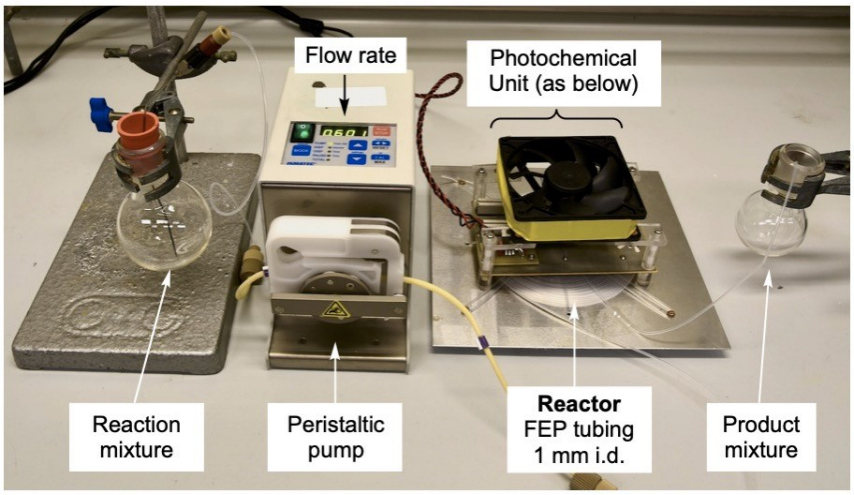
1. General Remarks

Tetrahydrofuran, hexane and pentane were all 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 CAMPH. 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 a Bruker AV400 (400/100 MHz) spectrometer at 298 K in $CDCl_3$. 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. Cyclobutenones **4a**, **4d**, **5a** and **5d** were each prepared using a literature proceduce,[1] as were arylacetylenes **13d-g**, *vide infra*.[2] Other starting materials and reagents were used as supplied.

2. Procedures

2.1. Preparation of Azocines 3 and Benzoazocines 6

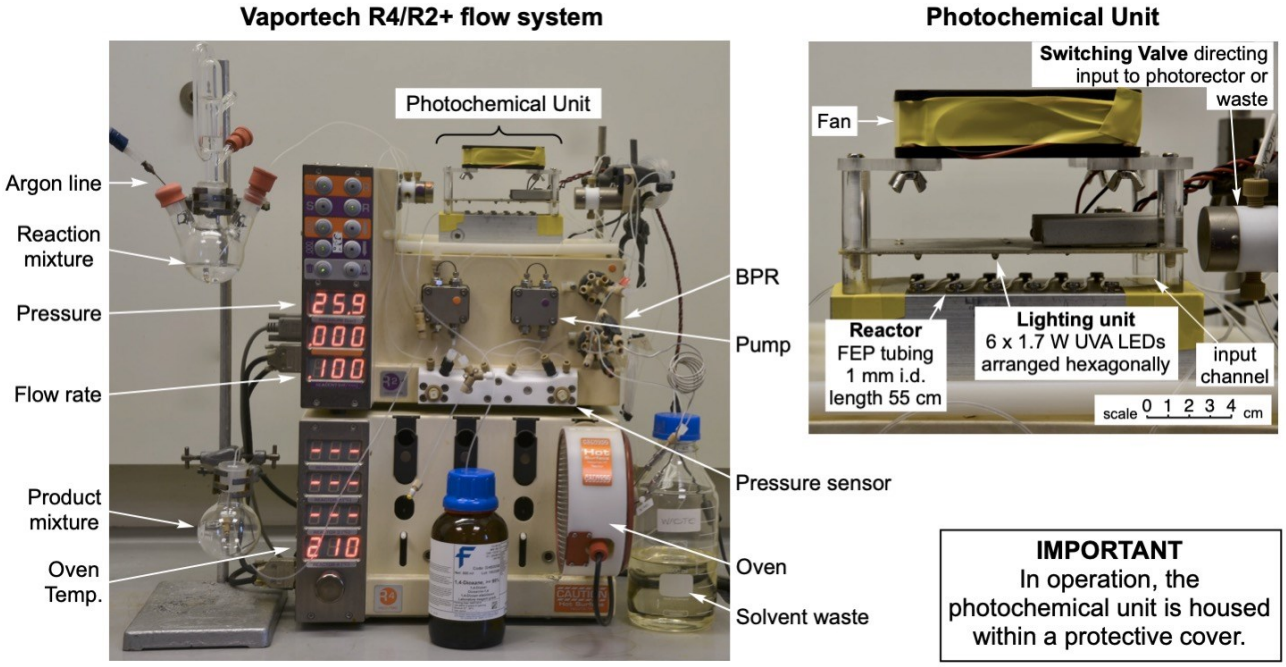
Set-Up A: for the Photochemical Rearrangement of Dihydrofuropyridinones 2 and 5.



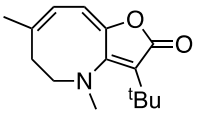
Light source: 6 × 1.7W UVA (365 nm) LEDs. Reactor: Spiral wound FEP tubing with 6 mL capacity.
SAFETY NOTE: In operation, the photochemical unit is housed within a protective cover.

Set-Up B: as detailed in *Angew. Chem. Int. Ed.* **2015**, *54*, 4531, scaled-up to accomodate a 36W Philips UVA PL36/10/4P lamp and a reactor capacity of 120 mL.[3]

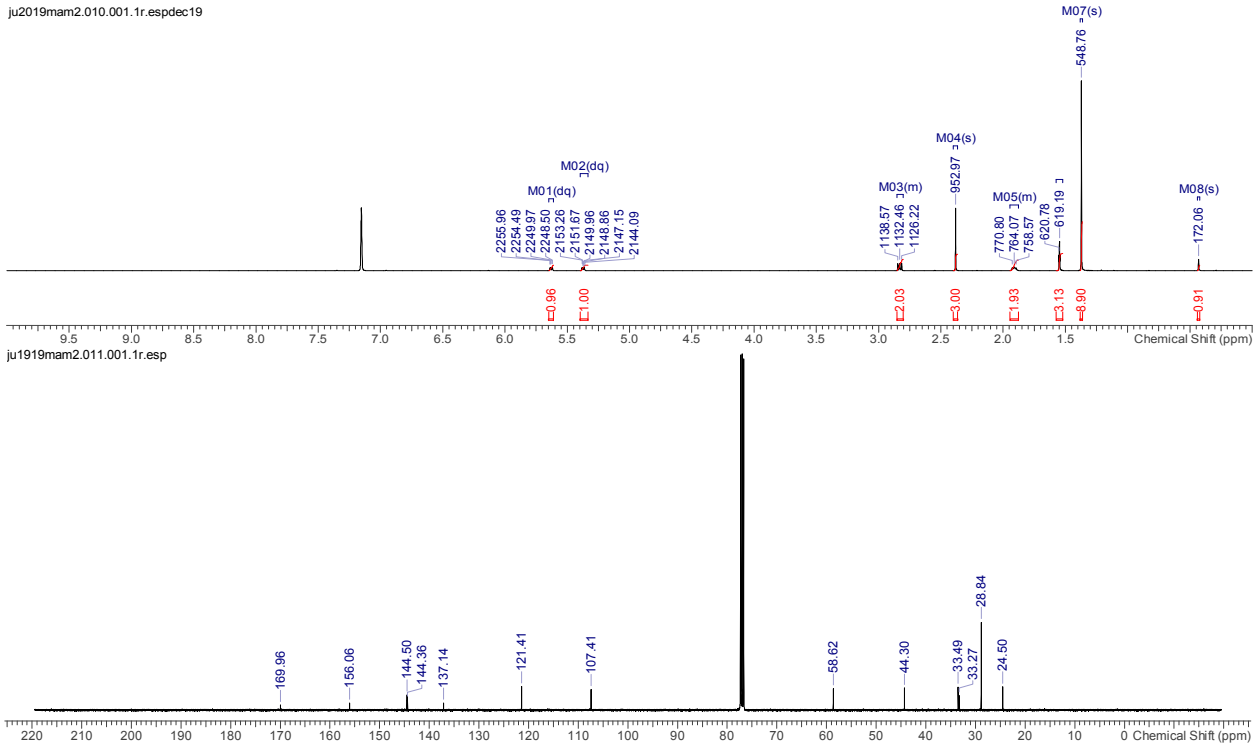
Set-up C: for Sequential Thermal and Photochemical Rearrangements of Cyclobutenones 1c, 4 a, e, g, i, l.
The sequenced experiments employ a Vapourtec R2 pumping module with a self-calibrating dual pumping system that allows a filtered solution of reagent/substrate to be pumped directly into the thermal reactor. There is no volume limit for this method but it does require a manual switch of the pump from reagent to solvent once all the reagent has loaded. The Vapourtec R4 reactor module supports one high temperature heating zone with a 10 mL stainless steel reactor that can be set at temperatures between RT and 250 °C. The control software and probe tightly maintain the temperature to within ±1 °C. In line back pressure regulators (BPR) maintain the system pressure at between 24 – 28 bar. Our bespoke 10W LED reactor was connected via a switching valve and was comprised of 6 × 1.7 W LEUVA45W70RL00 LEDs (UVA, 365 nm) which illuminate FEP tubing of 1 mm internal diameter and a capacity of 1 mL placed underneath the light source as illustrated below. In operation the lighting unit is housed within a protective cover.



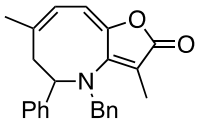
(7*Z*,9*E*)-3-(*t*-Butyl)-4,7-dimethyl-5,6-dihydrofuro[3,2-b]azocin-2(4*H*)-one (3a).



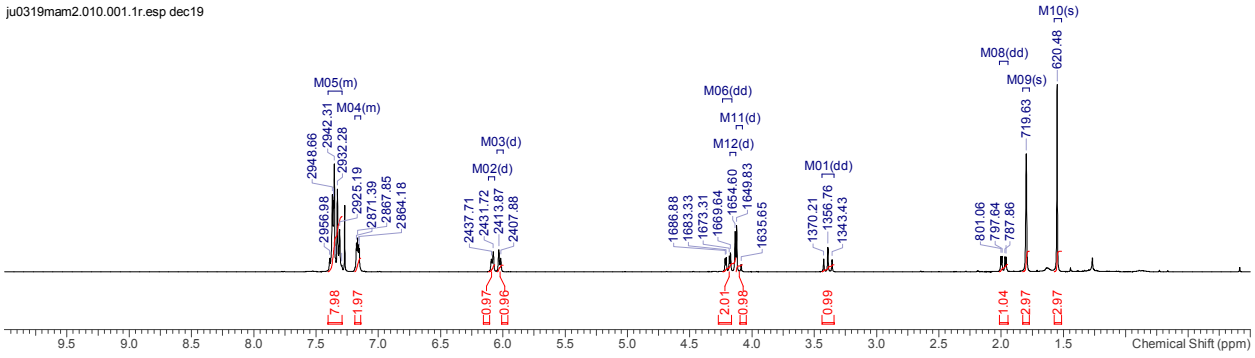
Using the flow photochemical set-up A: A solution of dihydrofuropyridinone **2a** (241 mg, 0.972 mmol) in acetonitrile (20 mL) was irradiated with UVA light for a residence time of 10 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (10 – 30% diethyl ether/hexane) to give the title compound **3a** (116 mg, 0.469 mmol, 48%) as a yellow solid. **MP**: 82–84 °C ($CHCl_3$). **IR** ν_{max} (film, cm^{-1}): 2955 (w), 2926 (w), 2866 (w), 1743 (vs), 1641 (w), 1590 (m). **^{1}H NMR** (400 MHz, benzene-d6): δ ppm 5.63 (1H, dq, *J* = 6.0, 1.5 Hz, =C**H**), 5.37 (1H, dq, *J* = 6.1, 1.6 Hz, =C**H**), 2.85 – 2.81 (2H, m, NC**H**$_2$), 2.38 (3H, s, NC**H**$_3$), 1.95 – 1.89 (2H, m, C**H**$_2$), 1.55 (3H, t, *J* = 1.5 Hz, C**H**$_3$), 1.37 (9H, s, 3×C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 170.0 (**C**), 156.1 (**C**), 144.5 (**C**), 144.4 (**C**), 137.1 (**C**), 121.4 (**C**H), 107.4 (**C**H), 58.6 (**C**H$_2$), 44.3 (**C**H$_3$), 33.5 (**C**H$_2$), 33.3 (**C**), 28.8 (3×**C**H$_3$), 24.5 (**C**H$_3$). **LRMS** (ESI$^+$): 248 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{15}H_{22}NO_2$ [M+H]$^+$ 248.1645, found: 248.1643.

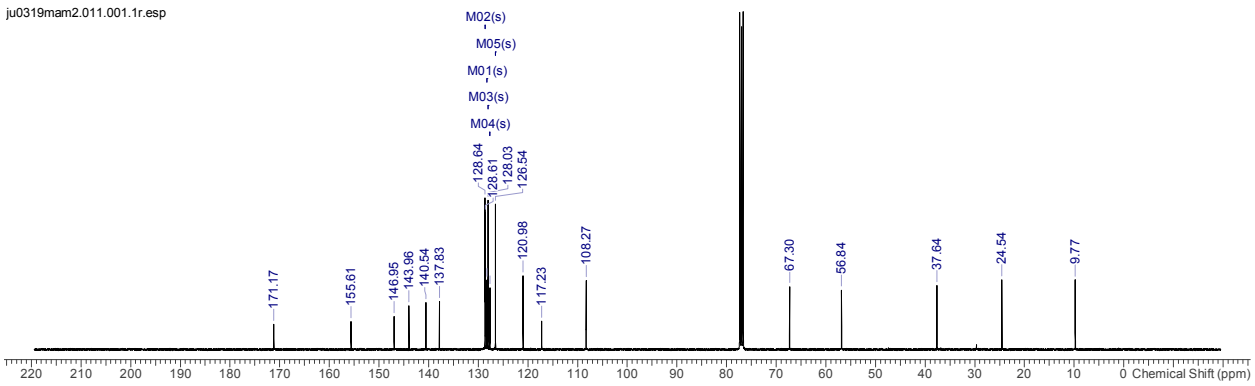


(7Z,9*E*)-4-Benzyl-3,7-dimethyl-5-phenyl-5,6-dihydrofuro[3,2-b]azocin-2(4*H*)-one (3b).

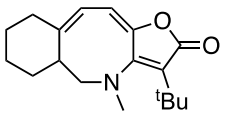


Using the flow photochemical set-up A: A solution of dihydrofuropyridinone **2b** (290 mg, 0.811 mmol) in acetonitrile (20 mL) was irradiated with UVA light for a residence time of 10 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (30% diethyl ether/hexane) to give the title compound **3b** (135 mg, 0.378 mmol, 47%) as a white solid. **MP**: 163 – 164 °C ($CHCl_3$). **IR** ν_{max} (film, cm^{-1}): 3027 (w), 2924 (w), 2854 (w), 1749 (vs), 1651 (w), 1597 (m), 1314 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.39 – 7.29 (8H, m, 8×Ar**H**), 7.16 (2H, m, 2×Ar**H**), 6.08 (1H, d, *J* = 6.0 Hz, =C**H**), 6.03 (1H, d, *J* = 6.0 Hz, =C**H**), 4.19 (1H, dd, *J* = 13.6, 3.6 Hz, NC**H**Ph), 4.15 (1H, d, *J* = 13.9 Hz, NC**H**H), 4.12 (1H, d, *J* = 13.9 Hz, NCH**H**), 3.39 (1H, app t, *J* = 13.4 Hz, C**H**H), 1.98 (1H, dd, *J* = 13.3, 3.5 Hz, CH**H**), 1.80 (3H, s, C**H**$_3$), 1.55 (3H, s, C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 171.2 (**C**), 155.6 (**C**), 147.0 (**C**), 144.0 (**C**), 140.5 (**C**), 137.8 (**C**), 128.6 (2×**C**H), 128.6 (2×**C**H), 128.3 (**C**H), 128.0 (2×**C**H), 127.7 (**C**H), 126.5 (2×**C**H), 121.0 (**C**H), 117.2 (**C**), 108.3 (**C**H), 67.3 (**C**H), 56.8 (**C**H$_2$), 37.6 (**C**H$_2$), 24.5 (**C**H$_3$), 9.8 (**C**H$_3$). **LRMS** (ESI$^+$): 358 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{24}H_{23}NNaO_2$ [M+Na]$^+$ 380.1621, found: 380.1625.





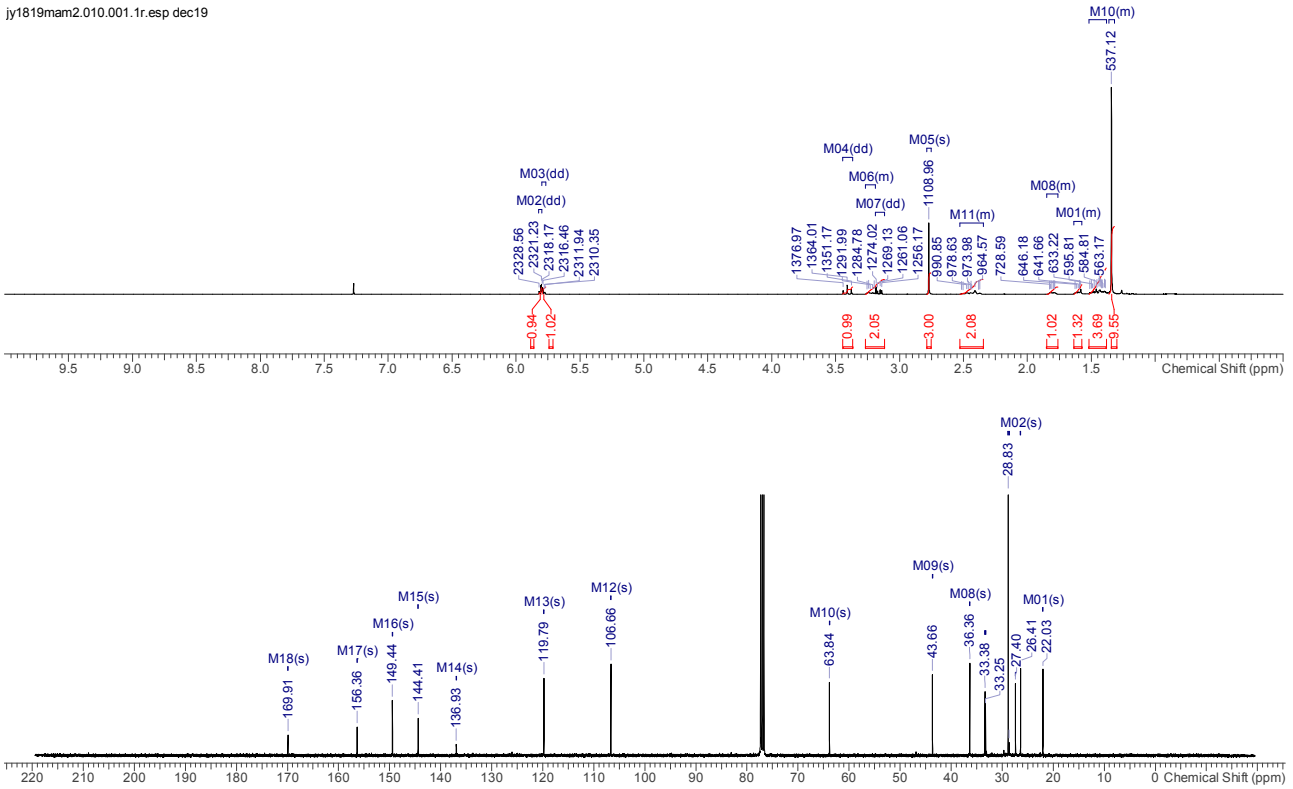
(9a*Z*,11*E*)-3-(*t*-Butyl)-4-methyl-5,5a,6,7,8,9-hexahydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (3c).



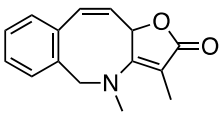
Using the sequenced flow thermal and photochemical set-up C: A solution of cyclobutenone **1c** (123 mg, 0.43 mmol) in 1,4-dioxane (21 mL, 0.02 M) was heated at 150 °C for 1 h, then at 210 °C for 100 min before being irradiated with UVA light for 10 min. The resulting solution was concentrated *in vacuo*, then purified by column chromatography (silica, 10% EtOAc / hexane) to give the title compound **3c** (75 mg, 0.26 mmol, 61%) as a yellow solid.

Alternatively: using the flow photochemical set-up A: A solution of dihydrofuropyridinone **2c** (208 mg, 0.724 mmol) in acetonitrile (20 mL) was irradiated with UVA light for a residence time of 10 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (10% ethyl acetate/hexane) to give the title compound **3c** (111 mg, 0.388 mmol, 54%) as a yellow solid. **MP**: 121 – 123 °C ($CHCl_3$). **IR** ν_{max} (film, cm^{-1}): 2928 (m), 2857 (m), 1748 (vs), 1636 (w), 1591 (m), 999 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 5.81 (1H, dd, *J* = 6.0, 1.5 Hz, =C**H**), 5.79 (1H, dd, *J* = 6.1, 1.8 Hz, =C**H**), 3.41 (1H, app t, *J* = 13.0 Hz, NC**H**H), 3.23

(1H, m, C**H**), 3.17 (1H, dd, *J* = 12.8, 4.9 Hz, NCH**H**), 2.77 (3H, s, NC**H**$_3$), 2.51 – 2.37 (2H, m, C**H**$_2$), 1.81 (1H, m, C**H**H), 1.60 (1H, m, CH**H**), 1.51 – 1.39 (4H, m, 2×C**H**$_2$), 1.34 (9H, s, 3×C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.9 (**C**), 156.4 (**C**), 149.4 (**C**), 144.4 (**C**), 136.9 (**C**), 119.8 (**C**H), 106.7 (**C**H), 63.8 (**C**H$_2$), 43.7 (**C**H$_3$), 36.4 (**C**H), 33.4 (**C**H$_2$), 33.3 (**C**), 28.8 (3×**C**H$_3$), 27.4 (**C**H$_2$), 26.4 (**C**H$_2$), 22.0 (**C**H$_2$). **LRMS** (ESI$^+$): 288 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{18}H_{26}NO_2$ [M+H]$^+$ 288.1958, found: 288.1963.

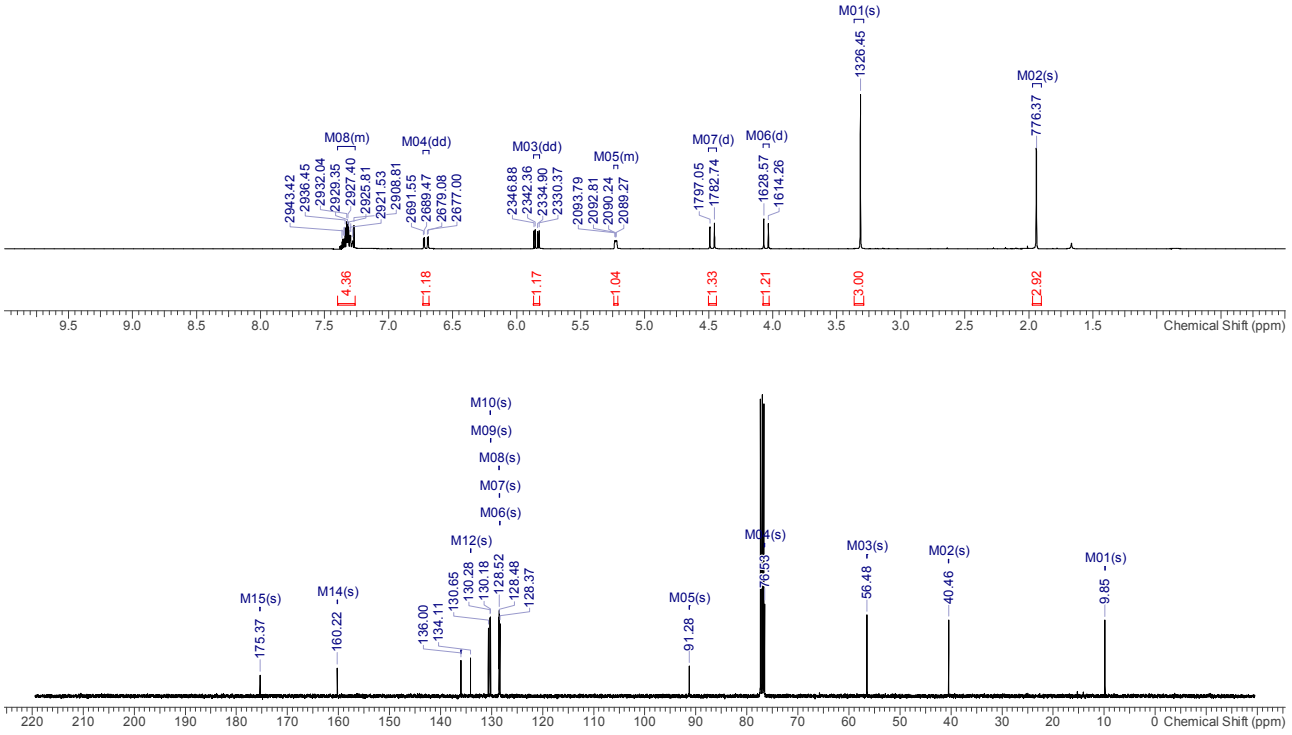


(*Z*)-3,4-Dimethyl-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6a).

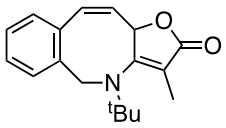


Using the sequenced flow thermal and photochemical set-up C: A solution of cyclobutenone **4a** (94 mg, 0.24 mmol) in 1,4-dioxane (12 mL, 0.02 M) was heated at 210 °C for 100 min then irradiated with UVA light for 10 min. The resulting solution was concentrated *in vacuo*, then purified by column chromatography (silica, 40 – 70% diethyl ether / petrol) to give the title compound **6a** (70 mg, 0.18 mmol, 74%, ~95%) as a yellow oil. On standing the sample solidified to give, after recrystallisation from ether/petrol, a white solid.

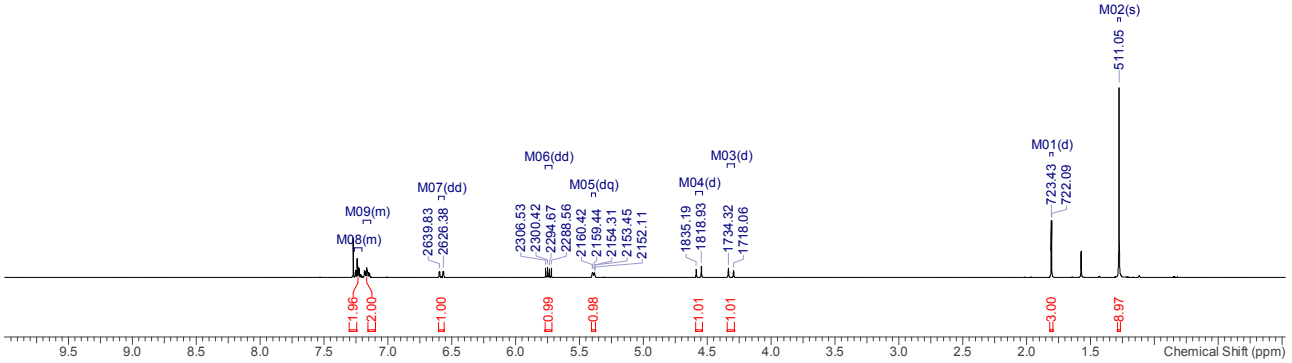
Alternatively: using the flow photochemical set-up B: A solution of dihydrofuropyridinone **5a** (91.6 mg, 0.380 mmol) in acetonitrile (20 mL) was irradiated with UVA light for a residence time of 2 h. The resulting solution was concentrated *in vacuo* and purified by column chromatography (30 – 70% ethyl acetate/petrol) to give the title compound **6a** (58.9 mg, 0.244 mmol, 64%) as a yellow oil. **MP** 129–130 °C; **IR** ν_{max} (film, cm^{-1}): 2928 (w), 1722 (s), 1611 (s), 1415 (m), 1316 (m), 1088 (m), 1025 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.38 – 7.28 (4H, m, 4×Ar**H**), 6.71 (1H, dd, *J* = 12.1, 2.1 Hz, =C**H**), 5.84 (1H, dd, *J* = 12.0, 4.6 Hz, =C**H**), 5.23 (1H, br dd, *J* = 4.5, 1.0 Hz, OC**H**), 4.48 (1H, d, *J* = 14.3 Hz, C**H**H), 4.05 (1H, d, *J* = 14.3 Hz, CH**H**), 3.32 (3H, s, NC**H**$_3$), 1.94 (3H, s, C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 175.4 (**C**), 160.2 (**C**), 136.0 (**C**), 134.1 (**C**), 130.6 (**C**H), 130.3 (**C**H), 130.2 (**C**H), 128.5 (**C**H), 128.5 (**C**H), 128.3 (**C**H), 91.2 (**C**), 76.5 (**C**H), 56.5 (**C**H$_2$), 40.4 (**C**H$_3$), 9.8 (**C**H$_3$). **LRMS** (ESI$^+$): 242 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{15}H_{16}NO_2$ [M+H]$^+$ 242.1103, found: 242.1181.

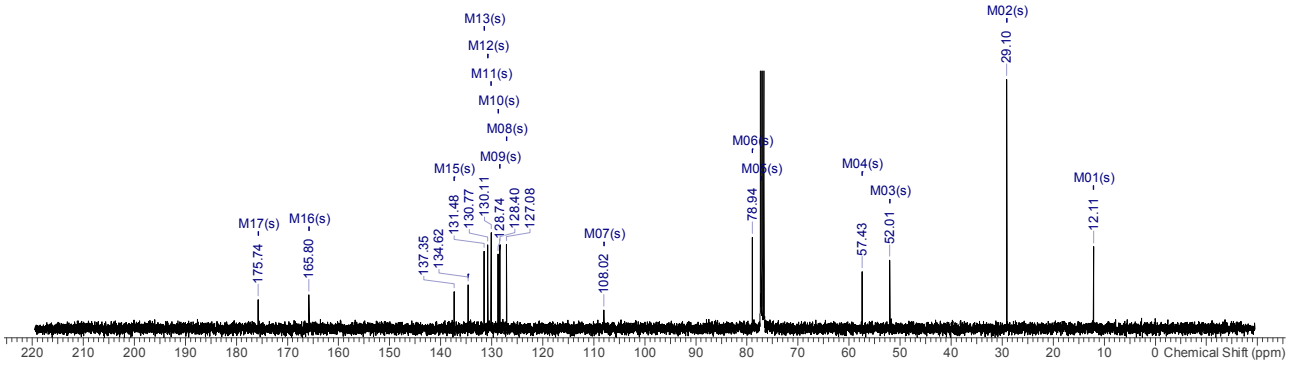


(*Z*)-4-(*t*-Butyl)-3-methyl-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6b).

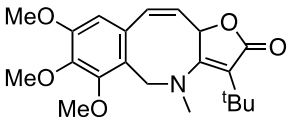


Using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5b** (43 mg, 0.0151 mmol) in acetonitrile (2 mL) was irradiated with UVA light for a residence time of 25 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (10 – 40% diethyl ether/petrol) to give the title compound **6b** (32 mg, 0.111 mmol, 74%, ~95% purity) as a yellow oil. On standing the sample solidified to give, after recrystallisation from ether/petrol, a white solid, **MP** 137–138 °C; **IR** ν_{max} (film, cm^{-1}): 2957 (w), 2917 (s), 2849 (m), 1742 (s), 1634 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.25 – 7.22 (2H, m, 2×Ar**H**), 7.18 – 7.14 (2H, m, 2×Ar**H**), 6.58 (1H, dd, *J* = 11.9, 1.3 Hz, =C**H**), 5.74 (1H, dd, *J* = 11.9, 6.1 Hz, =C**H**), 5.39 (1H, d with fine splitting, *J* = 6.1 Hz, OC**H**), 4.57 (1H, d, *J* = 16.3 Hz, C**H**H), 4.31 (1H, d, *J* = 16.3 Hz, CH**H**), 1.81 (3H, d, *J* = 1.2 Hz, C**H**$_3$), 1.28 (9H, s, NC(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 175.8 (**C**), 165.9 (**C**), 137.4 (**C**), 134.6 (**C**), 131.5 (**C**H), 130.8 (**C**H), 130.1 (**C**H), 128.7 (**C**H), 128.4 (**C**H), 127.1 (**C**H), 107.7 (**C**), 79.0 (**C**H), 57.5 (**C**), 52.1 (**C**H$_2$), 29.1 (3×**C**H$_3$), 12.2 (**C**H$_3$). **LRMS** (ESI$^+$): 284 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{18}H_{22}NO_2$ [M+H]$^+$ 284.1645, found: 284.1643.

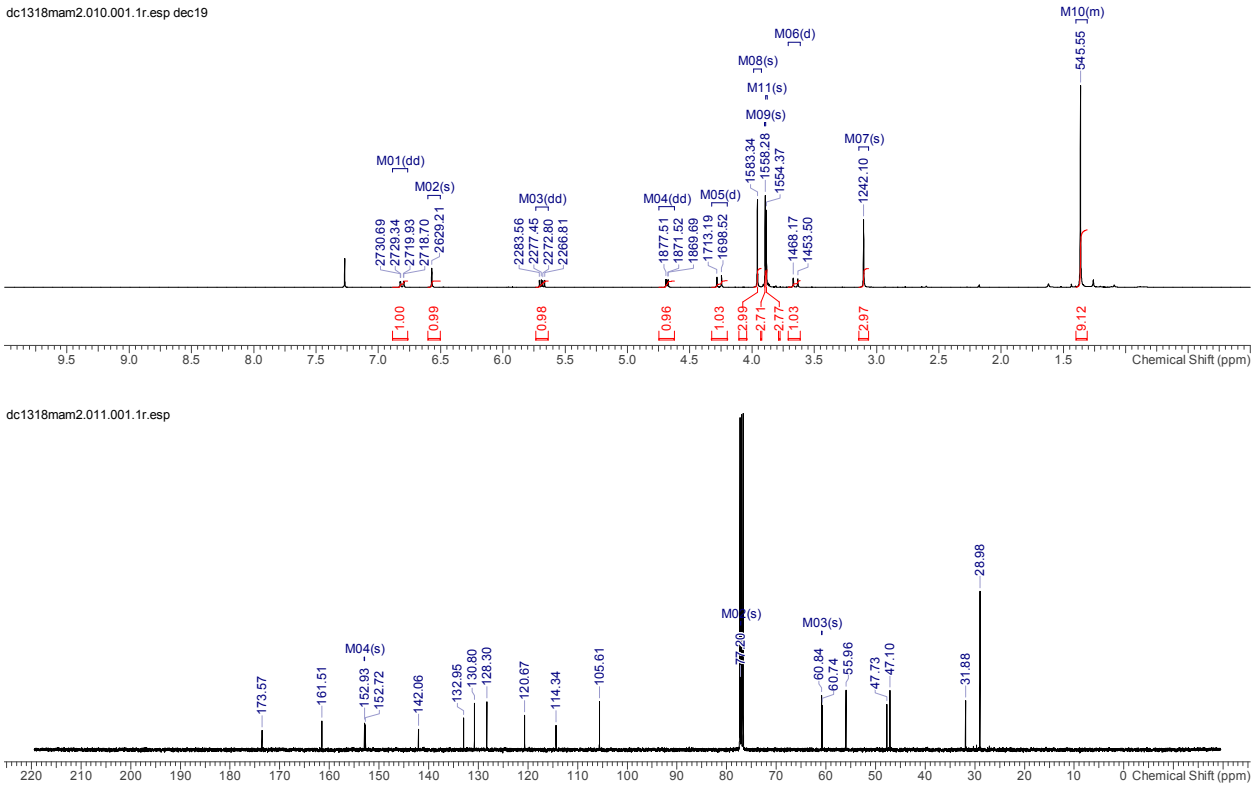




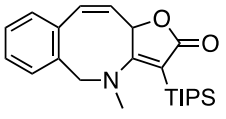
(*Z*)-3-(*t*-Butyl)-6,7,8-trimethoxy-4-methyl-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6c).



Using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5c** (124 mg, 0.332 mmol) in 1,4-dioxane (10 mL) was irradiated with UVA light for a residence time of 7 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (20 – 70% diethyl ether/petrol) to give the title compound **6c** (63 mg, 0.169 mmol, 51%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 2940 (m), 1739 (vs), 1608 (m), 1565 (w), 1490 (m), 1383 (m), 1334 (m), 1120 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 6.81 (1H, dd, *J* = 10.7, 1.4 Hz, C=C**H**), 6.57 (1H, s, Ar**H**), 5.69 (1H, dd, *J* = 10.7, 6.1 Hz, C=C**H**), 4.68 (1H, dd, *J* = 6.1, 1.7 Hz, OC**H**), 4.26 (1H, d, *J* = 14.7 Hz, C**H**H), 3.96 (3H, s, OC$\mathbf{H_3}$), 3.89 (3H, s, OC$\mathbf{H_3}$), 3.88 (3H, s, OC$\mathbf{H_3}$), 3.65 (1H, d, *J* = 14.7 Hz, CH**H**), 3.10 (3H, s, NC$\mathbf{H_3}$), 1.36 (9H, s, C(C$\mathbf{H_3}$)$_3$)). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 173.6 (**C**), 161.5 (**C**), 152.9 (**C**), 152.7 (**C**), 142.1 (**C**), 133.0 (**C**), 130.8 (**C**H), 128.3 (**C**H), 120.7 (**C**), 114.3 (**C**), 105.6 (**C**H), 77.2 (**C**H), 60.8 (**C**H_3), 60.7 (**C**H_3), 56.0 (**C**H_3), 47.7 (**C**H_2), 47.1 (**C**H_3), 31.9 (**C**), 29.0 (3×**C**H_3). **LRMS** (ESI^+): 374 ($[M+H]^+$, 100%). **HRMS** (ESI^+): Calculated for $C_{21}H_{28}NO_5$ $[M+H]^+$ 374.1962, found: 374.1966.

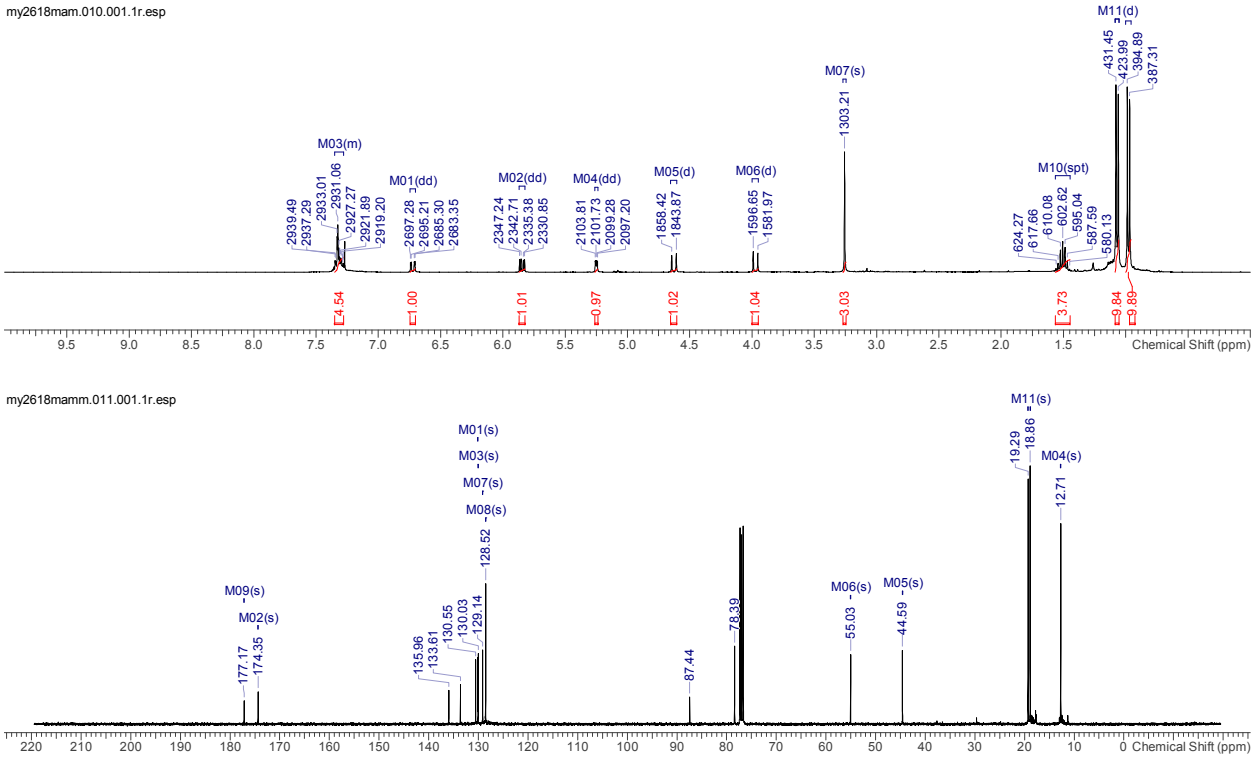


(*Z*)-4-Methyl-3-(tri*iso*propylsilyl)-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6d).

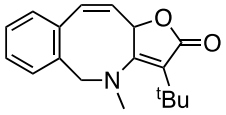


Using the flow photochemical set-up B: A solution of dihydrofuropyridinone **5d** (104 mg, 0.272 mmol) in THF (20 mL) was irradiated with UVA light for a residence time of 2 h. The resulting solution was concentrated *in vacuo* and purified by column chromatography (10 – 50% ethyl acetate/petrol) to give the title compound **6d** (54 mg, 0.244 mmol, 52%) as a yellow solid. **MP**: 147–148 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 2943 (m), 2864 (m), 1717

(m), 1568 (w). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.35 – 7.28 (4H, m , 4×Ar**H**), 6.72 (1H, dd, *J* = 11.9, 2.0 Hz, =C**H**), 5.85 (1H, dd, *J* = 11.9, 4.5 Hz, =C**H**), 5.25 (1H, dd, *J* = 4.5, 2.1 Hz, OC**H**), 4.63 (1H, d, *J* = 14.6 Hz, C**H**H), 4.97 (1H, d, *J* = 14.7 Hz, CH**H**), 3.26 (3H, s, NCH_3), 1.51 (3H, sep, *J* = 7.6 Hz, 3×SiC**H**), 1.07 (9H, d, *J* = 7.5 Hz, 3×CH_3), 0.98 (9H, d, *J* = 7.6 Hz, 3×CH_3). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 177.2 (**C**), 174.4 (**C**), 136.0 (**C**), 133.6 (**C**), 130.6 (**C**H), 130.1 (**C**H), 130.0 (**C**H), 129.1 (**C**H), 128.5 (2×**C**H), 87.4 (**C**), 78.4 (**C**H), 55.0 (**C**H_2), 44.6 (**C**H_3), 19.3 (3×**C**H_3), 18.9 (3×**C**H_3), 12.7 (3×**C**H). **LRMS** (ESI$^+$): 384 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{23}H_{34}NO_2Si$ [M+H]$^+$ 384.2353, found: 384.2360.



