Electronic Supplementary Material (ESI) for Chemical Communications.

Supporting Information

Wavelength Dependent Photoextrusion and Tandem Photoextrusion Reactions of Ninhydrin *bis*-Acetals for the Synthesis of 8-Ring Lactones, Benzocyclobutenes and Orthoanhydrides.

Wei Sun,[a] Surajit Kayal,[b] William A. T. Raimbach,[a] Xue-Zhong Sun,[b] Mark E. Light,[a] Magnus W. D. Hanson-Heine,[b] Michael W. George[b,c] and David C. Harrowven.[a,]*

[a] Chemistry, University of Southampton, Highfield, Southampton, SO17 1BJ, UK

[b] School of Chemistry, University of Nottingham, Nottingham NG7 2RD, UK

[c] Department of Chemical and Environmental Engineering, The University of Nottingham Ningbo China, 199 Taikang East Road, Ningbo 315100, China

1. Figure decanted from the article

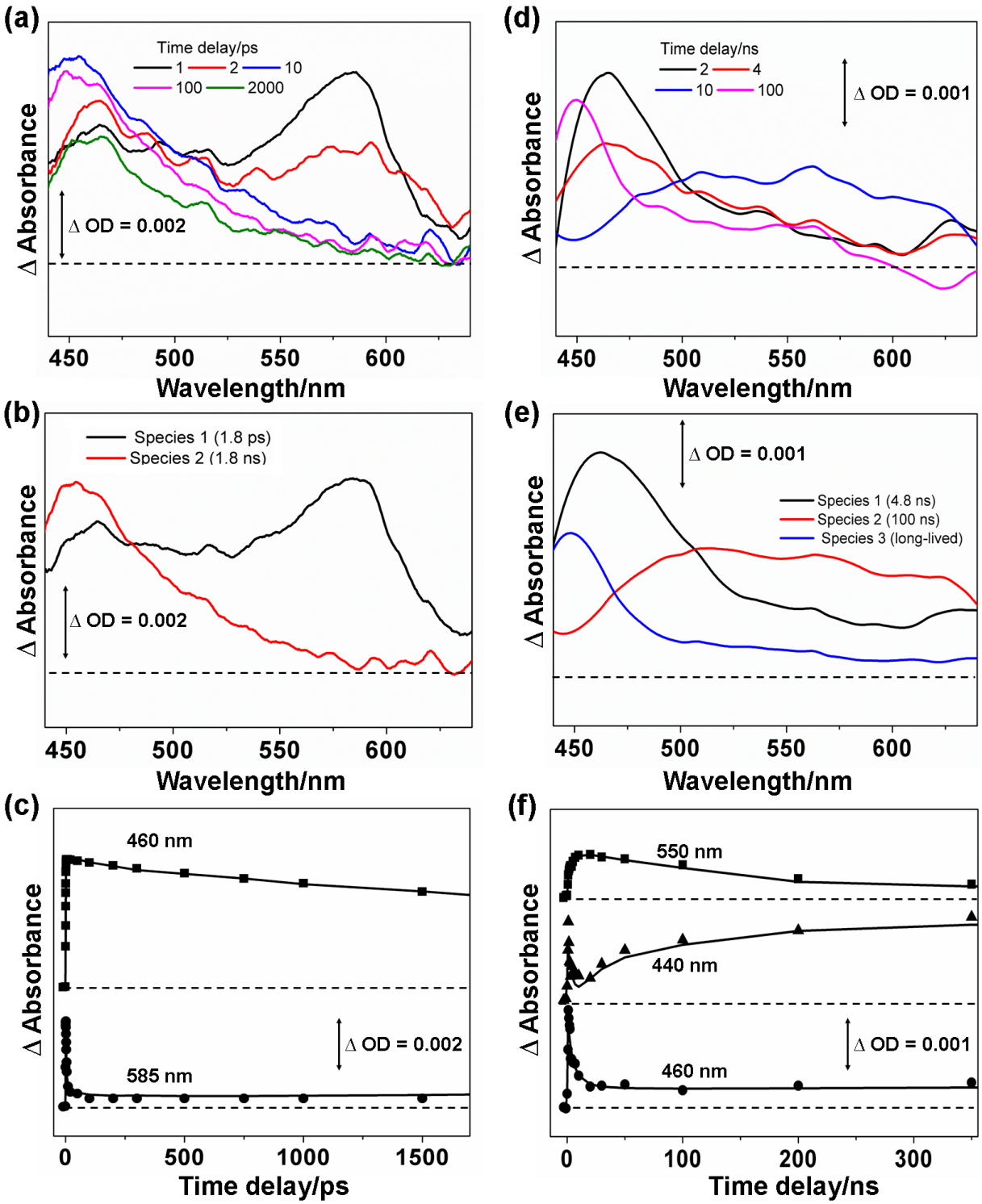


Figure S1. (a) ps-TA spectra at selected time delays. (b) Extracted species associated spectra from global analysis. (c) Representative kinetic traces at the selected probe wavelengths (symbols are the experimental data and the solid lines are the fits). (d) ns-TA spectra at selected time delays. (e) Extracted species associated spectra from global analysis. (f) Representative kinetic traces at the selected probe wavelengths (symbols are the experimental data and the solid lines are the fits).

2. General Remarks

Tetrahydrofuran was distilled from sodium benzophenone ketyl under argon. All air sensitive reactions were carried out under argon using flame dried apparatus. Reactions were monitored by TLC on Merck Silica Gel 60 Å F TLC plates and visualised with 254 nm UV followed by aqueous 1% $KMnO_4$ or PMA. Flash chromatography was performed under slight positive pressure on Sigma-Aldrich 40-63 µm 60 Å 230-400 Å silica. Reaction and chromatography solvents were removed using a rotary evaporator equipped with a diaphragm pump. ^{1}H and ^{13}C NMR spectroscopy was performed on Bruker AV400 (400/100 MHz) and AV500 (500/125 MHz) spectrometers at 298 K in $CDCl_3$ or DMSO-d6. Chemical shifts are quoted as δ values in ppm using residual solvent peaks as the reference. Coupling constants *J* are given in Hz and multiplicity is described as follows: s, singlet; d, doublet; t, triplet; q, quartet; quin, quintet; m, multiplet; br, broad. HRMS data were obtained using a Bruker APEX III FT-ICR-MS with samples run in HPLC grade methanol. Electrospray mass spectrometry was performed on a directly injected Waters quadrupole MSD using ESI+ or ESI– ionisation with MeOH as solvent. Infrared spectroscopy was performed on a Nicolet iS5 Laboratory FT-IR spectrometer and spectra were acquired from evaporated $CDCl_3$ or DCM solutions. Absorption maxima (ν_{max}) are quoted in wavenumbers (cm^{-1}) with the following abbreviations used to describe their intensity: s, strong; m, medium; w, weak; br, broad.

3. Photochemical Set ups

Set up A (circulating flow, Figure S2) **and Set up B** (single pass, photograph) only differ in respect of the output stream, which is returned to the original flask in set up A but goes to a collecting vessel in set up B.

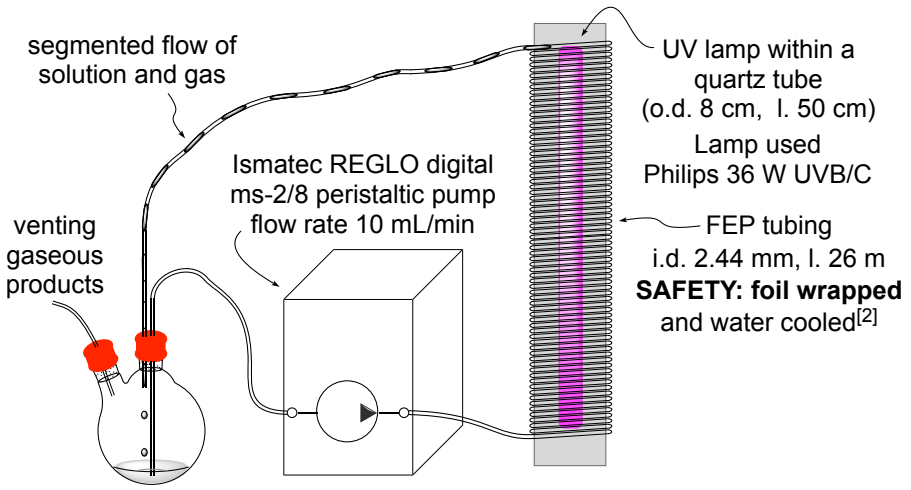


Figure S2. Schematic of a circulating flow photochemical set up adapted from Booker-Milburn and Berry *et al.*[1]

Set up C

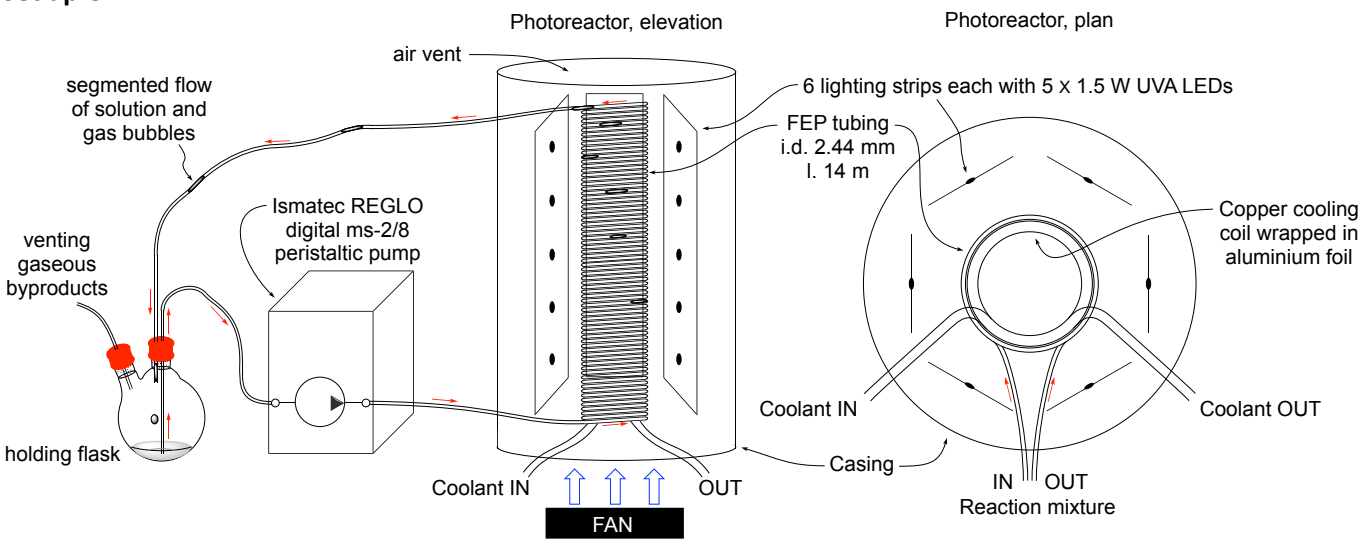
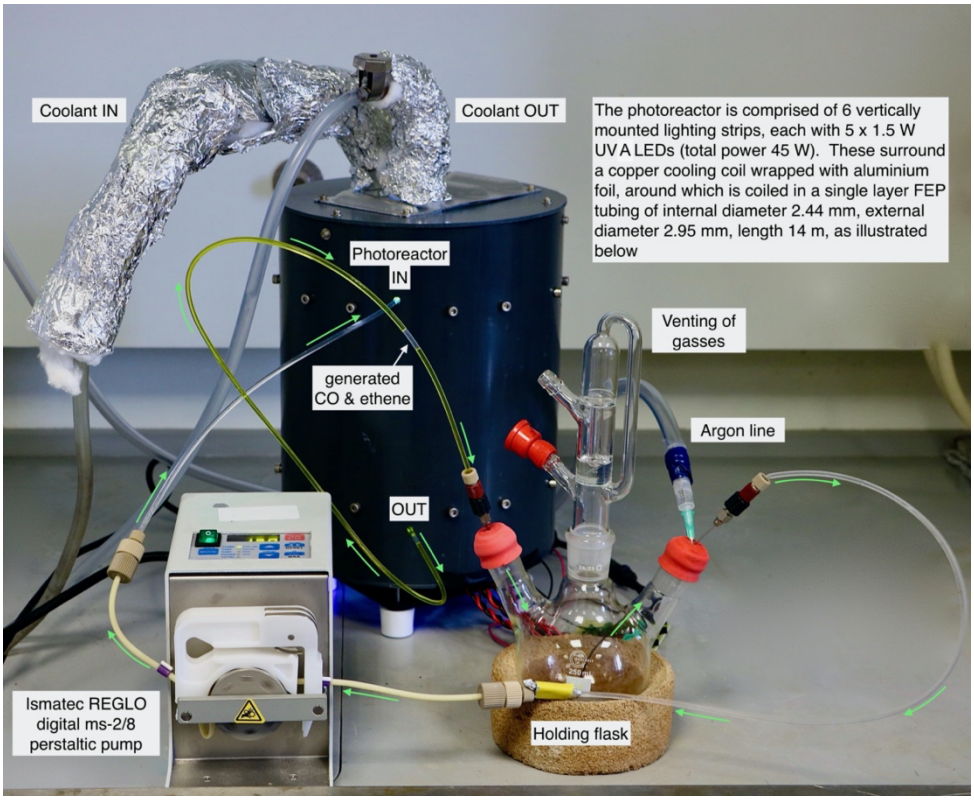


Figure S3. Schematic of a circulating flow photochemical set up for reactions on a larger scale.



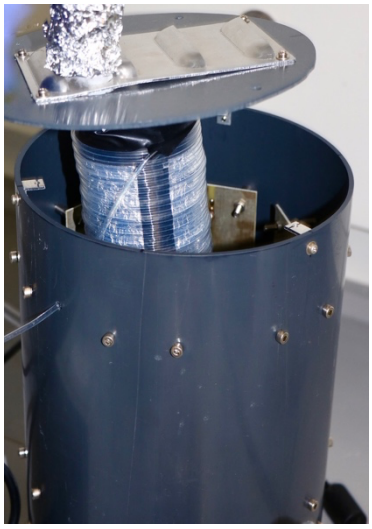
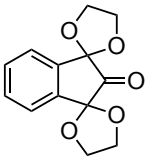


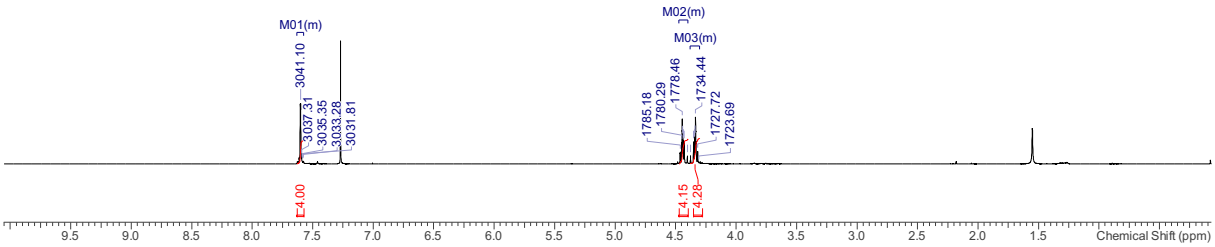
Figure S4. Annotated photographs of the circulating flow photochemical set up for reactions on a larger scale.

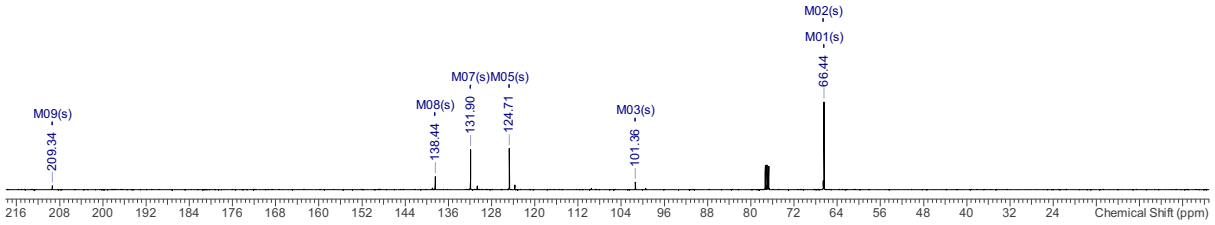
4. Experimental Procedures, Characterisation Data and NMR Spectra

2'H-Dispiro[[1,3]dioxolane-2,1'-indene-3',2''-[1,3]dioxolan]-2'-one, **2**

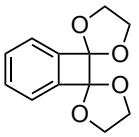


Ninhydrin **1** (5.12 g, 29 mmol), 1,3-propanediol (5 mL, 86.5 mmol) and *p*-TsOH (150 mg, 1.00 mmol) in toluene (150 mL) were heated at reflux under a Dean-Stark trap for 16 h then cooled to RT and concentrated *in vacuo*. Trituration with EtOAc (10 mL) gave the *title compound* **2** (5.17 mg, 21 mmol, 72%) as a white solid. **IR** ν_{max} ($CHCl_3$, cm^{-1}): 2967 (br), 2903 (br), 1722 (s), 1728 (m), 1469 (m), 1285 (s), 1022 (s) cm^{-1}. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.62–7.57 (4 H, m, 4 × Ar**H**), 4.45–4.39 (4 H, m, 4 × C**H**H), 4.36–4.28 (4 H, m, 4 × CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 209.3 (**C**), 138.4 (**C**), 131.9 (**C**H), 124.7 (**C**H), 101.4 (**C**), 66.4 (4 × **C**H_2) ppm. **LRMS** (ESI^+): 249 ([MH]$^+$, 100%). Data consistent with literature values.[2]

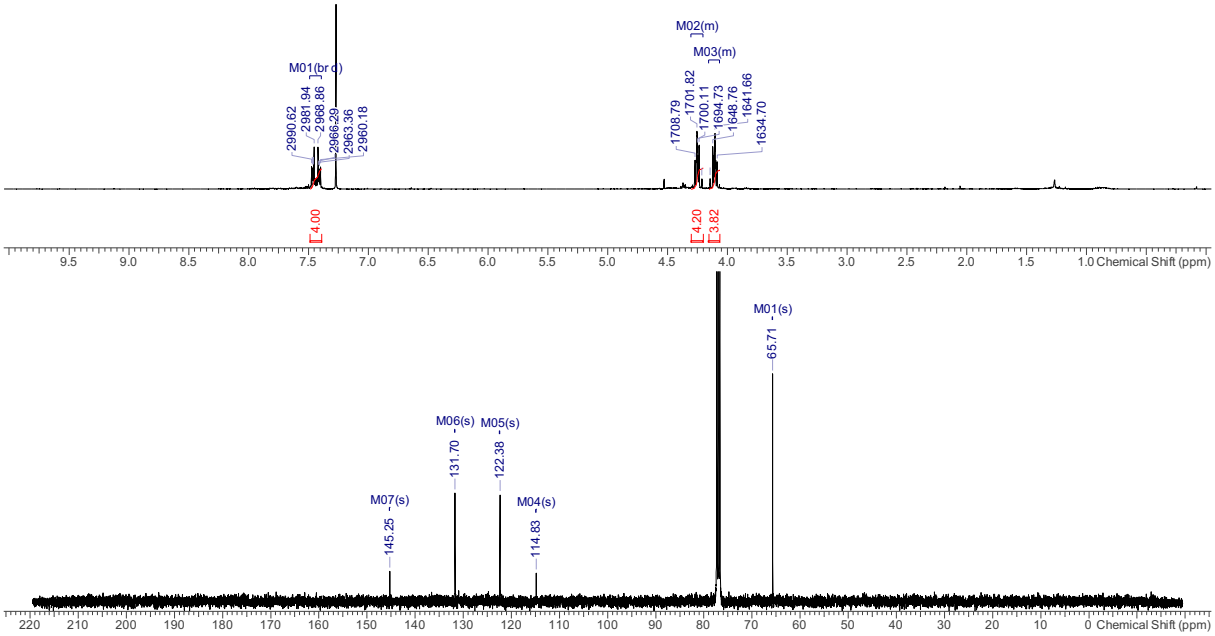




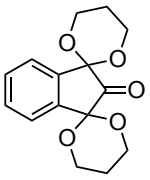
Dispiro[[1,3]dioxolane-2,7'-bicyclo[4.2.0]octane-8',2''-[1,3]dioxolane]-1'(6'),2',4'-triene, **3**



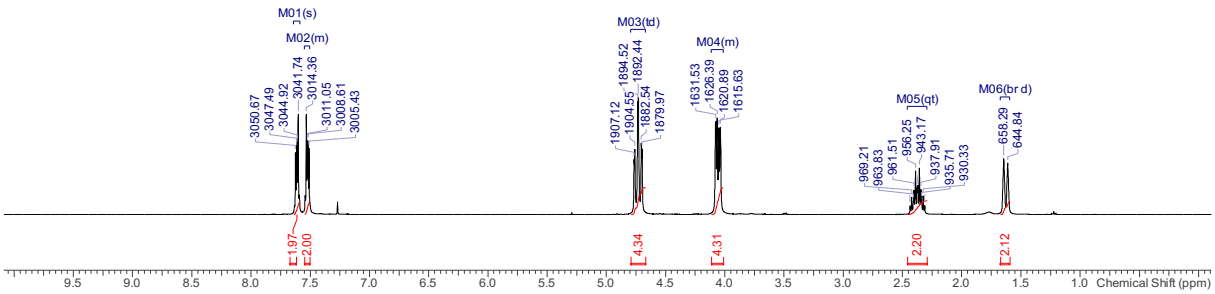
Using the flow photochemical set up C: A solution of *bis*-acetal **2** (600 mg, 2.40 mmol) in acetonitrile (50 mL) was irradiated with UVA light for a residence time of 3 h under circulating flow. The resulting solution was concentrated *in vacuo* then purified by column chromatography (50–70% EtOAc/petrol) to afford the *title compound* **3** as a white solid (300 mg, 1.4 mmol, 57%). **MP**: 142-141 °C. **IR** ν_{max} (film, cm^{-1}): 2975 (br), 2902 (br), 1720 (s), 1349 (s), 1263 (s), 1035 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.48–7.38 (4 H, M, 4 × Ar**H**), 4.28–4.20 (4 H, m, 4 × C**H**H), 4.13–4.05 (4 H, m, 4 × CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 145.3 (**C**), 131.7 (**C**H), 122.4 (**C**H), 114.8 (**C**), 65.7 (4 × **C**H_2) ppm. **LRMS** (ESI^+): 243 ([M+Na]$^+$, 20%), 221 ([MH]$^+$, 100%).[2]

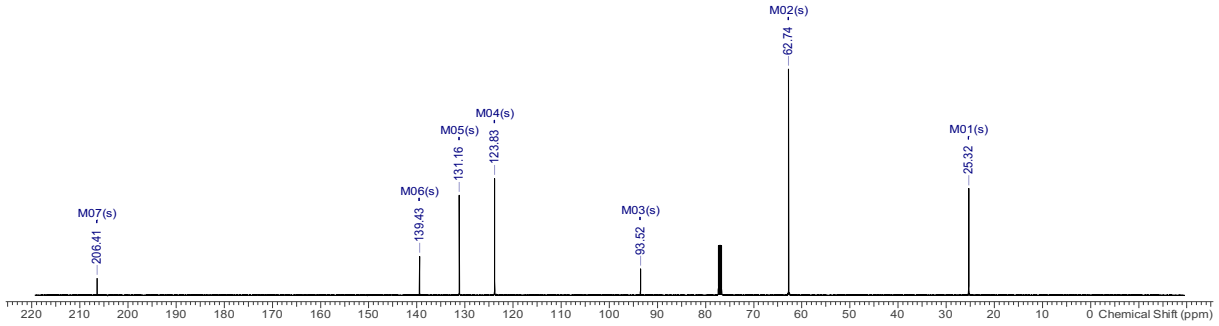


2'H-Dispiro[[1,3]dioxane-2,1'-indene-3',2''-[1,3]dioxan]-2'-one, **4a**

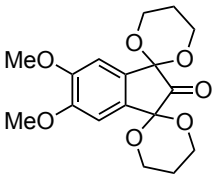


Ninhydrin **1** (18.17 g, 102 mmol), 1,3-propanediol (22 mL, 306 mmol) and *p*-TsOH (150 mg, 1.00 mmol) in toluene (150 mL) were heated at reflux under a Dean-Stark apparatus for 16 h then cooled to RT. Concentration *in vacuo* and trituration with cold EtOAc afforded the *title compound* **4a** (22.03 g, 79.8 mmol, 78%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 3486 (br), 2966 (br), 2902 (br), 1772 (s), 1469 (m), 1285 (s), 1021 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.61 (2 H, m, 2 × Ar**H**), 7.52 (2 H, m, 2 × Ar**H**), 4.73 (4 H, app. td, *J* = 12.3, 2.6 Hz, 4 × C**H**H), 4.06 (4 H, app. dd, *J* = 10.6, 5.0 Hz, 4 × CH**H**), 2.37 (2 H, qt, 12.9, 5.3 Hz, 2 × C**H**H), 1.63 (2 H, br. d, *J* = 13.5 Hz, 2 × CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 206.4 (**C**), 139.4 (**C**), 131.2 (**C**H), 123.8 (**C**H), 93.5 (**C**), 62.7 (**C**H_2), 25.3 (**C**H_2) ppm. **LRMS** (ESI^+): 277 ([MH]$^+$, 100%). **HRMS** (ESI^+): Found 299.0893, $C_{15}H_{16}NaO_5$ [M+Na]$^+$ requires 299.0890.

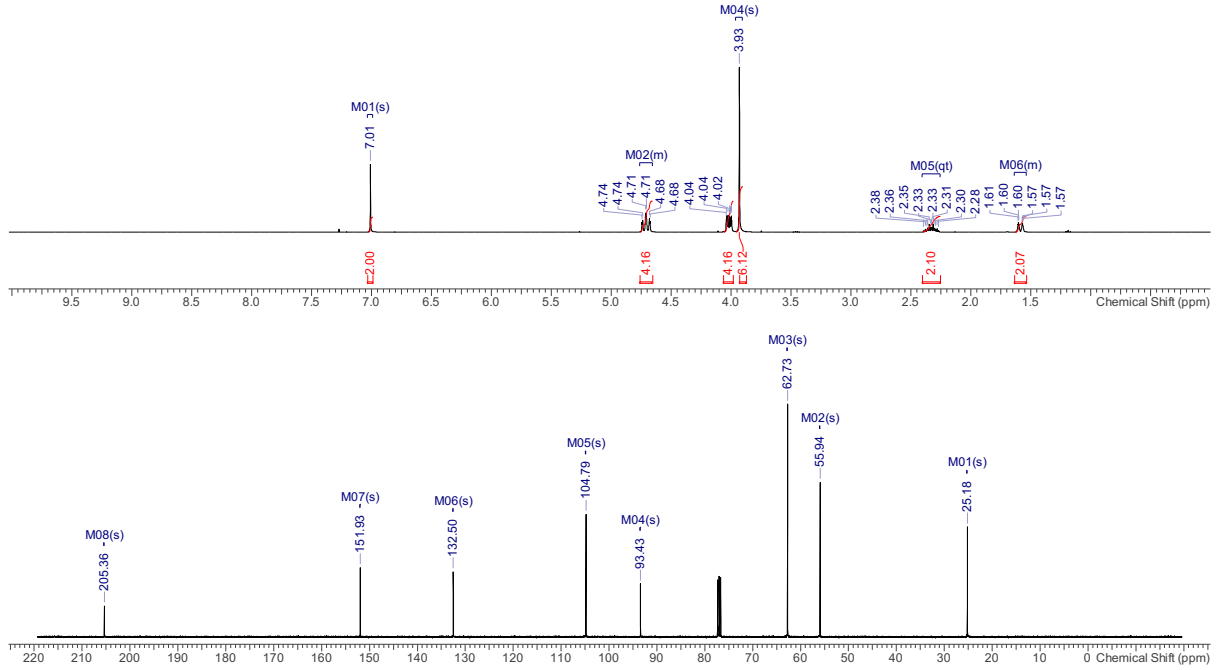




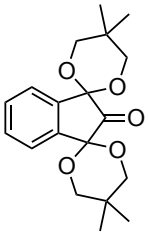
5',6'-Dimethoxy-2'H-dispiro[[1,3]dioxane-2,1'-indene-3',2''-[1,3]dioxan]-2'-one, **4b**



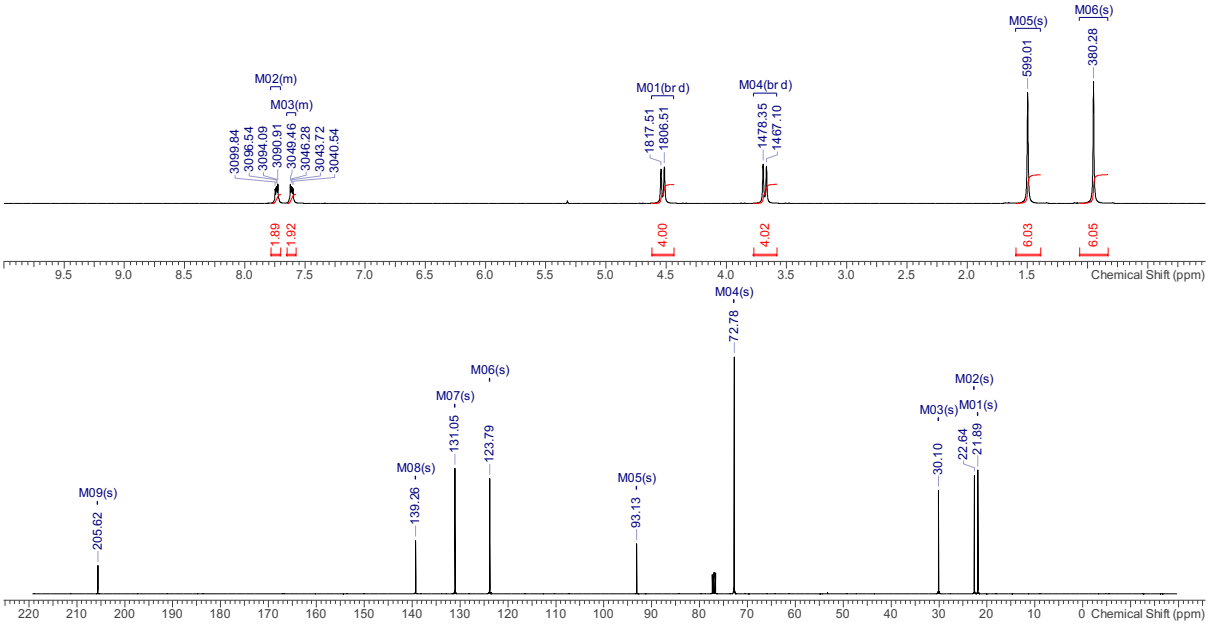
To a suspension of selenium dioxide (4.93 g, 44.0 mmol) in dioxane (25 mL) was added 5,6-dimethoxyindan-1-one (3.38 g, 17.6 mmol). The resulting mixture was heated at reflux for 3 h then cooled to RT, filtered and concentrated *in vacuo*. The residue was dissolved in DCM (50 mL), filtered and concentrated *in vacuo* to a brown solid. Toluene (200 mL), 1,3-propanediol (3.2 mL, 44 mmol) and *p*-TsOH (344 mg, 2.00 mmol) were then added, and the resulting solution was heated at reflux under a Dean-Stark trap for 16 h. The reaction mixture was then cooled to RT, concentrated in *vacuo*, and purified by column chromatography (20 - 40% Et_2O/hexane) to afford the *title compound* **4b** (3.13 g, 9.30 mmol, 53%) as a white solid. **MP**: 157–159 °C (Et_2O/hexane). **IR** ν_{max} (film, cm^{-1}): 2886 (br), 1748 (m), 1505 (s), 1326 (s), 1016 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.01 (2 H, s, 2 × Ar**H**), 4.74–4.68 (4 H, m, 4 × C**H**H), 4.04–3.99 (4 H, m, 4 × CH**H**), 3.93 (6 H, s, 2 × C**H**$_3$), 2.33 (2 H, app. qt, *J* = 13.0, 5.3 Hz, 2 × C**H**H), 1.61–1.57 (2 H, m, 2 × CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 205.4 (**C**), 151.9 (2 × **C**), 132.5 (2 × **C**), 104.8 (2 × **C**H), 93.4 (2 × **C**), 62.7 (4 × **C**H_2), 55.9 (2 × **C**H_3), 25.2 (2 × **C**H_2) ppm. **LRMS** (ESI^+): 337 $[MH]^+$. **HRMS** (ESI^+): Found 337.1279, $C_{17}H_{21}O_7$ $[MH]^+$ requires 337.1282.



