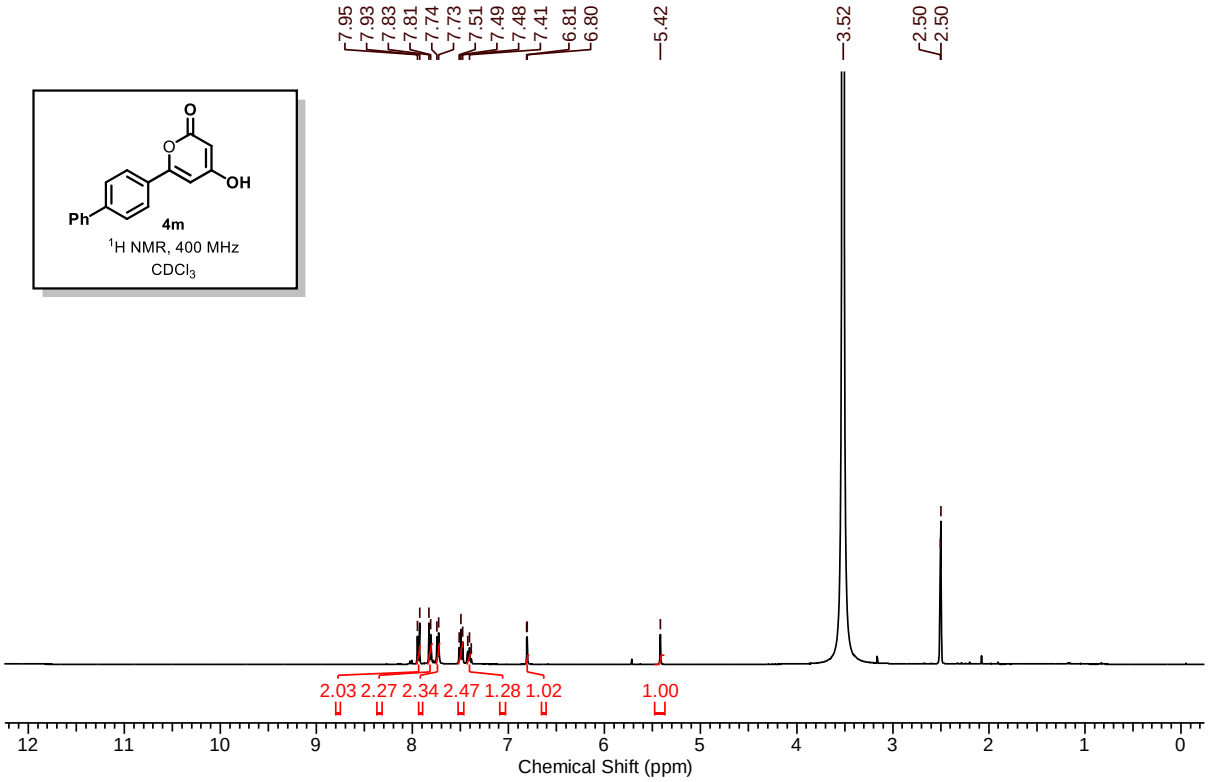


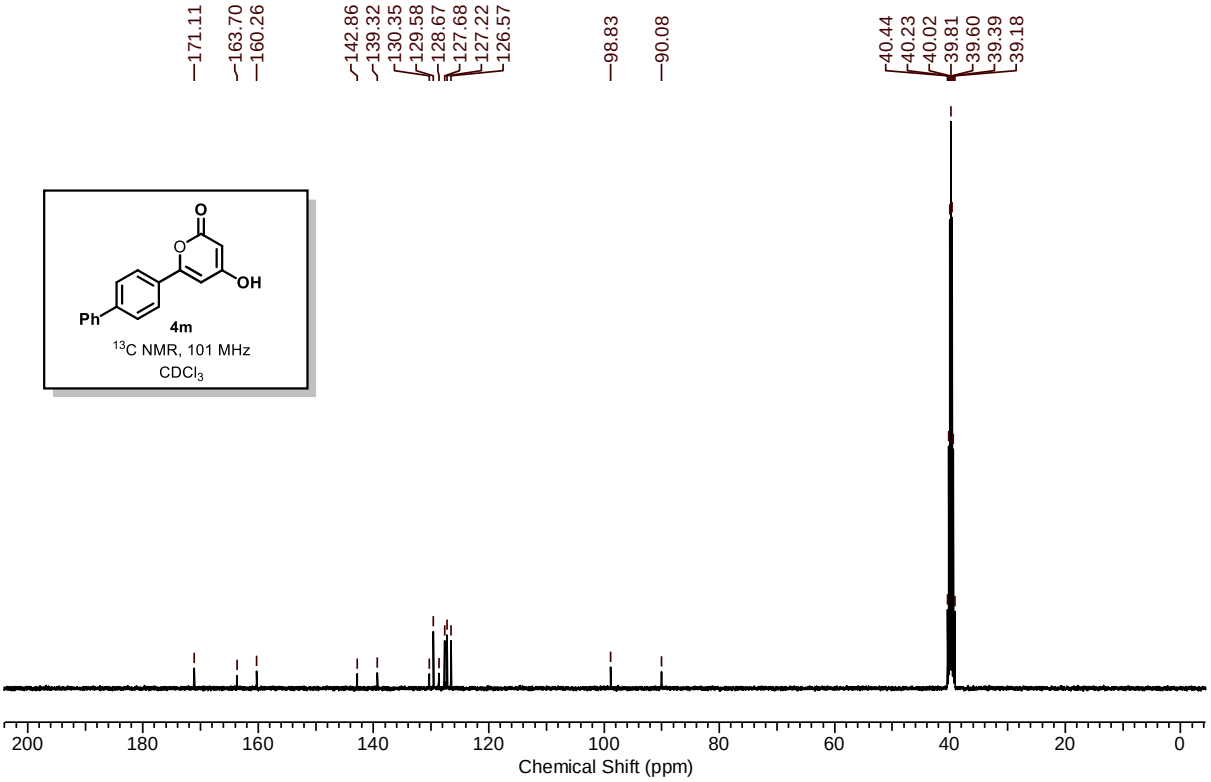


6-(2-([1,1'-Biphenyl]-4-yl)-2-oxoethyl)-2,2-dimethyl-4H-1,3-dioxin-4-one (S49):

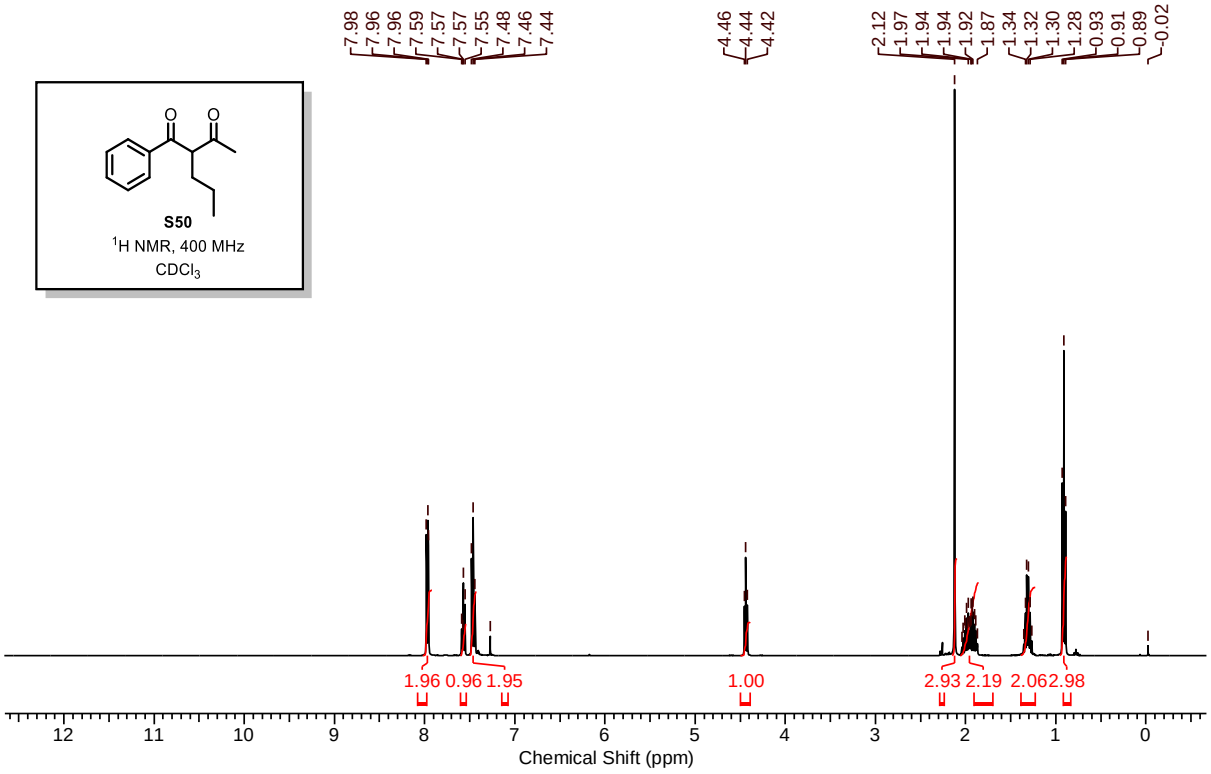


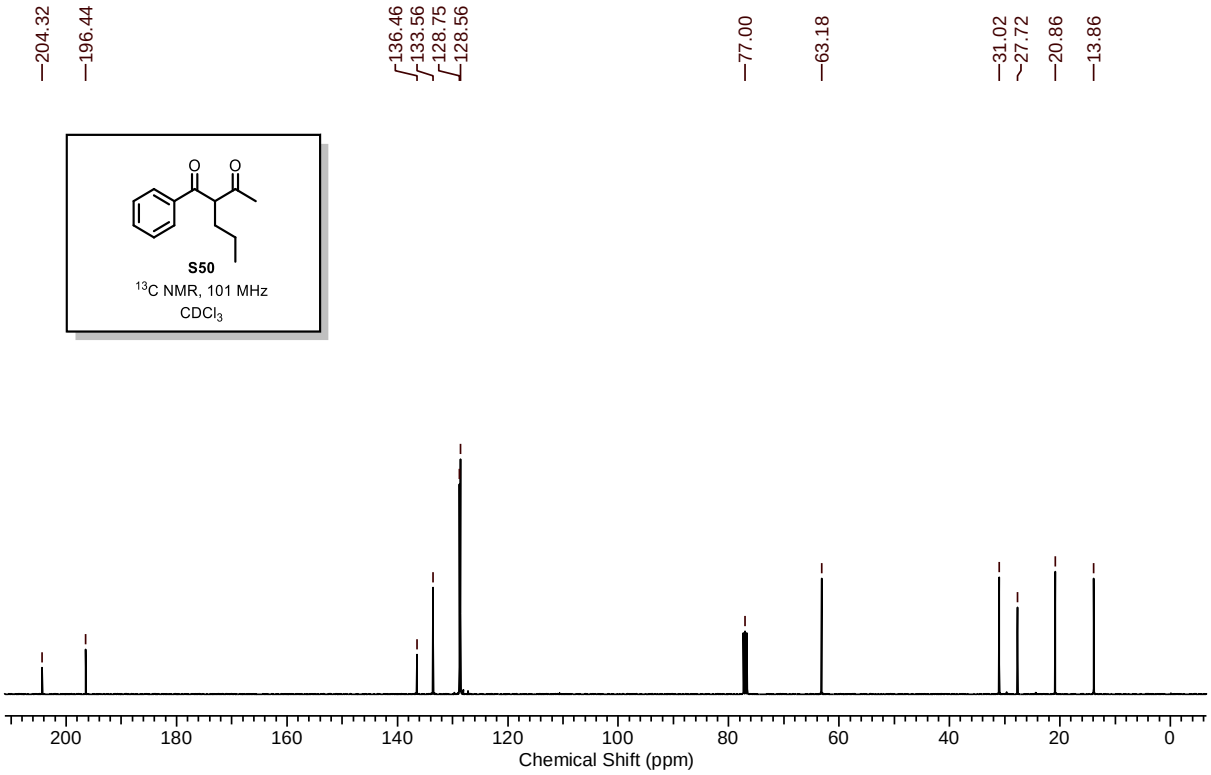
6-([1,1'-Biphenyl]-4-yl)-4-hydroxy-2H-pyran-2-one(4m):



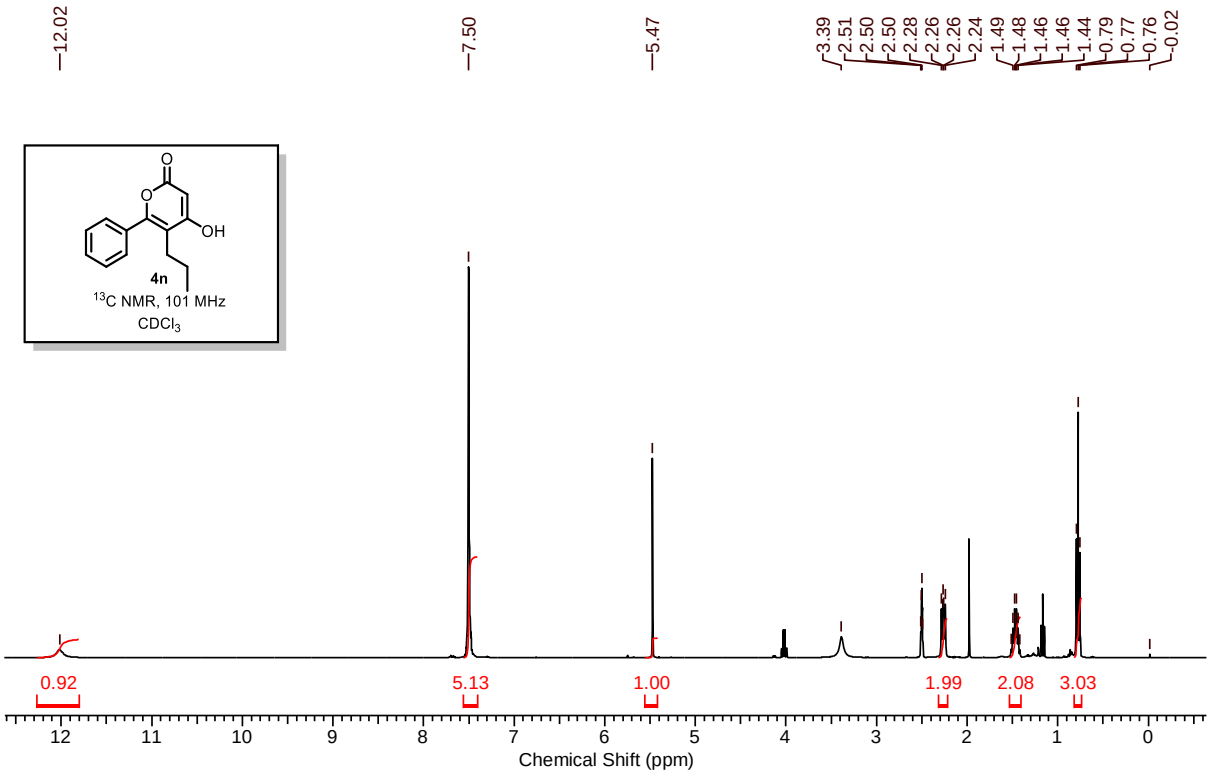


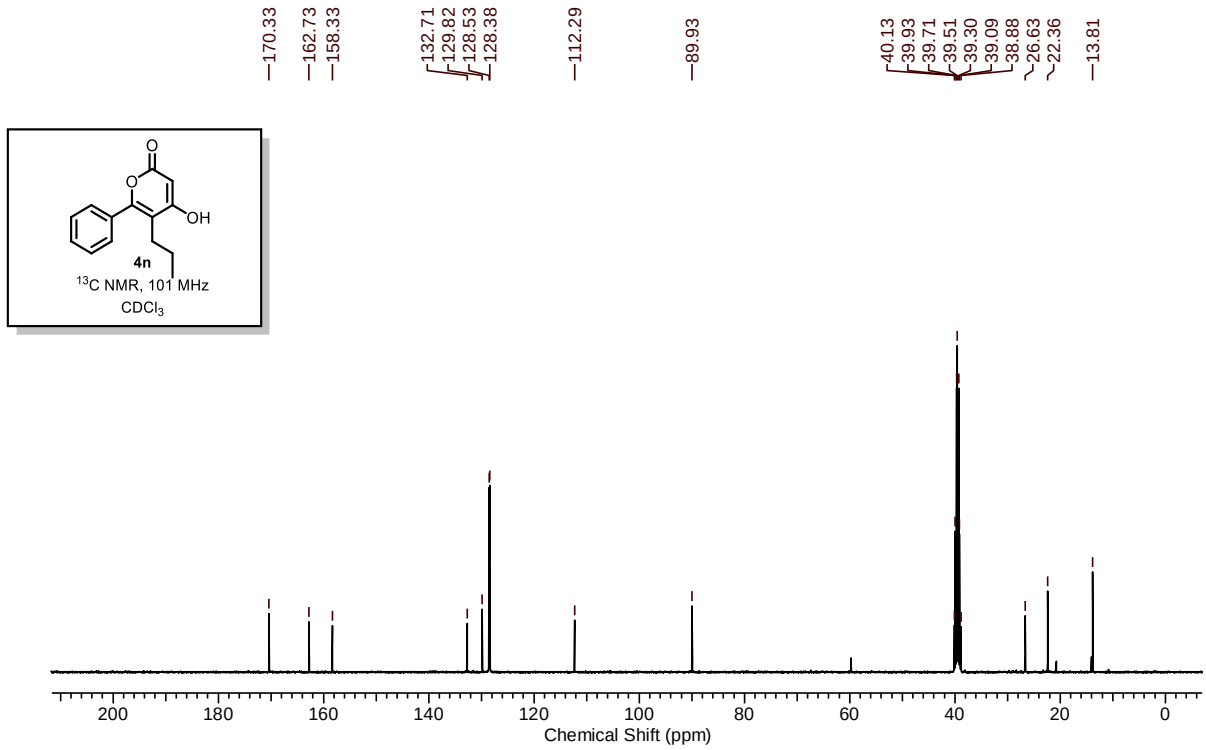
1-Phenyl-2-propylbutane-1,3-dione (S50):



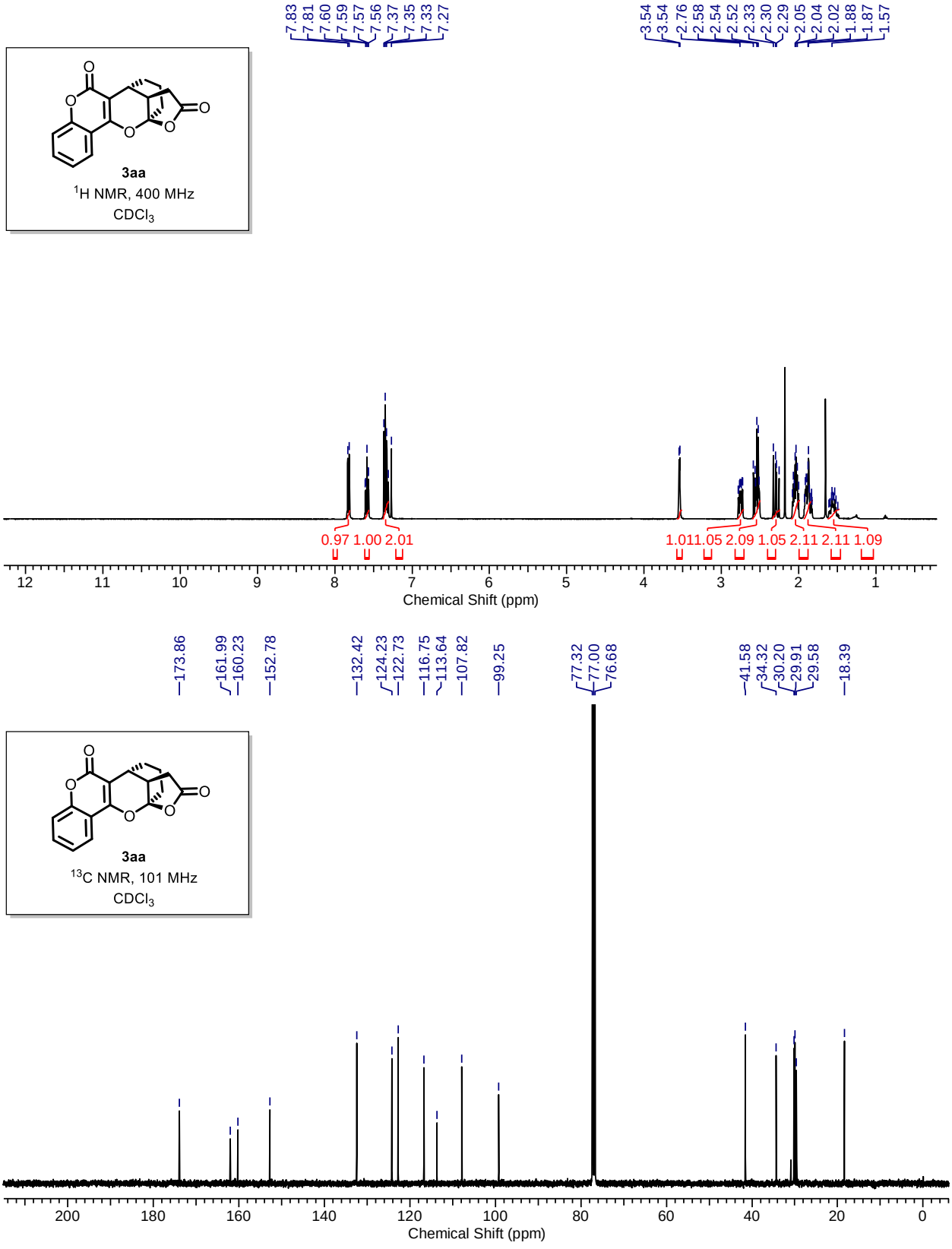


4-Hydroxy-6-phenyl-5-propyl-2*H*-pyran-2-one (4m):

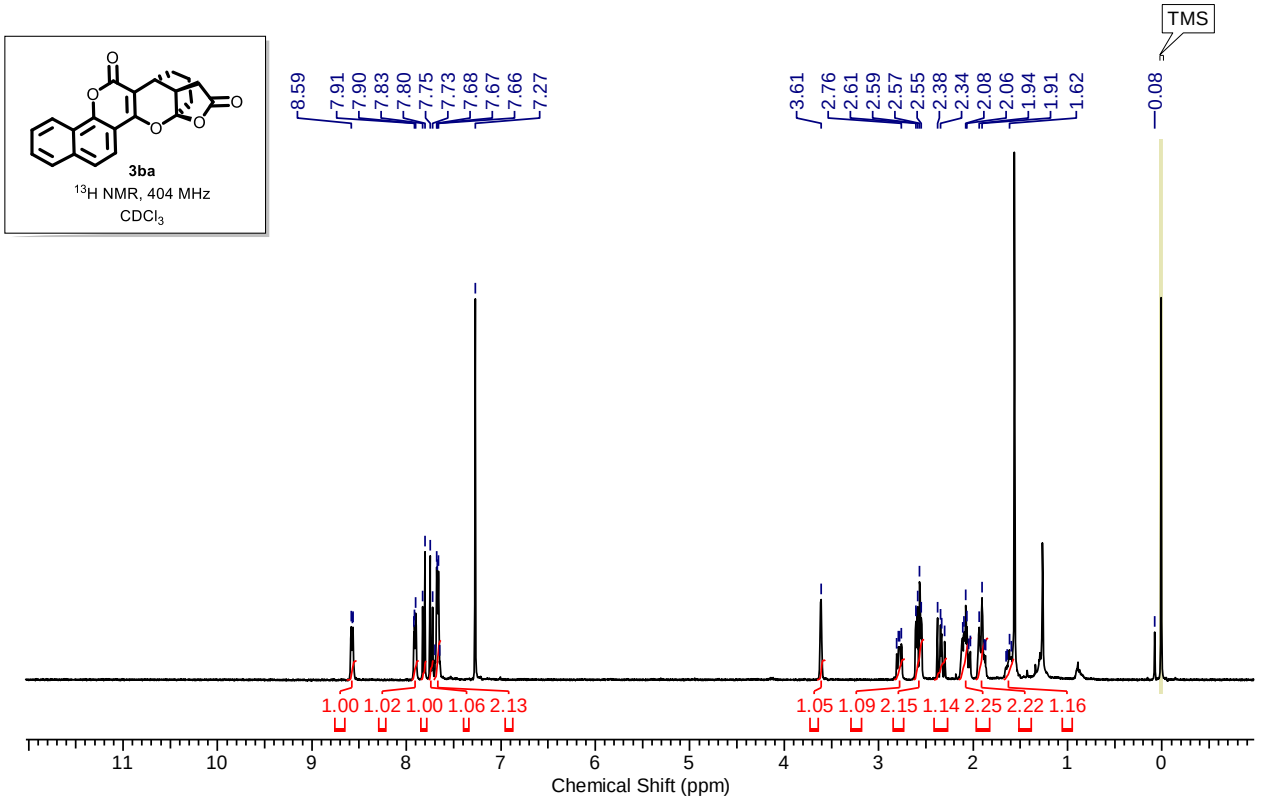


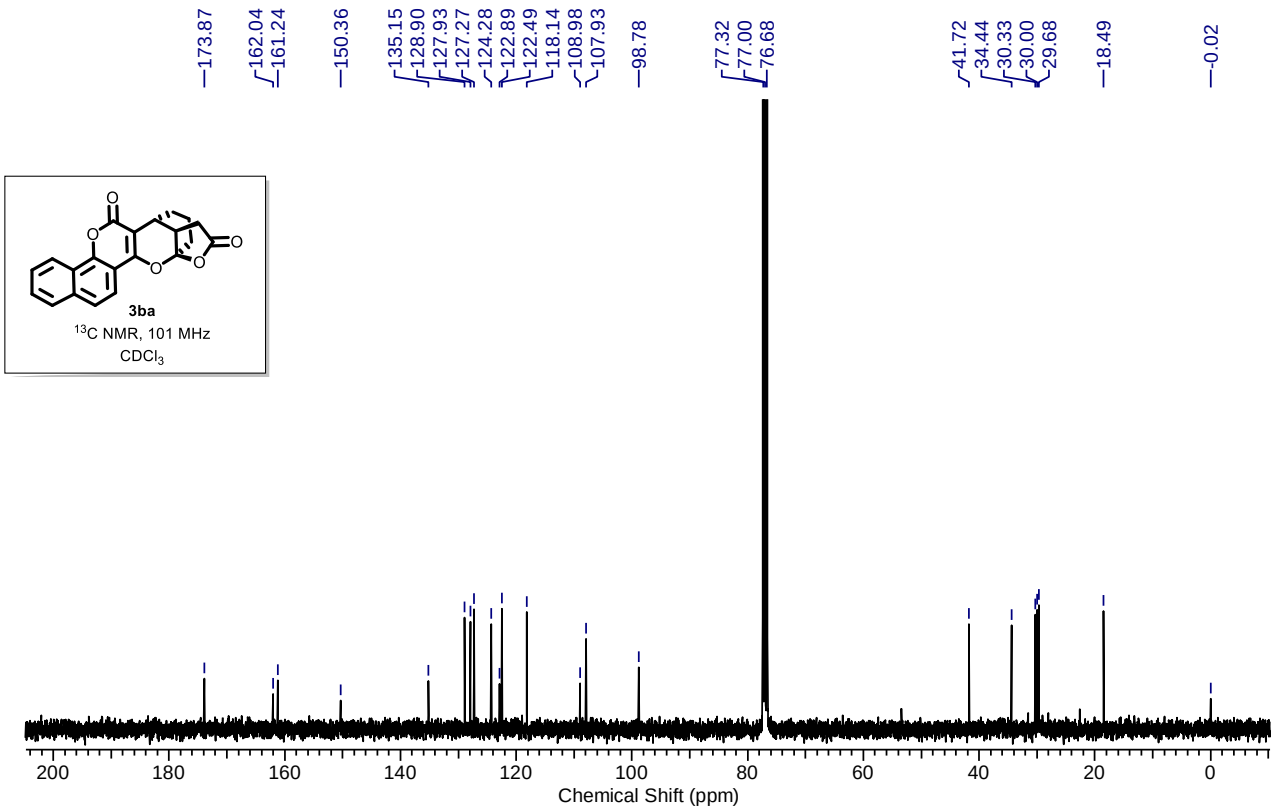


7a,8-Dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-*c*]chromene-6,9(7*H*)-dione (3aa):