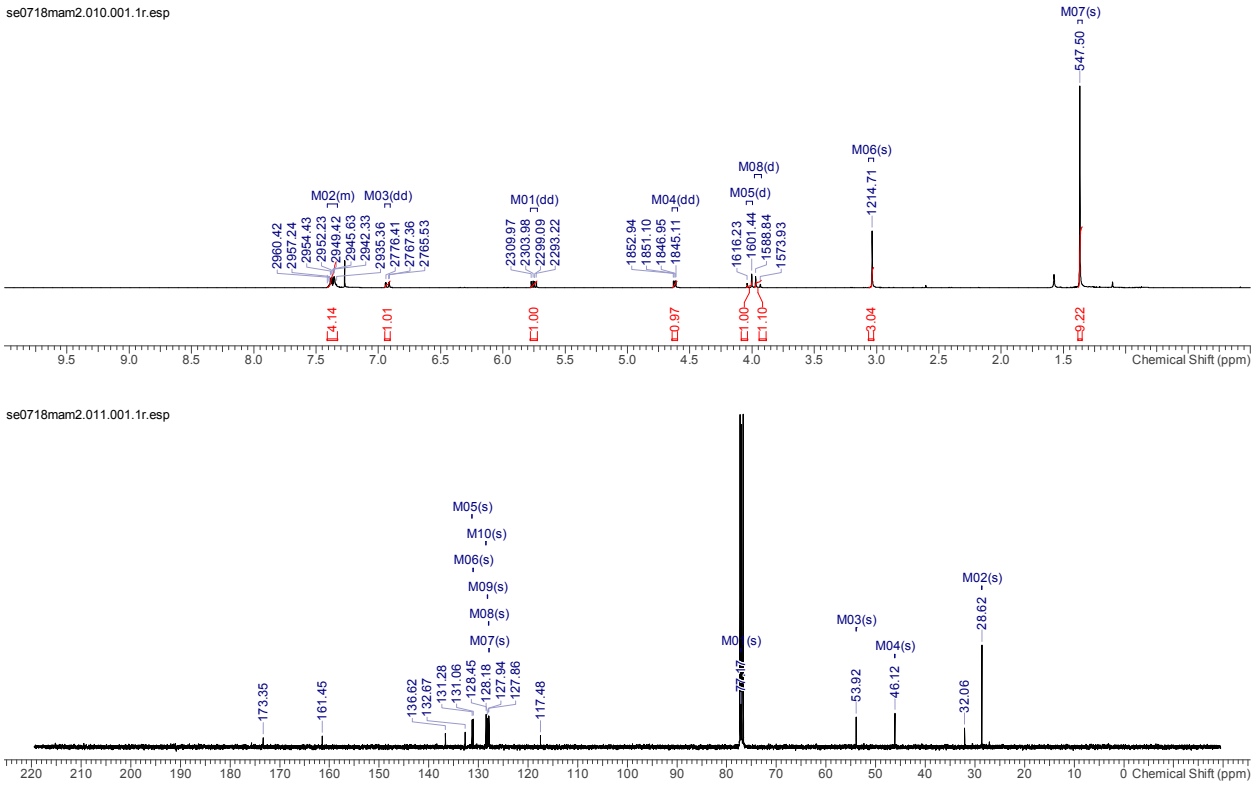
(*Z*)-3-(*t*-Butyl)-4-methyl-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6e).



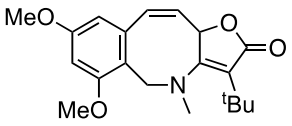
Using the sequenced flow thermal and photochemical set-up C: A solution of cyclobutenone **4e** (94 mg, 0.33 mmol) in 1,4-dioxane (17 mL, 0.02 M) was heated at 210 °C for 100 min then irradiated with UVA light for 10 min. The resulting solution was concentrated *in vacuo*, then purified by column chromatography (silica, 30 – 60% diethyl ether / petrol) to give the title compound **6e** (76 mg, 0.27 mmol, 81%) as a yellow oil.

Scaled to 1 mmol using the sequenced flow thermal and photochemical set-up C: A solution of cyclobutenone **4e** (320 mg, 1.13 mmol) in 1,4-dioxane (57 mL, 0.02 M) was heated at 210 °C over 12 h with a residence time of 100 min. The resulting solution was then irradiated with UVA light for a residence time of 10 min. The resulting solution was next concentrated *in vacuo*, then purified by column chromatography (silica, 30 – 60% diethyl ether / petrol) to give the title compound **6e** (221 mg, 0.78 mmol, 69%) as a yellow oil.

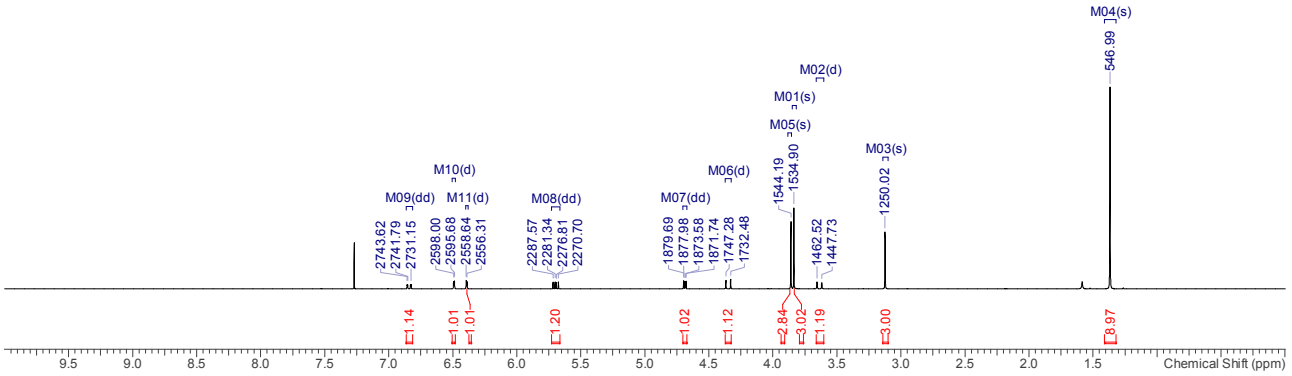
Alternatively: using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5e** (129 mg, 0.455 mmol) in acetonitrile (11 mL) was irradiated with UVA light for a residence time of 10 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (30 – 60% diethyl ether/hexane) to give the title compound **6e** (73 mg, 0.259 mmol, 57%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 2958 (s), 2927 (m), 2870 (w), 1718 (s), 1639 (s), 1463 (m), 1366 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.39 – 7.35 (4H, m, 4×Ar**H**), 6.93 (1H, dd, *J* = 10.8, 2.0 Hz, =C**H**), 5.75 (1H, dd, *J* = 10.9, 6.0 Hz, =C**H**), 4.62 (1H, dd, *J* = 6.0, 1.8 Hz, OC**H**), 4.01 (1H, d, *J* = 14.8 Hz, C**H**H), 3.96 (1H, d, *J* = 14.9 Hz, CH**H**), 3.04 (3H, s, NCH_3), 1.37 (9H, s, C(CH_3)$_3$)). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 173.4 (**C**), 161.5 (**C**), 136.6 (**C**), 132.7 (**C**), 131.3 (**C**H), 131.0 (**C**H), 128.5 (**C**H), 128.2 (**C**H), 127.9 (**C**H), 127.9 (**C**H), 117.5 (**C**), 77.2 (**C**H), 53.9 (**C**H_2), 46.1 (**C**H_3), 32.1 (**C**), 28.6 (3×**C**H_3). **LRMS** (ESI$^+$): 284 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{18}H_{22}NO_2$ [M+H]$^+$ 284.1645, found: 284.1643.

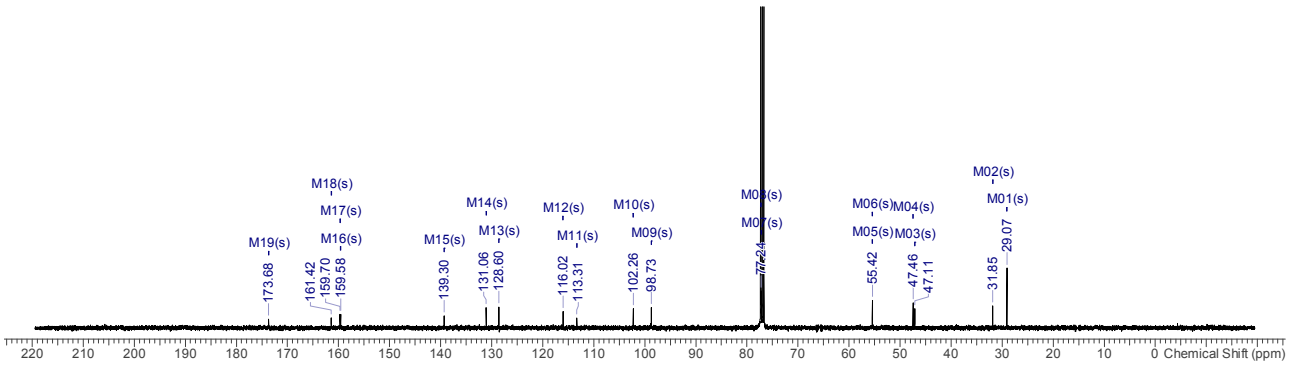


(*Z*)-3-(*t*-Butyl)-6,8-dimethoxy-4-methyl-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6f).

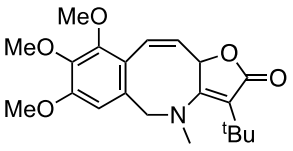


Using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5f** (83 mg, 0.223 mmol) in acetonitrile (7 mL) was irradiated with UVA light for a residence time of 15 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (30 – 60% diethyl ether/petrol) to give the title compound **6f** (51 mg, 0.136 mmol, 61%, ~95% purity) as a colourless oil. On standing the sample solidified to give, after recrystallisation from ether/petrol, a white solid, **MP** 115-117°C; **IR** ν_{max} (film, cm^{-1}): 2954 (w), 1735 (vs), 1598 (vs), 1458 (m), 1308 (m), 1295 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 6.84 (1H, dd, *J* = 10.7, 1.5 Hz, =C**H**), 6.49 (1H, d, *J* = 2.2 Hz, Ar**H**), 6.39 (1H, d, *J* = 2.3 Hz, Ar**H**), 5.69 (1H, dd, *J* = 10.6, 6.1 Hz, =C**H**), 4.68 (1H, dd, *J* = 6.1, 1.7 Hz, OC**H**), 4.35 (1H, d, *J* = 14.8 Hz, C**H**H), 3.86 (3H, s, OC$\mathbf{H}_3$), 3.83 (3H, s, OC$\mathbf{H}_3$), 3.63 (1H, d, *J* = 14.9 Hz, CH**H**), 3.12 (3H, s, NC$\mathbf{H}_3$), 1.36 (9H, s, 3×C$\mathbf{H}_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 173.7 (**C**), 161.4 (**C**), 159.7 (**C**), 159.6 (**C**), 139.3 (**C**), 131.1 (**C**H), 128.6 (**C**H), 116.0 (**C**), 113.3 (**C**), 102.3 (**C**H), 98.7 (**C**H), 77.2 (**C**H), 55.4 (2×C$\mathbf{H}_3$), 47.4 (C$\mathbf{H}_3$), 47.1 (C$\mathbf{H}_2$), 31.8 (**C**), 29.1 (3×C$\mathbf{H}_3$). **LRMS** (ESI^+): 344 ($[M+H]^+$, 100%). **HRMS** (ESI^+): Calculated for $C_{20}H_{25}NNaO_4$ $[M+Na]^+$ 366.1676, found: 366.1670.



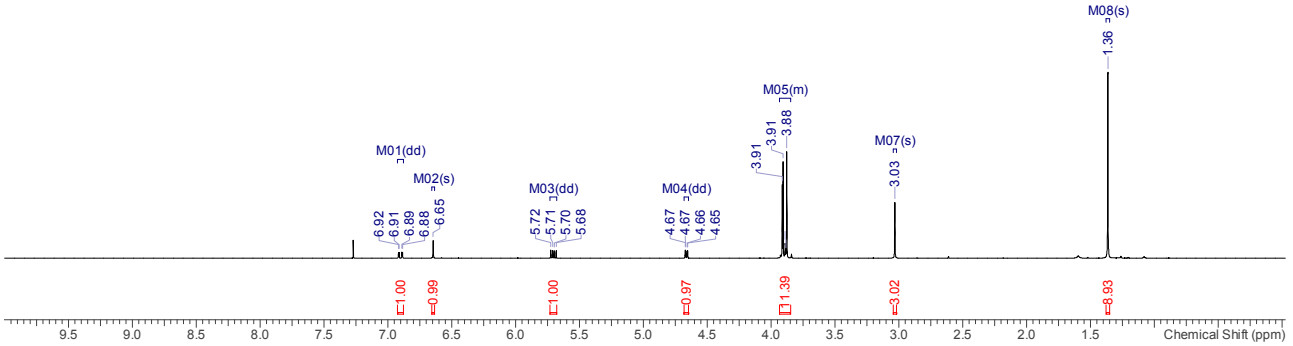


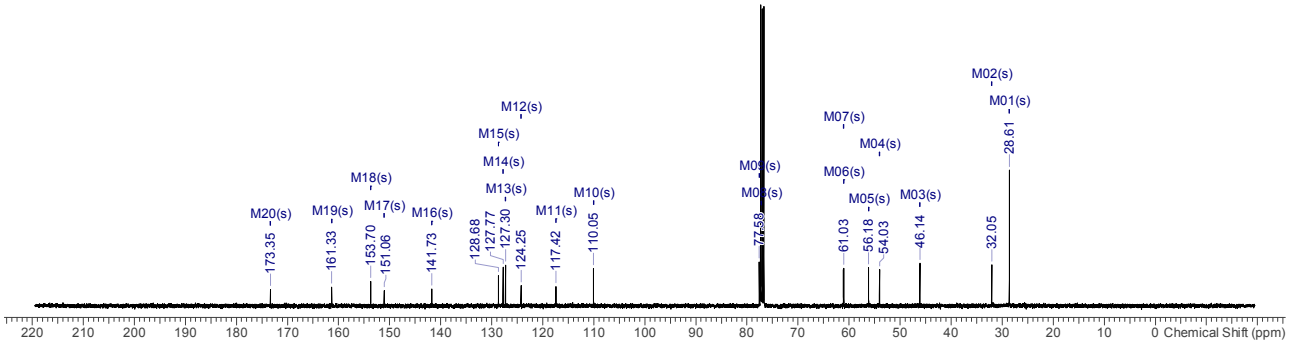
(*Z*)-3-(*t*-Butyl)-7,8,9-trimethoxy-4-methyl-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6g).



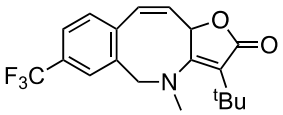
Using the sequenced flow thermal and photochemical set-up C: A solution of cyclobutenone **4g** (111 mg, 0.30 mmol) in 1,4-dioxane (15 mL, 0.02 M) was heated at 210 °C for 100 min then irradiated with UVA light for 10 min. The resulting solution was concentrated *in vacuo*, then purified by column chromatography (silica, 30 – 50% diethyl ether / petrol) to give the title compound **6g** (90 mg, 0.24 mmol, 81%) as a yellow oil that solidified on standing.

Alternatively: using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5g** (122 mg, 0.326 mmol) in acetonitrile (8 mL) was irradiated with UVA light for a residence time of 10 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (30 – 50% diethyl ether/petrol) to give the title compound **6g** (90 mg, 0.24 mmol, 74%, ~95% purity) as a yellow oil. On standing the sample solidified to give, after recrystallisation from ether/petrol, a white solid, **MP** 107–109 °C; **IR** ν_{max} (film, cm^{-1}): 2956 (w), 2917 (s), 2849 (m), 1741 (vs), 1616 (m), 1494 (m), 1458 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 6.89 (1H, dd, *J* = 10.7, 1.8 Hz, =C**H**), 6.64 (1H, s, Ar**H**), 5.70 (1H, dd, *J* = 10.6, 6.1 Hz, =C**H**), 4.66 (1H, dd, *J* = 6.1, 1.8 Hz, OC**H**), 3.92 – 3.84 (2H, m, CH_2), 3.91 (3H, s, OCH_3), 3.90 (3H, s, OCH_3), 3.87 (3H, s, OCH_3), 3.03 (3H, s, NCH_3), 1.36 (9H, s, C(CH_3)$_3$. **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 173.4 (**C**), 161.3 (**C**), 153.7 (**C**), 151.0 (**C**), 141.7 (**C**), 128.6 (**C**), 127.8 (**C**H), 127.2 (**C**H), 124.2 (**C**), 117.3 (**C**), 110.0 (**C**H), 77.6 (C**H**), 61.1 (CH_3), 61.1 (CH_3), 56.1 (CH_3), 54.0 (CH_2), 46.2 (CH_3), 32.0 (**C**), 28.6 (3×CH_3). **LRMS** (ESI$^+$): 374 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{21}H_{28}NO_5$ [M+H]$^+$ 374.1962, found: 374.1964.

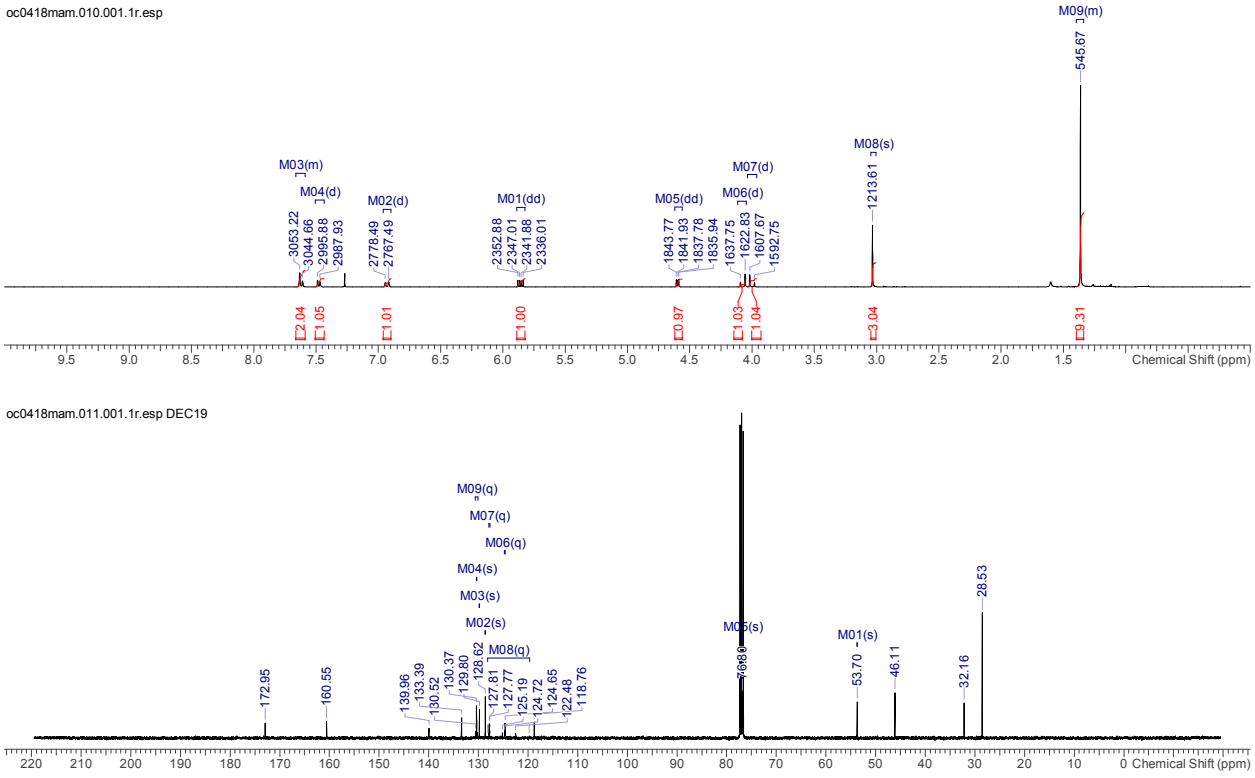




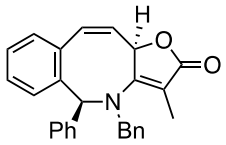
(*Z*)-3-(*t*-Butyl)-4-methyl-7-(trifluoromethyl)-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6h).



Using the flow photochemical set-up B: A solution of dihydrofuropyridinone **5h** (304 mg, 0.866 mmol) in acetonitrile (120 mL) was irradiated with UVA light for a residence time of 90 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (5 – 10% ethyl acetate/petrol) to give the title compound **6h** (86 mg, 0.246 mmol, 28%) as a yellow solid. **MP**: 127–128 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 2971 (m), 1790 (s), 1761 (s), 1736 (m), 1636 (w), 1589 (vs), 1356 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm: 7.63 – 7.61 (2H, m, 2×Ar**H**), 7.48 (1H, d, *J* = 8.0 Hz, Ar**H**), 6.93 (1H, br d, *J* = 11.0 Hz, C=C**H**), 5.86 (1H, dd, *J* = 11.0, 5.9 Hz, C=C**H**), 4.60 (1H, dd, *J* = 6.0, 1.8 Hz, OC**H**), 4.07 (1H, d, *J* = 15.4 Hz, C**H**H), 4.01 (1H, d, *J* = 15.3 Hz, CH**H**), 3.03 (3H, s, NC$\mathbf{H_3}$), 1.36 (9H, s, C(C$\mathbf{H_3}$)$_3$)). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 173.0 (**C**), 160.6 (**C**), 140.0 (**C**), 133.4 (**C**), 130.4 (**C**, q, *J* = 33 Hz), 129.8 (**C**H), 128.6 (2×**C**H), 127.8 (**C**H, q, *J* = 3.7 Hz), 124.7 (**C**H, q, *J* = 3.7 Hz), 123.2 (**C**F_3, q, J_{C-F} = 272 Hz), 118.8 (**C**), 76.8 (**C**H), 53.7 (**C**H_2), 46.1 (**C**H_3), 32.2 (**C**), 28.5 (3×**C**H_3). **LRMS** (ESI$^+$): 352 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{19}H_{21}F_3NO_2$ [M+H]$^+$ 352.1520, found: 352.1519.



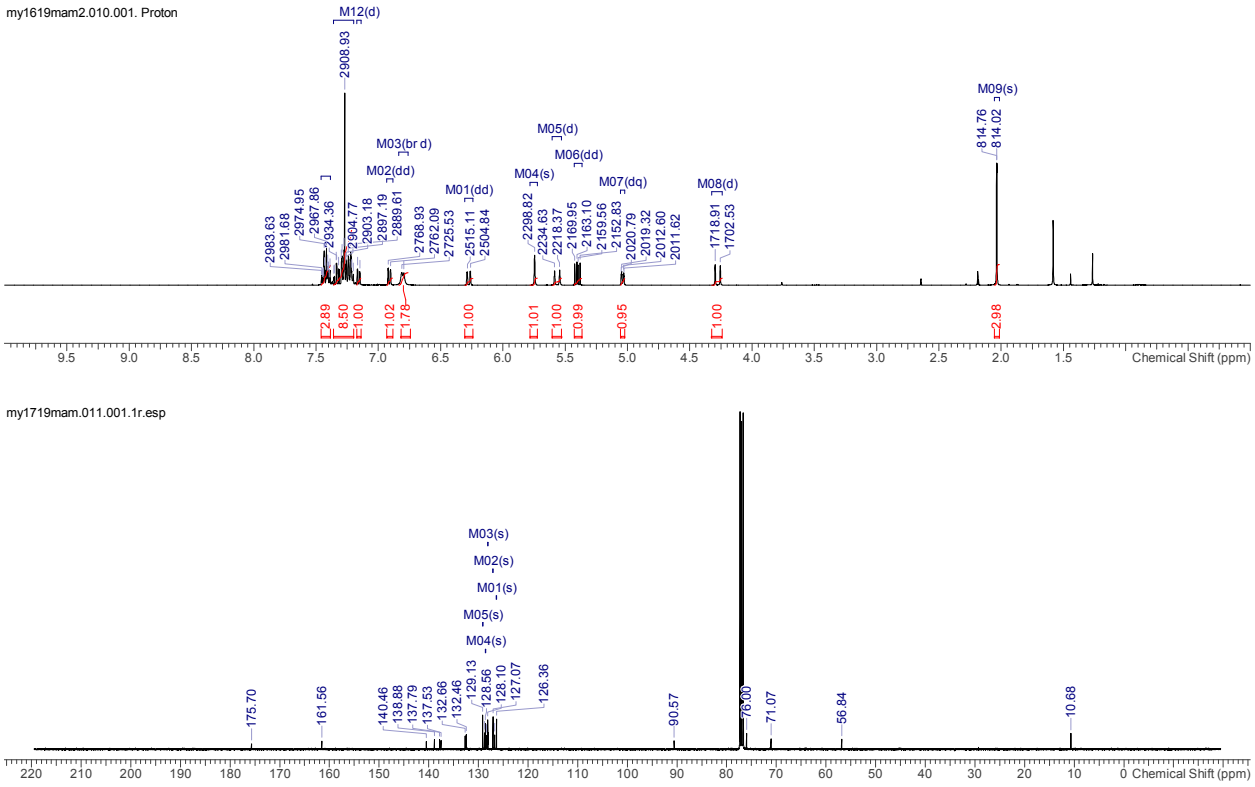
rel-(5*S*,11a*R*,10*Z*)-4-Benzyl-3-methyl-5-phenyl-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6i).



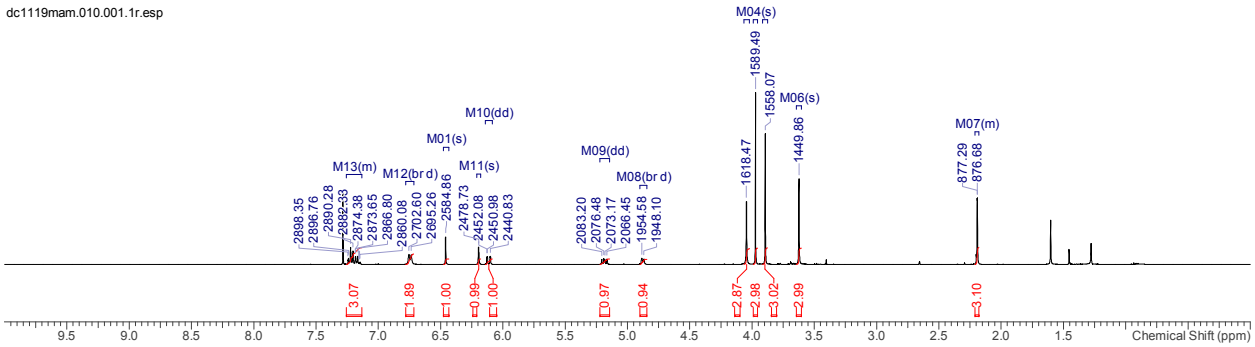
Using the sequenced flow thermal and photochemical set-up C: A solution of cyclobutenone **4i** (103 mg, 0.26 mmol) in 1,4-dioxane (13 mL, 0.02 M) was heated at 210 °C for 100 min then irradiated with UVA light for 10 min. The resulting solution was concentrated *in vacuo*, then purified by column chromatography (silica, 30 – 50% diethyl ether / petrol) to give the title compound **6i** (86 mg, 0.22 mmol, 84%) as a pale yellow oil.

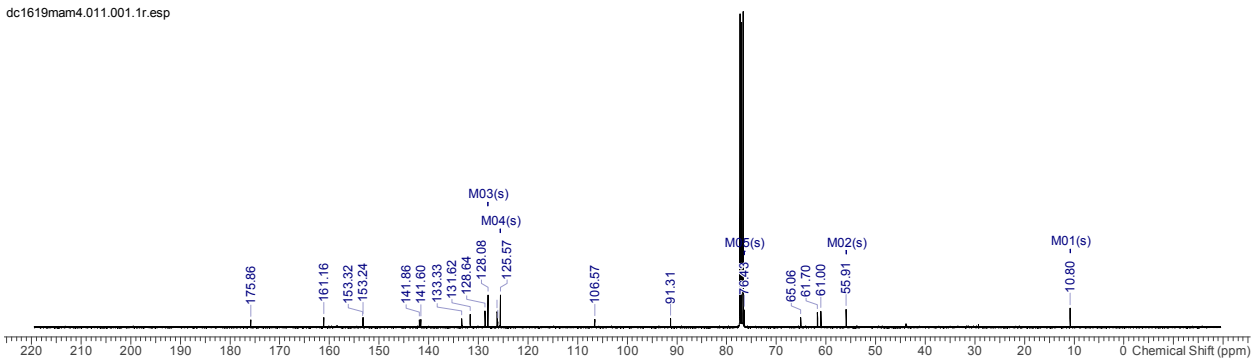
Alternatively: using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5i** (161 mg, 0.410 mmol) in THF (10 mL) was irradiated with UVA light for a residence time of 7 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (30 – 50% diethyl ether/petrol) to give the title compound **6i** (137 mg, 0.349 mmol, 85%) as a white foam. **IR** ν_{max} (film, cm^{-1}): 3059 (w), 3029 (w), 1731 (s), 1606 (vs), 1582 (m), 1436 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.46 – 7.39 (2H, m, 2×Ar**H**), 7.35 – 7.20 (8H, m, 8×Ar**H**), 7.16 (1H, d, *J* = 7.2 Hz, Ar**H**), 6.91 (1H, dd, *J* = 7.6, 0.7 Hz, Ar**H**), 6.80 (2H, br d, *J* = 6.5 Hz, Ar**H**), 6.27 (1H, dd, *J* = 10.3, 1.1 Hz, =C**H**), 5.75 (1H, s, PhC**H**), 5.56 (1H, d, *J* = 16.3 Hz, C**H**H), 5.40 (1H, dd, *J* = 10.5, 6.8 Hz, =C**H**), 5.04 (1H, d with fine splitting, *J* = 6.8 Hz, OC**H**), 4.28 (1H, d, *J* = 16.4 Hz, CH**H**), 2.03 (3H, s, C$\mathbf{H_3}$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 175.7 (**C**), 161.6 (**C**), 140.5 (**C**), 138.9 (**C**), 137.8 (**C**), 137.5 (**C**), 132.7 (**C**H), 132.5 (**C**H), 129.1 (2×**C**H), 128.7 (**C**H), 128.6 (2×**C**H), 128.4 (**C**H), 128.1 (2×**C**H), 128.1 (**C**H), 127.1 (2×**C**H), 126.8

(**C**H), 126.4 (2×**C**H), 90.6 (**C**), 76.0 (**C**H), 71.1 (**C**H), 56.8 (**C**H_2), 10.7 (**C**H_3). **LRMS** (ESI$^+$): 394 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{27}H_{24}NO_2$ [M+H]$^+$ 394.1802, found: 394.1804. **X-ray**: CCDC 1969077.

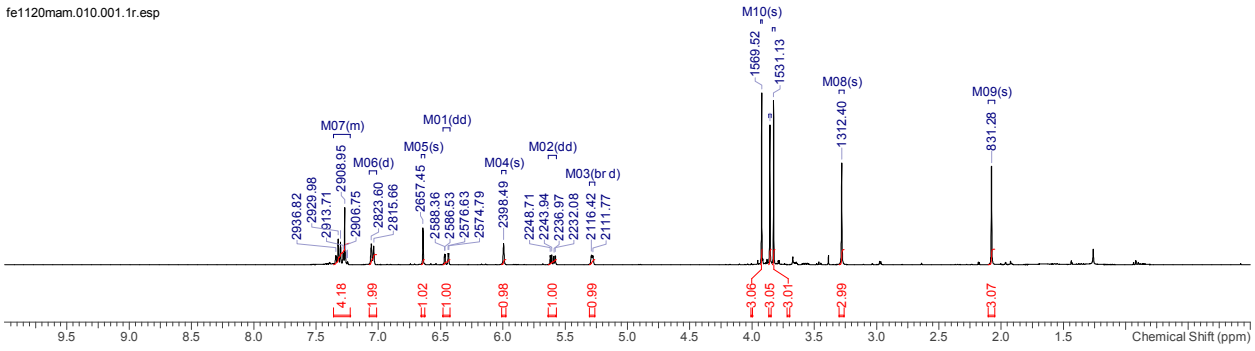


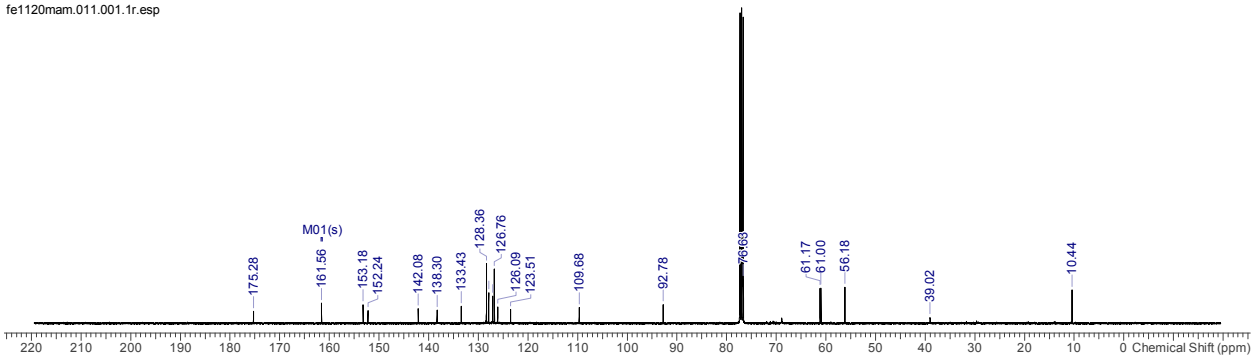
rel-(5*S*,11a*R*,10*Z*)-(*Z*)-6,7,8-Trimethoxy-3,4-dimethyl-5-phenyl-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6j). Using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5j** (86 mg, 0.212 mmol) in acetonitrile (6 mL) was irradiated with UVA light for a residence time of 4 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (70 – 100% diethyl ether/petrol) to give the title compound **6j** (78 mg, 0.191 mmol, 90%) as a white foam. **IR** ν_{max} (film, cm^{-1}): 2934 (w), 1728 (s), 1607 (vs), 1491 (m), 1445 (m), 1404 (m), 1376 (m), 1321 (m), 1308 (m), 1237 (m), 1124 (s), 1107 (m), 1081 (s), 1045 (s), 1017 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.24 – 7.15 (3H, m, 3×Ar**H**), 6.75 (2H, br d, *J* = 7.3 Hz, 2×Ar**H**), 6.46 (1H, s, Ar**H**), 6.19 (1H, s, C**H**Ph), 6.11 (1H, dd, *J* = 10.2, 1.1 Hz, C=C**H**), 5.19 (1H, dd, *J* = 10.0, 6.7 Hz, C=C**H**), 4.88 (1H, br d, *J* = 6.5 Hz, OC**H**), 4.04 (3H, s, OC**H**$_3$), 3.97 (3H, s, OC**H**$_3$), 3.89 (3H, s, OC**H**$_3$), 3.62 (3H, s, NC**H**$_3$), 2.19 (3H, s, C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 175.9 (**C**), 161.2 (**C**), 153.3 (**C**), 153.2 (**C**), 141.9 (**C**), 141.6 (**C**), 133.3 (**C**), 131.6 (**C**H), 128.6 (**C**H), 128.1 (2×**C**H), 126.2 (**C**H), 126.1 (**C**), 125.6 (2×**C**H), 106.6 (**C**H), 91.3 (**C**), 76.4 (**C**H), 65.1 (br, **C**H$_3$ + **C**H), 61.7 (**C**H$_3$), 61.0 (**C**H$_3$), 55.9 (**C**H$_3$), 10.8 (**C**H$_3$). **LRMS** (ESI$^+$): 408 ([M+H]$^+$, 100%), 430 ([M+Na]$^+$, 70%). **HRMS** (ESI$^+$): Calculated for $C_{24}H_{26}NO_5$ [M+H]$^+$ 408.1805, found: 408.1815.





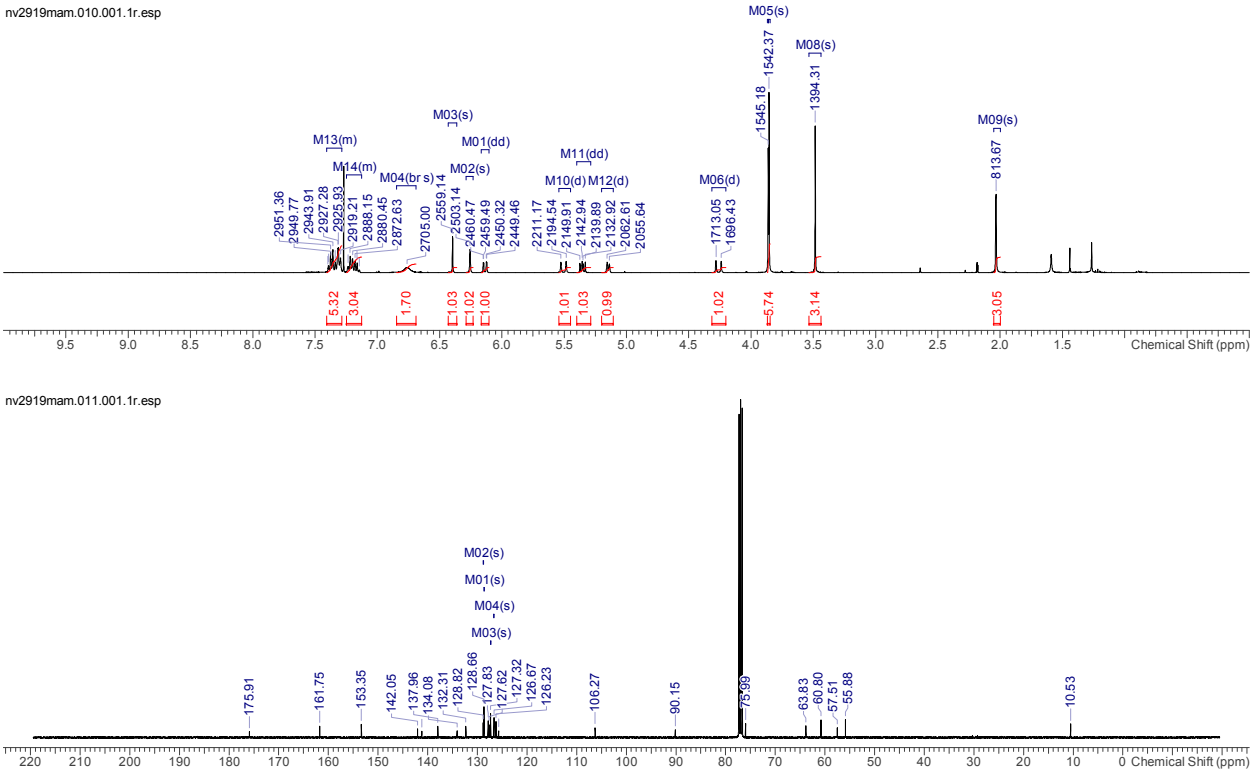
rel-(5*S*,11a*R*,10*Z*)-7,8,9-Trimethoxy-3,4-dimethyl-5-phenyl-5,11a-dihydrobenzo[*f*]furo[3,2-b]azocin-2(4*H*)-one (6k). Using flow photochemical set-up A: A solution of dihydrofuropyridinone **5k** (41.3 mg, 0.101 mmol) in acetonitrile (5 mL) was irradiated with UVA light for 6 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (80 – 100% diethyl ether/hexane) to give the title compound **6k** (24.0 mg, 0.059 mmol, 58%, ~95% purity) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 2933 (w), 1731 (s) 1610 (vs), 1495 (m), 1447 (m), 1408 (m), 1327 (s), 1125 (s), 1084 (m), 1024 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.34 – 7.25 (3H, m, 3×Ar**H**), 7.05 (2H, d, *J* = 8.0 Hz, 2×Ar**H**), 6.64 (1H, s, Ar**H**), 6.45 (1H, dd, *J* = 11.7, 1.8 Hz, C=C**H**), 5.99 (1H, s, C**H**Ph), 5.60 (1H, dd, *J* = 11.8, 4.8 Hz, HC=C**H**), 5.28 (1H, br d, *J* = 4.7 Hz, OC**H**), 3.92 (3H, s, OCH_3), 3.86 (3H, s, OCH_3), 3.83 (3H, s, OCH_3), 3.28 (3H, s, NCH_3), 2.08 (3H, s, CH_3). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 175.3 (**C**), 161.6 (**C**), 153.2 (**C**), 152.2 (**C**), 142.1 (**C**), 138.3 (**C**), 133.4 (**C**), 128.4 (2×**C**H), 127.9 (**C**H), 127.1 (**C**H), 126.8 (2×**C**H), 126.1 (**C**H), 123.5 (**C**), 109.7 (**C**H), 92.8 (**C**), 76.6 (**C**H), 68.9 (br, **C**H), 61.2 (**C**H_3), 61.0 (**C**H_3), 56.2 (**C**H_3), 39.0 (br, **C**H_3), 10.8 (**C**H_3). **LRMS** (ESI^+): 408 ($[M+H]^+$, 100%). **HRMS** (ESI^+): Calculated for $C_{24}H_{26}NO_5$ $[M+H]^+$, 408.1805, found: 408.1815.



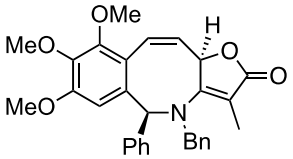


rel-(5*S*,11a*R*,10*Z*)-4-Benzyl-6,7,8-trimethoxy-3-methyl-5-phenyl-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6l). Using the sequenced flow thermal and photochemical set-up C: A solution of cyclobutenone **4l** (60 mg, 0.124 mmol) in 1,4-dioxane (6 mL, 0.02 M) was heated at 210 °C for 100 min then irradiated with UVA light for 10 min. The resulting solution was concentrated *in vacuo*, then purified by column chromatography (silica, 60 – 100% diethyl ether / petrol) to give the title compound **6l** (46 mg, 0.095 mmol, 77%) as a yellow solid.