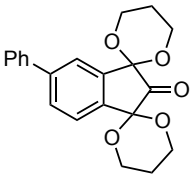
5,5,5'',5''-Tetramethyl-2'H-dispiro[[1,3]dioxane-2,1'-indene-3',2''-[1,3]dioxan]-2'-one, **4c**



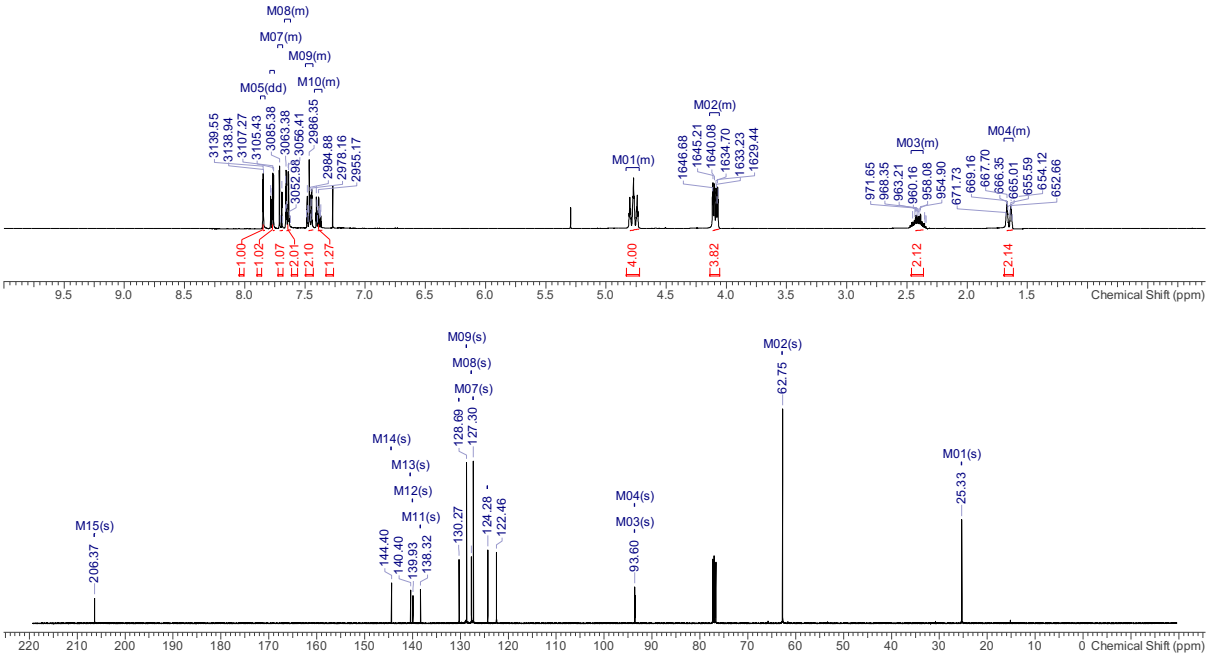
A solution of ninhydrin (2.13 g, 11.2 mmol), 2,2-dimethyl-1,3-propanediol (3.11 mL, 29.9 mmol) and *p*TsOH (86 mg, 0.50 mmol) in toluene (150 mL) was heated at reflux under a Dean-Stark apparatus for 16 h then cooled to RT. Concentration *in vacuo* and purification by column chromatography (20–50% EtOAc/hexane) afforded the title compound (2.69 g, 8.10 mmol, 72%) as a white solid. **MP:** 172–173 °C (EtOAc/hexane). **IR** ν_{max} (film, cm^{-1}): 2955 (br), 1748 (s), 1470 (s), 1338 (s), 1069 (s), 1037 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.75–7.72 (2 H, m, 2 × Ar**H**), 7.62–7.60 (2 H, m, 2 × Ar**H**), 4.53 (4 H, d, *J* = 11.4 Hz, 4 × C**H**H), 3.68 (4 H, d, *J* = 11.3 Hz, 4 × CH**H**), 1.50 (6 H, s, 2 × C**H**$_3$), 0.95 (6 H, s, 2 × C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 205.6 (**C**), 139.3 (2 × **C**), 131.1 (2 × **C**H), 123.8 (2 × **C**H), 93.1 (2 × **C**), 72.8 (4 × **C**H_2), 30.1 (2 × **C**), 22.6 (2 × **C**H_3), 21.9 (2 × **C**H_3) ppm. **LRMS** (ESI^+): 333 $[MH]^+$. **HRMS** (ESI^+): Found 355.1520, $C_{19}H_{24}NaO_5$ $[M + Na]^+$ requires 355.1516.



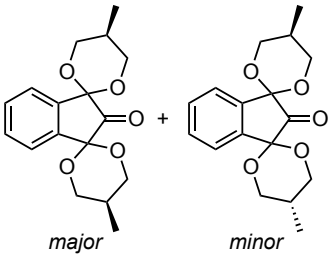
5'-Phenyl-2'H-dispiro[[1,3]dioxane-2,1'-indene-3',2''-[1,3]dioxan]-2'-one, **4d**



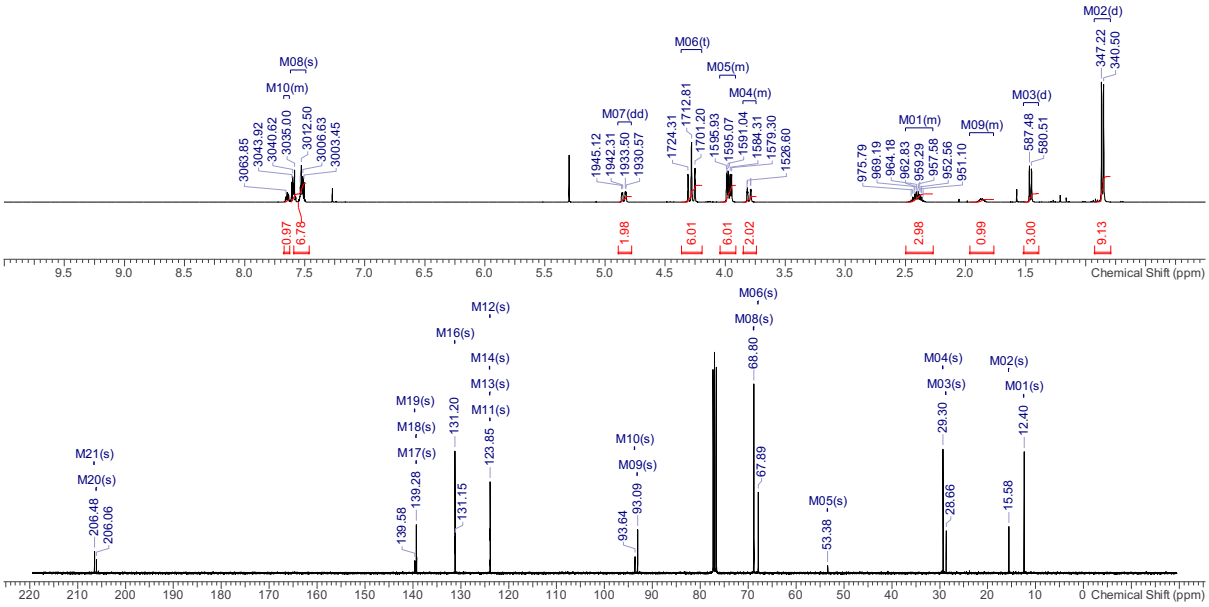
5-Phenylindan-1-one (1.96 g, 9.43 mmol) was added to suspension of selenium dioxide (2.62 g, 23.6 mmol) in dioxane (25 mL), then heated at reflux for 3 h. After cooling to RT, the solution was filtered, concentrated *in vacuo*, triturated with DCM (50 mL), filtered and concentrated *in vacuo* to a brown solid (4.00 g, 38.5 mmol). Toluene (200 mL), *p*-TsOH (300 mg, 2.00 mmol) and 2,2-dimethyl-1,3-propanediol (3.11 mL, 29.9 mmol) were added then the solution was heated at reflux under a Dean-Stark apparatus for 16 h. After cooling to RT, the resulting solution was concentrated *in vacuo* and purified by column chromatography (20–50% EtOAc/hexane) to afford the *title compound* **4d** (2.69 g, 8.10 mmol, 72%) as a white solid. **MP**: 201–202 °C (Et_2O/hexane). **IR** ν_{max} (film, cm^{-1}): 2961 (br), 1745 (m), 1329 (m), 1326 (s), 1241 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.85 (1 H, dd, *J* = 1.7, 0.6 Hz, Ar**H**), 7.77 (1 H, dd, *J* = 8.1, 1.8 Hz, Ar**H**), 7.70 (1 H, dd, *J* = 8.1, 0.6 Hz, Ar**H**), 7.66–7.63 (2 H, m, 2 × Ar**H**), 7.49–7.44 (2 H, m, 2 × Ar**H**), 7.39 (1 H, m, Ar**H**), 4.82–4.73 (4 H, m, 4 × C**H**H), 4.12–4.07 (4 H, m, 4 × CH**H**), 2.47–2.43 (2 H, m, 2 × C**H**H), 1.68–1.62 (2 H, m, 2 × CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 206.4 (**C**), 144.4 (**C**), 140.4 (**C**), 139.9 (**C**), 138.3 (**C**), 130.3 (**C**H), 128.7 (2 × **C**H), 127.0 (**C**H), 127.3 (2 × **C**H), 124.3 (**C**H), 122.5 (**C**H), 93.6 (2 × **C**), 62.8 (4 × **C**H_2), 25.3 (2 × **C**H_2) ppm. **LRMS** (ESI^+): 375 [M + Na]$^+$, 353 [MH]$^+$. **HRMS** (ESI^+): Found 375.1211, $C_{21}H_{20}NaO_5$ [M + Na]$^+$ requires 375.1203.



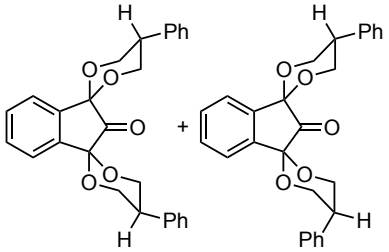
5,5''-Dimethyl-2'H-dispiro[[1,3]dioxane-2,1'-indene-3',2''-[1,3]dioxan]-2'-one, **4e** and **4e'**



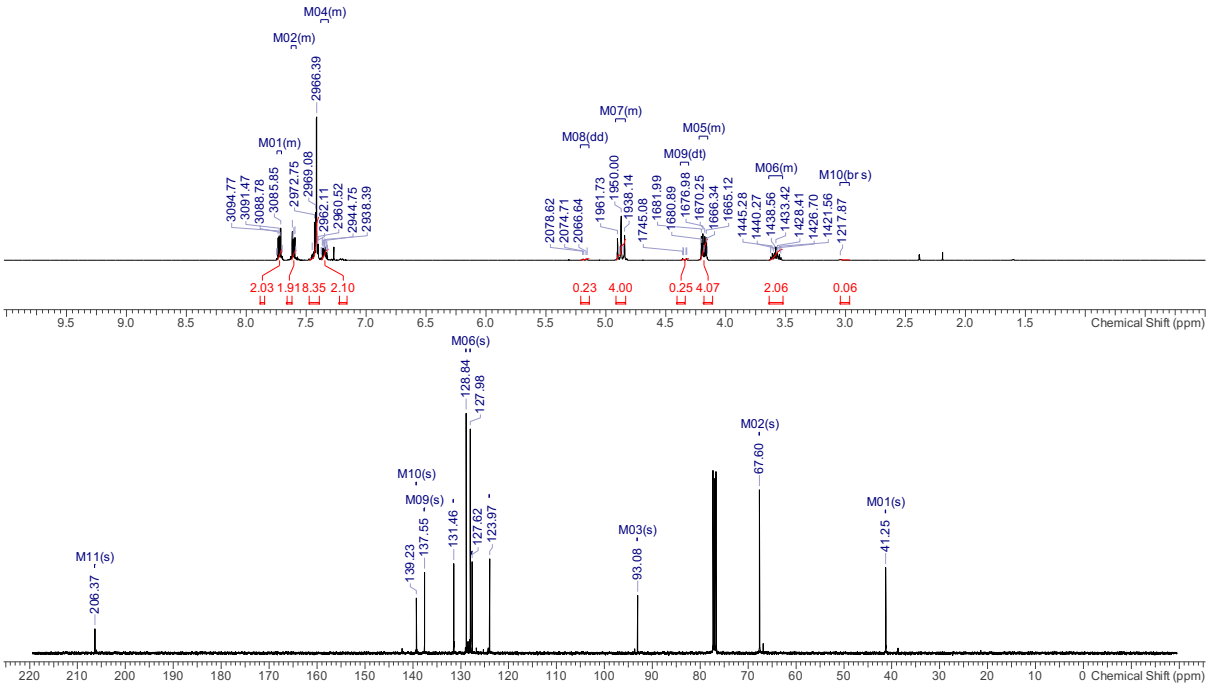
A solution of ninhydrin (2.33 g, 13.1 mmol), 2-methyl-1,3-propanediol (2.9 mL, 32.7 mmol) and *p*-TsOH (86 mg, 0.50 mmol) in toluene (150 mL) were heated at reflux under a Dean-Stark apparatus for 16 h then cooled to RT. Concentration *in vacuo* and purification by column chromatography (30–50% EtOAc/hexane) afforded the *title compound* **4e** (2.95 g, 9.70 mmol, 74%) as white solid and inseparable mixture of stereoisomers. **MP**: 131–132 °C (EtOAc/hexane). **IR** ν_{max} (film, cm^{-1}): 2964 (br), 1748 (s), 1333 (s), 1029 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ major isomer 7.61–7.51 (4 H, m, 4 × Ar**H**), 4.28 (4 H, app. t, *J* = 11.6 Hz, 4 × C**H**H), 3.99–3.95 (4 H, m, 4 × CH**H**), 2.45–2.35 (2 H, m, 2 × C**H**), 0.86 (6 H, d, *J* = 6.7 Hz, 2 × CH_3); additional signals attributed to the minor isomer 7.66–7.51 (4 H, m, 4 × Ar**H**), 4.84 (4 H, dd, *J* = 11.6, 2.8 Hz, 4 × C**H**H), 3.82–3.79 (4 H, m, 4 × CH**H**), 1.91–1.83 (2 H, m, 2 × C**H**), 1.46 (6 H, d, *J* = 7.0 Hz, 2 × CH_3) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ major isomer 206.5 (**C**), 139.3 (**C**), 131.20 (**C**H), 123.85 (**C**H), 93.1 (**C**), 68.8 (4 × **C**H_2), 29.3 (2 × **C**H), 12.4 (2 × **C**H_3); minor isomer 206.1 (**C**), 139.2 (**C**), 131.15 (**C**H), 123.87 (**C**H), 93.4 (**C**), 67.9 (4 × **C**H_2), 28.7 (2 × **C**H), 15.6 (2 × **C**H_3) ppm. **LRMS** (ESI^+): 305 $[MH]^+$. **HRMS** (ESI^+): Found 305.1381, $C_{17}H_{21}O_5$ $[MH]^+$ requires 305.1384.



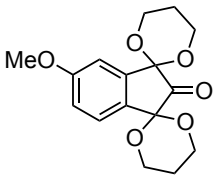
(Z,Z)-5,5''-Diphenyl-2'H-dispiro[[1,3]dioxane-2,1'-indene-3',2''-[1,3]dioxan]-2'-one, **4f**



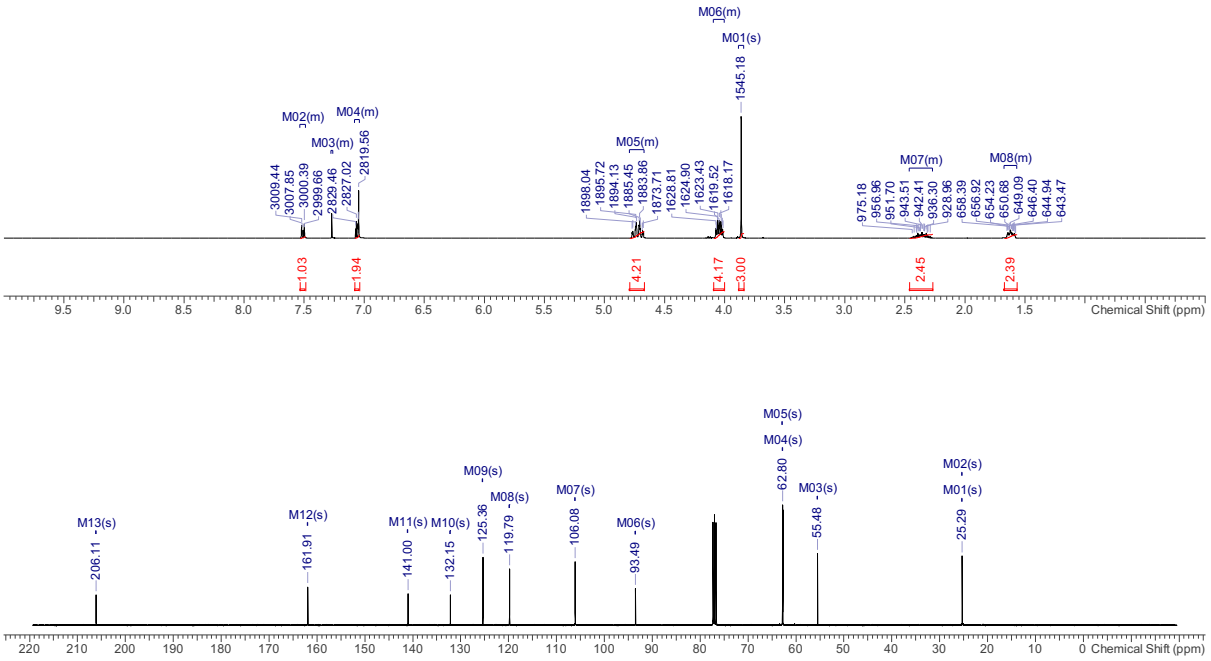
A solution of ninhydrin (1.37 g, 7.73 mmol), 2-phenyl-1,3-propanediol (2.94 g, 19.3 mmol) and *p*-TsOH (86 mg, 0.50 mmol) in toluene (150 mL) were heated at reflux under a Dean-Stark apparatus for 16 h then cooled to RT. Concentration *in vacuo* and washing with cold water afforded the *title compound* **4f** (2.27 g, 6.40 mmol, 83%) as a white solid and >10 : 1 mixture of diastereoisomers. **MP**: 143–145 °C (Et_2O). **IR** ν_{max} (film, cm^{-1}): 2961 (br), 1746 (s), 1335 (s), 1027 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.75–7.70 (2 H, m, 2 × Ar**H**), 7.62–7.59 (2 H, m, 2 × Ar**H**), 7.45–7.40 (8 H, m, 8 × Ar**H**), 7.37–7.32 (2 H, m, 2 × Ar**H**), 4.90–4.84 (4 H, m, 4 × C**H**H), 4.20–4.15 (4 H, m, 4 × CH**H**), 3.62–3.54 (2 H, m, 2 × C**H**); additional signals attributed to the minor isomer δ 5.18 (2 H, dd, *J* = 11.9, 3.9 Hz, 2 × C**H**H), 4.36–4.33 (2 H, m, 2 × CH**H**), 3.04 (1 H, m, C**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ major isomer 206.4 (**C**), 139.2 (2 × **C**), 137.6 (2 × **C**), 131.5 (2 × **C**H), 128.8 (4 × **C**H), 128.0 (4 × **C**H), 127.6 (2 × **C**H), 124.9 (2 × **C**H), 93.1 (2 × **C**), 67.6 (4 × **C**H_2), 41.3 (2 × **C**H); additional signals attributed to the minor isomer δ 206.0 (**C**), 142.2 (**C**), 131.3 (**C**H), 128.5 (**C**H), 128.2 (**C**H), 93.7 (**C**), 66.9 (**C**H_2), 38.7 (**C**H) ppm. **LRMS** (ESI^+): 429 $[MH]^+$; **HRMS** (ESI^+): Found 429.1692, $C_{27}H_{25}O_5$ $[MH]^+$ requires 429.1697.



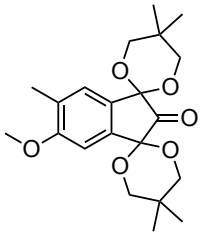
5'-Methoxy-2'H-dispiro[[1,3]dioxane-2,1'-indene-3',2''-[1,3]dioxan]-2'-one, ***4g***



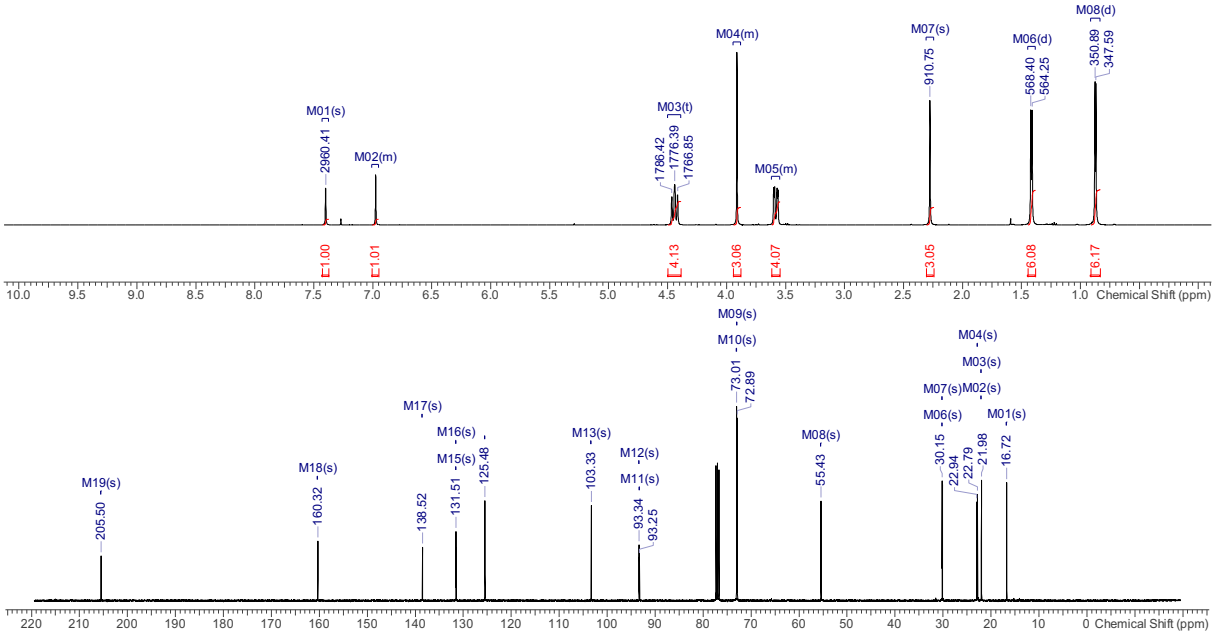
5-Methoxyninhydrin (1.90 g, 9.13 mmol), 1,3-propanediol (1.64 mL, 22.8 mmol) and *p*-TsOH (86 mg, 0.50 mmol) in toluene (150 mL) were heated at reflux under a Dean-Stark apparatus for 16 h then cooled to RT. Concentration *in vacuo* and purification by column chromatography (20–50% EtOAc/hexane) afforded the *title compound* **4g** (2.10 g, 6.85 mmol, 75%) as a white solid. **MP**: 171–172 °C (EtOAc/hexane). **IR** ν_{max} (film, cm^{-1}): 3452 (br), 2964 (br), 1718 (s), 1598 (s), 1327 (s), 1067 (s), 1020 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.51 (1 H, m, Ar**H**), 7.06 (1 H, dd, *J* = 8.2, 2.5 Hz, Ar**H**), 7.05 (1 H, br s, Ar**H**), 4.77–4.68 (4 H, m, 4 × C**H**H), 4.07–4.02 (4 H, m, 4 × CH**H**), 3.86 (3 H, s, C**H**$_3$), 2.44–2.28 (2 H, m, 2 × C**H**H), 1.65–1.58 (2 H, m, 2 × CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 206.1 (**C**), 161.9 (**C**), 141.0 (**C**), 132.2 (**C**), 125.4 (**C**H), 119.8 (**C**H), 106.1 (**C**H), 93.5 (2 × **C**), 62.8 (2 × **C**H$_2$), 62.7 (2 × **C**H$_2$), 55.5 (**C**H$_3$), 25.3 (2 × **C**H$_2$) ppm. **LRMS** (ESI$^+$): 307 [MH]$^+$. **HRMS** (ESI$^+$): Found 329.0995, $C_{16}H_{18}NaO_6$ [M + Na]$^+$ requires 329.0996.



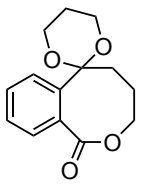
5'-Methoxy-5,5,5'',5'',6'-pentamethyl-2'H-dispiro[[1,3]dioxane-2,1'-indene-3',2''-[1,3]dioxan]-2'-one, **4h**



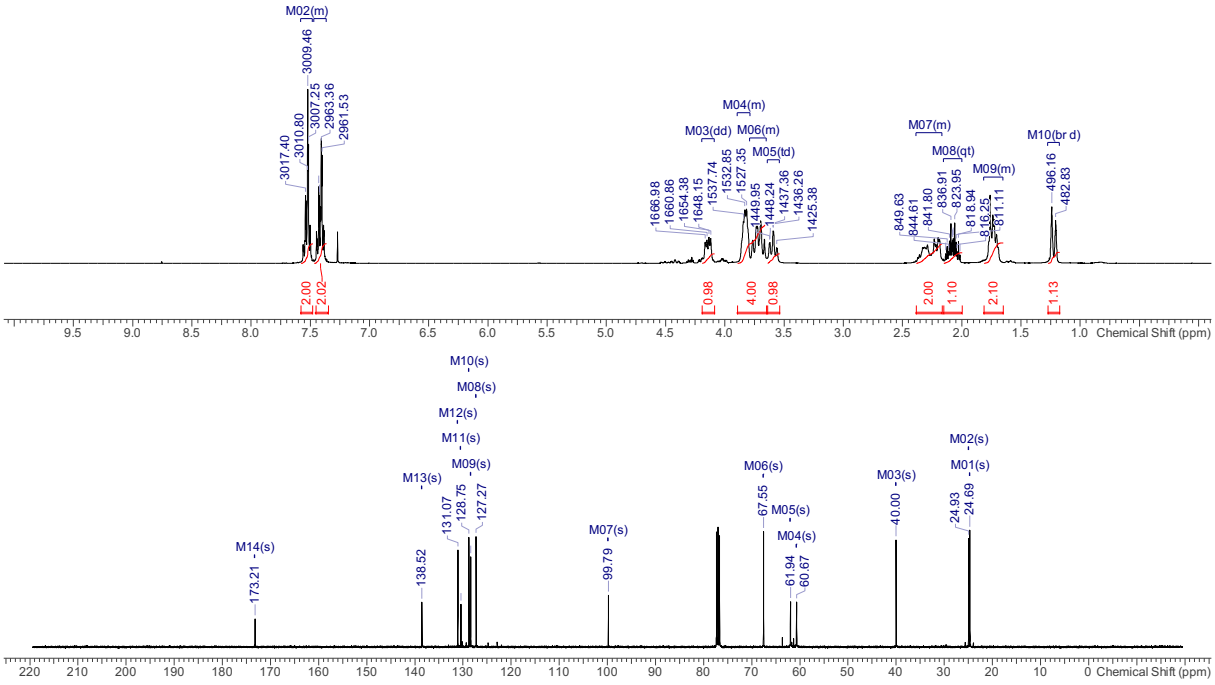
5-Methoxy-6-methyl-1-indanone **7** (2.69 g, 15.3 mmol) was added to a suspension of selenium dioxide (8.40 g, 76.5 mmol) in dioxane (25 mL), then heated at reflux for 3 h. After cooling to RT, the solution was filtered, concentrated *in vacuo*, triturated with DCM (50 mL), filtered, and concentrated *in vacuo* to a brown solid. Toluene (200 mL), *p*-TsOH (300 mg, 2.00 mmol) and 2,2-dimethyl-1,3-propanediol (4.00 g, 38.5 mmol) were added then the solution was heated at reflux under a Dean-Stark apparatus for 16 h. After cooling to RT, the resulting solution was concentrated *in vacuo* and purified by column chromatography (5–15% Et_2O/petrol) to afford the *title compound* **4h** (4.37 g, 11.6 mmol, 76%) as a white solid. **MP**: 97–98 °C. **IR** ν_{max} (film, cm^{-1}): 2956 (br), 1742 (m), 1619 (m), 1471 (m), 1344 (s), 1162 (s), 1122 (s), 1062 (s), 1032 (s), 1010 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.40 (1 H, s, Ar**H**), 6.98 (1 H, s, Ar**H**), 4.45 (2 H, br d, *J* = 10.0 Hz, 2 × C**H**H), 4.43 (2 H, br d, *J* = 10.0 Hz, 2 × C**H**H), 3.91 (3 H, s, OC**H**$_3$), 3.63–3.57 (4 H, m, 4 × CH**H**), 2.28 (3 H, s, C**H**$_3$), 1.42 (3 H, s, C**H**$_3$), 1.41 (3 H, s, C**H**$_3$), 0.88 (3 H, s, C**H**$_3$), 0.87 (3 H, s, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 205.5 (**C**), 160.3 (**C**), 138.5 (**C**), 131.51 (**C**), 131.47 (**C**), 125.5 (**C**H), 103.3 (**C**H), 93.34 (**C**), 93.25 (**C**), 73.0 (2 × **C**H$_2$), 72.9 (2 × **C**H$_2$), 55.4 (**C**H$_3$), 30.2 (**C**), 30.1 (**C**), 22.9 (**C**H$_3$), 22.8 (**C**H$_3$), 22.00 (**C**H$_3$), 21.96 (**C**H$_3$), 16.7 (**C**H$_3$) ppm. **LRMS** (ESI$^+$): 399 ([M+Na]$^+$, 10%), 377 ([MH]$^+$, 100%). **HRMS** (ESI$^+$): Found 377.1965, $C_{21}H_{29}O_6$ [MH]$^+$ requires 377.1959.