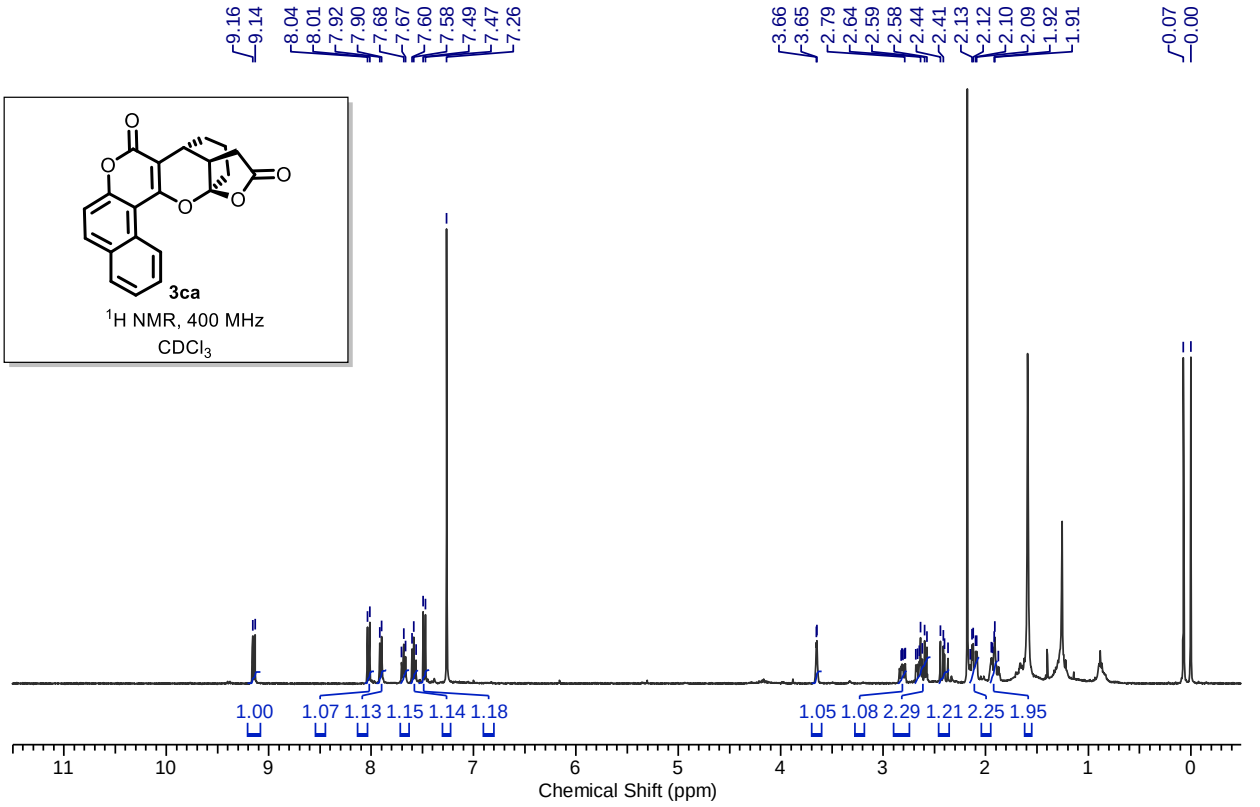


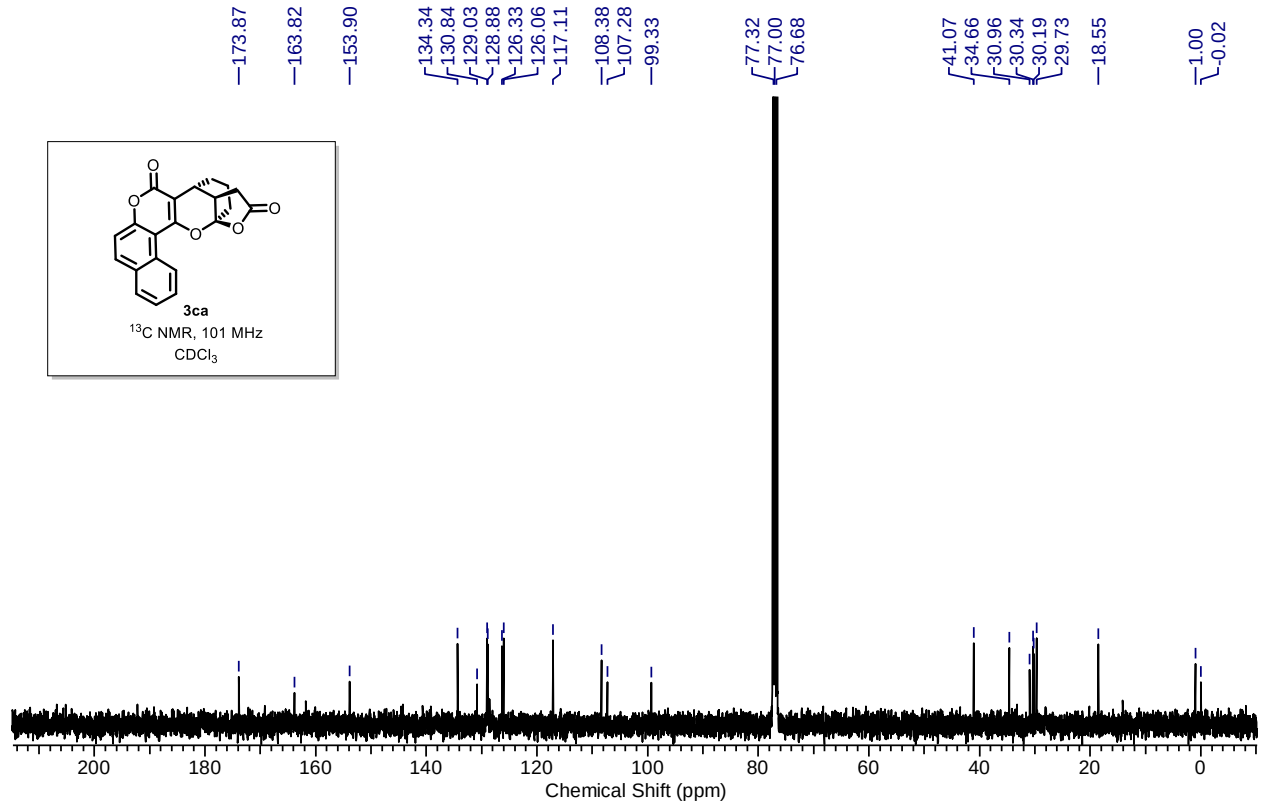
7a,8-Dihydro-6*H*-7,10a-propanobenzo[h]furo[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione (3ba)



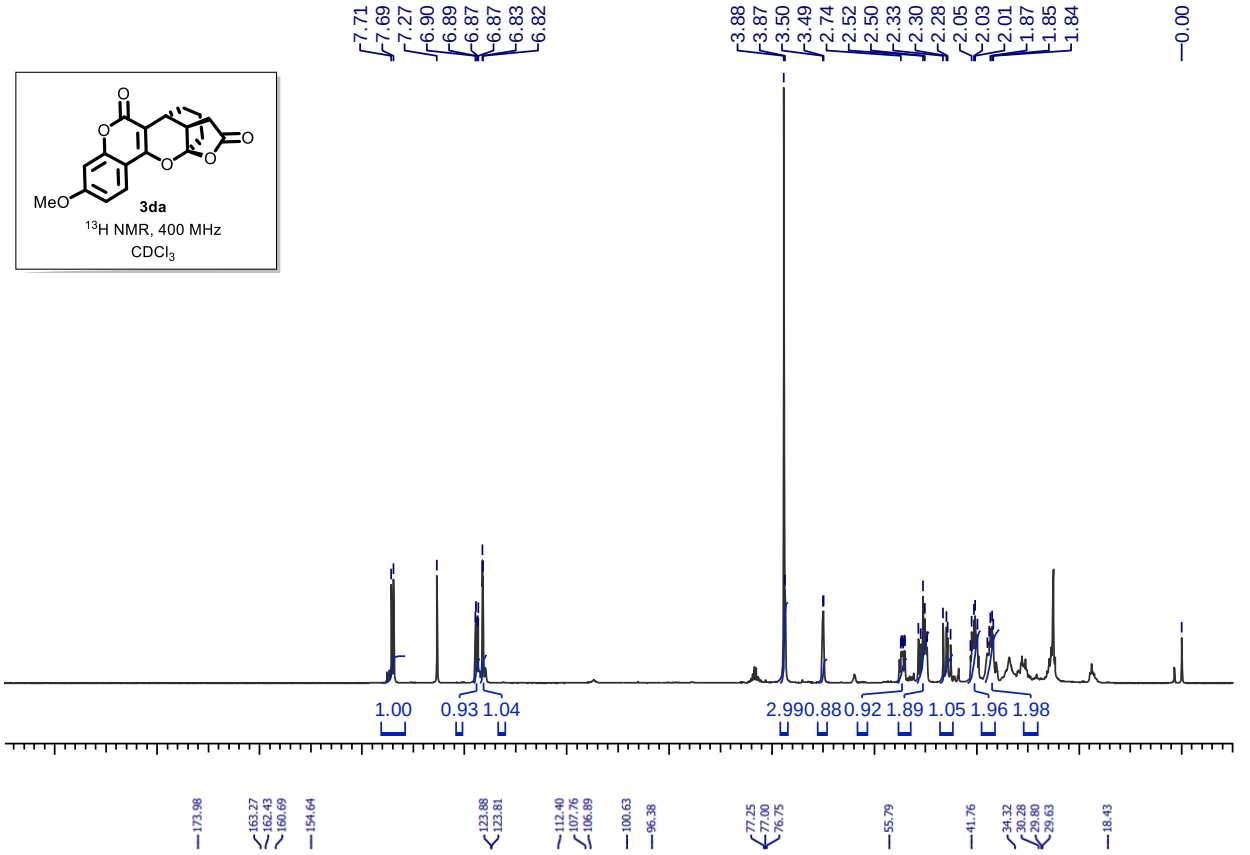


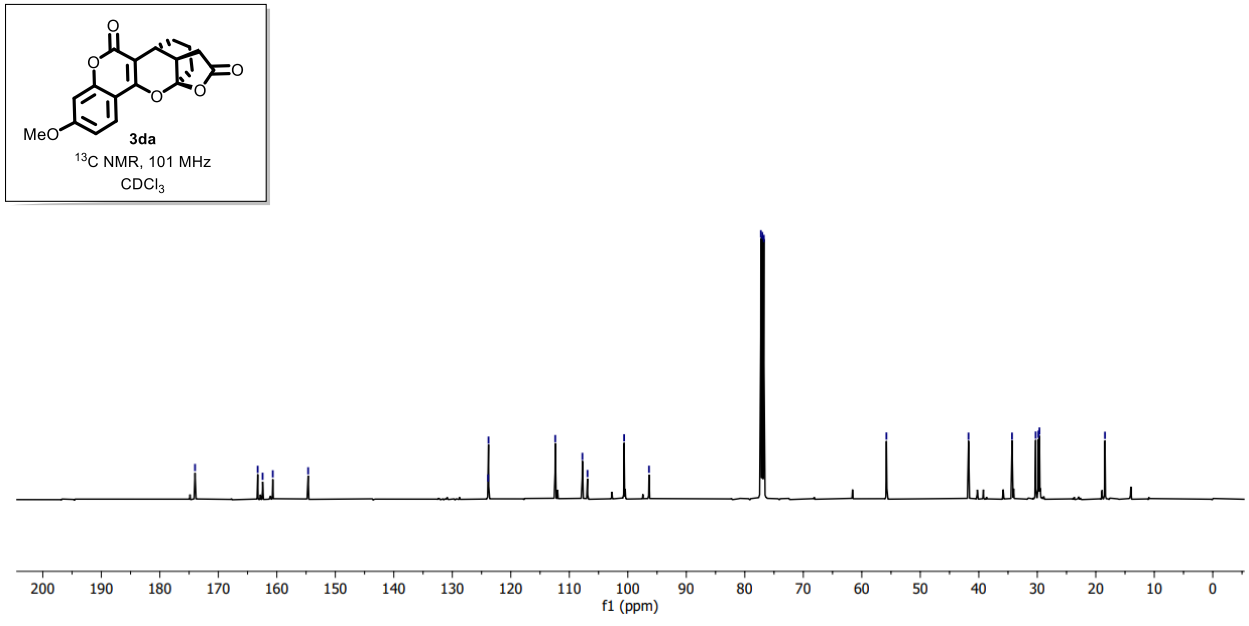
9a,10-Dihydro-8*H*-9,12a-propanobenzo[f]furo[3',2':5,6]pyrano[3,2-c]chromene-8,11(9*H*)-dione(3ca):



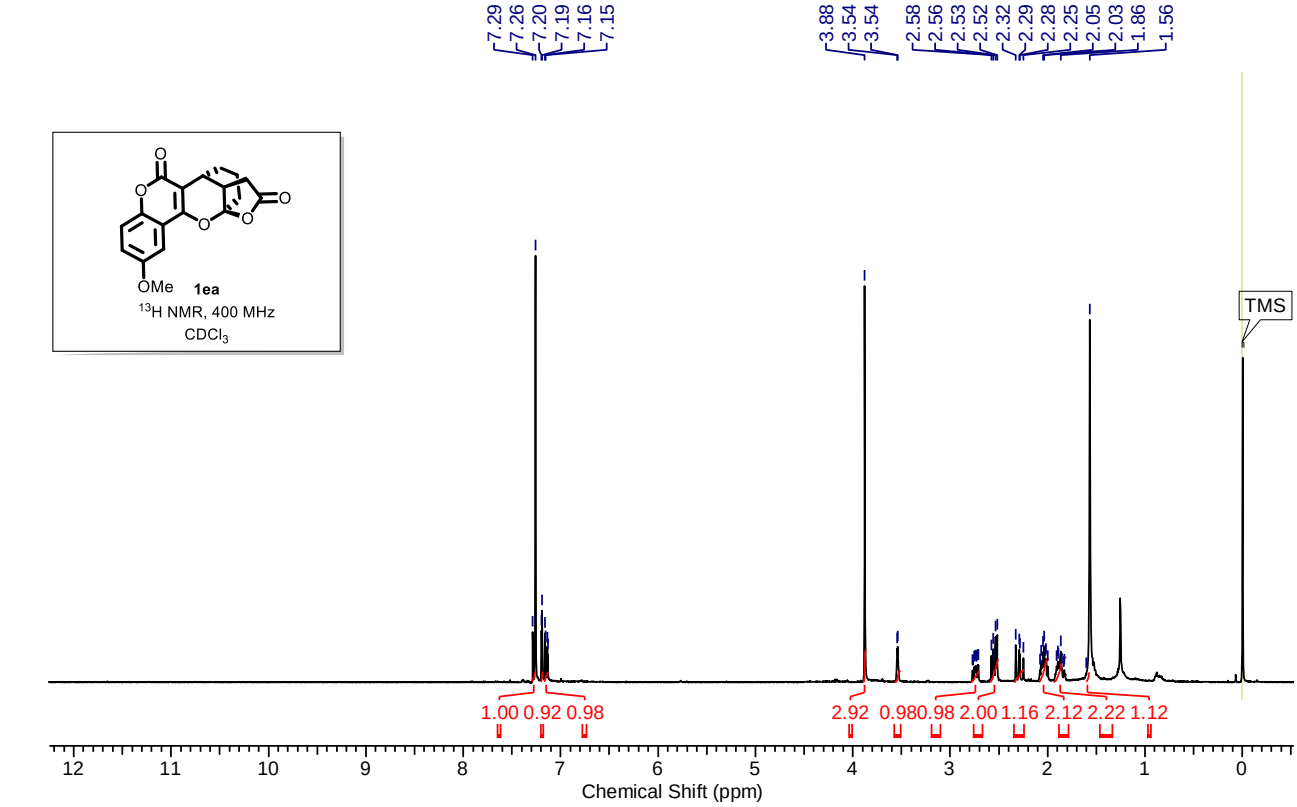


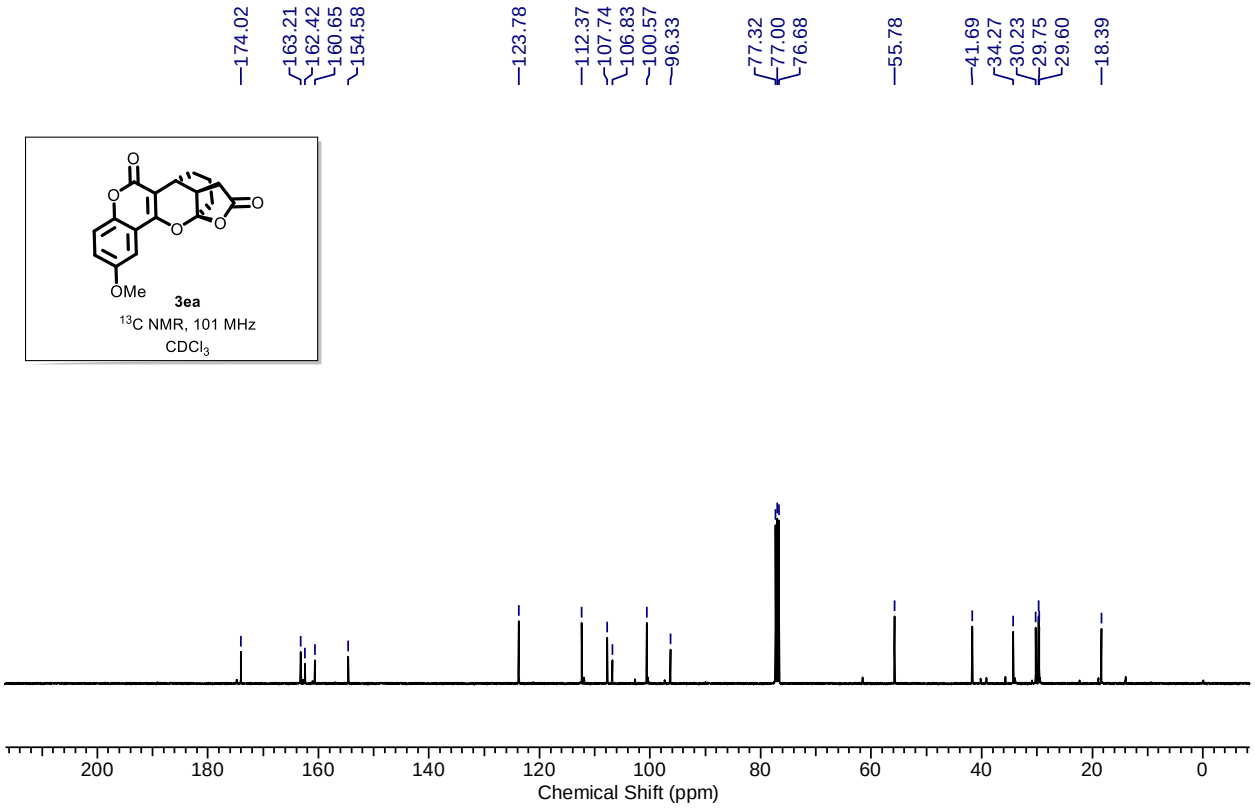
3-Methoxy-7a,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione (3da):



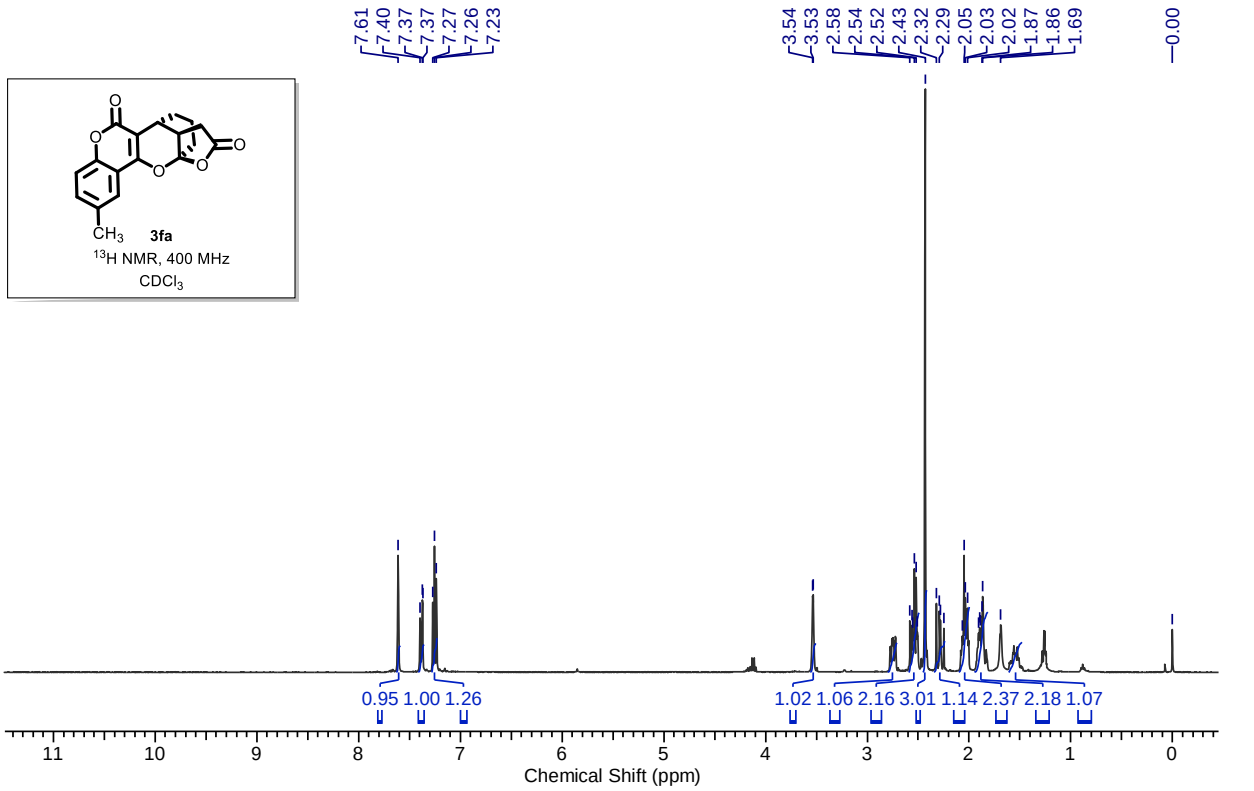


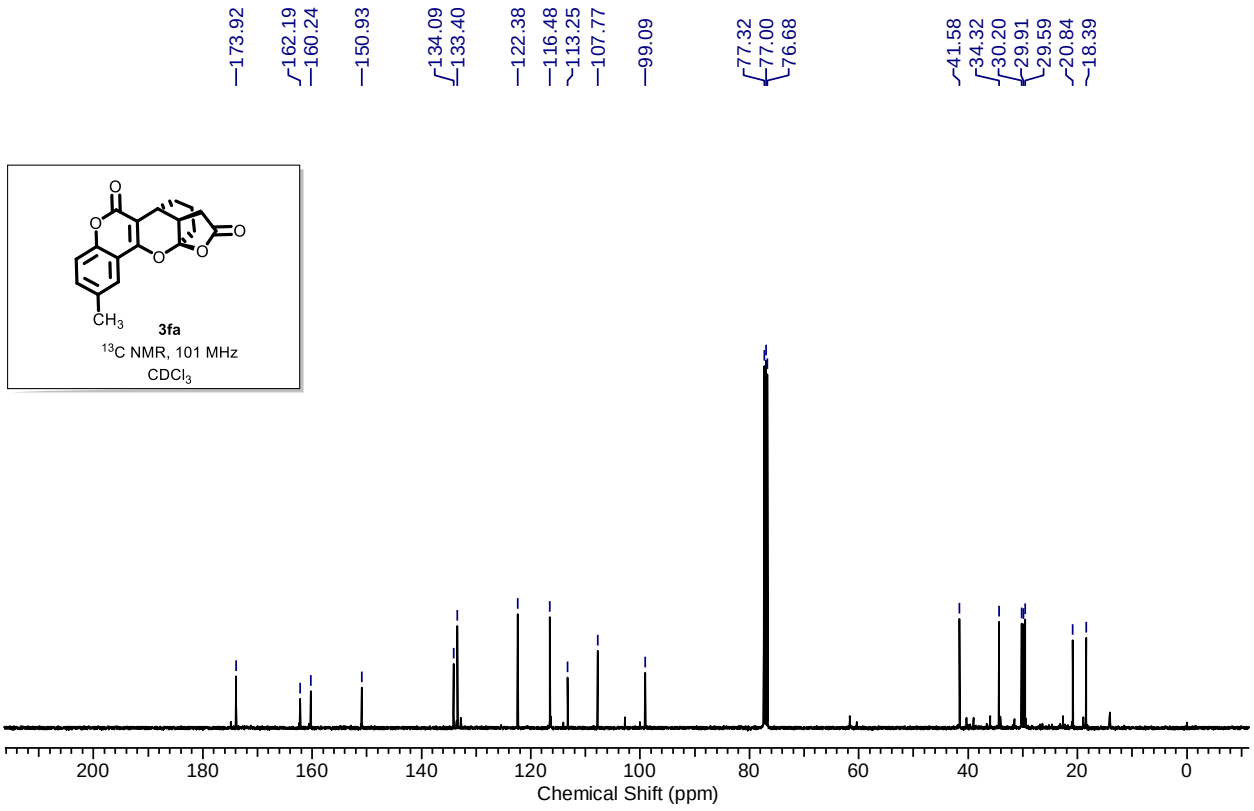
2-Methoxy-7a,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione (3ea):