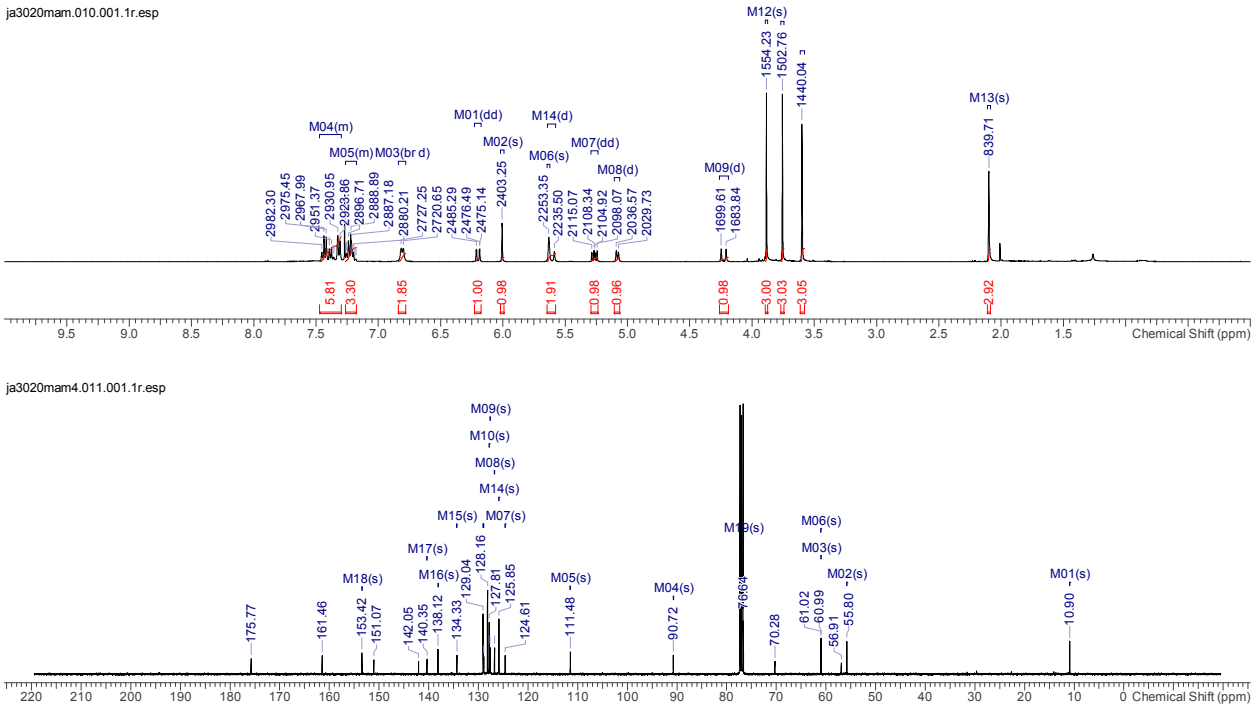
Alternatively: using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5l** (107 mg, 0.22 mmol) in acetonitrile (6 mL) was irradiated with UVA light for a residence time of 4 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (60 – 100% diethyl ether/petrol) to give the title compound **6l** (74 mg, 0.153 mmol, 69%) as a yellow solid. **MP**: 75–77 °C (CH_2Cl_2). **IR** ν_{max} (film, cm^{-1}): 2934 (w), 1730 (s), 1600 (vs), 1581 (m), 1490 (m), 1446 (m), 1347 (m), 1313 (m), 1122 (s), 1069 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.40 – 7.30 (5H, m, 5×Ar**H**), 7.23 – 7.14 (3H, m, 3×Ar**H**), 6.76 (2H, br s, 2×Ar**H**), 6.40 (1H, s, Ar**H**), 6.26 (1H, s, C**H**Ph), 6.14 (1H, dd, *J* = 10.1, 0.9 Hz, C=C**H**), 5.51 (1H, d, *J* = 16.6 Hz, NC**H**H), 5.35 (1H, dd, *J* = 10.0, 7.0 Hz, C=C**H**), 5.15 (1H, d, *J* = 7.0 Hz, OC**H**), 4.26 (1H, d, *J* = 16.6 Hz, NCH**H**), 3.86 (3H, s, OC$\mathbf{H}_3$), 3.85 (3H, s, OC$\mathbf{H}_3$), 3.48 (3H, s, OC$\mathbf{H}_3$), 2.03 (3H, s, C$\mathbf{H}_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 175.9 (**C**), 161.8 (**C**), 153.4 (2×**C**), 142.1 (**C**), 141.2 (**C**), 138.0 (**C**), 134.1 (**C**), 132.3 (**C**H), 128.8 (**C**H), 128.7 (3×**C**H), 127.8 (**C**H), 127.6 (**C**H), 127.3 (2×**C**H), 126.7 (**C**H), 126.2 (2×**C**H), 125.7 (**C**), 106.3 (**C**H), 90.2 (**C**), 76.0 (**C**H), 63.8 (**C**H), 60.8 (**C**H_3), 60.8 (**C**H_3), 57.5 (**C**H_2), 55.9 (**C**H_3), 10.5 (**C**H_3). **LRMS** (ESI$^+$): 484 ([M+H]$^+$, 100%), 506 ([M+Na]$^+$, 59%). **HRMS** (ESI$^+$): Calculated for $C_{30}H_{30}NO_5$ [M+H]$^+$ 484.2118, found: 484.2126. **X-ray**: CCDC 2025763.



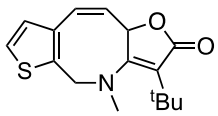
rel-(5*S*,11a*R*,10*Z*)-4-Benzyl-7,8,9-trimethoxy-3-methyl-5-phenyl-5,11a-dihydrobenzo[f]furo[3,2-b]azocin-2(4*H*)-one (6m). Using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5m** (43 mg, 0.088 mmol) in acetonitrile (4 mL) was irradiated with UVA light for a residence time of 6 min. The resulting solution was concentrated *in vacuo* to give the title compound **6m** (40 mg, 0.083 mmol, 93%) as a yellow oil.



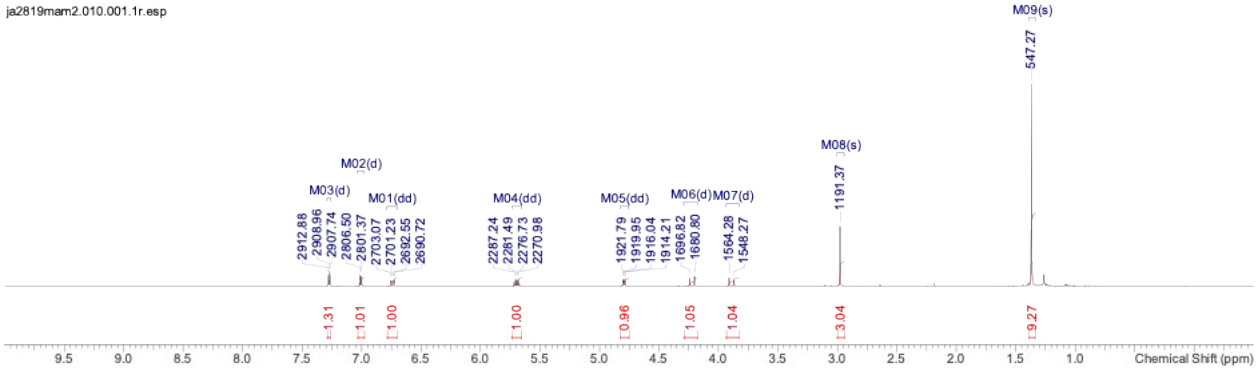
IR ν_{max} (film, cm^{-1}): 2934 (w), 1729 (s), 1599 (vs), 1582 (s), 1494 (s), 1452 (m), 1436 (m), 1408 (m), 1325 (m), 1124 (s), 1091 (m), 1057 (m), 1032 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.45 – 7.31 (6H, m, 6×Ar**H**), 7.25 – 7.18 (3H, m, 3×Ar**H**), 6.81 (2H, br d, *J* = 6.6 Hz, 2×Ar**H**), 6.20 (1H, dd, *J* = 10.2, 1.3 Hz, C=C**H**), 5.63 (1H, s, C**H**Ph), 5.59 (1H, d, *J* = 15.8 Hz, NC**H**H), 5.26 (1H, dd, *J* = 10.2, 6.8 Hz, C=C**H**), 5.08 (1H, d, *J* = 6.9 Hz, OC**H**), 4.23 (1H, d, *J* = 15.8 Hz, NCH**H**), 3.88 (3H, s, OC$\mathbf{H}_3$), 3.76 (3H, s, OC$\mathbf{H}_3$), 3.60 (3H, s, OC$\mathbf{H}_3$), 2.10 (3H, s, C$\mathbf{H}_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 175.8 (**C**), 161.5 (**C**), 153.4 (**C**), 151.1 (**C**), 142.1 (**C**), 140.4 (**C**), 138.1 (**C**), 134.3 (**C**), 129.0 (2×**C**H), 128.9 (**C**H), 128.2 (3×**C**H), 127.8 (2×**C**H), 127.6 (**C**H), 126.8 (**C**H), 125.9 (2×**C**H), 124.6 (**C**), 111.5 (**C**H), 90.7 (**C**), 76.6 (**C**H), 70.3 (**C**H), 61.0 (**C**H_3), 61.0 (**C**H_3), 56.9 (**C**H_2), 55.8 (**C**H_3), 10.9 (**C**H_3). **LRMS** (ESI$^+$): 484 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{30}H_{30}NO_5$ [M+H]$^+$ 484.2118, found: 484.2127.

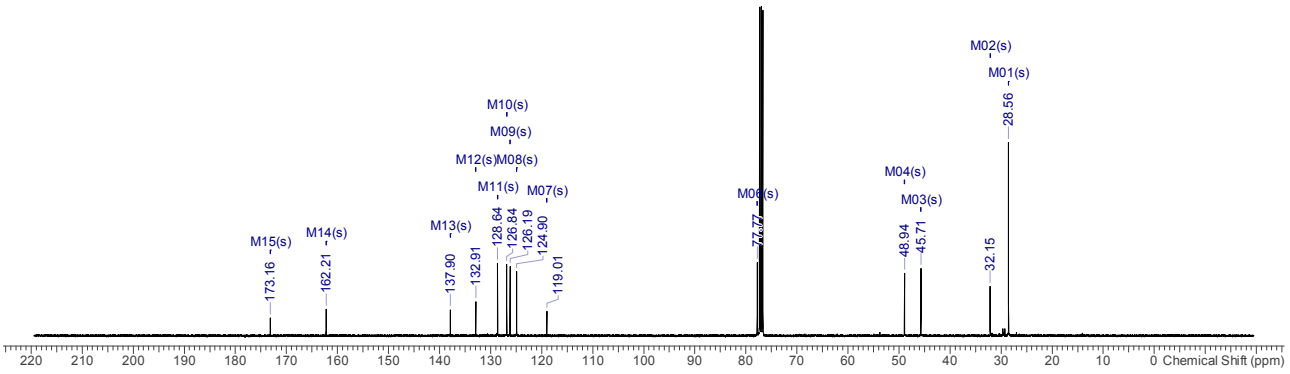


(*Z*)-4-(*tert*-Butyl)-3-methyl-5,10a-dihydrofuro[3,2-b]thieno[3,2-f]azocin-2(4*H*)-one (6n).

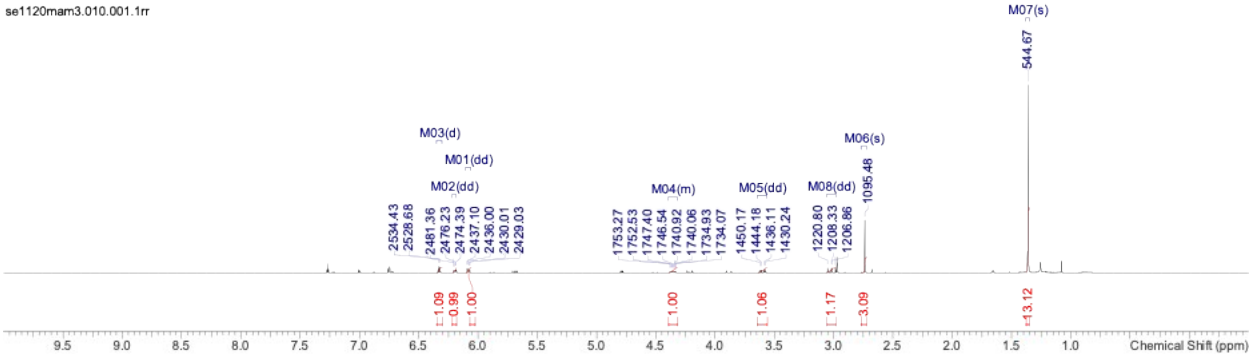


Using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5n** (68.4 mg, 0.236 mmol) in acetonitrile (8 mL) and under argon was degassed then irradiated with UVA light for a residence time of 20 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (5 – 20% diethyl ether / petroleum ether 40 – 60 °C) to give firstly the title compound **6n** (18.4 mg, 0.064 mmol, 27%) as a yellow oil followed by a 4:1 mixture of the title compound **6n** and dihydrofuropyridinone **5n** (24.1 mg, 35%) as yellow oil. **IR** ν_{max} (film, cm^{-1}): 2955 (w), 2918 (m), 2850 (w), 1742 (vs), 1618 (m), 1463 (w), 1365 (w), 1345 (w), 1291 (w).**^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.27 (1H, d, *J* = 5.1 Hz, Ar**H**), 7.01 (1H, d, *J* = 5.1 Hz, Ar**H**), 6.74 (1H, dd, *J* = 10.5, 1.8 Hz, =C**H**C), 5.70 (1H, dd, *J* = 10.5, 5.8 Hz, =C**H**CH), 4.79 (1H, dd, *J* = 5.8, 1.8 Hz, OC**H**), 4.22 (1H, d, *J* = 16.0 Hz, C**H**H), 3.89 (1H, d, *J* = 16.0 Hz, CH**H**), 2.98 (3H, s, NC**H**$_3$), 1.37 (9H, s, C(C**H**$_3$)$_3$)). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 173.2 (**C**), 162.2 (**C**), 137.9 (**C**), 132.9 (**C**), 128.6 (**C**H), 126.8 (**C**H), 126.2 (**C**H), 124.9 (**C**H), 119.0 (**C**), 77.8 (**C**H), 48.9 (**C**H$_2$), 45.7 (**C**H$_3$), 32.2 (**C**), 28.6 (3×**C**H$_3$). **LRMS** (ESI$^+$): 290 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{16}H_{19}NNaO_2S$ [M+Na]$^+$ 312.1029, found: 312.1023.

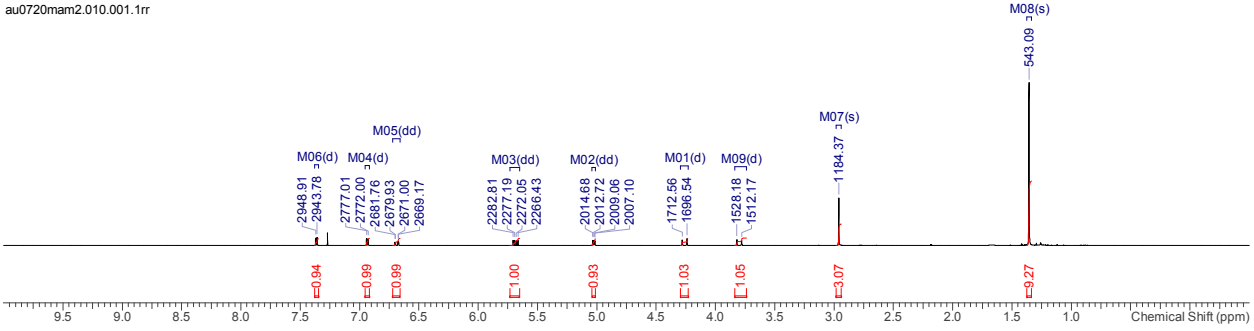


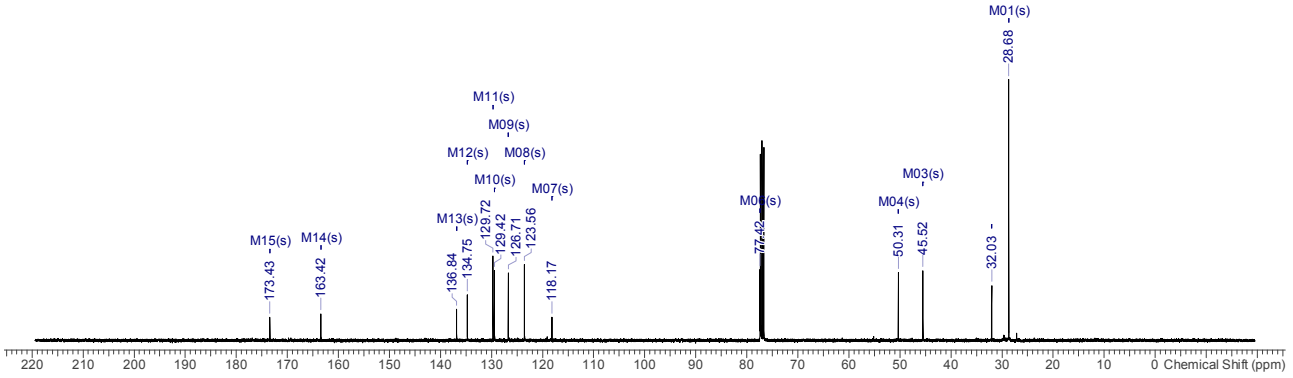


Note: An NMR spectra run shortly after chromatographic purification showed the title compound **6n** to be contaminated with a second product assigned as tetraene **7n** (see the following NMR spectrum). Isomerisation occured on standing to give the spectra above. Additional signals attributed to **7n**: **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 6.75 (1H, m, Ar**H**), 6.33 (1H, d, *J* = 5.8 Hz, Ar**H**), 6.20 (1H, dd, *J* = 7.0, 1.9 Hz, =C**H**), 6.08 (1H, dd, *J* = 7.0, 1.0 Hz, C=C**H**), 4.36 (1H, m, C**H**CH_2), 3.60 (1H, dd, *J* = 14.0, 5.6 Hz, C**H**H), 3.02 (1H, dd, *J* = 14.0, 12.5 Hz, CH**H**), 2.74 (3H, s, N$C\mathbf{H}_3$), 1.36 (9H, s, C($C\mathbf{H}_3$)$_3$)).

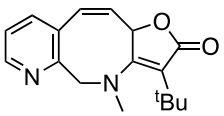


(*Z*)-3-(*tert*-Butyl)-4-methyl-5,10a-dihydrofuro[3,2-b]thieno[2,3-f]azocin-2(4*H*)-one (6o). Using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5o** (139 mg, 0.479 mmol) in THF (20 mL) under argon was degassed, then irradiated with UVA light for a residence time of 20 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (10 – 40% diethyl ether/ petroleum ether 40 – 60 °C) to give firstly the title compound **6o** (39 mg, 0.133 mmol, 28%) as a yellow oil then a 2:3 mixture of the title compound **6o** and staring material **5o** (95 mg, 68%) as an orange oil. **IR** ν_{max} (film, cm^{-1}): 2954 (m), 2867 (w), 1782 (w), 1736 (vs), 1615 (s), 1479 (w), 1438 (w), 1396 (w), 1289 (m), 1206 (m), 1095 (w), 1036 (s), 989 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.36 (1H, d, *J* = 5.1 Hz, Ar**H**), 6.93 (1H, d, *J* = 5.0 Hz, Ar**H**), 6.69 (1H, dd, *J* = 10.8, 1.8 Hz, C=C**H**), 5.68 (1H, dd, *J* = 10.8, 5.6 Hz, HC=C**H**), 5.03 (1H, dd, *J* = 5.6, 2.0 Hz, OC**H**), 4.26 (1H, d, *J* = 16.0 Hz, C**H**H), 3.80 (1H, d, *J* = 16.0 Hz, CH**H**), 2.96 (3H, s, N$C\mathbf{H}_3$), 1.36 (9H, s, C($C\mathbf{H}_3$)$_3$)). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 173.4 (**C**), 163.4 (**C**), 136.8 (**C**), 134.8 (**C**), 129.7 (**C**H), 129.4 (**C**H), 126.7 (**C**H), 123.6 (**C**H), 118.2 (**C**), 77.4 (**C**H), 50.3 ($\mathbf{C}H_2$), 45.5 ($\mathbf{C}H_3$), 32.0 (**C**), 28.7 (3×$\mathbf{C}H_3$). **LRMS** (ESI$^+$): 290 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{16}H_{20}NO_2S$ [M+H]$^+$ 290.1209, found: 290.1211.

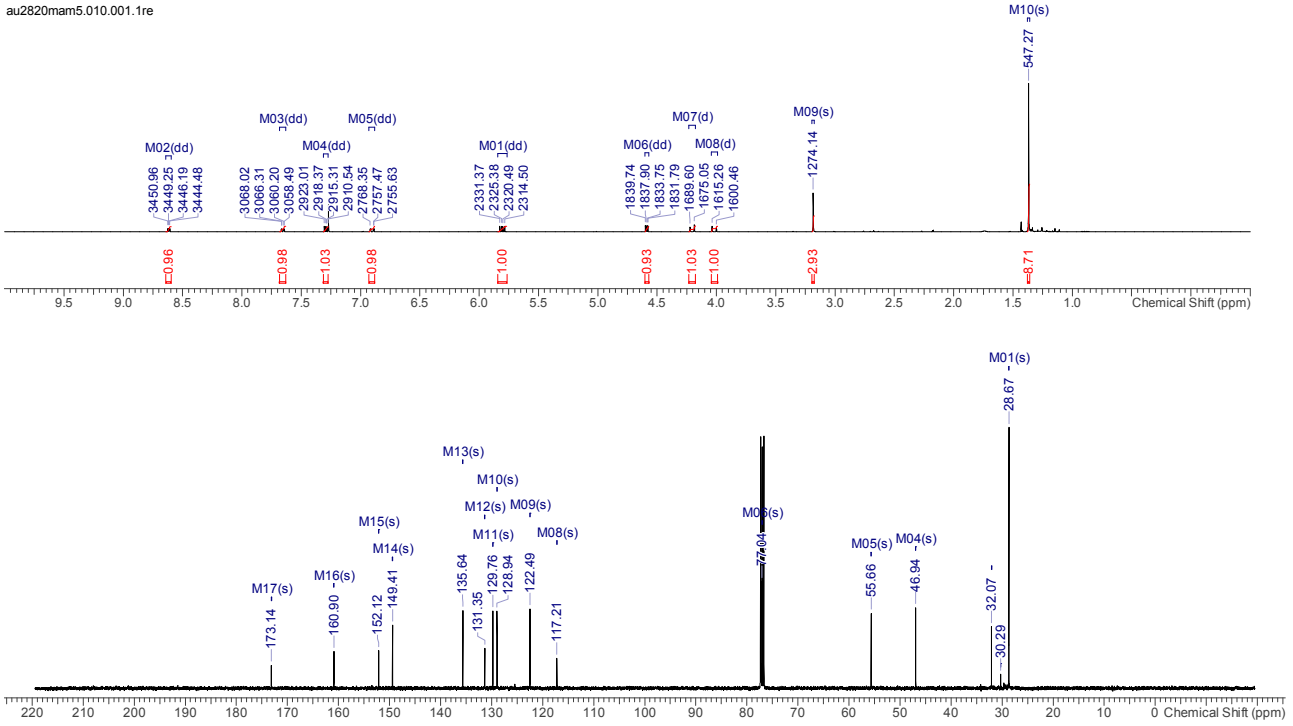




(*Z*)-3-(*tert*-Butyl)-4-methyl-5,11a-dihydrofuro[3,2-b]pyrido[3,2-f]azocin-2(4*H*)-one (6p).

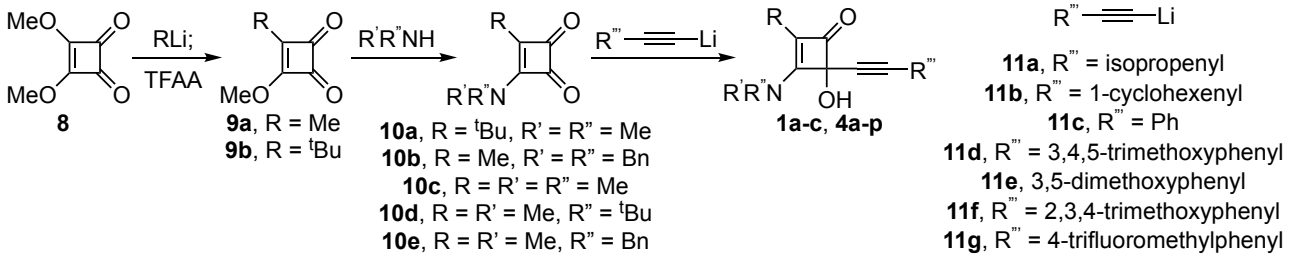


Using the flow photochemical set-up A: A solution of dihydrofuropyridinone **5p** (94 mg, 0.330 mmol) in tetrahydrofuran (11 mL) under argon was degassed and irradiated with UVA light for a residence time of 20 min. The resulting solution was concentrated *in vacuo* and purified by column chromatography (40 – 80% diethyl ether/petrol) to give the title compound **6p** (23 mg, 0.081 mmol, 25%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 2955 (w), 1740 (vs), 1613 (m), 1428 (w), 1365 (w), 1297 (w), 1202 (w), 1117 (w), 1051 (m), 1035 (m), 1001 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 8.62 (1H, dd, *J* = 4.8, 1.7 Hz, Ar**H**), 7.66 (1H, dd, *J* = 7.8, 1.7 Hz, Ar**H**), 7.29 (1H, dd, *J* = 7.8, 4.7 Hz, Ar**H**), 6.90 (1H, dd, *J* = 10.9, 1.8 Hz, C=C**H**), 5.81 (1H, dd, *J* = 10.9, 6.0 Hz, =C**H**CH), 4.59 (1H, dd, *J* = 6.1, 1.9 Hz, OC**H**), 4.20 (1H, d, *J* = 14.6 Hz, C**H**H), 4.02 (1H, d, *J* = 14.8 Hz, CH**H**), 3.18 (3H, s, NC**H**$_3$), 1.37 (9H, s, C(C**H**$_3$)$_3$)). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 173.1 (**C**), 160.1 (**C**), 152.1 (**C**), 149.4 (**C**H), 135.6 (**C**H), 131.4 (**C**), 129.8 (**C**H), 128.9 (**C**H), 122.5 (**C**H), 117.2 (**C**), 77.0 (**C**H), 55.7 (**C**H$_2$), 46.9 (**C**H$_3$), 32.1 (**C**), 28.7 (3×**C**H$_3$). **LRMS** (ESI$^+$): 285 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{17}H_{21}N_2O_2$ [M+H]$^+$ 285.1598, found: 285.1597.

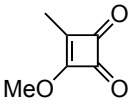


2.2. Preparation of Cyclobutenones 1a-c and 4a-q

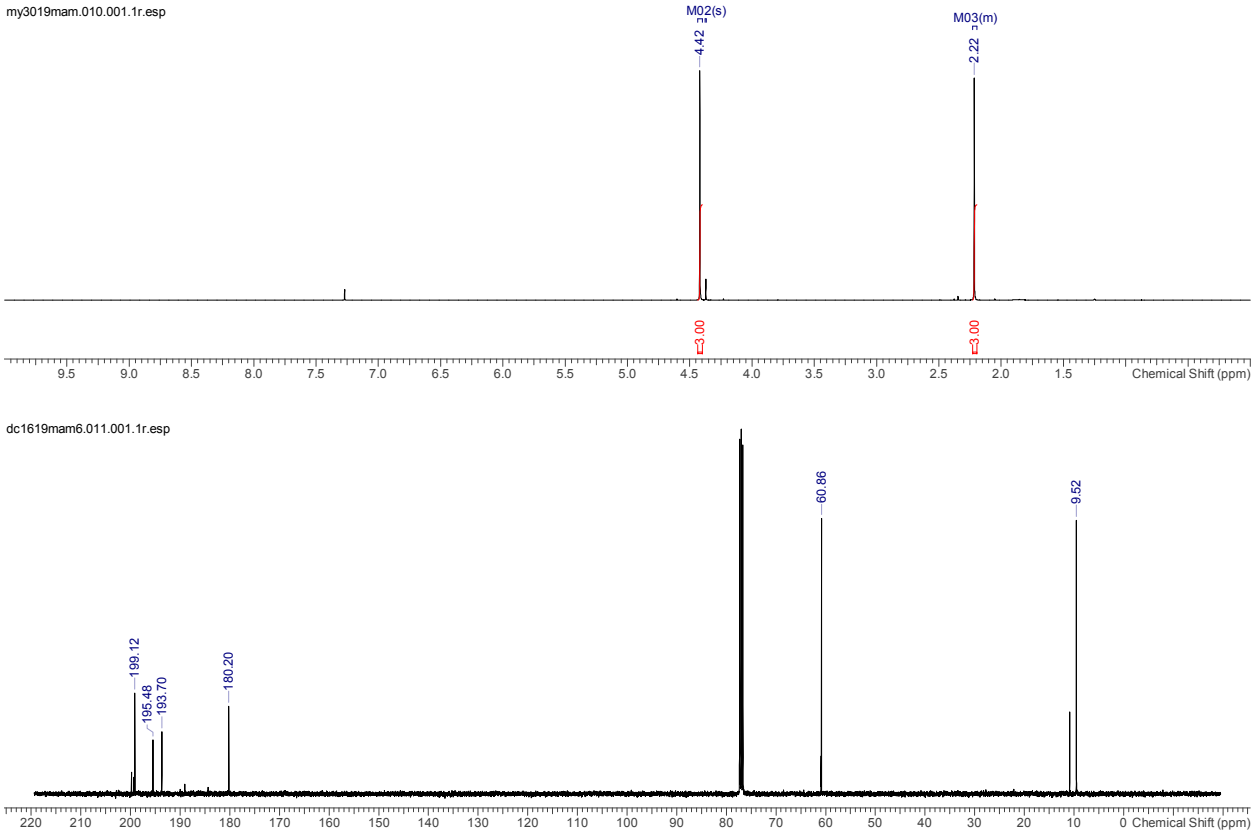
The cyclobutenone starting materials, **1a-c**, **4a-q**, were conveniently prepared from dimethyl squarate **8** using the following three step sequence.



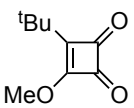
3-Methoxy-4-methylcyclobut-3-ene-1,2-dione (9a).



To a solution of dimethyl squarate **8** (3.53 g, 24.8 mmol) in THF (100 mL) at –78 °C was added a solution methyllithium (1.6 M in Et_2O, 17.1 mL, 27.3 mmol) in THF (100 mL) *via* cannula. After 40 min, TFAA (3.85 mL, 27.3 mmol) was added slowly. After a further 1 h sat. NH_4Cl (30 mL) was added, the reaction mixture was warmed to RT and diluted with water (100 mL). The aqueous phase was separated and extracted with DCM (2 × 100 mL) then the combined organic phases were dried over magnesium sulfate and concentrated *in vacuo* to afford the title compound **9a** (2.49 g, 19.8 mmol, 83%) as a white solid. **IR** ν_{max} (film, cm^{-1}): 2960 (w), 1803 (m), 1787 (m), 1751 (s), 1593 (vs), 1383 (m), 1343 (s), 1072 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 4.42 (3H, s, OC**H**$_3$), 2.22 (3H, s, C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 199.1 (**C**), 195.5 (**C**), 193.7 (**C**), 180.2 (**C**), 60.9 (**C**H_3), 9.52 (**C**H_3). **LRMS** (ESI^+): 127 ([M+H]$^+$, 100%). Data consistent with literature values.[4,5]

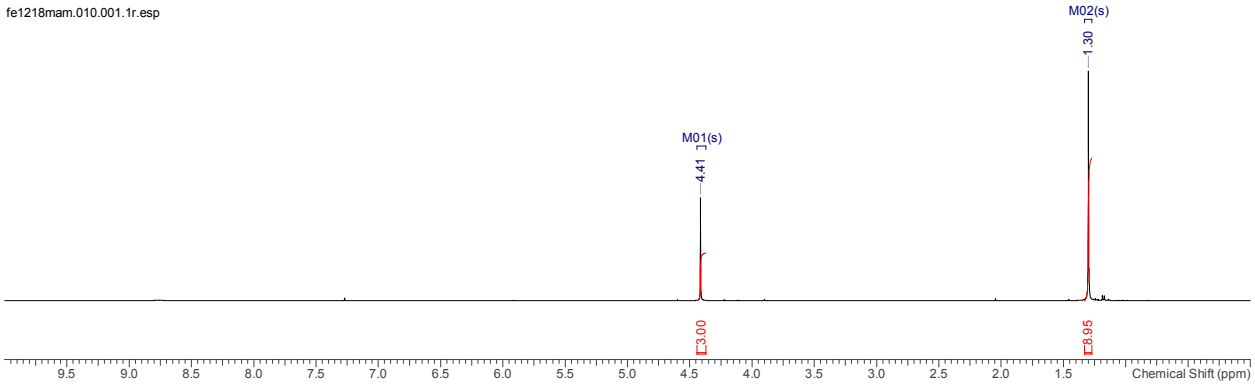


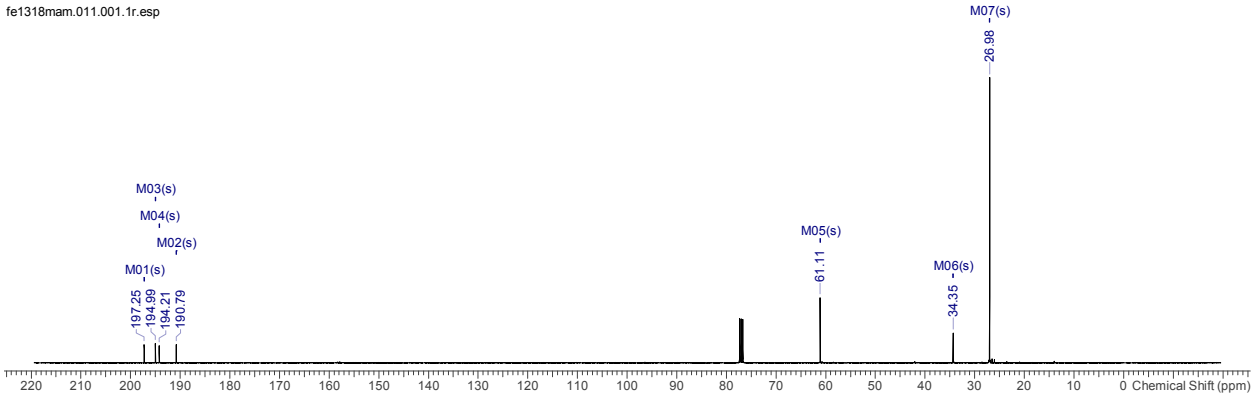
3-(*t*-Butyl)-4-methoxycyclobut-3-ene-1,2-dione (9b).



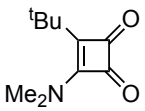
To a solution of dimethyl squarate **8** (22.0 g, 155 mmol) in THF (500 mL) at –78 °C was added ^{t}butyllithium (1.6 M in Et_2O, 100 mL, 170 mmol). After 75 min, TFAA (26.1 mL, 186 mmol) was added dropwise and after a further 70 min sat. NH_4Cl (100 mL) was added. The reaction mixture was then warmed to RT and diluted with water (100 mL). The aqueous phase was separated

and extracted with DCM (400 mL and then 2 × 100 mL), then the organic phases were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (5 – 20% ethyl acetate/petrol) to afford the title compound **9b** (22.3 g, 132 mmol, 86%) as an orange oil. **IR** ν_{max} (film, cm^{-1}): 2970 (br m), 1791 (m), 1761 (s), 1737 (s), 1602 (m), 1587 (s), 1483 (m), 1360 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 4.41 (3H, s, OCH_3), 1.30 (9H, s, $C(CH_3)_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 197.3 (**C**), 195.0 (**C**), 194.2 (**C**), 190.8 (**C**), 61.1 (CH_3), 34.4 (**C**), 27.0 ($3\times CH_3$). **LRMS** (ESI^+): 169 ($[M+H]^+$, 100%). Data consistent with literature values.[5,6]

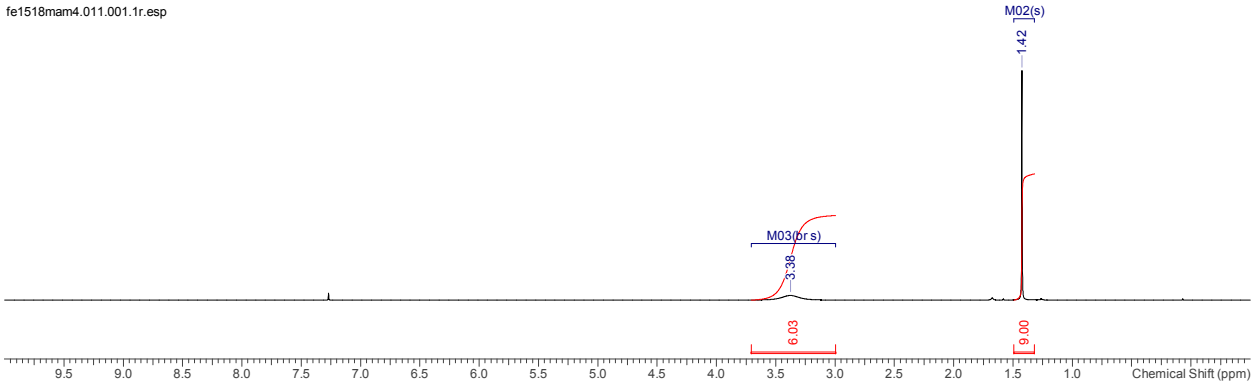


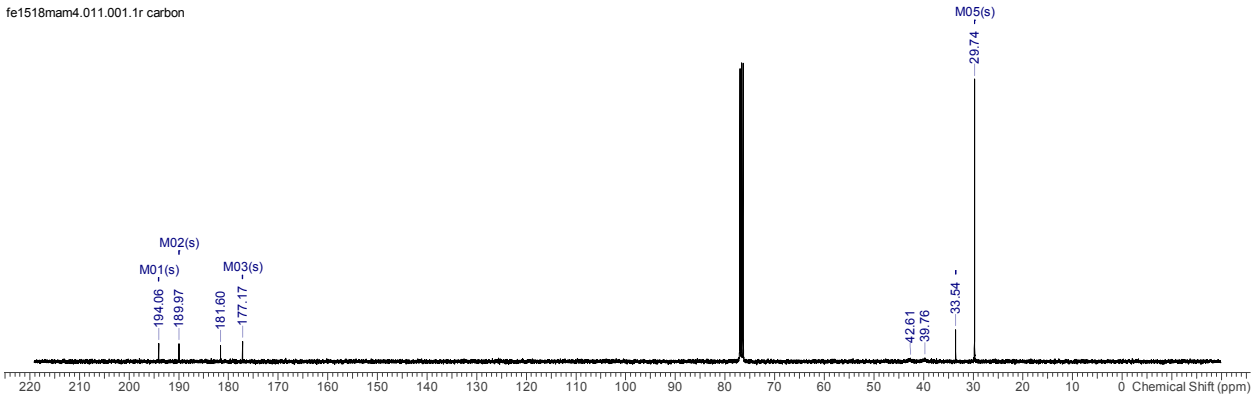


3-(*t*-Butyl)-4-(dimethylamino)cyclobut-3-ene-1,2-dione (10a).

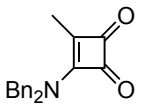


A solution of cyclobutenedione **9b** (637 mg, 3.79 mmol), dimethylamine hydrochloride (401 mg, 4.93 mmol) and triethylamine (1.10 mL, 7.58 mmol) in methanol (50 mL) was stirred at RT for 80 min then concentrated *in vacuo.* Purification by column chromatography (50 – 60% ethyl acetate/petrol) gave the title compound **10a** (547 mg, 3.02 mmol, 80%) as an off-white solid. **MP**: 82–83 °C (film). **IR** ν_{max} (film, cm^{-1}): 2972 (w), 2933 (w), 1772 (m), 1720 (s), 1584 (s), 1426 (m), 1405 (m), 1366 (m), 1250 (m), 1167 (s), 1113 (s), 1063 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 3.37 (6H, br s, $N(CH_3)_2$), 1.42 (9H, s, $C(CH_3)_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 194.1 (**C**), 190.0 (**C**), 181.6 (**C**), 177.2 (**C**), 42.6 (br, CH_3), 39.8 (br, CH_3), 33.5 (**C**), 29.7 ($3\times CH_3$). **LRMS** (ESI^+): 182 ($[M+H]^+$, 100%). Data consistent with literature values.[1]

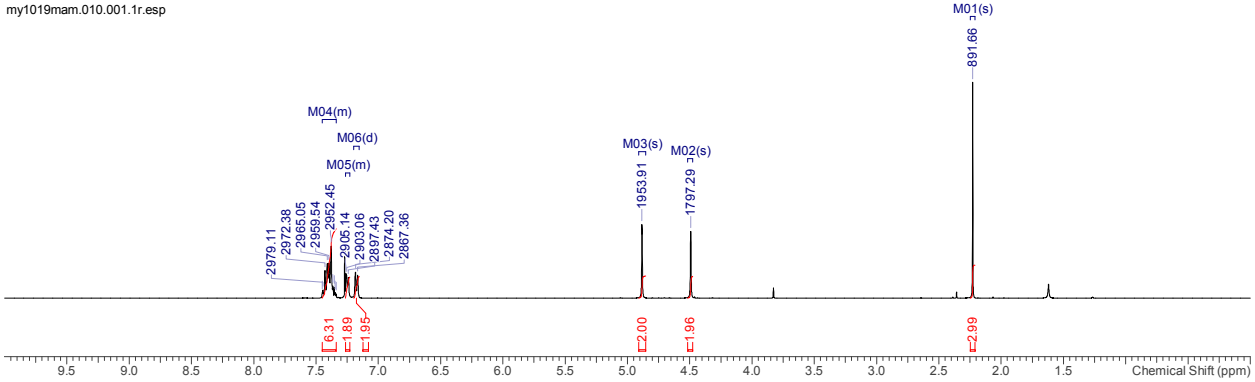


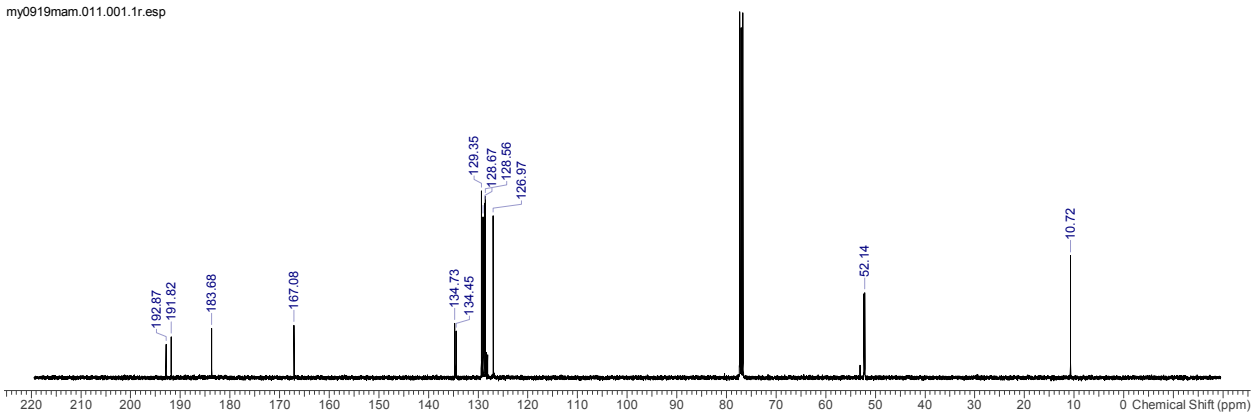


3-(Dibenzylamino)-4-methylcyclobut-3-ene-1,2-dione (10b).