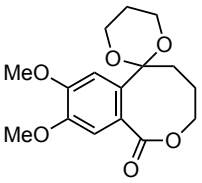
4,5-Dihydro-3H-dispiro[furan-2,1'-isobenzofuran-3',2''-[1,3]dioxane], **5a**



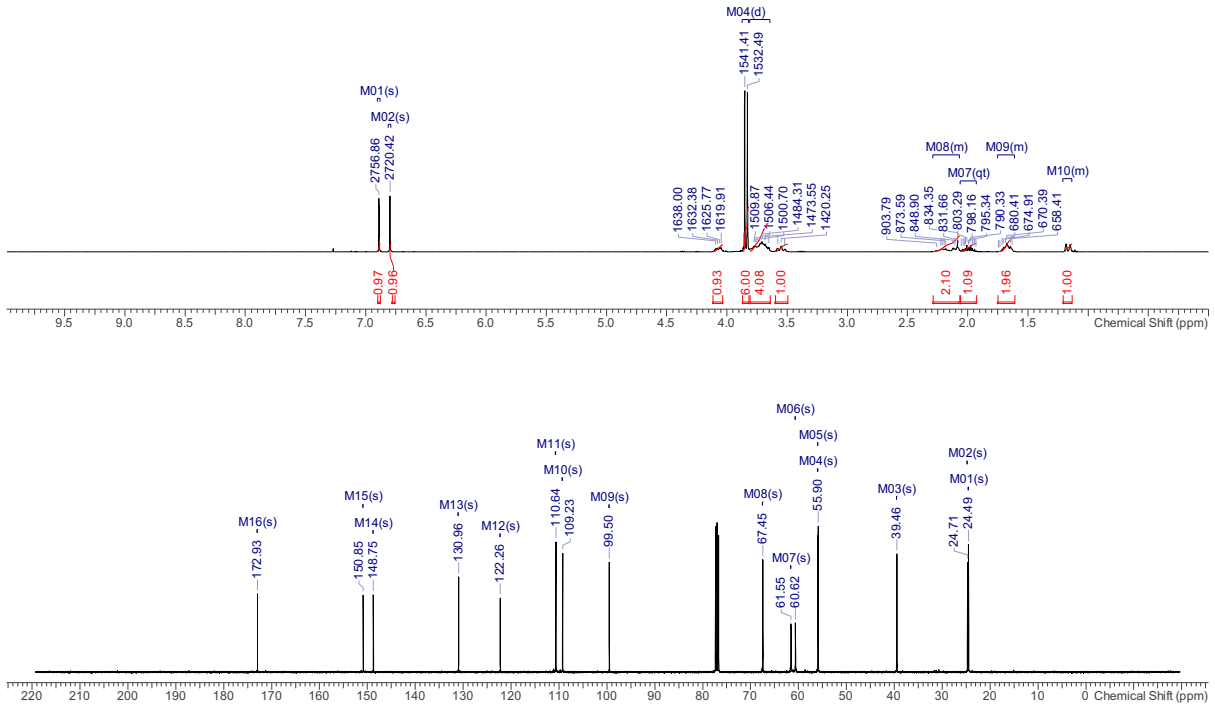
Using the flow photochemical set up B, a solution of *bis*-acetal **4a** (660 mg, 2.39 mmol) in THF (130 mL) was irradiated with UVC light for a residence time of 1 h. The resulting solution was concentrated *in vacuo* then purified by recrystallization (DCM) to afford the *title compound* **5a** (504 mg, 2.03 mmol, 85%, purity ~95%) as a moisture sensitive white solid. **MP**: 97–98 °C. **IR** ν_{max} (film, cm^{-1}): 2968 (br), 2874 (br), 1725 (s), 1293 (m), 1248 (s), 1091 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.56–7.50 (2 H, m, 2 × Ar**H**), 7.45–7.38 (2 H, m, 2 × Ar**H**), 4.14 (1 H, br dd, *J* = 12.7, 6.2 Hz, OC**H**H), 3.88–3.79 (2 H, m, 2 × OC**H**H), 3.76–3.67 (2 H, m, 2 × OCH**H**), 3.59 (1 H, br t, *J* = 12.3 Hz, OCH**H**), 2.37–2.17 (2 H, m, 2 × C**H**H), 2.08 (1 H, app qt, *J* = 12.8, 5.0 Hz, C**H**H), 1.79–1.69 (2 H, m, 2 × CH**H**), 1.22 (1 H, br d, *J* = 13.3 Hz, CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 173.2 (**C**), 138.5 (**C**), 131.1 (**C**H), 130.4 (**C**), 128.8 (**C**H), 128.4 (**C**H), 127.3 (**C**H), 99.8 (**C**), 67.6 (**C**H$_2$), 61.9 (**C**H$_2$), 60.7 (**C**H$_2$), 40.0 (**C**H$_2$), 24.9 (**C**H$_2$), 24.7 (**C**H$_2$) ppm. **LRMS** (ESI$^+$): 271 ([M+Na]$^+$, 20%), 249 ([MH]$^+$, 100%). **HRMS** (ESI$^+$): Found 249.1122, $C_{14}H_{17}O_4$ [MH]$^+$ requires 249.1121.



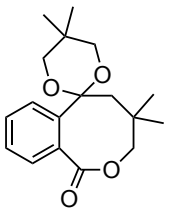
8,9-Dimethoxy-4,5-dihydro-1H,3H-spiro[benzo[c]oxocine-6,2'-[1,3]dioxan]-1-one, **5b**



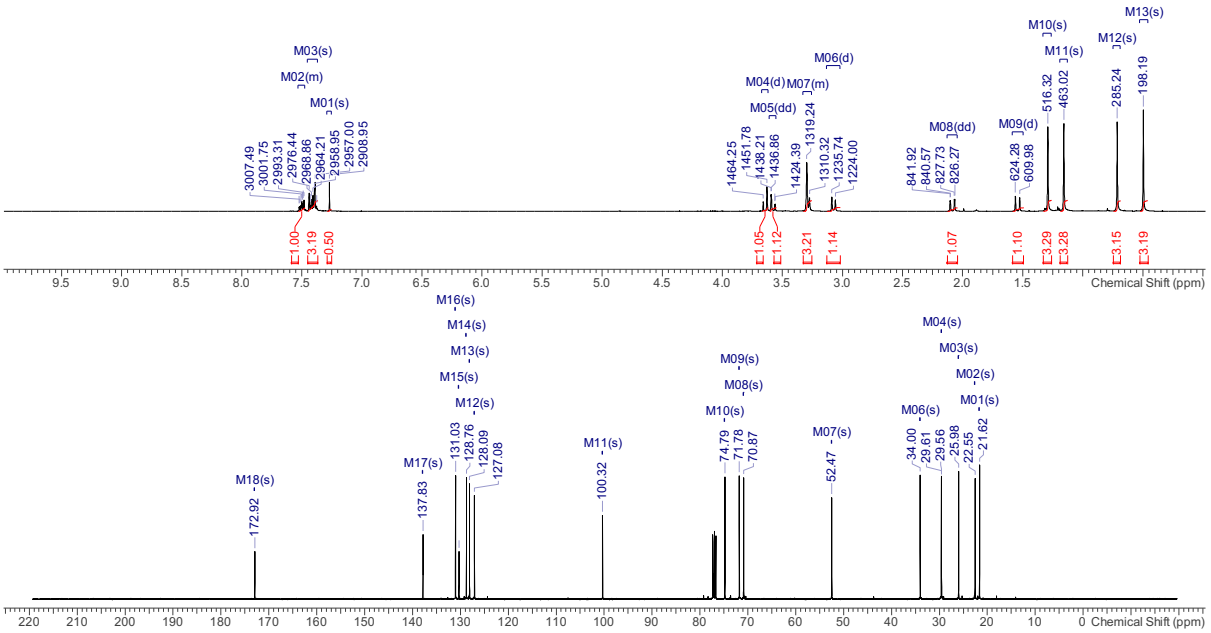
Using the flow photochemical set up A, a solution of *bis*-acetal **4b** (600 mg, 1.79 mmol) in THF (120 mL) was irradiated with UVC light for 1 h under circulating flow. The resulting solution was concentrated *in vacuo* then purified by recrystallization (DCM) to afford the *title compound* **5a** (447 mg, 1.45 mmol, 81%) as a white solid. **MP**: 97–98 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 2961(br), 1718 (s), 1513 (s), 1262 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 6.89 (1 H, s, Ar**H**), 6.80 (1 H, s, Ar**H**), 4.07 (1 H, dd, *J* = 12.4, 5.8 Hz, OC**H**H), 3.85 (3 H, s, C**H**$_3$), 3.83 (3 H, s, C**H**$_3$), 3.80–3.52 (5 H, m, 2 × OC**H**$_2$ + OCH**H**), 2.26–2.08 (2 H, m, 2 × C**H**H), 1.99 (1 H, m, C**H**H), 1.73–1.63 (2 H, m, 2 × CH**H**), 1.17 (1 H, m, CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 172.9 (**C**), 150.9 (**C**), 148.8 (**C**), 131.0 (**C**), 122.3 (**C**), 110.6 (**C**H), 109.2 (**C**H), 99.5 (**C**), 67.5 (**C**H$_2$), 61.6 (**C**H$_2$), 60.6 (**C**H$_2$), 55.94 (**C**H$_3$), 55.90 (**C**H$_3$), 39.5 (**C**H$_2$), 24.7 (**C**H$_2$), 24.5 (**C**H$_2$) ppm. **LRMS** (ESI$^+$): 309 $[MH]^+$. **HRMS** (ESI$^+$): Found 331.1159, $C_{16}H_{20}NaO_6$ $[M + Na]^+$ requires 331.1152.



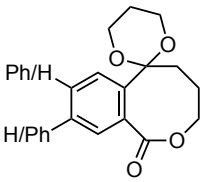
4,4,5',5'-Tetramethyl-4,5-dihydro-1H,3H-spiro[benzo[c]oxocine-6,2'-[1,3]dioxan]-1-one, **5c**



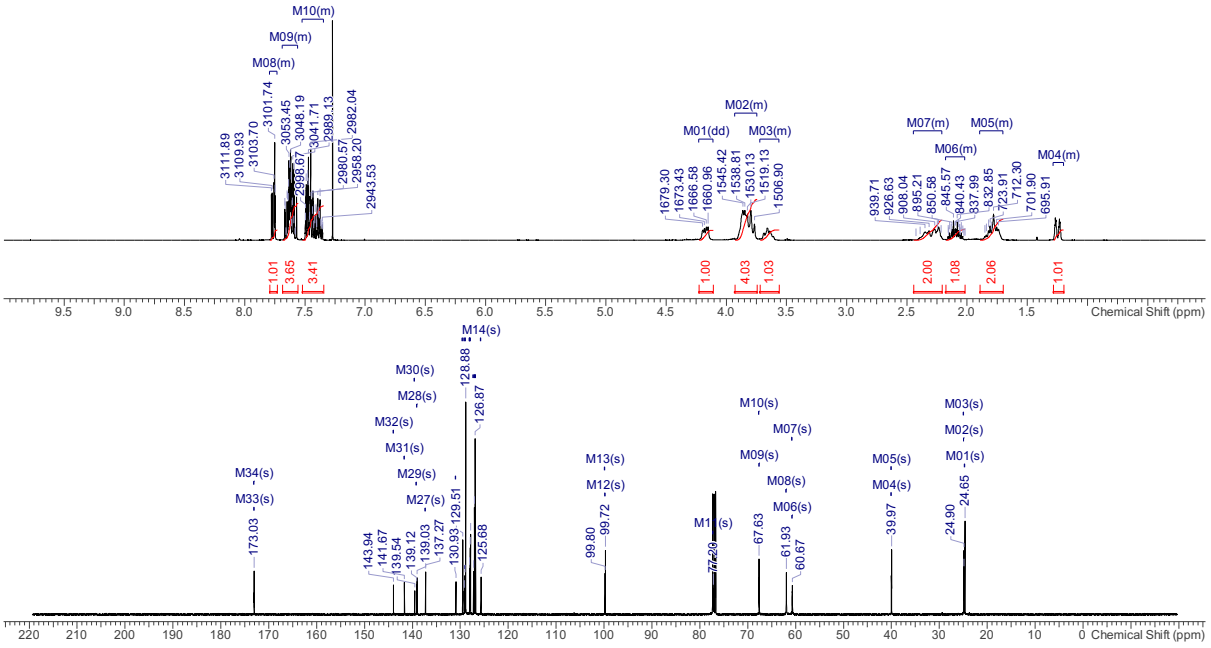
Using the flow photochemical set up B, a solution of *bis*-acetal **4c** (931 mg, 2.80 mmol) in THF (140 mL) was irradiated with UVC light for a residence time of 1 h. The resulting solution was concentrated *in vacuo* then purified by column chromatography (30–50% Et_2O/hexane) to afford the *title compound* **5c** (660 mg, 2.03 mmol, 73%) as a colourless oil. **IR** ν_{max} (film, cm^{-1}): 2960 (br), 1719 (s), 1283 (s), 1250 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.50 (1 H, m, Ar**H**), 7.44–7.38 (3 H, m, 3 × Ar**H**), 3.64 (1 H, d, *J* = 12.5 Hz, OC**H**H), 3.58 (1 H, dd, *J* = 12.5, 1.3 Hz, OCH**H**), 3.30–3.27 (3 H, m, OC**H**$_2$ + OC**H**H), 3.07 (1 H, d, *J* = 11.7 Hz, OCH**H**), 2.08 (1 H, dd, *J* = 14.2, 1.4 Hz, C**H**H), 1.54 (1 H, d, *J* = 14.3 Hz, CH**H**), 1.29 (3 H, s, C**H**$_3$), 1.16 (3 H, s, C**H**$_3$), 0.71 (3 H, s, C**H**$_3$), 0.50 (3 H, s, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 172.9 (**C**), 137.8 (**C**), 131.0 (**C**H), 130.3 (**C**), 128.8 (**C**H), 128.1 (**C**H), 127.1 (**C**H), 100.3 (**C**), 74.8 (**C**H_2), 71.8 (**C**H_2), 70.9 (**C**H_2), 52.5 (**C**H_2), 34.0 (**C**), 29.61 (**C**H_3), 29.56 (**C**), 26.0 (**C**H_3), 22.6 (**C**H_3), 21.6 (**C**H_3) ppm. **LRMS** (ESI^+): 305 $[MH]^+$, 219 $[MH–C_5H_{10}O]$. **HRMS** (ESI^+): Found 305.1751, $C_{18}H_{24}O_4$ $[MH]^+$ requires 305.1753.



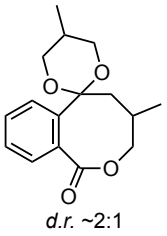
8-Phenyl-4,5-dihydro-1H,3H-spiro[benzo[c]oxocine-6,2'-[1,3]dioxan]-1-one and 9-phenyl-4,5-dihydro-1H,3H-spiro[benzo[c]oxocine-6,2'-[1,3]dioxan]-1-one, **5d** and **5d'**



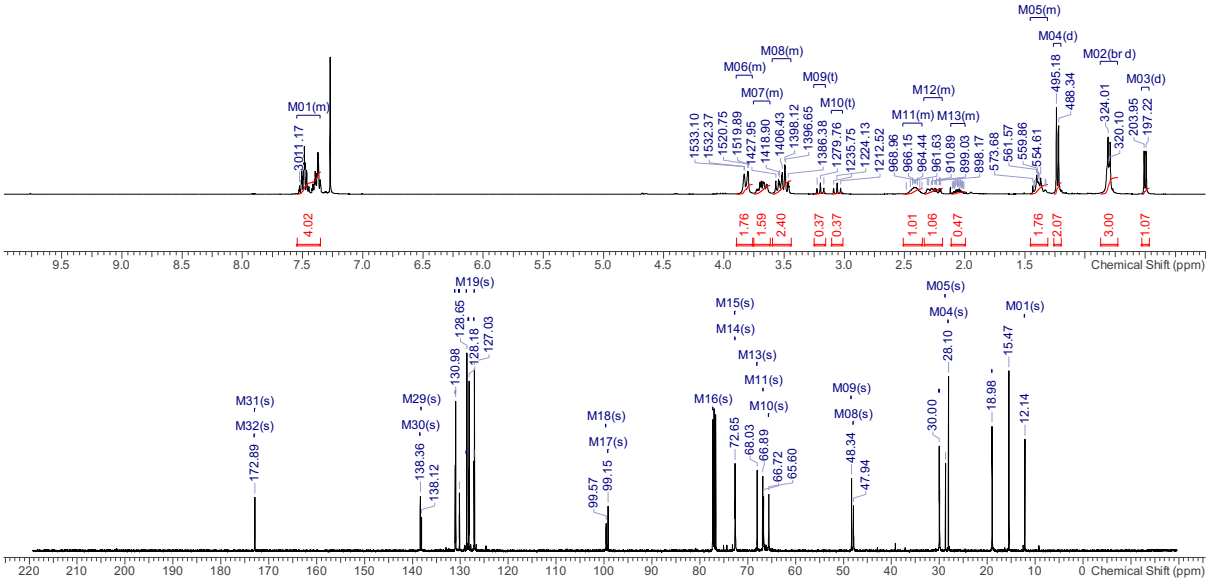
Using the flow photochemical set up B, a solution of *bis*-acetal **4d** (472 mg, 1.34 mmol) in THF (67 mL) was irradiated with UVC light for a residence time of 1 h. The resulting solution was concentrated *in vacuo* then purified by column chromatography (20–40% Et_2O/hexane) to afford an inseparable ~5 : 3 mixture of the *title compounds* **5d** and **5d'** (311 mg, 0.961 mmol, 72%) as a colourless oil. **IR** ν_{max} (film, cm^{-1}): 2962 (br), 1719 (s), 1092 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.78–7.75 (1 H + 1 H, m, Ar**H**), 7.67–7.35 (7 H + 7 H, m, 7 × Ar**H**), 4.17 (1 H + 1 H, br dd, *J* = 12.5, 5.9 Hz, C**H**H), 3.86–3.77 (4 H + 4 H, m, 2 × C**H**$_2$), 3.64 (1 H + 1 H, m, CH**H**), 2.42–2.21 (2 H + 2 H, m, 2 × C**H**H), 2.10 (1 H + 1 H, m, C**H**H), 1.85–1.74 (2 H + 2 H, m, 2 × CH**H**), 1.24 (1 H + 1 H, m, CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ major isomer 173.0 (**C**), 143.9 (**C**), 141.7 (**C**), 139.0 (**C**), 137.3 (**C**), 130.9 (**C**H), 129.5 (**C**H), 128.9 (2 × **C**H), 127.0 (**C**H), 126.9 (2 × **C**H), 126.6 (**C**H), 99.7 (**C**), 67.63 (**C**H_2), 61.9 (**C**H_2), 60.67 (**C**H_2), 39.97 (**C**H_2), 24.90 (**C**H_2), 24.7 (**C**H_2), minor isomer 173.1 (**C**), 143.9 (**C**), 141.7 (**C**), 139.5 (**C**), 139.1 (**C**), 129.0 (**C**H), 128.1 (**C**H), 128.0 (**C**H), 127.9 (2 × **C**H), 127.3 (2 × **C**H), 125.7 (**C**H), 99.8 (**C**), 67.56 (**C**H_2), 61.93 (**C**H_2), 60.71 (**C**H_2), 40.00 (**C**H_2), 24.86 (**C**H_2), 24.7 (**C**H_2) ppm. **LRMS** (ESI^+): 325 $[MH]^+$. **HRMS** (ESI^+): Found 325.1436, $C_{20}H_{21}O_4$ $[MH]^+$ requires 325.1434.



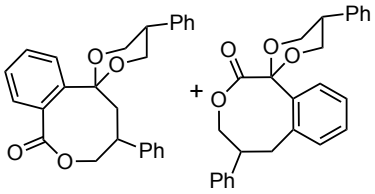
(E)- & (Z)-4,5'-Dimethyl-4,5-dihydro-1H,3H-spiro[benzo[c]oxocine-6,2'-[1,3]dioxan]-1-one, **5e**



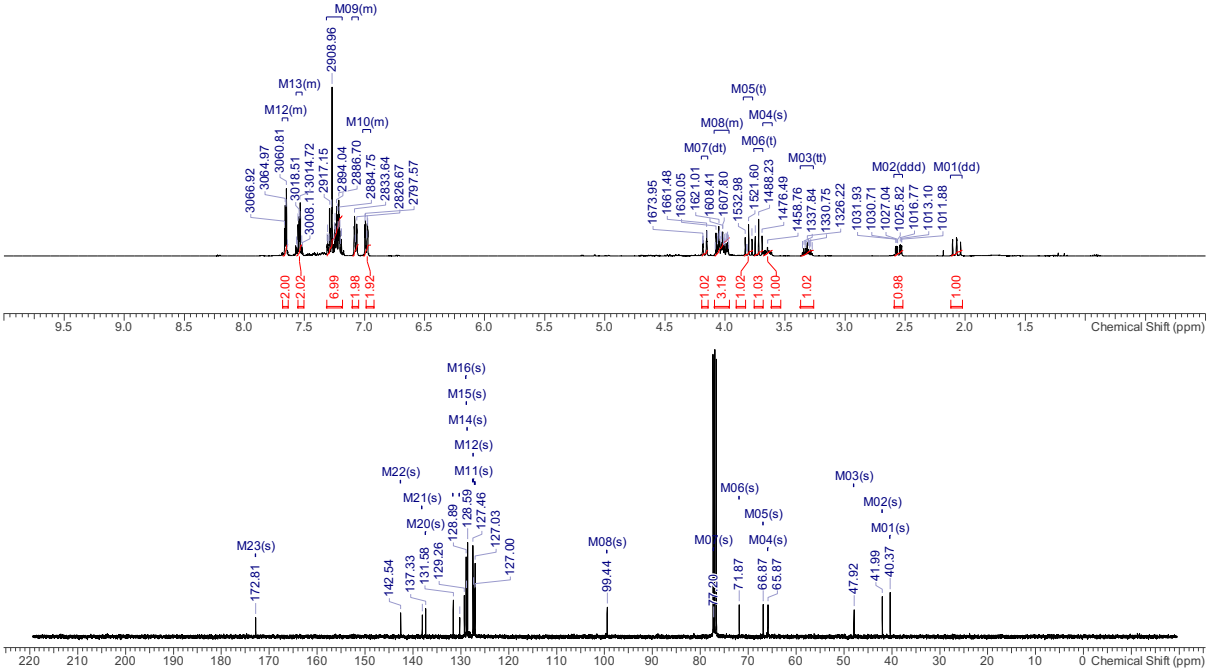
Using the flow photochemical set up B, a solution of *bis*-acetal **4e** (2.01 g, 6.62 mmol) in THF (330 mL) was irradiated with UVC light for a residence time of 1 h. The resulting solution was concentrated *in vacuo* then purified by column chromatography (20–50% Et_2O/hexane) to afford an inseparable 2 : 1 mixture the *title compounds* **5e** and **5e'** (1.56 g, 5.65 mmol, 85%) as a colourless oil. **IR** ν_{max} (film, cm^{-1}): 2959 (br), 1722 (s), 1263 (s), 1156 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ major isomer δ 7.53–7.35 (4 H, m, 4 × Ar**H**), 3.87–3.77 (2 H, m, 2 × OC**H**H), 3.69 (1 H, m, OC**H**H), 3.57–3.46 (3 H, m, 3 × OCH**H**), 2.41 (1 H, m, C**H**), 2.22 (1 H, m, C**H**H), 1.42–1.32 (2 H, m, CH**H** + C**H**), 1.23 (3 H, d, *J* = 6.9 Hz, C$\mathbf{H_3}$), 0.80 (3 H, d, *J* = 7.2 Hz, C$\mathbf{H_3}$); minor isomer 7.53–7.35 (4 H, m, 4 × Ar**H**), 3.73–3.65 (2 H, m, 2 × OC**H**H), 3.87–3.77 (2 H, m, OC$\mathbf{H_2}$), 3.20 (1 H, t, *J* = 11.3 Hz, OCH**H**), 3.06 (1 H, t, *J* = 11.4 Hz, OCH**H**), 2.41 (1 H, m, C**H**), 2.26 (1 H, m, C**H**H), 2.05 (1 H, m, C**H**), 1.42–1.32 (1 H, m, CH**H**), 0.80 (3 H, d, *J* = 6.9 Hz, C$\mathbf{H_3}$), 0.50 (3 H, d, *J* = 6.7 Hz, C$\mathbf{H_3}$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ major isomer 172.9 (**C**), 138.4 (**C**), 130.98 (**C**H), 130.17 (**C**), 128.65 (**C**H), 128.2 (**C**H), 127.0 (**C**H), 99.2 (**C**), 72.7 (C$\mathbf{H_2}$), 68.0 (C$\mathbf{H_2}$), 66.9 (C$\mathbf{H_2}$), 48.3 (C$\mathbf{H_2}$), 30.00 (**C**H), 28.1 (**C**H), 19.0 (C$\mathbf{H_3}$), 15.5 (C$\mathbf{H_3}$); minor isomer 173.0 (**C**), 138.1 (**C**), 131.08 (**C**H), 130.21 (**C**), 128.72 (**C**H), 128.3 (**C**H), 127.1 (**C**H), 99.6 (**C**), 72.6 (C$\mathbf{H_2}$), 66.7 (C$\mathbf{H_2}$), 65.6 (C$\mathbf{H_2}$), 48.3 (C$\mathbf{H_2}$), 29.96 (**C**H), 28.7 (**C**H), 19.0 (C$\mathbf{H_3}$), 12.1 (C$\mathbf{H_3}$) ppm. **LRMS** (ESI^+): 299 [M + Na]$^+$. **HRMS** (ESI^+): Found 299.1259, $C_{16}H_{20}NaO_4$ [M + Na]$^+$ requires 299.1254.



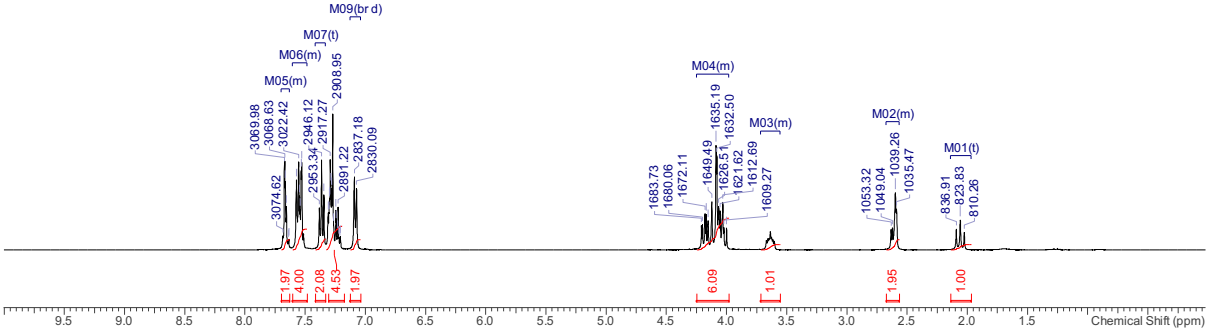
(E)- and *(Z)-4,5'-Diphenyl-4,5-dihydro-1H,3H-spiro[benzo[c]oxocine-6,2'-[1,3]dioxan]-1-one*, **5f** and **5f'**

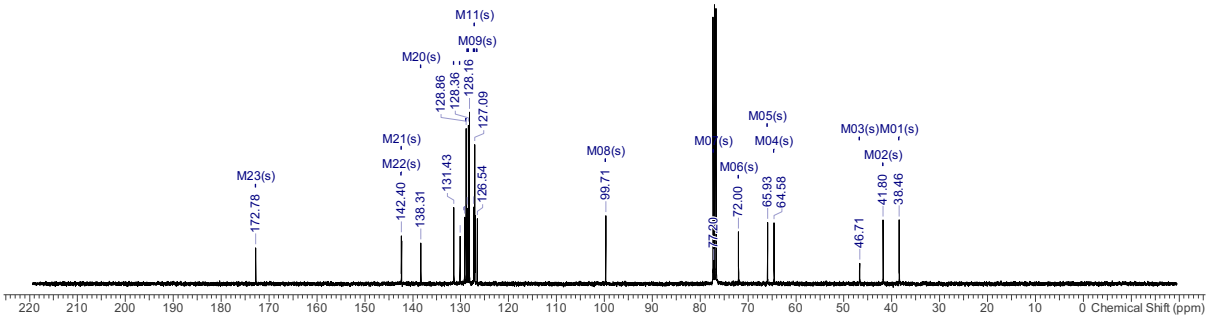


Using the flow photochemical set up B, a solution of *bis*-acetal **4f** (500 mg, 1.17 mmol) in THF (60 mL) was irradiated with UVC light for a residence time of 1 h. The resulting solution was concentrated *in vacuo* then purified by column chromatography (20–50% Et_2O/hexane) to afford firstly the *title compound* **5f** (195 mg, 0.49 mmol, 42%) as a yellow oil then the *title compound* **5f'** as a yellow oil (169 mg, 0.42 mmol, 36%). The stereochemical assignment in the article is tentative, being based on a presumed conformational preference for the cyclohexane ring and its influence on ^{1}H NMR signals. Data for **5f**: **IR** ν_{max} (film, cm^{-1}): 2972 (br), 1731 (s), 1264 (s), 1136 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.66–7.64 (2 H, m, 2 × Ar**H**), 7.57–7.52 (2 H, m, 2 × Ar**H**), 7.31–7.19 (6 H, m, 6 × Ar**H**), 7.09–7.06 (2 H, m, 2 × Ar**H**), 7.00–6.97 (2 H, m, 2 × Ar**H**), 4.17 (1 H, dt, *J* = 12.4, 1.1 Hz, OC**H**H), 4.08–3.97 (3 H, m, OCH**H** + OC**H**$_2$), 3.80 (1 H, t, *J* = 11.4 Hz, OC**H**H), 3.72 (1 H, t, *J* = 11.7 Hz, OCH**H**), 3.65 (1 H, m, PhC**H**), 3.31 (1 H, tt, *J* = 11.6, 4.5 Hz, PhC**H**), 2.44 (1 H, ddd, *J* = 14.1, 4.9, 1.2 Hz, C**H**H), 2.07 (1 H, dd, *J* = 13.9, 12.7 Hz, CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 172.8 (**C**), 142.5 (**C**), 138.1 (**C**), 137.3 (**C**), 131.6 (**C**H), 130.2 (**C**), 129.3 (**C**H), 128.9 (2 × **C**H), 128.7 (**C**H), 128.6 (2 × **C**H), 127.5 (2 × **C**H), 127.4 (**C**H), 127.3 (**C**H), 127.03 (2 × **C**H), 127.00 (**C**H), 99.4 (**C**), 71.9 (**C**H$_2$), 66.9 (**C**H$_2$), 65.9 (**C**H$_2$), 47.9 (**C**H$_2$), 42.0 (**C**H), 40.4 (**C**H) ppm. **LRMS** (ESI$^+$): 401 [MH]$^+$. **HRMS** (ESI$^+$): Found 423.1574, $C_{26}H_{24}NaO_4$ [M + Na]$^+$ requires 423.1567.

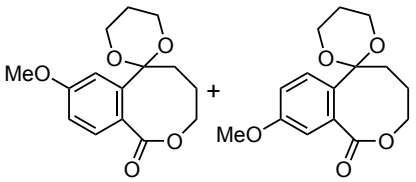


Data for **5f'**: **IR** ν_{max} (film, cm^{-1}): 2956 (br), 1726 (s), 1267 (s), 1165 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.68–7.63 (2 H, m, 2 × Ar**H**), 7.57–7.53 (4 H, m, 4 × Ar**H**), 7.36 (2 H, t, *J* = 7.1 Hz, 2 × Ar**H**), 7.31–7.21 (4 H, m, 4 × Ar**H**), 7.08 (2 H, d, *J* = 7.1 Hz, 2 × Ar**H**), 4.21–4.00 (6 H, m, 3 × OC**H**$_2$), 3.64 (1 H, m, PhC**H**), 2.63–2.59 (2 H, m, C**H**H + PhC**H**), 2.06 (1 H, t, *J* = 13.3 Hz, CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 172.8 (**C**), 142.4 (**C**), 142.3 (**C**), 138.3 (**C**), 131.4 (**C**H), 130.1 (**C**), 129.2 (**C**H), 128.9 (2 × **C**H), 128.6 (**C**H), 128.4 (2 × **C**H), 128.2 (2 × **C**H), 127.3 (**C**H), 127.1 (2 × **C**H), 127.0 (**C**H), 126.5 (**C**H), 99.7 (**C**), 72.0 (**C**H$_2$), 65.9 (**C**H$_2$), 64.6 (**C**H$_2$), 46.7 (**C**H$_2$), 41.8 (**C**H), 36.5 (**C**H) ppm. **LRMS** (ESI$^+$): 401 [MH]$^+$, **HRMS** (ESI$^+$): Found 423.1572, $C_{26}H_{24}NaO_4$ [M + Na]$^+$ requires 423.1567.