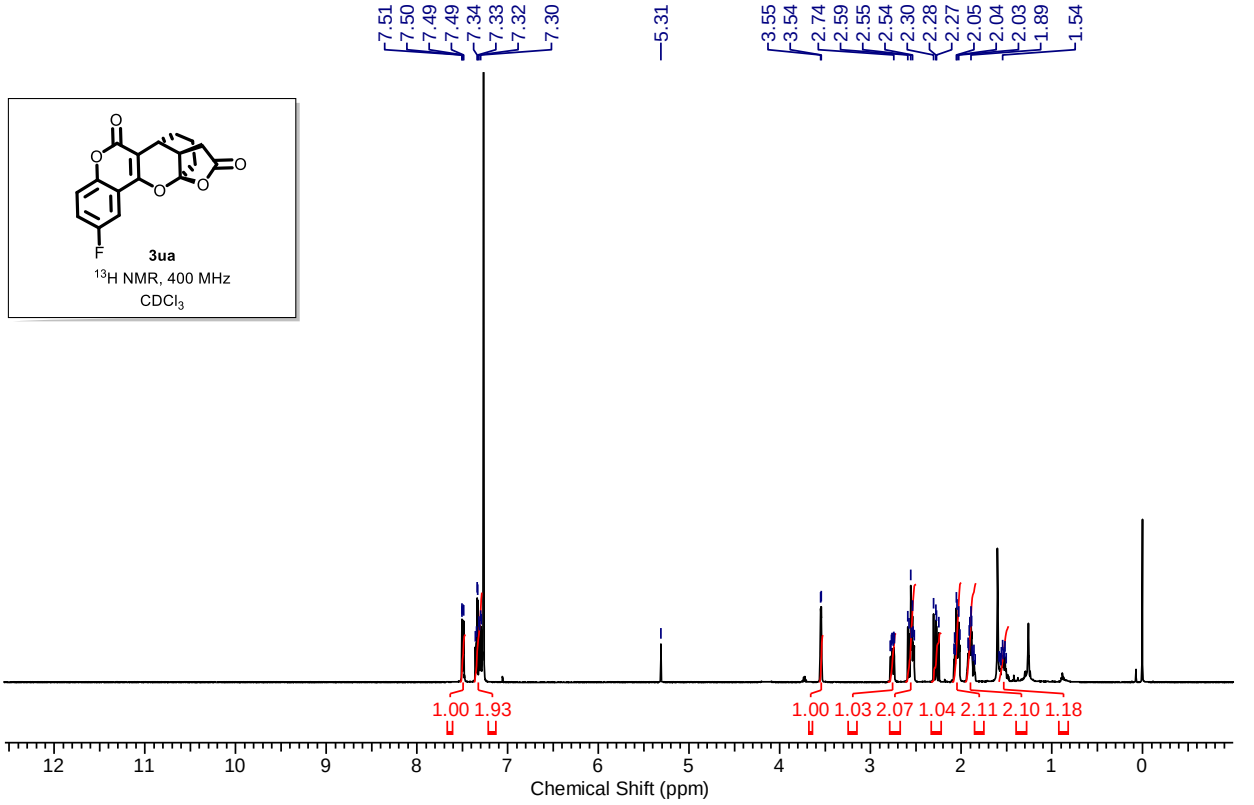


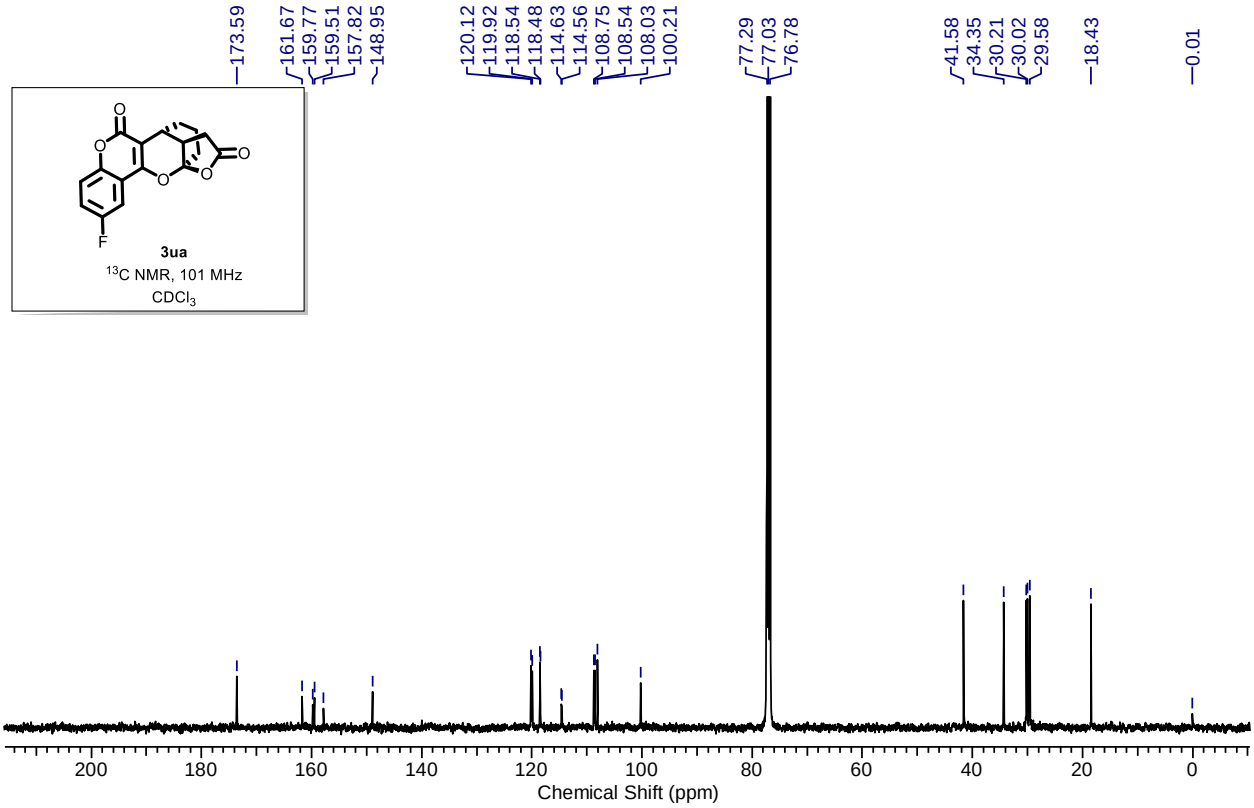
2-Methyl-7*a*,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-*c*]chromene-6,9(7*H*)-dione (3fa):

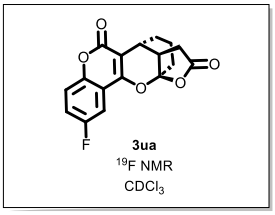




2-Fluoro-7a,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-c]chromene-6,9(7*H*)-dione(3ua)

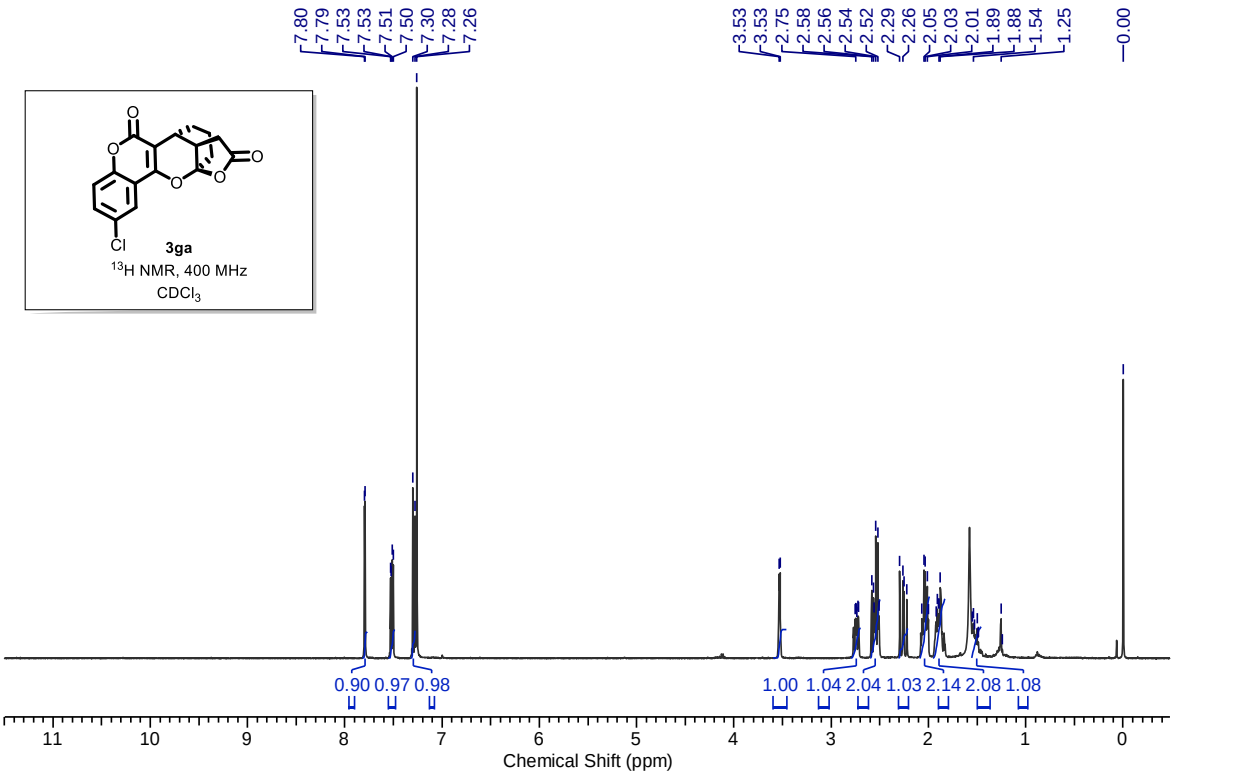


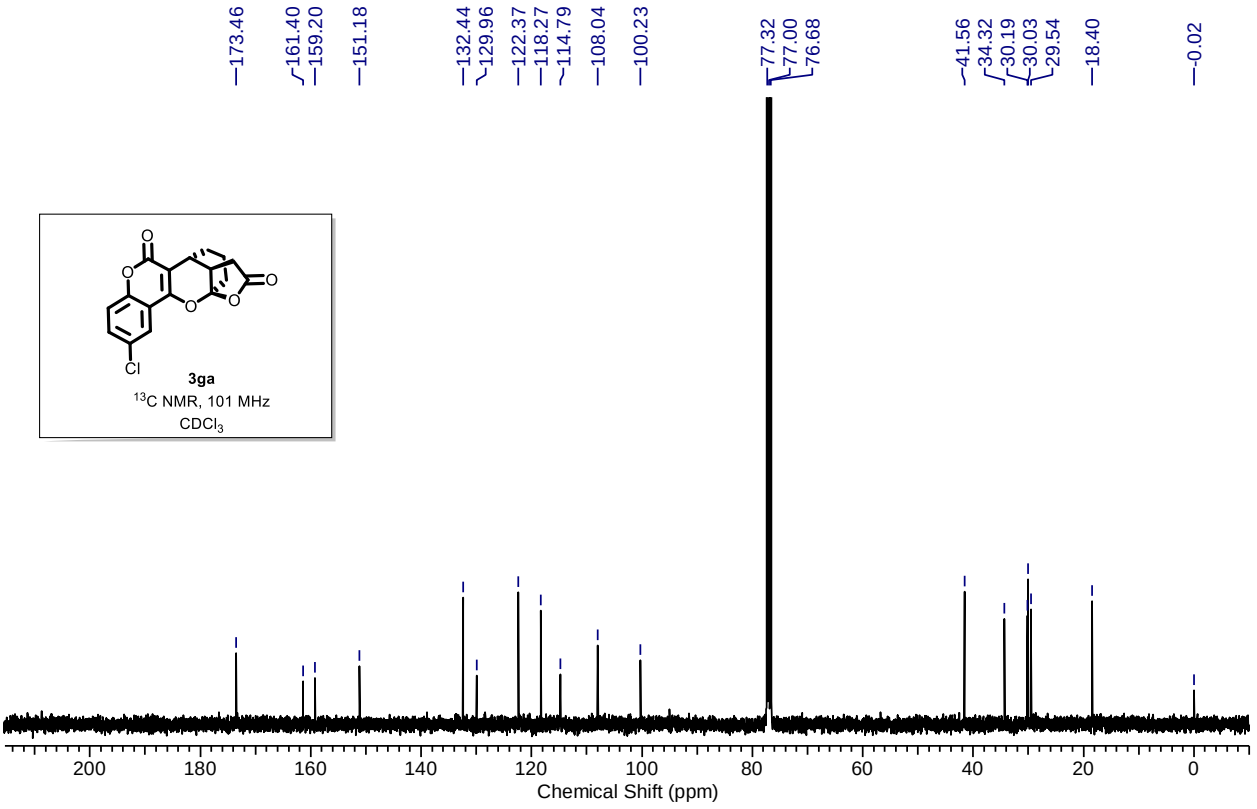



3ua
19F NMR
CDCl3

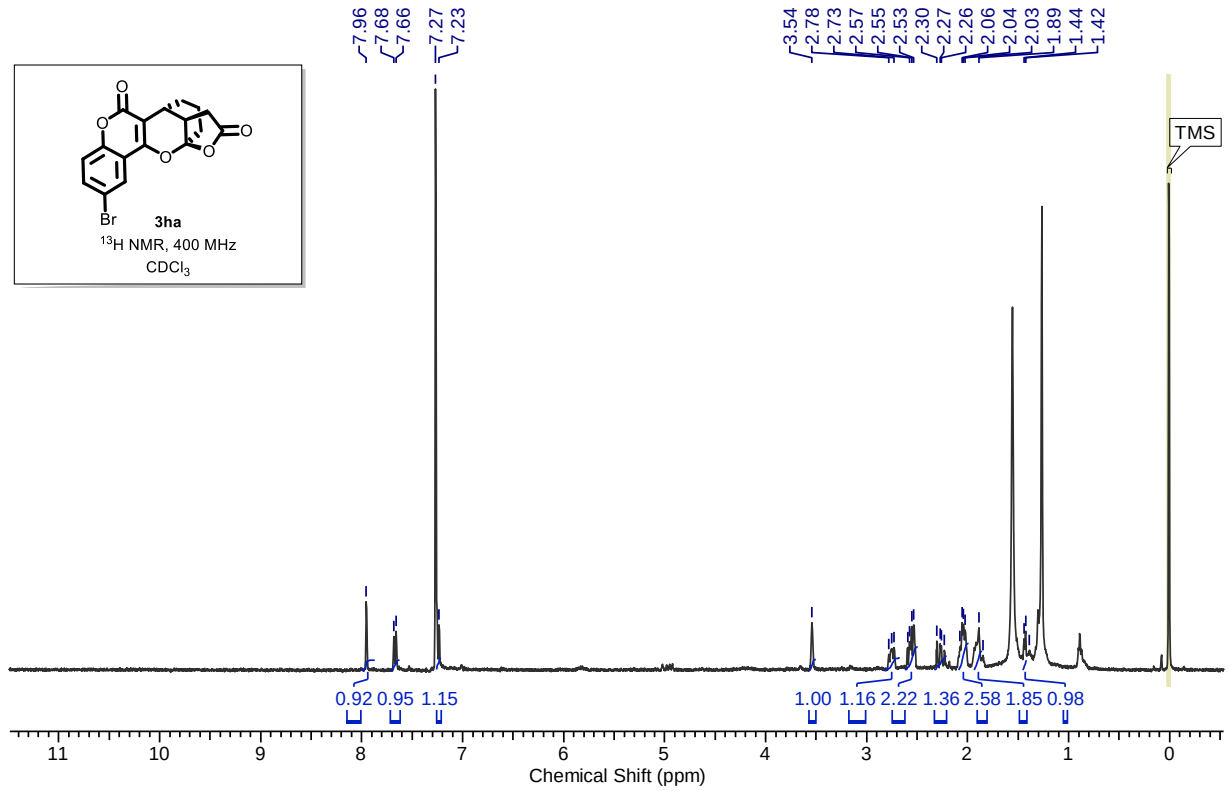
-116.29
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

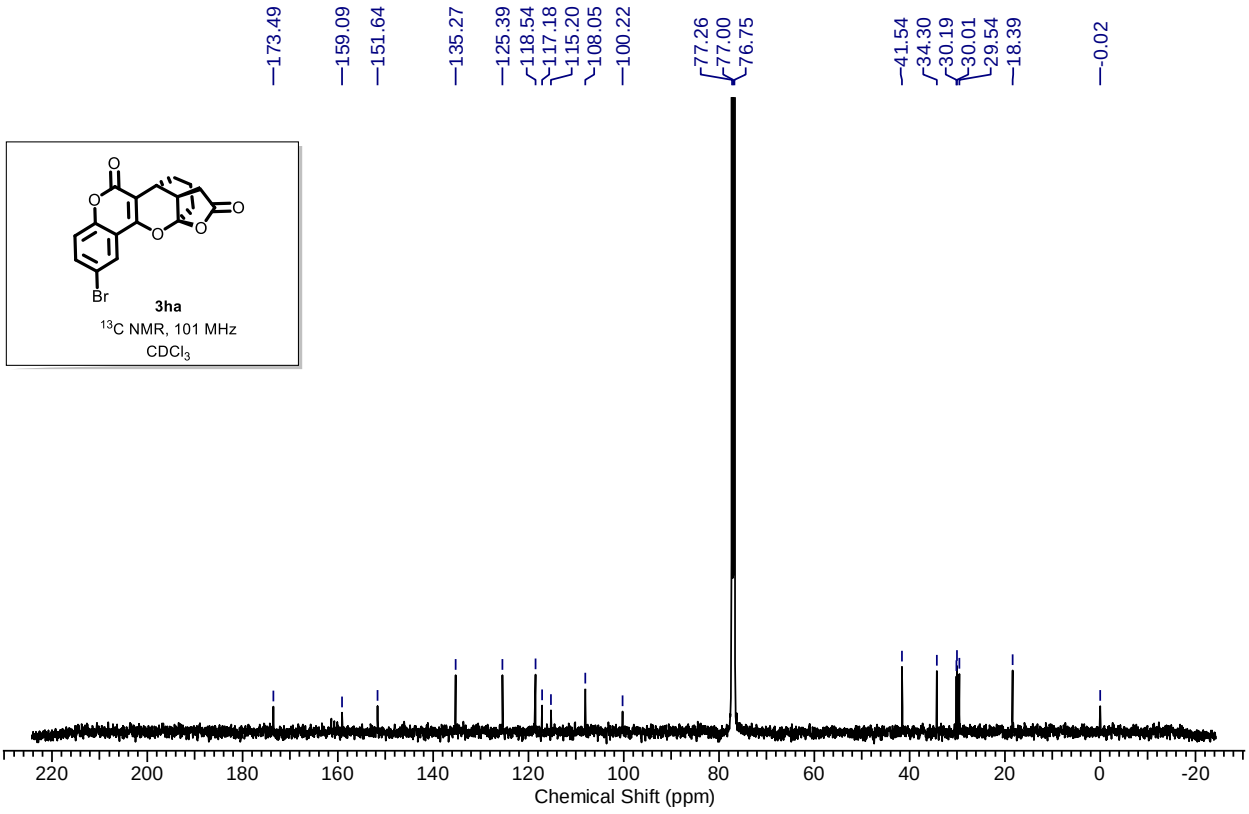
2-Chloro-7a,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-*c*]chromene-6,9(7*H*)-dione (3ga)



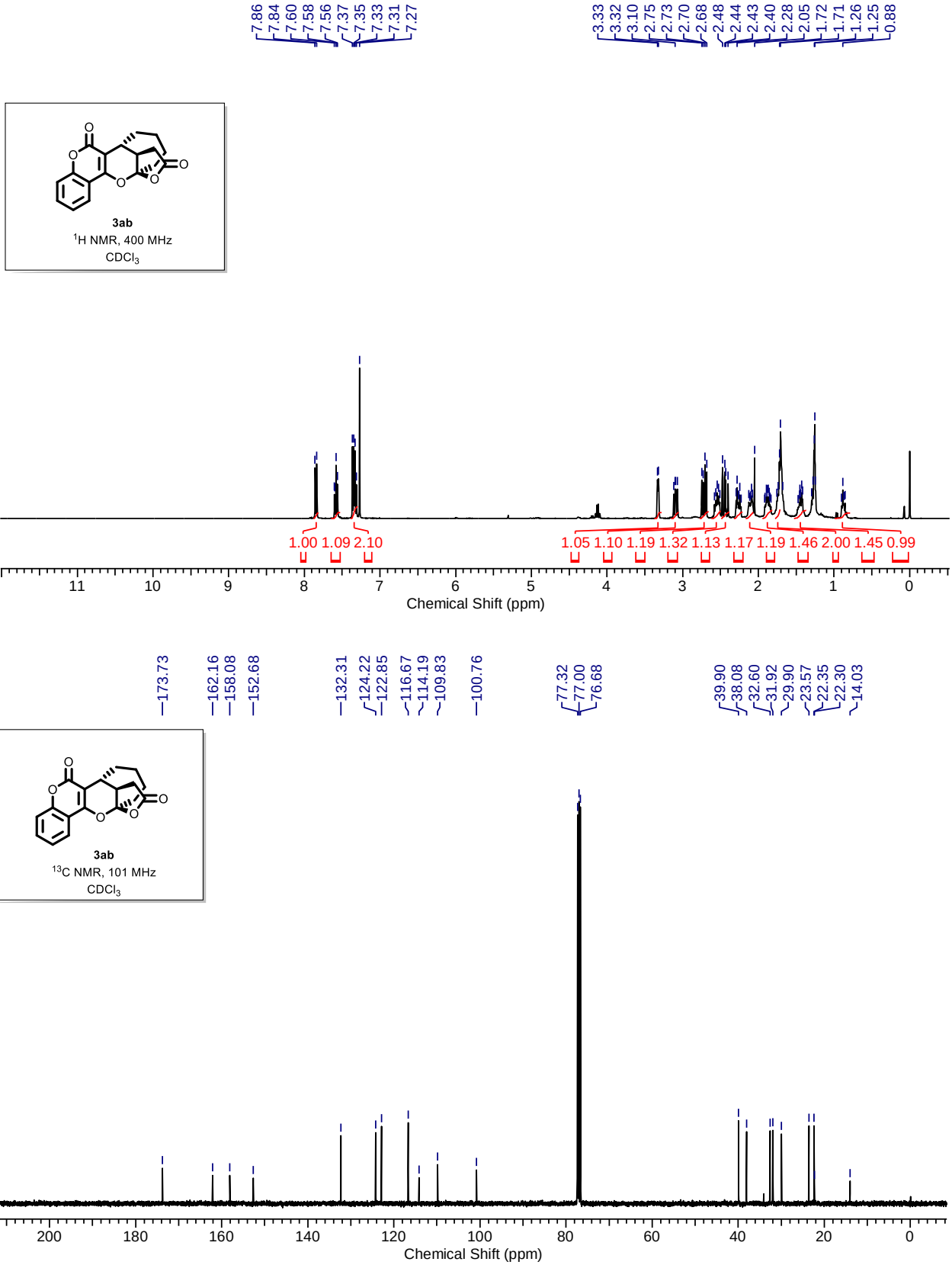


2-Bromo-7a,8-dihydro-6*H*-7,10a-propanofuro[3',2':5,6]pyrano[3,2-*c*]chromene-6,9(7*H*)-dione (3ha)