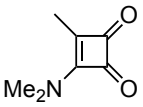


A solution of cyclobutenedione **9a** (537 mg, 4.26 mmol) and dibenzylamine (1.25 mL, 6.38 mmol) in methanol (100 mL) was stirred at RT for 130 min then concentrated *in vacuo.* Purification by column chromatography (30 – 40% ethyl acetate/petrol) gave the title compound **10b** (1.21 g, 4.15 mmol, 98%) as a yellow solid. **MP**: 90–91 °C ($CHCl_3$). **IR** ν_{max} (film, cm^{-1}): 3063 (w), 3029 (w), 1783 (m), 1732 (m), 1596 (s), 1581 (s), 1443 (m), 1068 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.45 – 7.34 (6H, m, 6×Ar**H**), 7.26 – 7.24 (2H, m, 2×Ar**H**), 7.17 (2H, br d, *J* = 6.9 Hz, 2×Ar**H**), 4.88 (2H, s, NC$\mathbf{H}_2$), 4.49 (2H, s, NC$\mathbf{H}_2$), 2.23 (3H, s, C$\mathbf{H}_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 192.9 (**C**), 191.8 (**C**), 183.7 (**C**), 167.1 (**C**), 134.7 (**C**), 134.5 (**C**), 129.4 (2×**C**H), 129.1 (2×**C**H), 128.7 (2×**C**H), 128.6 (2×**C**H), 127.0 (2×**C**H), 52.1 (2×**C**H_2), 10.7 (**C**H_3). **LRMS** (ESI^+): 292 ($[M+H]^+$, 100%).[7]



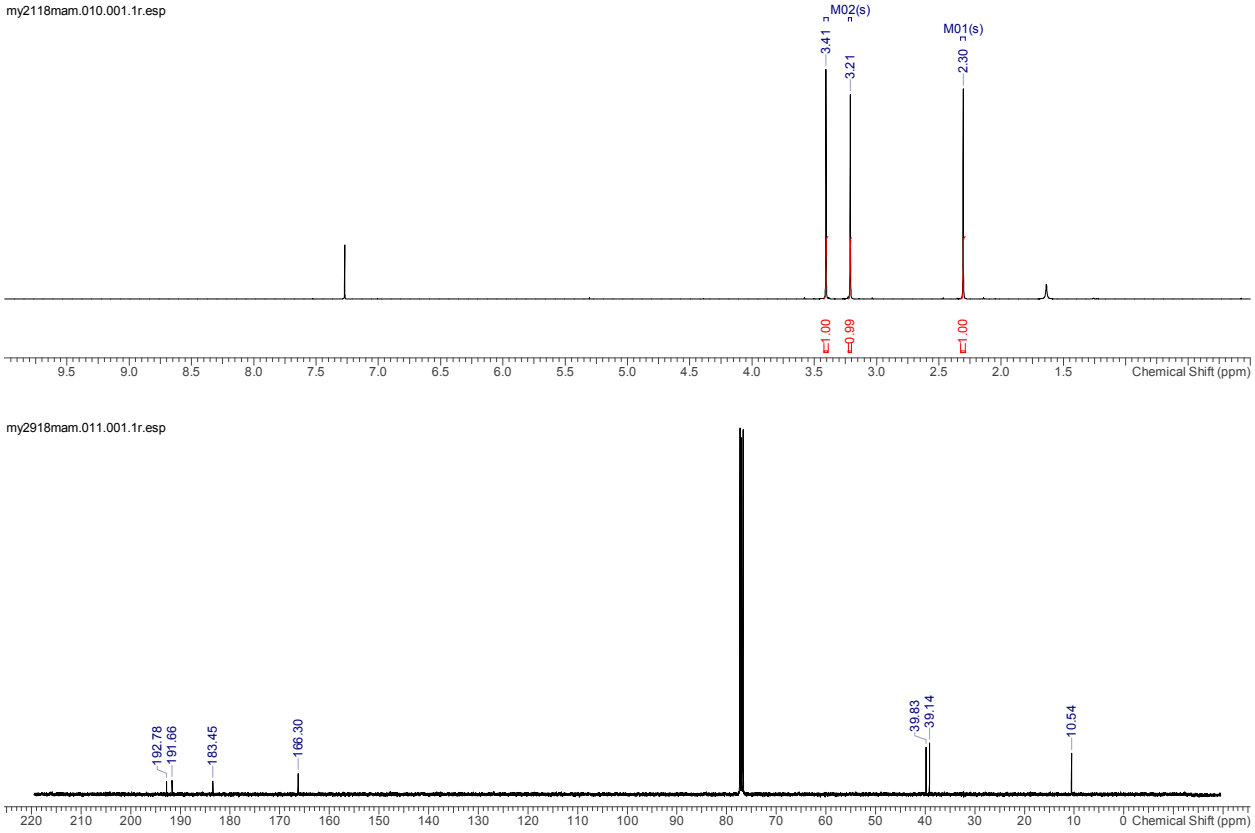


3-(Dimethylamino)-4-methylcyclobut-3-ene-1,2-dione (10c).

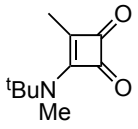


To a solution of cyclobutenedione **9a** (1.80 g, 14.3 mmol) in methanol (100 mL) was added dimethylamine hydrochloride (1.51 g, 18.6 mmol) and triethylamine (2.59 mL, 18.6 mmol). After 45 min at RT, the reaction mixture was concentrated *in vacuo* and purified by column chromatography (60 – 100% ethyl acetate/petrol) to give the title compound **10c** (1.66g, 11.9 mmol, 83%) as a white solid.[1] **MP**: 130–133 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 2942 (br w), 1778 (s), 1726 (m), 1616 (vs), 1411 (m), 1067 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 3.41 (3H, s, NC$\mathbf{H_3}$), 3.21 (3H, s, NC$\mathbf{H_3}$) , 2.31 (3H, s, C$\mathbf{H_3}$). **^{13}C**

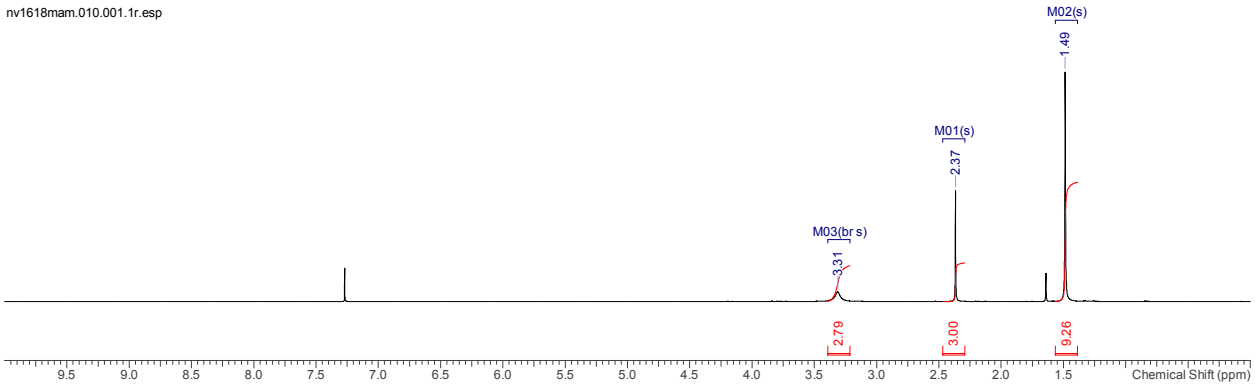
NMR (100 MHz, $CDCl_3$): δ ppm 192.8 (**C**), 191.7 (**C**), 183.4 (**C**), 166.3 (**C**), 39.8 (**C**H_3), 39.1 (**C**H_3), 10.5 (**C**H_3). **LRMS** (ESI^+): 162 ($[M+H]^+$, 100%). Data consistent with literature values.[1]

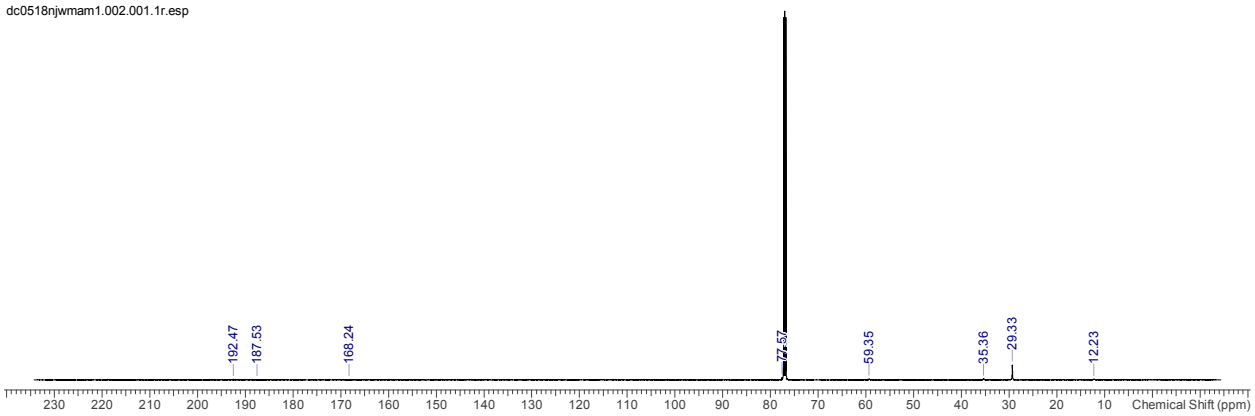


3-(*t*-Butyl(methyl)amino)-4-methylcyclobut-3-ene-1,2-dione (10d).

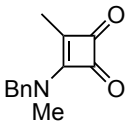


A solution of cyclobutenedione **9a** (879 mg, 6.97 mmol) and *N-tert*-butylmethylamine (1.25 mL, 10.5 mmol) in methanol (100 mL) was stirred at RT for 17 h then concentrated *in vacuo.* Purification by column chromatography (60 – 80% ethyl acetate/petrol) gave the title compound **10d** (857 mg, 4.73 mmol, 68%) as an off-white solid. **MP**: 94–95 °C (Et_2O). **IR** ν_{max} (film, cm^{-1}): 2962 (w), 1772 (m), 1726 (m), 1557 (s), 1399 (w), 1172 (w), 1053 (m). **^{1}H NMR** (500 MHz, $CDCl_3$): δ ppm 3.31 (3H, br s, NC**H**$_3$), 2.36 (3H, s, C**H**$_3$), 1.48 (9H, s, C(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 192.5 (2×**C**), 187.5 (**C**), 168.2 (**C**), 59.4 (**C**H_3), 35.4 (**C**), 29.3 (3× **C**H_3), 12.1 (**C**H_3). **LRMS** (ESI^+): 183 ($[M+H]^+$, 100%).

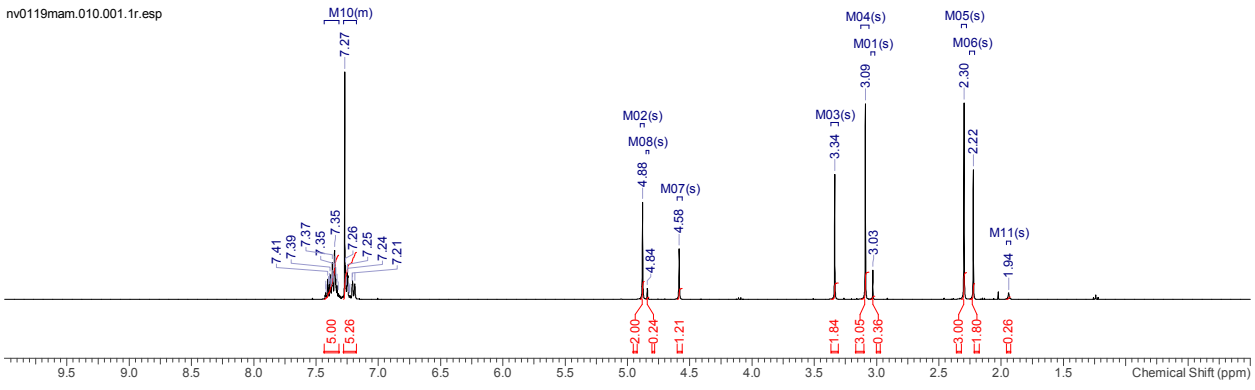


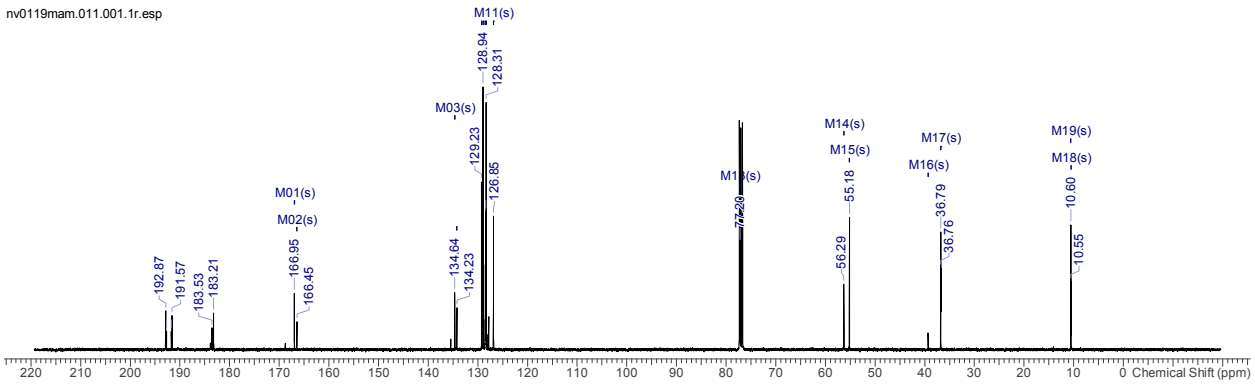


3-(Benzyl(methyl)amino-4-methylcyclobut-3-ene-1,2-dione (10e).

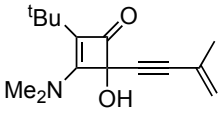


A solution of cyclobutenedione **9a** (601 mg, 4.76 mmol) and *N*-benzylmethylamine (0.922 mL, 7.15 mmol) in methanol (50 mL) was stirred at RT for 90 min then concentrated *in vacuo* and partitioned between EtOAc (50 mL) and HCl (2M, 30 mL). sat. $NaHCO_3$ (60 mL) was added then the aqueous phase was separated, extracted with EtOAc (2×30 mL). The organic layers were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (60 – 80% ethyl acetate/petrol) to give the title compound **10e** (777 mg, 3.61 mmol, 76%) as an orange oil. **IR** ν_{max} (film, cm^{-1}): 2924 (w), 1781 (m), 1727 (m), 1596 (vs), 1496 (w), 1447 (m), 1414 (m), 1060 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): 3:1 mixture of rotamers, *major rotamer*: δ ppm 7.44 – 7.34 (3H, m, 3×Ar**H**), 7.27 (1H, m, Ar**H**), 7.20 (1H, m, Ar**H**), 4.89 (2H, s, NC**H**$_2$), 3.10 (3H, s, NC**H**$_3$)**,** 2.31 (3H, s, C**H**$_3$); *minor rotamer*: 7.44 – 7.34 (3H, m, 3×Ar**H**), 7.27 (1H, m, Ar**H**), 7.20 (1H, m, Ar**H**), 4.59 (2H, s, NC**H**$_2$), 3.35 (3H, s, NC**H**$_3$), 2.23 (3H, s, C**H**$_3$). **^{13}C NMR** (125 MHz, $CDCl_3$): *major rotamer*: δ ppm 192.9 (**C**), 191.6 (**C**), 183.3 (**C**), 167.0 (**C**), 134.7 (**C**), 129.0 (2×**C**H), 128.5 (**C**H), 128.4 (2×**C**H), 55.2 (**C**H$_2$), 36.8 (**C**H$_3$), 10.6 (**C**H$_3$); *minor rotamer:* 192.7 (**C**), 191.8 (**C**), 183.6 (**C**), 166.5 (**C**), 134.3 (**C**), 129.3 (2×**C**H), 128.6 (**C**H), 126.9 (2×**C**H), 56.3 (**C**H$_2$), 36.8 (**C**H$_3$), 10.6 (**C**H$_3$). **LRMS** (ESI^+): 238 ([M+Na]$^+$, 100%). **HRMS** (ESI^+): Calculated for $C_{13}H_{13}NO_2$ [M+H]$^+$ 216.1019, found: 216.1022.

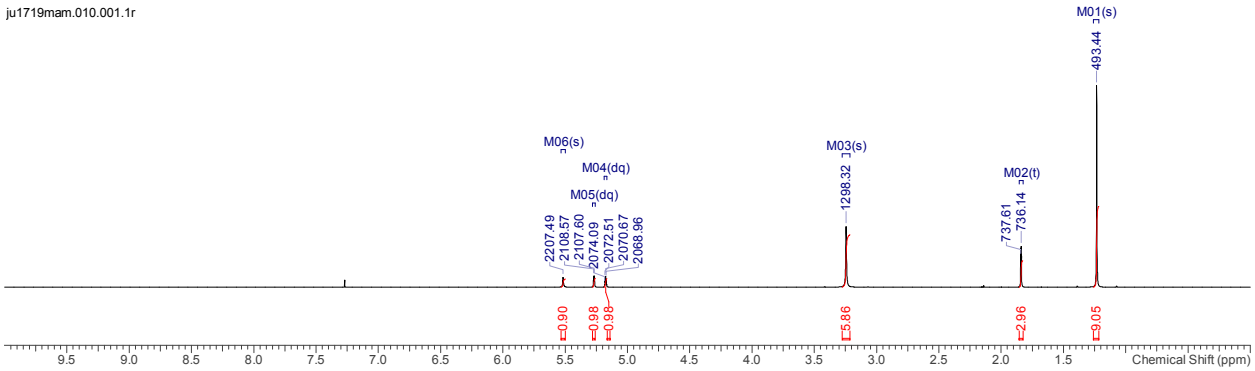


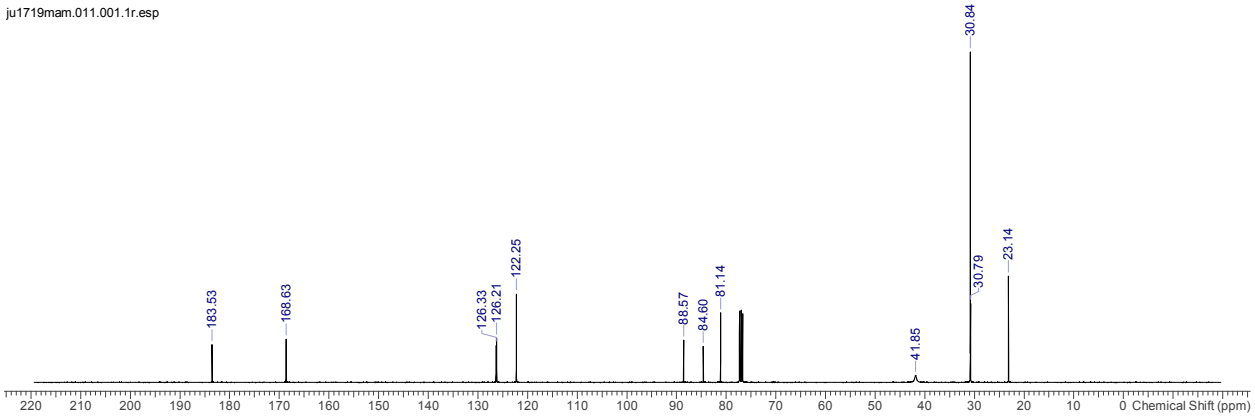


2-(*t*-Butyl)-3-(dimethylamino)-4-hydroxy-4-(3-methylbut-3-en-1-yn-1-yl)cyclobut-2-en-1-one (1a).

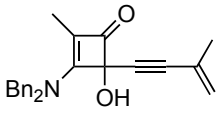


To a solution of 2-methyl-1-buten-3-yne **11a** (0.42 mL, 4.43 mmol) in THF (40 mL) at –78 °C was added *n*butyllithium (2.5 M in hexanes, 1.8 mL, 4.50 mmol) dropwise. After 10 min, the solution was added *via* cannula to a solution of cyclobutenedione **10b** (669 mg, 3.69 mmol) in THF (60 mL) at –78 °C. After a further 70 min, sat. NH_4Cl (30 mL) was added then the solution was warmed to RT and diluted with water (50 mL). The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the organic phases were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (10 – 30% acetone/DCM) to afford the title compound **1a** (871 mg, 3.52 mmol, 95%) as an off-white solid. **MP**: 146–148 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 3243 (br w), 2957 (w), 2868 (w), 1732 (m), 1569 (vs), 1405 (m), 1364 (m), 1255 (m), 1188 (m), 1150 (m), 1111 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 5.52 (1H, br s, O**H**), 5.27 (1H, dq, *J* = 2.0, 1.0 Hz, C=C**H**H), 5.18 (1H, dq, *J* = 2.0, 1.6 Hz, C=CH**H**), 3.24 (6H, s, NC**H**$_3$), 1.84 (3H, app t, *J* = 1.3 Hz, C**H**$_3$), 1.23 (9H, s 3×C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 182.5 (**C**), 168.6 (**C**), 126.3 (**C**), 126.2 (**C**), 122.3 (**C**H$_2$), 88.6 (**C**), 84.6 (**C**), 81.1 (**C**), 41.9 (br s, 2×**C**H$_3$), 30.8 (3×**C**H$_3$), 30.8 (**C**), 23.1 (**C**H$_3$). **LRMS** (ESI^+): 248 ([M+H]$^+$, 100%).



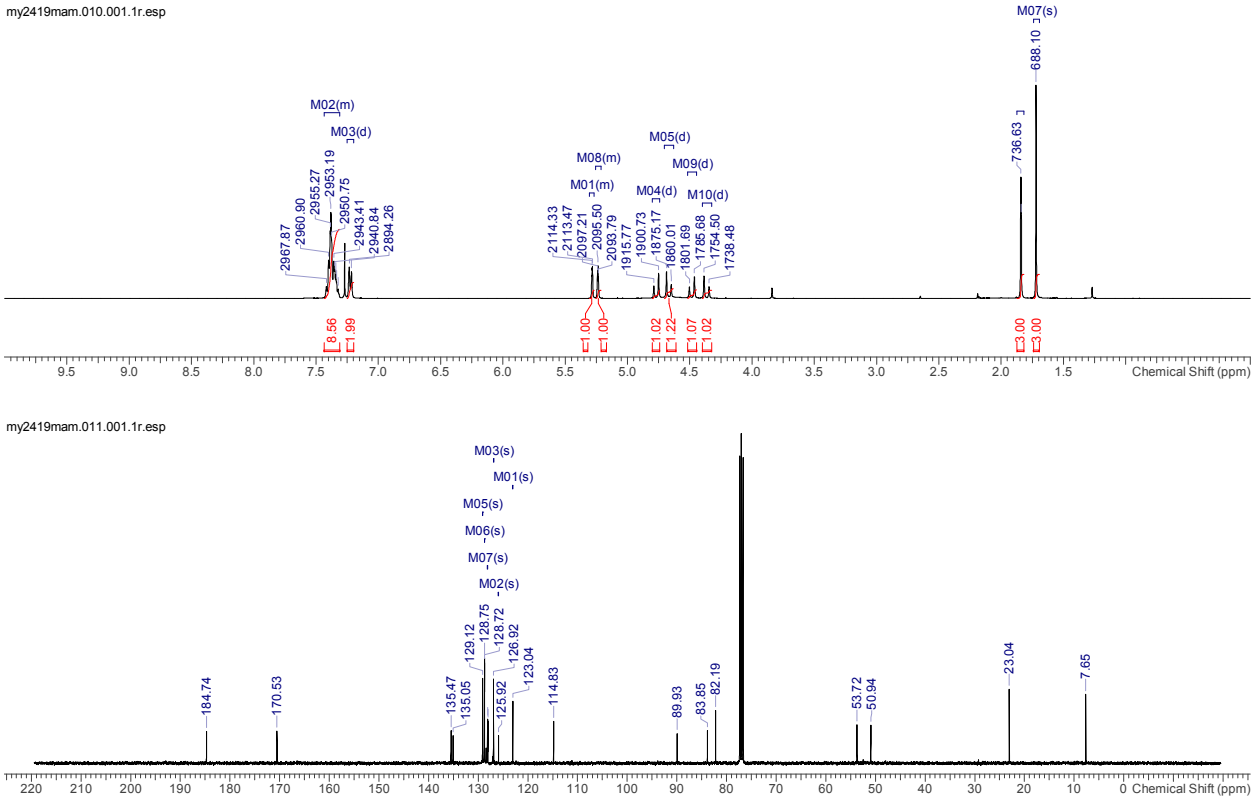


3-(Dibenzylamino)-4-hydroxy-2-methyl-4-(3-methylbut-3-en-1-yn-1-yl)cyclobut-2-en-1-one (1b).

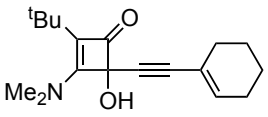


To a solution of 2-methyl-1-buten-3-yne **11a** (0.18 mL, 1.94 mmol) in THF (20 mL) at –78 °C was added *n*butyllithium (2.5 M in hexanes, 0.90 mL, 2.25 mmol) dropwise. After 15 min, the solution was added *via* cannula to a solution of cyclobutenedione **10b** (473 mg, 1.62 mmol) in THF (50 mL) at –78 °C. After a further 75 min, sat. NH_4Cl (20 mL) was added then the solution was warmed to RT and diluted with water (30 mL). The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the organic phases were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (10 – 30% acetone/DCM) to afford the title compound **1b** (544 mg, 1.52 mmol, 94%) as an off-white solid. **IR** ν_{max} (film, cm^{-1}): 3242 (br w), 2921 (w), 1748 (m), 1590 (s), 1572 (vs), 1440 (m), 1258 (m), 1118 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.42 – 7.32 (8H, m, 8×Ar**H**), 7.22 (2H, d, *J* = 7.1 Hz, 2×Ar**H**), 5.28 (1H, dq, *J* = 1.8, 1.0 Hz, =C**H**H), 5.24 (1H, dq, *J* = 1.8, 1.2 Hz, =CH**H**), 4.76 (1H, d, *J* = 15.3 Hz, NC**H**H), 4.67 (1H, d, *J* = 15.2 Hz, NCH**H**), 4.48 (1H, d, *J* = 16.0 Hz, NC**H**H), 4.37 (1H, d, *J* = 16.0 Hz, NCH**H**), 1.84 (3H, t, *J* = 1.2 Hz, C**H**$_3$), 1.72 (3H, s C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 184.7 (**C**), 170.5 (**C**), 135.5 (**C**), 135.1 (**C**), 129.1 (2×**C**H), 128.8 (2×**C**H), 128.7 (2×**C**H), 128.1 (**C**H),

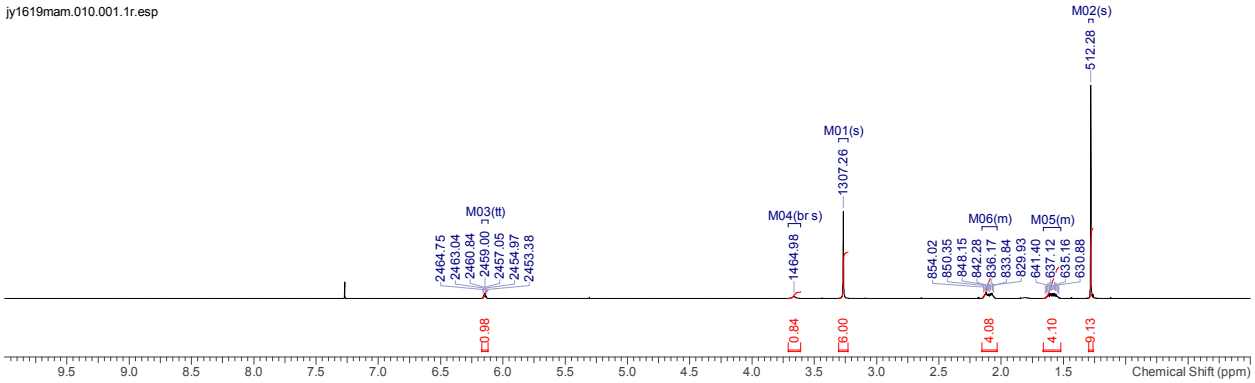
128.1 (**C**H), 126.9 (2×**C**H), 125.9 (**C**), 123.0 (**C**H_2), 114.8 (**C**), 88.9 (**C**), 83.9 (**C**), 82.2 (**C**), 53.7 (**C**H_2), 50.9 (**C**H_2), 23.0 (**C**H_3), 7.7 (**C**H_3). **LRMS** (ESI$^+$): 358 ([M+H]$^+$, 100%).

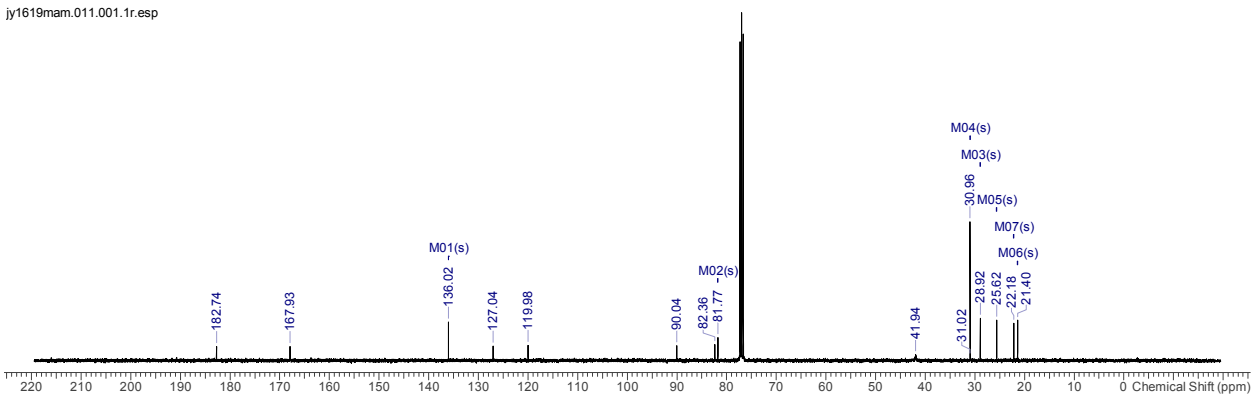


2-(*t*-Butyl)-4-(cyclohex-1-en-1-ylethynyl)-3-(dimethylamino)-4-hydroxycyclobut-2-en-1-one (1c).

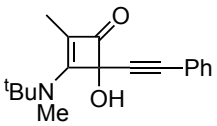


To a solution of 1-ethenylcyclohexene **11b** (0.718 mL, 6.10 mmol) in THF (30 mL) at –78 °C was added ^{n}butyllithium (2.5 M in hexanes, 2.44 mL, 6.25 mmol) dropwise. After 20 min, the solution was added *via* cannula to a solution of cyclobutenedione **10a** (852 mg, 4.70 mmol) in THF (70 mL) at –78 °C. After a further 105 min, sat. NH_4Cl (20 mL) was added then the solution was warmed to RT and diluted with water (50 mL). The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the organic phases were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (10 – 20% acetone/DCM) to afford the title compound **1c** (1.33 g, 4.64 mmol, 99%) as an off-white oil. **IR** ν_{max} (film, cm^{-1}): 3252 (br w), 2930 (m), 2861 (w), 1732 (m), 1577 (vs), 1436 (w), 1406 (m), 1137 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 6.15 (1H, tt, *J* = 3.9, 1.8 Hz, C=C**H**), 3.66 (1H, br s, O**H**), 3.27 (6H, s, 2×NC**H**$_3$), 2.14 – 2.06 (4H, m, 2×C**H**$_2$), 1.65 – 1.54 (4H, m, 2×C**H**$_2$), 1.28 (9H, s, C(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 182.7 (**C**), 167.9 (**C**), 136.0 (**C**H), 127.0 (**C**), 120.0 (**C**), 90.0 (**C**), 82.4 (**C**), 81.8 (**C**), 41.9 (br s, 2×**C**H$_3$), 31.0 (**C**), 31.0 (3×**C**H$_3$), 28.9 (**C**H$_2$), 25.6 (**C**H$_2$), 22.2 (**C**H$_2$), 21.4 (**C**H$_2$). **LRMS** (ESI$^+$): 288 ([M+H]$^+$, 100%).

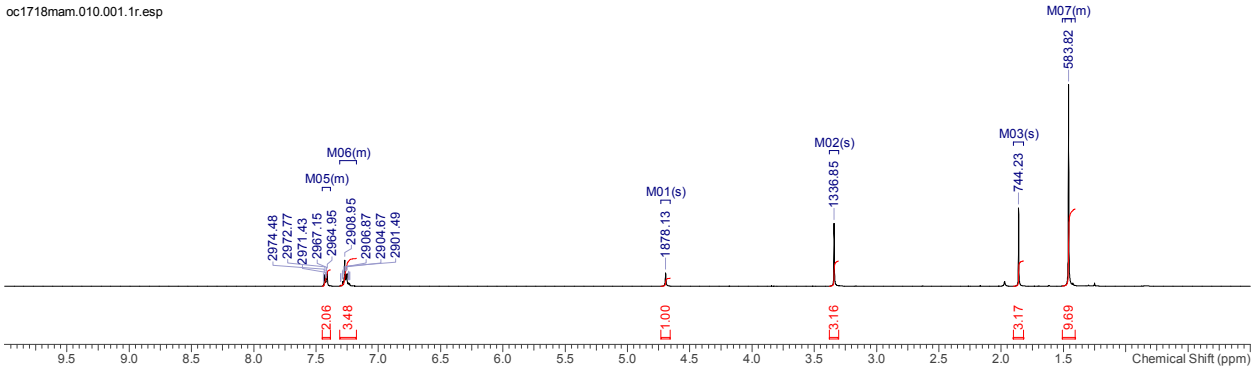


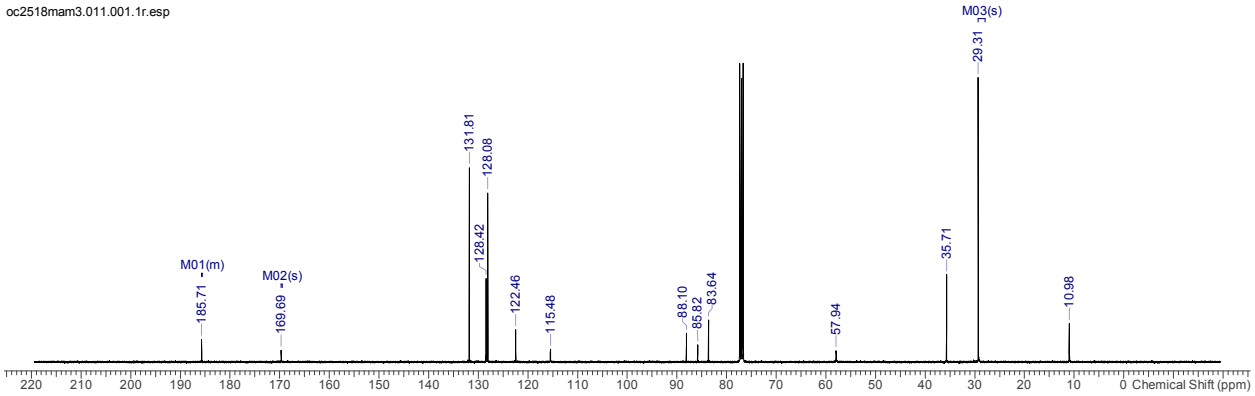


3-(*t*-Butyl(methyl)amino)-4-hydroxy-2-methyl-4-(phenylethynyl)cyclobut-2-en-1-one (4b).

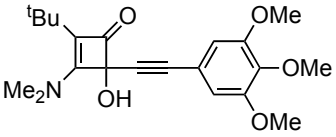


To a solution of phenylacetylene **11a** (0.470 mL, 4.28 mmol) in THF (30 mL) at –78 °C was added ^{n}butyllithium (2.5 M in hexanes, 1.71 mL, 4.28 mmol) dropwise. After 10 min, the solution was added *via* cannula to a solution of cyclobutenedione **10d** (646 mg, 3.56 mmol) in THF (50 mL) at –78 °C. After a further 80 min, sat. NH_4Cl (20 mL) was added then the solution warmed to RT and diluted with water (40 mL). The aqueous phase was separated and extracted with DCM (3 × 50 mL) then the combined organic phases were dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (80 – 100% ethyl acetate/petrol) to afford the title compound **4b** (791 mg, 2.79 mmol, 78%) as a white solid. **MP**: 160 °C dec (Et_2O). **IR** ν_{max} (film, cm^{-1}): 3248 (br w), 2981 (m), 1734 (m), 1556 (vs), 1394 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.44 – 7.41 (2H, m, 2×Ar**H**), 7.29 – 7.23 (3H, m, 3×Ar**H**), 4.69 (1H, s, O**H**), 3.34 (3H, s, NC**H$_3$**), 1.86 (3H, s, C**H$_3$**), 1.46 (9H, s, C(C**H$_3$**)$_3$). **^{13}C NMR** (125 MHz, $CDCl_3$): δ ppm 185.7 (**C**), 169.7 (**C**), 131.8 (2×**C**H), 128.4 (**C**H), 128.1 (2×**C**H), 122.5 (**C**), 115.5 (**C**), 88.1 (**C**), 85.8 (**C**), 83.6 (**C**), 57.9 (**C**), 35.7 (**C**H$_3$), 29.3 (3×**C**H$_3$), 11.0 (**C**H$_3$). **LRMS** (ESI$^+$): 284 ([M+H]$^+$, 100%).



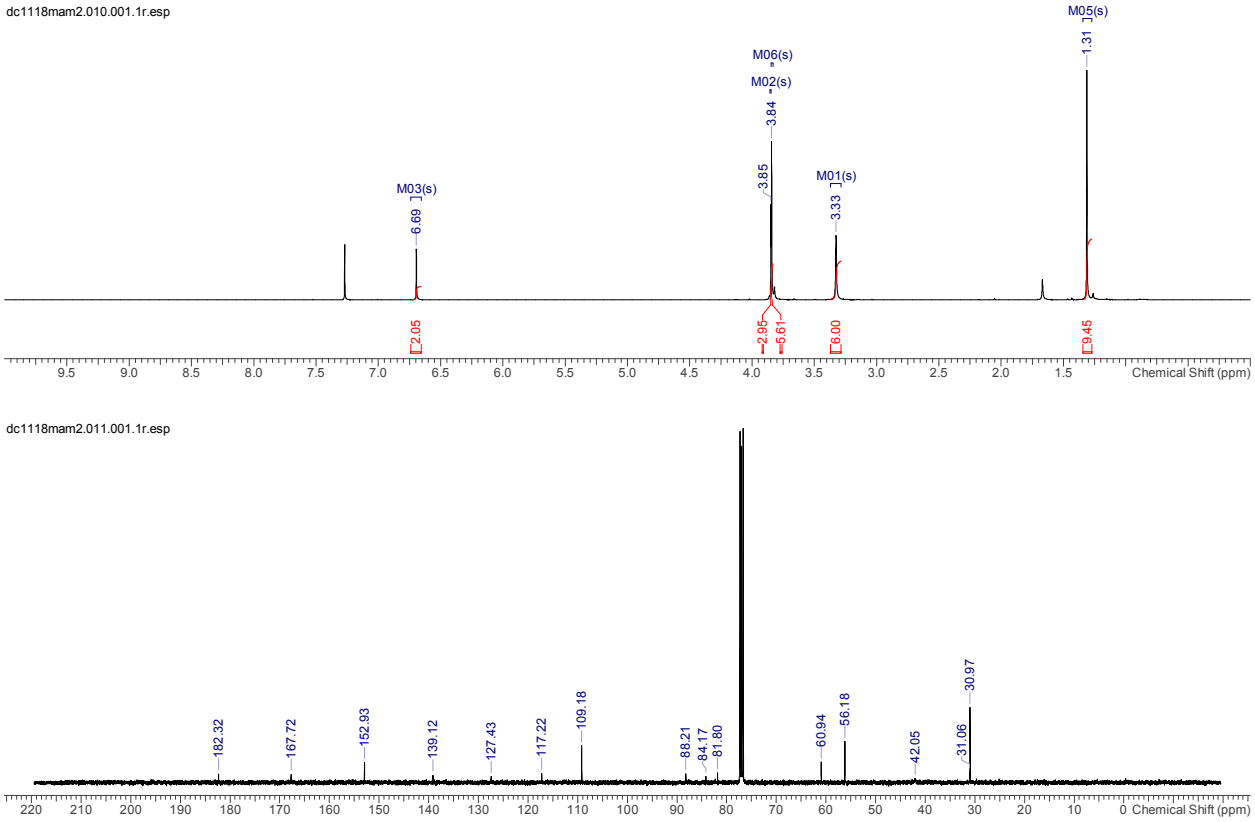


2-(*t*-Butyl)-3-(dimethylamino)-4-hydroxy-4-((3,4,5-trimethoxyphenyl)ethynyl)cyclobut-2-en-1-one (4c).

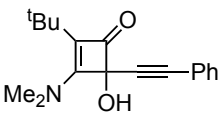


To a solution of 1-ethynyl-3,4,5-trimethoxybenzene **11d** (362 mg, 1.88 mmol) in THF (30 mL) at –78 °C was added ^{n}butyllithium (2.5 M in hexanes, 0.75 mL, 1.88 mmol) dropwise. After 15 min, the solution was added *via* cannula to a

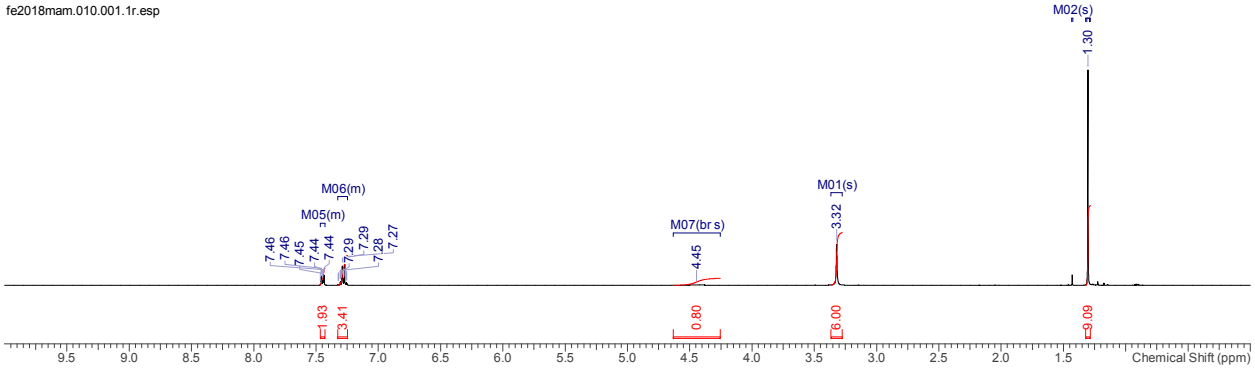
solution of cyclobutenedione **10a** (284 mg, 1.57 mmol) in THF (30 mL) at –78 °C. After a further 100 min, sat. NH_4Cl (20 mL) was added and the solution warmed to RT. The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the combined organic phases were dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (60 – 100% ethyl acetate/petrol) to afford the title compound **4c** (544 mg, 1.46 mmol, 93%) as a yellow solid. **MP**: 160 °C dec (DCM). **IR** ν_{max} (film, cm^{-1}): 3225 (br w), 2959 (w), 1732 (w), 1575 (vs), 1503 (m), 1408 (m), 1236 (m), 1126 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 6.69 (2H, s, 2×Ar**H**), 3.85 (3H, s, O**CH$_3$**), 3.84 (6H, s, 2×O**CH$_3$**), 3.82 (1H, br s, O**H**), 3.33 (6H, s, 2×N**CH$_3$**), 1.31 (9H, s, C(**CH$_3$**)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 182.3 (**C**), 167.7 (**C**), 152.9 (2×**C**), 139.1 (**C**), 127.4 (**C**), 117.2 (**C**), 109.2 (2×**C**H), 88.2 (**C**), 84.2 (**C**), 81.8 (**C**), 60.9 (**C**H$_3$), 56.2 (2×**C**H$_3$), 42.1 (br s, 2×**C**H$_3$), 31.1 (**C**), 31.0 (3×**C**H$_3$). **LRMS** (ESI$^+$): 374 ([M+H]$^+$, 100%).

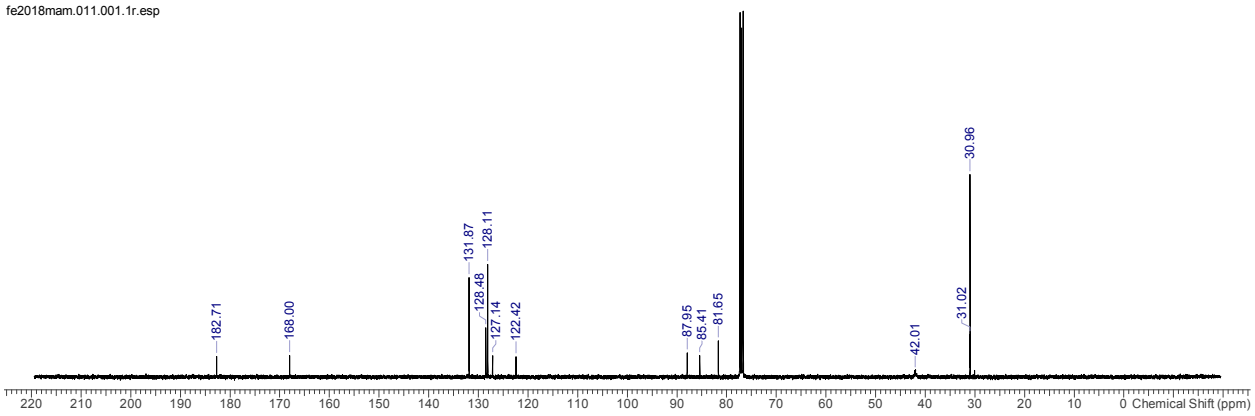


2-(*t*-Butyl)-3-(dimethylamino)-4-hydroxy-4-(phenylethynyl)cyclobut-2-en-1-one (4e).