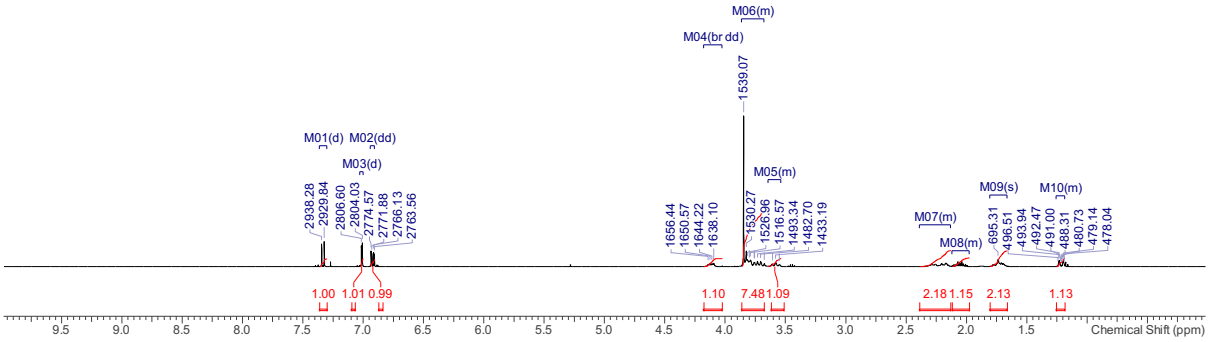


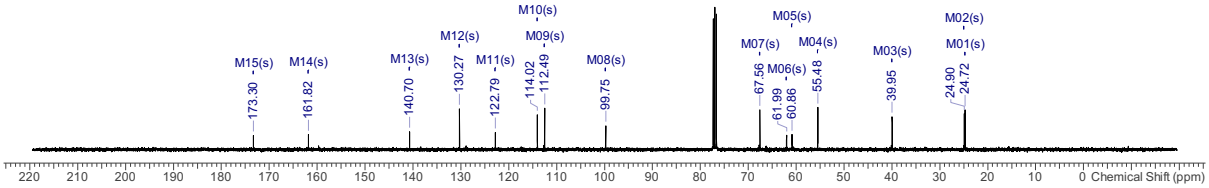


9-Methoxy-4,5-dihydro-1H,3H-spiro[benzo[c]oxocine-6,2'-[1,3]dioxan]-1-one and *8-methoxy-4,5-dihydro-1H,3H-spiro[benzo[c]oxocine-6,2'-[1,3]dioxan]-1-one*, **5g** and **5g'**

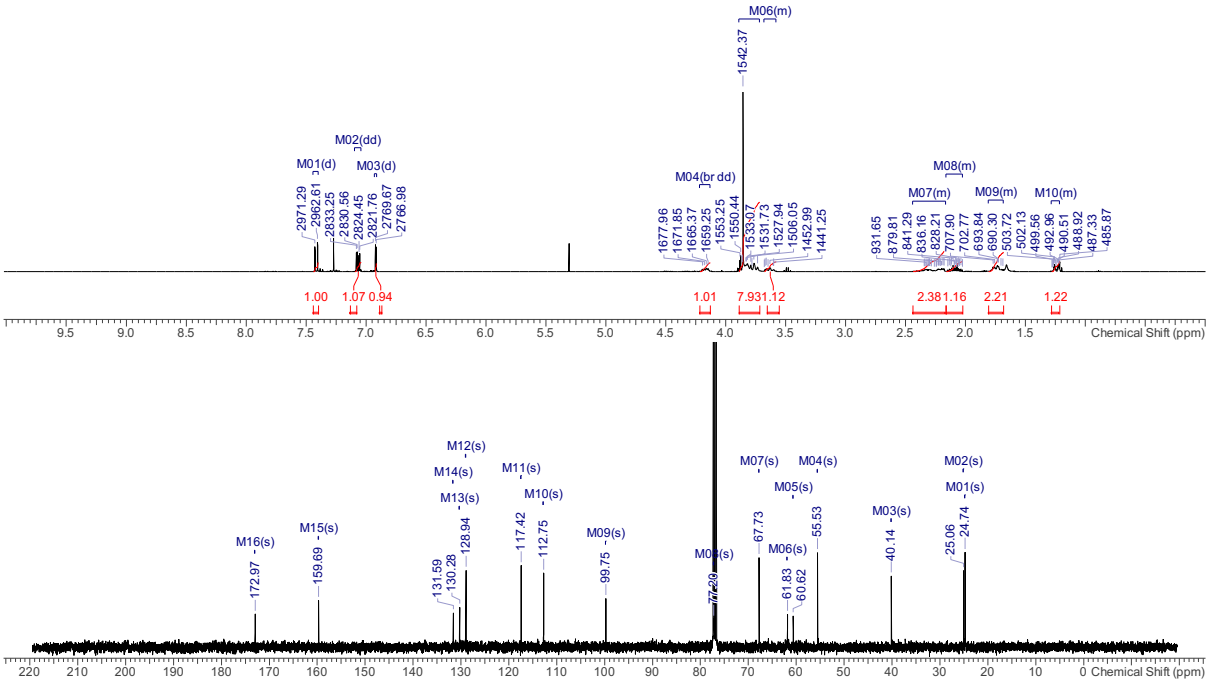


Using the flow photochemical set up B, a solution of *bis*-acetal **4g** (1.03 g, 3.37 mmol) in THF (170 mL) was irradiated with UVC light for a residence time of 1 h. The resulting solution was concentrated *in vacuo* then purified by column chromatography (10–30% Et_2O/hexane) to afford firstly lactone **5g'** (372 mg, 1.34 mmol, 40%) as a yellow oil then lactone **5g** (403 mg, 1.45 mmol, 43%) as a yellow oil. Data for **5g**: **IR** ν_{max} (film, cm^{-1}): 2961 (br), 1717 (s), 1604 (m), 1279 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.28 (1 H, d, *J* = 8.6 Hz, Ar**H**), 6.97 (1 H, d, *J* = 2.5 Hz, Ar**H**), 6.88 (1 H, dd, *J* = 8.3, 2.6 Hz, Ar**H**), 4.07 (1 H, m, OC**H**H), 3.81 (3 H, s, C**H**$_3$), 3.81–3.50 (5 H, m, 2 × OC**H**$_2$ + OCH**H**), 2.29–1.94 (3 H, m, 3 × C**H**H), 1.74–1.66 (2 H, m, 2 × CH**H**), 1.18 (1 H, m, CH**H**) ppm (NMR contaminated by ~5% of **5g'**). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 173.1 (**C**), 161.6 (**C**), 140.5 (**C**), 130.0 (**C**H), 122.6 (**C**), 113.8 (**C**H), 112.3 (**C**H), 99.6 (**C**), 67.4 (**C**H_2), 61.8 (**C**H_2), 60.6 (**C**H_2), 55.3 (**C**H_3), 39.7 (**C**H_2), 24.7 (**C**H_2), 24.5 (**C**H_2) ppm. **LRMS** (ESI^+): 279 $[MH]^+$. **HRMS** (ESI^+): Found 301.1050, $C_{15}H_{18}NaO_5$ $[M + Na]^+$ requires 301.1046.

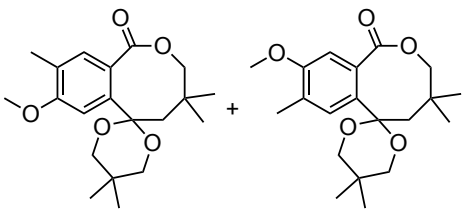




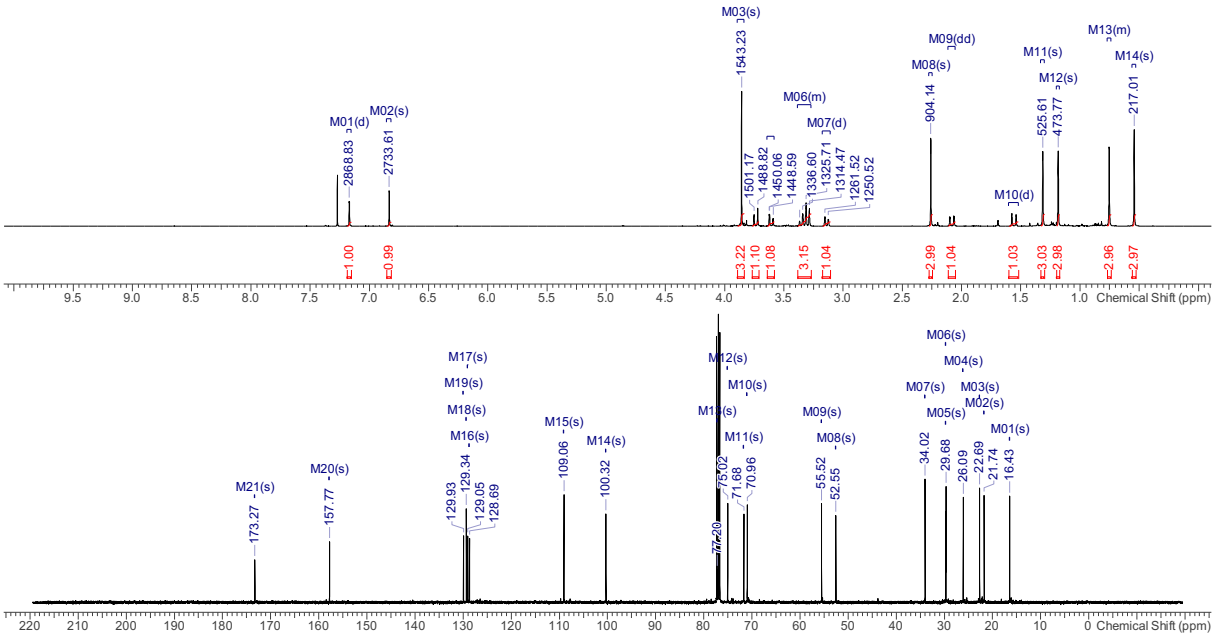
Data for **5g'**: **IR** ν_{max} (film, cm^{-1}): 2960 (br), 1719 (s), 1283 (s), 1250 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.41 (1 H, d, *J* = 8.7 Hz, Ar**H**), 7.07 (1 H, dd, *J* = 8.7, 2.7 Hz, Ar**H**), 6.92 (1 H, d, *J* = 2.7 Hz, Ar**H**), 4.17 (1 H, dd, *J* = 12.6, 6.1 Hz, OC**H**H), 3.82 (3 H, s, C**H**$_3$), 3.80–3.57 (5 H, m, 2 × OC**H**$_2$ + OCH**H**), 2.30–2.15 (2 H, m, 2 × C**H**H), 2.04 (1 H, m, C**H**H), 1.78–1.66 (2 H, m, 2 × CH**H**), 1.22 (1 H, m, CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$) δ 173.0 (**C**), 159.7 (**C**), 131.6 (**C**), 130.3 (**C**), 128.9 (**C**H), 117.4 (**C**H), 112.8 (**C**H), 99.8 (**C**), 67.7 (**C**H_2), 61.8 (**C**H_2), 60.6 (**C**H_2), 55.5 (**C**H_3), 40.1 (**C**H_2), 25.1 (**C**H_2), 24.7 (**C**H_2) ppm. **LRMS** (ESI^+): 279 $[MH]^+$. **HRMS** (ESI^+): Found 301.1049, $C_{15}H_{18}NaO_5$ $[M + Na]^+$ requires 301.1046.



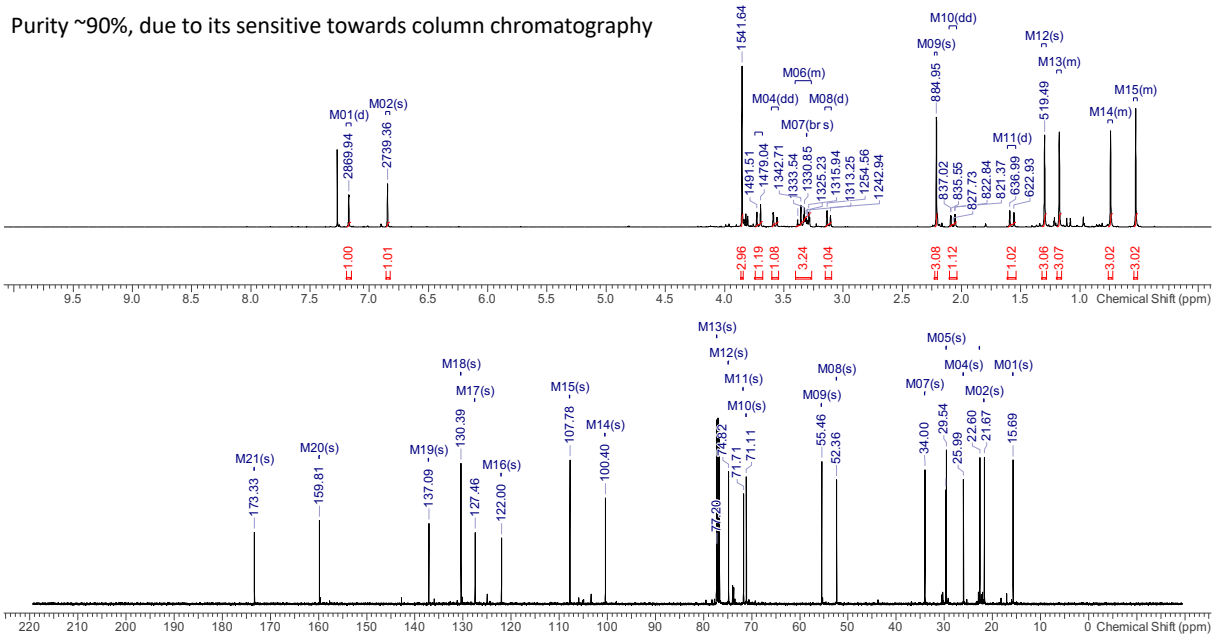
8-Methoxy-4,4,5',5',9-pentamethyl-4,5-dihydro-1H,3H-spiro[benzo[c]oxocine-6,2'-[1,3]dioxan]-1-one **5h** and *9-methoxy-4,4,5',5',8-pentamethyl-4,5-dihydro-1H,3H-spiro[benzo[c]oxocine-6,2'-[1,3]dioxan]-1-one* **5h'**.



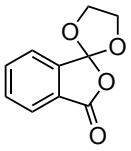
Using the flow photochemical set up A: A solution of *bis*-acetal **4h** (2.32 g, 6.17 mmol) in THF (120 mL) under argon was degassed then pumped through the photoreactor (UVC, 36W, 120 mL) under circulating flow for 5 h. The resulting solution was concentrated *in vacuo* then purified by column chromatography (20–50% Et_2O/petrol) to afford firstly lactone **5h** (1.21 g, 3.49 mmol, 57%) as a yellow oil, then its regioisomer **5h'** (678 mg, 1.94 mmol, 31%, purity ~90%) as a yellow oil. Data for **5h**: **IR** ν_{max} (film, cm^{-1}): 2954 (br), 1720 (s), 1608 (m), 1499 (m), 1463 (m), 1318 (s), 1270 (s), 1260 (s), 1183 (m), 1127 (s), 1067 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.17 (1 H, d, *J* = 0.6 Hz, Ar**H**), 6.83 (1 H, m, Ar**H**), 3.86 (3 H, s, OC**H**$_3$), 3.74 (1 H, d, *J* = 12.5 Hz, OC**H**H), 3.61 (1 H, dd, *J* = 12.4, 1.5 Hz, OCH**H**), 3.39–3.27 (3 H, m, OCH**H** + OC**H**$_2$), 3.14 (1 H, d, *J* = 11.0 Hz, OCH**H**), 2.26 (3 H, s, C**H**$_3$), 2.08 (1 H, dd, *J* = 14.2, 1.5 Hz, C**H**H), 1.56 (1 H, d, *J* = 14.0 Hz, CH**H**), 1.31 (3 H, s, C**H**$_3$), 1.18 (3 H, s, C**H**$_3$), 0.75 (3 H, s, C**H**$_3$), 0.54 (3 H, s, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 173.4 (**C**), 159.8 (**C**), 137.1 (**C**), 130.4 (**C**H), 127.5 (**C**), 122.0 (**C**), 107.8 (**C**H), 100.4 (**C**), 74.9 (**C**H$_2$), 71.7 (**C**H$_2$), 71.1 (**C**H$_2$), 55.5 (**C**H$_3$), 52.4 (**C**H$_2$), 34.0 (**C**), 29.7 (**C**H$_3$), 29.6 (**C**), 26.0 (**C**H$_3$), 22.6 (**C**H$_3$), 21.7 (**C**H$_3$), 15.7 (**C**H$_3$) ppm. **LRMS** (ESI$^+$): 719 ([2M+Na]$^+$, 10%), 371 ([M+Na]$^+$, 40%), 349 ([MH]$^+$, 100%). **HRMS** (ESI$^+$): Found 349.2020, $C_{20}H_{29}O_5$ [MH]$^+$ requires 349.2010.



Data for **5h'**: **IR** ν_{max} (film, cm^{-1}): 2953 (br), 1727 (s), 1610 (w), 1500 (m), 1463 (m), 1320 (s), 1267 (s), 1238 (m), 1184 (m), 1132 (s), 1068 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.17 (1 H, d, *J* = 0.6 Hz, Ar**H**), 6.83 (1 H, m, Ar**H**), 3.86 (3 H, s, OC**H**$_3$), 3.74 (1 H, d, *J* = 12.4 Hz, OC**H**H), 3.62 (1 H, dd, *J* = 12.4, 1.5 Hz, OCH**H**), 3.35 (1 H, d, *J* = 10.5 Hz, OC**H**H), 3.30 (2 H, d, *J* = 11.3 Hz, OC**H**$_2$), 3.11 (1 H, d, *J* = 11.0 Hz, OCH**H**), 2.26 (3 H, s, C**H**$_3$), 2.08 (1 H, dd, *J* = 14.1, 1.5 Hz, C**H**H), 1.56 (1 H, d, *J* = 14.2 Hz, CH**H**), 1.31 (3 H, s, C**H**$_3$), 1.18 (3 H, s, C**H**$_3$), 0.75 (3 H, s, C**H**$_3$), 0.54 (3 H, s, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 173.3 (**C**), 157.8 (**C**), 129.9 (**C**), 129.3 (**C**H), 129.1 (**C**), 128.7 (**C**), 109.1 (**C**H), 100.3 (**C**), 75.0 (**C**H$_2$), 71.7 (**C**H$_2$), 71.0 (**C**H$_2$), 55.5 (**C**H$_3$), 52.6 (**C**H$_2$), 34.0 (**C**), 29.72 (**C**), 29.68 (**C**H$_3$), 26.1 (**C**H$_3$), 22.7 (**C**H$_3$), 21.7 (**C**H$_3$), 16.4 (**C**H$_3$) ppm. **LRMS** (ESI$^+$): 719 ([2M+Na]$^+$, 10%), 371 ([M+Na]$^+$, 30%), 349 ([MH]$^+$, 100%). **HRMS** (ESI$^+$): Found 349.2018, $C_{20}H_{29}O_5$ [MH]$^+$ requires 349.2010.

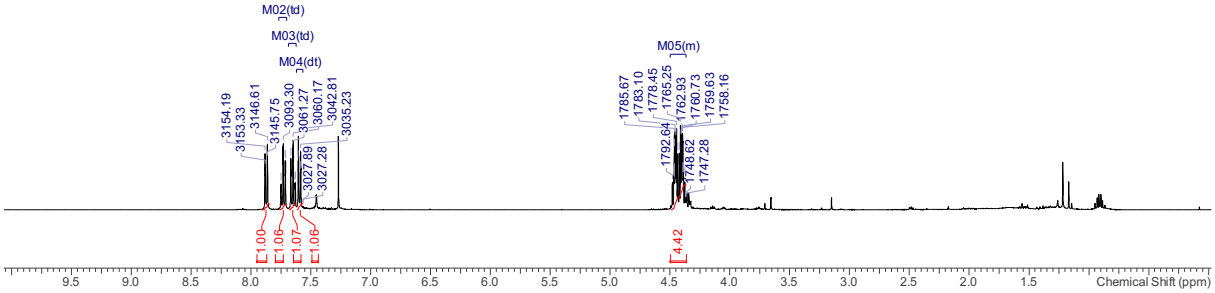


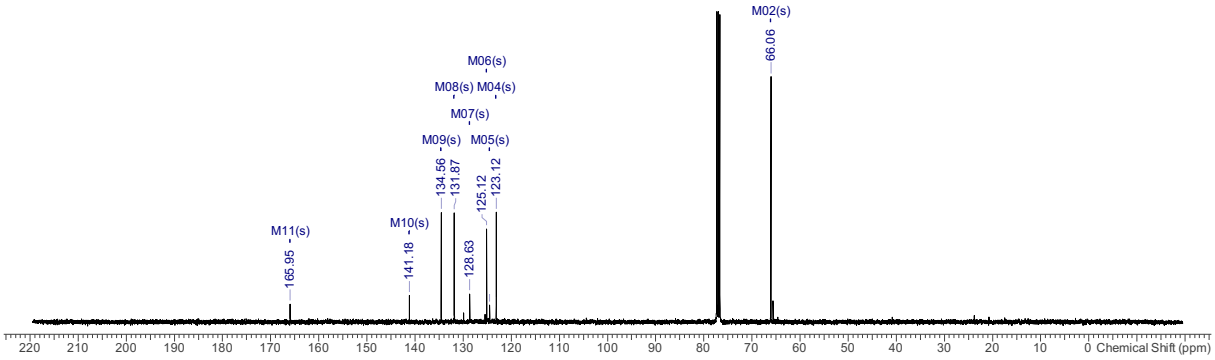
3H-Spiro[isobenzofuran-1,2'-[1,3]dioxolan]-3-one, **6**



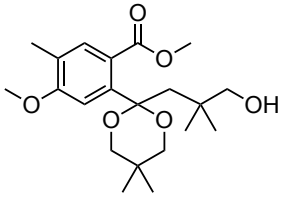
Using the flow photochemical set up A: A solution of *bis*-acetal **2** (500 mg, 2.02 mmol) in acetonitrile (40 mL) was irradiated with UVB light for 2 h under circulating flow. The resulting solution was concentrated *in vacuo* to afford the *title compound* **6** (380 mg, 1.98 mmol, 98%) as a yellow oil. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.87 (1 H, dt, *J* = 7.6, 1.0 Hz, Ar**H**), 7.73 (1 H, td, *J* = 7.5, 1.1 Hz, Ar**H**), 7.65 (1 H, td, *J* = 7.6, 1.0 Hz, Ar**H**), 7.60 (1 H, dt, *J* = 7.6, 0.9 Hz, Ar**H**), 4.48–4.38 (4 H, m, 2 × C**H**$_2$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 166.0 (**C**), 141.2 (**C**), 134.6 (**C**H), 131.9 (**C**H), 128.6 (**C**), 125.1 (**C**H), 124.5 (**C**), 123.1 (**C**H), 66.1 (**C**H$_2$) ppm. **LRMS** (ESI$^+$): 233 (100%), 211 ([MH+H$_2$O]$^+$, 50%), 193 ([MH]$^+$, 80%).

NMR taken of the crude product mixture due to its high reactivity towards water and other nucleophiles.

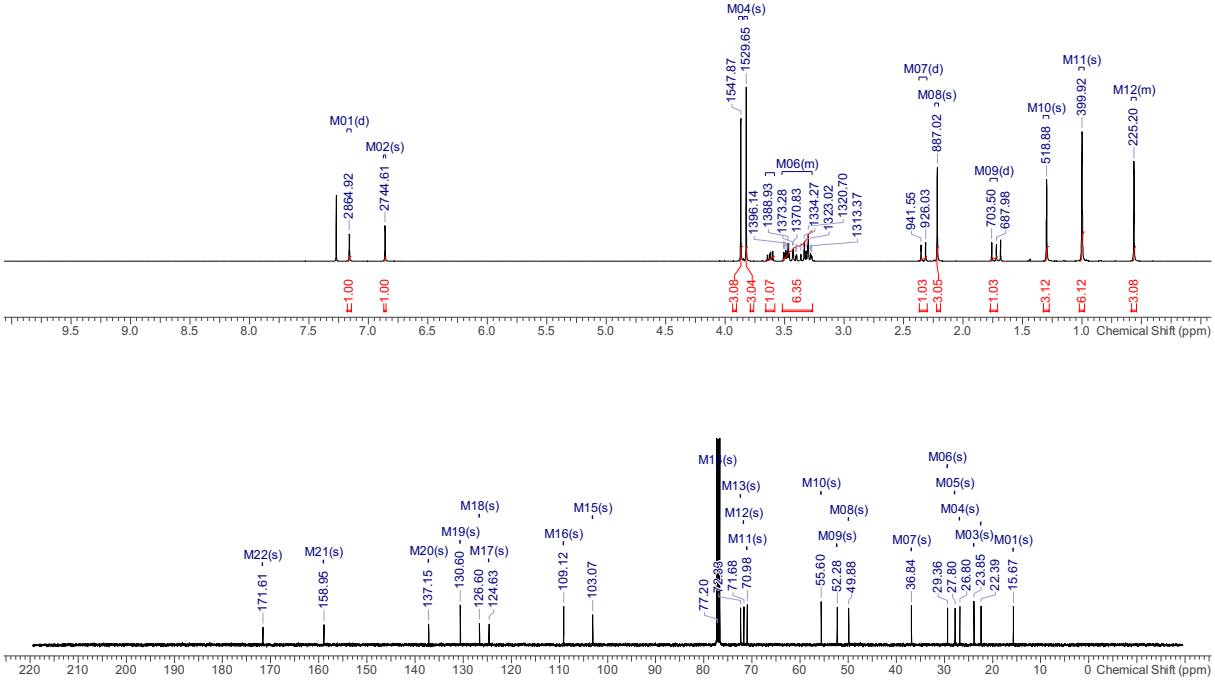




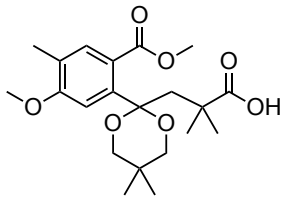
Methyl 2-(2-(3-hydroxy-2,2-dimethylpropyl)-5,5-dimethyl-1,3-dioxan-2-yl)-4-methoxy-5-methylbenzoate, **9**



To a solution of lactone **5h** (1.10 g, 3.16 mmol) in MeOH (20 mL) was added NaOMe (25% in MeOH, 10 mL, 175 mmol). After 16 h at reflux, the solution was cooled to RT, filtered, concentrated *in vacuo* and purified by column chromatography (30–80% Et_2O/petrol) to afford the *title compound* **9** (1.09 g, 2.87 mmol, 91%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 3550 (br), 2951 (br), 1724 (s), 1610 (m), 1500 (m), 1316 (m), 1270 (s), 1174 (m), 1139 (s), 1090 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.16 (1 H, d, *J* = 0.6 Hz, Ar**H**), 6.86 (1 H, s, Ar**H**), 3.87 (3 H, s, OC**H**$_3$), 3.82 (3 H, s, OC**H**$_3$), 3.62 (1 H, dd, *J* = 11.1, 7.1 Hz, OC**H**H), 3.51–3.28 (6 H, m, 2 × OC**H**$_2$ + OCH**H** + O**H**), 2.33 (1 H, d, *J* = 15.5 Hz, C**H**H), 2.22 (3 H, s, C**H**$_3$), 1.74 (1 H, d, *J* = 15.5 Hz, CH**H**), 1.30 (3 H, s, C**H**$_3$), 1.00 (6 H, s, 2 × C**H**$_3$), 0.56 (3 H, s, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 171.6 (**C**), 159.0 (**C**), 137.2 (**C**), 130.6 (**C**H), 126.6 (**C**), 124.6 (**C**), 109.1 (**C**H), 103.1 (**C**), 72.3 (**C**H$_2$), 71.7 (**C**H$_2$), 71.0 (**C**H$_2$), 55.6 (**C**H$_3$), 52.3 (**C**H$_3$), 49.9 (**C**H$_2$), 36.8 (**C**), 29.4 (**C**), 27.8 (**C**H$_3$), 26.8 (**C**H$_3$), 23.9 (**C**H$_3$), 22.4 (**C**H$_3$), 15.7 (**C**H$_3$) ppm. **LRMS** (ESI$^+$): 403 ([M+Na]$^+$, 70%), 277 (100%). **HRMS** (ESI$^+$): Found 403.2097, $C_{21}H_{32}O_6Na$ [M+Na]$^+$ requires 403.2091.

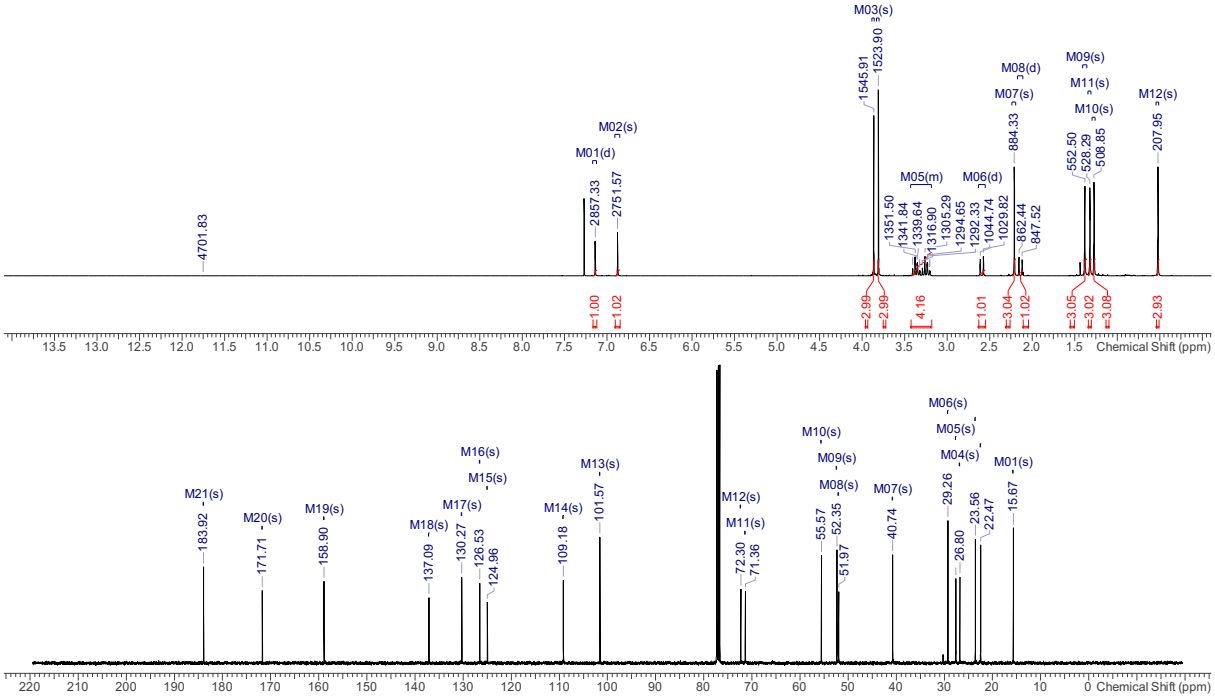


3-(2-(5-Methoxy-2-(methoxycarbonyl)-4-methylphenyl)-5,5-dimethyl-1,3-dioxan-2-yl)-2,2-dimethylpropanoic acid, **10**.