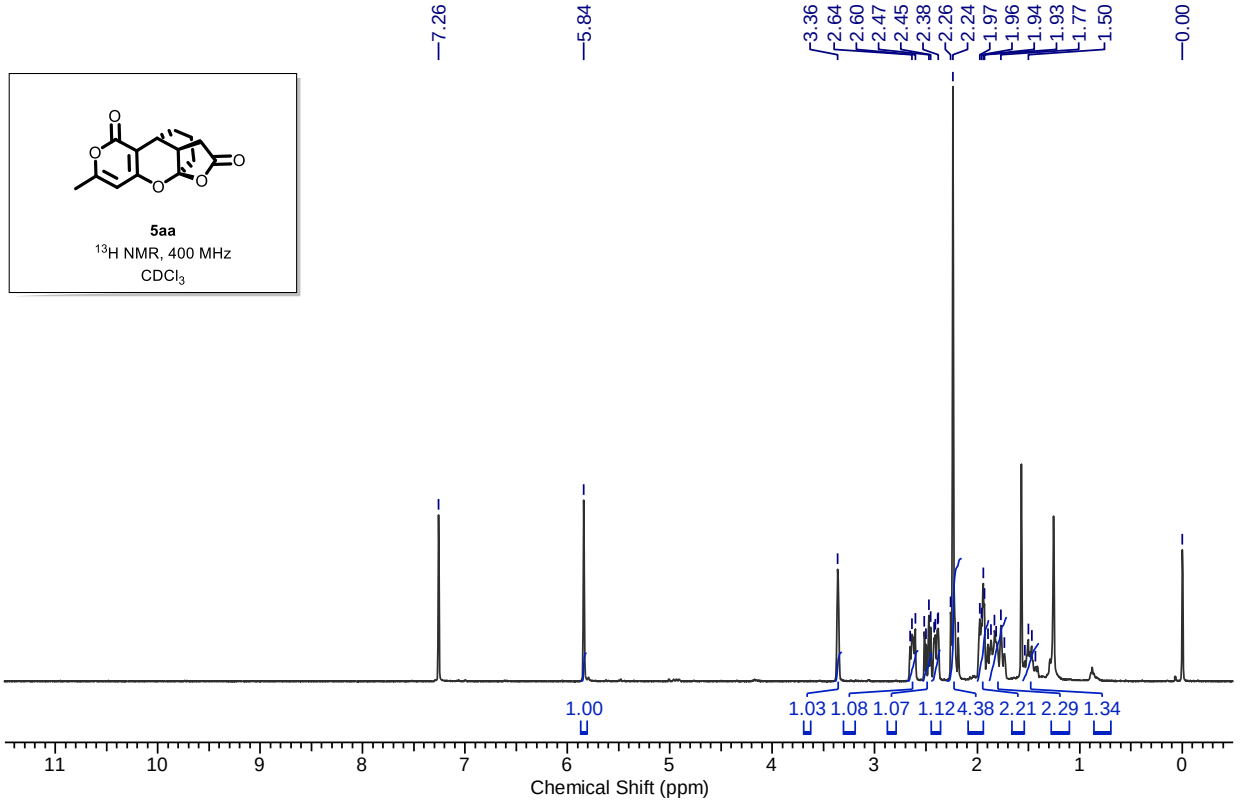


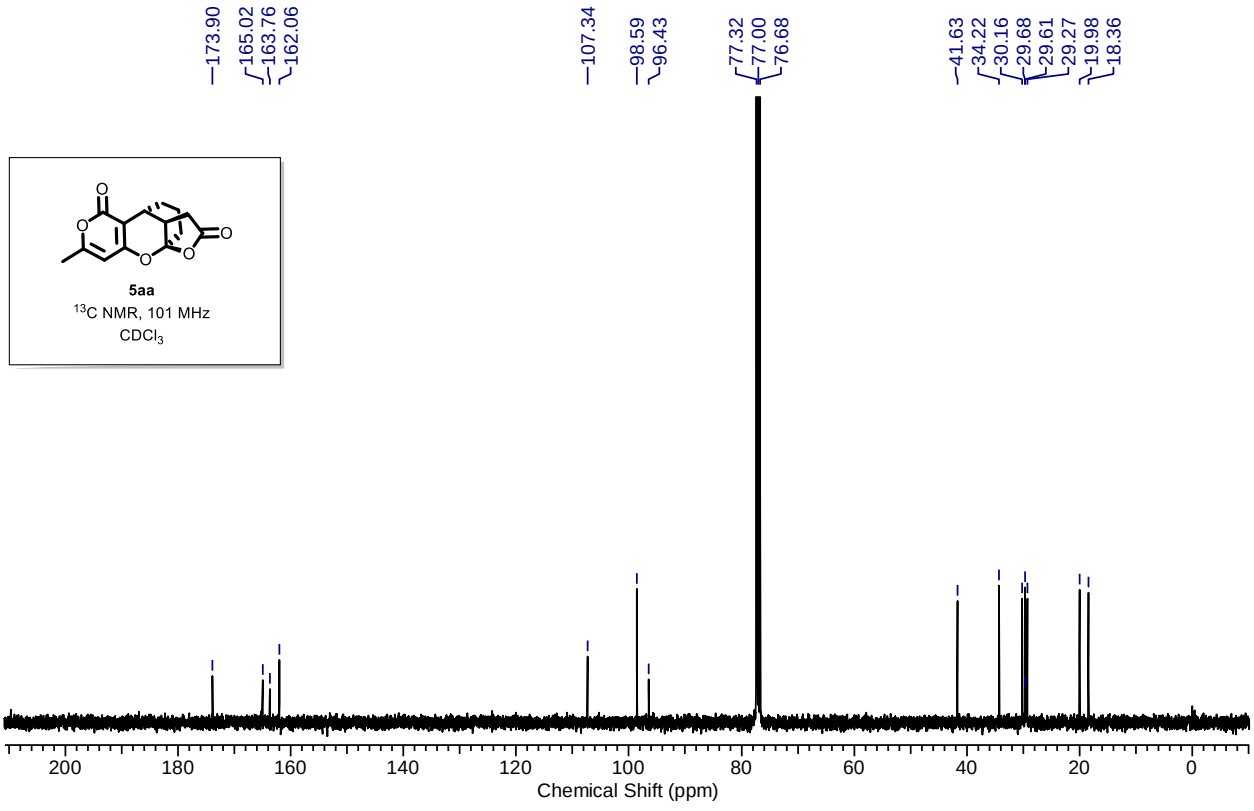


7*a*,8-Dihydro-6*H*-7,10*a*-butanofuro[3',2':5,6]pyrano[3,2-*c*]chromene-6,9(7*H*)-dione (3ab):

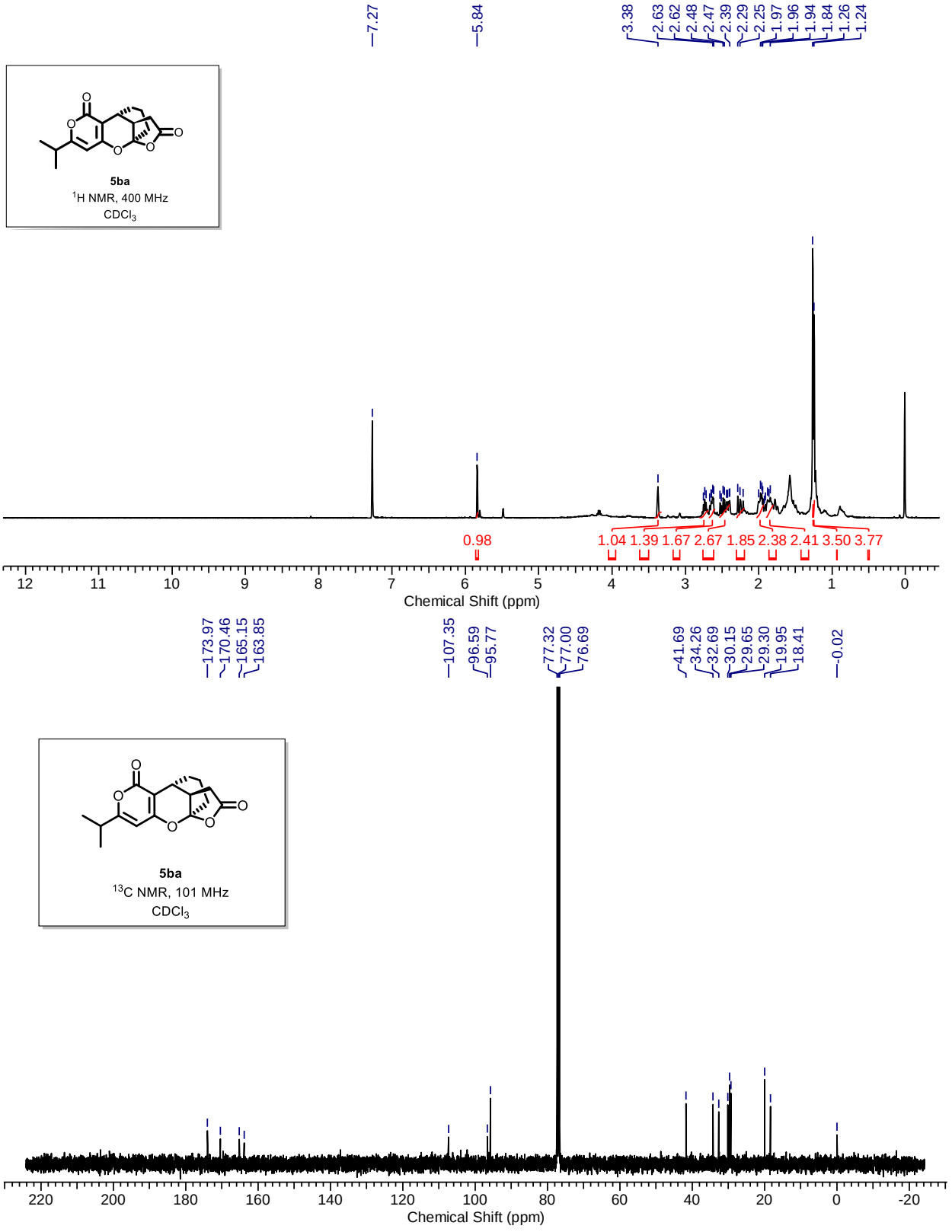


7-Methyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-*b*]pyrano[3,4-*e*]pyran-2,5(3*H*)-dione(5aa)

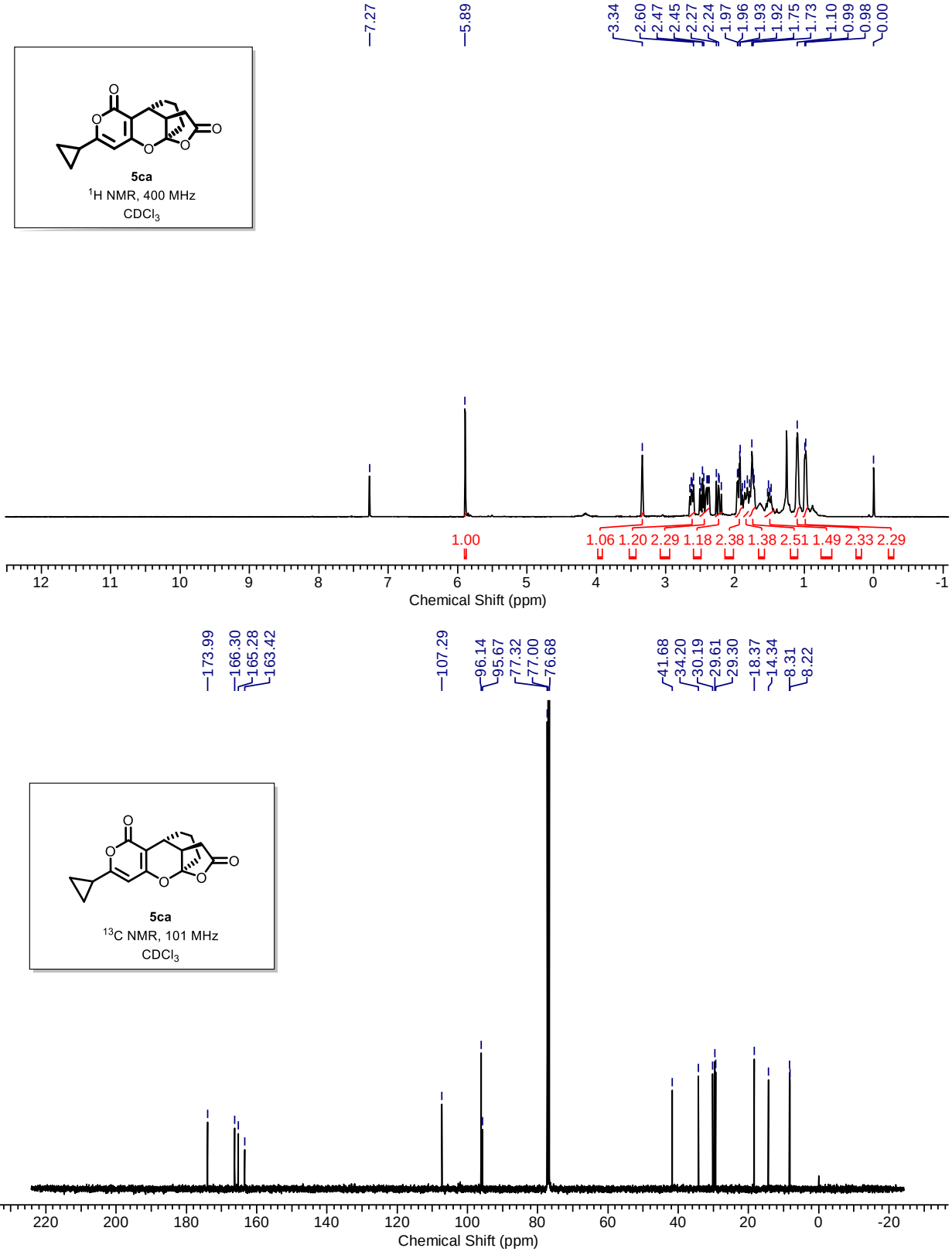




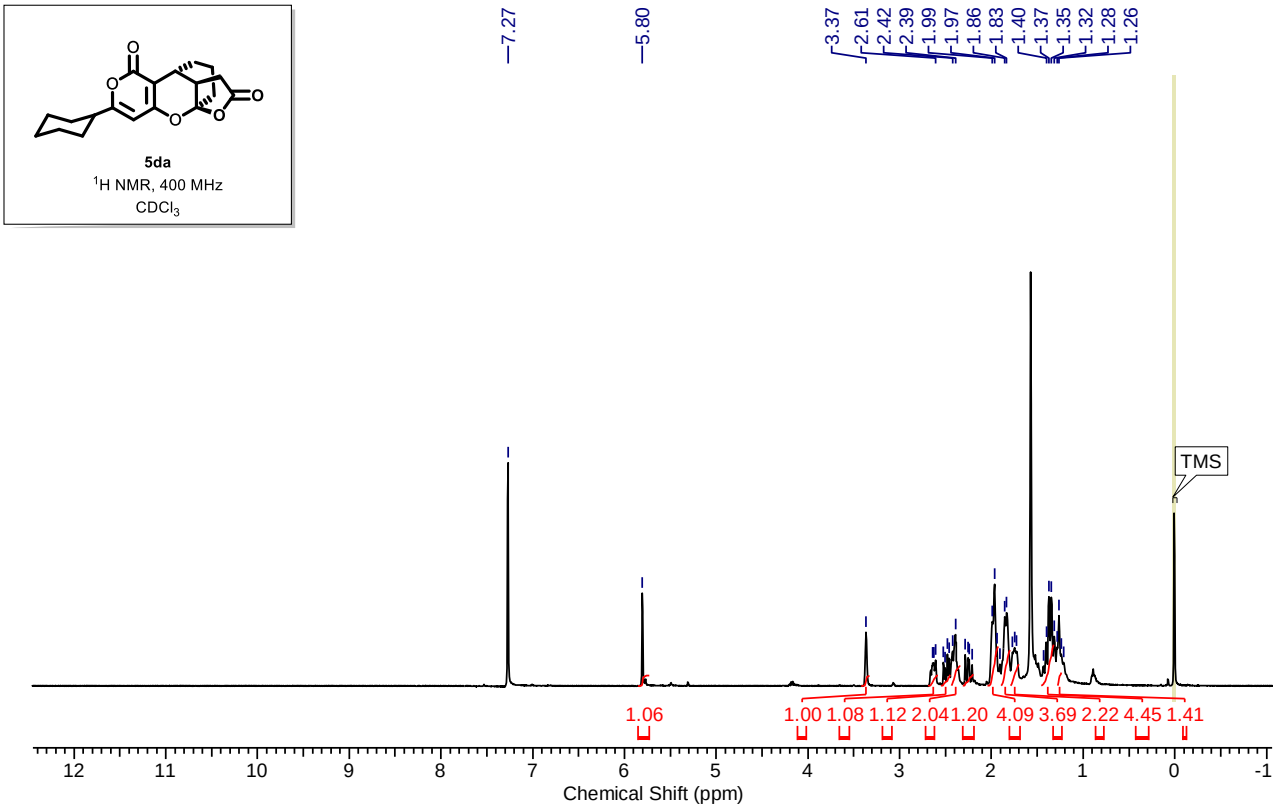
7-Isopropyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ba)

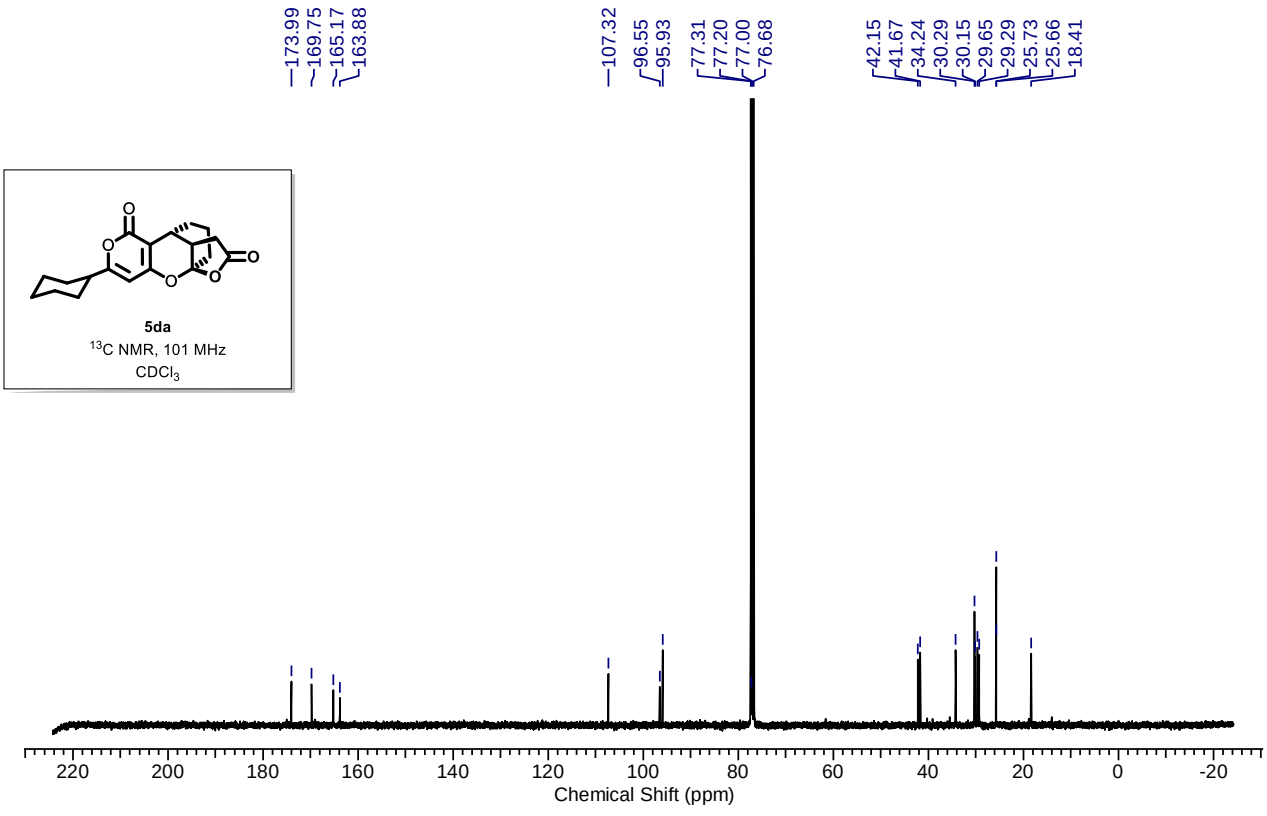


7-Cyclopropyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ca)

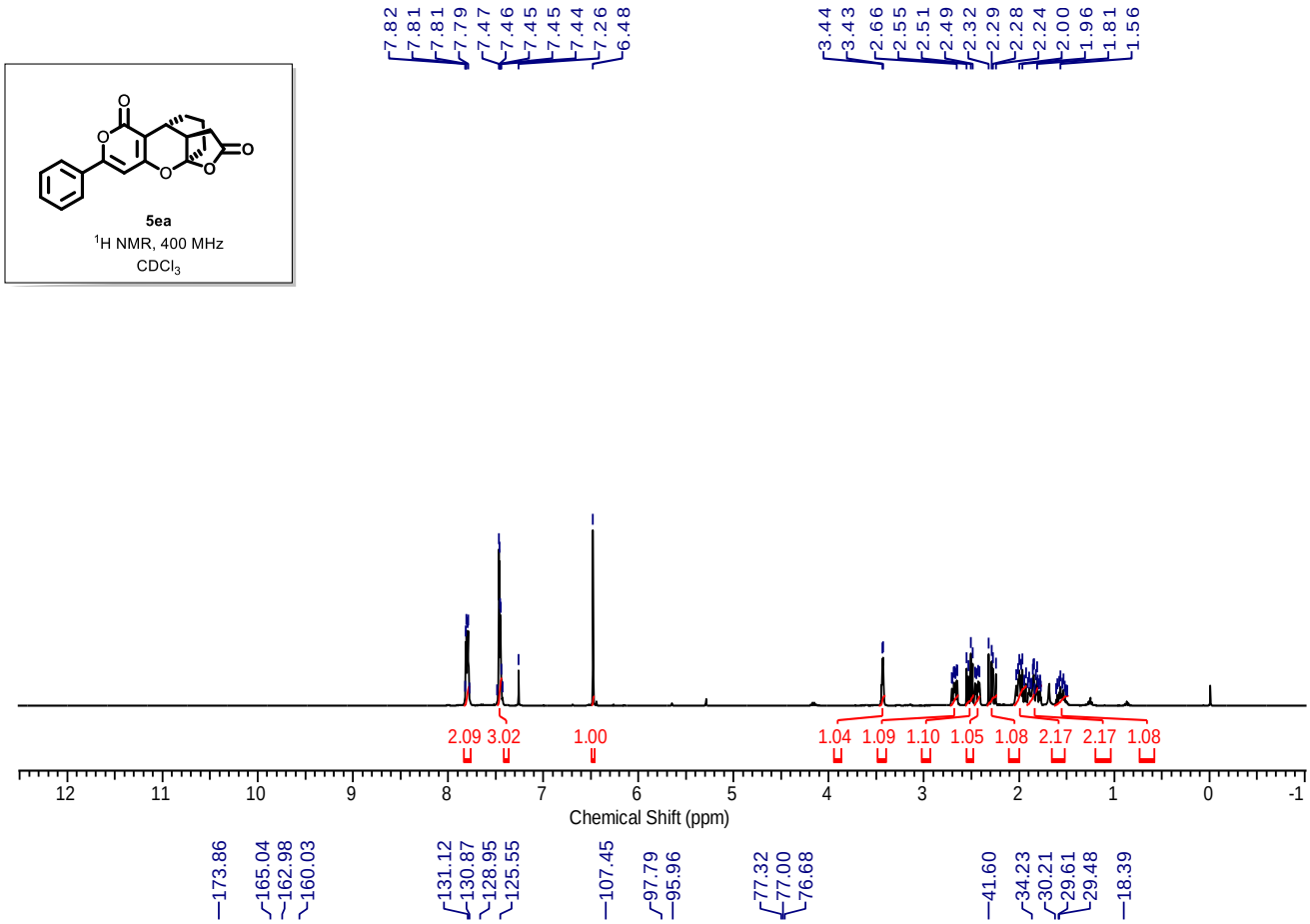


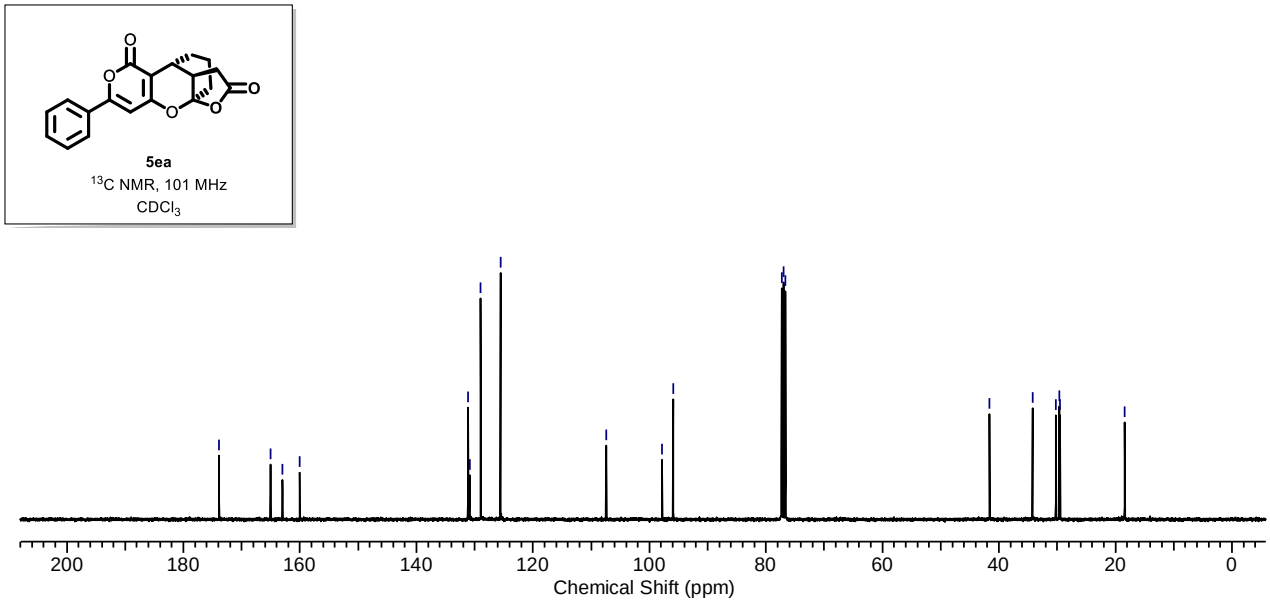
7-Cyclohexyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5da)