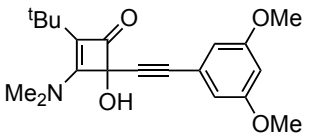


To a solution of phenylacetylene **11c** (5.0 mL, 45.5 mmol) in THF (150 mL) at –78 °C was added *n*butyllithium (2.5 M in hexanes, 17.2 mL, 43.1 mmol) dropwise. After 20 min, the solution was added *via* cannula to a solution of cyclobutenedione **10a** (6.51 g, 35.9 mmol) in THF (250 mL) at –78 °C. After a further 70 min, sat. NH_4Cl (50 mL) was added then the solution was warmed to RT and diluted with water (100 mL). The aqueous phase was separated and extracted with DCM (300 mL then 2 × 100 mL) then the combined organic phases were dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (10 – 100% ethyl acetate/petrol) to afford the title compound **4e** (9.76 g, 34.4 mmol, 96%) as a yellow solid. **MP**: 150 °C dec (DCM). **IR** ν_{max} (film, cm^{-1}): 3239 (br w), 2959 (w), 1732 (m), 1572 (s), 1489 (w), 1406 (m), 1364 (w), 1256 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.46 – 7.44 (2H, m, 2×Ar**H**), 7.30 – 7.27 (3H, m, 3×Ar**H**), 4.45 (1H, br s, O**H**), 3.32 (6H, br s, N(**CH$_3$**)$_2$), 1.30 (9H, s, C(**CH$_3$**)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 182.7 (**C**), 168.0 (**C**), 131.9 (2×**C**H), 128.5 (**C**H), 128.1 (2×**C**H), 127.1 (**C**), 122.4 (**C**), 88.0 (**C**), 85.4 (**C**), 81.7 (**C**), 42.0 (br s, 2×**C**H$_3$), 31.0 (**C**), 31.0 (3×**C**H$_3$). **LRMS** (ESI$^+$): 284 ([M+H]$^+$, 100%). Data consistent with literature values.[1]

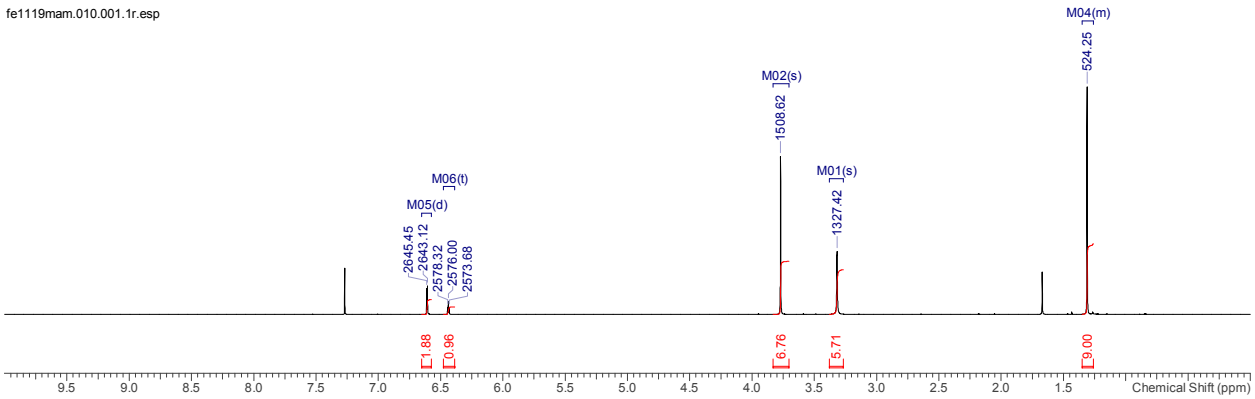


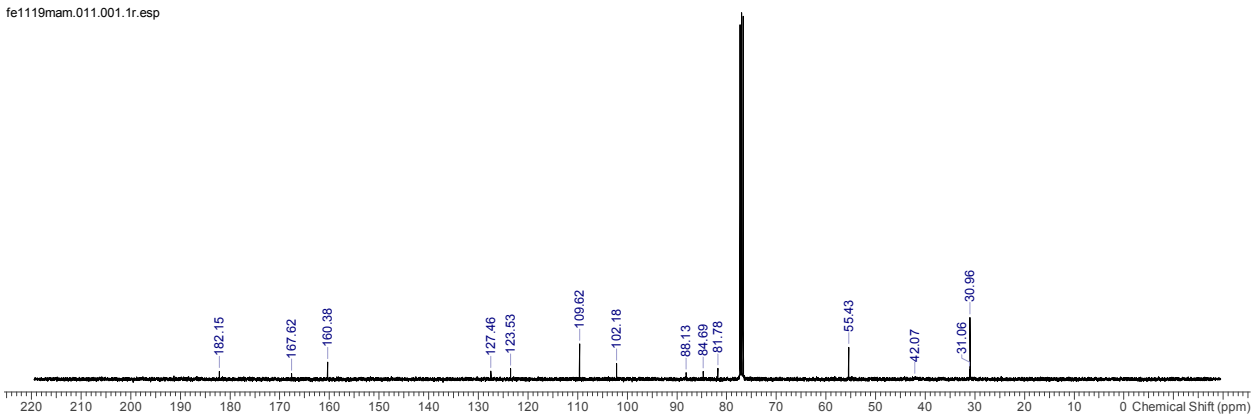


2-(*t*-Butyl)-4-((3,5-dimethoxyphenyl)ethynyl)-3-(dimethylamino)-4-hydroxycyclobut-2-en-1-one (4f).

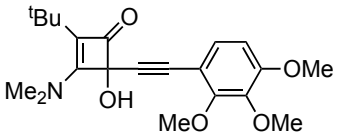


To a solution of 1-ethynyl-3,5-dimethoxybenzene **11e** (129 mg, 0.794 mmol) in THF (20 mL) at –78 °C was added ^{n}butyllithium (2.5 M in hexanes, 0.35 mL, 0.875 mmol) dropwise. After 15 min, the solution was added *via* cannula to a solution of cyclobutenedione **10a** (120 mg, 0.661 mmol) in THF (30 mL) at –78 °C. After a further 2 h, sat. NH_4Cl (20 mL) was added then the solution was warmed to RT and diluted with water (20 mL). The aqueous phase was separated and extracted with DCM (3 × 50 mL) then the combined organic phases were dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (40 – 60% ethyl acetate/petrol) afforded the title compound **4f** (128 mg, 0.372 mmol, 56%) as a white solid. **MP**: 140 °C dec (DCM). **IR** ν_{max} (film, cm^{-1}): 3227 (br w), 2961 (w), 1732 (w), 1580 (vs), 1205 (m), 1156 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 6.61 (2H, d, *J* = 2.3 Hz, 2×Ar**H**), 6.44 (1H, t, *J* = 2.3 Hz, Ar**H**), 3.77 (6H, s, 2×OC**H**$_3$), 3.32 (6H, s, 2×NC**H**$_3$), 1.31 (9H, s, C(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 182.2 (**C**), 167.6 (**C**), 160.4 (2×**C**), 127.5 (**C**), 123.5 (**C**), 109.6 (2×**C**H), 102.2 (**C**H), 88.1 (**C**), 84.7 (**C**), 81.8 (**C**), 55.4 (2×**C**H$_3$), 42.1 (br s, 2×**C**H$_3$), 31.1 (**C**), 31.0 (3×**C**H$_3$). **LRMS** (ESI$^+$): 344 ([M+H]$^+$, 100%).

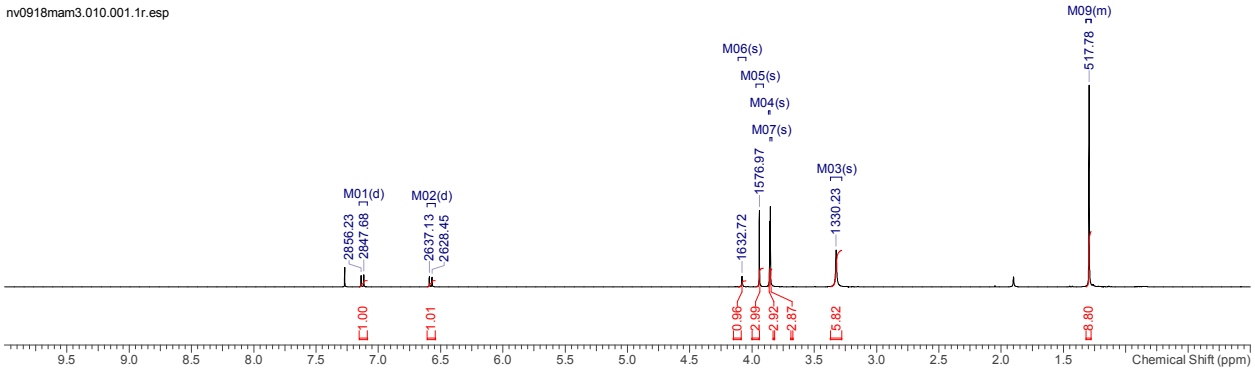


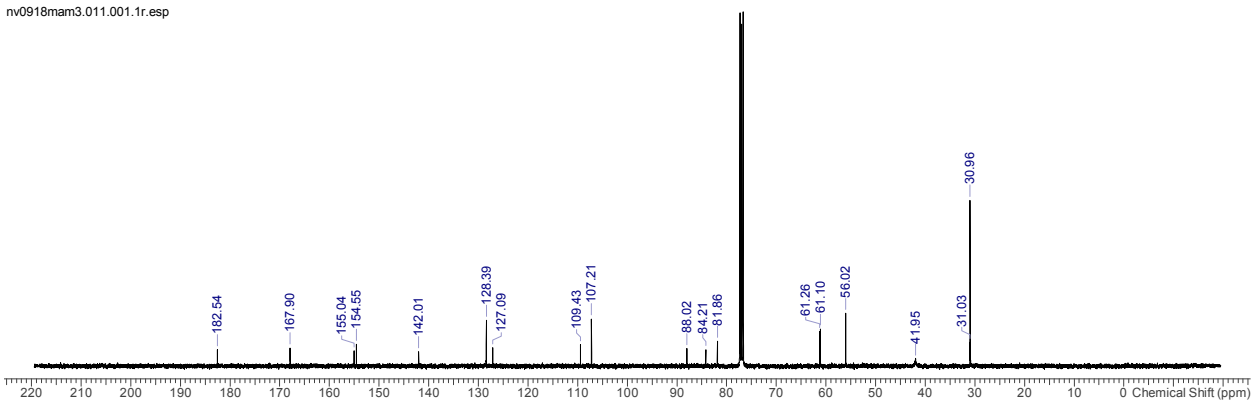


2-(*t*-Butyl)-3-(dimethylamino)-4-hydroxy-4-((4-(trifluoromethyl)phenyl)ethynyl)cyclobut-2-en-1-one (4g).

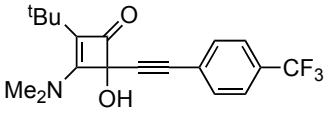


To a solution of 1-ethynyl-2,3,4-trimethoxybenzene **11f** (925 mg, 4.81 mmol) in THF (20 mL) at –78 °C was added *n*butyllithium (2.5 M in hexanes, 2.00 mL, 5.00 mmol) dropwise. After 20 min, the solution was added *via* cannula to a solution of cyclobutenedione **10a** (702 mg, 3.87 mmol) in THF (60 mL) at –78 °C. After a further 90 min, sat. NH_4Cl (20 mL) was added then the solution was warmed to RT and diluted with water (50 mL). The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the organic phases were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (50 – 100% ethyl acetate/petrol) to afford the title compound **4g** (1.28 g, 3.44 mmol, 89%) as a white foam. **IR** ν_{max} (film, cm^{-1}): 3253 (br w), 2960 (w), 1733 (w), 1580 (vs), 1493 (m), 1410 (m), 1090 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.13 (1H, d, *J* = 8.6 Hz, Ar**H**), 6.58 (1H, d, *J* = 8.7 Hz, Ar**H**), 4.08 (1H, br s, O**H**), 3.94 (3H, s, OC**H**$_3$), 3.86 (6H, s, 2×OC**H**$_3$), 3.32 (6H, br s, N(C**H**$_3$)$_2$), 1.29 (9H, s, C(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 182.5 (**C**), 167.9 (**C**), 155.0 (**C**), 154.6 (**C**), 142.0 (**C**), 128.4 (**C**H), 127.1 (**C**), 109.4 (**C**), 107.2 (**C**H), 88.0 (**C**), 84.2 (**C**), 81.9 (**C**), 61.3 (**C**H$_3$), 61.1 (**C**H$_3$), 56.0 (**C**H$_3$), 42.0 (br s, 2×**C**H$_3$), 31.0 (**C**), 31.0 (3×**C**H$_3$). **LRMS** (ESI$^+$): 374 ([M+H]$^+$, 100%).

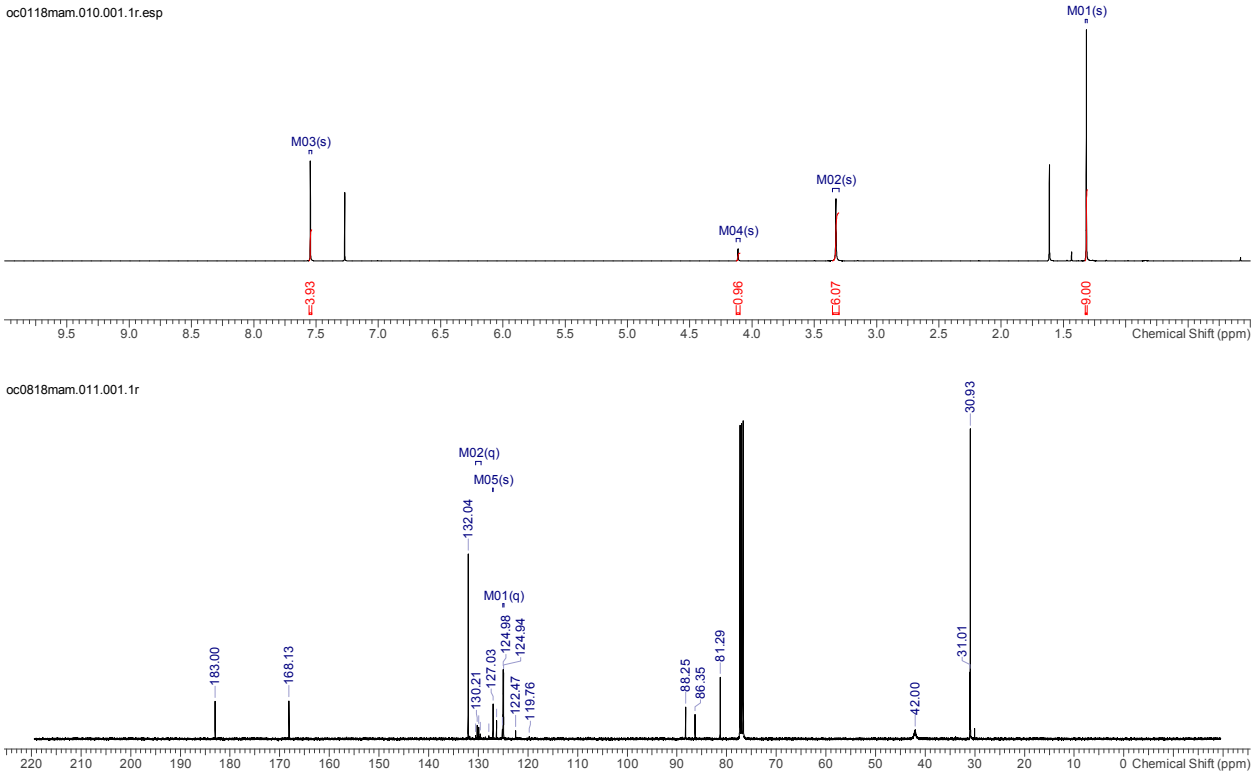




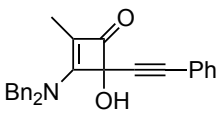
2-(*t*-Butyl)-3-(dimethylamino)-4-hydroxy-4-((4-(trifluoromethyl)phenyl)ethynyl)cyclobut-2-en-1-one (4h).



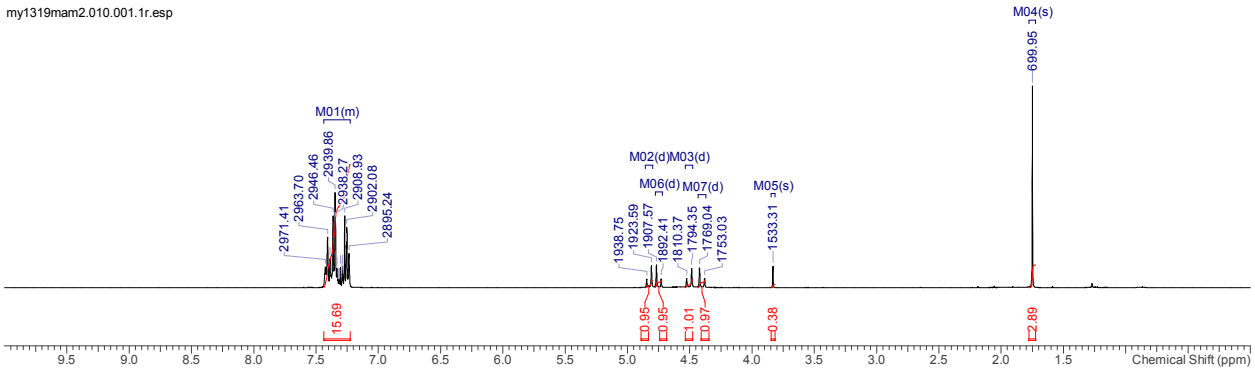
To a solution of 4-(trifluoromethyl)phenylacetylene **11g** (0.6 mL, 3.71 mmol) in THF (40 mL) at –78 °C was added *n*butyllithium (2.5 M in hexanes, 1.5 mL, 3.71 mmol) dropwise. After 15 min, the solution was added *via* cannula to a solution of cyclobutenedione **10a** (560 mg, 3.09 mmol) in THF (60 mL) at –78 °C. After a further 80 min, sat. NH_4Cl (20 mL) was added then the solution was warmed to RT and diluted with water (25 mL). The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the organic phases were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (50 – 70% ethyl acetate/petrol) to afford the title compound **4h** (992 mg, 2.82 mmol, 91%) as a white solid. **MP**: 150 °C dec (DCM). **IR** ν_{max} (film, cm^{-1}): 3235 (br w), 2962 (w), 1733 (w), 1577 (s), 1407 (m) 1322 (s), 1167 (m), 1126 (m), 1106 (s), 1063 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.55 – 7.50 (4H, m, 4×Ar**H**), 4.89 (1H, s, O**H**), 3.33 (6H, br s, N(C**H**$_3$)$_2$), 1.31 (9H, s, C(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 183.0 (**C**), 168.1 (**C**), 132.0 (2×**C**H), 130.1 (**C**, q, *J* = 32.8 Hz), 127.0 (**C**), 126.3 (**C**), 125.0 (2×**C**H, q, *J* = 3.7 Hz), 123.8 (**C**F$_3$, q, J_{C-F} = 272 Hz), 88.3 (**C**), 86.4 (**C**), 81.3 (**C**), 42.0 (br s, 2×**C**H$_3$), 31.0 (**C**), 30.9 (3×**C**H$_3$). **LRMS** (ESI$^+$): 352 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{19}H_{20}F_3NO_2$ [M+H]$^+$ 352.1519, found: 352.1525.

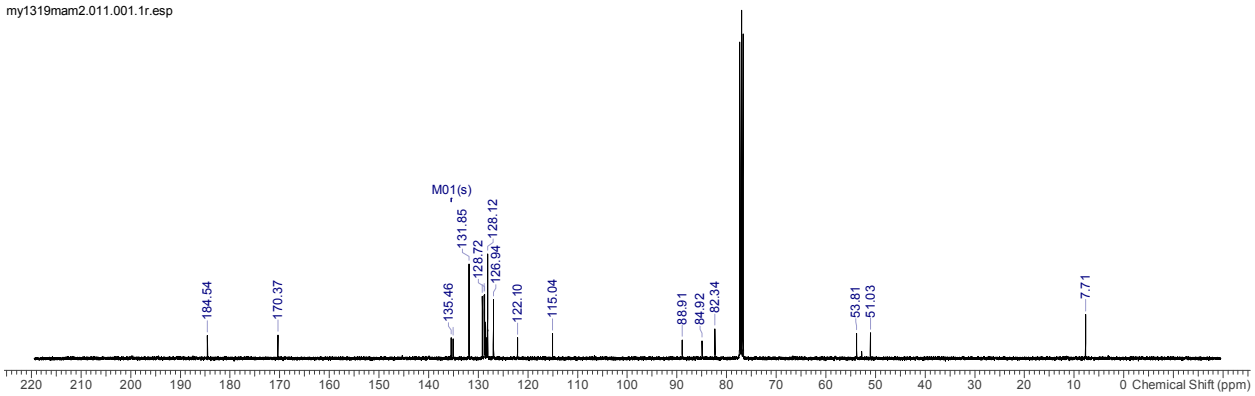


3-(Dibenzylamino)-4-hydroxy-2-methyl-4-(phenylethynyl)cyclobut-2-en-1-one (4i).

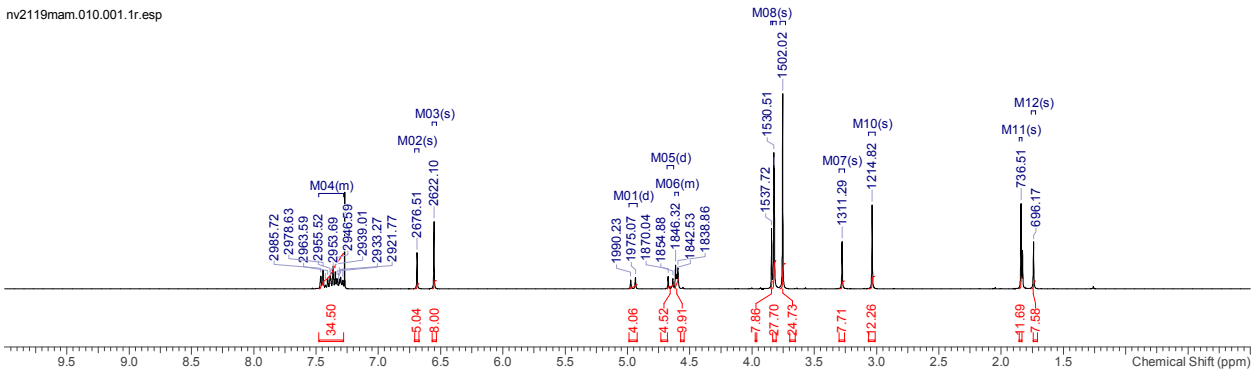


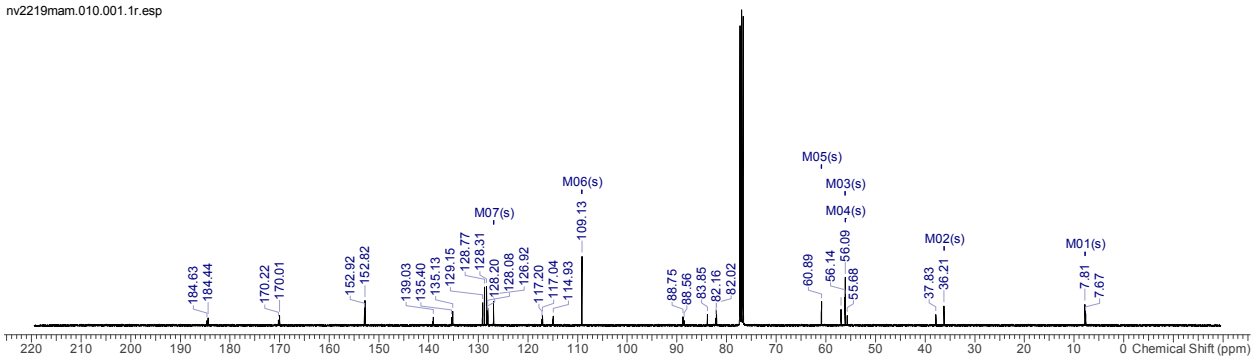
To a solution of phenylacetylene **11c** (0.30 mL, 2.76 mmol) in THF (25 mL) at –78 °C was added *n*butyllithium (2.5 M in hexanes, 1.2 mL, 2.99 mmol) dropwise. After 15 min, the solution was added *via* cannula to a solution of cyclobutenedione **10b** (672 mg, 2.30 mmol) in THF (65 mL) at –78 °C. After a further 70 min, sat. NH_4Cl (30 mL) was added then the solution was warmed to RT and diluted with water (50 mL). The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the combined organic phases were dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (40 – 50% ethyl acetate/petrol) to afforded the title compound **4i** (862 mg, 2.19 mmol, 95%) as an off-white solid. **MP**: 162–163 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 3227 (br w), 1748 (m), 1590 (s), 1570 (vs), 1490 (w), 1442 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.43 – 7.24 (15H, m, 15×Ar**H**), 4.82 (1H, d, *J* = 15.3 Hz, NC**H**H), 4.76 (1H, d, *J* = 15.0 Hz, NCH**H**), 4.50 (1H, d, *J* = 16.1 Hz, NC**H**H), 4.41 (1H, d, *J* = 16.0 Hz, NCH**H**), 3.83 (1H, br s, O**H**), 1.75 (3H, s C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 184.5 (**C**), 170.4 (**C**), 135.5 (**C**), 135.1 (**C**), 131.9 (2×**C**H), 129.2 (2×**C**H), 128.8 (2×**C**H), 128.7 (2×**C**H), 128.6 (**C**H), 128.1 (2×**C**H), 128.1 (**C**H), 126.9 (2×**C**H), 122.1 (**C**), 115.0 (**C**), 88.9 (**C**), 84.9 (**C**), 82.3 (**C**), 53.8 (**C**H$_2$), 51.0 (**C**H$_2$), 7.7 (**C**H$_3$). **LRMS** (ESI$^+$): 394 ([M+H]$^+$, 100%).



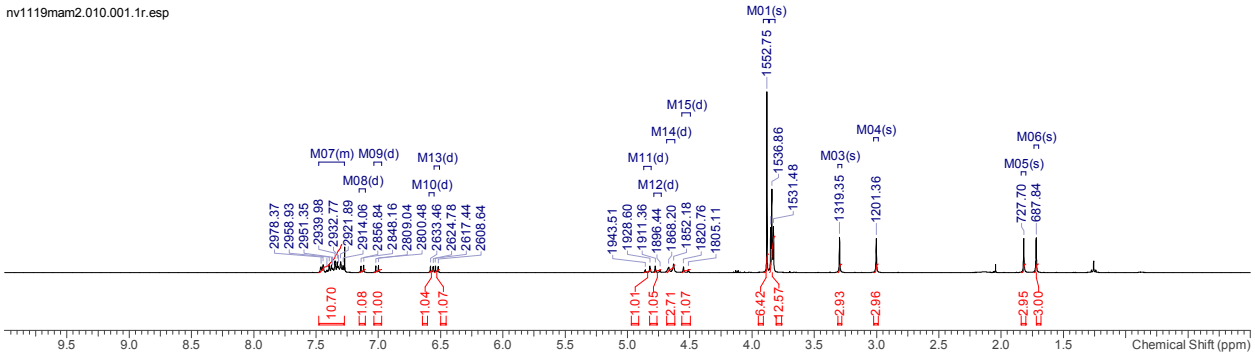


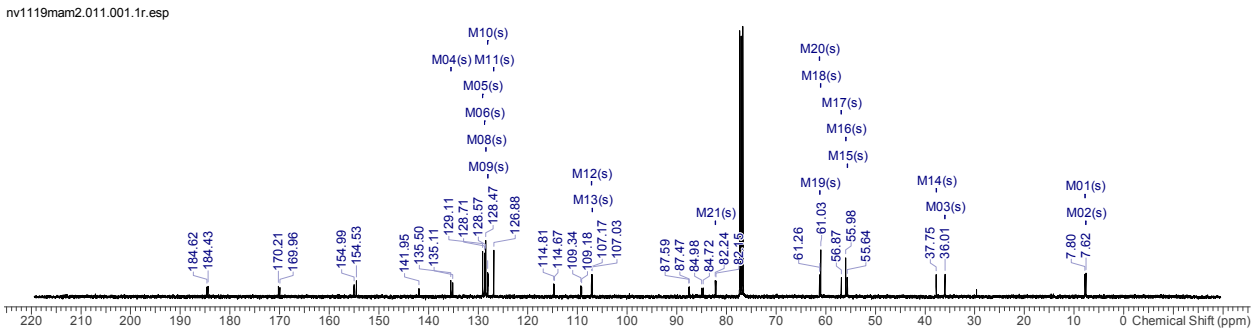
3-(Benzyl(methyl)amino)-4-hydroxy-2-methyl-4-((3,4,5-trimethoxyphenyl)ethynyl)cyclobut-2-en-1-one (4j). To a solution of 5-ethynyl-1,2,3-trimethoxybenzene **11d** (926 mg, 4.88 mmol) in THF (40 mL) at –78 °C was added *n*butyllithium (2.5 M in hexanes, 1.22 mL, 3.10 mmol) dropwise. After 10 min, the solution was added *via* cannula to a solution of cyclobutenedione **10e** (876 mg, 4.07 mmol) in THF (70 mL) at –78 °C. After a further 75 min, sat. NH_4Cl (20 mL) was added and the solution warmed to RT. The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the combined organic phases were dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (50 – 100% ethyl acetate/petrol) to afford the title compound **4j** (533 mg, 1.31 mmol, 32%) as a pale brown solid. **MP**: 80 – 83 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 3257 (br w), 2938 (w), 1749 (w), 1590 (s), 1574 (vs), 1503 (m), 1451 (m), 1411 (m), 1237 (m), 1125 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): 8:5 mixture of rotamers, *major rotamer*: δ ppm 7.46 – 7.28 (5H, m, 5×Ar**H**), 6.55 (2H, s, Ar**H**), 4.96 (1H, d, *J* = 15.2 Hz, NC**H**H), 4.65 (1H, d, *J* = 15.2 Hz, NCH**H**), 3.82 (3H, s, OC$\mathbf{H}_3$), 3.75 (6H, s, 2×OC$\mathbf{H}_3$), 3.04 (3H, s, NC$\mathbf{H}_3$), 1.84 (3H, s C$\mathbf{H}_3$); *minor rotamer*: 7.46 – 7.28 (5H, m, 5×Ar**H**), 6.69 (2H, s, Ar**H**), 4.61 (2H, m, NC$\mathbf{H}_2$), 3.84 (3H, s, OC$\mathbf{H}_3$), 3.82 (6H, s, 2×OC$\mathbf{H}_3$), 3.28 (3H, s, NC$\mathbf{H}_3$), 1.74 (3H, s C$\mathbf{H}_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): *major rotamer*: δ ppm 184.4 (**C**), 170.0 (**C**), 152.8 (2×**C**), 139.0 (**C**), 135.1 (**C**), 128.8 (2×**C**H), 128.3 (2×**C**H), 126.9 (**C**H), 117.0 (**C**), 114.9 (**C**), 109.1 (2×**C**H), 88.8 (**C**), 83.9 (**C**), 82.2 (**C**), 60.9 (**C**H_3), 56.9 (**C**H_2), 56.1 (2×**C**H_3), 36.2 (**C**H_3), 7.8 (**C**H_3); *minor rotamer*: 184.6 (**C**), 170.2 (**C**), 152.9 (2×**C**), 139.1 (**C**), 135.4 (**C**), 129.2 (2×**C**H), 128.2 (**C**H), 128.1 (2×**C**H), 117.2 (**C**), 115.0 (**C**), 109.1 (2×**C**H), 88.6 (**C**), 83.9 (**C**), 82.2 (**C**), 60.9 (**C**H_3), 56.1 (2×**C**H_3), 55.7 (**C**H_2), 37.8 (**C**H_3), 7.7 (**C**H_3). **LRMS** (ESI^+): 408 ($[M+H]^+$, 100%). **HRMS** (ESI^+): Calculated for $C_{24}H_{26}NO_5$ $[M+H]^+$ 408.1805, found: 408.1810.



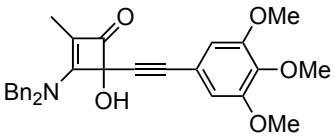


3-(Benzyl(methyl)amino)-4-hydroxy-2-methyl-4-((2,3,4-trimethoxyphenyl)ethynyl)cyclobut-2-en-1-one (4k). To a solution of 5-ethynyl-1,2,3-trimethoxybenzene **11f** (613 mg, 3.19 mmol) in THF (30 mL) at –78 °C was added ^{n}butyllithium (2.5 M in hexanes, 1.50 mL, 3.75 mmol) dropwise. After 15 min, the solution was added *via* cannula to a solution of cyclobutenedione **10e** (734 mg, 3.41 mmol) in THF (70 mL) at –78 °C. After a further 1 h, sat. NH_4Cl (20 mL) was added and the solution warmed to RT. The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the combined organic phases were dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (50 – 100% ethyl acetate/petrol) to afford the title compound **4k** (376 mg, 0.922 mmol, 27%) as a pale brown gum. **IR** ν_{max} (film, cm^{-1}): 3241 (br s), 2939 (w), 1749 (w), 1091 (vs), 1577 (vs), 1493 (m), 1458 (m), 1413 (s), 1298 (m), 1091 (s), 1017 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): 1:1 mixture of rotamers, 7.46 – 7.28 (10H, m, 10×Ar**H**), 7.13 (1H, d, *J* = 8.7 Hz, Ar**H**), 7.01 (1H, d, *J* = 8.6 Hz, Ar**H**), 6.57 (1H, d, *J* = 8.7 Hz, Ar**H**), 6.53 (1H, d, *J* = 8.8 Hz, Ar**H**), 4.83 (1H, d, *J* = 14.9 Hz, NC**H**H), 4.77 (1H, d, *J* = 14.8 Hz, NCH**H**), 4.64 (2H, brs, 2×O**H**), 4.64 (1H, d, *J* = 15.9 Hz, NC**H**H), 4.54 (1H, d, *J* = 15.9 Hz, NCH**H**), 3.88 (6H, s, 2×OC**H**$_3$), 3.84 (12H, m, 4×OC**H**$_3$), 3.30 (3H, s, NC**H**$_3$), 3.00 (3H, s, NC**H**$_3$), 1.82 (3H, s C**H**$_3$), 1.72 (3H, s C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): 184.6 + 184.4 (**C**), 170.2 + 170.0 (**C**), 155.0 + 155.0 (**C**), 154.6 + 154.5 (**C**), 142.0 + 141.9 (**C**), 135.5 + 135.1 (**C**), 129.1 + 128.7 (2×**C**H), 128.6 + 128.5 (2×**C**H), 128.1 + 128.1 (**C**H), 126.9 (2×**C**H), 114.8 + 114.7 (**C**), 109.3 + 109.2 (**C**), 107.2 + 107.0 (**C**H), 87.6 + 87.5 (**C**), 85.0 + 84.7 (**C**), 82.2 + 82.2 (**C**), 61.3 + 61.2 (**C**H$_3$), 61.0 + 56.0 (2×**C**H$_3$), 56.9 + 55.6 (**C**H$_2$), 37.7 + 36.0 (**C**H$_3$), 7.8 + 7.6 (**C**H$_3$). **LRMS** (ESI$^+$): 408 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{24}H_{26}NO_5$ [M+H]$^+$ 408.1805, found: 408.1812.

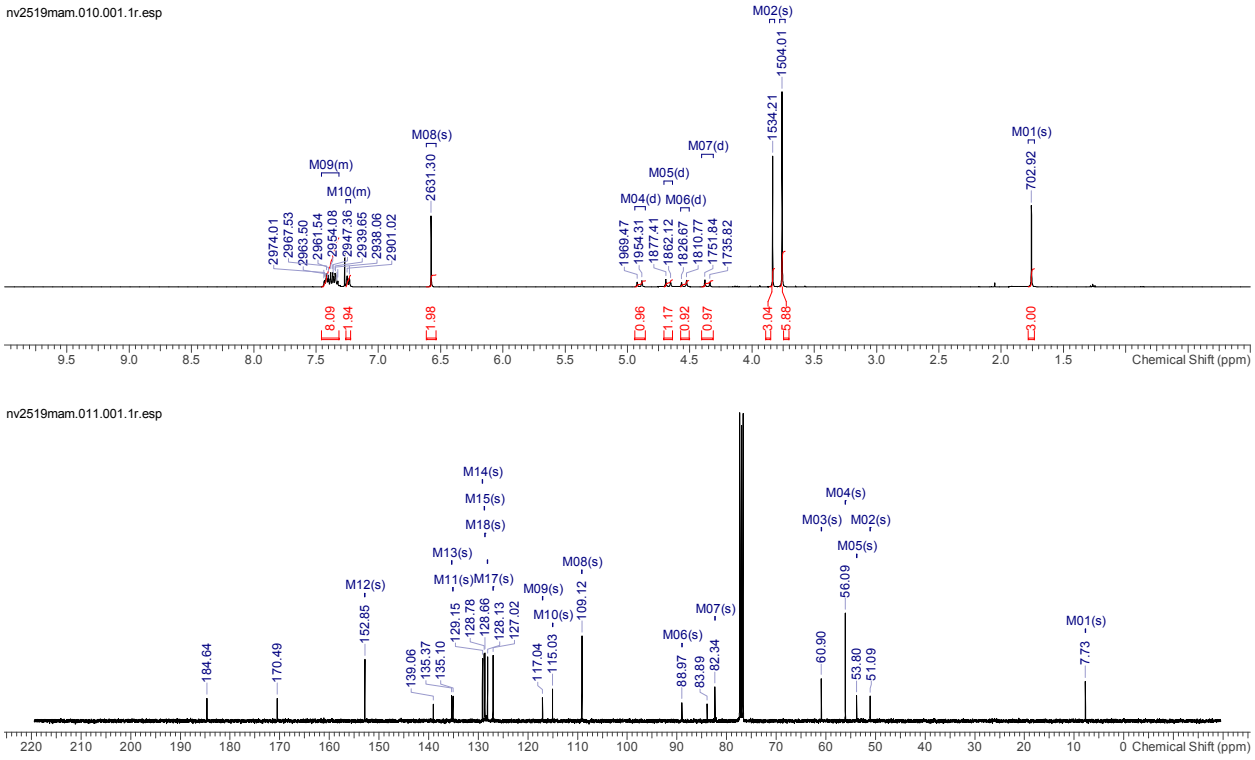




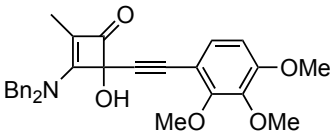
3-(Dibenzylamino)-4-hydroxy-2-methyl-4-((3,4,5-trimethoxyphenyl)ethynyl)cyclobut-2-en-1-one (4l).



To a solution of 5-ethynyl-1,2,3-trimethoxybenzene **11f** (511 mg, 2.66 mmol) in THF (30 mL) at –78 °C was added *n*butyllithium (2.5 M in hexanes, 1.1 mL, 2.75 mmol) dropwise. After 20 min, the solution was added *via* cannula to a solution of cyclobutenedione **10b** (692 mg, 2.37 mmol) in THF (60 mL) at –78 °C. After a further 70 min, sat. NH_4Cl (20 mL) was added and the solution warmed to RT. The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the combined organic phases were dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (50 – 80% ethyl acetate/petrol) to afford the title compound **4l** (772 mg, 1.60 mmol, 67%) as a pale brown solid. **MP**: 63 – 64 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 3246 (br w), 2938 (w), 1747 (m), 1590 (s), 1569 (vs), 1442 (s), 1411 (m), 1237 (s), 1125 (s), 1092 (m), 1002 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.46 – 7.33 (8H, m, 8×Ar**H**), 7.27 – 7.23 (2H, m, 2×Ar**H**), 6.58 (2H, s, 2×Ar**H**), 4.90 (1H, d, *J* = 15.2 Hz, NC**H**H), 4.67 (1H, d, *J* = 15.3 Hz, NCH**H**), 4.55 (1H, d, *J* = 15.9 Hz, NC**H**H), 4.36 (1H, d, *J* = 16.0 Hz, NCH**H**), 3.83 (3H, s, OC**H**$_3$), 3.76 (6H, s, 2×OC**H**$_3$), 1.76 (3H, s, C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 184.6 (**C**), 170.5 (**C**), 152.9 (2×**C**), 139.1 (**C**), 135.4 (**C**), 135.1 (**C**), 129.2 (2×**C**H), 128.8 (2×**C**H), 128.7 (2×**C**H), 128.1 (2×**C**H), 127.0 (2×**C**H), 117.0 (**C**), 115.0 (**C**), 109.1 (2×**C**H), 89.0 (**C**), 83.9 (**C**), 82.3 (**C**), 60.9 (**C**H$_3$), 56.1 (2×**C**H$_3$), 53.8 (**C**H$_2$), 51.1 (**C**H$_2$), 7.7 (**C**H$_3$). **LRMS** (ESI$^+$): 484 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{31}H_{29}NO_5$ [M+H]$^+$ 484.2118, found: 484.2128.

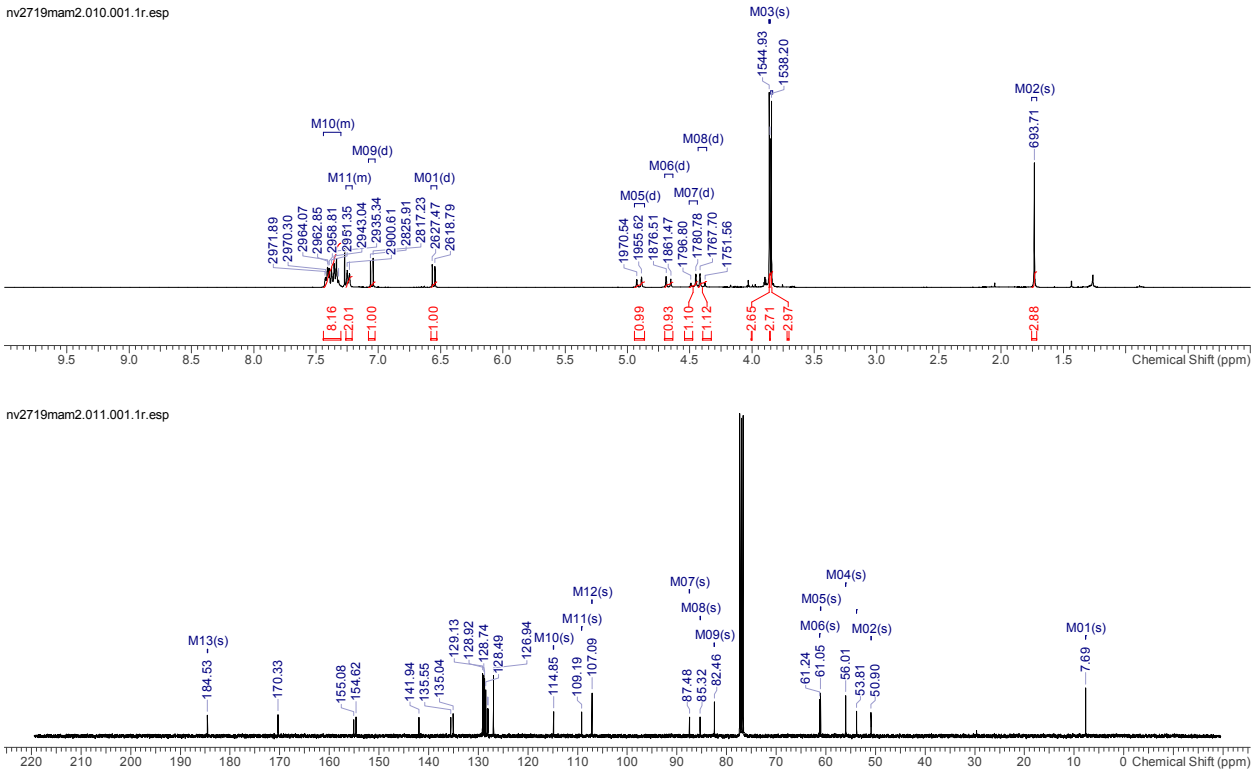


3-(Dibenzylamino)-4-hydroxy-2-methyl-4-((2,3,4-trimethoxyphenyl)ethynyl)cyclobut-2-en-1-one (4m).