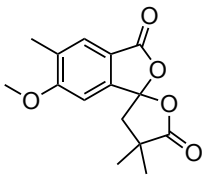


To a vigorously stirred solution of alcohol **9** (720 mg, 1.89 mmol) and ruthenium chloride (40 mg, 0.2 mmol) in acetonitrile (4 mL), carbon tetrachloride (4 mL) and water (6 mL), was added sodium periodate (1.62 g, 7.58 mmol) in one portion. After 3 h the reaction mixture was partitioned between DCM (30 mL) and water (30 mL). The organic phase was separated, washed with sat. potassium carbonate (30 mL) and sat. potassium thiosulfate (30 mL), dried over $MgSO_4$, concentrated in *vacuo* and purified by column chromatography (60–80% EtOAc/petrol) to afford the *title compound* **10** as a yellow oil (663 mg, 1.68 mmol, 89%). **IR** ν_{max} (film, cm^{-1}): 2952 (br), 1724 (s), 1700 (s), 1610 (m), 1500 (s), 1473 (s), 1314 (s), 1270 (s), 1174 (s), 1138 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 11.75 (1 H, br, COO**H**), 7.14 (1 H, d, *J* = 0.73, Ar**H**), 6.88 (1 H, s, Ar**H**), 3.86 (3 H, s, OC**H**$_3$), 3.81 (3 H, s, OC**H**$_3$), 3.41–3.20 (4 H, m, 2 × OC**H**$_2$), 2.59 (1 H, d, *J* = 14.9 Hz, C**H**H), 2.21 (3 H, s, C**H**$_3$), 2.14 (1 H, d, *J* = 14.9 Hz, CH**H**), 1.38 (3 H, s, C**H**$_3$), 1.32 (3 H, s, C**H**$_3$), 1.27 (3 H, s, C**H**$_3$), 0.52 (3 H, s, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz,

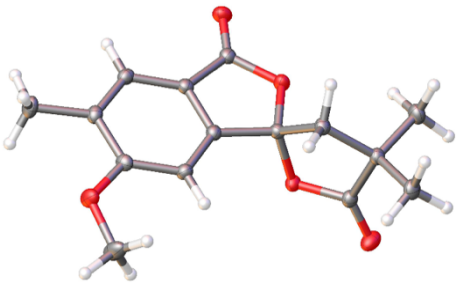
$CDCl_3$): δ 183.9 (**C**), 171.7 (**C**), 158.9 (**C**), 137.1 (**C**), 130.3 (**C**H), 126.5 (**C**), 125.0 (**C**), 109.2 (**C**H), 101.6 (**C**), 72.3 (CH_2), 71.4 (CH_2), 55.6 (CH_3), 52.4 (CH_3), 52.0 (**C**), 40.7 (CH_2), 29.3 (**C**), 27.6 (CH_3), 26.8 (CH_3), 23.6 (CH_3), 22.5 (CH_3), 15.7 (CH_3) ppm. **LRMS** (ESI^+): 417 ($[M+Na]^+$, 70%), 291 (100%). **HRMS** (ESI^+): Found 417.1887, $C_{21}H_{30}O_7Na$ $[M+Na]^+$ requires 417.1884.

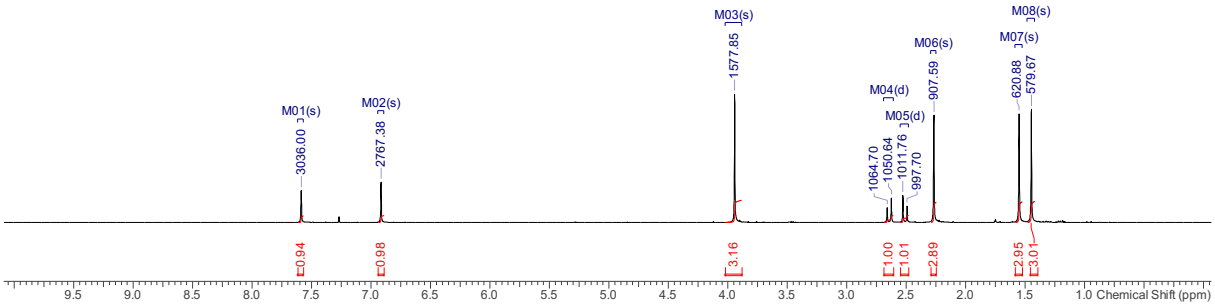


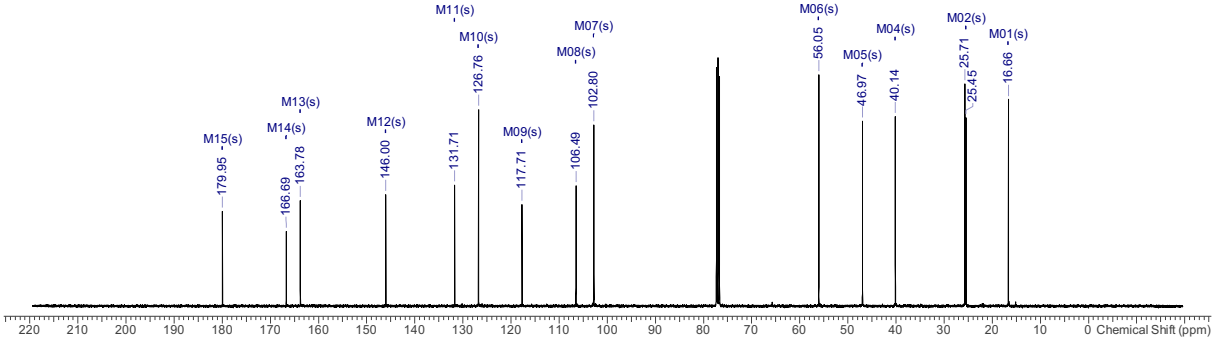
Fimbricalyxlactone B, **11**



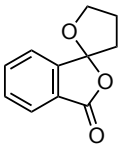
To a solution of acetal **10** (511 mg, 1.30 mmol) in DCM (20 mL) was added conc. HCl (5 mL). After 16 h the mixture was partitioned between DCM (30 mL) and water (30 mL) then the organic layer was separated, washed with sat. potassium carbonate (30 mL) and water (30 mL), dried over $MgSO_4$ and concentrated in *vacuo*. Purification by column chromatography (30–50% Et_2O/petrol) afforded the *title compound* **11** (320 mg, 1.16 mmol, 89%) as a white solid. **MP**: 178–180 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 2974 (br), 1776 (s), 1609 (m), 1472 (w), 1345 (m), 1307 (m), 1237 (m), 1159 (m), 1119 (m), 1025 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.59 (1 H, s, Ar**H**), 6.92 (1 H, s, Ar**H**), 3.94 (3 H, s, O**C**H_3), 2.64 (1 H, d, *J* = 14.1 Hz, C**H**H), 2.51 (1 H, d, *J* = 14.1 Hz, CH**H**), 2.27 (3 H, s, CH_3), 1.55 (3 H, s, CH_3), 1.45 (3 H, s, CH_3) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 180.0 (**C**), 166.7 (**C**), 163.8 (**C**), 146.0 (**C**), 131.7 (**C**), 126.8 (**C**H), 117.7 (**C**), 106.5 (**C**), 102.8 (**C**H), 56.1 (CH_3), 47.0 (CH_2), 40.1 (**C**), 25.7 (CH_3), 25.6 (CH_3), 16.7 (CH_3) ppm. **LRMS** (ESI^+): 277 ($[MH]^+$, 100%). **HRMS** (ESI^+): Found 299.0898, $C_{15}H_{16}O_5Na$ $[M+Na]^+$ requires 299.0890. X-ray: CCDC: 1908866, see insert. Data is consistent with literature values but with some discrepancies in the ^{13}C NMR data. These data were tentatively described in the isolation paper as they were attained from an NMR spectrum recorded on a 10:1 mixture fimbricalyxlactone A and B (it being the minor component).[3]



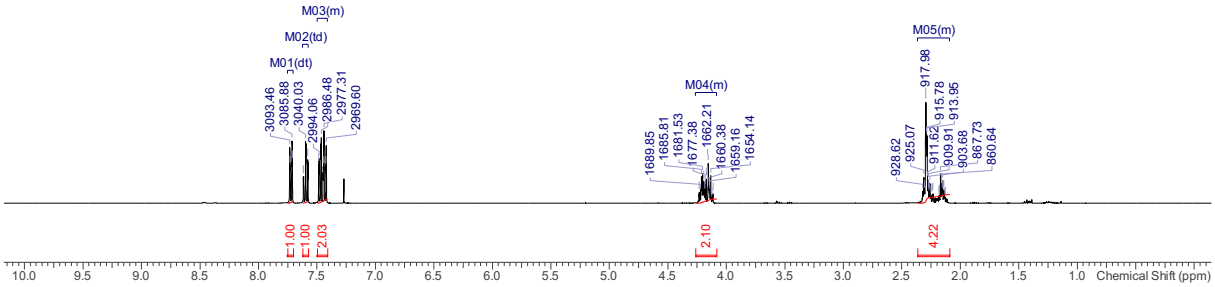


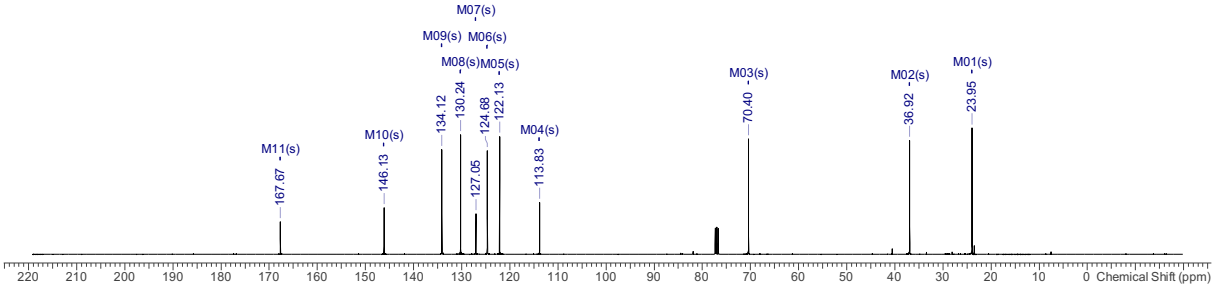


4,5-Dihydro-3H,3'H-spiro[furan-2,1'-isobenzofuran]-3'-one, **12**

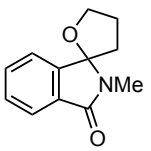


To a solution of lactone **5a** (500 mg, 2.02 mmol) in DCM (15 mL) was added conc. HCl (10 mL). After 16 h at RT, the solution was concentrated *in vacuo* and purified by column chromatography (20–50% EtOAc/hexane) to afford the *title compound* **12** (340 mg, 1.79 mmol, 89%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 2966 (br), 1749 (s), 1469 (m), 1275 (s), 1240 (s), 1121 (s), 1020 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.70 (1 H, dt, *J* = 7.6, 1.0 Hz, Ar**H**), 7.60 (1 H, td, *J* = 7.6, 1.1 Hz, Ar**H**), 7.47 (1 H, td, *J* = 7.6, 0.9 Hz, Ar**H**), 7.43 (1 H, dt, *J* = 7.6, 0.7 Hz, Ar**H**), 4.24–4.11 (2 H, m, O**C**H_2), 2.33–2.11 (4 H, m, 2 × **C**H_2) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 167.7 (**C**), 146.1 (**C**), 134.1 (**C**H), 130.2 (**C**H), 127.1 (**C**), 124.7 (**C**H), 122.1 (**C**H), 113.8 (**C**), 70.4 (**C**H_2), 36.9 (**C**H_2), 24.0 (**C**H_2) ppm. **LRMS** (ESI^+): 213 ([M + Na]$^+$, 10%), 191 ([MH]$^+$, 100%). Data consistent with literature values.[4]

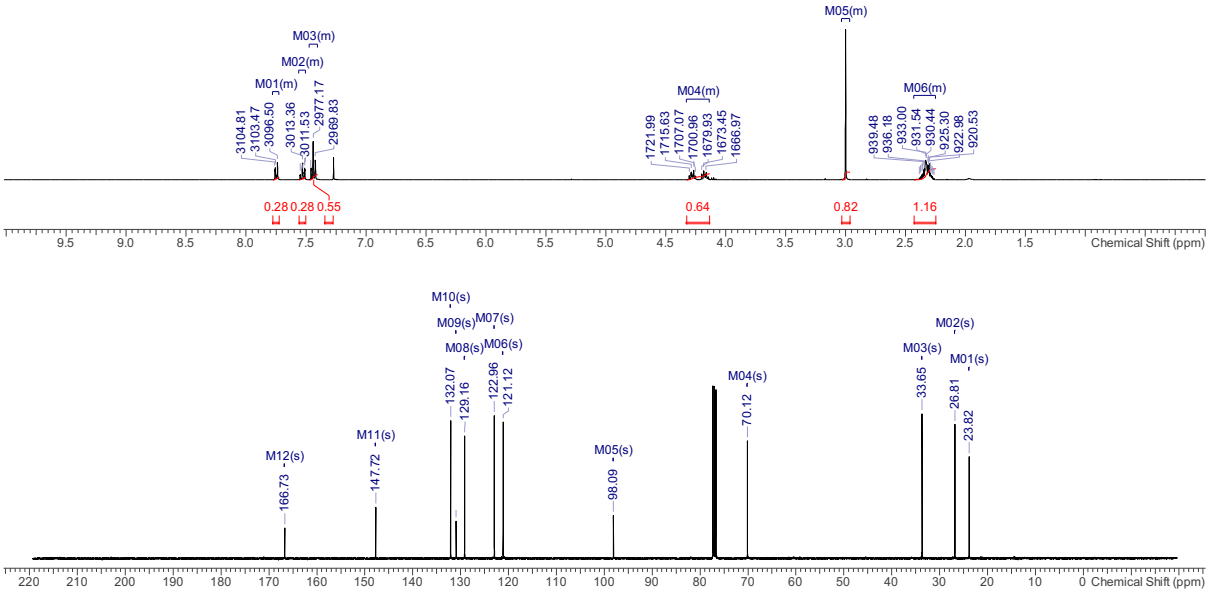




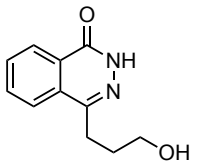
2'-Methyl-4,5-dihydro-3H-spiro[furan-2,1'-isoindolin]-3'-one [isoshihunine], **13**



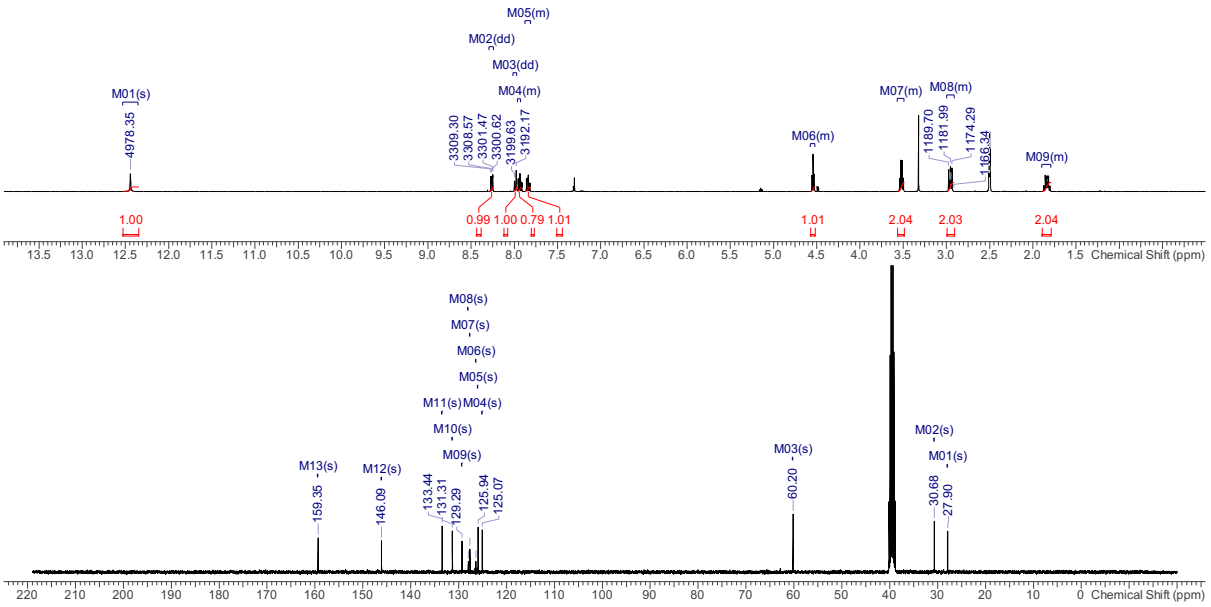
To a solution of lactone **12** (330 mg, 1.74 mmol) in dioxane (50 mL) was added methylamine hydrochloride (117 mg, 1.74 mmol) and Et_3N (0.1 mL, 1.74 mmol). After 2 h at RT, *p*-TsOH (10 mg) was added then the solution was heated at 100 °C for 16 h. The solution was concentrated *in vacuo* and purified by column chromatography (30–80% EtOAc/petrol) to afford the *title compound* **13** (271 mg, 1.33 mmol, 77%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 1483 (br), 2957 (br), 1702 (s), 1386 (m), 1049 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.75 (1 H, m, Ar**H**), 7.53 (1 H, m, Ar**H**), 7.44 (2 H, app. t, *J* = 6.7 Hz, 2 × Ar**H**), 4.28 (1 H, m, C**H**H), 4.17 (1 H, m, CH**H**), 3.00 (3 H, s, CH_3), 2.38–2.26 (4 H, m, 2 × **C**H_2) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 166.7 (**C**), 147.7 (**C**), 132.1 (**C**H), 130.9 (**C**), 129.3 (**C**H), 123.0 (**C**H), 121.1 (**C**H), 98.1 (**C**), 70.1 (**C**H_2), 33.7 (**C**H_2), 26.8 (**C**H_2), 23.8 (**C**H_3) ppm. **LRMS** (ESI^+): 204 ([MH]$^+$. Data consistent with literature values.[5]



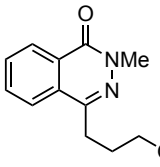
4-(3-Hydroxypropyl)phthalazin-1(2H)-one, **16**



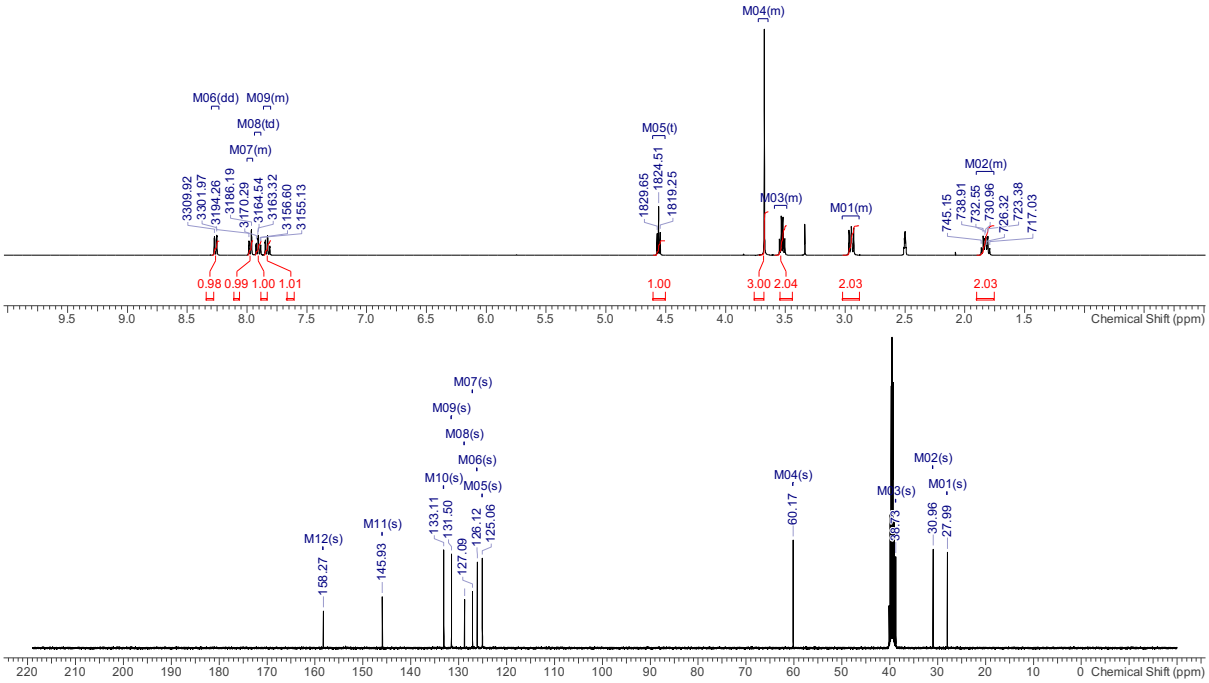
To a solution of lactone **12** (458 mg, 2.41 mmol) in dioxane (10 mL) was added hydrazine (1 M in THF, 2.41 mL, 2.41 mmol). After 16 h at RT, the solution was concentrated *in vacuo* and purified by column chromatography (30–80% EtOAc/petrol) to afford the *title compound* **16** (428 mg, 2.19 mmol, 88%) as a white solid. **MP** 138–139 °C. **IR** ν_{max} (film, cm^{-1}): 3163 (br), 2901 (br), 1659 (s), 1346 (m), 1152 (m), 1046 (m). **^{1}H NMR** (400 MHz, DMSO-d6): δ 12.44 (1 H, s, N**H**), 8.26 (1 H, app. dd, *J* = 7.6, 1.0 Hz, Ar**H**), 7.98 (1 H, m, Ar**H**), 7.93 (1 H, td, *J* = 8.0, 1.5 Hz, Ar**H**), 7.84 (1 H, m, Ar**H**), 4.54 (1 H, t, *J* = 5.3 Hz, O**H**), 3.54–3.50 (2 H, m, OC$\mathbf{H}_2$), 2.97–2.93 (2 H, m, C$\mathbf{H}_2$), 1.87–1.80 (2 H, m, C$\mathbf{H}_2$) ppm. **^{13}C NMR** (100 MHz, DMSO-d6): δ 159.4 (**C**), 146.1 (**C**), 133.4 (**C**H), 131.3 (**C**H), 129.3 (**C**), 127. 6 (**C**), 125.9 (**C**H), 125.1 (**C**H), 60.2 (**C**H_2), 30.7 (**C**H_2), 27.9 (**C**H_2) ppm. **LRMS** (ESI$^+$): 205 ([MH]$^+$. **HRMS** (ESI$^+$): Found 205.0975, $C_{11}H_{13}N_2O_2$ [MH]$^+$ requires 205.0972.



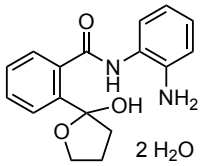
4-(3-Hydroxypropyl)-2-methylphthalazin-1(2H)-one, **17**



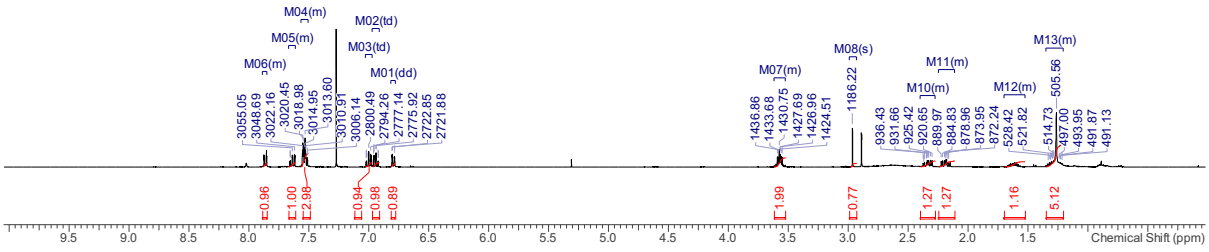
To a solution of lactone **12** (428 mg, 2.25 mmol) in dioxane (10 mL) was added methylhydrazine (1 M in THF, 2.25 mL, 2.25 mmol). After 16 h at RT, the solution was concentrated *in vacuo* and purified by column chromatography (30–80% EtOAc/petrol) to afford the *title compound* **17** (438 mg, 2.01 mmol, 89%) as a white solid. **MP:** 119–120 °C. **IR** ν_{max} (film, cm^{-1}): 3361 (br), 2888 (br), 1630 (s), 1577 (s), 1330 (m), 1068 (m). **^{1}H NMR** (400 MHz, DMSO-d6): 8.26 (1 H, app. dd, *J* = 7.9, 0.8 Hz, Ar**H**), 7.97 (1 H, m, Ar**H**), 7.91 (1 H, td, *J* = 7.6, 1.4 Hz, Ar**H**), 7.83 (1 H, m, Ar**H**), 4.56 (1 H, t, *J* = 4.9 Hz, O**H**), 3.68 (3 H, s, C**H**$_3$), 3.55–3.50 (2 H, m, OC**H**$_2$), 2.97–2.93 (2 H, m, C**H**$_2$), 1.86–1.79 (2 H, m, C**H**$_2$) ppm. **^{13}C NMR** (100 MHz, DMSO-d6): δ 159.3 (**C**), 145.9 (**C**), 133.1 (**C**H), 131.5 (**C**H), 128.8 (**C**), 127.1 (**C**), 126.1 (**C**H), 125.1 (**C**H), 60.2 (**C**H$_2$), 38.7 (**C**H$_3$), 31.0 (**C**H$_2$), 28.0 (**C**H$_2$) ppm. **LRMS** (ESI$^+$): 219 [MH]$^+$. **HRMS** (ESI$^+$): Found 219.1127, $C_{12}H_{15}N_2O_2$ [MH]$^+$ requires 219.1128.

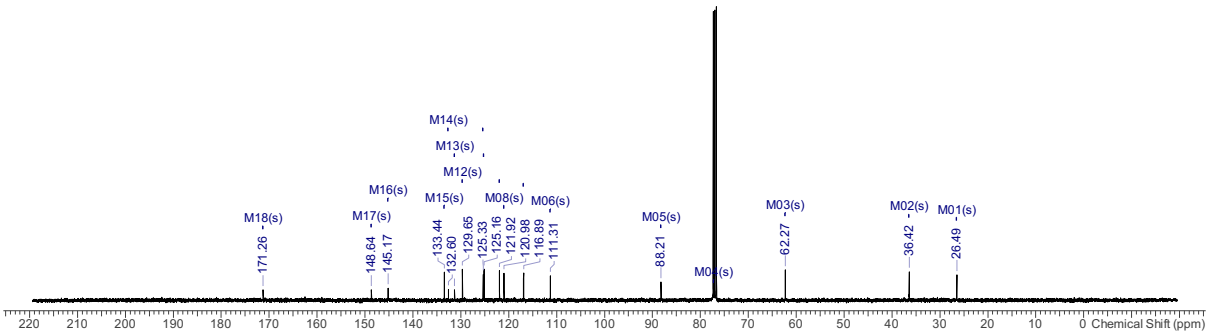


N-(2-aminophenyl)-2-(2-hydroxytetrahydrofuran-2-yl)benzamide, **18**

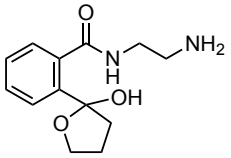


To a solution of lactone **12** (546 mg, 2.91 mmol) in MeCN (50 mL) was added *o*-phenylenediamine (313 mg, 2.91 mmol) and K_2CO_3 (800 mg, 5.82 mmol). After 16 h at 60 °C, the solution was concentrated *in vacuo* and purified by column chromatography (60–80% EtOAc/hexane) to afford the *title compound* **18** (580 mg, 1.95 mmol, 67%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 3318 (br), 1700 (s), 1608 (m), 1487(s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.86 (1 H, m, Ar**H**), 7.63 (1 H, m, Ar**H**), 7.55–7.51 (3 H, m, 3 × Ar**H**), 7.00 (1 H, td, *J* = 7.6, 1.3 Hz, Ar**H**), 6.94 (1 H, td, *J* = 7.5, 1.3 Hz, Ar**H**), 6.79 (1 H, dd, *J* = 7.3, 1.2 Hz, Ar**H**), 3.59–3.55 (2 H, m, OC**H**$_2$), 2.96 (1 H, s, N**H**), 2.89 (1 H, s, N**H**), 2.62 (2 H, br s, O**H** + N**H**), 2.34 (1 H, m, CH**H**), 2.19 (1 H, m, CH**H**), 1.61 (1 H, m, C**H**H), 1.29 (5 H, m, CH**H** + 2 × H_2O) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 171.3 (**C**), 148.8 (**C**), 145.2 (**C**), 133.4 (**C**H), 132.6 (**C**), 131.3 (**C**), 129.7 (**C**H), 125.3 (**C**H), 125.2 (**C**H), 121.9 (**C**H), 121.0 (**C**H), 116.9 (**C**H), 111.3 (**C**H), 88.2 (**C**), 62.3 (**C**H$_2$), 36.4 (**C**H$_2$), 26.5 (**C**H$_2$) ppm. **LRMS** (ESI$^+$): 281 [MH–H_2O]$^+$. **HRMS** (ESI$^+$): Found 281.1280, $C_{17}H_{17}N_2O_2$ [MH–H_2O]$^+$ requires 281.1285.

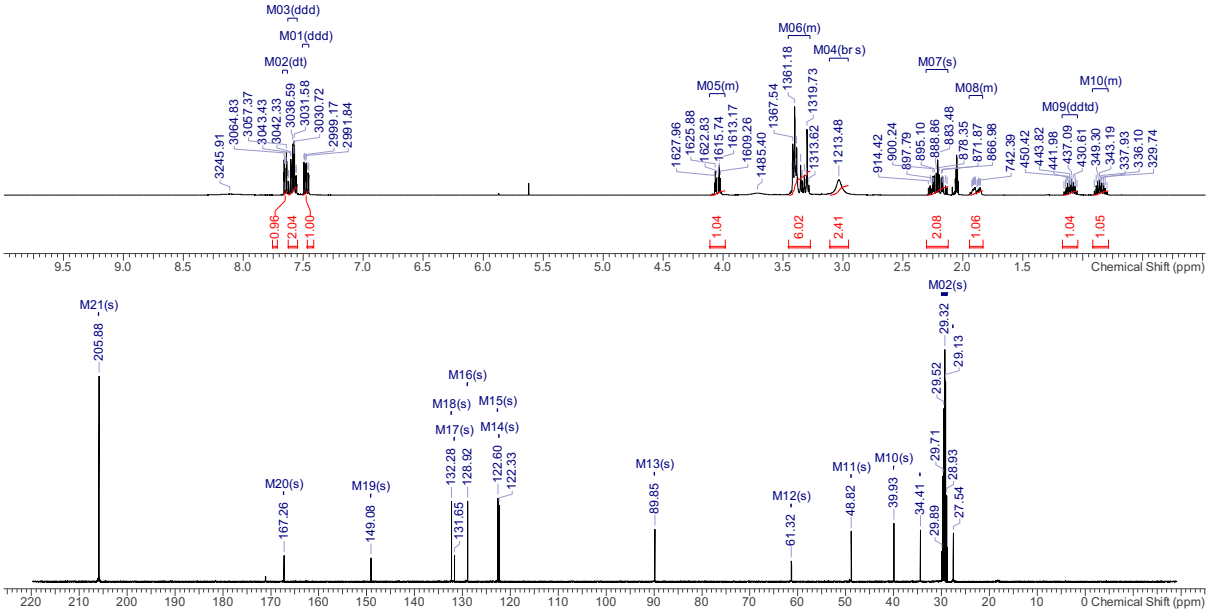




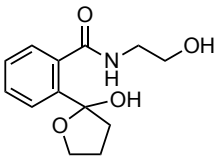
N-(2-aminoethyl)-2-(2-hydroxytetrahydrofuran-2-yl)benzamide, **19**



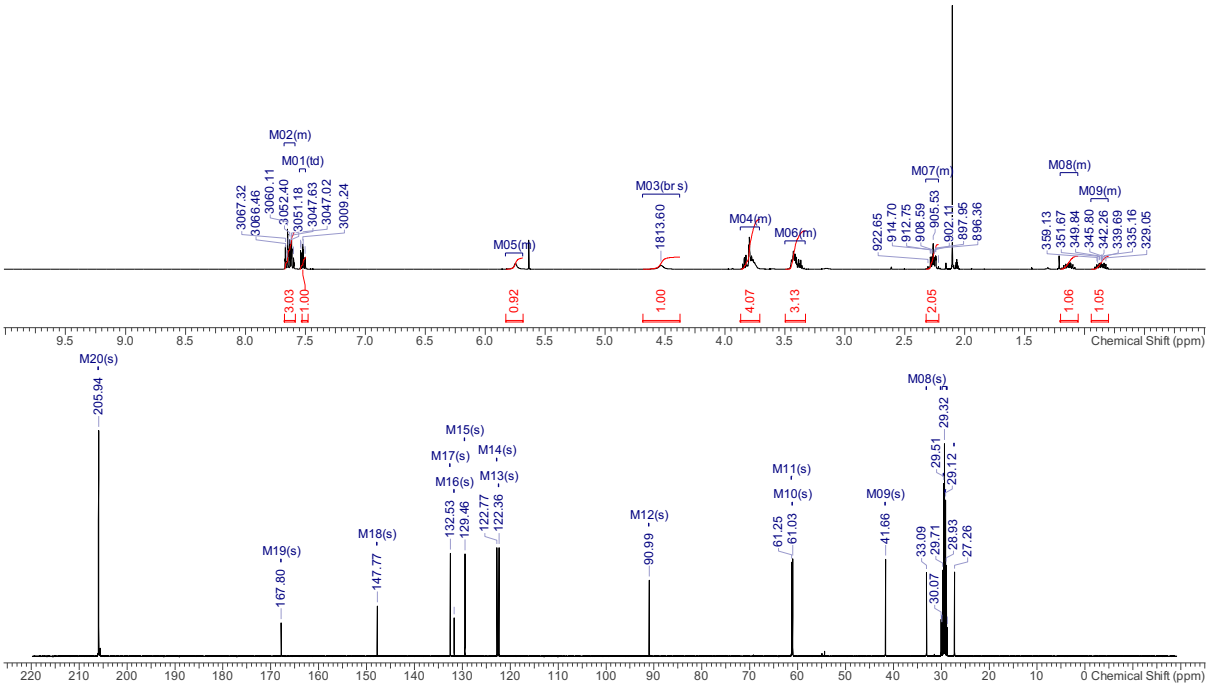
To a solution of lactone **12** (380 mg, 2.00 mmol) in MeCN (50 mL) was added ethylenediamine (0.13 mL, 2.00 mmol). After 16 h at RT, the solution was concentrated *in vacuo* and purified by column chromatography (60–90% EtOAc/hexane) to afford the *title compound* **19** (400 mg, 1.72 mmol, 86%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 3362 (br), 2925 (br), 1683 (s), 1395 (m), 1040 (s). **^{1}H NMR** (400 MHz, acetone-d6): δ 7.65 (1 H, dt, *J* = 7.5, 1.0 Hz, Ar**H**), 7.59–7.52 (2 H, m, 2 × Ar**H**), 7.48 (1 H, ddd, *J* = 7.3, 6.8, 1.5 Hz, Ar**H**), 4.04 (1 H, m, OC**H**H), 3.42–3.28 (6 H, m, OCH**H** + O**H** + 2 × NC**H**$_2$), 3.01 (2 H, br s, N**H**$_2$), 2.24 (1 H, ddd, *J* = 14.2, 11.4, 5.1 Hz, C**H**H), 2.18 (1 H, ddd, *J* = 14.2, 11.4, 5.1 Hz, C**H**H), 1.89 (1 H, m , N**H**), 1.10 (1 H, ddtd, *J* = 13.2, 11.5, 6.6, 5.0 Hz, C**H**H), 0.85 (1 H, m, CH**H**) ppm. **^{13}C NMR** (100 MHz, acetone d6): δ 167.3 (**C**), 149.1 (**C**), 132.3 (**C**H), 131.7 (**C**), 128.9 (**C**H), 122.6 (**C**H), 122.3 (**C**H), 89.9 (**C**), 61.3 (**C**H$_2$), 48.8 (**C**H$_2$), 39.9 (**C**H$_2$), 34.4 (**C**H$_2$), 27.5 (**C**H$_2$) ppm. **LRMS** (ESI$^+$): 233 [MH–H$_2$O]$^+$. **HRMS** (ESI$^+$): Found 233.1283, $C_{13}H_{17}N_2O_2$ [MH–H$_2$O]$^+$ requires 233.1285.