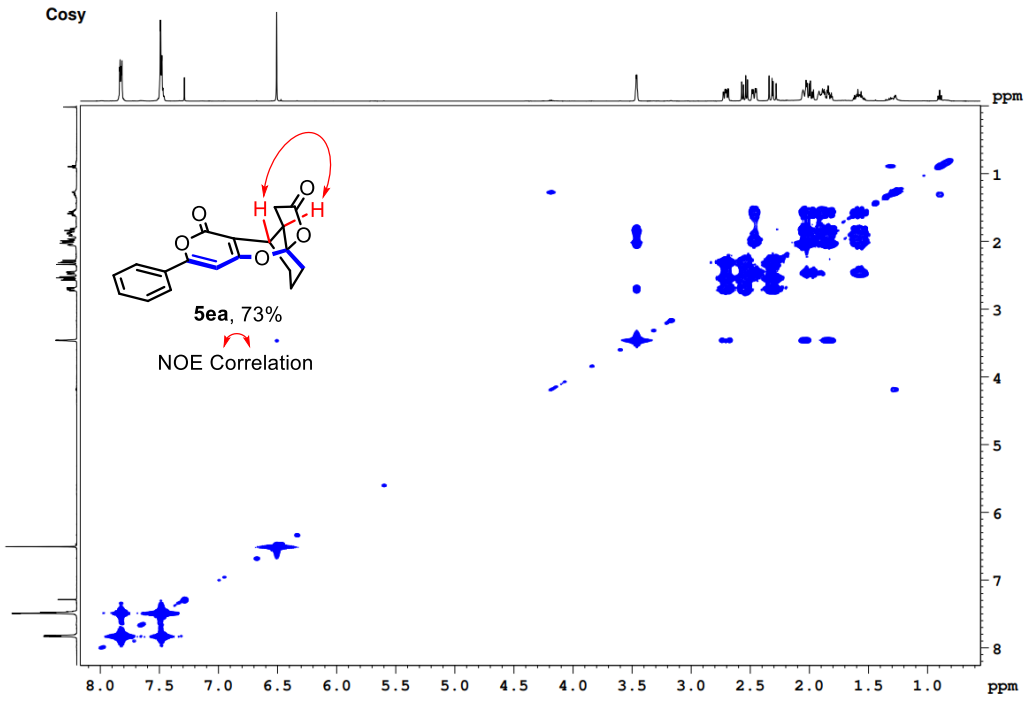
7-Phenyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ea)



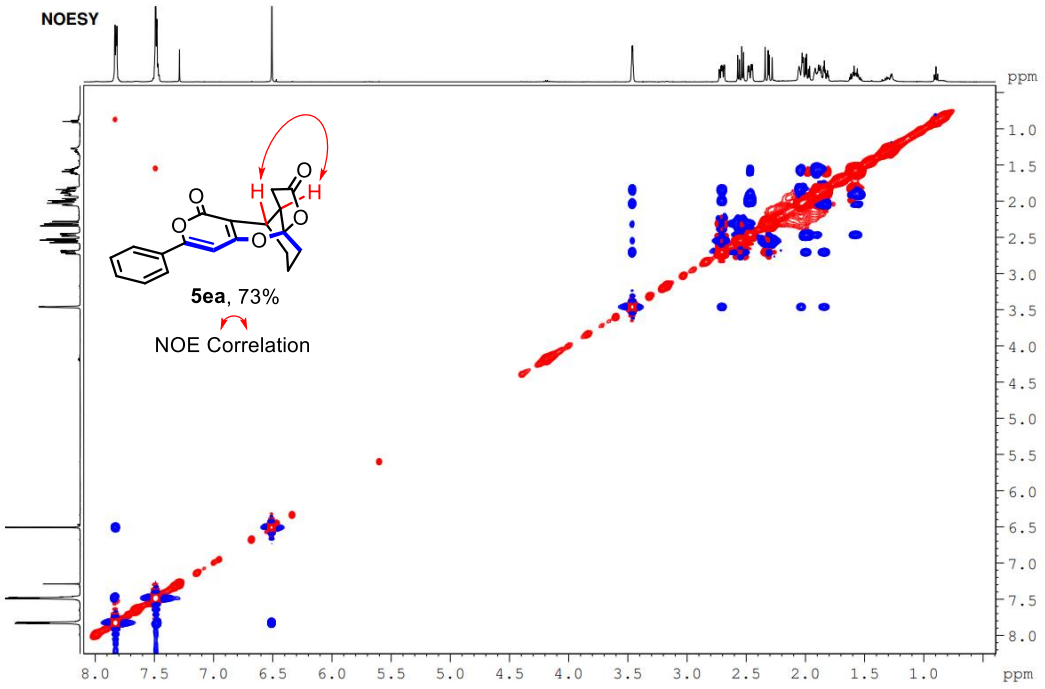


2D NMR for 7-Phenyl-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ea)

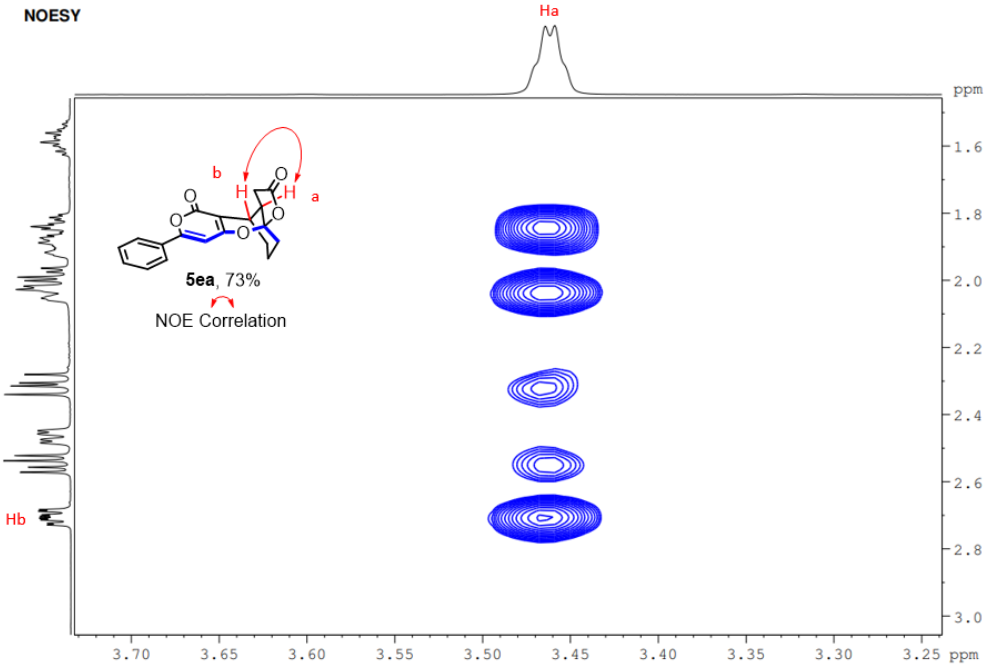
COSY of 5ea:



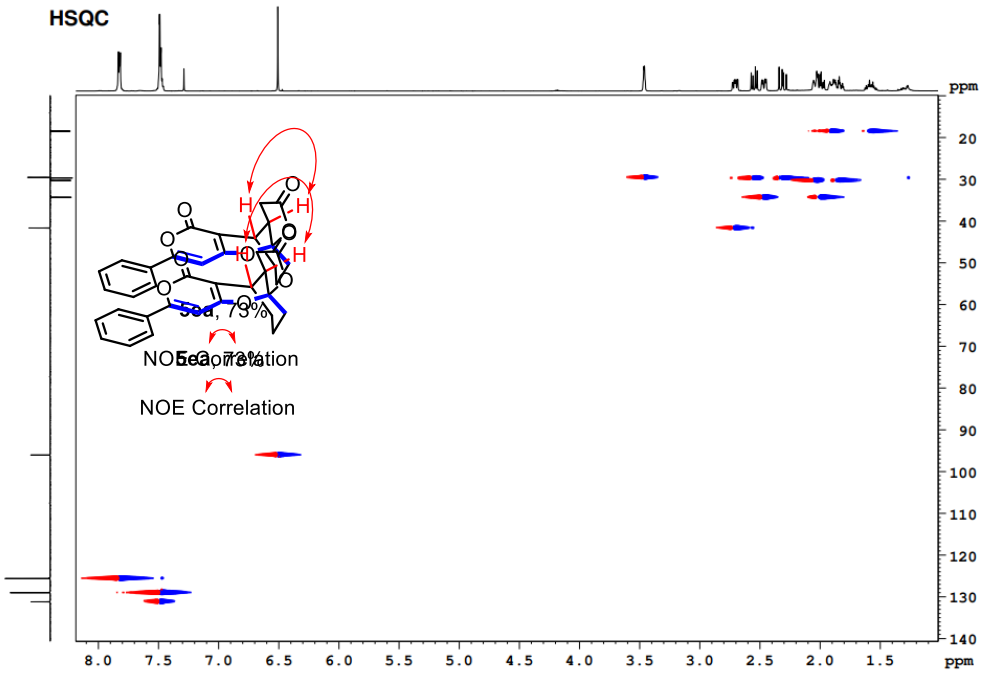
NOESY of 5ea:



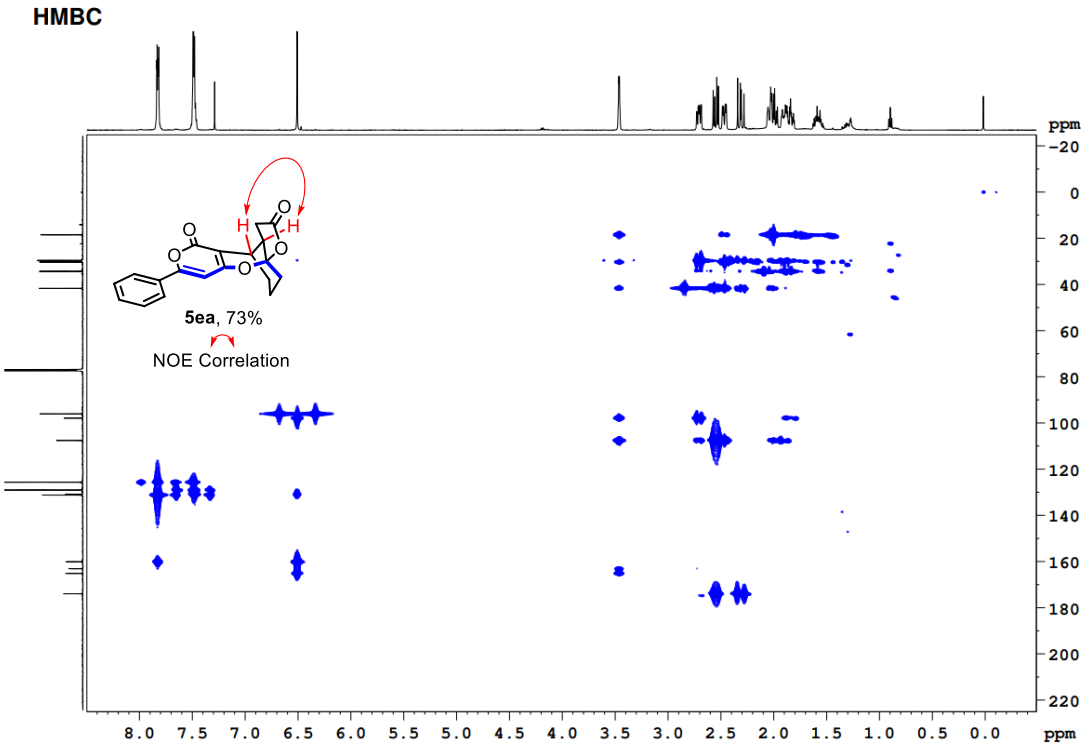
NOESY of 5ea (Zoomed in):



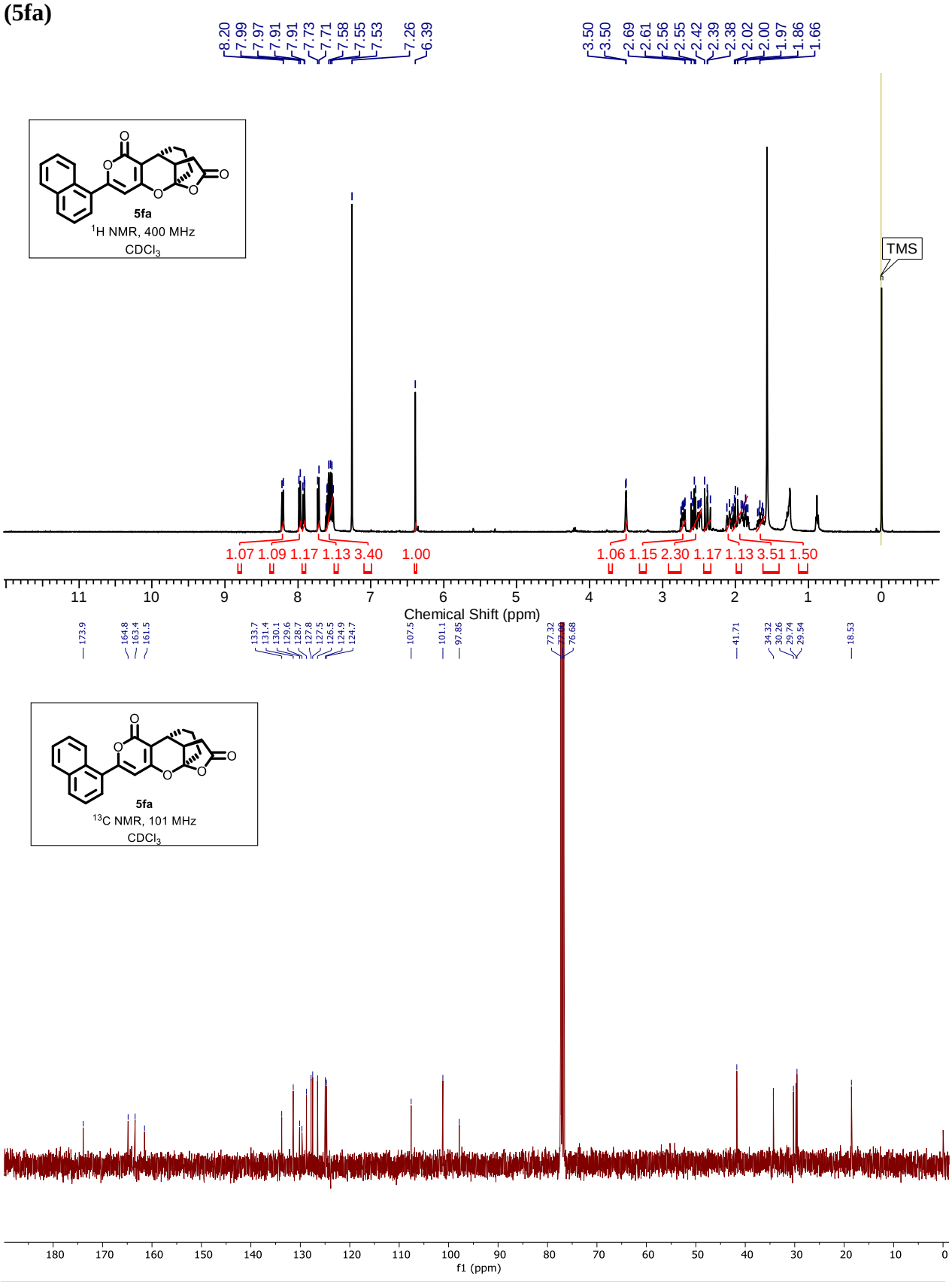
HSQC of 5ea:



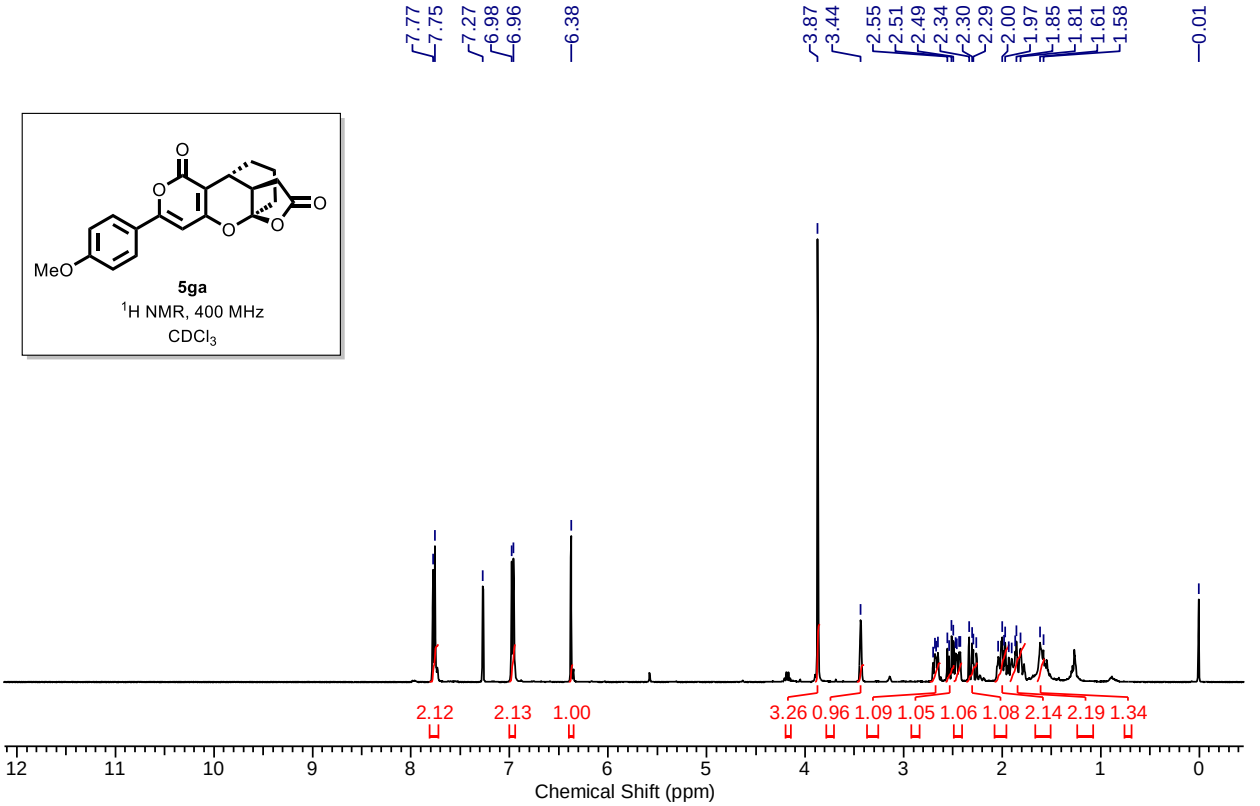
HMBC of 5ea:

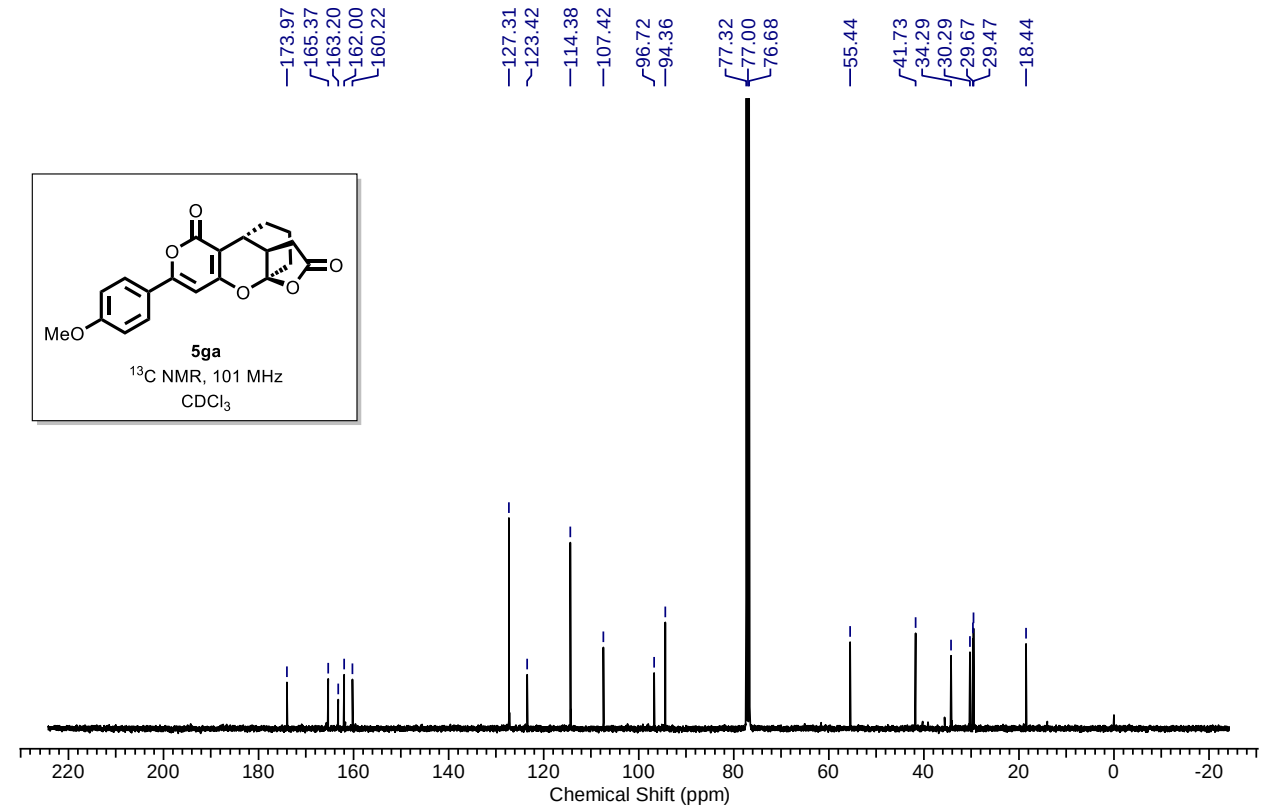

HMBC
ppm
-20
0
20
40
60
80
100
120
140
160
180
200
220
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
5ea, 73%
NOE Correlation

7-(Naphthalen-1-yl)-3,3a,4,9-tetrahydro-4,9a-propanofuro[2,3-g]isochromene-2,5-dione (5fa)

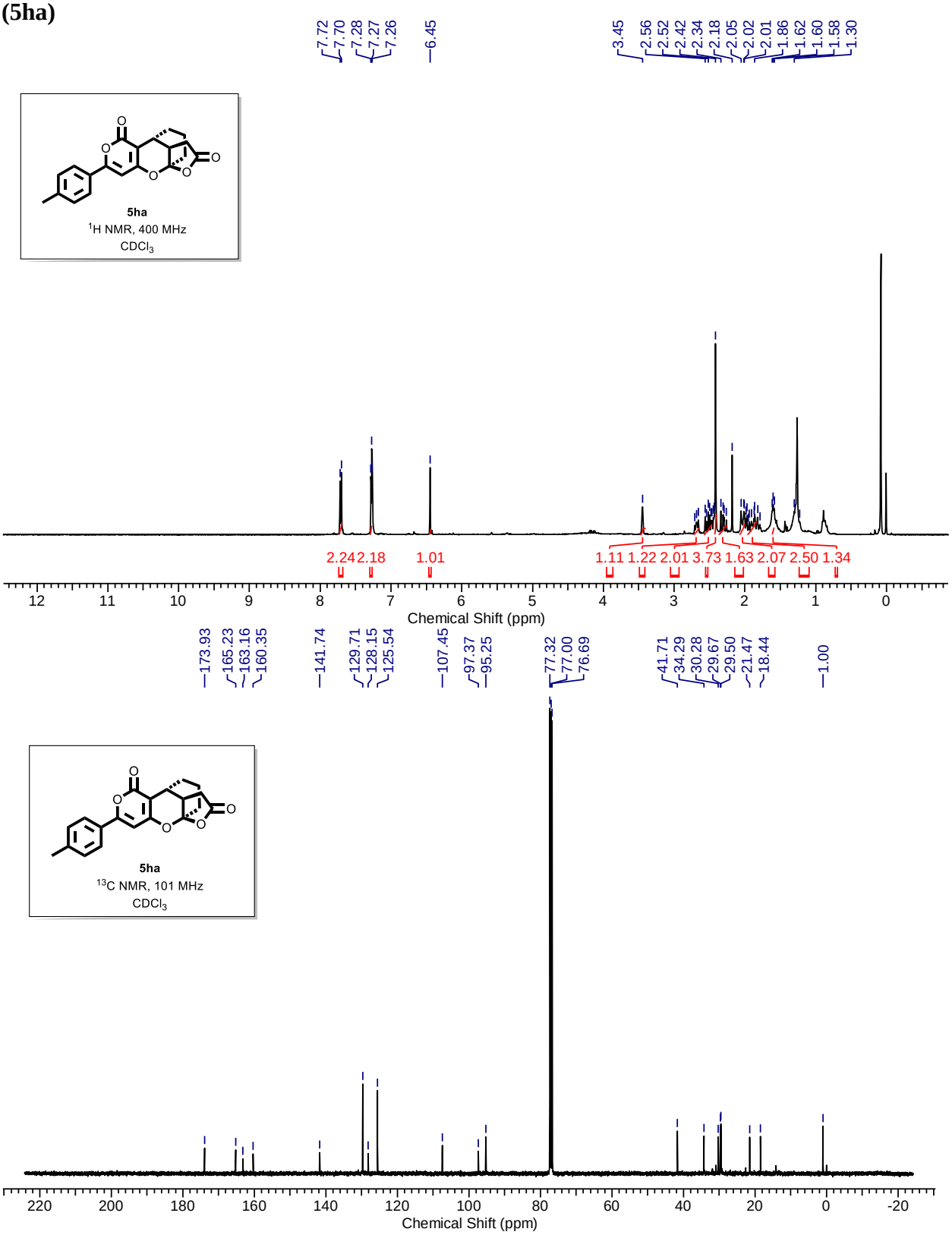


7-(4-Methoxyphenyl)-3a,4-dihydro-5H-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)- (5ga)