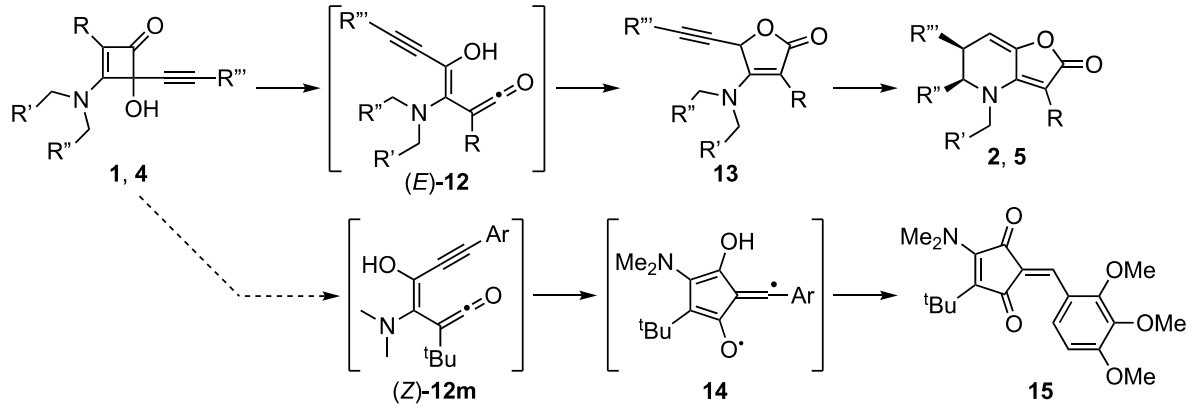
To a solution of 1-ethynyl-2,3,4-trimethoxybenzene **11f** (465 mg, 2.42 mmol) in THF (22 mL) at –78 °C was added *n*butyllithium (2.5 M in hexanes, 1.0 mL, 2.50 mmol) dropwise. After 20 min, the solution was added *via* cannula to a solution of cyclobutenedione **10b** (541 mg, 1.86 mmol) in THF (50 mL) at –78 °C. After a further 70 min, sat. NH_4Cl (20 mL) was added then the solution was warmed to RT and diluted with water (50 mL). The aqueous phase was separated and extracted with DCM (2 × 50 mL) then the organic phases were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (40 – 70% ethyl acetate/petrol) to afford the title compound **4m** (676 mg, 1.40 mmol, 75%) as an orange foam. **IR** ν_{max} (film, cm^{-1}): 3241 (br w), 2938 (w), 1748 (m), 1591 (vs), 1574 (vs), 1466 (m), 1452 (m), 1442 (m), 1413 (m), 1290 (m), 1092 (s), 1016 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.43 – 7.32 (8H, m, 8×Ar**H**), 7.25 – 7.23 (2H, m, 2×Ar**H**), 7.05 (1H, d, *J* = 8.7 Hz, Ar**H**), 6.56 (1H, d, *J* = 8.7 Hz, Ar**H**), 4.91 (1H, d, *J* = 14.9 Hz, NC**H**H), 4.67 (1H, d, *J* = 15.0 Hz, NCH**H**), 4.46 (1H, d, *J* = 16.4 Hz, NC**H**H), 4.41 (1H, d, *J* = 16.1 Hz, NCH**H**), 3.86 (3H, s, OC**H**$_3$), 3.86 (3H, s, OC**H**$_3$), 3.84 (3H, s, OC**H**$_3$), 1.73 (3H, s, C**H**$_3$).

^{13}C NMR (100 MHz, $CDCl_3$): δ ppm 184.5 (**C**), 170.3 (**C**), 155.1 (**C**), 154.6 (**C**), 141.9 (**C**), 135.6 (**C**), 135.0 (**C**), 129.1 (2×**C**H), 128.9 (2×**C**H), 128.7 (2×**C**H), 128.5 (**C**H), 128.1 (**C**H), 128.0 (**C**H), 126.9 (2×**C**H), 114.9 (**C**), 109.2 (**C**), 107.1 (**C**H), 87.5 (**C**), 85.3 (**C**), 82.5 (**C**), 61.2 (**C**H_3), 61.1 (**C**H_3), 53.8 (**C**H_2), 56.0 (**C**H_3), 50.9 (**C**H_2), 7.7 (**C**H_3). **LRMS** (ESI$^+$): 484 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{30}H_{30}NO_5$ [M+H]$^+$ 484.2118, found: 484.2132.

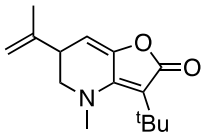


2.3. Preparation of Furopyridinones 2 and 5 by Thermal Rearrangement

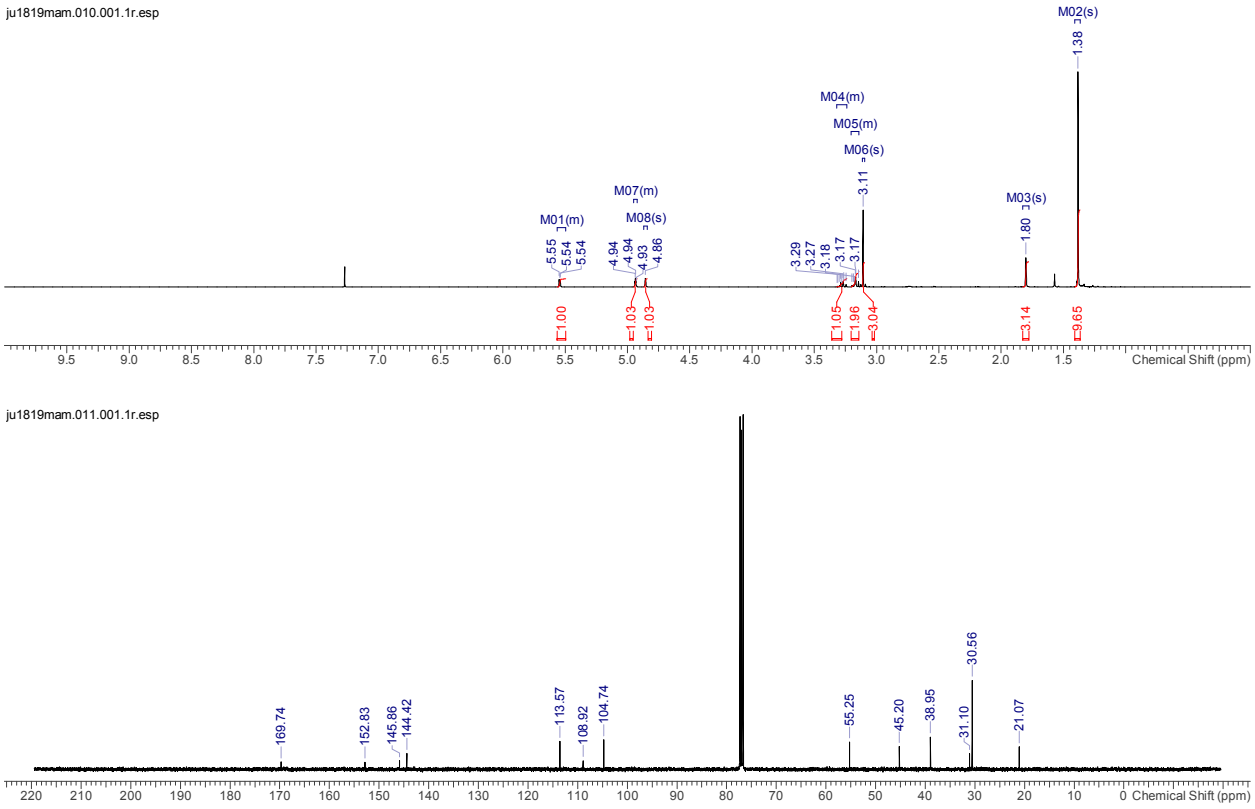
The thermal rearrangements of cyclobutenones **1** and **4** could be conduced in batch or flow. Reactions conducted in batch were more prone to decomposition so were performed at lower reaction temperatures and for shorter reaction times. As a consequence, the intermediate furanone **13** was often observed as a significant byproduct. Substantial improvements in yield were realised when the thermal and photochemical steps were sequenced in flow, as detailed in Schemes 4 and 5 of the paper and in the experimental accounts above. For alkynylcyclobutenone **4m**, cyclopentenedione **15** was also observed as a significant byproduct. It is presumed to arise from a competative opening of cyclobutenone **4m** to vinylketene (*Z*)-**12m** with subsequent cyclisation to diradical intermediate **14** and H-atom abstraction to **15**.[1]



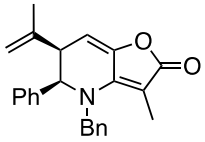
3-(*t*-Butyl)-4-methyl-6-(prop-1-en-2-yl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (2a).



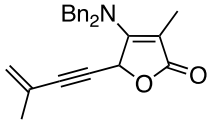
A solution of alkynylcyclobutenone **1a** (505 mg, 2.04 mmol) in DMSO (60 mL) was heated at 150 °C for 25 min then cooled to RT and partitioned between ethyl acetate (60 mL) and water (60 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 60 mL) then the combined organic phases were washed with water (3 × 180 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (10 – 20% diethyl ether/petrol) afforded the title compound **2a** as an orange solid (290 mg, 1.17 mmol, 57%). **MP**: 62 – 63 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 2959 (w), 2912 (w), 2869 (w), 1749 (vs), 1683 (w), 1585 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 5.54 (1H, m, =C**H**), 4.93 (1H, m, =C**H**H), 4.86 (1H, s, =CH**H**), 3.28 (1H, m, NC**H**H), 3.17 (2H, m, NCH**H** + C**H**), 3.11 (3H, s, NC$\mathbf{H}_3$), 1.80 (3H, s, C$\mathbf{H}_3$), 1.38 (9H, s, 3×C$\mathbf{H}_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.7 (**C**), 152.8 (**C**), 145.9 (**C**), 144.4 (**C**), 113.6 (C$\mathbf{H}_2$), 108.9 (**C**), 104.7 (**C**H), 55.3 (C$\mathbf{H}_2$), 45.2 (C$\mathbf{H}_3$), 39.0 (**C**H), 31.0 (**C**), 30.6 (3×C$\mathbf{H}_3$), 21.1 (C$\mathbf{H}_3$). **LRMS** (ESI$^+$): 248 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{15}H_{21}NNaO_2$ [M+Na]$^+$ 270.1465, found: 270.1467.



***rel*-(5*S*,6*S*)-4-Benzyl-3-methyl-5-phenyl-6-(prop-1-en-2-yl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (2b).**

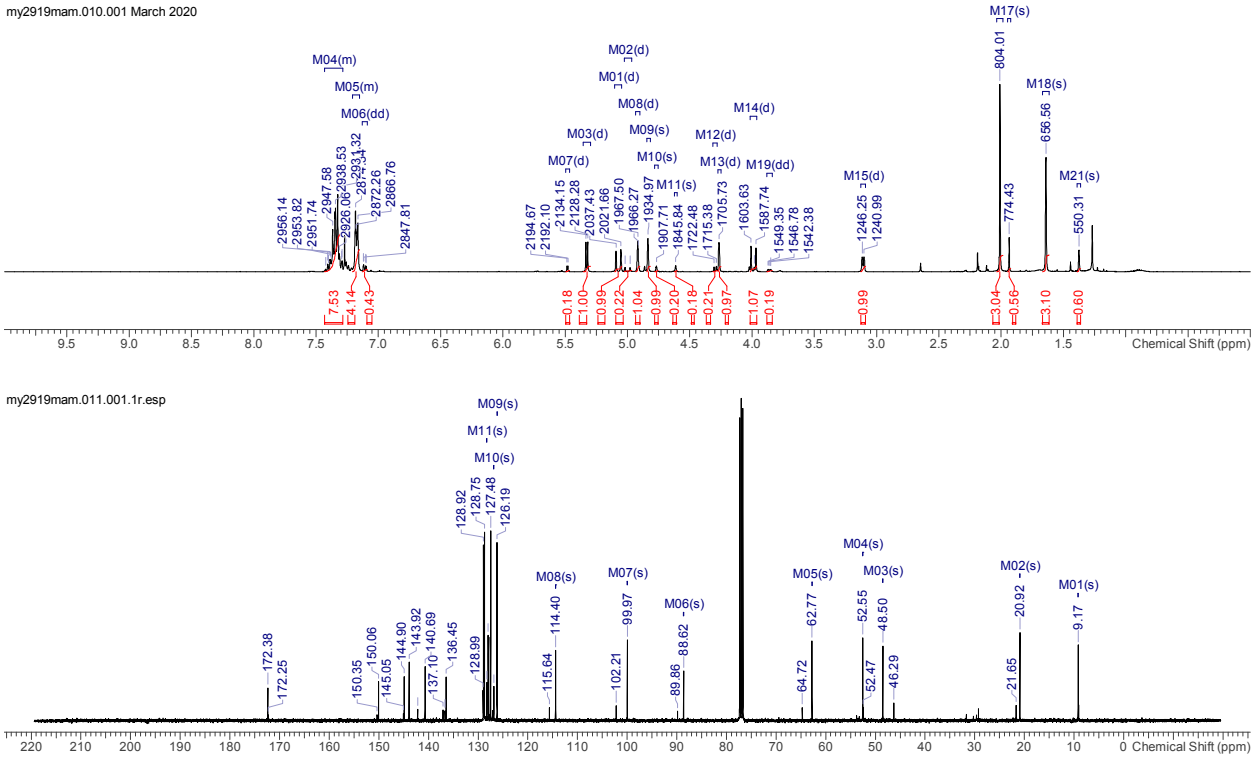


d.r. ~5:1

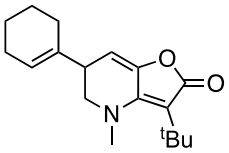


A solution of alkynylcyclobutenone **1b** (504 mg, 1.40 mmol) in DMSO (60 mL) was heated at 150 °C for 30 min then cooled to RT and partitioned between ethyl acetate (60 mL) and water (60 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 60 mL) then the combined organic phases were washed with water (3 × 180 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (20 – 50% diethyl ether/petrol) afforded firstly the title compound **2b** (175 mg, 0.491 mmol, 35%) as an inseparable 5:1 mixture of diastereoisomers: yellow oil, **IR** ν_{max} (film, cm^{-1}): 3028 (w), 2924 (w), 1754 (s), 1696 (w), 1617 (s), 1584 (m), 1450 (br m), 1289 (br m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm *major isomer* 7.37 – 7.31 (6H, m, 6×Ar**H**), 7.18 – 7.16 (4H, m, 4×Ar**H**), 5.33 (1H, d, *J* = 5.9 Hz, =C**H**), 5.07 (1H, d, *J* = 15.8, C**H**H), 4.92 (1H, m, C=C**H**H), 4.84 (1H, m, =CH**H**), 4.26 (1H, d, *J* = 1.5 Hz, PhC**H**), 3.99 (1H, d, *J* = 15.9 Hz, CH**H**), 3.11 (1H, br d, *J* = 5.3 Hz, C**H**), 2.01 (3H, s, C$\mathbf{H}_3$), 1.64 (3H, s, C$\mathbf{H}_3$); *minor isomer* 7.37 – 7.31 (5H, m, 5×Ar**H**), 7.18 – 7.16 (3H, m, 3×Ar**H**), 7.11 (2H, m, 2×Ar**H**), 5.48 (1H, d, *J* = 2.6 Hz, =C**H**), 5.00 (1H, d, *J* = 16.3, C**H**H), 4.77 (1H, m, =C**H**H), 4.61 (1H, br s, =CH**H**), 4.30 (1H, d, *J* = 7.1 Hz, PhC**H**), 4.00 (1H, d, *J* = 16.6 Hz, CH**H**), 3.86 (1H, dd, *J* = 7.0, 2.6 Hz, C**H**), 1.94 (3H, s, C$\mathbf{H}_3$), 1.38 (3H, s, C$\mathbf{H}_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm *major isomer* 172.4 (**C**), 150.1 (**C**), 144.9 (**C**), 143.9 (**C**), 140.7 (**C**), 136.5 (**C**), 128.9 (2×**C**H), 128.8 (2×**C**H), 128.0 (**C**H), 127.9 (**C**H), 127.5 (2×**C**H),

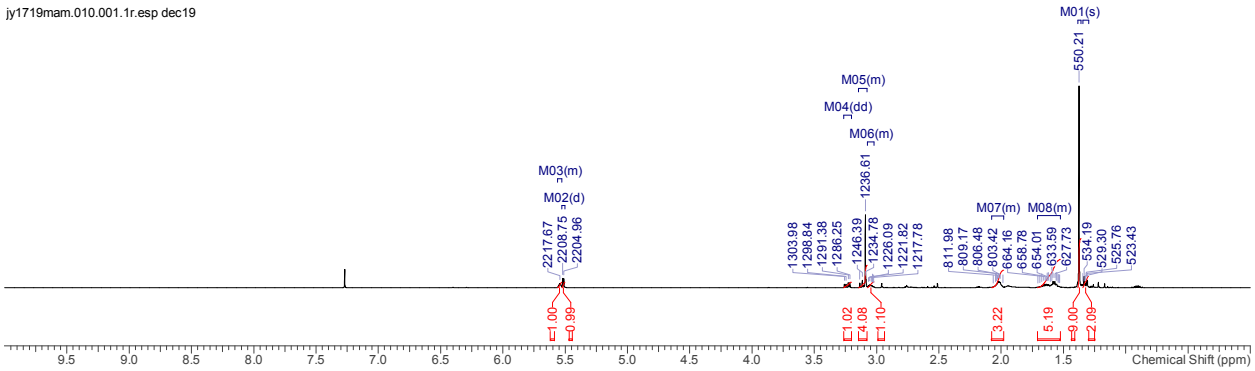
126.2 (2×**C**H), 114.4 (**C**H_2), 100.0 (**C**H), 88.6 (**C**), 62.8 (**C**H), 52.6 (**C**H_2), 48.5 (**C**H), 20.9 (**C**H_3), 9.2 (**C**H_3); *minor isomer* 172.3 (**C**), 150.4 (**C**), 144.1 (**C**), 142.2 (**C**), 137.1 (**C**), 136.7 (**C**), 129.0 (2×**C**H), 128.9 (**C**H), 128.3 (**C**H), 128.3 (2×**C**H), 128.3 (2×**C**H), 126.9 (2×**C**H), 115.6 (**C**H_2), 102.2 (**C**H), 89.9 (**C**), 64.7 (**C**H), 52.5 (**C**H_2), 46.3 (**C**H), 21.7 (**C**H_3), 9.1 (**C**H_3). **LRMS** (ESI$^+$): 358 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{24}H_{24}NO_2$ [M+H]$^+$ 358.1802, found: 358.1799. Furanone **13b** (102 mg, 0.285 mmol, 20%, ca. 95% pure) followed as a brown oil, **IR** ν_{max} (film, cm^{-1}): 3029 (w), 2922 (w), 1738 (s), 1619 (vs), 1495 (w), 1430 (m), 1354 (w), 1296 (m), 1165 (w), 1086 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.40 – 7.31 (5H, m, 5×Ar**H**), 7.24 – 7.22 (4H, m, 4×Ar**H**), 5.53 (1H, s, C**H**), 5.31 – 5.29 (2H, m, =CH_2), 4.80 (2H, d, *J* = 16.4 Hz, 2×NC**H**H), 4.43 (2H, d, *J* = 16.5 Hz, 2×NCH**H**), 1.93 + 1.93 (3H, 2×s, CH_3), 1.84 (3H, app dd, *J* = 1.1, 0.4 Hz, CH_3). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 175.1 (**C**), 161.5 (**C**), 136.5 (2×**C**), 129.0 (4×**C**H), 127.9 (2×**C**H), 126.8 (4×**C**H), 125.3 (**C**), 124.0 (**C**H_2), 90.1 (**C**), 89.1 (**C**), 81.1 (**C**), 67.2 (**C**H), 53.0 (2×**C**H_2), 22.8 (**C**H_3), 9.9 (**C**H_3). **LRMS** (ESI$^+$): 358 ([M+H]$^+$, 100%).

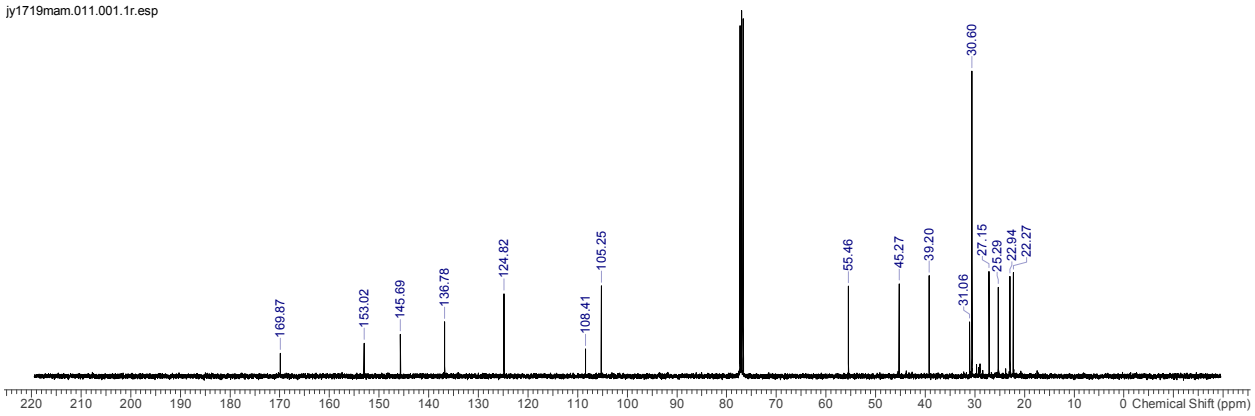


3-(*t*-Butyl)-6-(cyclohex-1-en-1-yl)-4-methyl-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (2c).

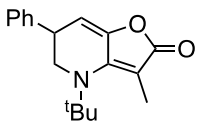


A solution of alkynylcyclobutenone **1c** (729 mg, 2.54 mmol) in DMSO (60 mL) was heated at 150 °C for 20 min then cooled to RT and partitioned between ethyl acetate (60 mL) and water (60 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 60 mL) then the combined organic phases were washed with water (3 × 180 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (10 – 50% diethyl ether/petrol) afforded the title compound **2c** (384 mg, 1.34 mmol, 48%) as an orange solid. **MP**: 84 – 86 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 2927 (br m), 2859 (m), 1746 (vs), 1584 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 5.54 (1H, m, C=C**H**), 5.52 (1H, d, *J* = 3.8 Hz, C=C**H**), 3.24 (1H, dd, *J* = 12.6, 5.1 Hz, NC**H**H), 3.13 – 3.02 (2H, m, NCH**H** + =CHC**H**), 3.09 (3H, s, NC$\mathbf{H_3}$), 2.06 – 1.99 (2H, m, 2×C**H**H), 1.70 – 1.53 (4H, m, 2×C**H**H + 2×CH**H**), 1.38 (9H, s, C(C$\mathbf{H_3}$)$_3$), 1.34 – 1.31 (2H, m, 2×CH**H**). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.9 (**C**), 153.0 (**C**), 145.7 (**C**), 136.8 (**C**), 124.8 (**C**H), 108.4 (**C**), 105.3 (**C**H), 55.5 (**C**H_2), 45.3 (**C**H_3), 39.2 (**C**H), 31.1 (**C**), 30.6 (3×**C**H_3), 27.2 (**C**H_2), 25.3 (**C**H_2), 22.9 (**C**H_2), 22.3 (**C**H_2). **LRMS** (ESI$^+$): 288 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{18}H_{26}NO_2$ [M+H]$^+$ 288.1958, found: 288.1964.

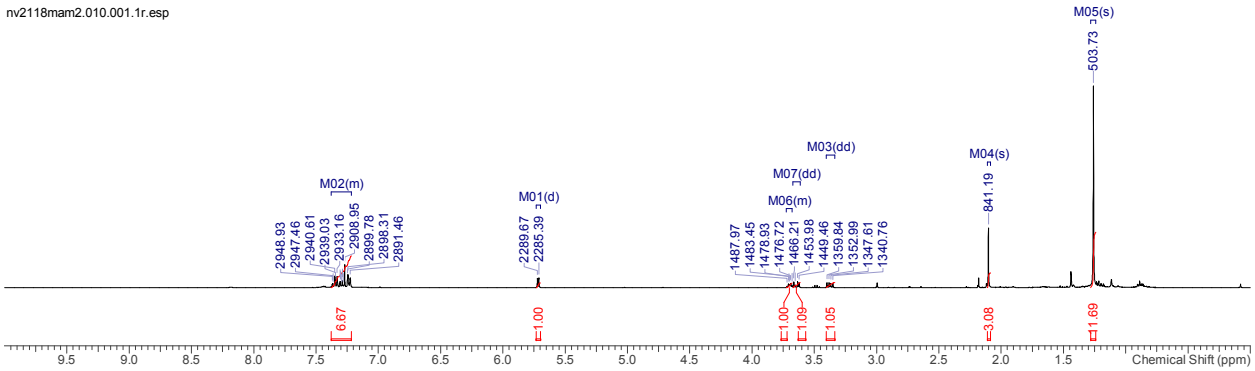


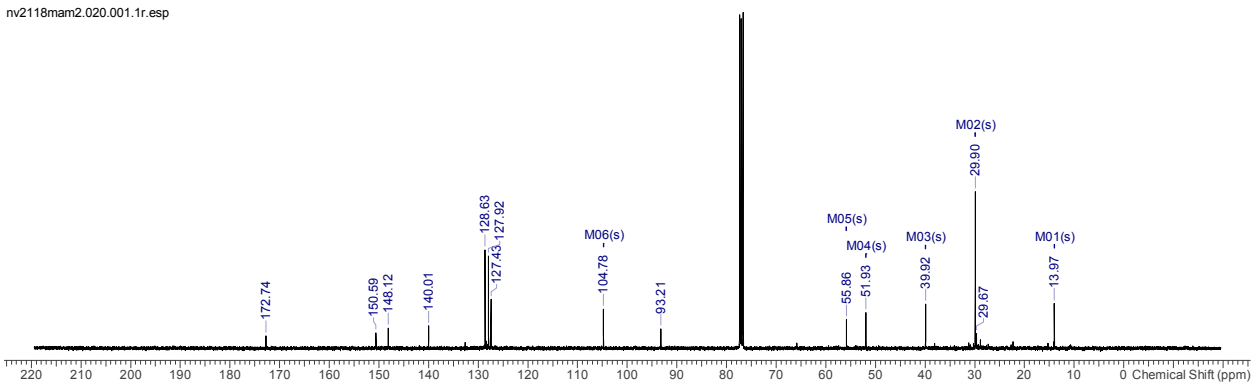


4-(*t*-Butyl)-3-methyl-6-phenyl-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5b).

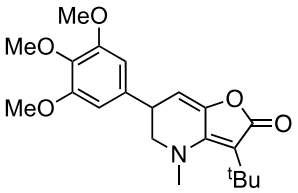


A solution of alkynylcyclobutenone **4b** (237 mg, 0.835 mmol) in DMSO (50 mL) was heated at 150 °C for 25 min then cooled to RT and partitioned between ethyl acetate (50 mL) and water (50 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 50 mL) then the combined organic phases washed were with water (3 × 150 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (10 – 100% diethyl ether/petrol) afforded the title compound **5b** (19 mg, 0.066 mmol, 8%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 2919 (m), 2850 (w), 1754 (vs), 1684 (w), 1591 (vs), 1288 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.37 – 7.28 (3H, m, 3×Ar**H**), 7.25 – 7.22 (2H, m, 2×Ar**H**), 5.72 (1H, d, *J* = 4.4 Hz, C=C**H**), 3.70 (1H, m, PhC**H**), 3.64 (1H, dd, *J* = 12.2, 4.8 Hz, C**H**H), 3.38 (1H, dd, *J* = 12.2, 6.7 Hz, CH**H**), 2.10 (3H, s, C$\mathbf{H_3}$), 1.26 (9H, s, NC($\mathbf{CH_3}$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 172.7 (**C**), 150.6 (**C**), 148.1 (**C**), 140.0 (**C**), 128.6 (2×**C**H), 127.9 (2×**C**H), 127.4 (**C**H), 104.8 (**C**H), 93.2 (**C**), 55.9 (**C**), 51.9 ($\mathbf{C}H_2$), 39.9 (**C**H), 29.9 (3×$\mathbf{C}H_3$), 14.0 ($\mathbf{C}H_3$). **LRMS** (ESI^+): 284 ($[M+H]^+$, 100%). **HRMS** (ESI^+): Calculated for $C_{18}H_{22}NO_2$ $[M+H]^+$ 284.1645, found: 284.1646.

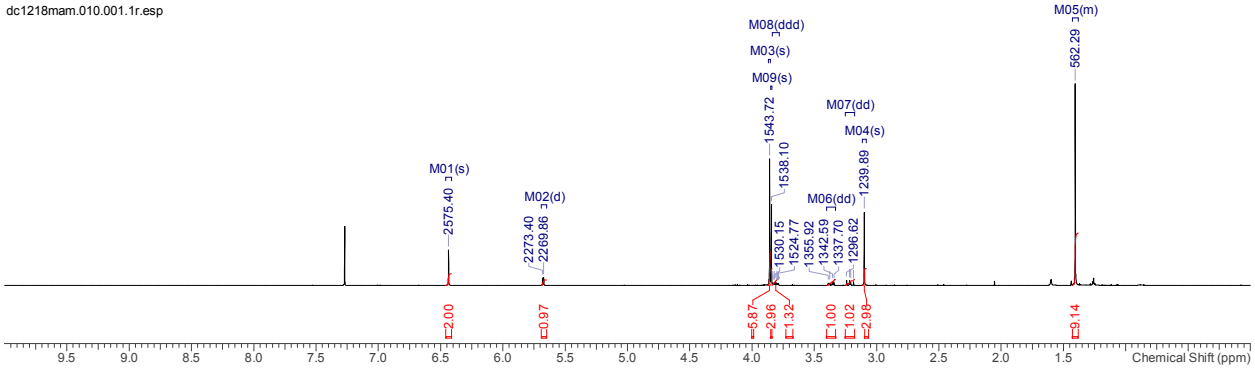


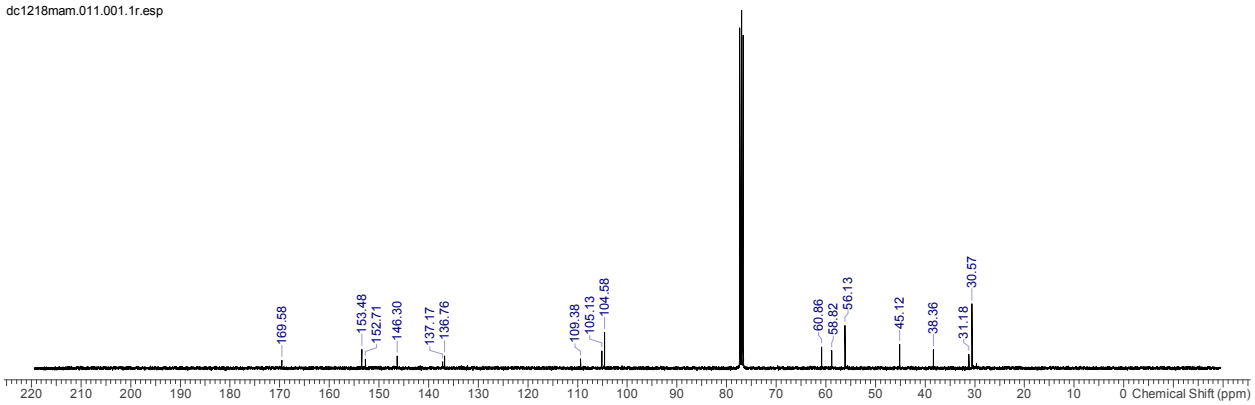


3-(*t*-Butyl)-4-methyl-6-(3,4,5-trimethoxyphenyl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5c).

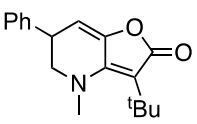


A solution of alkynylcyclobutenone **4c** (260 mg, 0.697 mmol) in DMSO (60 mL) was heated at 150 °C for 25 min then cooled to RT and partitioned between ethyl acetate (60 mL) and water (60 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 60 mL) then the combined organic phases were washed with water (3 × 180 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (20 – 60% diethyl ether/petrol) afforded the title compound **5c** (171 mg, 0.458 mmol, 66%) as an orange oil. **IR** ν_{max} (film, cm^{-1}): 2956 (br m), 1745 (s), 1681 (w), 1588 (s), 1507 (m), 1458 (m), 1337 (m), 1235 (m), 1125 (vs). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 6.44 (2H, s, 2×Ar**H**), 5.68 (1H, d, *J* = 3.6 Hz, C=C**H**), 3.86 (6H, s, 2×OC**H**$_3$), 3.84 (3H, s, OC**H**$_3$), 3.81 (1H, ddd, *J* = 9.1, 5.3, 3.6 Hz, PhC**H**), 3.37 (1H, dd, *J* = 13.1, 5.1 Hz, C**H**H), 3.21 (1H, dd, *J* = 13.0, 9.2 Hz, CH**H**), 3.10 (3H, s, NC**H**$_3$), 1.41 (9H, s, C(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.6 (**C**), 153.5 (2×**C**), 152.7 (**C**), 146.3 (**C**), 137.2 (**C**), 136.8 (**C**), 109.4 (**C**), 105.1 (**C**H), 104.6 (2×**C**H), 60.9 (**C**H$_3$), 58.8 (**C**H$_2$), 56.1 (2×**C**H$_3$), 45.1 (**C**H$_3$), 38.4 (**C**H), 31.2 (**C**), 30.6 (3×**C**H$_3$). **LRMS** (ESI$^+$): 374 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{21}H_{28}NO_5$ [M+H]$^+$ 374.1962, found: 374.1961.



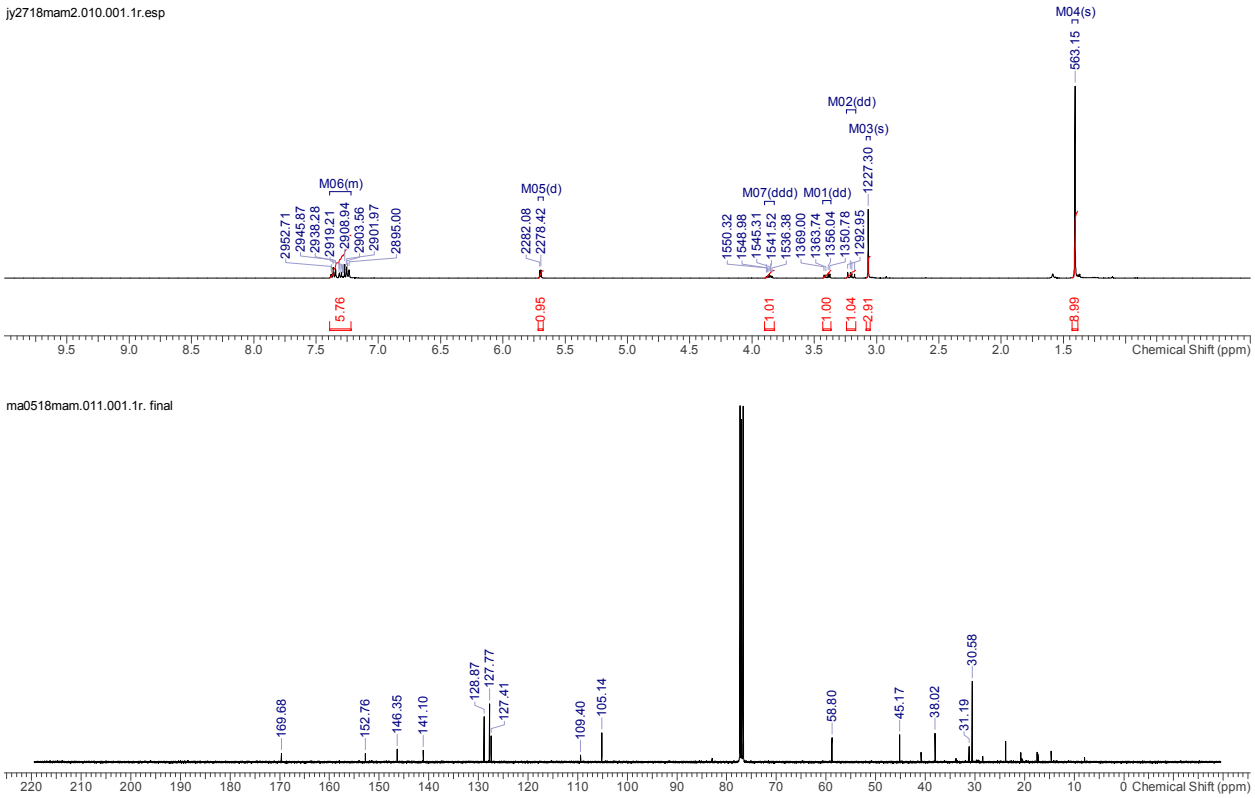


3-(*t*-Butyl)-4-methyl-6-phenyl-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5e).

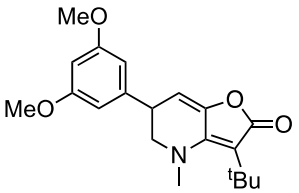


A solution of alkynylcyclobutenone **4e** (522 mg, 1.84 mmol) in DMSO (100 mL) was heated at 150 °C for 1 h then cooled to RT and partitioned between ethyl acetate (100 mL) and

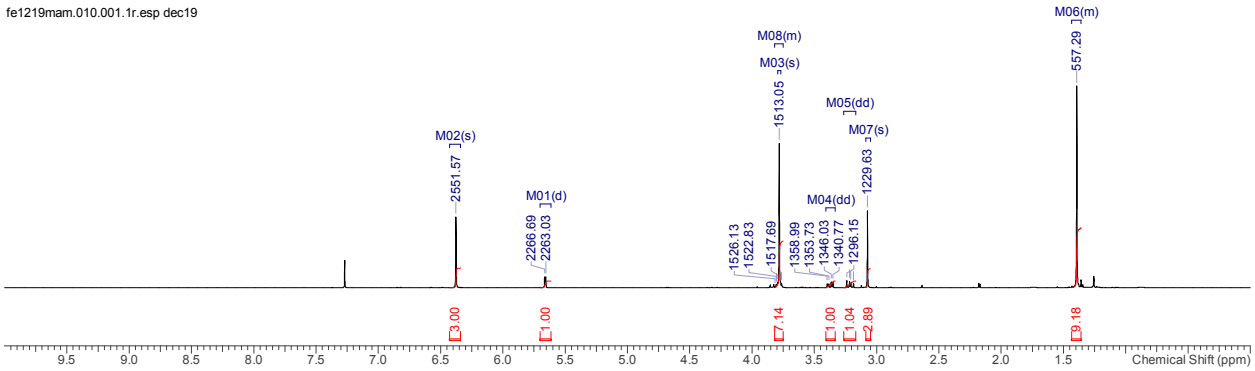
water (100 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 100 mL) then the combined organic phases were washed with water (3 × 150 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (20 – 25% diethyl ether/petrol) afforded the title compound **5e** (386 mg, 1.36 mmol, 74%) as an orange solid. **MP**: 97–98 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 2959 (m), 1749 (s), 1682 (w), 1587 (s), 1046 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.38 – 7.24 (5H, m, 5×Ar**H**), 5.70 (1H, d, *J* = 3.7 Hz, C=C**H**), 3.86 (1H, ddd, *J* = 8.8, 5.1, 3.8 Hz, PhC**H**), 3.40 (1H, dd, *J* = 13.0, 5.3 Hz, NC**H**H), 3.20 (1H, dd, *J* = 13.0, 8.8 Hz, NCH**H**), 3.07 (3H, s, NC**H**$_3$), 1.41 (9H, s, C(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.7 (**C**), 152.8 (**C**), 146.4 (**C**), 141.1 (**C**), 128.9 (2×**C**H), 127.8 (2×**C**H), 127.4 (**C**H), 109.4 (**C**), 105.1 (**C**H), 58.8 (**C**H$_2$), 45.2 (**C**H), 38.0 (**C**H$_3$), 31.2 (**C**), 30.6 (3×**C**H$_3$). **LRMS** (ESI$^+$): 284 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{18}H_{21}NO_2$ [M+H]$^+$ 284.1645, found: 284.1652. Data consistent with a literature values.[2]

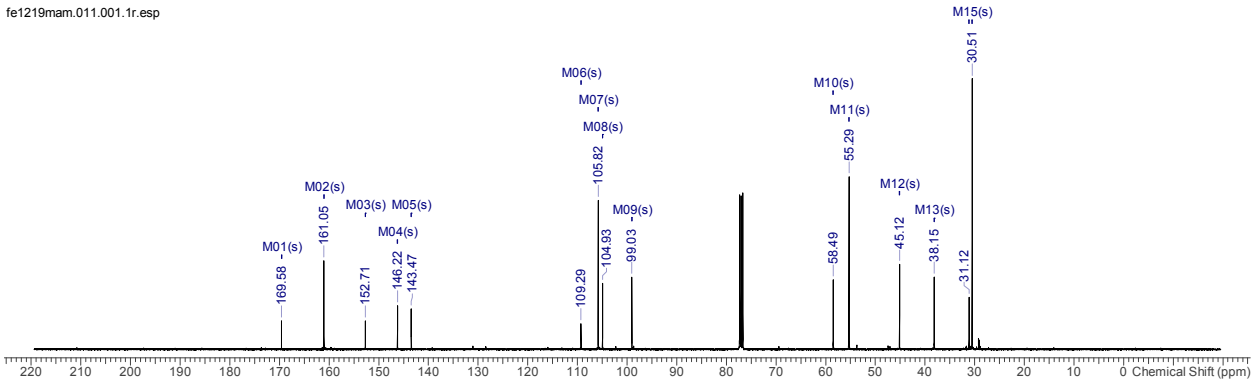


3-(*t*-Butyl)-6-(3,5-dimethoxyphenyl)-4-methyl-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5f).