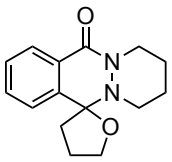
N-(2-Hydroxyethyl)-2-(2-hydroxytetrahydrofuran-2-yl)benzamide, **20**



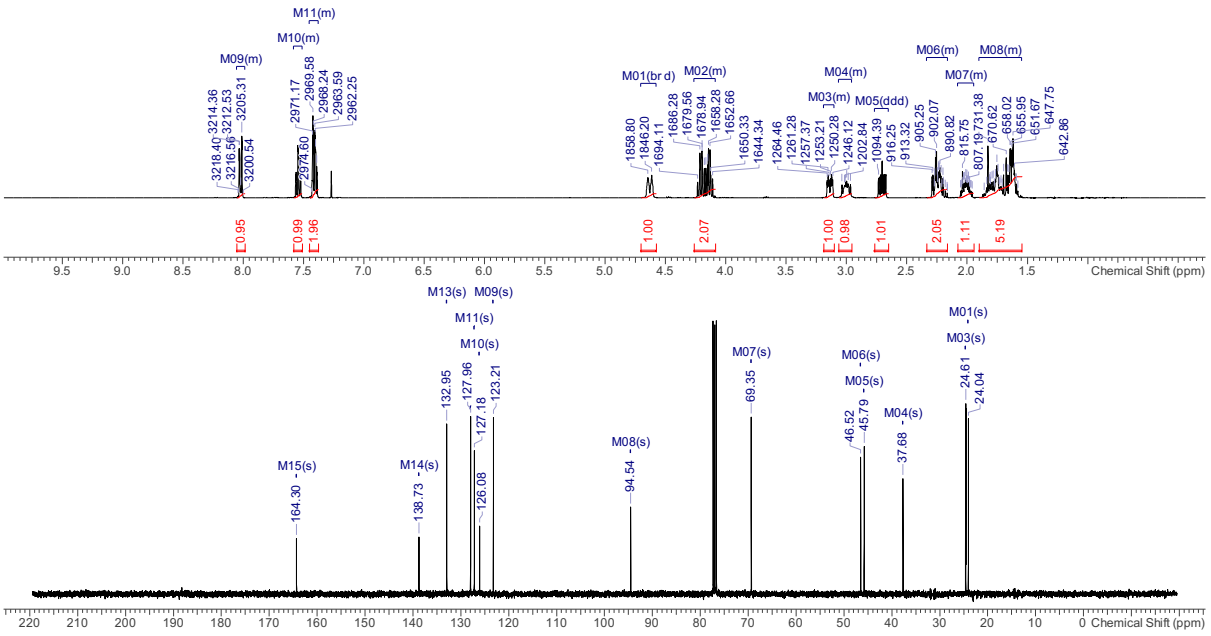
To a solution of lactone **12** (420 mg, 2.21 mmol) in MeCN (50 mL) was added ethanolamine (0.13 mL, 2.21 mmol). After 16 h at 60 °C, the solution was concentrated *in vacuo* and purified by column chromatography (5–20% acetone/DCM) to afford the *title compound* **20** (333 mg, 1.33 mmol, 60%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 3310 (br), 2936 (br), 1670 (s), 1405 (s), 1031 (s). **^{1}H NMR** (400 MHz, acetone-d$_6$): δ 7.67–7.60 (3 H, m, 3 × Ar**H**), 7.52 (1 H, td, *J* = 7.3, 1.5 Hz, Ar**H**), 5.75 (1 H, br s, N**H**), 4.53 (1 H, br s, O**H**), 3.85–3.77 (4 H, m, OC**H**H + OC**H**$_2$ + O**H**), 3.44–3.36 (3 H, m, OCH**H** + NC**H**$_2$), 2.31–2.22 (2 H, m, C**H**$_2$), 1.13 (1 H, m, C**H**H), 0.86 (1 H, m, CH**H**) ppm. **^{13}C NMR** (100 MHz, acetone-d$_6$): δ 167.8 (**C**), 147.8 (**C**), 132.5 (**C**H), 131.7 (**C**), 129.5 (**C**H), 122.8 (**C**H), 122.4 (**C**H), 91.0 (**C**), 61.3 (**C**H$_2$), 61.0 (**C**H$_2$), 41.7 (**C**H$_2$), 33.1 (**C**H$_2$), 27.3 (**C**H$_2$) ppm. **LRMS** (ESI$^+$): 274 [M + Na]$^+$. **HRMS** (ESI$^+$): Found 274.1051, $C_{11}H_{12}NNaO_4$ [M + Na]$^+$ requires 274.1050.



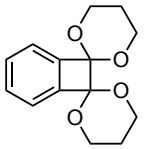
1',2',3',4,4',5-Hexahydro-3H,11'H-spiro[furan-2,6'-pyridazino[1,2-b]phthalazin]-11'-one, **21**



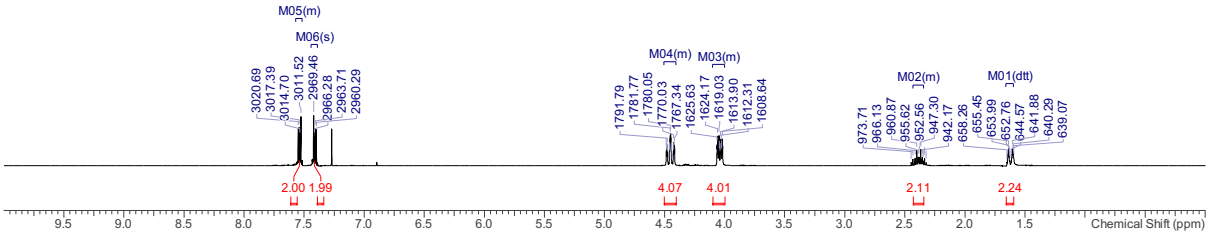
To a solution of lactone **12** (404 mg, 2.12 mmol) in MeCN (50 mL) was added hexahydropyridazine dihydrochloride (304 mg, 1.91 mmol) and Et_3N (0.59 mL, 4.26 mmol). After 16 h at RT, the solution was concentrated *in vacuo* and purified by column chromatography (30–60% EtOAc/hexane) to afford the *title compound* **21** (402 mg, 1.56 mmol, 82%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 2942 (br), 1648 (s), 1363 (m), 1052(s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.02 (1 H, m, Ar**H**), 7.54 (1 H, m, Ar**H**), 7.43–7.39 (2 H, m, 2 × Ar**H**), 4.63 (1 H, br d, *J* = 12.6 Hz, OC**H**H), 4.23–4.21 (2 H, m, OCH**H** + NC**H**), 3.13 (1 H, m, NCH**H**), 3.00 (1 H, m, NC**H**H), 2.70 (1 H, ddd, *J* = 12.6, 8.2, 4.0 Hz, NCH**H**), 2.29–2.18 (2 H, m, 2 × C**H**H), 2.01 (1 H, m, C**H**H), 1.86–1.58 (5 H, m, C**H**H + 2 × C**H**$_2$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 164.3 (**C**), 138.7 (**C**), 133.0 (**C**H), 128.0 (**C**H), 127.2 (**C**H), 126.1 (**C**), 123.2 (**C**H), 94.5 (**C**), 69.4 (**C**H$_2$), 46.5 (**C**H$_2$), 45.8 (**C**H$_2$), 37.7 (**C**H$_2$), 24.61 (**C**H$_2$), 24.57 (**C**H$_2$), 24.0 (**C**H$_2$) ppm. **LRMS** (ESI$^+$): 259 $[MH]^+$. **HRMS** (ESI$^+$): Found 259.1439, $C_{15}H_{19}N_2O_2$ $[MH]^+$ requires 259.1441.

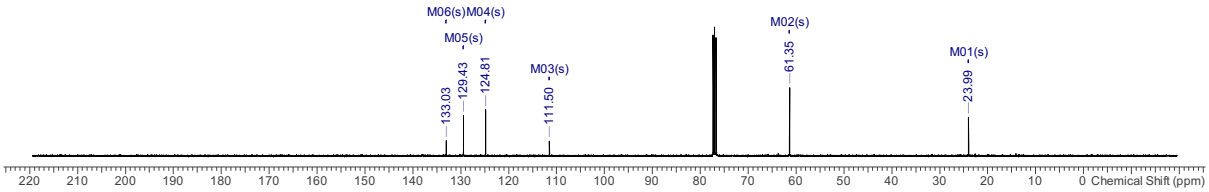


Dispiro[[1,3]dioxane-2,7'-bicyclo[4.2.0]octane-8',2''-[1,3]dioxane]-1'(6'),2',4'-triene, **24**

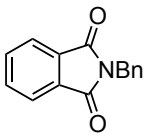


Using the flow photochemical set up A: A solution of *bis*-acetal **4a** (831 mg, 3.00 mmol) in acetonitrile (150 mL) was irradiated for 7 h under circilating flow. The resulting solution was concentrated *in vacuo* then purified by column chromatography (20–40% EtOAc/hexane) to afford firstly the *title compound* **24** (361 mg, 1.46 mmol, 49%) as an off-white solid, then lactone **5a** (233 mg, 0.94 mmol, 31%) as a white solid. Data for **5a**, **MP**: 156–157 °C. **IR** ν_{max} (film, cm^{-1}): 2965 (br), 1346 (m), 1254 (s), 1215 (s), 1033 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.55–7.53 (2 H, m, 2 × Ar**H**), 7.42–7.40 (2 H, m, 2 × Ar**H**), 4.49–4.42 (4 H, m, 4 × C**H**H), 4.05–4.02 (4 H, m, 4 × CH**H**), 2.45–2.32 (2 H, m, 2 × C**H**H), 1.65–1.59 (2 H, m, 2 × CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 133.0 (2 × **C**), 129.4 (2 × **C**H), 124.8 (2 × **C**H), 111.5 (2 × **C**), 61.4 (4 × **C**H_2), 24.0 (2 × **C**H_2) ppm. **LRMS** (ESI$^+$): 249 [MH]$^+$. **HRMS** (ESI$^+$): Found 249.1122, $C_{14}H_{17}O_2$ [MH]$^+$ requires 249.1121.

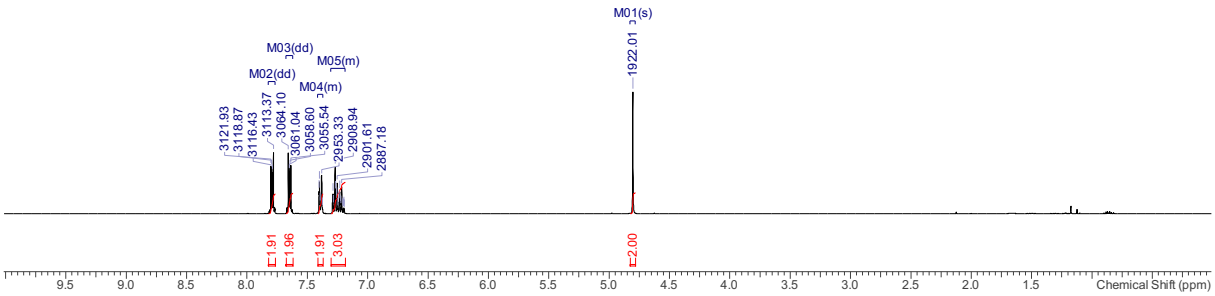


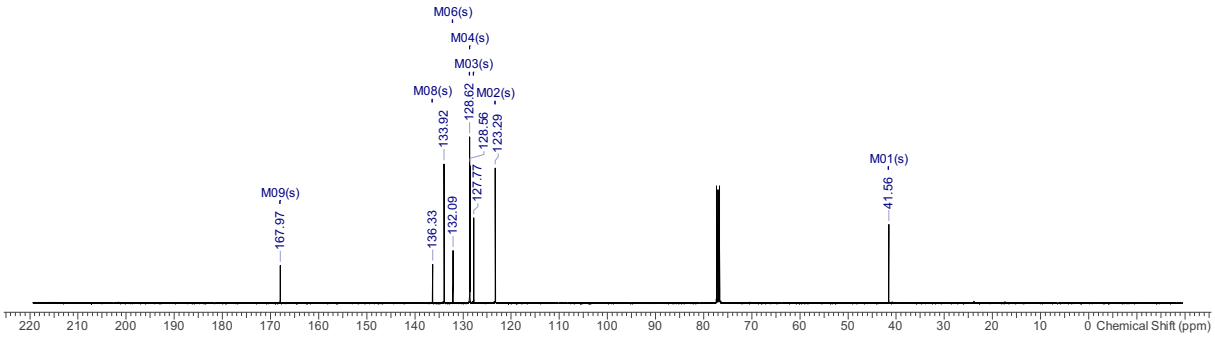


2-Benzylisoindoline-1,3-dione, **30a**

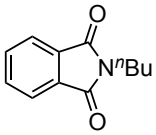


Using the flow photochemical set up A: A solution of *bis*-acetal **2** (598 mg, 2.41 mmol) in acetonitrile (40 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added benzylamine (0.24 mL, 2.19 mmol). After 16 h at RT, the mixture was concentrated *in vacuo* and purified by column chromatography (30–60% EtOAc/petrol) to afford the *title compound* **30a** (466 mg, 1.97 mmol, 90%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 3341 (br), 1774 (w), 1716 (s), 1329 (w). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.82–7.77 (2 H, m, 2 × Ar**H**), 7.67–7.62 (2 H, m, 2 × Ar**H**), 7.40–7.37 (2 H, m, 2 × Ar**H**), 7.29–7.20 (3 H, m, 3 × Ar**H**), 4.80 (2 H, s, CH_2) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 168.0 (2 × **C**), 136.3 (**C**), 133.9 (2 × **C**H), 132.1 (2 × **C**), 128.62 (2 × **C**H), 128.56 (2 × **C**H), 127.8 (**C**H), 123.3 (2 × **C**H), 41.6 (**C**H_2) ppm. **LRMS** (ESI$^+$): 259 ([M+Na]$^+$, 15%), 237 ([MH]$^+$, 100%). Commercially available from Aldrich.

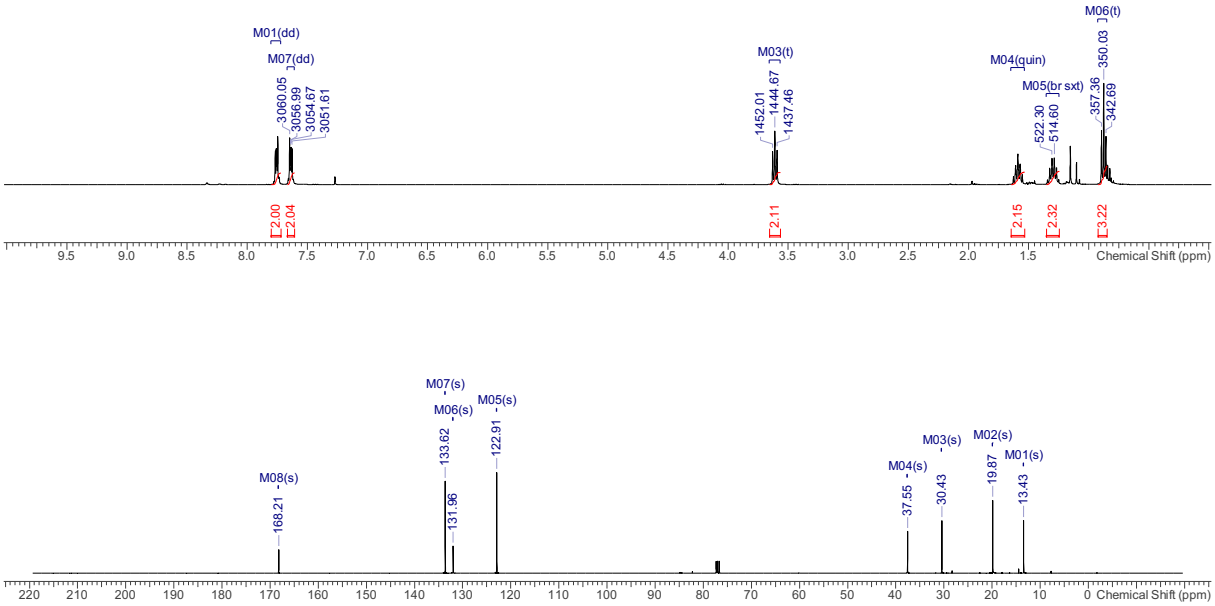




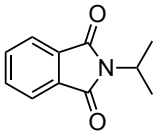
2-Butylisoindoline-1,3-dione, **30b**



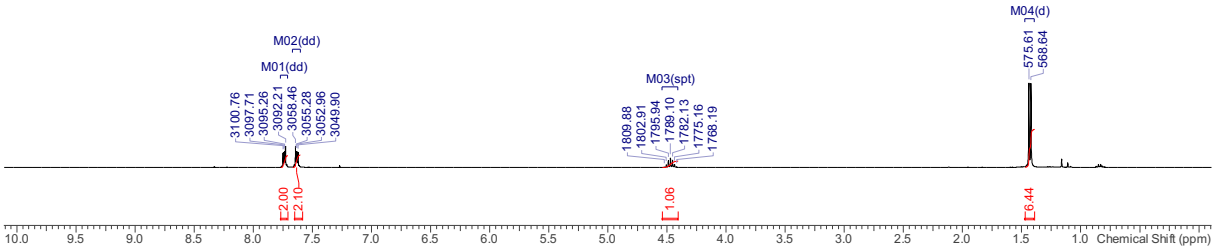
Using the flow photochemical set up A: A solution of *bis*-acetal **2** (596 mg, 2.40 mmol) in acetonitrile (50 mL) was irradiated with UVB light 2 h under circulating flow. To the resulting solution was added *n*-butylamine (596 mg, 2.40 mmol). After 16 h at 80 °C, the mixture was cooled to RT, concentrated *in vacuo* and purified by column chromatography (30–60% EtOAc/petrol) to afford the *title compound* **30b** (296 mg, 1.46 mmol, 80%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 2959 (br), 2934 (br), 1771 (m), 1702 (s), 1393 (m), 1359 (m), 1050 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.76 (2 H, dd, *J* = 5.4, 2.9 Hz, 2 × Ar**H**), 7.64 (2 H, dd, *J* = 5.4, 3.1 Hz, 2 × Ar**H**), 3.61 (2 H, t, *J* = 7.3 Hz, NC$\mathbf{H}_2$), 1.59 (2 H, app. quin, *J* = 7.6 Hz, C$\mathbf{H}_2$), 1.30 (2 H, app. sext, *J* = 7.7 Hz, C$\mathbf{H}_2$), 0.87 (3 H, t, *J* = 7.3 Hz, C$\mathbf{H}_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 168.2 (2 × **C**), 133.6 (2 × **C**H), 132.0 (2 × **C**), 122.9 (2 × **C**H), 37.6 (**C**H_2), 30.4 (**C**H_2), 19.9 (**C**H_2), 13.4 (**C**H_3) ppm. **LRMS** (ESI^+): 407 ($[2M+H]^+$, 5%), 204 ($[MH]^+$, 100%). Data consistent with literature values.[6]

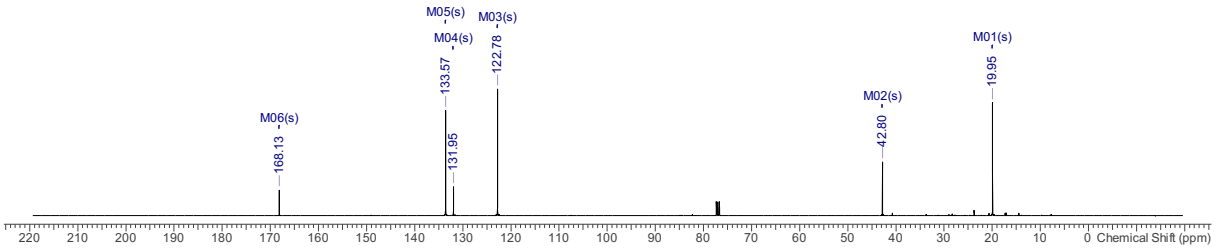


2-Isopropylisoindoline-1,3-dione, **30c**

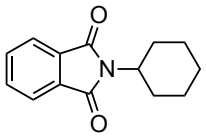


Using the flow photochemical set up A: A solution of *bis*-acetal **2** (599 mg, 2.42 mmol) in acetonitrile (50 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added isopropylamine (0.19 mL, 2.20 mmol). After 16 h at 80 °C, the mixture was cooled to RT, concentrated *in vacuo* and purified by column chromatography (20–60% EtOAc/petrol) to afford the *title compound* **30c** (380 mg, 2.01 mmol, 91%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 2979 (br), 1691 (s), 1367 (s), 1140 (w), 1039 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.74 (2 H, dd, *J* = 5.5, 3.1 Hz, 2 × Ar**H**), 7.63 (2 H, dd, *J* = 5.6, 3.1 Hz, 2 × Ar**H**), 4.47 (1 H, sept, *J* = 7.0 Hz, C**H**), 1.43 (6 H, d, *J* = 7.0 Hz, 2 × C$\mathbf{H}_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 168.1 (2 × **C**), 133.6 (2 × **C**H), 132.0 (2 × **C**), 122.8 (2 × **C**H), 42.8 (**C**H), 20.0 (2 × **C**H_3) ppm. **LRMS** (ESI^+): 190 ($[MH]^+$, 100%). Data consistent with literature values.[7]

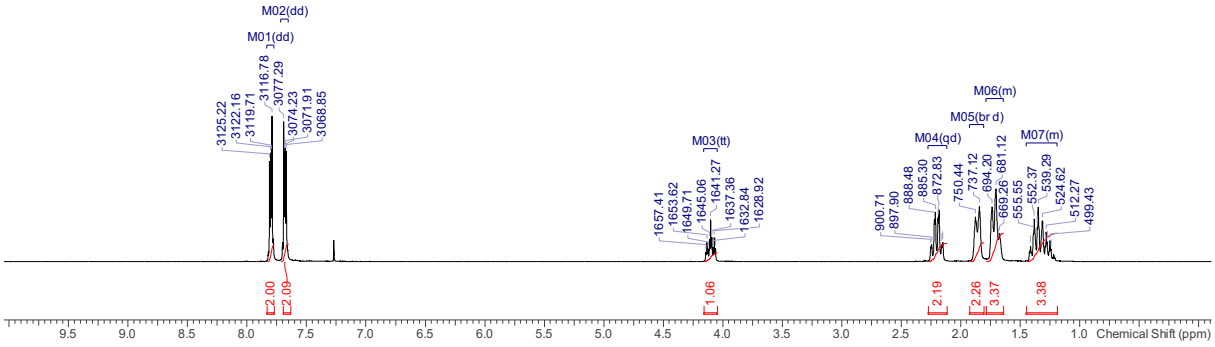


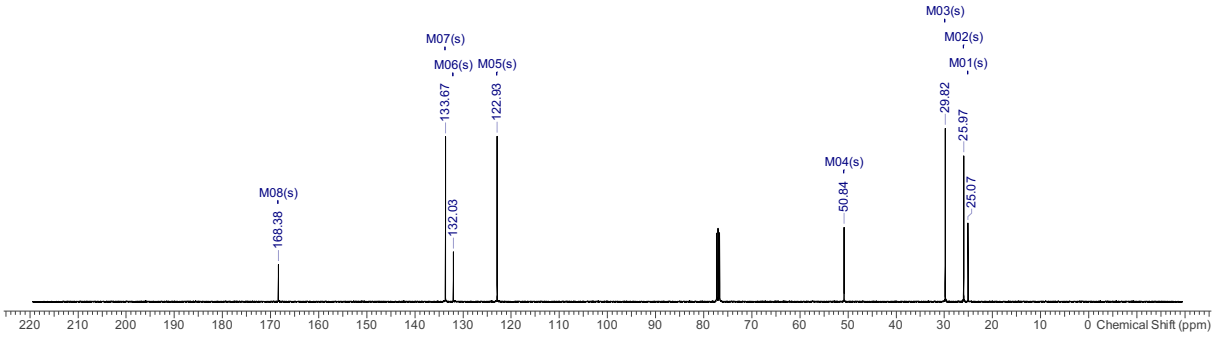


2-Cyclohexylisoindoline-1,3-dione, **30d**

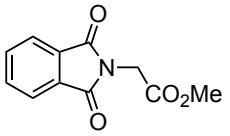


Using the flow photochemical set up A: A solution of *bis*-acetal **2** (588 mg, 2.37 mmol) in acetonitrile (50 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added cyclohexylamine (0.25 mL, 2.16 mmol) and *p*-TsOH (100 mg, 0.53 mmol). After 16 h at 80 °C, the mixture was cooled to RT, concentrated *in vacuo* and purified by column chromatography (20–60% EtOAc/petrol) to afford the *title compound* **30d** (459 mg, 2.00 mmol, 93%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 2925 (br), 1767 (w), 1700 (s), 1390 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.80 (2 H, dd, *J* = 5.4, 3.0 Hz, 2 × Ar**H**), 7.68 (2 H, dd, *J* = 5.4, 3.1 Hz, 2 × Ar**H**), 4.10 (1 H, tt, *J* = 12.3, 3.9 Hz, C**H**), 2.20 (2 H, qd, *J* = 12.5, 3.0 Hz, 2 × C**H**H), 1.86 (2 H, br d, *J* = 13.3 Hz, 2 × CH**H**), 1.73–1.67 (3 H, m, 3 × C**H**H), 1.42–1.24 (3 H, m, 3 × CH**H**) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 168.4 (2 × **C**), 133.7 (2 × **C**H), 132.0 (2 × **C**), 122.9 (2 × **C**H), 50.8 (**C**H), 29.8 (2 × **C**H_2), 26.0 (2 × **C**H_2), 25.1 (**C**H_2) ppm. **LRMS** (ESI$^+$): 230 ([MH]$^+$, 100%). Data consistent with literature values.[6]

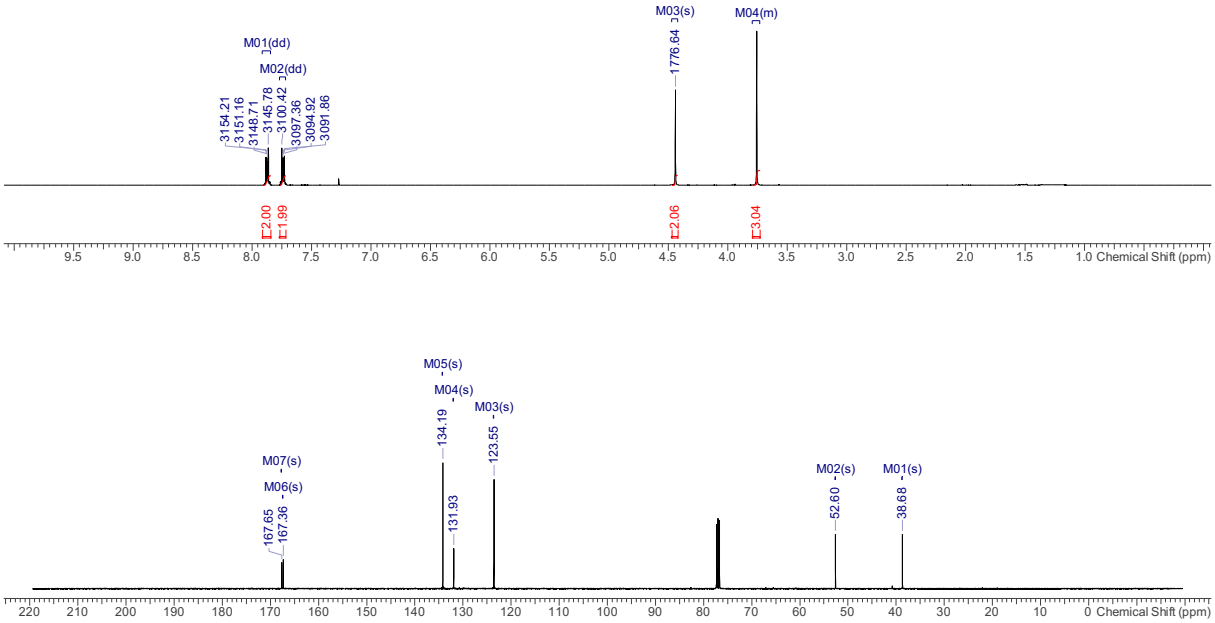




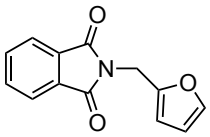
Methyl 2-(1,3-dioxoisoindolin-2-yl)acetate, **30e**