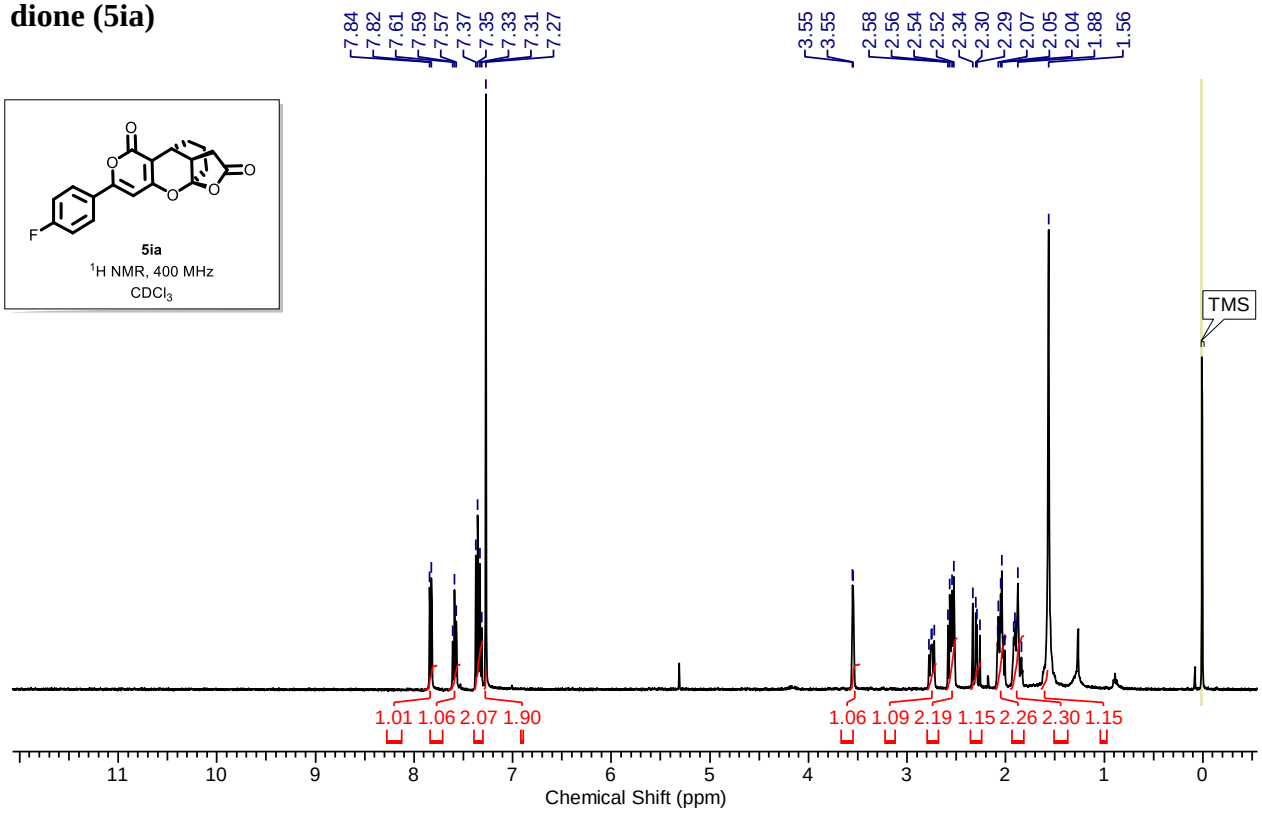


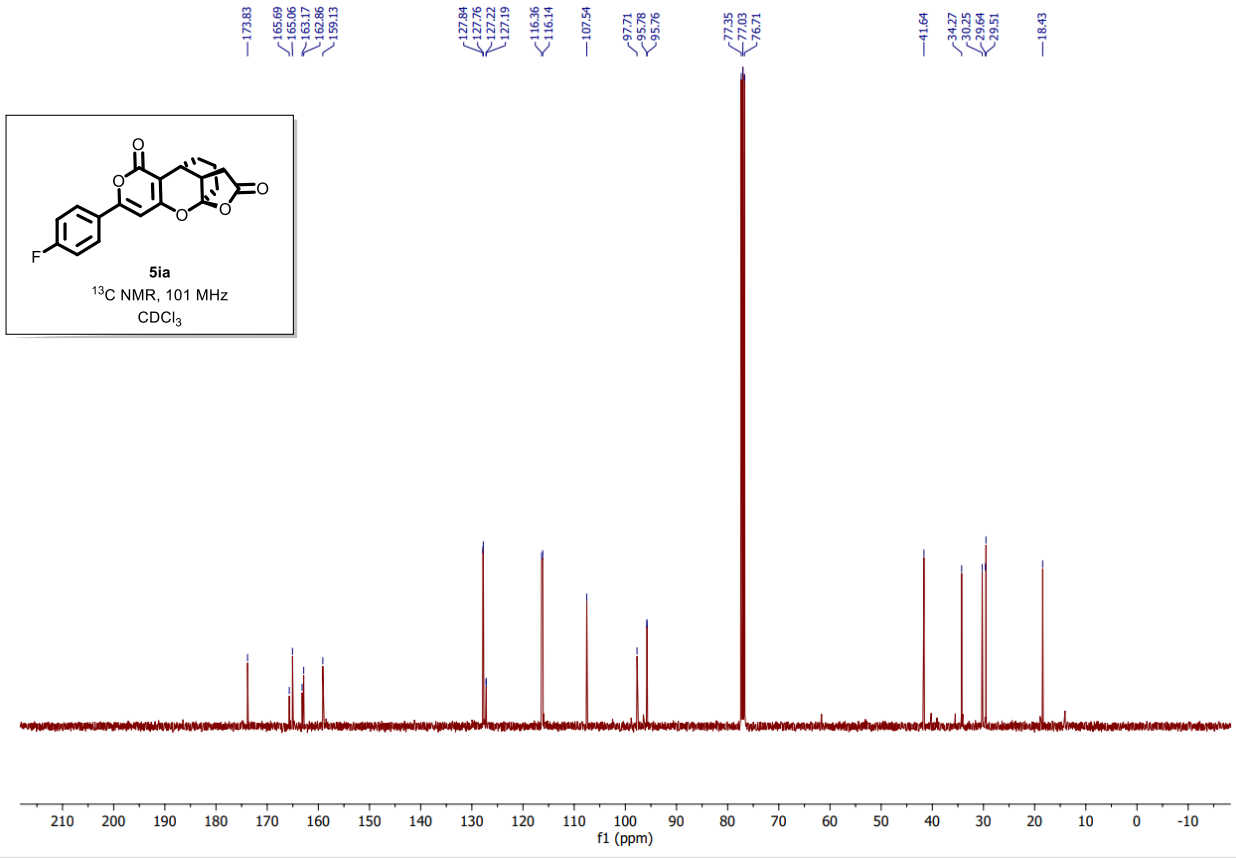


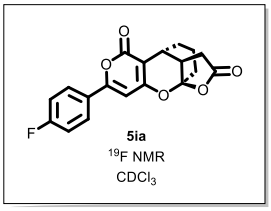
7-(p-Tolyl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ha)



7-(4-Fluorophenyl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ia)

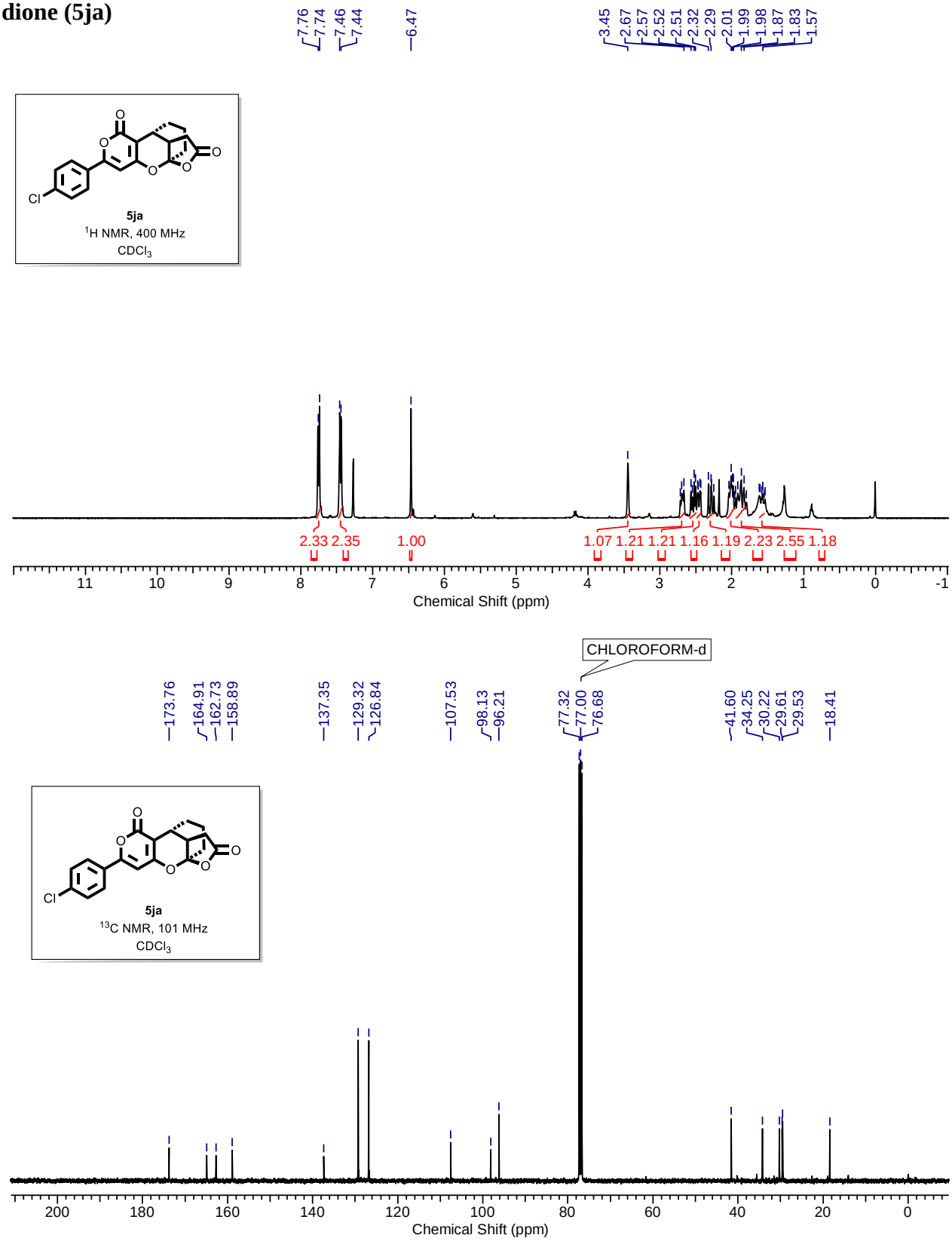




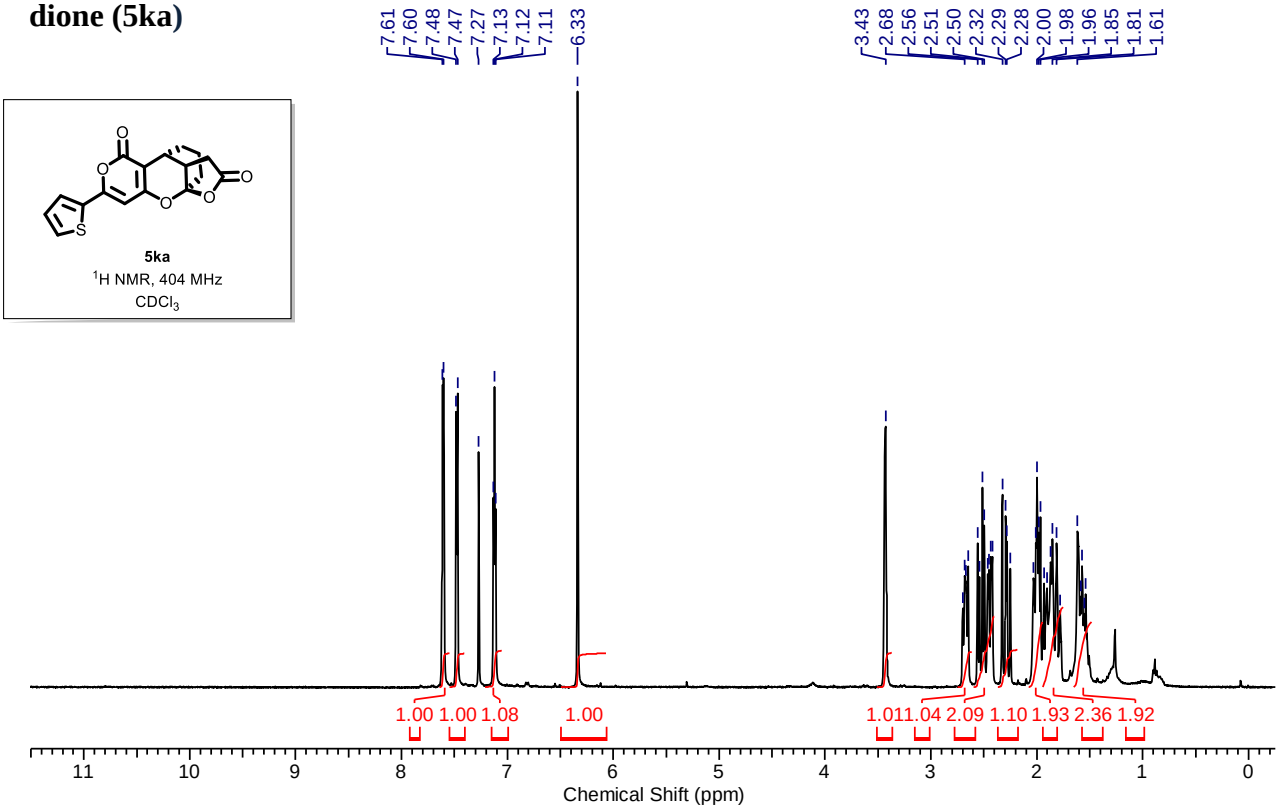


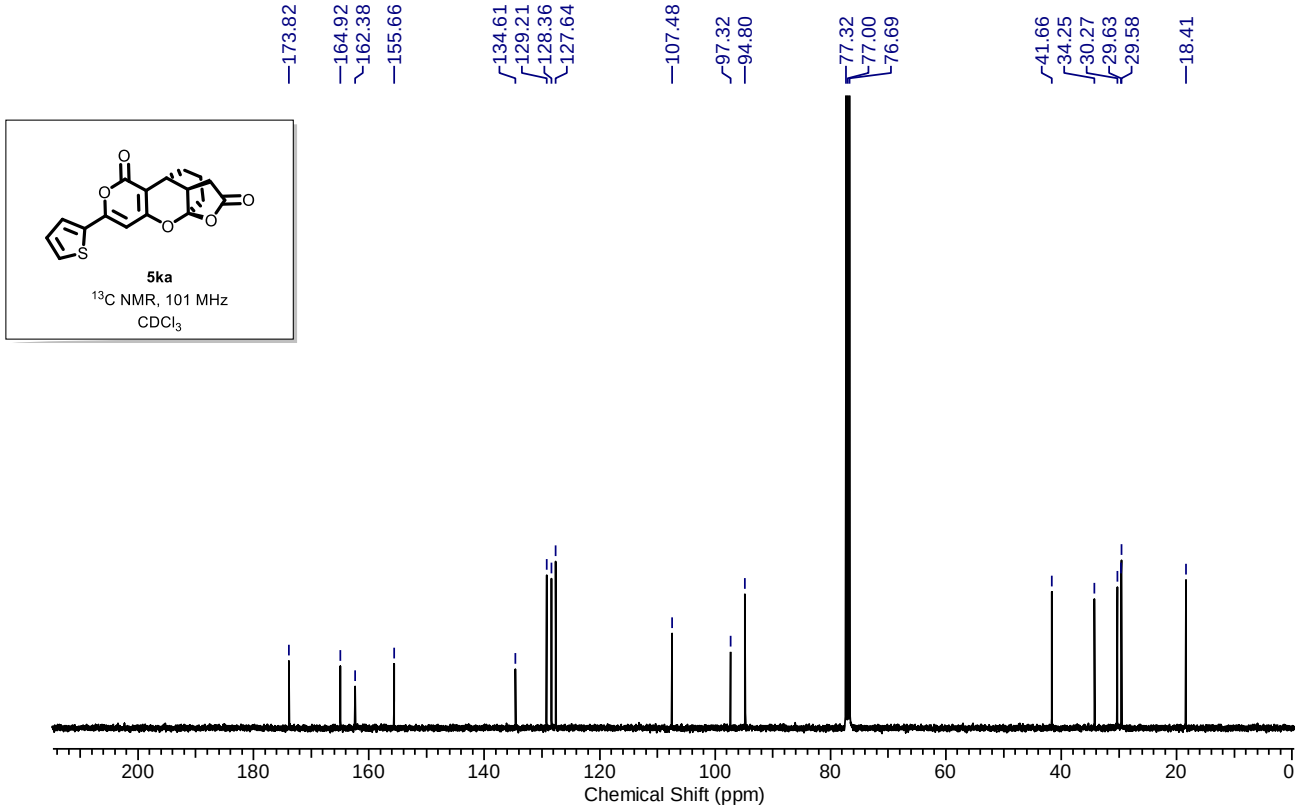
5ia
^{19}F NMR
$CDCl_3$

7-(4-Chlorophenyl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ja)

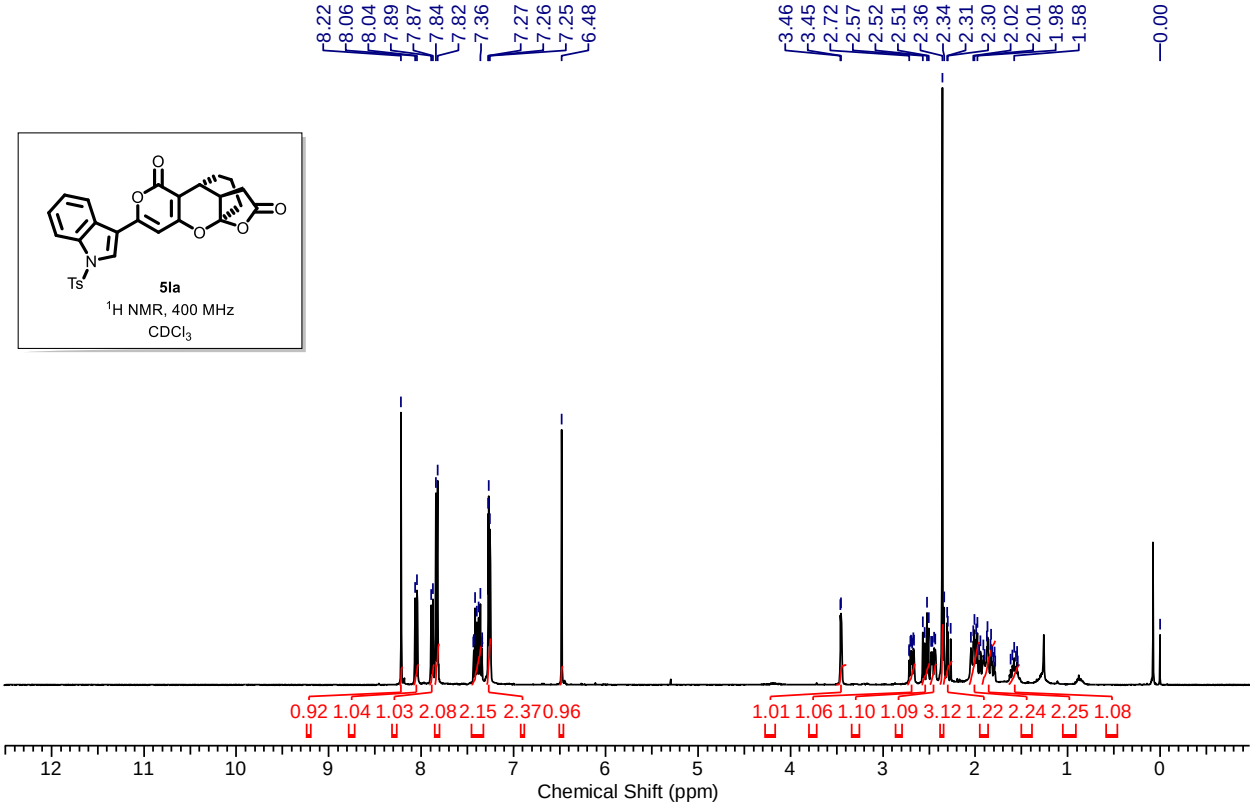


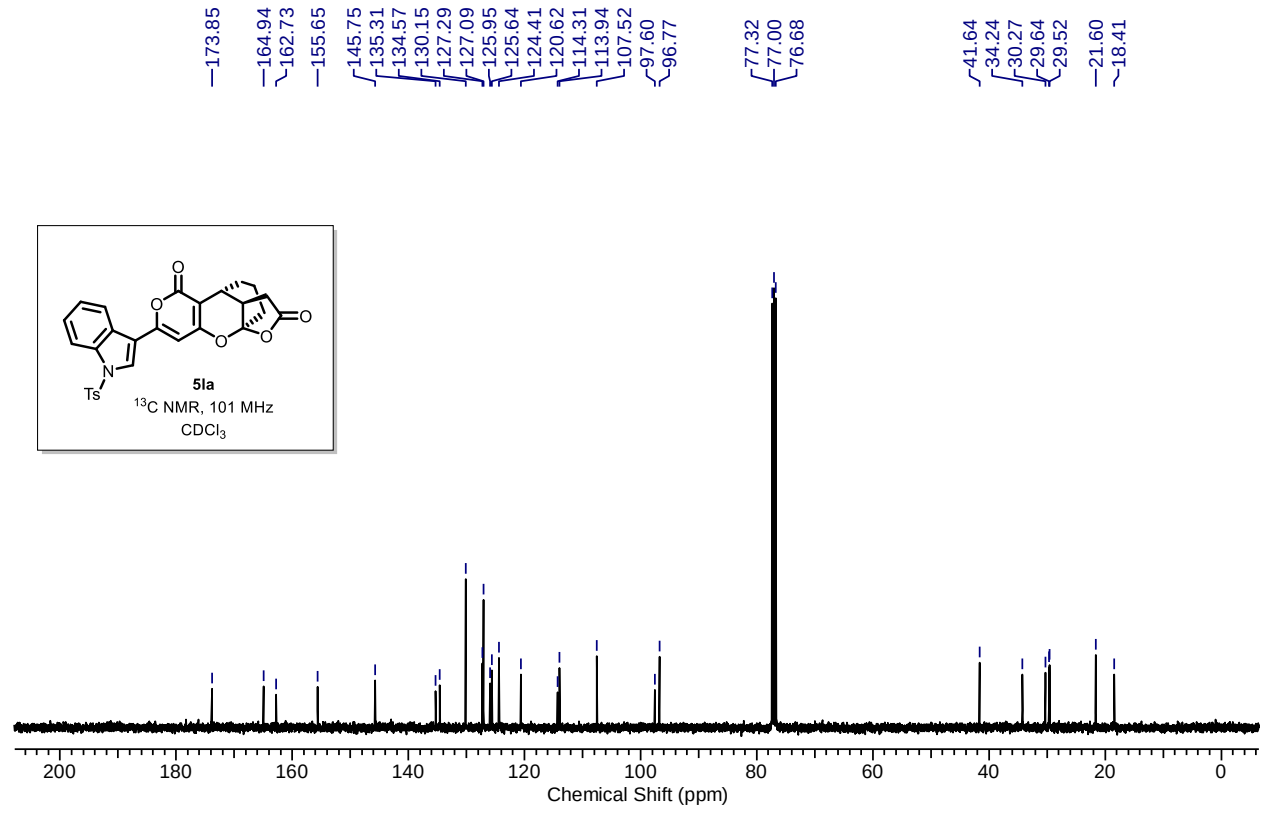
7-(Thiophen-2-yl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5ka)