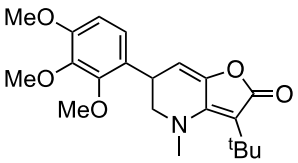


A solution of alkynylcyclobutenone **4f** (125 mg, 0.363 mmol) in DMSO (50 mL) was heated at 150 °C for 25 min then cooled to RT and partitioned between ethyl acetate (50 mL) and water (50 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 50 mL) then the combined organic phases were washed with water (3 × 150 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (10 – 30% diethyl ether/petrol) afforded the title compound **5f** (94.7 mg, 0.276 mmol, 76%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 2956 (w), 1747 (s), 1682 (w), 1594 (vs), 1459 (m), 1203 (m), 1155 (s), 1066 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 6.38 (3H, s, 3×Ar**H**), 5.66 (1H, d, *J* = 3.7 Hz, C=C**H**), 3.81– 3.76 (1H, obscured, PhC**H**), 3.78 (6H, s, 2×OC**H**$_3$), 3.37 (1H, dd, *J* = 13.0, 5.3 Hz, C**H**H), 3.21 (1H, dd, *J* = 13.0, 8.8 Hz, CH**H**), 3.07 (3H, s, NC**H**$_3$), 1.39 (9H, s, C(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.6 (**C**), 161.1 (2×**C**), 152.7 (**C**), 146.2 (**C**), 143.5 (**C**), 109.3 (**C**), 105.8 (2×**C**H), 104.9 (**C**H), 99.0 (**C**H), 58.5 (**C**H$_2$), 55.3 (2×**C**H$_3$), 45.1 (**C**H$_3$), 38.2 (**C**H), 31.1 (**C**), 30.5 (3×**C**H$_3$). **LRMS** (ESI$^+$): 344 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{20}H_{25}NNaO_4$ [M+Na]$^+$ 366.1676, found: 366.1675.

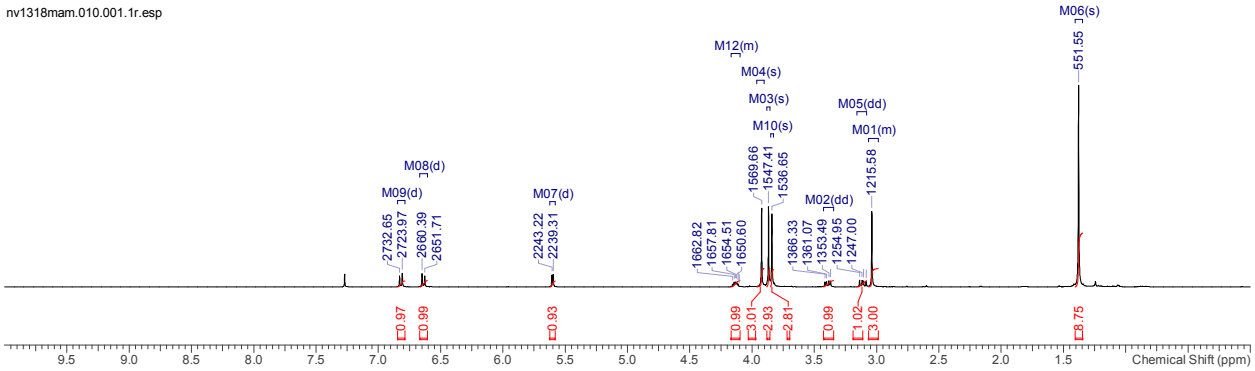


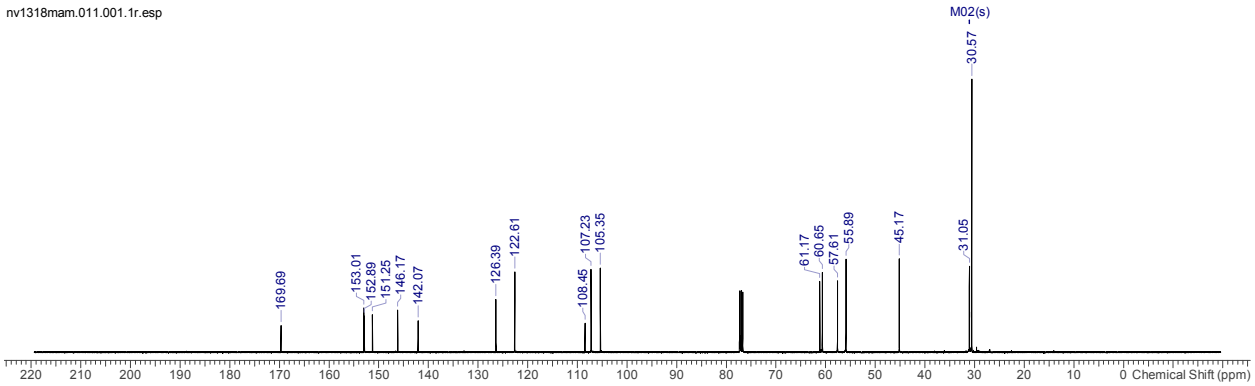


3-(*t*-Butyl)-4-methyl-6-(2,3,4-trimethoxyphenyl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5g).

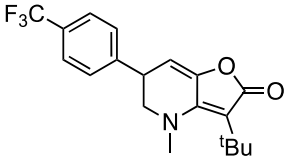


A solution of alkynylcyclobutenone **4g** (310 mg, 0.830 mmol) in DMSO (50 mL) was heated at 150 °C for 30 min them cooled to RT and partitioned between ethyl acetate (50 mL) and water (50 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 50 mL) then the combined organic phases were washed with water (3 × 150 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (20 – 40% diethyl ether/petrol) afforded the title compound **5g** (161 mg, 0.432 mmol, 54%) as a yellow oil. **IR** ν_{max} (film, cm^{-1}): 2955 (br m), 1745 (s), 1681 (w), 1583 (s), 1493 (s), 1463 (s), 1417 (m), 1281 (m), 1093 (vs). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 6.82 (1H, d, *J* = 8.7 Hz, Ar**H**), 6.64 (1H, d, *J* = 8.7 Hz, Ar**H**), 5.60 (1H, d, *J* = 3.9 Hz, C=C**H**), 4.13 (1H, m, PhC**H**), 3.92 (3H, s, OC$\mathbf{H}_3$), 3.87 (3H, s, OC$\mathbf{H}_3$), 3.84 (3H, s, OC$\mathbf{H}_3$), 3.39 (1H, dd, *J* = 12.8, 5.3 Hz, C**H**H), 3.11 (1H, dd, *J* = 12.8, 8.0 Hz, CH**H**), 3.04 (3H, s, NC$\mathbf{H}_3$), 1.38 (9H, s, C(C$\mathbf{H}_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.7 (**C**), 153.0 (**C**), 152.9 (**C**), 151.3 (**C**), 146.2 (**C**), 142.1 (**C**), 126.4 (**C**), 122.6 (**C**H), 108.5 (**C**H), 107.2 (**C**), 105.4 (**C**H), 61.2 (**C**H_3), 60.7 (**C**H_3), 57.6 (**C**H_2), 55.9 (**C**H_3), 45.2 (**C**H_3), 31.1 (**C**H), 31.0 (**C**), 30.6 (3×**C**H_3). **LRMS** (ESI$^+$): 374 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{21}H_{28}NO_5$ [M+H]$^+$ 374.1962, found: 374.1968.

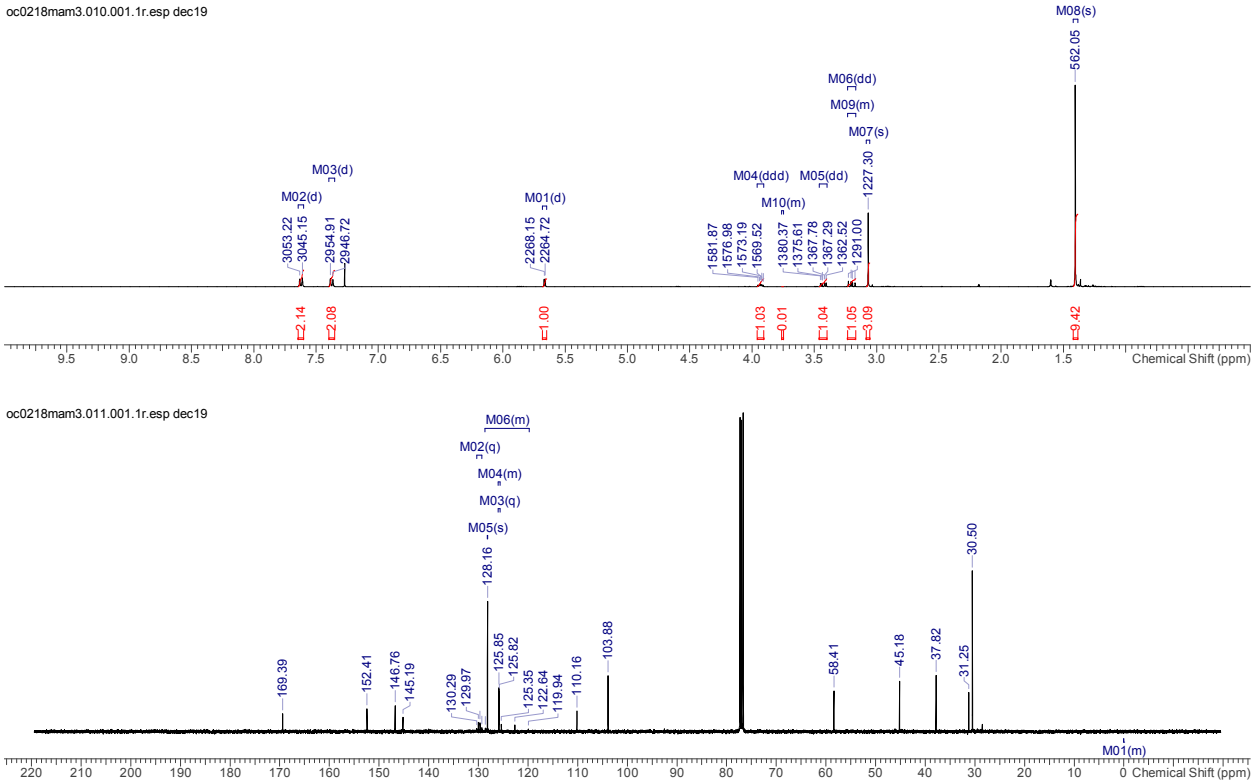




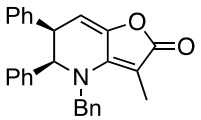
3-(*t*-Butyl)-4-methyl-6-(4-(trifluoromethyl)phenyl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5h).



A solution of alkynylcyclobutenone **4h** (955 mg, 2.72 mmol) in DMSO (100 mL) was heated at 150 °C for 25 min then cooled to RT and partitioned between ethyl acetate (100 mL) and water (100 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 100 mL) then the combined organic phases were washed with water (3 × 150 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (20 – 50% diethyl ether/petrol) afforded the title compound **5h** (834 mg, 2.37 mmol, 87%) as a yellow solid. **MP**: 94–95 °C (DCM). **IR** ν_{max} (film, cm^{-1}): 2960 (w), 1750 (m), 1682 (w), 1588 (m), 1324 (s), 1124 (m), 1067 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.62 (2H, d, *J* = 8.1 Hz, 2×Ar**H**), 7.37 (2H, d, *J* = 8.2 Hz, 2×Ar**H**), 5.66 (1H, d, *J* = 3.4 Hz, C=C**H**), 3.93 (1H, ddd, *J* = 8.4, 5.0, 3.6 Hz, C**H**Ar), 3.43 (1H, dd, *J* = 13.0, 5.2 Hz, NC**H**H), 3.20 (1H, dd, *J* = 13.1, 8.4 Hz, NCH**H**), 3.07 (3H, s, NC**H**$_3$), 1.40 (9H, s, C(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.4 (**C**), 152.4 (**C**), 146.8 (**C**), 145.2 (**C**), 129.8 (**C**, q, *J* = 32.8 Hz), 128.2 (2× **C**H), 125.8 (2×**C**H, q, *J* = 4.2 Hz), 124.0 (**C**F$_3$, q, J_{C-F} = 272 Hz), 110.2 (**C**), 103.9 (**C**H), 58.4 (**C**H$_2$), 45.2 (**C**H$_3$), 37.8 (**C**H), 31.3 (**C**), 30.5 (3×**C**H$_3$). **LRMS** (ESI$^+$): 352 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{19}H_{20}F_3NO_2$ [M+H]$^+$ 352.1519, found: 352.1519.



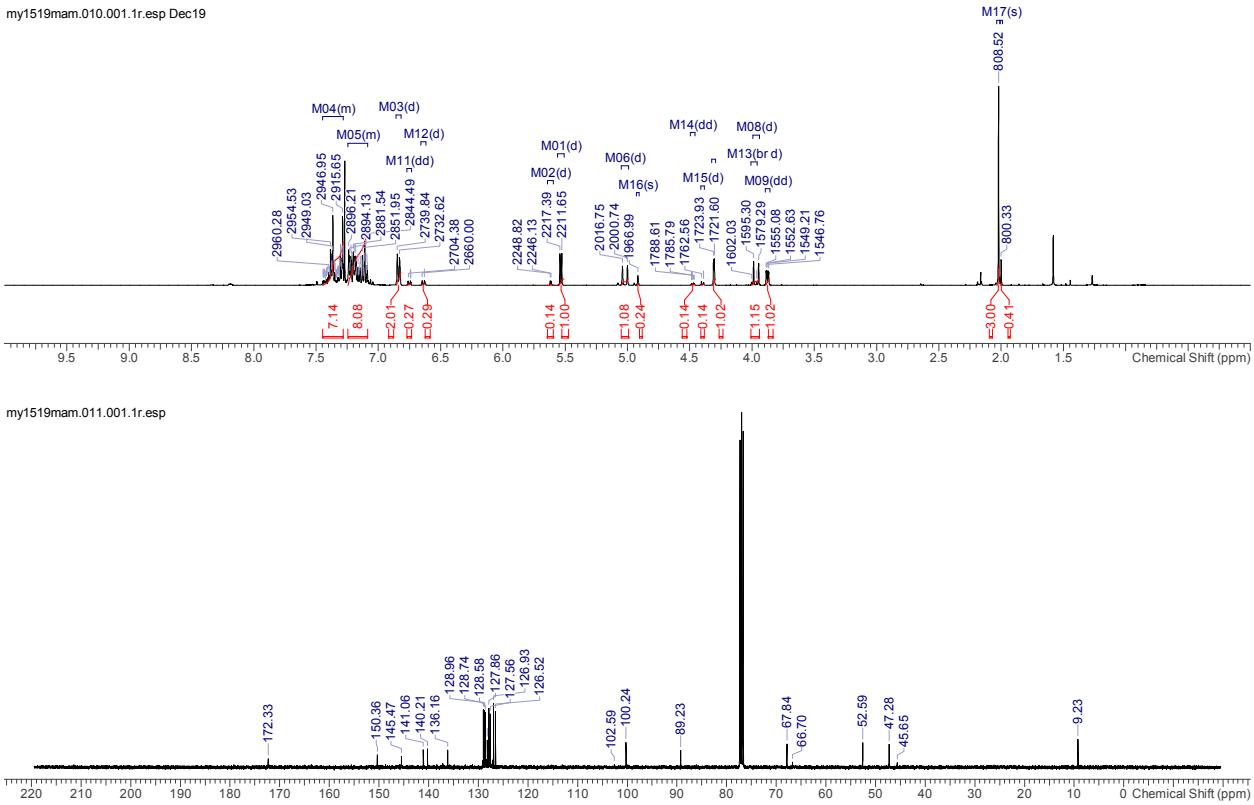
***rel*-(5*S*,6*S*)-4-Benzyl-3-methyl-5,6-diphenyl-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5i).**



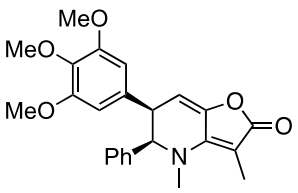
d.r. ~7:1

A solution of alkynylcyclobutenone **4i** (279 mg, 0.779 mmol) in DMSO (40 mL) was heated at 150 °C for 20 min, then cooled to RT and partitioned between ethyl acetate (40 mL) and water (40 mL). The aqueous phase was separated and extracted with ethyl acetate (2 ×

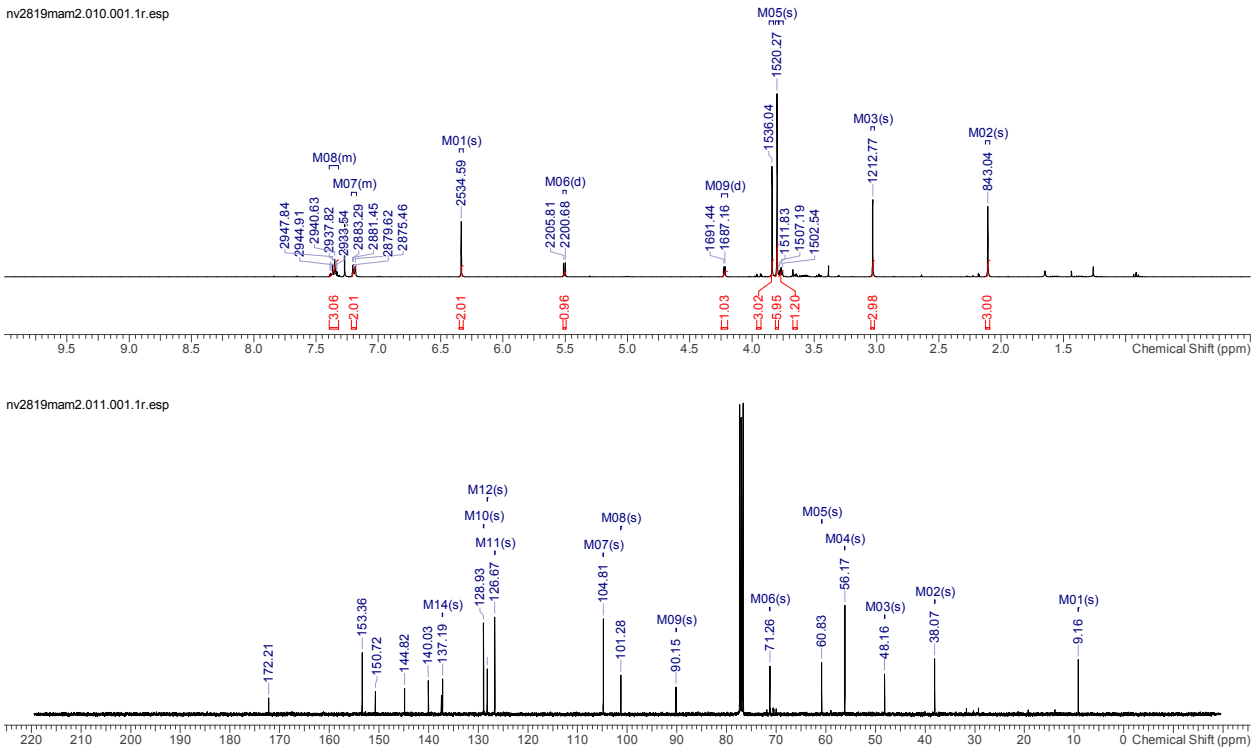
40 mL) then the combined organic phases were washed were with water (3 × 120 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (20 – 30% diethyl ether/petrol) afforded the title compound **5i** (134 mg, 0.341 mmol, 48%, *d.r.* 7:1) as a yellow foam. **IR** ν_{max} (film, cm^{-1}): 3061 (w), 3028 (w), 2923 (br w), 1755 (s), 1694 (w), 1618 (vs), 1584 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): *major isomer* δ ppm 7.44 – 7.29 (6H, m, 6×Ar**H**), 7.24 – 7.09 (7H, m, 7×Ar**H**), 6.84 (2H, d, *J* = 7.2 Hz, 2×Ar**H**), 5.53 (1H, d, *J* = 5.8 Hz, C=C**H**), 5.02 (1H, d, *J* = 16.0, C**H**H), 4.31 (1H, d, *J* = 2.3 Hz, NCPh**H**), 3.97 (1H, d, *J* = 16.0 Hz, CH**H**), 3.88 (1H, dd, *J* = 5.9, 2.5 Hz, PhC**H**), 2.02 (3H, s, C$\mathbf{H}_3$); *minor isomer* 7.44 – 7.29 (6H, m, 4×Ar**H**), 7.24 – 7.09 (5H, m, 5×Ar**H**), 6.75 (2H, dd, *J* = 8.0, 1.4 Hz, 2×Ar**H**), 6.64 (2H, d, *J* = 7.2 Hz, 2×Ar**H**), 5.62 (1H, d, *J* = 2.7 Hz, C=C**H**), 4.92 (1H, d, *J* = 16.1 Hz, NC**H**H), 4.48 (1H, dd, *J* = 6.8, 2.9 Hz, PhC**H**), 4.40 (1H, d, *J* = 7.0 Hz, NCPh**H**), 3.98 (1H, d, *J* = 16.1 Hz, NCH**H**), 2.00 (3H, s, C$\mathbf{H}_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): *major isomer* δ ppm 172.3 (**C**), 150.4 (**C**), 145.5 (**C**), 141.1 (**C**), 140.2 (**C**), 136.2 (**C**), 129.0 (2×**C**H), 128.7 (2×**C**H), 128.6 (2×**C**H), 128.2 (**C**H), 127.9 (2×**C**H), 127.6 (2×**C**H), 126.9 (2×**C**H), 126.5 (2×**C**H), 100.2 (**C**H), 89.2 (**C**), 67.8 (**C**H), 52.6 (C$\mathbf{H}_2$), 47.3 (**C**H), 9.2 (C$\mathbf{H}_3$); *additional signals attributed to the minor isomer* 102.6 (**C**H), 66.7 (**C**H), 53.2 (C$\mathbf{H}_2$), 45.7 (**C**H). **LRMS** (ESI$^+$): 394 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{27}H_{24}NO_2$ [M+H]$^+$ 394.1802, found: 394.1806.



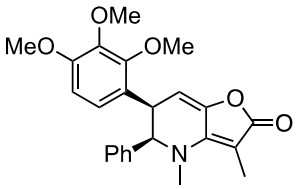
rel-(5*S*,6*S*)-3,4-Dimethyl-5-phenyl-6-(3,4,5-trimethoxyphenyl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5j). A solution of alkynylcyclobutenone **4j** (443 mg, 1.09 mmol) in tetraethylene glycol dimethyl ether (50 mL) was heated at 200 °C under an argon atmosphere for 1 h then cooled to RT and partitioned between ethyl acetate (50 mL) and water (50 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 50 mL) then the combined organic phases were washed with water (3 × 150 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (40 – 80% diethyl ether/petrol) afforded the title compound **5j** (240 mg, 0.588 mmol, 54%) as a brown oil.



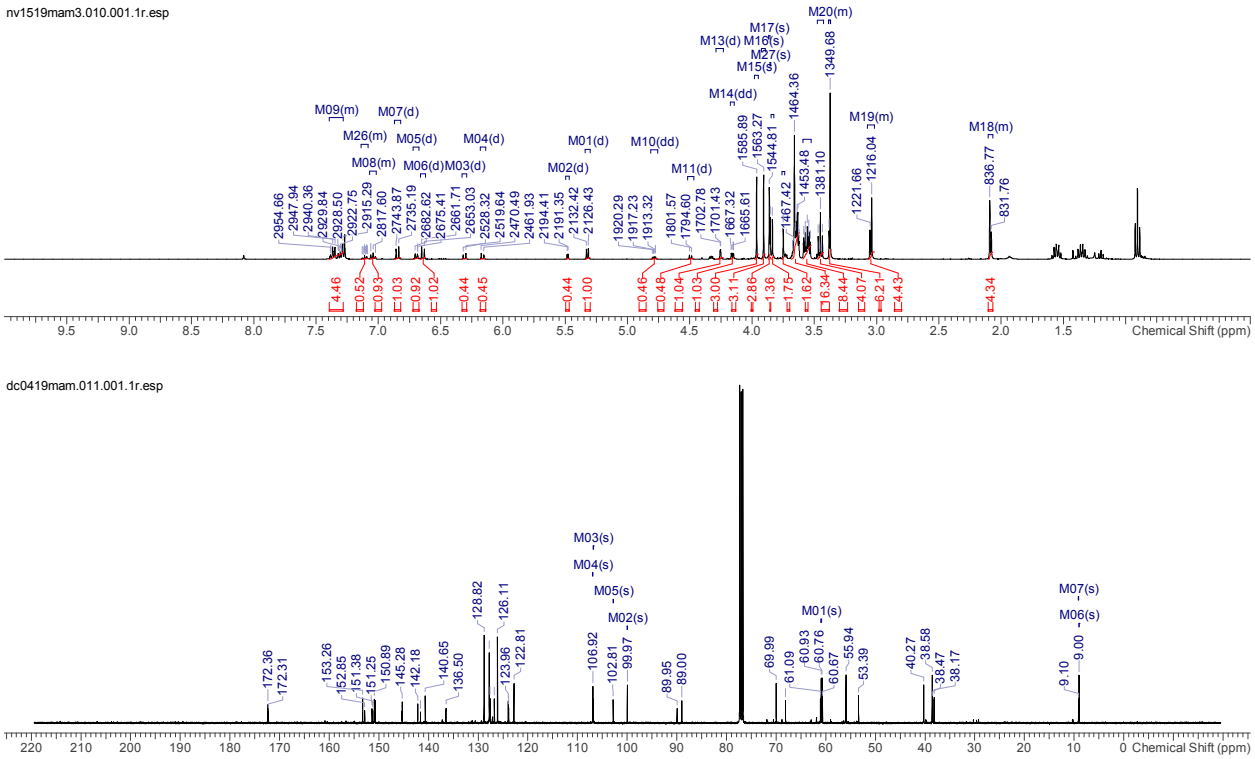
IR ν_{max} (film, cm^{-1}): 2935 (br w), 2838 (w), 1753 (s), 1695 (w), 1618 (vs), 1590 (s), 1505 (m), 1452 (m), 1417 (m), 1313 (m), 1291 (m), 1235 (m), 1124 (vs), 1028 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.39 – 7.33 (3H, m, 3×Ar**H**), 7.21 – 7.18 (2H, m, 2×Ar**H**), 6.33 (2H, s, 2×Ar**H**), 5.51 (1H, d, *J* = 5.1 Hz, C=C**H**), 4.22 (1H, d, *J* = 4.3 Hz, NC**H**Ph), 3.84 (3H, s, OC$\mathbf{H}_3$), 3.80 (6H, s, 2×OC$\mathbf{H}_3$), 3.77 (1H, dd, *J* = 5.1, 4.3 Hz, C**H**Ph), 3.03 (3H, s, NC$\mathbf{H}_3$), 2.11 (3H, s, C$\mathbf{H}_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 172.2 (**C**), 153.4 (**C**), 150.7 (2×**C**), 144.8 (**C**), 140.0 (**C**), 137.4 (**C**), 137.2 (**C**), 128.9 (2×**C**H), 128.2 (**C**H), 126.7 (2×**C**H), 104.8 (2×**C**H), 101.3 (**C**H), 90.2 (**C**), 71.3 (**C**H), 60.8 (C$\mathbf{H}_3$), 56.2 (2×C$\mathbf{H}_3$), 48.2 (**C**H), 38.1 (C$\mathbf{H}_3$), 9.2 (C$\mathbf{H}_3$). **LRMS** (ESI$^+$): 408 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{24}H_{26}NO_5$ [M+H]$^+$ 408.1805, found: 408.1814.



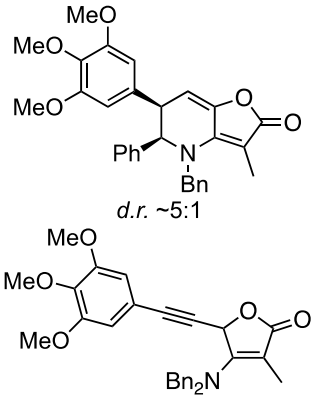
rel-(5*S*,6*S*)-3,4-Dimethyl-5-phenyl-6-(2,3,4-trimethoxyphenyl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5k). A solution of alkynylcyclobutenone **4k** (342 mg, 0.839 mmol) in tetraethylene glycol dimethyl ether (30 mL) was heated at 200 °C under an argon atmosphere for 25 min then cooled to RT and partitioned between ethyl acetate (30 mL) and water (30 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 30 mL) then the combined organic phases were washed with water (3 × 120 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (50 – 100% diethyl ether/petrol) afforded the intermediate furanone **13k** (138 mg, 0.338 mmol, 40%, *d.r*. 13:2). The furanone was disolved in tetraethylene glycol dimethyl ether (20 mL) and heated at 200 °C under an argon atmosphere for 1 h then cooled to RT and partitioned between ethyl acetate (20 mL) and water (20 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 20 mL) then the combined organic phases were washed with water (3 × 60 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (10 – 30% diethyl ether/petrol) afforded **5k** (41.3 mg, 0.101 mmol, 45%) as an inseparable 7:3 mixture of diastereoisomers: brown oil, **IR** ν_{max} (film, cm^{-1}): 2935 (br w), 1754 (s), 1617 (vs), 1493 (m), 1463 (m), 1416 (m), 1287 (m), 1094 (s), 1037 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): *major isomer* δ ppm*:* 7.39 – 7.29 (3H, m, 3×Ar**H**), 7.04 (1H, m, Ar**H**), 6.85 (1H, d, *J* = 8.7 Hz, Ar**H**), 6.69 (1H, m, Ar**H**), 6.64 (1H, d, *J* = 8.7 Hz, Ar**H**), 5.32 (1H, d, *J* = 6.0 Hz, C=C**H**), 4.25 (1H, d, *J* = 1.7 Hz, NC**H**Ph), 4.16 (1H, dd, *J* = 6.0, 1.7 Hz, C**H**Ph), 3.96 (3H, s, OC**H**$_3$), 3.91 (3H, s, OC**H**$_3$), 3.86 (3H, s, OC**H**$_3$), 3.37 (3H, s, NC**H**$_3$), 2.09 (3H, s, C**H**$_3$); *minor isomer* 7.39 – 7.29 (4H, m, 4×Ar**H**), 7.11 (1H, m, Ar**H**), 6.31 (1H, d, *J* = 8.7 Hz, Ar**H**), 6.16 (1H, d, *J* = 8.6 Hz, Ar**H**), 5.48 (1H, d, *J* = 3.1 Hz, C=C**H**), 4.79 (1H, dd, *J* = 7.0, 3.1 Hz, C**H**Ph), 4.49 (1H, d, *J* = 7.0 Hz, NC**H**Ph), 3.85 (3H, s, OC**H**$_3$), 3.84 (3H, s, OC**H**$_3$), 3.75 (3H, s, OC**H**$_3$), 3.38 (3H, s, NC**H**$_3$), 2.08 (3H, s, C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): *major isomer* δ ppm*:* 172.4 (**C**), 153.3 (**C**), 150.9 (**C**), 150.8 (**C**), 145.3 (**C**), 142.2 (**C**), 140.7 (**C**), 128.8 (2×**C**H), 127.8 (**C**H), 126.7 (**C**), 126.1 (2×**C**H), 122.8 (**C**H), 106.9 (**C**H), 100.0 (**C**H), 89.0 (**C**), 70.0 (**C**H), 60.9 (**C**H$_3$), 60.8 (**C**H$_3$), 55.9 (**C**H$_3$), 40.3 (**C**H), 38.6 (**C**H$_3$), 9.0 (**C**H$_3$); *minor isomer* 172.3 (**C**), 152.9 (**C**), 151.4 (**C**), 151.3 (**C**), 145.3 (**C**), 141.6 (**C**), 136.5 (**C**), 127.8 (2×**C**H), 127.7 (2×**C**H), 124.0 (**C**), 123.9 (**C**H), 106.8 (**C**H), 102.8 (**C**H), 90.0 (**C**), 68.1 (**C**H), 61.1 (**C**H$_3$), 60.7 (**C**H$_3$), 55.9 (**C**H$_3$), 38.5 (**C**H), 38.2 (**C**H$_3$), 9.1 (**C**H$_3$). **LRMS** (ESI$^+$): 408 ([M+H]$^+$, 100%).

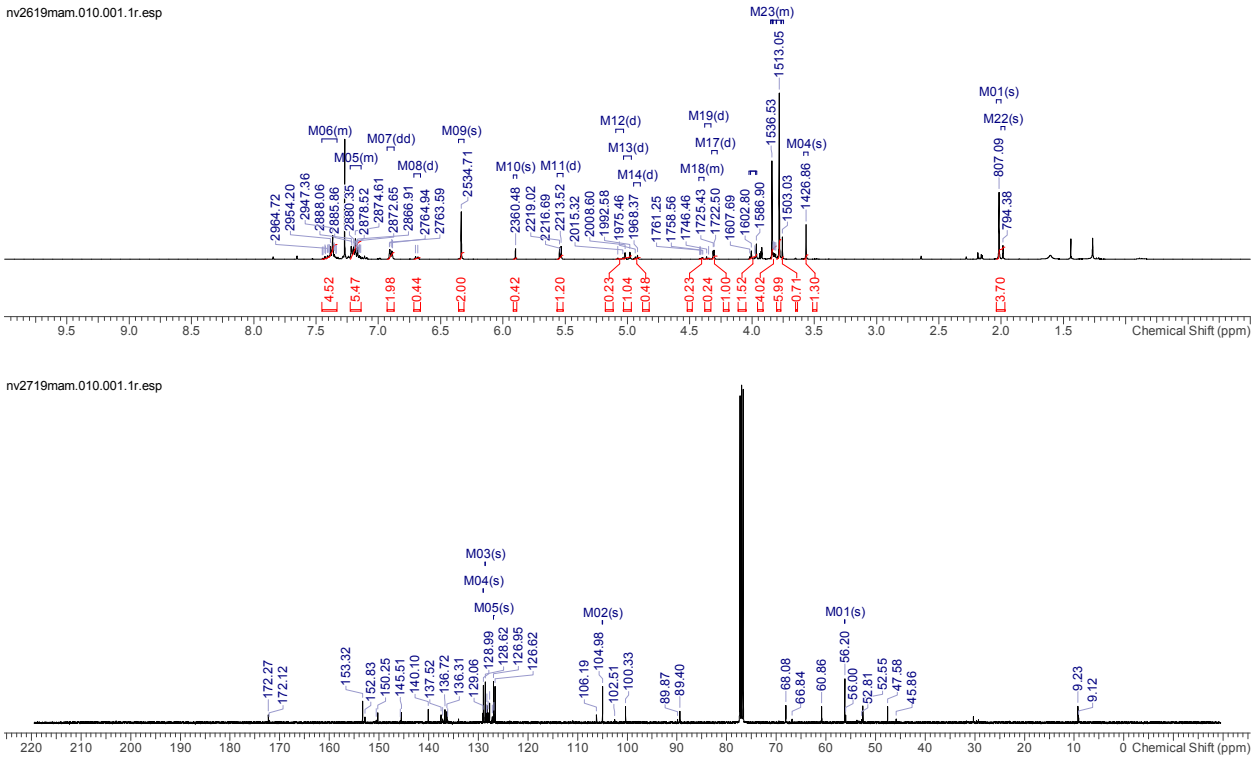


d.r. ~7:3

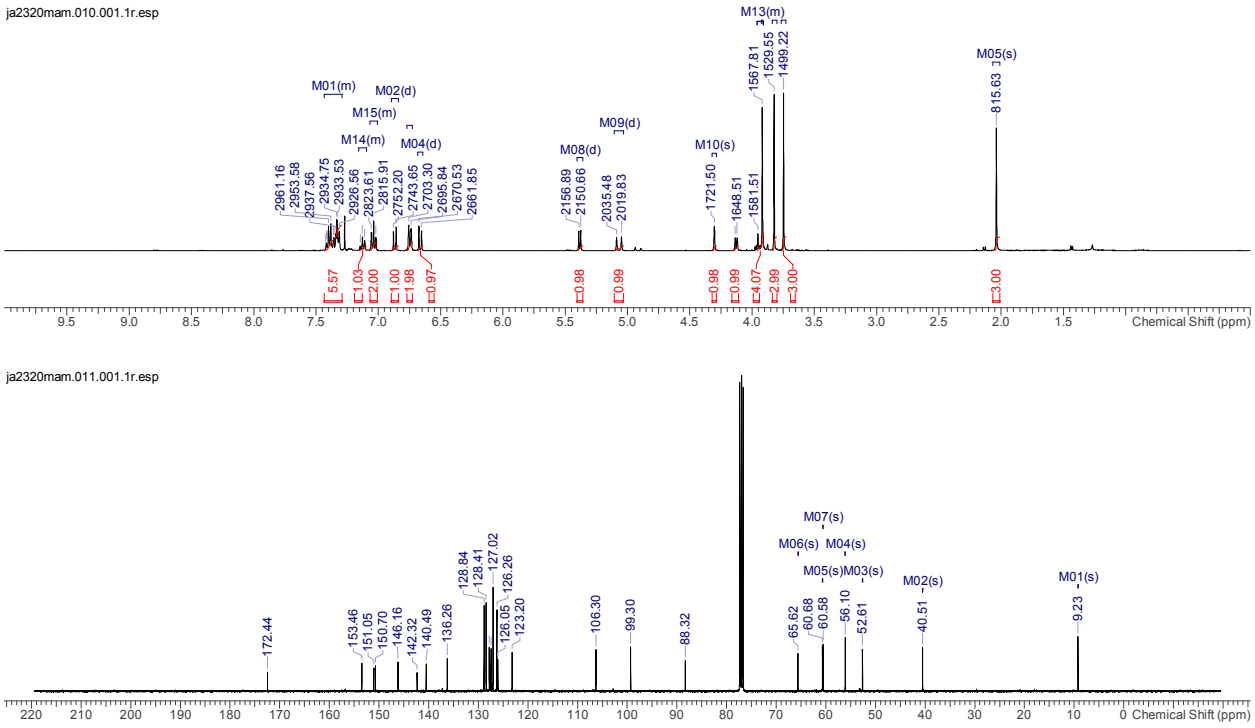


rel-(5*S*,6*S*)-4-Benzyl-3-methyl-5-phenyl-6-(3,4,5-trimethoxyphenyl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5l). A solution of alkynylcyclobutenone **4l** (553 mg, 1.14 mmol) in DMSO (50 mL) was heated at 150 °C under an argon atmosphere for 30 min then cooled to RT and partitioned between ethyl acetate (50 mL) and water (50 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 50 mL) then the combined organic phases were washed with water (3 × 150 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (20 – 60% diethyl ether/petrol) afforded firstly the title compound **5l** (142 mg, 0.293 mmol, 26%) as an inseparable 5:1 mixture of diastereoisomers: orange oil, **IR** ν_{max} (film, cm^{-1}): 2938 (w), 2838 (w), 1756 (s), 1695 (w), 1618 (vs), 1505 (m), 1452 (m), 1421 (m), 1126 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): *major isomer* δ ppm 7.45 – 7.34 (4H, m, 4×Ar**H**), 7.22 – 7.14 (4H, m, 4×Ar**H**), 6.90 (2H, dd, *J* = 7.6, 1.7 Hz, 2×Ar**H**), 6.33 (2H, s, 2×Ar**H**), 5.54 (1H, m, *J* = 5.8 Hz, C=C**H**), 5.00 (1H, d, *J* = 16.0 Hz, NC**H**H), 4.31 (1H, d, *J* = 2.9 Hz, NC**H**Ph), 3.98 (1H, d, *J* = 16.0 Hz, NCH**H**), 3.84 (3H, s, OC**H**$_3$), 3.82 (1H, dd, *J* = 5.6, 3.0 Hz, C**H**Ph), 3.78 (6H, s, 2×OC**H**$_3$), 2.02 (3H, s, C**H**$_3$); *minor isomer* 7.45 – 7.34 (4H, m, 4×Ar**H**), 7.22 – 7.14 (4H, m, 4×Ar**H**), 6.70 – 6.68 (2H, m, 2×Ar**H**), 5.90 (2H, s, 2×Ar**H**), 5.54 (1H, obscured d, C=C**H**), 5.06 (1H, d, *J* = 16.4 Hz, NC**H**H), 4.40 (1H, dd, *J* = 7.1, 2.6 Hz, C**H**Ph), 4.00 (1H, d, *J* = 16.6 Hz, NCH**H**), 3.76 (3H, s, OC**H**$_3$), 3.57 (6H, s, 2×OC**H**$_3$), 1.99 (3H, s, C**H**$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): *major isomer* 172.3 (**C**), 153.3 (2×**C**), 150.3 (**C**), 145.5 (**C**), 140.1 (**C**), 137.5 (**C**), 136.7 (**C**), 136.3 (**C**), 129.0 (2×**C**H), 128.6 (2×**C**H), 128.2 (**C**H), 127.7 (**C**H), 127.0 (2×**C**H), 126.6 (2×**C**H), 105.0 (2×**C**H), 100.3 (**C**H), 89.4 (**C**), 68.1 (**C**H), 60.9 (**C**H$_3$), 56.2 (2×**C**H$_3$), 52.6 (**C**H$_2$), 47.6 (**C**H), 9.2 (**C**H$_3$); *minor isomer* δ ppm 172.1 (**C**), 152.8 (2×**C**), 150.6 (**C**), 145.7 (**C**), 140.1 (**C**), 137.2 (**C**), 137.2 (**C**), 136.2 (**C**), 129.1 (**C**H), 128.9 (**C**H), 128.9 (**C**H), 128.3 (**C**H), 128.0 (2×**C**H), 127.9 (**C**H), 127.2 (**C**H), 126.9 (2×**C**H), 106.2 (2×**C**H), 102.5 (**C**H), 89.9 (**C**), 66.8 (**C**H), 60.8 (**C**H$_3$), 56.0 (2×**C**H$_3$), 52.8 (**C**H$_2$), 45.9 (**C**H), 9.1 (**C**H$_3$). **LRMS** (ESI$^+$): 484 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{30}H_{30}NO_5$ [M+H]$^+$ 484.2118, found: 484.2125. Furanone **13l** (81.5 mg, 0.169 mmol, 15%) followed as a brown oil. **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.39 – 7.30 (8H, m, 8×Ar**H**), 7.26 – 7.25 (2H, m, 2×Ar**H**), 6.56 (2H, s, 2×Ar**H**), 5.65 (1H, s, C**H**), 4.78 (2H, d, *J* = 16.4 Hz, 2×NC**H**H), 4.54 (2H, d, *J* = 16.5 Hz, 2×NCH**H**), 3.86 (3H, s, OC**H**$_3$), 3.82 (6H, s, 2×OC**H**$_3$), 1.96 (3H, s, C**H**$_3$). **LRMS** (ESI$^+$): 484 ([M+H]$^+$, 100%).