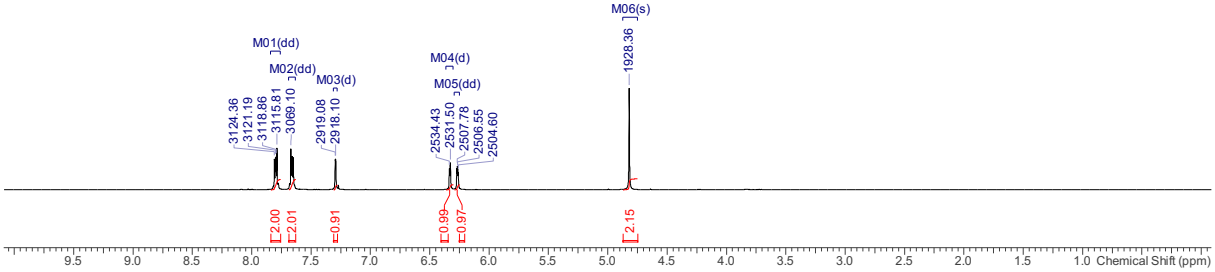
Using the flow photochemical set up A: A solution of *bis*-acetal **2** (650 mg, 2.62 mmol) in acetonitrile (50 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added methyl glycinate (212 mg, 2.38 mmol). After 16 h at 80 °C, the mixture was cooled to RT, concentrated *in vacuo* and purified by column chromatography (20–50% EtOAc/petrol) to afford the *title compound* **30e** (393 mg, 1.81 mmol, 76%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 2955 (br), 1751 (m), 1716 (s), 1416 (m), 1216 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.87 (2 H, dd, *J* = 5.4, 3.1 Hz, 2 × Ar**H**), 7.74 (2 H, dd, *J* = 5.5, 2.9 Hz, 2 × Ar**H**), 4.44 (2 H, s, C$\mathbf{H}_2$), 3.76 (3 H, s, C$\mathbf{H}_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 167.7 (**C**), 167.4 (2 × **C**), 134.2 (2 × **C**H), 131.9 (2 × **C**), 123.5 (2 × **C**H), 52.6 (**C**H_3), 38.7 (**C**H_2) ppm. **LRMS** (ESI^+): 242 ($[M+Na]^+$, 10%), 220 ($[MH]^+$, 100%). Data consistent with literature values.[8]

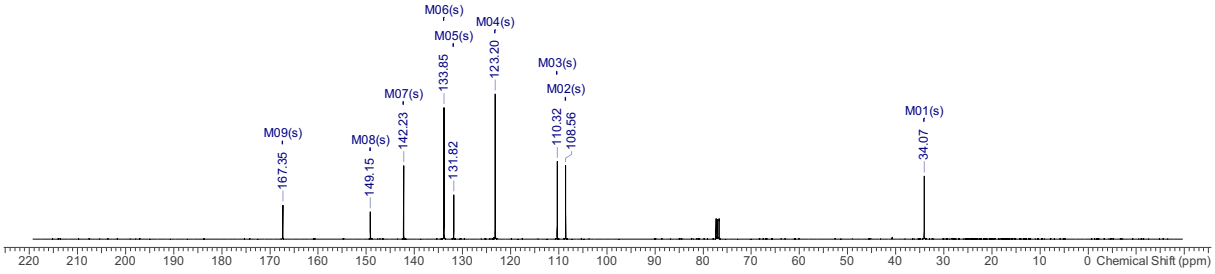


2-(Furan-2-ylmethyl)isoindoline-1,3-dione, **30f**

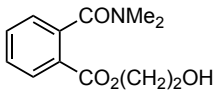


Using the flow photochemical set up A: A solution of *bis*-acetal **2** (589 mg, 2.38 mmol) in acetonitrile (50 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added furfurylamine (0.19 mL, 2.16 mmol). After 16 h at RT, the mixture was concentrated *in vacuo* and purified by column chromatography (30–60% EtOAc/petrol) to afford the *title compound* **30f** (446 mg, 1.96 mmol, 91%) as a white solid. **MP**: 113–114 °C [Lit.[9] 109–111 °C (EtOH)]. **IR** ν_{max} (film, cm^{-1}): 3122 (br), 1770 (s), 1702 (s), 1391 (s), 1343 (m), 1067 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.80 (2 H, dd, *J* = 5.4, 3.1 Hz, 2 × Ar**H**), 7.66 (2 H, dd, *J* = 5.3, 3.1 Hz, 2 × Ar**H**), 7.29 (1 H, br d, *J* = 1.0 Hz, Ar**H**), 6.33 (1 H, d, *J* = 2.9 Hz, Ar**H**), 6.27 (1 H, dd, *J* = 3.1, 1.9 Hz, Ar**H**), 4.81 (2 H, s, C$\mathbf{H}_2$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 167.4 (2 × **C**), 149.2 (**C**), 142.2 (**C**H), 133.9 (2 × **C**H), 131.8 (2 × **C**), 123.2 (2 × **C**H), 110.3 (**C**H), 108.6 (**C**H), 34.1 (**C**H_2) ppm. **LRMS** (ESI^+): 250 ($[M+Na]^+$, 3%), 228 ($[MH]^+$, 100%). Data consistent with literature values.[9]

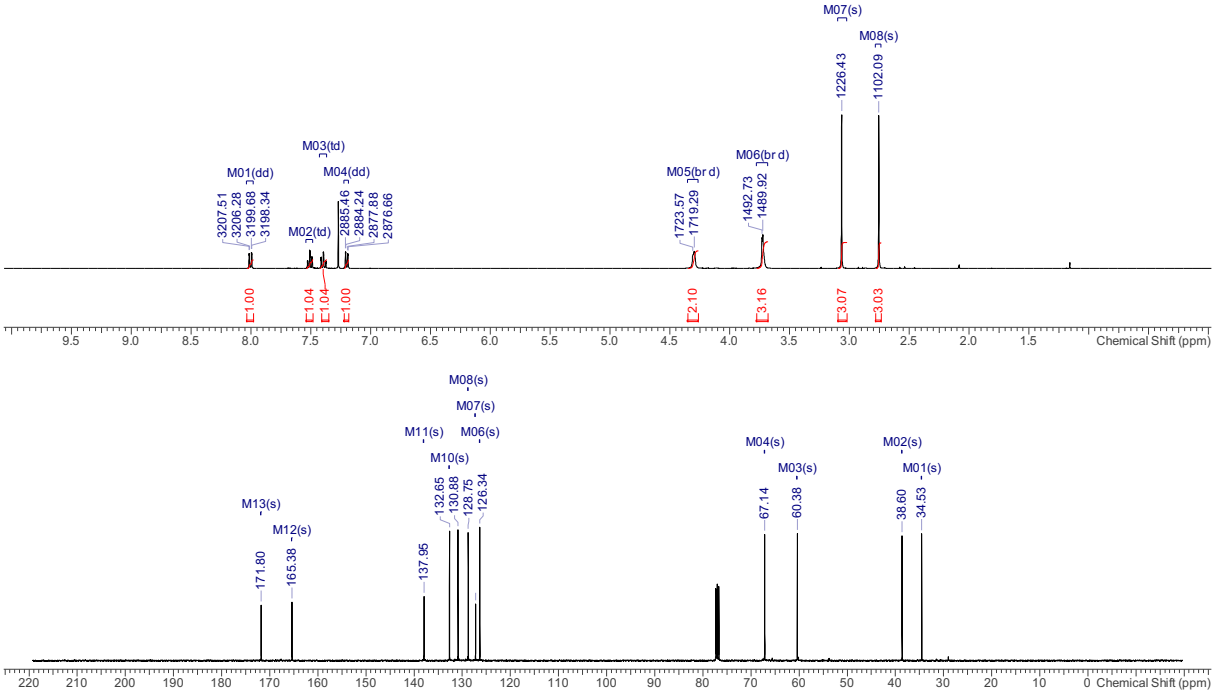




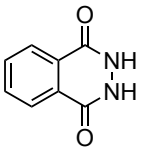
2-Hydroxyethyl 2-(dimethylcarbamoyl)benzoate, **31**



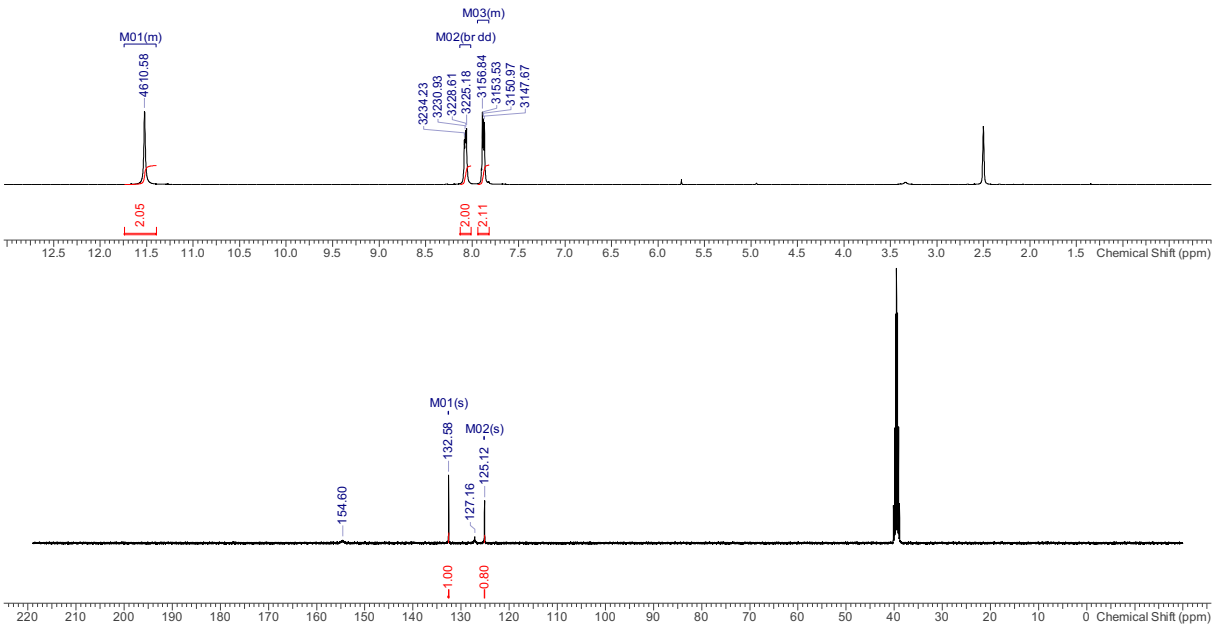
Using the flow photochemical set up A: A solution of *bis*-acetal **2** (601 mg, 2.42 mmol) in acetonitrile (50 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added dimethylamine (2 M in THF, 1.21 mL, 2.42 mmol). After 16 h at RT, the mixture was concentrated *in vacuo* and purified by column chromatography (50–80% acetone/DCM) to afford the *title compound* **31** (465 mg, 1.96 mmol, 81%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 3396 (br), 2937 (w), 1717 (s), 1617 (vs), 1266 (s), 1134 (m), 1064 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.00 (1 H, dd, *J* = 7.9, 1.3 Hz, Ar**H**), 7.53 (1 H, dd, *J* = 7.5, 1.3 Hz, Ar**H**), 7.39 (1 H, dd, *J* = 7.6, 1.3 Hz, Ar**H**), 7.20 (1 H, dd, *J* = 7.6, 1.2 Hz, Ar**H**), 4.34–4.29 (2 H, m, C**H**$_2$), 3.76–3.17 (3 H, m, C**H**$_2$ + O**H**), 3.08 (3 H, s, C**H**$_3$), 2.77 (3 H, s, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 171.8 (**C**), 165.4 (**C**), 138.0 (**C**), 132.7 (**C**H), 130.9 (**C**H), 128.8 (**C**H), 127.3 (**C**), 126.4 (**C**H), 67.2 (**C**H$_2$), 60.5 (**C**H$_2$), 38.7 (**C**H$_3$), 34.6 (**C**H$_3$) ppm. **LRMS** (ESI$^+$): 260 ([M+Na]$^+$, 75%), 238 ([MH]$^+$, 100%). **HRMS** (ESI$^+$): Found 238.1076, $C_{12}H_{16}NO_4$ [MH]$^+$ requires 238.1074.



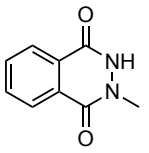
2,3-Dihydrophthalazine-1,4-dione, **32**



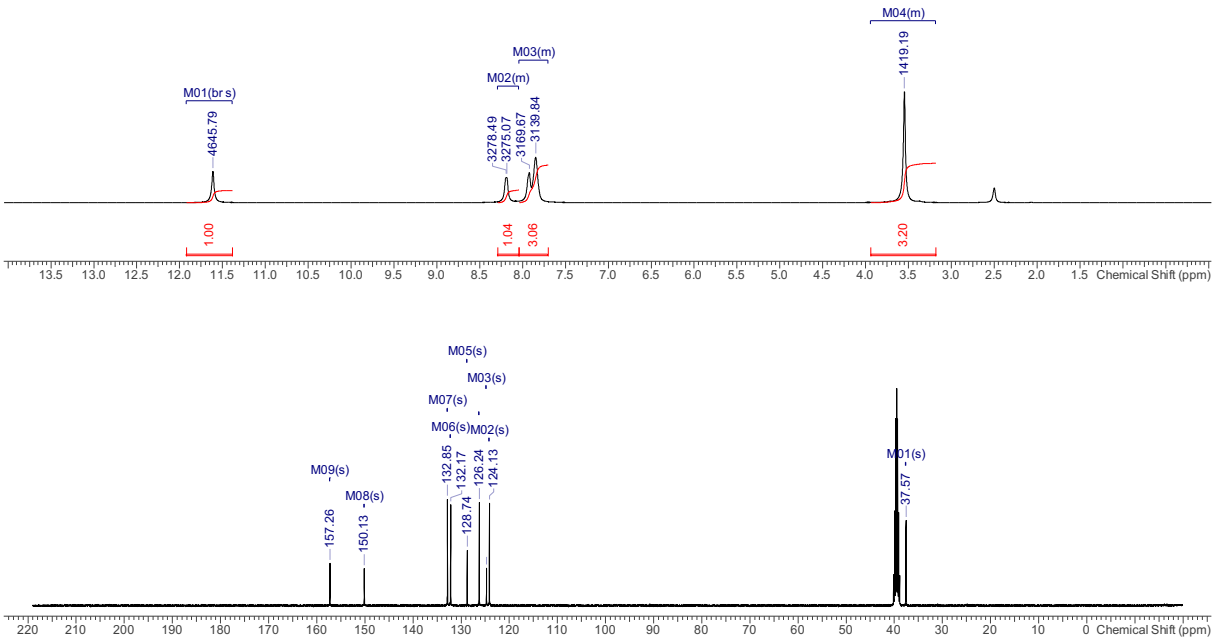
Using the flow photochemical set up B: A solution of *bis*-acetal **2** (601 mg, 2.42 mmol) in acetonitrile (50 mL) was irradiated with UVB light for a residence time of 2 h. To the resulting solution was added hydrazine solution (1M in THF, 2.2 mL, 2.2 mmol). After 16 h at RT, the mixture was concentrated *in vacuo* and purified by filtration and washing with $CHCl_3$ to afford the *title compound* **35** (355 mg, 2.19 mmol, 99%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 3504 (br), 2979 (br), 2897 (br), 1720 (s), 1350 (m), 1263 (m), 1037 (s). **^{1}H NMR** (400 MHz, DMSO-d6): δ 11.52 (2 H, br s, 2 × N**H**), 8.07 (2 H, m, 2 × Ar**H**), 7.86 (2 H, m, 2 × Ar**H**) ppm. **^{13}C NMR** (100 MHz, DMSO-d6): δ 154.5 (2 × **C**), 132.6 (2 × **C**H), 127.2 (2 × **C**), 125.1 (2 × **C**H) ppm. **LRMS** (ESI$^+$): 163 ([MH]$^+$, 100%). Data consistent with literature values.[10]



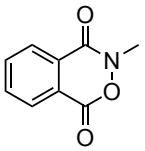
2-Methyl-2,3-dihydrophthalazine-1,4-dione, **33**



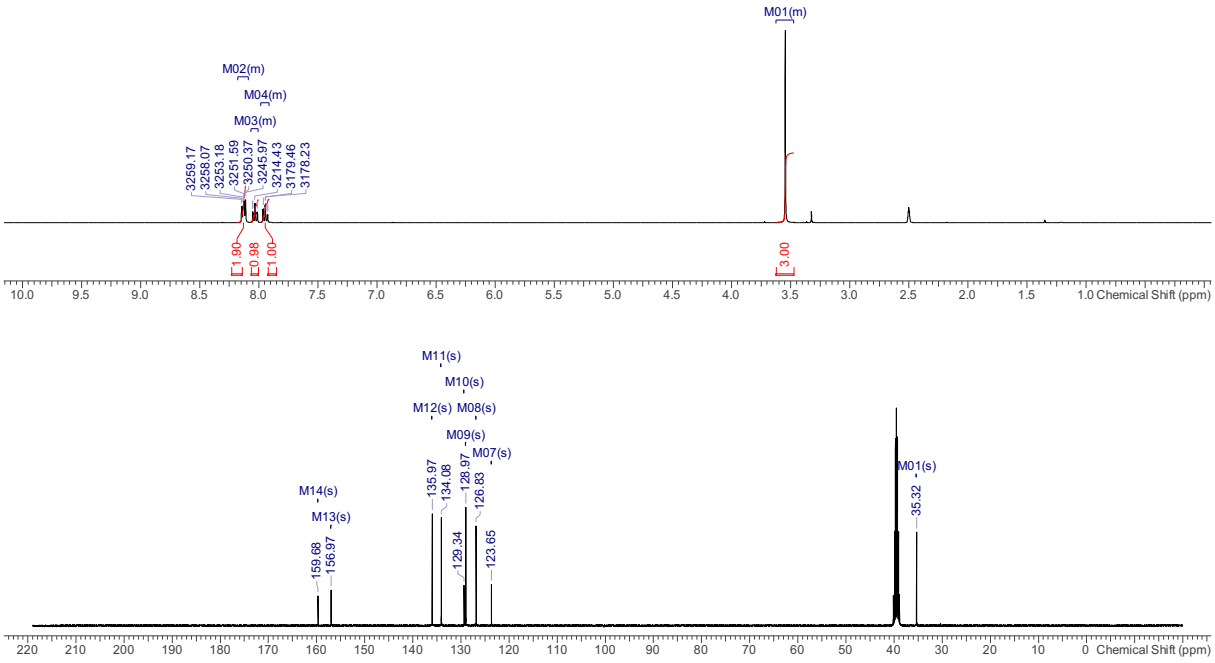
Using the flow photochemical set up A: A solution of *bis*-acetal **2** (617 mg, 2.49 mmol) in acetonitrile (50 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added methylhydrazine (0.12 mL, 2.26 mmol). After 16 h at RT, the mixture was concentrated *in vacuo*, and purified by filtration and washing with $CHCl_3$ to afford the *title compound* **36** (392 mg, 2.23 mmol, 99%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 3086 (br), 2937 (br), 1623 (s), 1567 (s), 1367 (m), 1252 (s) 1103 (m). **^{1}H NMR** (400 MHz, DMSO-d6): δ 11.61 (1 H, br s, N**H**), 8.19 (1 H, br, Ar**H**), 8.00–7.75 (3 H, m, 3 × Ar**H**), 3.55 (3 H, s, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, DMSO-d6): δ 157.3 (**C**), 150.1 (**C**), 132.9 (**C**H), 132.2 (**C**H), 128.7 (**C**), 126.2 (**C**H), 124.7 (**C**), 124.1 (**C**H), 37.6 (**C**H$_3$) ppm. **LRMS** (ESI$^+$): 177 ([MH]$^+$, 100%). Data consistent with literature values.[11]



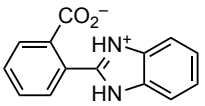
3-Methyl-1H-benzo[d][1,2]oxazine-1,4(3H)-dione, **34**



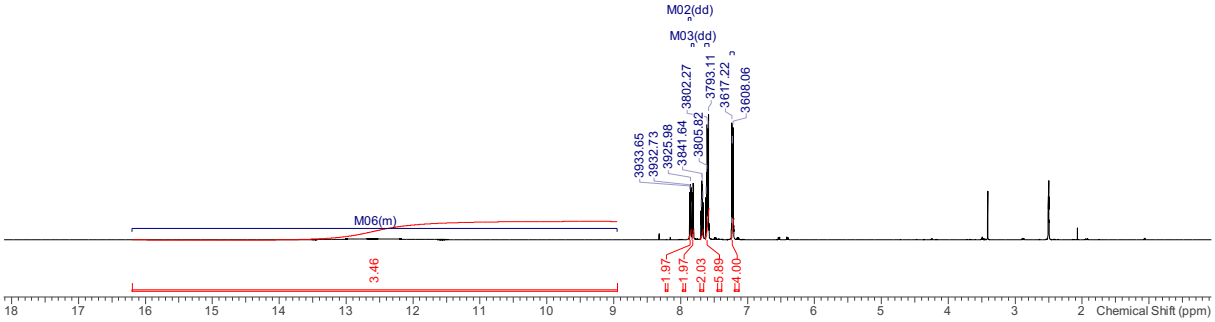
Using the flow photochemical set up A: A solution of *bis*-acetal **2** (617 mg, 2.49 mmol) in acetonitrile (50 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added *N*-methylhydroxylamine hydrochloride (206 mg, 2.49 mmol) and Et_3N (0.34 mL, 2.49 mmol). After 16 h at RT, the mixture was concentrated *in vacuo* and purified by filtration and washing with Et_2O to afford the *title compound* **34** (392 mg, 2.23 mmol, 90%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 3076 (br), 1757 (s), 1735 (s), 1656 (s), 1385 (m), 1105 (m), 1008 (m). **^{1}H NMR** (400 MHz, DMSO-d6): δ 8.14 (1 H, dd, *J* = 8.0, 1.2 Hz, Ar**H**), 8.12 (1 H, dd, *J* = 7.3, 1.3 Hz, Ar**H**), 8.03 (1 H, td, *J* = 7.6, 1.3 Hz, Ar**H**), 7.94 (1 H, td, *J* = 7.2, 1.1 Hz, Ar**H**), 3.55 (3 H, s, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, DMSO-d6): δ 159.7 (**C**), 157.0 (**C**), 136.0 (**C**H), 134.1 (**C**H), 129.3 (**C**), 129.0 (**C**H), 126.8 (**C**H), 123.7 (**C**), 35.3 (**C**H$_3$) ppm. **LRMS** (ESI$^+$): 178 ([MH]$^+$, 100%). Data consistent with literature values.[12]

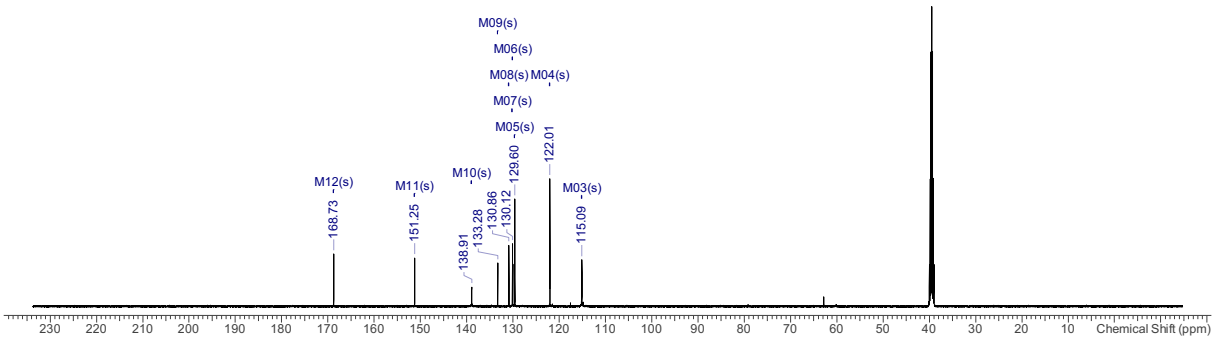


2-(1H-Benzo[d]imidazol-3-ium-2-yl)benzoate, **35**

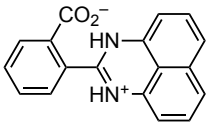


Using the flow photochemical set up A: A solution of *bis*-acetal **2** (612 mg, 2.47 mmol) in acetonitrile (50 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added *o*-phenylenediamine (242 mg, 2.24 mmol). After 16 h at RT, the mixture was concentrated *in vacuo* and purified by filtration and washing with acetone to afford the *title compound* **40** (414 mg, 1.74 mmol, 78%) as a yellow-brown solid. **MP**: 240 °C dec. **IR** ν_{max} (film, cm^{-1}): 3150–2303 (br), 1639 (m), 1695 (m), 1433 (m), 1381 (s). **^{1}H NMR** (500 MHz, DMSO-d6): δ 12.33 (2 H, br s, 2 × N**H**), 7.86 (1 H, dd, *J* = 7.7, 0.9 Hz, Ar**H**), 7.82 (1 H, dd, *J* = 7.7, 1.0 Hz, Ar**H**), 7.68 (1 H, td, *J* = 7.6, 1.4 Hz, Ar**H**), 7.61 (1 H, td, *J* = 7.6, 1.4 Hz, Ar**H**), 7.60 (2 H, m, 2 × Ar**H**), 7.19 (2 H, m, 2 × Ar**H**) ppm. **^{13}C NMR** (125 MHz, DMSO-d6): δ 168.7 (**C**), 151.3 (2 × **C**), 138.9 (**C**), 133.3 (**C**), 130.9 (**C**H), 130.1 (**C**H), 130.0 (**C**), 129.6 (2 × **C**H), 122.0 (2 × **C**H), 115.1 (**C**H) ppm. **LRMS** (ESI$^-$): 475 ([2M–H]$^-$, 25%), 237 ([M–H]$^-$, 100%). Data consistent with literature values.[13]

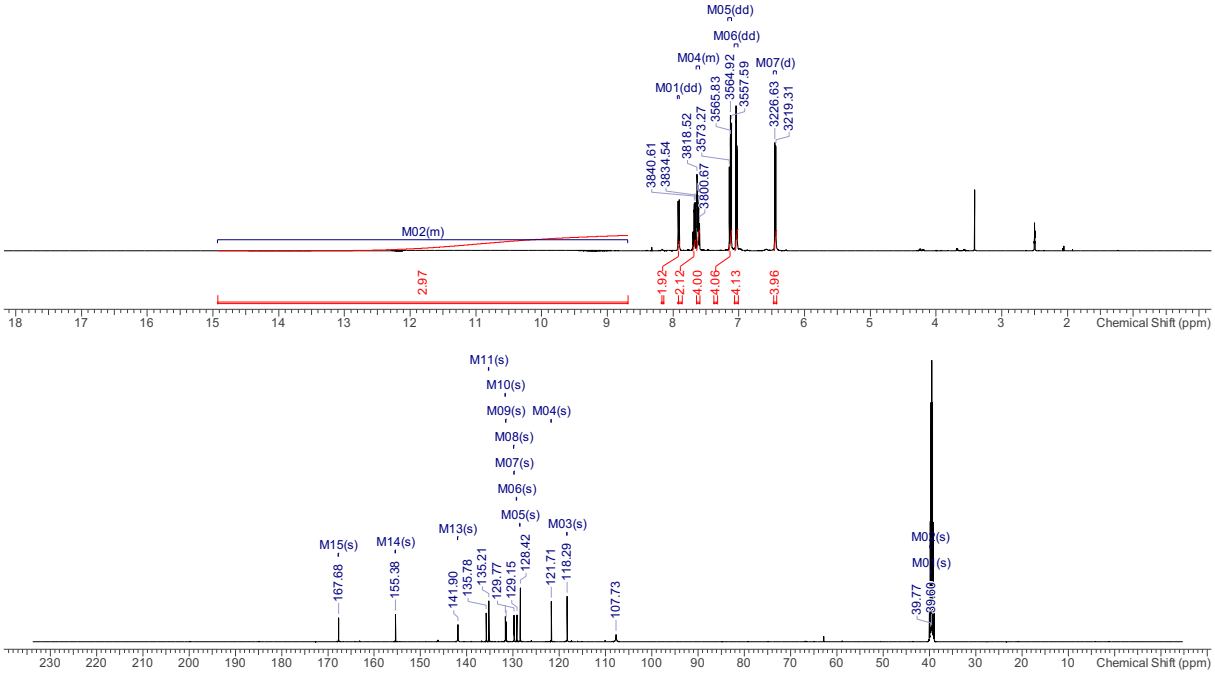




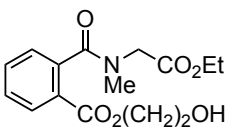
2-(1H-Perimidin-3-ium-2-yl)benzoate, **36**.



Using the flow photochemical set up A: A solution of *bis*-acetal **2** (603 mg, 2.43 mmol) in acetonitrile (50 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added 1,8-diaminonaphthalene (349 mg, 2.21 mmol). After 16 h at RT, the mixture was concentrated *in vacuo* and purified by filtration and washing with acetone to afford the *title compound* **39** (468 mg, 1.63 mmol, 74%) as a yellow-brown solid. **MP**: 210 °C dec. **IR** ν_{max} (film, cm^{-1}): 3174-2086 (br), 1653 (m), 1542 (m), 1481 (m), 1377 (s). **^{1}H NMR** (500 MHz, DMSO-d6): δ 11.81 (2 H, br s, 2 × N**H**), 7.92 (1 H, dd, *J* = 7.8, 1.0 Hz, Ar**H**), 7.70-7.66 (1 H, td, *J* = 7.2, 1.1 Hz, Ar**H**), 7.64–7.60 (2 H, m, 2 × Ar**H**), 7.13 (2 H, dd, *J* = 8.2, 7.3 Hz, 2 × Ar**H**), 7.04 (2 H, dd, *J* = 8.4, 0.8 Hz, 2 × Ar**H**), 6.44 (2H, d, *J* = 7.3 Hz, 2 × Ar**H**) ppm. **^{13}C NMR** (125 MHz, DMSO-d6): δ 167.7 (**C**), 155.4 (2 × **C**), 141.9 (**C**), 135.8 (**C**), 135.2 (**C**), 131.6 (**C**H), 131.5 (**C**H), 129.8 (**C**H), 129.7 (**C**H), 129.2 (**C**H), 128.4 (2 × **C**H), 121.7 (**C**), 118.3 (2 × **C**H), 107.7 (2 × **C**H) ppm [one **C** coincident or not observed]. **LRMS** (ESI^-): 575 ([2M–H]$^-$, 30%), 287 ([M–H]$^-$, 100%).