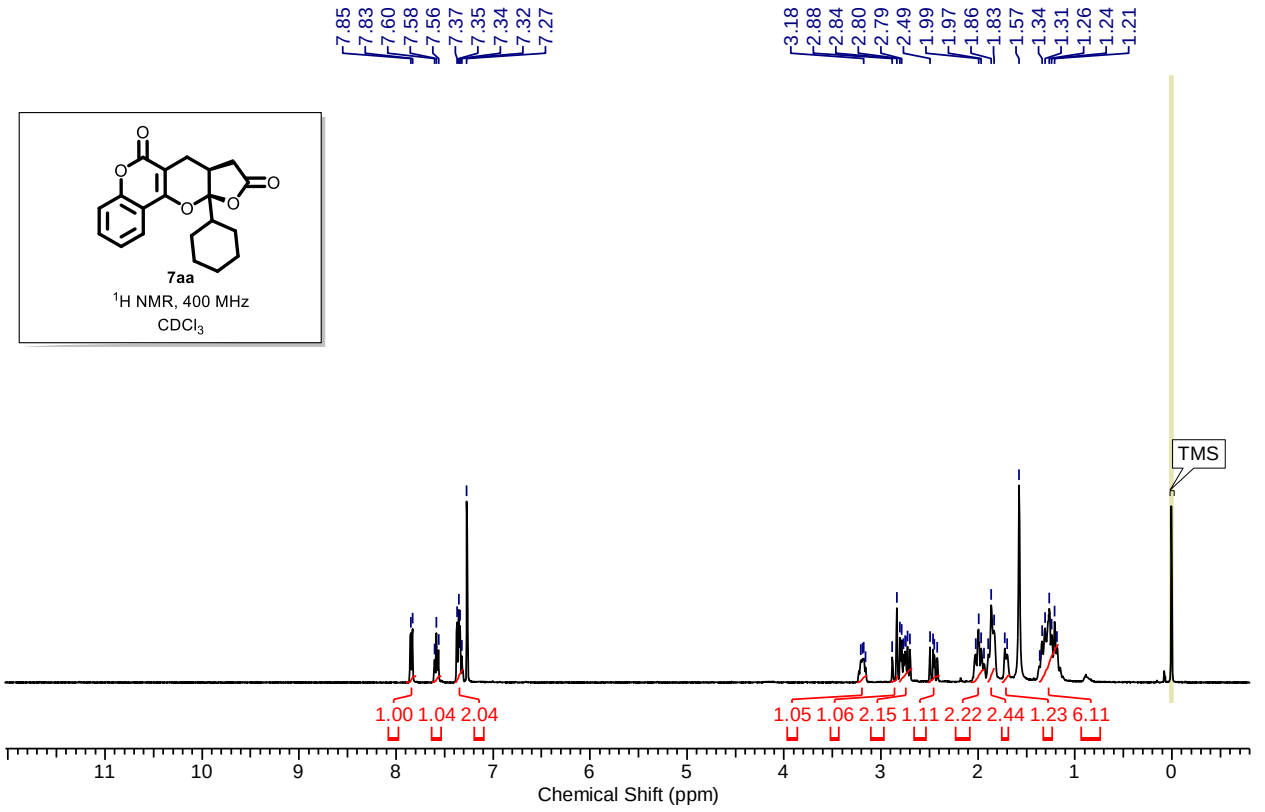


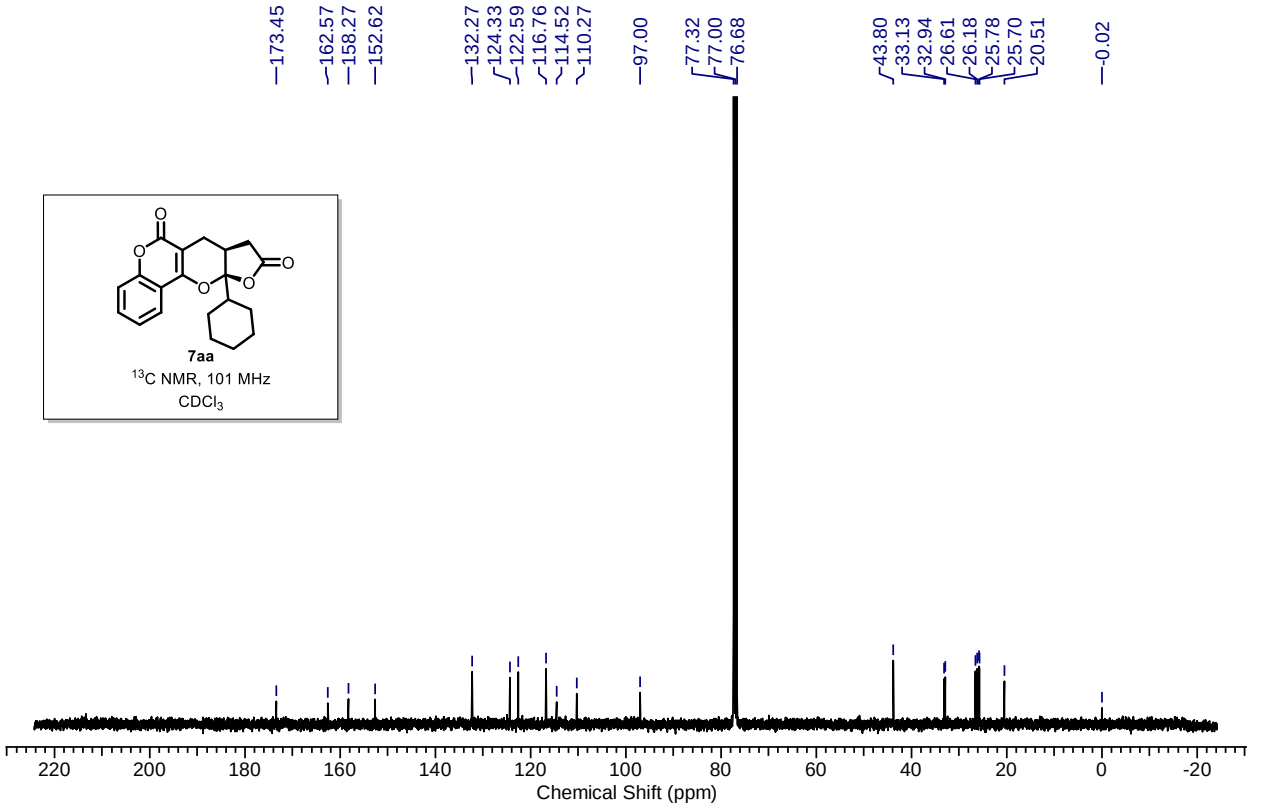
7-(1-Tosyl-1*H*-indol-3-yl)-3a,4-dihydro-5*H*-4,9a-propanofuro[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (5la)



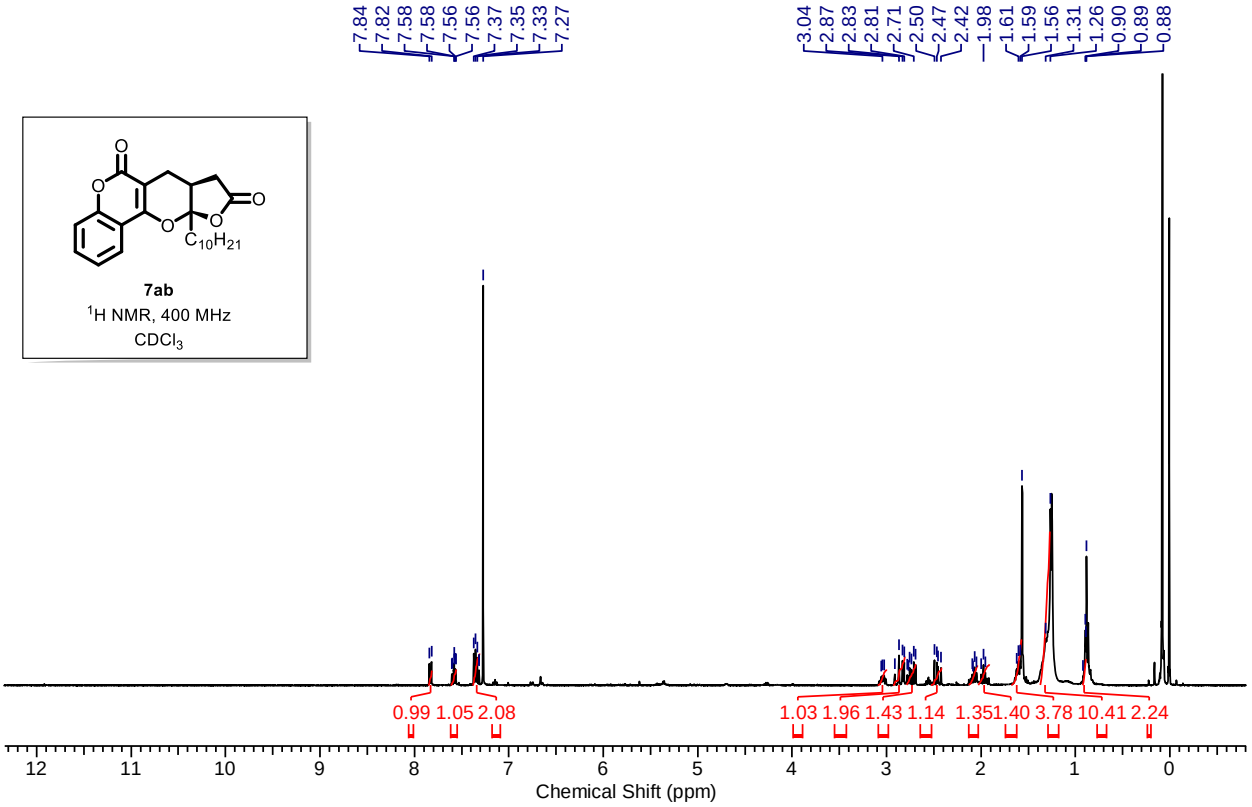


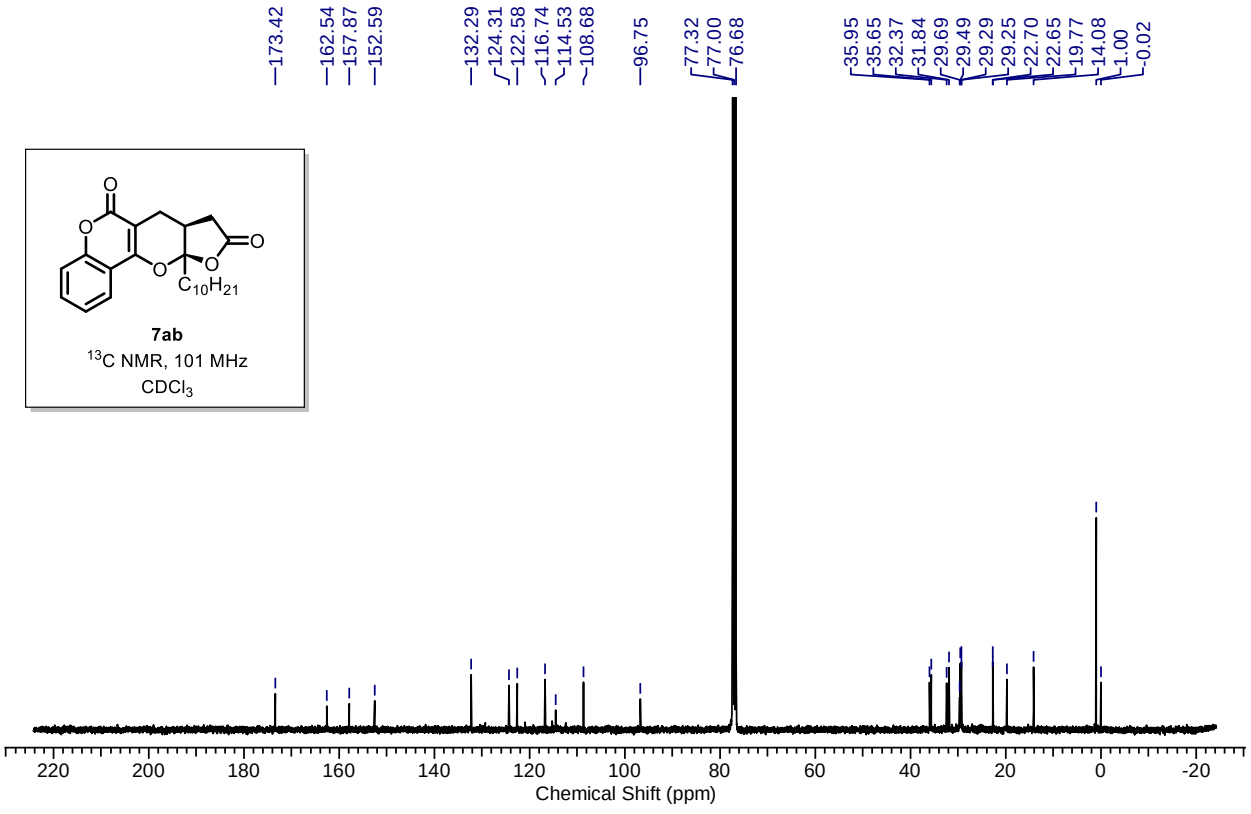
(7a,10a)-10a-Cyclohexyl-7a,10a-dihydro-6*H*,7*H*-furo[3',2':5,6]pyrano[3,2-c]chromene-6,9(8*H*)-dione (7aa)



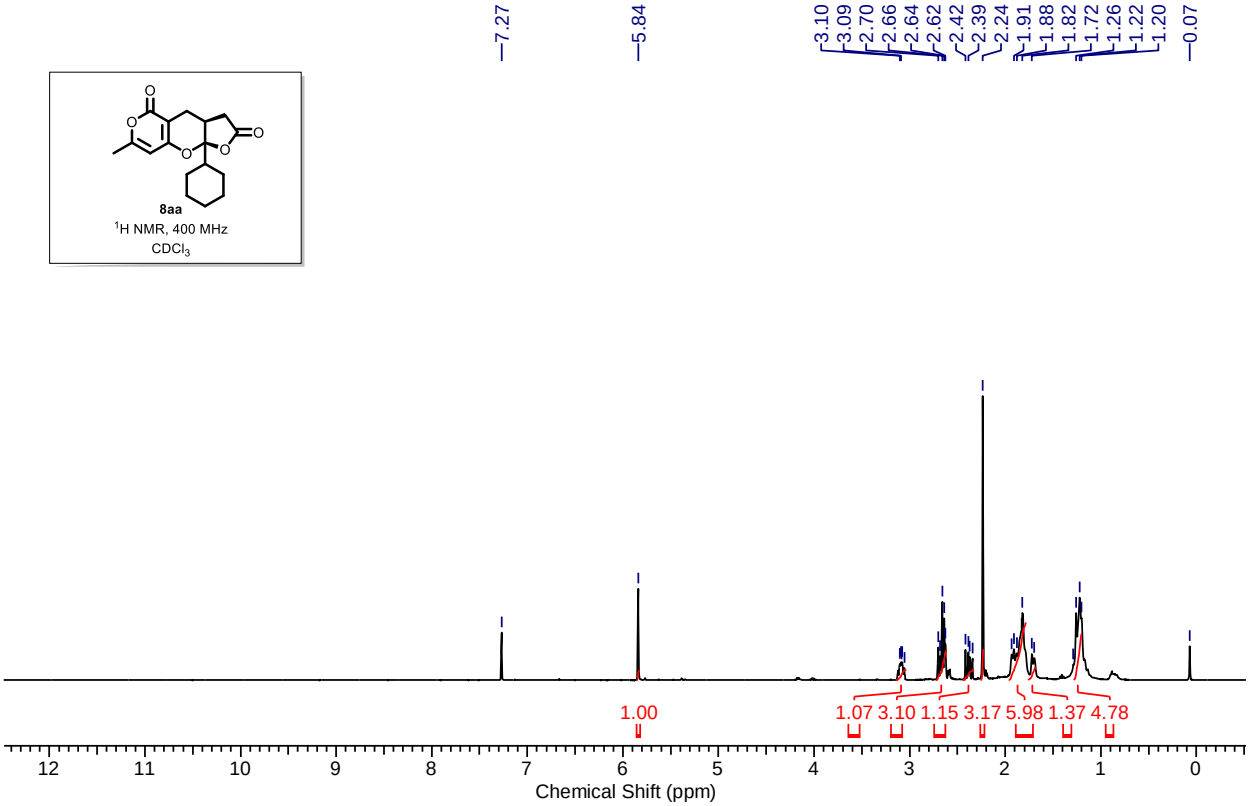


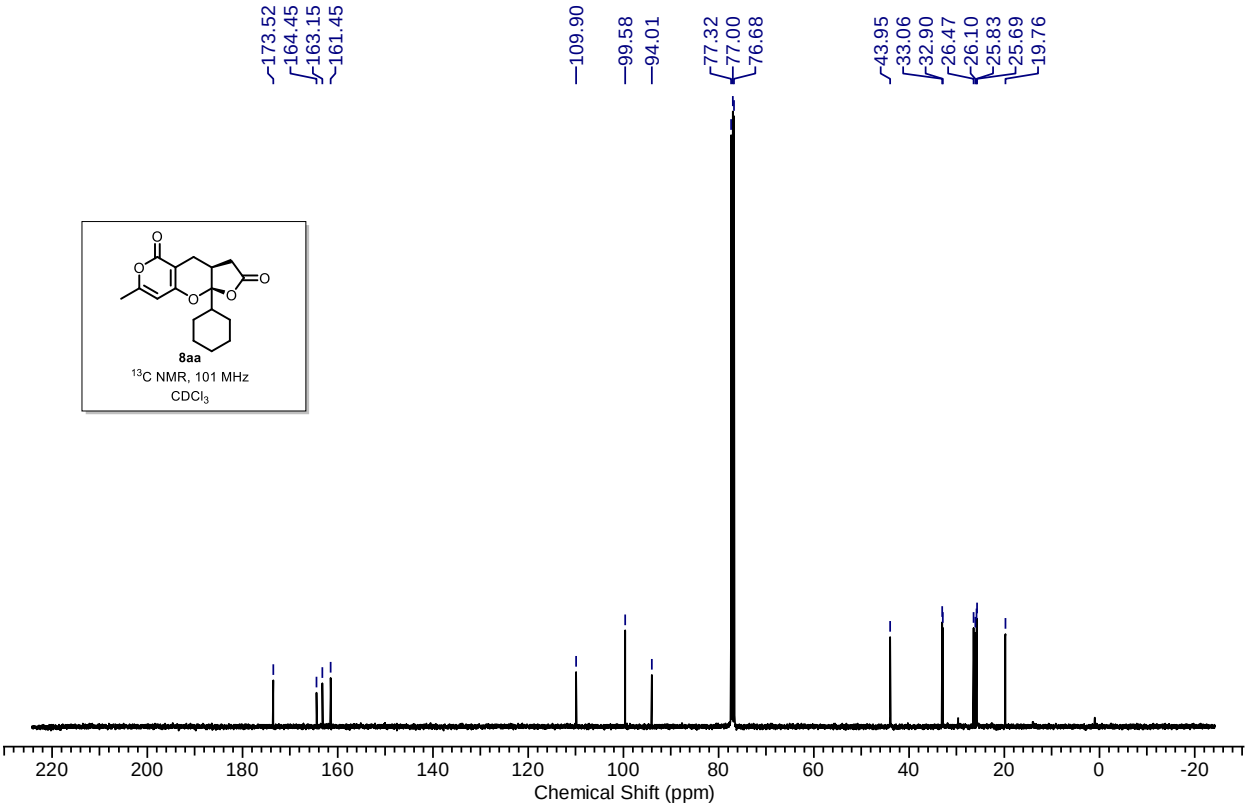
10a-(Deca-1,3,5,7,9-pentayn-1-yl)-7a,10a-dihydro-6*H*,7*H*-furo[3',2':5,6]pyrano[3,2-c]chromene-6,9(8*H*)-dione--dihydrogen (1/9) (7ab)



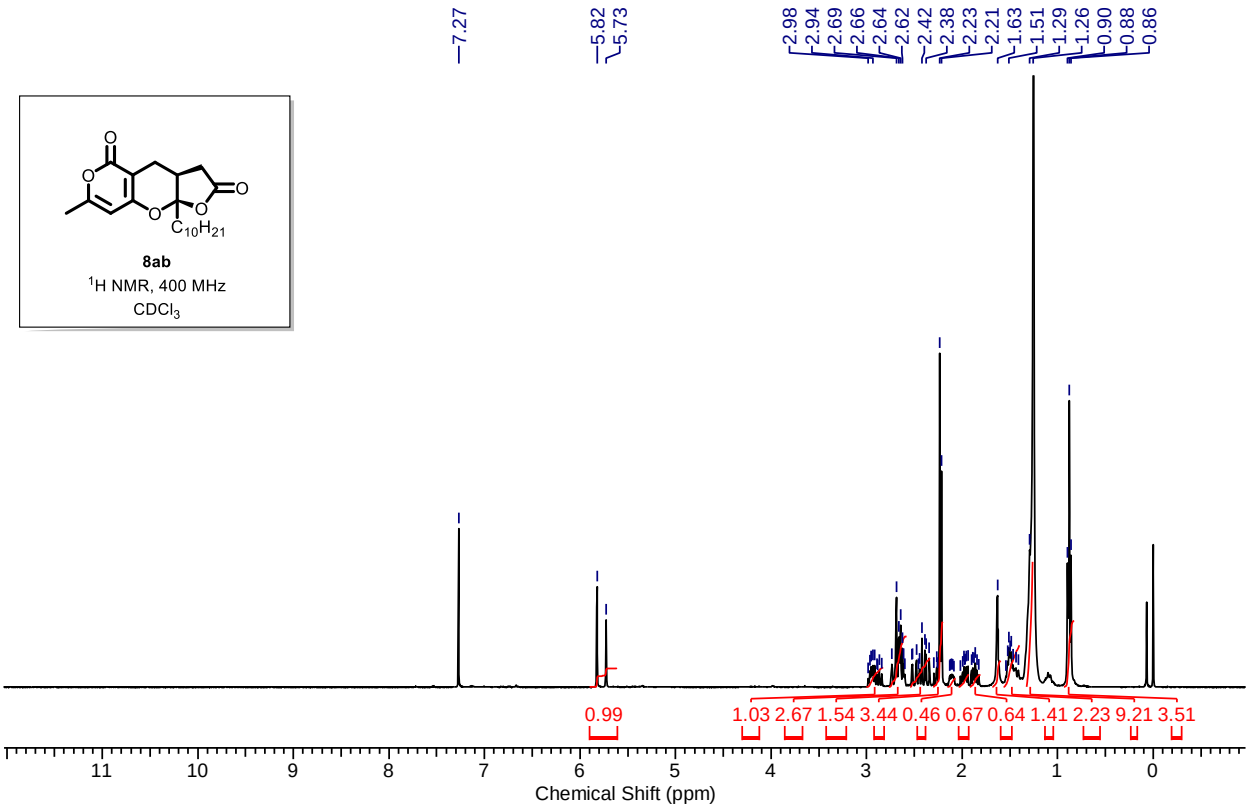


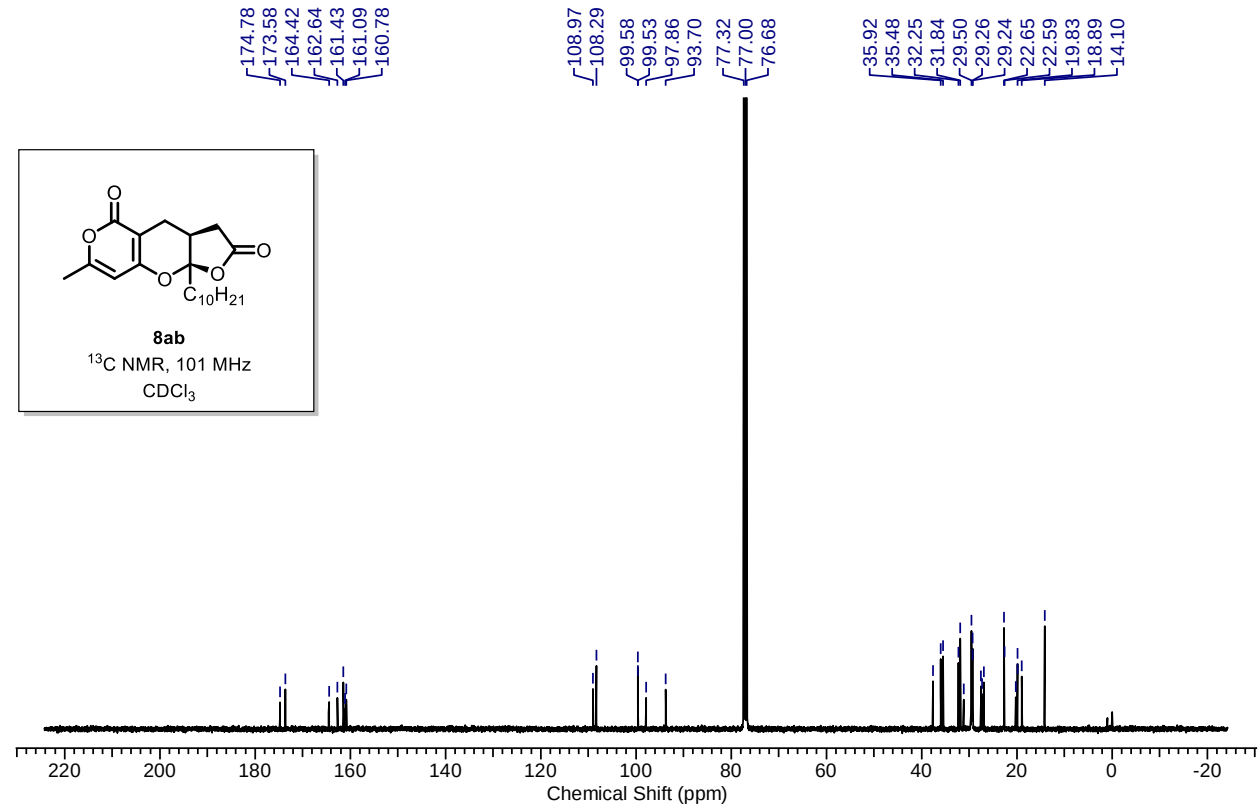
9a-Cyclohexyl-7-methyl-3a,9a-dihydro-4*H*,5*H*-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (8aa)