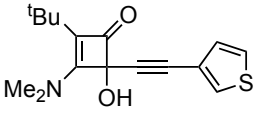




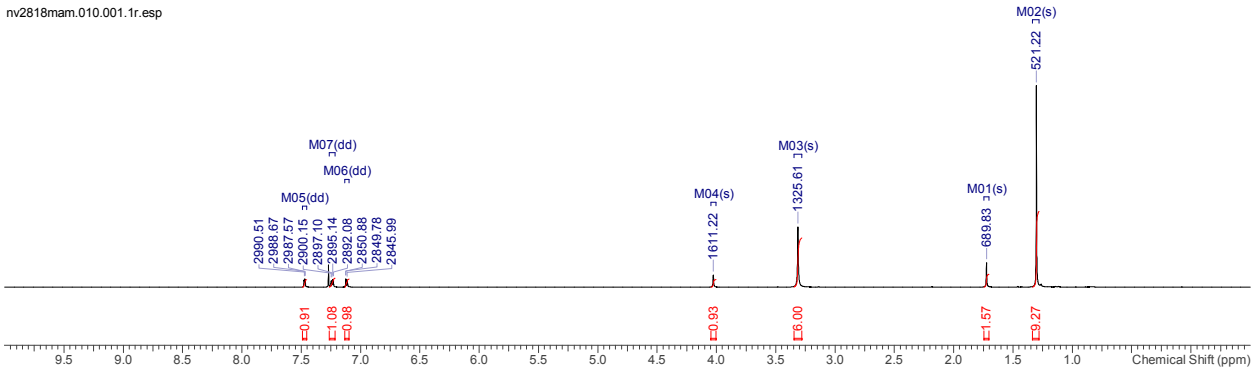
***rel*-(5*S*,6*S*)-4-Benzyl-3-methyl-5-phenyl-6-(2,3,4-trimethoxyphenyl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5m).** A solution of alkynylcyclobutenone **4m** (650 mg, 1.34 mmol) in DMSO (50 mL) was heated at 160 °C under an argon atmosphere for 1 h then cooled to RT and partitioned between ethyl acetate (50 mL) and water (50 mL). The aqueous phase was separated and extracted with ethyl acetate (2 × 50 mL) then the combined organic phases were washed with water (3 × 150 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (50 – 100% diethyl ether/petrol) gave a mixed fraction (333 mg, 0.689 mmol, 51%) and furanone **5m** (246 mg, 0.509 mmol, 38%, ~80% pure): **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.40 – 7.25 (10H, m, 10×Ar**H**), 7.05 (1H, d, *J* = 8.7 Hz, Ar**H**), 6.62 (1H, d, *J* = 8.8 Hz, Ar**H**), 5.63 (1H, s, C**H**), 4.99 (2H, d, *J* = 16.5 Hz, NC**H**H), 4.41 (2H, d, *J* = 16.6 Hz, NCH**H**), 3.89 (3H, s, OC$\mathbf{H}_3$), 3.88 (3H, s, OC$\mathbf{H}_3$), 3.87 (3H, s, OC$\mathbf{H}_3$), 1.96 (3H, s, C$\mathbf{H}_3$). **LRMS** (ESI$^+$): 484 ([M+H]$^+$, 100%). The mixed fraction was separated by HPLC (50% diethyl ether/petrol) to afford firstly the title compound **5m** (42.7 mg, 0.088 mmol, 7%) as a yellow solid. **MP**: 125 °C dec (CH_2Cl_2). **IR** ν_{max} (film, cm^{-1}): 2981 (m), 2971 (m), 1757 (s), 1631 (vs), 1493 (m), 1463 (m), 1273 (m), 1095 (s). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.42 – 7.31 (5H, m, 5×Ar**H**), 7.12 (1H, m, Ar**H**), 7.06 – 7.02 (2H, m, 2×Ar**H**), 6.87 (1H, d, *J* = 8.6 Hz, Ar**H**), 6.76 – 6.74 (2H, m, 2×Ar**H**), 6.66 (1H, d, *J* = 8.6 Hz, Ar**H**),5.38 (1H, d, *J* = 6.2 Hz, C=C**H**), 5.07 (1H, d, *J* = 15.7 Hz, NC**H**H), 4.30 (1H, s, NC**H**Ph), 4.13 (1H, d, *J* = 6.2 Hz, C**H**), 3.93 (1H, d, *J* = 15.7 Hz, NCH**H**), 3.92 (3H, s, OC$\mathbf{H}_3$), 3.82 (3H, s, OC$\mathbf{H}_3$), 3.75 (3H, s, OC$\mathbf{H}_3$), 2.04 (3H, s, C$\mathbf{H}_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 172.4 (**C**), 153.5 (**C**), 151.1 (**C**), 150.1 (**C**), 146.2 (**C**), 142.3 (**C**), 140.5 (**C**), 136.3 (**C**), 128.8 (2×**C**H), 128.4 (2×**C**H), 127.8 (**C**H), 127.4 (**C**H), 127.0 (2×**C**H), 126.3 (2×**C**H), 126.1 (**C**), 123.2 (**C**H), 106.3 (**C**H), 99.3 (**C**H), 88.3 (**C**), 65.6 (**C**H), 60.7 (**C**H_3), 60.6 (**C**H_3), 56.1 (**C**H_3), 52.6 (**C**H_2), 40.5 (**C**H), 9.2 (**C**H_3). **LRMS** (ESI$^+$): 484 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{30}H_{30}NO_5$ [M+H]$^+$ 484.2118, found: 484.2125. The (*E*)- and (*Z*)-isomers of cyclopentenedione **15** (79.8 mg, 0.165 mmol, 12%) and (21.3 mg, 0.044 mmol, 3%) followed, each as yellow oils. The former exhibited **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 8.78 (1H, d, *J* = 9.1 Hz, Ar**H**), 7.76 (1H, s, =C**H**), 7.40 – 7.30 (6H, m, 6×Ar**H**), 7.24 – 7.22 (4H, m, 4×Ar**H**), 6.76 (1H, d, *J* = 9.1 Hz, Ar**H**), 4.94 (4H, s, 2×NC$\mathbf{H}_2$), 3.96 (3H, s, OC$\mathbf{H}_3$), 3.94 (3H, s, OC$\mathbf{H}_3$), 3.87 (3H, s, OC$\mathbf{H}_3$), 2.13 (3H, s, C$\mathbf{H}_3$). **LRMS** (ESI$^+$): 484 ([M+H]$^+$, 100%). The latter exhibited **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 8.41 (1H, d, *J* = 9.1 Hz, Ar**H**), 7.85 (1H, s, =C**H**), 7.39 – 7.29 (6H, m, 6×Ar**H**), 7.23 – 7.21 (4H, m, 4×Ar**H**), 6.72 (1H, d, *J* = 9.1 Hz, Ar**H**), 4.89 (4H, s, 2×NC$\mathbf{H}_2$), 3.97 (3H, s, OC$\mathbf{H}_3$), 3.91 (3H, s, OC$\mathbf{H}_3$), 3.87 (3H, s, OC$\mathbf{H}_3$), 2.14 (3H, s, C$\mathbf{H}_3$). **LRMS** (ESI$^+$): 484 ([M+H]$^+$, 100%).

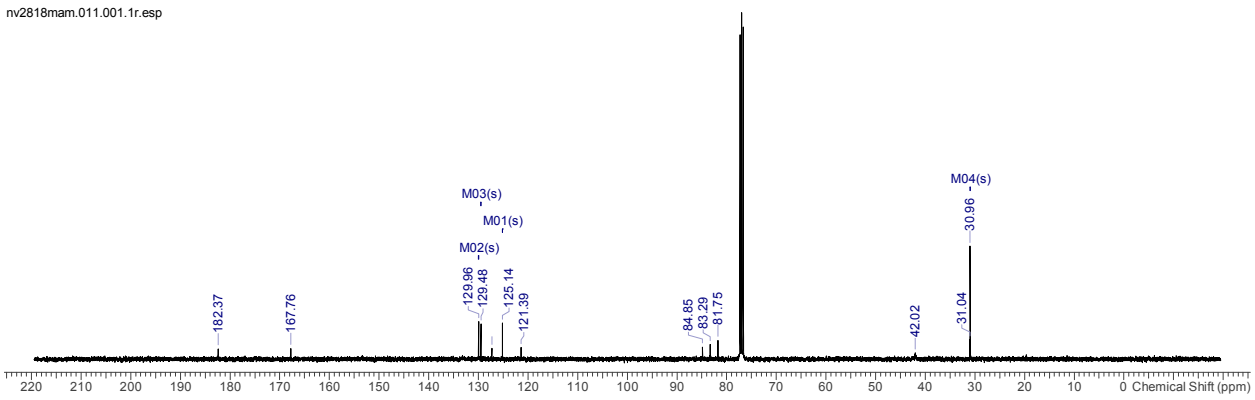


2-(*tert*-Butyl)-3-(dimethylamino)-4-hydroxy-4-(thiophen-3-ylethynyl)cyclobut-2-en-1-one (4n).

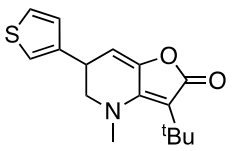


To a solution of 3-ethynylthiophene (0.17 mL, 1.68 mmol) in THF (20 mL) at –78 °C was added ^{n}butyllithium (2.5 M in hexanes, 0.6 mL, 1.46 mmol) dropwise. After 30 min, the solution was added *via* cannula to a solution of cyclobutenedione **10a** (203 mg, 1.12 mmol) in THF (30 mL) at –78 °C. After a further 65 min, sat. NH_4Cl (15 mL) was added, the solution warmed to RT and diluted with water (20 mL). The aqueous phase was separated and extracted with DCM (3 x 50 mL) then the organic phases were combined, dried over magnesium sulfate, concentrated *in vacuo* and purified by column chromatography (5 – 10% acetone/DCM) to afford the title compound **4n** (300 mg, 1.04 mmol, 93%) as a white solid. **MP**: 150 °C (dec). **IR** ν_{max} (film, cm^{-1}): 3240 (w), 2959 (w), 1732 (w), 1577 (vs), 1407 (m), 1364 (w), 1258 (w), 1183 (w), 1140 (w), 1072 (w). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.47 (1H, dd, *J* = 2.9, 1.1 Hz, Ar**H**), 7.24 (1H, dd, *J* = 5.0, 3.1 Hz, Ar**H**), 7.12 (1H, dd, *J* = 5.0, 1.2 Hz, Ar**H**), 4.03 (1H, br s, O**H**), 3.31 (6H, s, 2×N**C**H_3), 1.30 (9H, s, C(**C**H_3)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 182.4 (**C**), 167.8 (**C**), 130.0 (**C**H), 129.5 (**C**H), 127.3 (**C**), 125.1 (**C**H), 121.4 (**C**), 84.9 (**C**), 83.3 (**C**), 81.8 (**C**), 42.0 (br s, 2×**C**H_3), 31.0 (**C**), 31.0 (3×**C**H_3). **LRMS** (ESI^+): 290 ([M+H]$^+$, 100%). **HRMS** (ESI^+): Calculated for $C_{16}H_{20}NO_2S$ [M+H]$^+$ 290.1209, found: 290.1214.

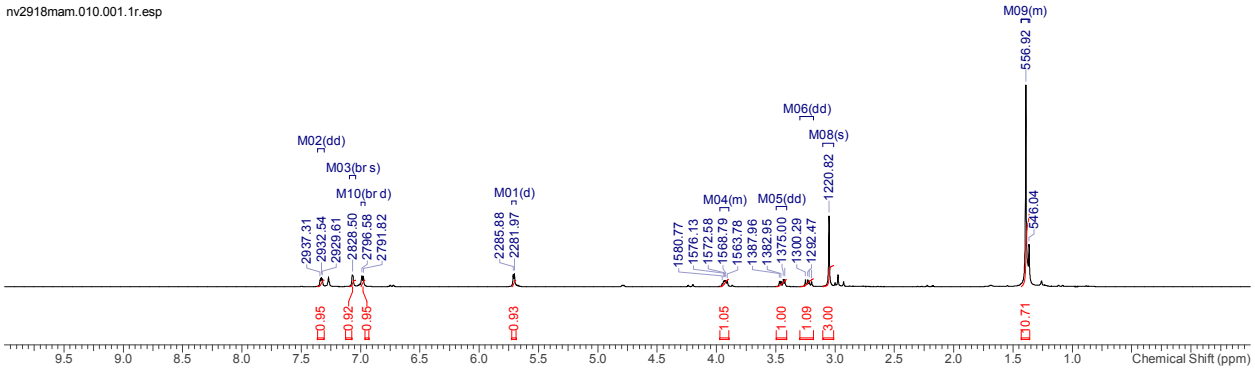


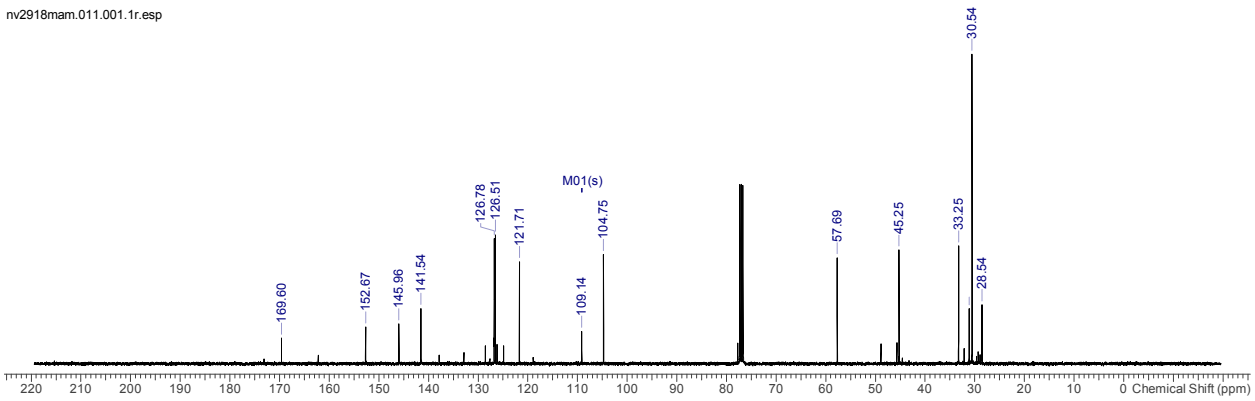


3-(*tert*-Butyl)-4-methyl-6-(thiophen-3-yl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5n).

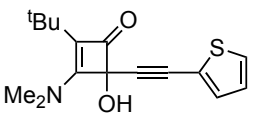


A solution of alkynylcyclobutenone **4n** (415 mg, 1.43 mmol) in DMSO (100 mL) was heated at 150 °C for 30 min then cooled to RT and partitioned between ethyl acetate (100 mL) and water (100 mL). The aqueous phase was separated and extracted with ethyl acetate (2 x 100 mL) then the combined organic layers were washed with water (3 x 300 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (5 – 10% diethyl ether/petroleum ether 40 – 60 °C) afforded the title compound **5n** (252 mg, 0.872 mmol, 61%, ~90% purity) as a yellow gel. **IR** ν_{max} (film, cm^{-1}): 2956 (w), 2924 (m), 1745 (vs), 1681 (w), 1585 (s), 1458 (w), 1407 (w), 1365 (w), 1333 (w), 1393 (w), 1064 (w). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.33 (1H, dd, *J* = 4.7, 3.0 Hz, Ar**H**), 7.07 (1H, br s, Ar**H**), 6.98 (1H, br d, *J* = 4.8 Hz, Ar**H**), 5.71 (1H, d, *J* = 3.9 Hz, C=C**H**), 3.93 (1H, m, ArC**H**), 3.45 (1H, dd, *J* = 13.0, 5.0 Hz, C**H**H), 3.22 (1H, dd, *J* = 12.9, 7.8 Hz, CH**H**), 3.05 (3H, s, NC$\mathbf{H_3}$), 1.39 (9H, s, C(C$\mathbf{H_3}$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.6 (**C**), 152.7 (**C**), 146.0 (**C**), 141.5 (**C**), 126.8 (**C**H), 126.5 (**C**H), 121.7 (**C**H), 109.1 (**C**), 104.8 (**C**H), 57.7 (**C**H_2), 45.3 (**C**H_3), 33.3 (**C**H), 31.1 (**C**), 30.5 (3×**C**H_3). **LRMS** (ESI^+): 290 ([M+H]$^+$, 100%). **HRMS** (ESI^+): Calculated for $C_{16}H_{20}NO_2S$ [M+H]$^+$ 290.1209, found: 290.1210.



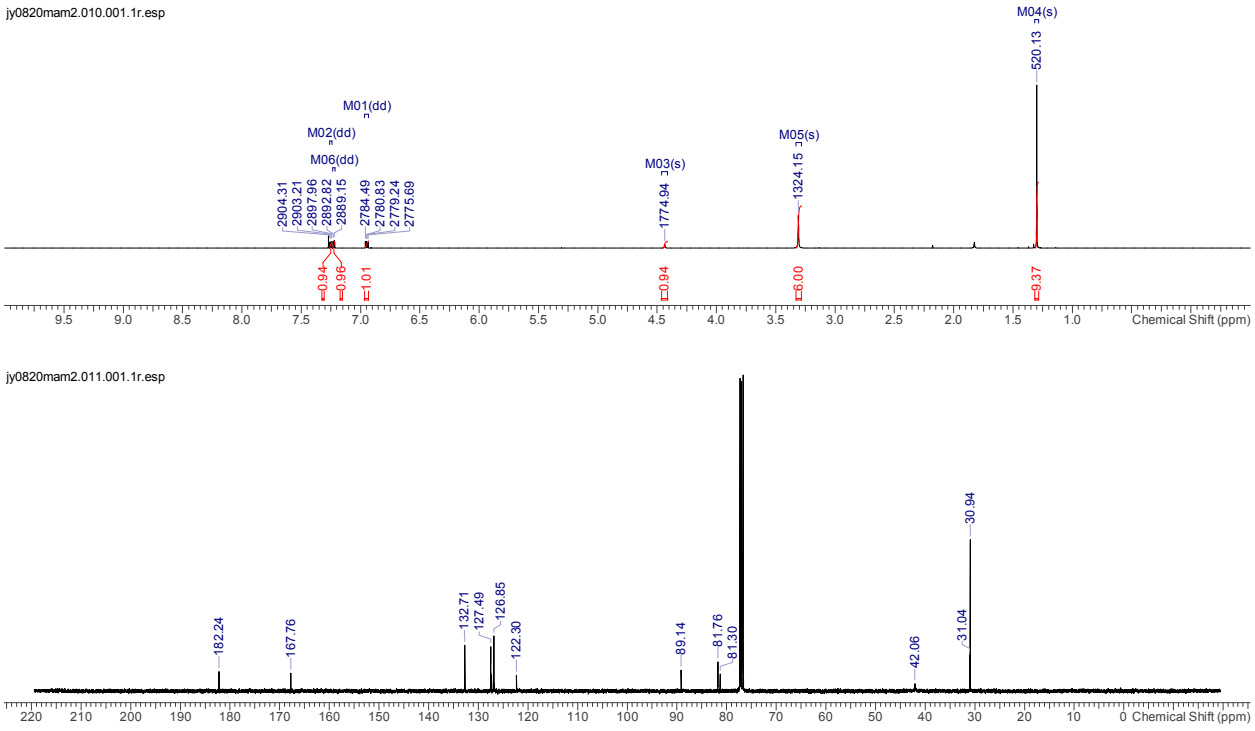


2-(*tert*-Butyl)-3-(dimethylamino)-4-hydroxy-4-(thiophen-2-ylethynyl)cyclobut-2-en-1-one (4o).

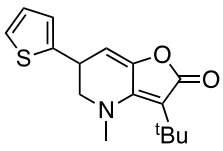


To a solution of 2-ethynylthiophene (0.50 mL, 5.27 mmol) in THF (30 mL) at –78 °C was added ^{n}butyllithium (2.5 M in hexanes, 2.2 mL, 5.50 mmol) dropwise. After 20

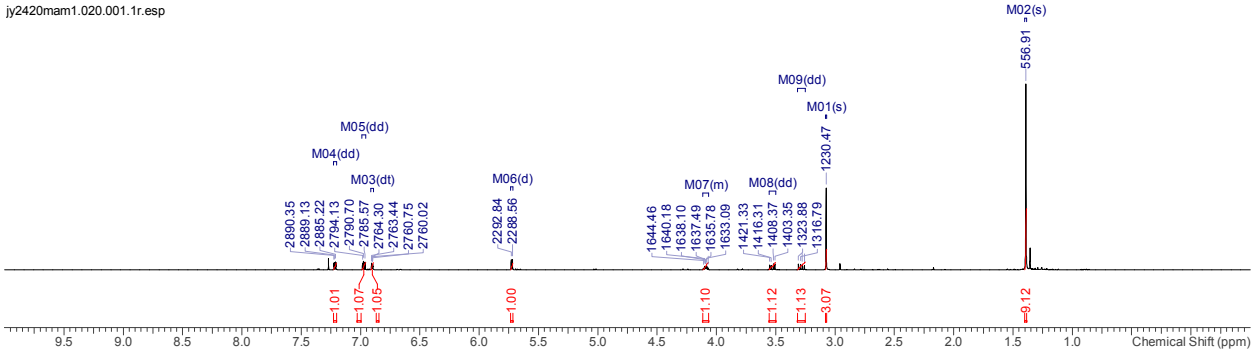
min, the solution was added *via* cannula to a solution of cyclobutenedione **10a** (759 mg, 4.19 mmol) in THF (60 mL) at –78 °C. After a further 95 min, sat. NH_4Cl solution (30 mL) was added then the reaction mixture was warmed to RT and diluted with water (70 mL). The aqueous phase was separated and extracted with DCM (3 x 70 mL) then the combined organic phases were dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (10 – 40% acetone/DCM) afforded the title compound **4o** (894 mg, 3.09 mmol, 74%) as a pale brown foam. **IR** ν_{max} (film, cm^{-1}): 3225 (br w), 2959 (w), 1731 (m), 1569 (vs), 1436 (w), 1406 (s), 1364 (m), 1257 (m), 1202 (w), 1186 (m), 1137 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.25 (1H, dd, *J* = 5.2, 1.2 Hz, Ar**H**), 7.22 (1H, dd, *J* = 3.6, 1.2 Hz, Ar**H**), 6.95 (1H, dd, *J* = 5.2, 3.6 Hz, Ar**H**), 4.44 (1H, br s, O**H**), 3.31 (6H, s, 2×NC**H$_3$**), 1.30 (9H, s, C(C**H$_3$**)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 182.2 (**C**), 167.8 (**C**), 132.7 (**C**H), 127.5 (**C**H), 127.3 (**C**), 126.9 (**C**H), 122.3 (**C**), 89.1 (**C**), 81.8 (**C**), 81.3 (**C**), 42.1 (br s, 2×**C**H$_3$), 31.0 (**C**), 30.9 (3×**C**H$_3$). **LRMS** (ESI$^+$): 290 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{16}H_{20}NO_2S$ [M+H]$^+$ 290.1209, found: 290.1217.

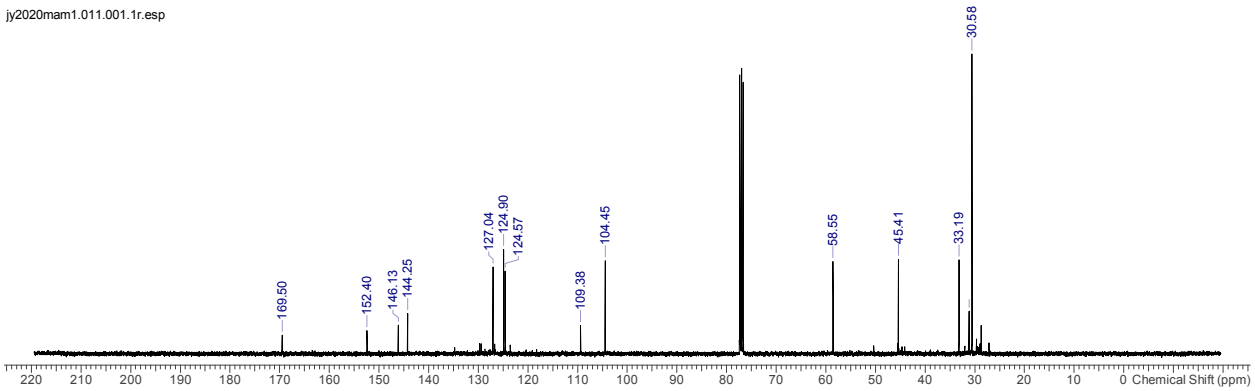


3-(*tert*-Butyl)-4-methyl-6-(thiophen-2-yl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5o).

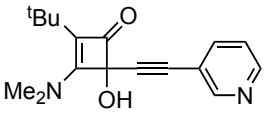


A solution of alkynylcyclobutenone **4o** (429 mg, 1.48 mmol) in DMSO (50 mL) was heated at 150 °C for 30 min then cooled to RT and partitioned between ethyl acetate (50 mL) and water (50 mL). The aqueous phase was separated and extracted with ethyl acetate (2 x 100 mL) then the combined organic layers were washed with water (3 x 150 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (5 – 10% acetone/DCM) afforded the title compound **5o** (316 mg, 1.09 mmol, 74%) as a brown gel. **IR** ν_{max} (film, cm^{-1}): 2959 (w), 2906 (w), 2016 (w), 1979 (w), 1749 (vs), 1683 (w), 1587 (s), 1457 (w), 1406 (w), 1365 (w), 1329 (w), 1290 (w). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 7.22 (1H, dd, *J* = 5.1, 1.2 Hz, Ar**H**), 6.97 (1H, dd, 5.1, 3.5 Hz, Ar**H**), 6.90 (1H, dt, *J* = 3.5, 1.0 Hz, Ar**H**), 5.72 (1H, d, *J* = 4.3 Hz, =C**H**), 4.09 (1H, m, ArC**H**), 3.53 (1H, dd, *J* = 13.0, 5.0 Hz, C**H**H), 3.28 (1H, dd, *J* = 13.0, 7.0 Hz, CH**H**), 3.08 (3H, s, NC**H$_3$**), 1.39 (9H, s, C(C**H$_3$**)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.5 (**C**), 152.4 (**C**), 146.1 (**C**), 144.3 (**C**), 127.0 (**C**H), 124.9 (**C**H), 124.6 (**C**H), 109.4 (**C**), 104.5 (**C**H), 58.6 (**C**H$_2$), 45.4 (**C**H$_3$), 33.2 (**C**H), 31.2 (**C**), 30.6 (3×**C**H$_3$). **LRMS** (ESI$^+$): 290 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{16}H_{20}NO_2S$ [M+H]$^+$ 290.1209, found: 290.1214.

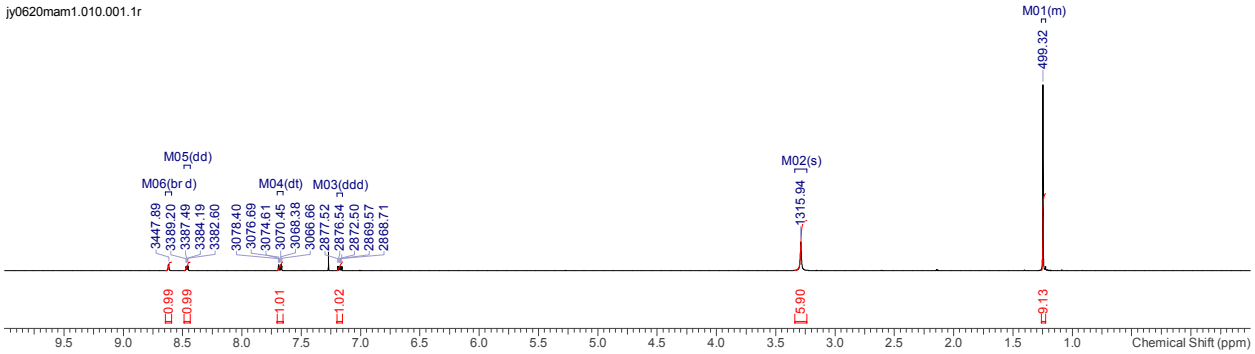


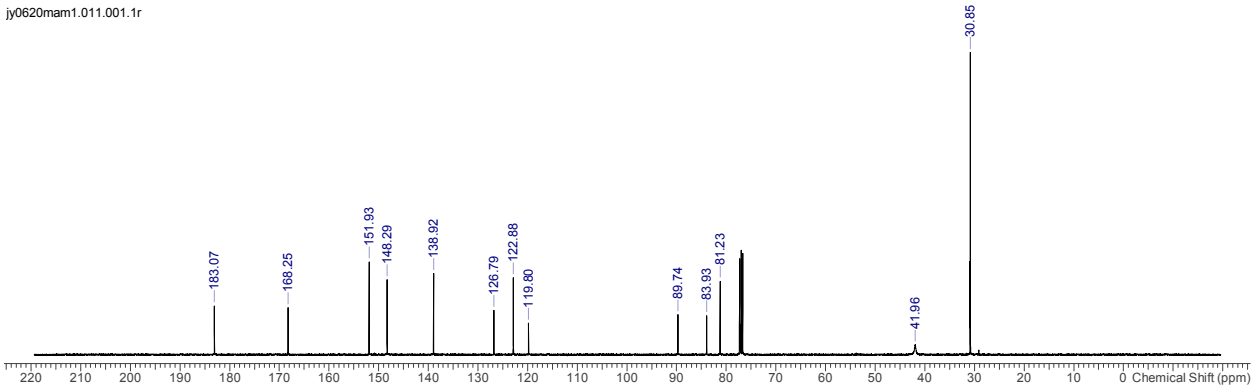


2-(*tert*-Butyl)-3-(dimethylamino)-4-hydroxy-4-(pyridin-3-ylethynyl)cyclobut-2-en-1-one (4p).

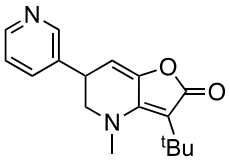


To a solution of 3-ethynylpyridine (759 mg, 7.36 mmol) in THF (40 mL) at –78 °C was added *n*butyllithium (2.5 M in hexanes, 3.1 mL, 7.75 mmol) dropwise. After 20 min, the solution was added *via* cannula to a solution of cyclobutenedione **10a** (1.12 g, 6.19 mmol) in THF (70 mL) at –78 °C. After a further 160 min, sat. NH_4Cl (30 mL) was added then the reaction mixture was warmed to RT and diluted with water (80 mL). The aqueous phase was separated and extracted with DCM (3 x 100 mL) then the combined organic phases were dried over magnesium sulfate, concentrated *in vacuo*. Purification by column chromatography (10 – 70% acetone/DCM) afforded the title compound **4p** (1.68 g, 5.91 mmol, 95%) as a pale brown gel. **IR** ν_{max} (film, cm^{-1}): 2959 (br m), 2868 (w), 1733 (m), 1574 (vs), 1476 (w), 1405 (s), 1364 (m), 1255 (m), 1185 (m), 1140 (m). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 8.62 (1H, br d, *J* = 1.3 Hz, Ar**H**), 8.46 (1H, dd, *J* = 5.0, 1.7 Hz, Ar**H**), 7.68 (1H, app dt, *J* = 8.1, 1.8 Hz, Ar**H**), 7.17 (1H, ddd, 7.9, 5.0, 1.0 Hz, Ar**H**), 3.29 (6H, s, 2×NC**H$_3$**), 1.25 (9H, s, C(C**H$_3$**)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 183.1 (**C**), 168.3 (**C**), 151.9 (**C**H), 148.3 (**C**H), 138.9 (**C**H), 126.8 (**C**), 122.9 (**C**H), 119.8 (**C**), 89.7 (**C**), 83.9 (**C**), 81.2 (**C**), 42.0 (br s, 2×**C**H$_3$), 30.9 (**C**), 30.9 (3×**C**H$_3$). **LRMS** (ESI^+): 285 ($[M+H]^+$, 100%). **HRMS** (ESI^+): Calculated for $C_{17}H_{21}N_2O_2$ $[M+H]^+$ 285.1598, found 285.1602.

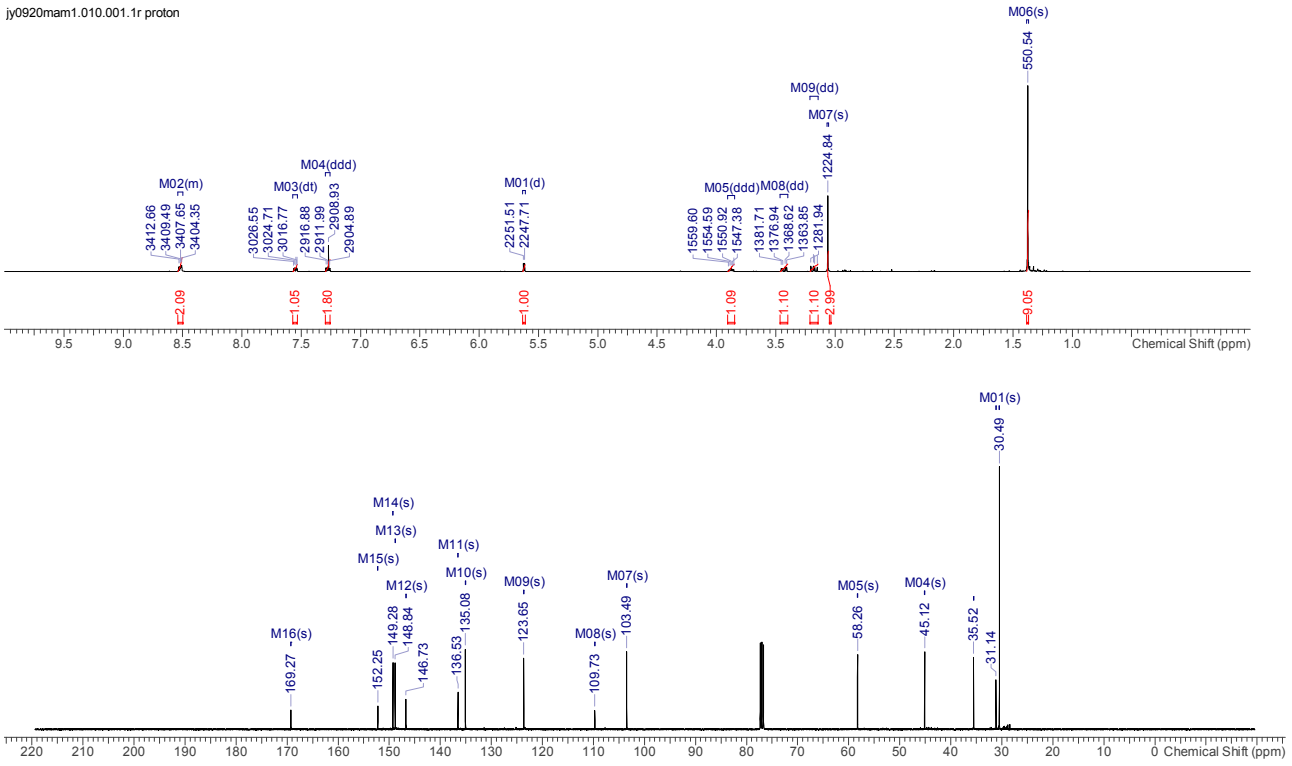




3-(*tert*-Butyl)-4-methyl-6-(pyridin-3-yl)-5,6-dihydrofuro[3,2-b]pyridin-2(4*H*)-one (5p).



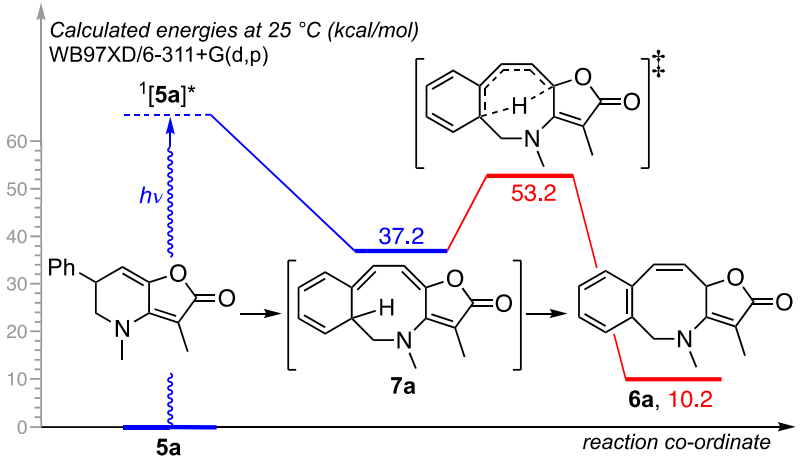
A solution of alkynylcyclobutenone **4p** (630 mg, 2.22 mmol) in DMSO (70 mL) was heated at 160 °C for 40 min then cooled to RT and partitioned between ethyl acetate (70 mL) and water (70 mL). The aqueous phase was separated and extracted with ethyl acetate (2 x 70 mL) then the combined organic phases were washed with water (3 x 210 mL), dried over magnesium sulfate and concentrated *in vacuo*. Purification by column chromatography (40 – 100% ethyl acetate/petroleum ether 40 – 60 °C) afforded the title compound **5p** (556 mg, 1.96 mmol, 88%) as a brown gel. **IR** ν_{max} (film, cm^{-1}): 2958 (m), 2906 (w), 1745 (vs), 1683 (w), 1584 (vs), 1479 (w), 1425 (m), 1406 (m), 1365 (w), 1299 (m), 1285 (w). **^{1}H NMR** (400 MHz, $CDCl_3$): δ ppm 8.53 – 8.51 (2H, m, Ar**H**), 7.55 (1H, dt, *J* = 7.9, 1.9 Hz, Ar**H**), 7.27 (1H, ddd, 8.0, 4.9, 0.7 Hz, Ar**H**), 5.62 (1H, d, *J* = 3.8 Hz, C=C**H**), 3.88 (1H, ddd, *J* = 8.3, 4.9, 3.9 Hz, ArC**H**), 3.43 (1H, dd, *J* = 13.1, 4.8 Hz, C**H**H), 3.18 (1H, dd, *J* = 13.1, 8.2 Hz, CH**H**), 3.06 (3H, s, NC**H**$_3$), 1.38 (9H, s, C(C**H**$_3$)$_3$). **^{13}C NMR** (100 MHz, $CDCl_3$): δ ppm 169.3 (**C**), 152.3 (**C**), 149.3 (**C**H), 148.8 (**C**H), 146.7 (**C**), 136.5 (**C**), 135.1 (**C**H), 123.7 (**C**H), 109.7 (**C**), 103.5 (**C**H), 58.3 (**C**H$_2$), 45.1 (**C**H$_3$), 35.5 (**C**H), 31.1 (**C**), 30.5 (3×**C**H$_3$). **LRMS** (ESI$^+$): 285 ([M+H]$^+$, 100%). **HRMS** (ESI$^+$): Calculated for $C_{17}H_{21}N_2O_2$ [M+H]$^+$ 285.1598, found: 285.1605.



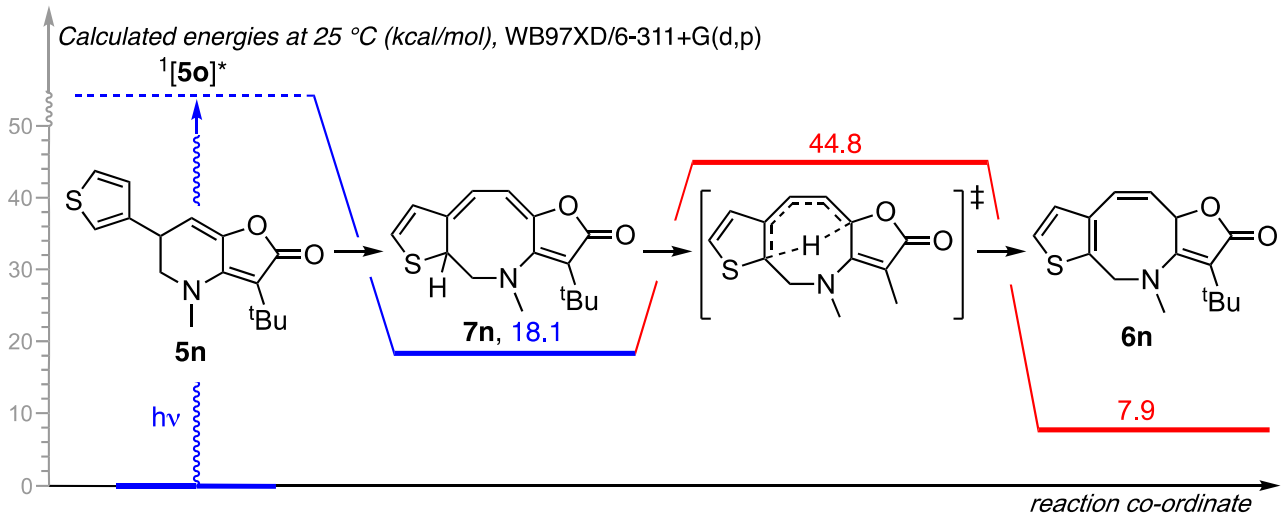
3. DFT Calculations

DFT calculations for Figure 2 and the rearrangement of **5n** to **6n** were carried out with the Gaussian 09W C.01 program.[8] Gibbs free energies (ΔG) at 298.15 K (25 °C) and 1 atm were calculated at the WB97XD/6-311+G(d,p) level of theory. The geometries of all intermediate species were optimized and confirmed by the

absence of imaginary frequencies. The transition states were found by relaxed scans of the bond distance between atoms directly involved and checked by the existence of a single imaginary frequency corresponding to their reaction coordinates.



Compound	WB97XD/6-311+G(d,p) calculations	Hartree/particle
5a	Zero-point correction	0.271958
	Thermal correction to Energy	0.287292
	Thermal correction to Enthalpy	0.288236
	Thermal correction to Gibbs Free Energy	0.228646
	Sum of electronic and zero-point Energies	–785.496228
	Sum of electronic and thermal Energies	–785.480895
	Sum of electronic and thermal Enthalpies	–785.479951
	Sum of electronic and thermal Free Energies	–785.539541
7a	Zero-point correction	0.272132
	Thermal correction to Energy	0.287138
	Thermal correction to Enthalpy	0.288083
	Thermal correction to Gibbs Free Energy	0.230534
	Sum of electronic and zero-point Energies	–785.438715
	Sum of electronic and thermal Energies	–785.423709
	Sum of electronic and thermal Enthalpies	–785.422764
	Sum of electronic and thermal Free Energies	–785.480313
TS	Zero-point correction	0.267311
	Thermal correction to Energy	0.281850
	Thermal correction to Enthalpy	0.282794
	Thermal correction to Gibbs Free Energy	0.226201
	Sum of electronic and zero-point Energies	–785.413602
	Sum of electronic and thermal Energies	–785.399063
	Sum of electronic and thermal Enthalpies	–785.398119
	Sum of electronic and thermal Free Energies	–785.454712
6a	Zero-point correction	0.273699
	Thermal correction to Energy	0.288434
	Thermal correction to Enthalpy	0.289378
	Thermal correction to Gibbs Free Energy	0.232176
	Sum of electronic and zero-point Energies	–785.481816
	Sum of electronic and thermal Energies	–785.467080
	Sum of electronic and thermal Enthalpies	–785.466136
	Sum of electronic and thermal Free Energies	–785.523338



Compound	WB97XD/6-311+G(d,p) calculations	Hartree/particle
5n	Zero-point correction	0.241282
	Thermal correction to Energy	0.255959
	Thermal correction to Enthalpy	0.256903
	Thermal correction to Gibbs Free Energy	0.198437
	Sum of electronic and zero-point Energies	–1106.300185
	Sum of electronic and thermal Energies	–1106.285508
	Sum of electronic and thermal Enthalpies	–1106.284564
	Sum of electronic and thermal Free Energies	–1106.343029
7n	Zero-point correction	0.240685
	Thermal correction to Energy	0.255246
	Thermal correction to Enthalpy	0.256191
	Thermal correction to Gibbs Free Energy	0.199515
	Sum of electronic and zero-point Energies	–1106.272982
	Sum of electronic and thermal Energies	–1106.258421
	Sum of electronic and thermal Enthalpies	–1106.257476
	Sum of electronic and thermal Free Energies	–1106.314152
TS	Zero-point correction	0.236266
	Thermal correction to Energy	0.250410
	Thermal correction to Enthalpy	0.251354
	Thermal correction to Gibbs Free Energy	0.195099
	Sum of electronic and zero-point Energies	–1106.230516
	Sum of electronic and thermal Energies	–1106.216372
	Sum of electronic and thermal Enthalpies	–1106.215428
	Sum of electronic and thermal Free Energies	–1106.271683
6n	Zero-point correction	0.240559
	Thermal correction to Energy	0.255397
	Thermal correction to Enthalpy	0.256341
	Thermal correction to Gibbs Free Energy	0.198395
	Sum of electronic and zero-point Energies	–1106.288261
	Sum of electronic and thermal Energies	–1106.273423
	Sum of electronic and thermal Enthalpies	–1106.272479
	Sum of electronic and thermal Free Energies	–1106.330425

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