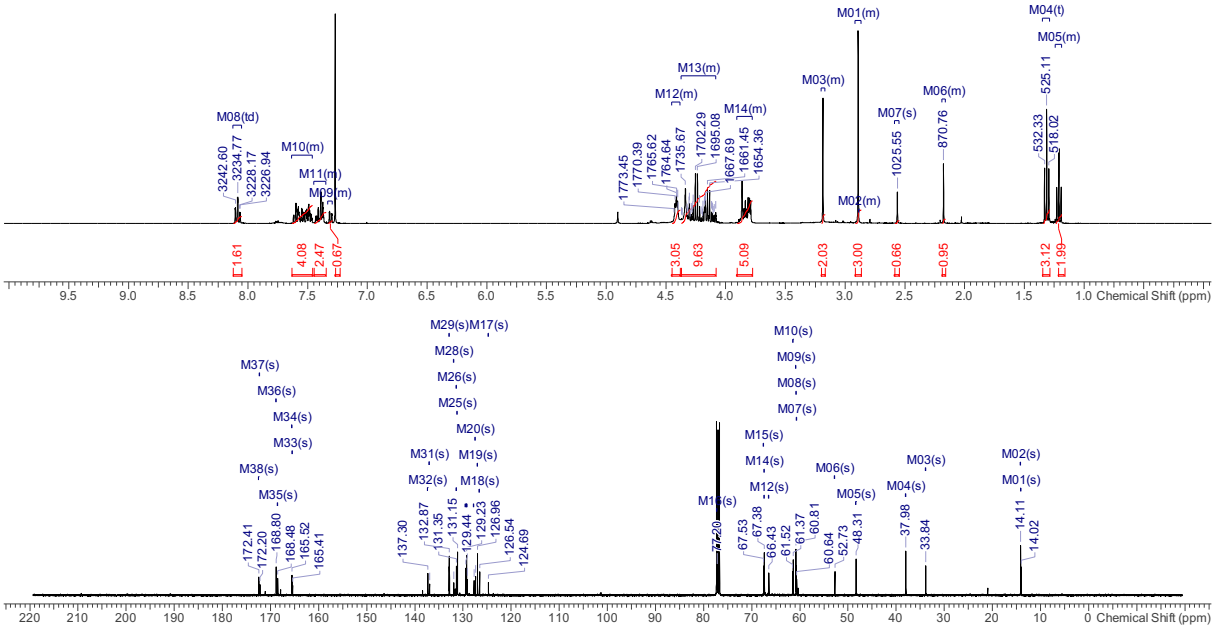


2-Hydroxyethyl 2-((2-ethoxy-2-oxoethyl)(methyl)carbamoyl)benzoate, **37**

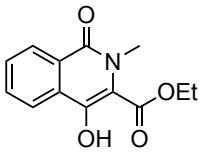


Using the flow photochemical set up A: A solution of *bis*-acetal **2** (650 mg, 2.62 mmol) in acetonitrile (50 mL) was irradiated with UVB light for 2 h under circulating flow. To the resulting solution was added ethyl *N*-methylglycinate (278 mg, 2.38 mmol). After 16 h at RT, the mixture was concentrated *in vacuo* and purified by column chromatography (50–80% EtOAc/petrol) to afford the *title compound* **32** (393 mg, 1.81 mmol, 76%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 3430 (br), 2957 (br), 1720 (s), 1628 (s), 1285 (s), 1204 (m), 1065 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): 3:2 mixture of rotamers: major rotamer: δ 8.10 (1 H, obscured dd, *J* = 8.0, 1.2 Hz, Ar**H**), 7.64–7.50 (2 H, m, 2 × Ar**H**), 7.40 (1 H, ddd, *J* = 7.6, 1.2, 0.5 Hz 1 × Ar**H**), 4.45–4.42 (2 H, m, OC**H**$_2$), 4.35 (2 H, s, NC**H**$_2$), 4.26 (2 H, q, *J* = 7.2 Hz, OC**H**$_2$), 3.88–3.82 (2 H, m, OC**H**$_2$), 2.91 (3 H, s, NC**H**$_3$) 1.33 (3 H, t, *J* = 7.2 Hz, C**H**$_3$) ppm; minor rotamer δ 8.06 (1 H, obscured dd, *J* = 8.1, 1.2 Hz, Ar**H**), 7.64–7.50 (2 H, m, 2 × Ar**H**), 7.32 (1 H, ddd, *J* = 7.5, 1.3, 0.4 Hz Ar**H**), 4.36–4.31 (2 H, m, OC**H**$_2$), 4.16 (2 H, q, *J* = 7.2 Hz, OC**H**$_2$), 3.88 (2 H, s, NC**H**$_2$), 3.88–3.82 (2 H, m, OC**H**$_2$), 3.20 (3 H, s, NC**H**$_3$), 1.23 (3 H, t, *J* = 7.2 Hz, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$) major rotamer: δ 172.5 (**C**), 168.9 (**C**), 165.6 (**C**), 137.4 (**C**), 132.9 (**C**H), 131.4 (**C**H), 129.5

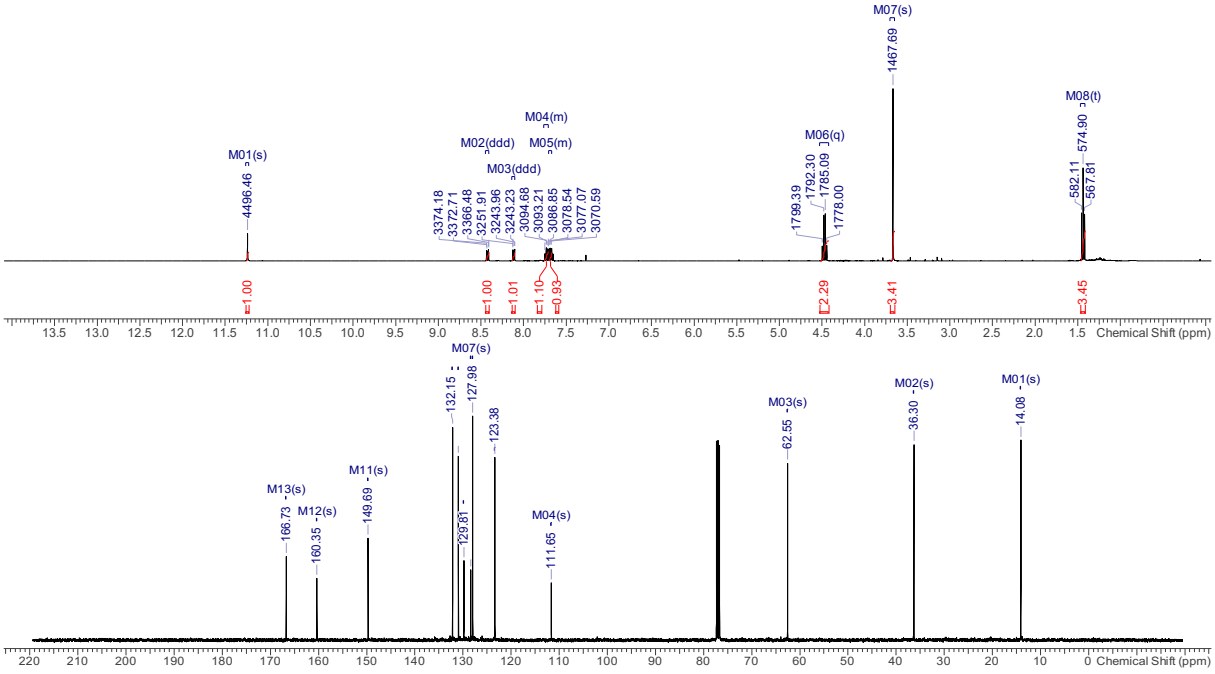
(**C**H), 127.5 (**C**), 127.0 (**C**H), 67.6 (**C**H_2), 61.4 (**C**H_2), 60.9 (**C**H_2), 48.4 (**C**H_2), 38.0 (**C**H_3), 14.2 (**C**H_3) ppm; minor rotamer: δ 172.3 (**C**), 168.6 (**C**), 165.5 (**C**), 137.0 (**C**), 132.9 (**C**H), 131.2 (**C**H), 129.3 (**C**H), 127.8 (**C**), 126.6 (**C**H), 67.5 (**C**H_2), 61.4 (**C**H_2), 60.8 (**C**H_2), 52.8 (**C**H_2), 33.9 (**C**H_3), 14.1 (**C**H_3) ppm. **LRMS** (ESI$^+$): 322 ([M+Na]$^+$, 50%), 310 ([MH]$^+$, 90%), 292 ([MH–H_2O]$^+$, 100%). **HRMS** (ESI$^+$): Found 310.1294, $C_{15}H_{20}NO_6$ [MH]$^+$ requires 310.1285.



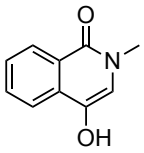
Ethyl 4-hydroxy-2-methyl-1-oxo-1,2-dihydroisoquinoline-3-carboxylate, **38**



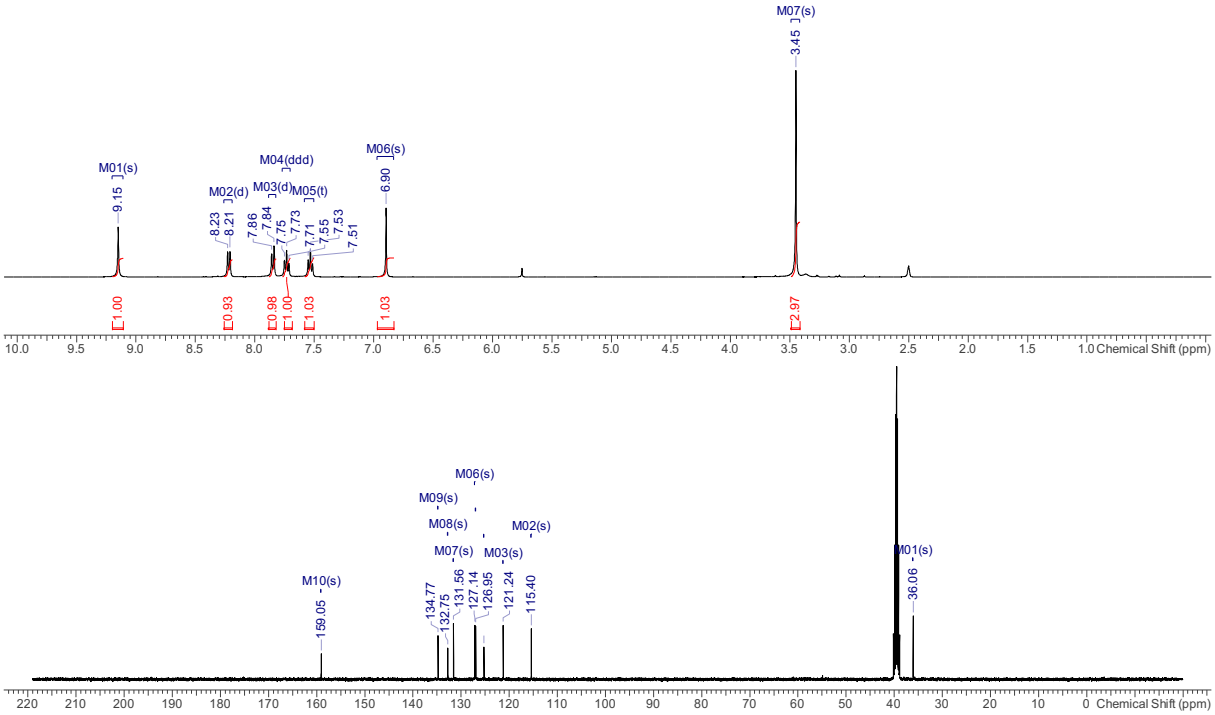
To a solution of amide **32** (310 mg, 1.00 mmol) in THF (40 mL) at 0 °C was added LDA (2M in THF, 0.65 mL, 1.3 mmol) dropwise. After 16 h at RT, sat. NH_4Cl (40 mL) and EtOAc (50 mL) were added. The aqueous phase was separated and extracted with EtOAc (2 × 50 mL) then the organic phases were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (50–80% EtOAc/petrol) to afford the *title compound* **37** (205 mg, 0.83 mmol, 83%) as a yellow solid. **IR** ν_{max} (film, cm^{-1}): 2980 (br), 1703 (w), 1640 (s), 1566 (m), 1318 (m), 1285 (m), 1241(m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 11.24 (1 H, s, O**H**), 8.42 (1 H, ddd, *J* = 7.8, 1.5, 0.6 Hz, Ar**H**), 8.12 (1 H, ddd, *J* = 8.0, 1.5, 0.6 Hz, Ar**H**), 7.75–7.65 (2 H, m, 2 × Ar**H**), 4.47 (2 H, q, *J* = 7.1 Hz, OC**H**$_2$), 3.67 (3 H, s, NC**H**$_3$), 1.44 (3 H, t, *J* = 7.2 Hz, C**H**$_3$) ppm. **^{13}C NMR** (100 MHz, $CDCl_3$): δ 166.7 (**C**), 160.4 (**C**), 149.7 (**C**), 132.2 (**C**H), 130.9 (**C**H), 129.8 (**C**), 128.4 (**C**), 128.0 (**C**H), 123.4 (**C**H), 111.7 (**C**), 62.6 (**C**H_2), 36.3 (**C**H_3), 14.1 (**C**H_3) ppm. **LRMS** (ESI$^+$): 248 ([MH]$^+$, 100%). Data consistent with literature values.[14]



4-Hydroxy-2-methylisoquinolin-1(2H)-one, **39**



A solution of ester **37** (190 mg, 0.77 mmol) and 2M NaOH (5 mL) in dioxane (20 mL) was heated at 80 °C for 16 h then cooled to RT and partitioned between DCM (50 mL) and water (50 mL). The aqueous phase was separated and extracted with DCM (3 × 50 mL) then the organic phases were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (60–80% EtOAc/petrol) to afford the *title compound* **38** (117 mg, 0.67 mmol, 87%) as a white solid. **MP**: 220-221 °C. **IR** ν_{max} (film, cm^{-1}):3008 (br), 1564 (s), 1542 (s), 1415 (s), 1334 (m), 1094 (s). **^{1}H NMR** (400 MHz, DMSO-d6): δ 9.15 (1 H, s, O**H**), 8.22 (1 H, d, *J* = 8.0 Hz, Ar**H**), 7.85 (1 H, d, *J* = 7.9 Hz, Ar**H**), 7.73 (1 H, ddd, *J* = 8.0, 7.0, 1.0 Hz, Ar**H**), 7.53 (1 H, app. td, *J* = 7.5, 0.9 Hz, Ar**H**), 6.90 (1 H, s, =C**H**), 3.45 (3 H, s, NC**H**$_3$) ppm. **^{13}C NMR** (100 MHz, DMSO-d6): δ 159.1 (**C**), 134.8 (**C**), 132.8 (**C**), 131.6 (**C**H), 127.1 (**C**H), 127.0 (**C**H), 125.2 (**C**), 121.2 (**C**H), 115.4 (**C**H), 36.1 (**C**H$_3$) ppm. **LRMS** (ESI$^+$): 176 ([MH]$^+$, 100%). **HRMS** (ESI$^+$): Found 176.0706, $C_{10}H_{10}O_2N$ [MH]$^+$ requires 176.0706.



5. Time-resolved Experimental

The TA measurements were conducted at the Nottingham ultrafast facility. The set up has been discussed in detail elsewhere.[15] Briefly, the 100 fs, 800 nm, 80 MHz fundamental pulses are generated with commercial Ti:Sapphire oscillator (MaiTai). Subsequently, the pulses are amplified in a Ti:Sapphire amplifier (Spitfire Pro/Spectra Physics) to produce 800 nm, 100 fs, 1 kHz, 2 mJ pulses. Half of the output is used to pump a harmonic generator (Timeplate tripler, Minioptic Technology) to produce 266 nm, 100 fs pump pulse. The probe beam is a pulsed white light continuum, generated by focussing small amount of 800 nm laser beam into a 4 mm thick Sapphire disk. The white light beam is split into two parts. One part passes through the sample and spatially overlapped with the pump beam. Another part serves as a reference to the probe beam change. The polarization of the pump pulse is set at the magic angle (54.7 degree) relative to the probe pulse. The pump pulse was optically delayed relative to the probe pulse by using a translation stage (LMA Actuator, Aerotech, USA), and focused onto the sample. The polarization of the pump pulse was set at the magic angle (54.7°) relative to the probe pulse to avoid rotational diffusion. For a measurement with a longer time delay, a Q-switched Nd : YVO laser (ACE- 25QSPXHP/MOPA, Advanced Optical Technology, UK) was employed as a pump source which is synchronized relative to the Spitfire Pro amplifier. Fourth harmonic (266 nm) of the Nd:YVO output was used as the pump pulse for the ns experiments. The delay between pump and probe pulses is controlled with a pulse generator (DG535, Stanford Research System,USA) from 0.5 ns to 100 µs. Two parts of probe beam are monitored by a duel array detector (512 pixels) (Cronin Camera, Spectronic device Ltd, UK). The detector is mounted in the focal plane of a 303 mm Acton spectrograph (Acton, USA) with a 300 g/mm grating and a 150 g/mm grating. The array detector equips a 16-bit analogue-to-digital digitizer. The pump-induced change in the absorbance ΔA is determined by chopping the pump pulse at half the repetition frequency of the laser and calculating the ratio between the pump-on and pump-off transmittance. The signal of the reference is served as reference to normalize the shot to shot fluctuation. All the measurements were done

with 30 mM solution. Each solution was freeze pump thaw three times before time-resolved measurements. All the measurements were performed in flow condition by pumping the solution through a peristaltic pump (Masterflex, Cole-Parmer). A Harrick flowing solution cell with 2-mm-thick CaF_2 windows (path-length: 400 µm) is mounted on a motorized cell mount, which moves the cell in x and y dimensions rapidly and continuously. The measured time-resolved data were analysed in Glotaran. The ground state photolysis was done with high pressure Hg arc lamp in a Harrick Cell. Subsequently FTIR spectra were measured in a Nicolet FTIR spectrometer.

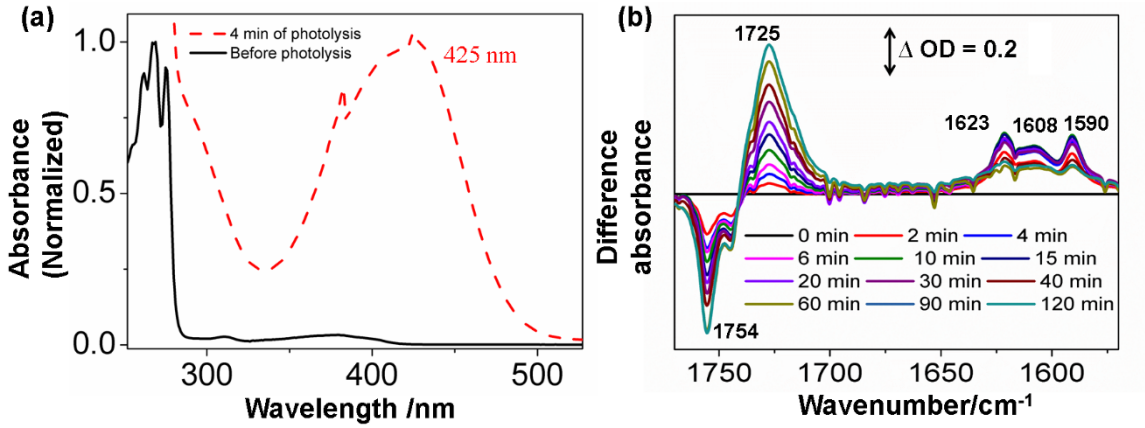


Figure S5. (a) Ground state absorption spectrum of ninhydrin *bis*-acetal **4a** in CD_3CN before photolysis (black spectrum) and after photolysis (red spectrum). The strong absorption band around 260 nm is due to the allowed $S_2 \leftarrow S_0$ ($\pi\pi^*$) transition while the weak band near 380 nm assigned to the forbidden $S_1 \leftarrow S_0$ ($n\pi^*$) transition. The new transient band at 425 is assigned to quinodimethane **26**. (b) FT-IR difference spectra of ninhydrin *bis*-acetal **4a** after photolysis in CD_3CN. Time refers to the time of photolysis. The transient bands at 1623, 1608 and 1590 cm^{-1} are assigned to quinodimethane **26** while the band at 1725 cm^{-1} is assigned to lactone **5a**.

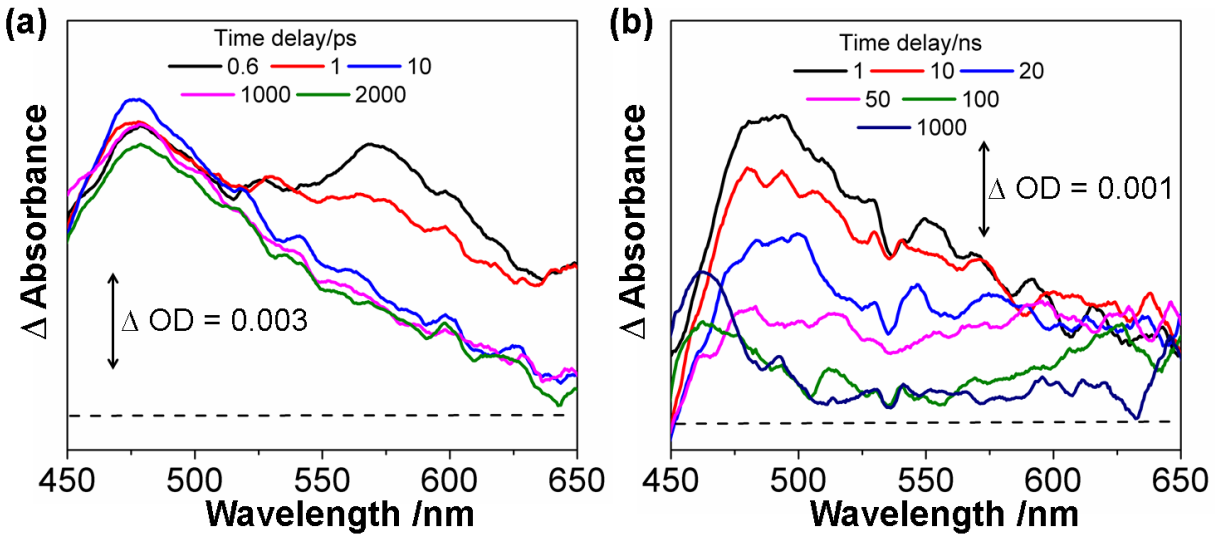


Figure S6. (a) Selected ps TA spectra of *bis*-acetal **2** after 266 nm photoexcitation. (b) Selected ns TA spectrum of *bis*-acetal **2** after 266 nm photoexcitation.

Table 1. Comparison of time constants obtained from global analysis of TA data for *bis*-acetal **4a** and **2**

Time constants	*bis*-acetal **4a**	*bis*-acetal **2**	Tentative assignments
τ_1	1.8 ps	2.2 ps	Formation of singlet acyl-alkyl radical by α C-C bond cleavage
τ_2	1.8 ns	1.5 ns	ISC of singlet acyl-alkyl radical to a triplet acyl-alkyl radical
τ_3	4.8 ns	13 ns	decarbonylation
τ_4	100 ns	66 ns	Formation of quinodimethane

6. Computational Details

The ground state UV/vis spectra were calculated using Time-Dependent Density Functional Theory (TD-DFT)[16] at the CAM-B3LYP/6-311+G(d,p) level of theory with a conductor-like polarizable continuum solvent model including a dielectric constant of 37.5.[17] These calculations were performed following initial geometry optimization using Kohn-Sham Density Functional Theory (DFT) at the B3LYP/6-311G(d,p) level *in vacuo*,[18] and scaled in eV to match the experimental peak maxima. The UV/vis spectrum of the S_1 singlet excited state, ^{1}[**4a**], was calculated using an excited state DFT procedure during both the geometry optimization and the reference self-consistent field calculation for the TD-DFT. A β-spin electron was moved from the highest occupied molecular orbital to the lowest unoccupied molecular orbital, and the maximum-overlap-method was used to prevent variational collapse to the ground state.[19] Calculations were carried out using a developmental version of the Q-Chem software package.[20] TD-DFT excitations for ^{1}[**28**] and ^{3}[**29**] were calculated within the Tamm–Dancoff approximation.

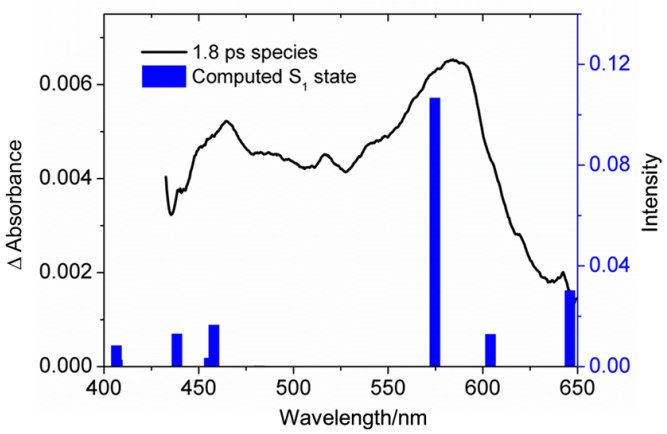


Figure S7. Comparison of the extracted S_1 state absorption spectrum from TA studies and the computed (stick plot, scaling by a factor of 1.06) absorption spectrum for **4a**.

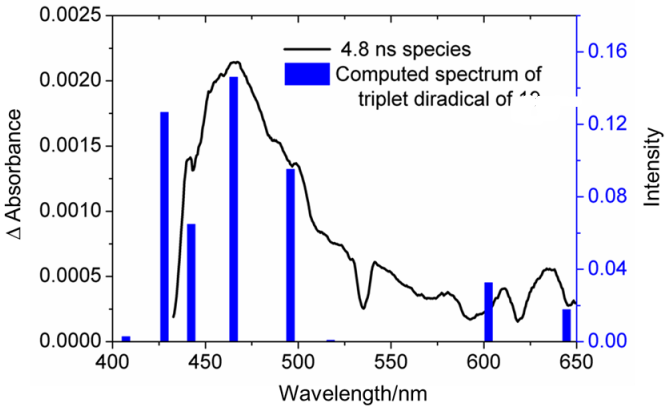


Figure S8. Comparison of the extracted absorption spectrum from TA studies and computed (stick plot, scaling by a factor of 0.64) absorption spectrum of ^{3}[**22**].

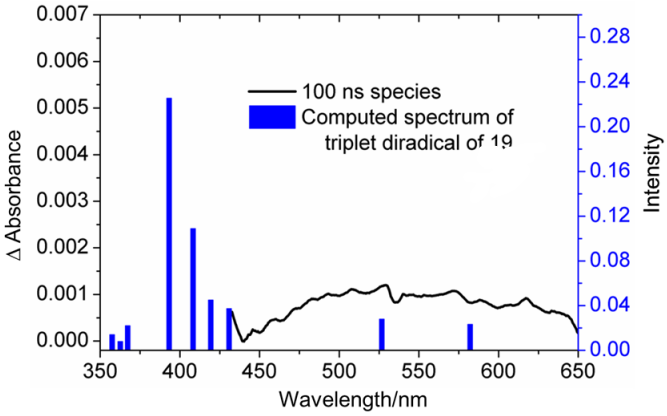


Figure S9. Comparison of the extracted absorption spectrum from TA studies and computed (stick plot, scaling by a factor of 0.76) absorption spectrum of ^{3}[**23**].

7. References

1 B. D. Hook, W. Dohle, P. R. Hirst, M. Pickworth, M. B. Berry and K. I. Booker-Milburn, *J. Org. Chem.*, 2005, **70**, 7558–7564; D. C. Harrowven, M. Mohamed, T. P. Gonçalves, R. J. Whitby, D. Bolien and H. F. Sneddon, *Angew. Chem. Int. Ed.*, 2012, **51**, 4405–4408; L. D. Elliott, J. P. Knowles, P. J. Koovits, K. G. Maskill, M. J. Robertson-Ralph, G. Lejeune, L. J. Edwards, R. I. Robinson, I. R. Clemens, B. Cox, D. D. Pascoe, G. Koch, M. Eberle, M. B. Berry and K. I. Booker-Milburn, *Chem. Eur. J.*, 2014, **20**, 15226–15232; D. E. Collin, E. H. Jackman, N. Jouandon, W. Sun, D. C. Harrowven and B. Linclau, *Synthesis*, 2021, **53**, 1307; M. A. Manning, W. Sun, M. E. Light and D. C. Harrowven, *Chem. Commun.*, 2021, **57**, 4556–4559; W. Sun, W. A. T. Raimbach, L. D. Elliott, K. I. Booker-Milburn and D. C. Harrowven, *Chem. Commun.*, 2021, DOI: 10.1039/d1cc05700f.

2 D. Leinweber, R. Wartchow and H. Butenschön, *Eur. J. Org. Chem.*, 1999, 167–179; D. Leinweber, M. Schnebel, R. Wartchow, H. G. Wey and H. Butenschoen, *Eur. J. Org. Chem.*, 2002, 2385–2390.

3 P. Seephonkai, S. G. Pyne, A. C. Willis and W. Lie, *J. Nat. Prod.*, 2013, **76**, 1358–1364.

4 N. Dussart, H. V. Trinh and D. Gueyrard, *Org. Lett.*, 2016, **18**, 4790–4793; M. A. Brimble and S. G. Robinson, *Tetrahedron*, 1996, **52**, 9553–9562; M. A. Brimble, G. M. Horner and R. J. Stevenson, *Aust. J. Chem.*, 1996, **49**, 189–196.

5 V. G. Gore, M. D. Chordia and N. S. Narasimhan, *Tetrahedron*, 1990, **46**, 2483–2494.

6 T. Kaicharla, M. Thangaraj and A. T. Biju, *Org. Lett.*, 2014, **16**, 1728–1731.

7 Y. Wang, Y. Zhou, M. Lei, J. Hou, Q. Jin, D, Guo and W. Wu, *Tetrahedron*, 2019, **75**, 1180–1185.

8 P. Dawar, M. B. Raju and R. A. Ramakrishna, *Synth. Commun.*, 2014, **44**, 836–846.

9 R. C. Brewster, J. T. Suitor, A. W. Bennett and S. Wallace, *Angew. Chem. Int. Ed.*, 2019, **58**, 12409–12414; X. Wu, G. Ding, L. Yang, W. Lu, W. Li, Z. Zhang and X. Xie, *Org. Lett.*, 2018, **20**, 5610–5613.

10 F. Ji, J. Li, X. Li, W. Guo, W. Wu and H. Jiang, *J. Org. Chem.*, 2018, **83**, 104–112.

11 M. Javier, E. Quezada, A. Cuiñasa, M. Campos-Toimil, E. Uriarte, L. Santana and D. Viña, *Eur. J. Med. Chem.*, 2014, **82**, 407–415.

12 R. Tilvawala and R. F. Pratt, *Biochemistry*, 2013, **52**, 7060–7070.

13 M. She, D. Xiao, B. Yin, Z. Yang, P. Liu, J. Li and Z Shi, *Tetrahedron*, 2013, **69**, 7264–7268.

14 M. M. Blanco, M. S. Shmidt, C. B. Schapira and I. A. Perillo, *Synthesis*, 2006, 1971–1974.

15 P. Brennan, M. W. George, O. S. Jina, C. Long, J. McKenna, M. T. Pryce, X.-Z. Sun and K. Q. Vuong, *Organometallics*, 2008, **27**, 3671–3680.

16 A. Dreuw and M. Head-Gordon, *Chem. Rev.*, 2005, **105**, 4009–4037.

17 T. Yanai, D. P. Tew and N. C. Handy, *Chem. Phys. Lett.* 2004, **393**, 51–57; R. Improta, V. Barone, G. Scalmani and M. J. Frisch, *J. Chem. Phys.*, 2006, **125**, 054103.

18 A. D. Becke, *J. Chem. Phys.*, 1993, **98**, 5648–5652; J. Stephens, F. J. Devlin, C. F. Chabalowski and M. J. Frisch, *J. Phys. Chem.*, 1994, **98**, 11623–11627.

19 A. T. B. Gilbert, N. A. Besley and P. M. W. Gill, *J. Phys. Chem. A*, 2008, **112**, 13164–13171.

20 Y. Shao, Z. Gan, E. Epifanovsky, A. T. B. Gilbert, M. Wormit, J. Kussmann, A. W. Lange, A. Behn, J. Deng, X. Feng, D. Ghosh, M. Goldey, P. R. Horn, L. D. Jacobson, I. Kaliman, R. Z. Khaliullin, T. Kuś, A. Landau, J. Liu, E. I. Proynov, Y. M. Rhee, R. M. Richard, M. A. Rohrdanz, R. P. Steele, E. J. Sundstrom, H. L. Woodcock, P. M. Zimmerman, D. Zuev, B. Albrecht, E. Alguire, B. Austin, G. J. O. Beran, Y. A. Bernard, E. Berquist, K. Brandhorst, K. B. Bravaya, S. T. Brown, D. Casanova, C.-M. Chang, Y. Chen, S. H. Chien, K. D. Closser, D. L. Crittenden, M. Diedenhofen, R. A. DiStasio, H. Do, A. D. Dutoi, R. G. Edgar, S. Fatehi, L. Fusti-Molnar, A. Ghysels, A. Golubeva-Zadorozhnaya, J. Gomes, M. W. D. Hanson-Heine, P. H. P. Harbach, A. W. Hauser, E. G. Hohenstein, Z. C. Holden, T.-C. Jagau, H. Ji, B. Kaduk, K. Khistyaev, J. Kim, J. Kim, R. A. King, P. Klunzinger, D. Kosenkov, T. Kowalczyk, C. M. Krauter, K. U. Lao, A. D. Laurent, K. V. Lawler, S. V. Levchenko, C. Y. Lin, F. Liu, E. Livshits, R. C. Lochan, A. Luenser, P. Manohar, S. F. Manzer, S.-P. Mao, N. Mardirossian, A. V. Marenich, S. A. Maurer, N. J. Mayhall, E. Neuscamman, C. M. Oana, R. Olivares-Amaya, D. P. O'Neill, J. A. Parkhill, T. M. Perrine, R. Peverati, A. Prociuk, D. R. Rehn, E. Rosta, N. J. Russ, S. M. Sharada, S. Sharma, D. W. Small and A. Sodt, *Mol. Phys.*, 2014, **113**, 184–215.