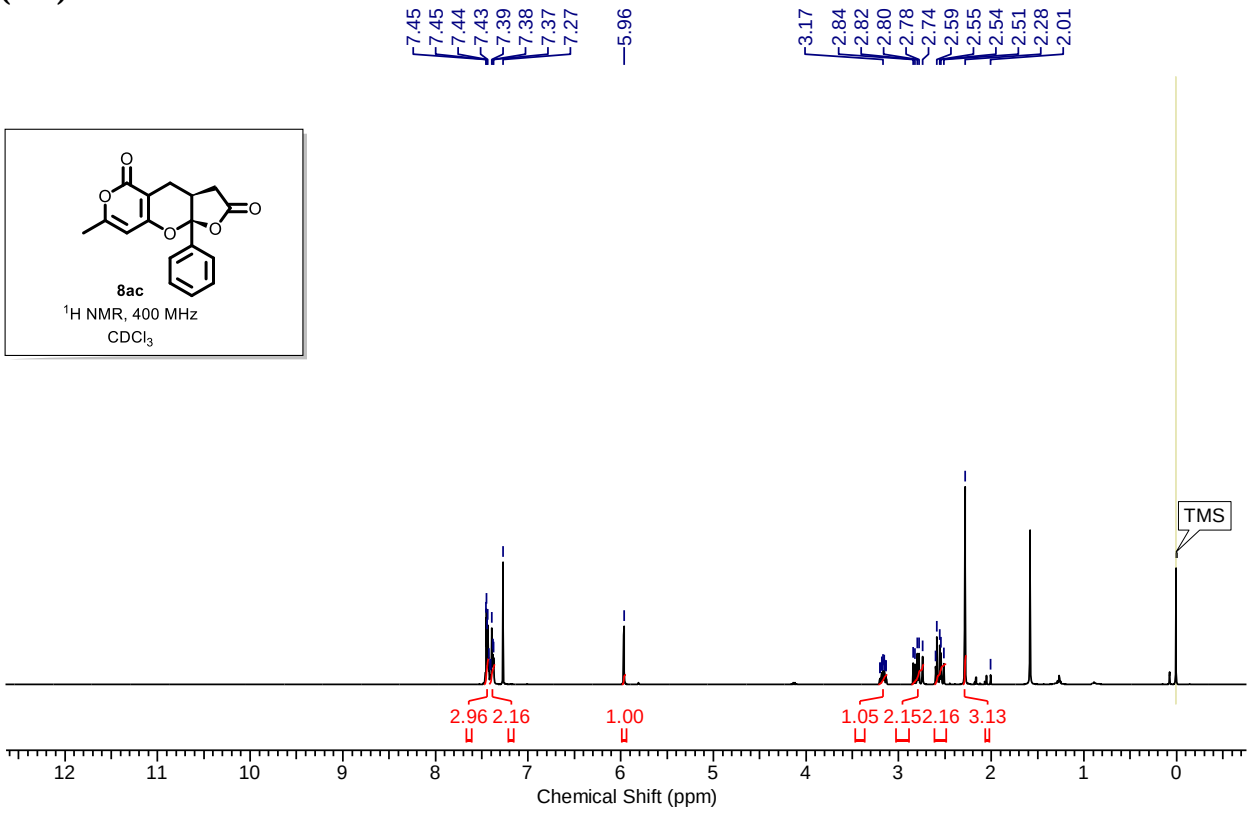


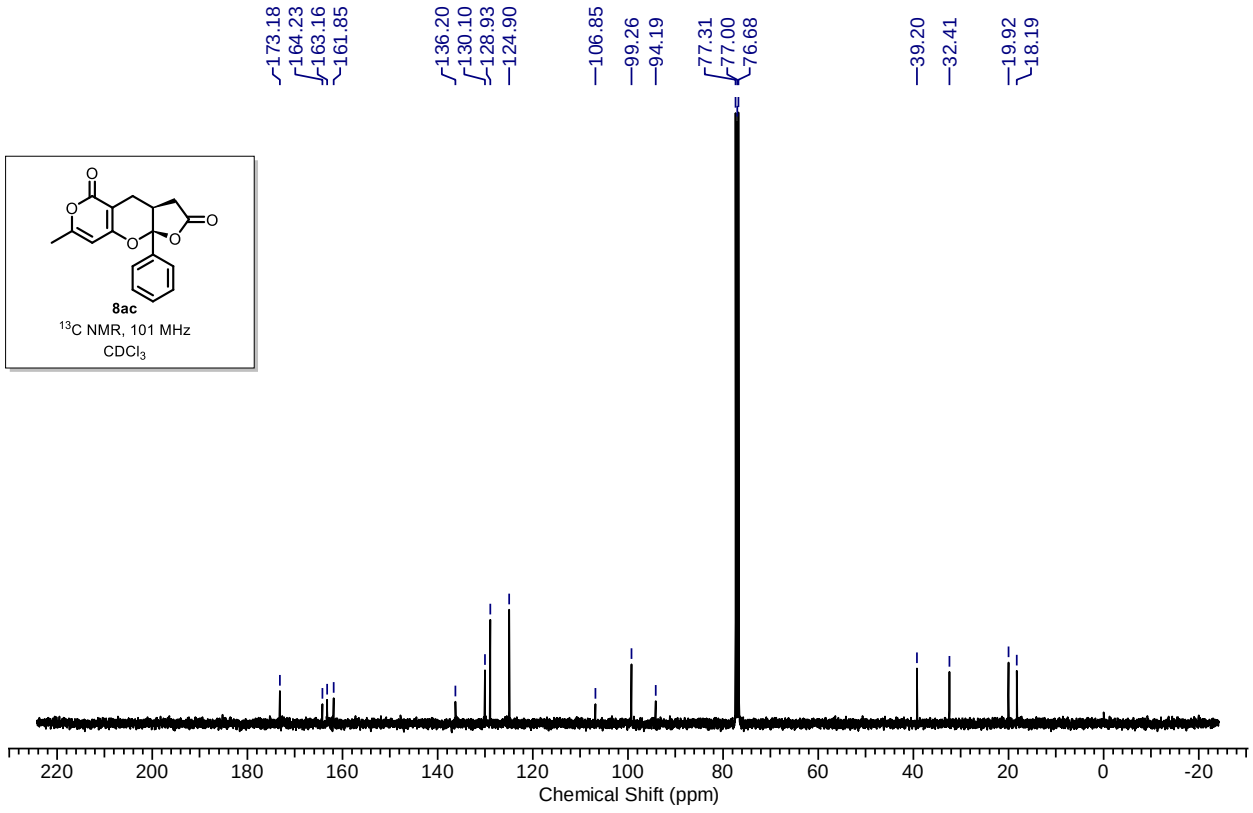
9a-(Deca-1,3,5,7,9-pentayn-1-yl)-7-methyl-3a,9a-dihydro-4*H*,5*H*-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione--dihydrogen (8ab)



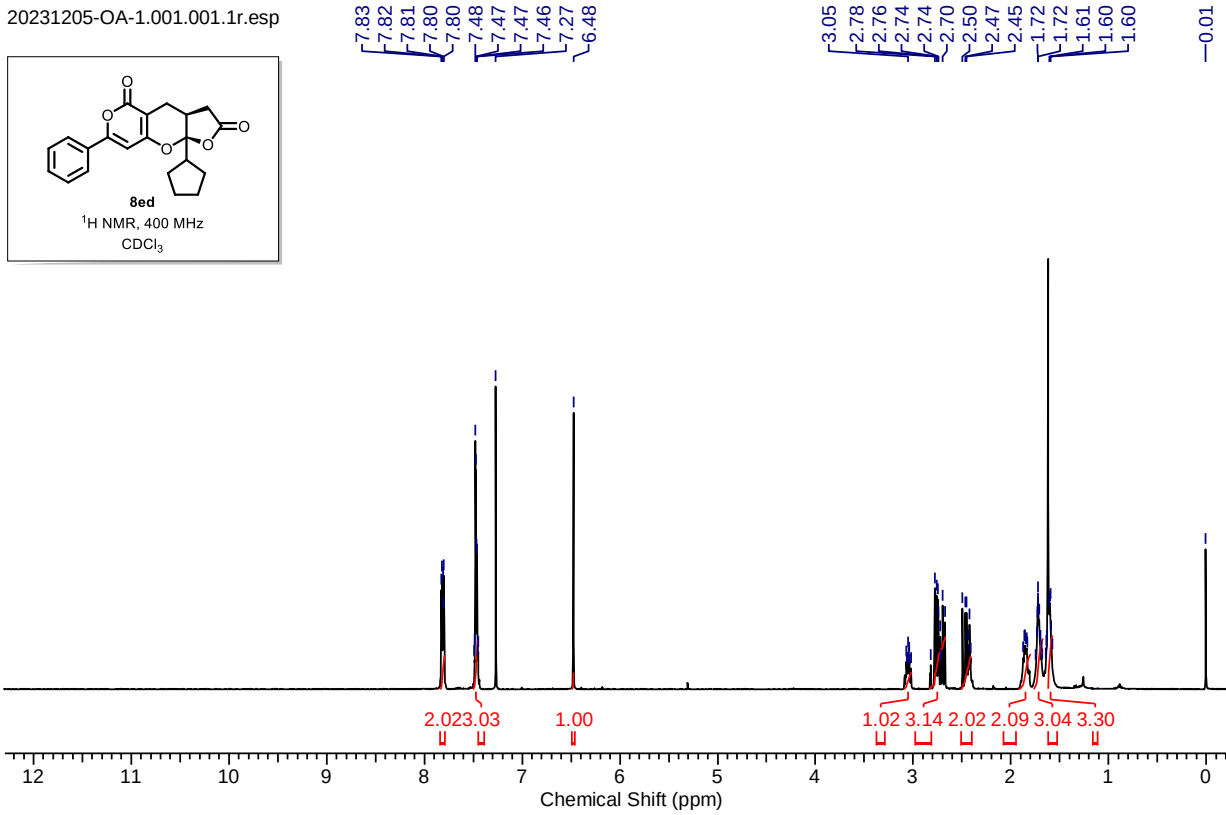


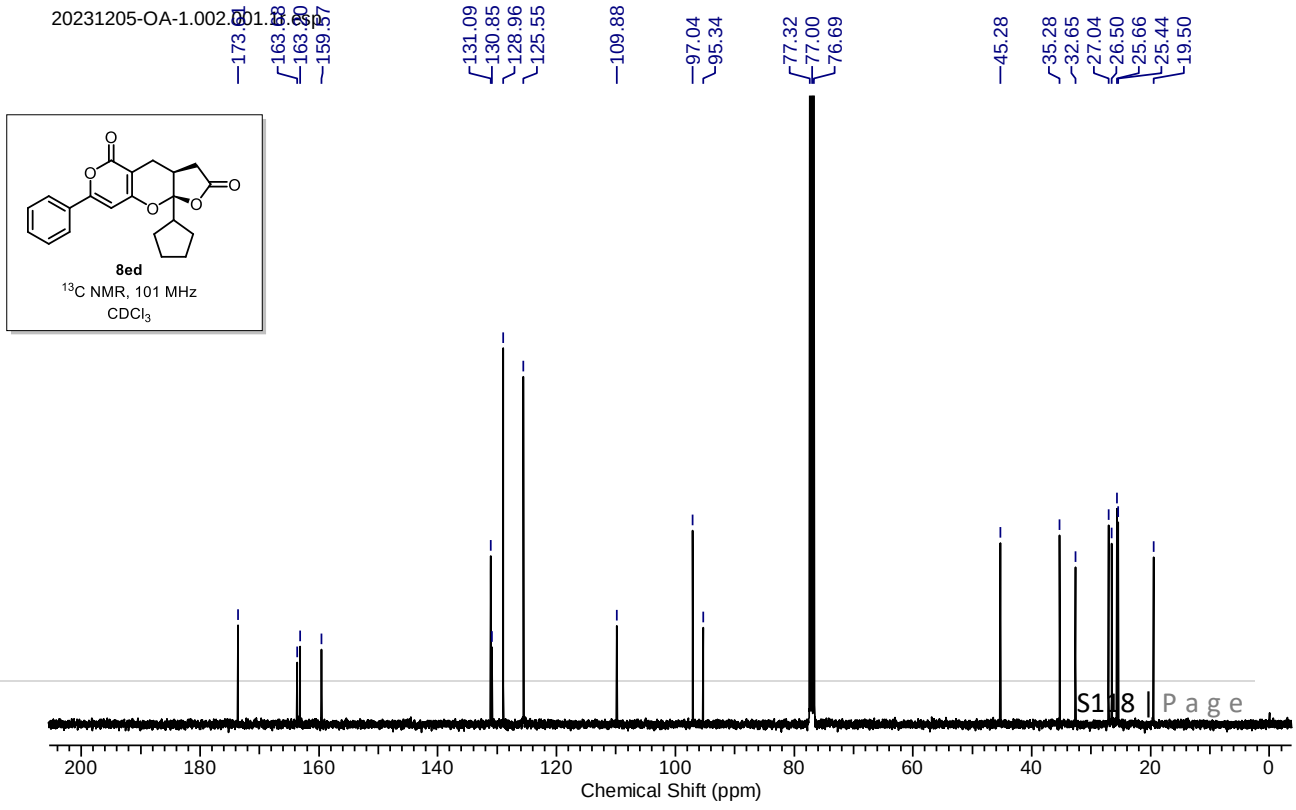
7-Methyl-9a-phenyl-3a,9a-dihydro-4*H*,5*H*-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3*H*)-dione (8ac)



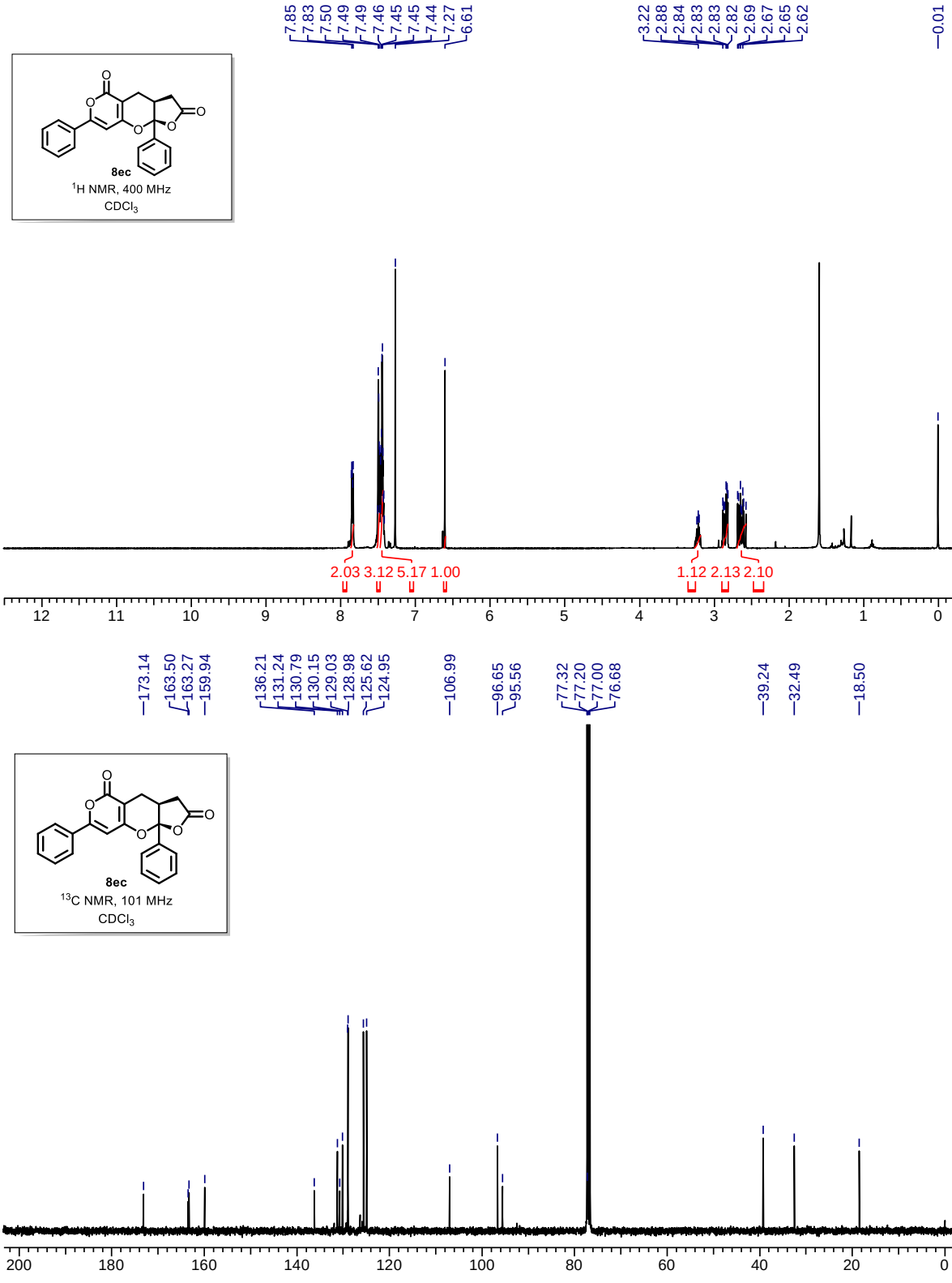


9a-Cyclopentyl-7-phenyl-3a,9a-dihydro-4H,5H-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3H)-dione (8ed):

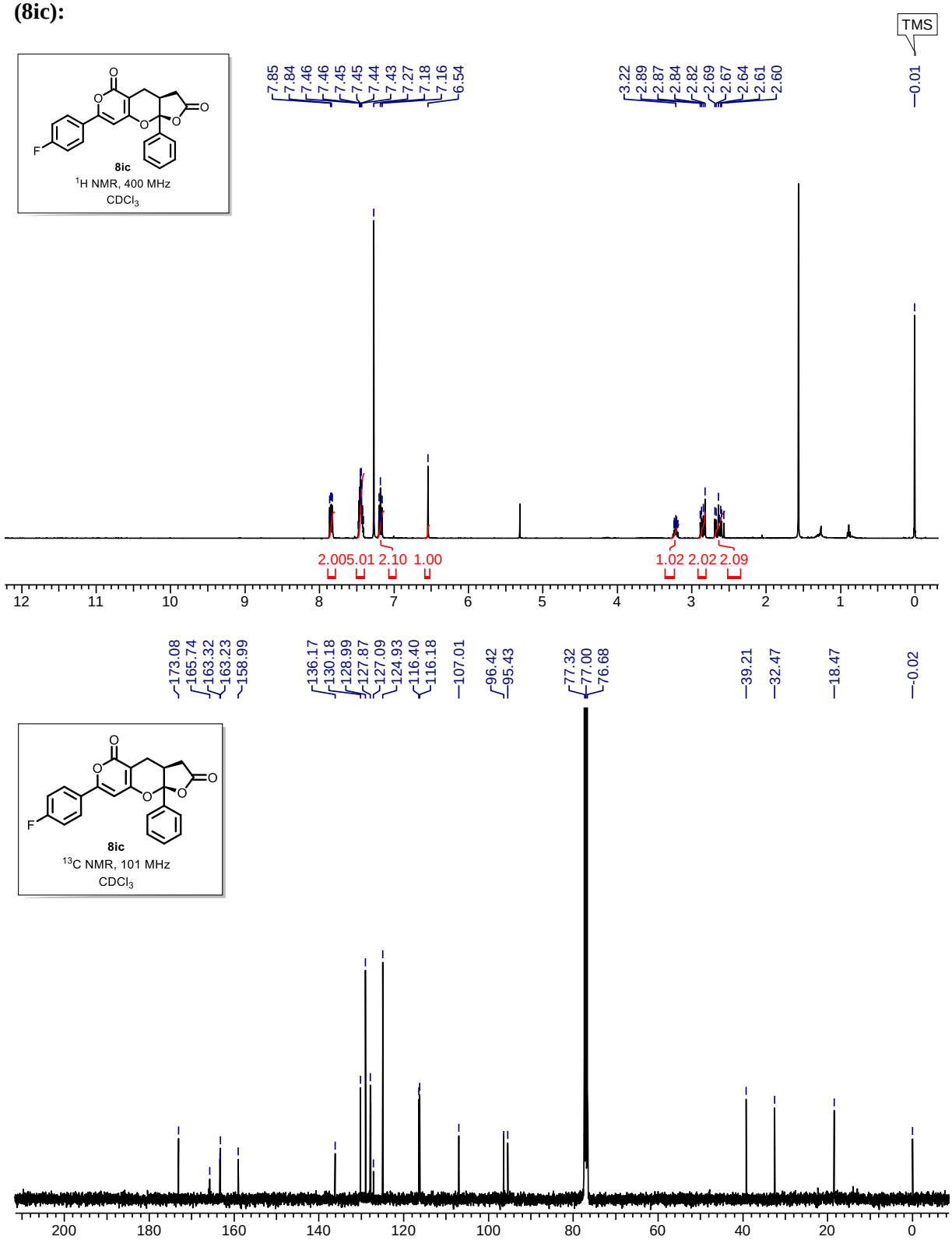




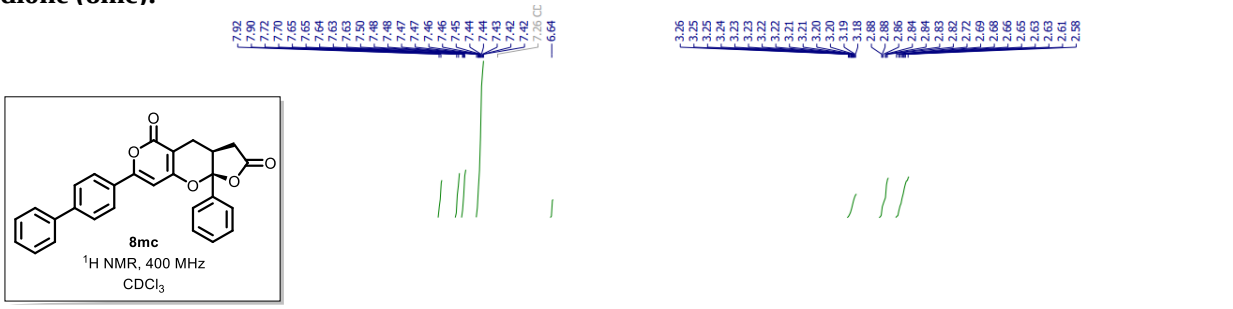
9a-Diphenyl-3a,9a-dihydro-4H,5H-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3H)-dione (8ec):

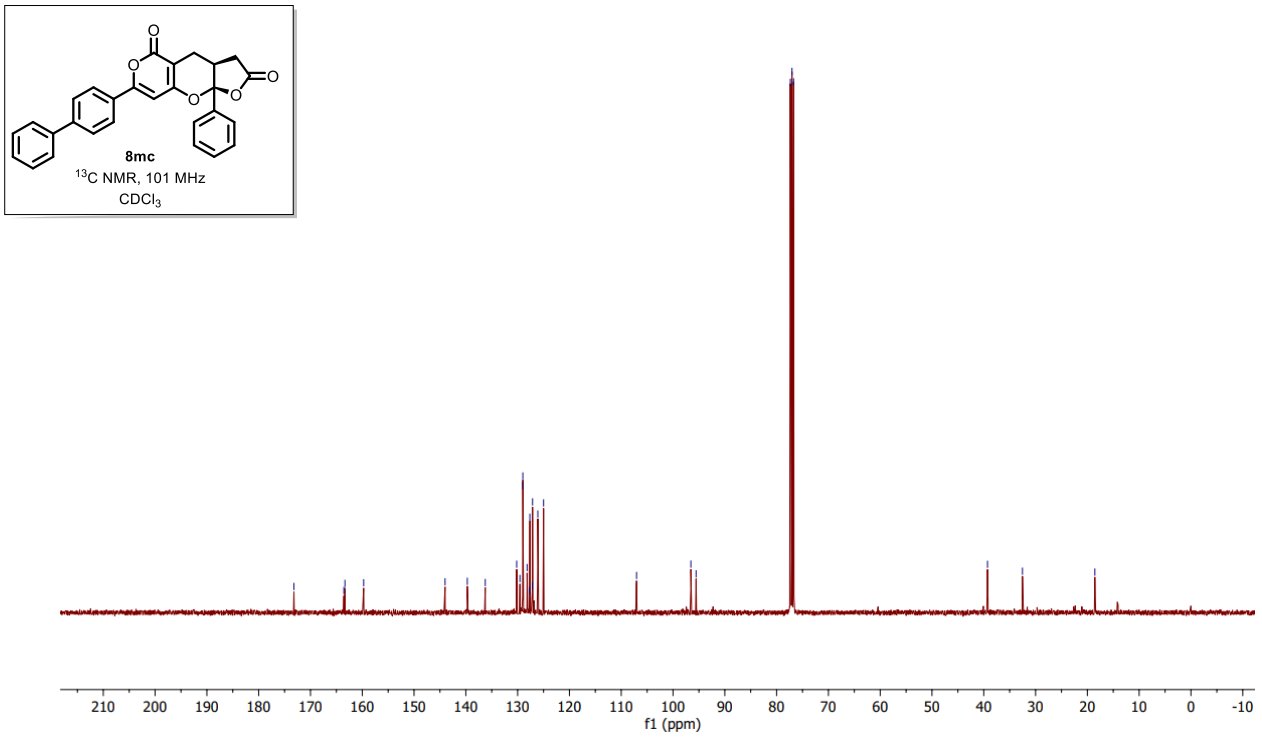


(4-Fluorophenyl)-9a-phenyl-3a,9a-dihydro-4H,5H-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3H)-dione (8ic):



7-([1,1'-Biphenyl]-4-yl)-9a-phenyl-3a,9a-dihydro-4H,5H-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3H)-dione (8mc):





9a-Diphenyl-8-propyl-3a,9a-dihydro-4H,5H-furo[2,3-b]pyrano[3,4-e]pyran-2,5(3H)-dione (8nc):