Gold Catalysed Synthesis of 3-Alkoxy Furans at Room Temperature

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Table of Contents

1. Propargylic Alcohol Synthesis
2. Furan Synthesis
3. Reactions of Furan Products
4. 1H and 13C NMR Spectra for Novel Compounds
5. References
All reactions were carried out under an atmosphere of air unless otherwise indicated. Tetrahydrofuran was used following purification from a zeolite drying apparatus. All other chemicals were used as supplied unless otherwise indicated. Column chromatography was carried out using silica gel (40-60 µm) and analytical thin layer chromatography was carried out using aluminium-backed plates coated with silica gel. Components were visualised using combinations of ultra-violet lights, iodine, ceric ammonium molybdate, phosphomolybdic acid and potassium permanganate.

$^1$H NMR spectra were recorded at 400 MHz, 500 MHz or at 600 MHz on a spectrometer in CDCl$_3$ using residual protic solvent CHCl$_3$ (δ = 7.26 ppm, s) as the internal standard. Chemical shifts are quoted in ppm using the following abbreviations: s, singlet; d, doublet; t, triplet; q, quartet; qn, quintet; m, multiplet; br, broad or a combination of these. The coupling constants (J) are measured in Hertz.

$^{13}$C NMR spectra were recorded at 100 MHz, 125 MHz or at 150 MHz on a spectrometer in CDCl$_3$ using the central reference of CHCl$_3$ (δ = 77.0 ppm, t) as the internal standard.

1. Propargylic Alcohol Synthesis

General Procedure: n-Butyllithium (1.6M in hexanes, 1.2 eq.) was added dropwise to a stirred solution of 3,3-diethoxypropyne (1 eq.) in dry THF (1 mL mmol$^{-1}$) at -78 °C under an argon atmosphere. After 30 min the aldehyde (1 eq.) was added and the resulting solution was allowed to warm to rt and stirred overnight. The reaction was quenched with sat. aq. NaHCO$_3$ and the organic phase extracted with diethyl ether.

The combined organic extracts were washed with brine, dried (MgSO$_4$) and concentrated in vacuo. The residue was purified by column chromatography to give the propargylic alcohol. Reactions were performed on scales using up to 9.3 g of 3,3-diethoxypropyne.

4,4-Diethoxy-1-(4-(trifluoromethyl)phenyl)but-2-yn-1-ol 1a

99% yield; IR (film) ν = 3404, 2980, 2936, 2888, 2246 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) δ = 7.66-7.59 (m, 4H), 5.56 (d, J = 5.7 Hz, 1H), 5.33 (s, 1H), 3.77-3.68 (m, 2H), 3.63-3.54 (m, 2H), 3.41 (br s, 1H), 1.21 (t, J = 7.1 Hz, 6H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) δ = 143.9, 130.5 (q, J = 32.3 Hz), 126.9, 125.5 (q, J = 3.7 Hz), 124.3 (q, J = 272.0 Hz), 91.2, 84.5, 82.3, 65.8, 63.5, 61.1, 15.0 ppm; Found (ES): [M-H]$^+$ 301.1051, C$_{15}$H$_{16}$O$_3$F$_3$ requires 301.1052.

6,6-Diethoxy-1-phenylhex-4-yn-3-ol 1b

75% yield; IR (film) ν = 3418, 2977, 2930, 2885, 2248 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) δ = 7.28-7.15 (m, 5H), 5.30 (s, 1H), 4.40 (br s, 1H), 3.77-3.70 (m, 2H), 3.62-3.54 (m, 2H), 2.89 (br s, 1H), 2.78 (t, J = 7.9 Hz, 2H), 2.07-1.98 (m, 2H), 1.22 (t, J = 7.1 Hz, 6H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) δ = 141.2, 128.51, 128.46, 126.0, 91.3, 86.5, 80.3, 61.3, 60.99, 60.91, 39.0, 31.4, 15.1 ppm; Found (Cl): [M-OEt]$^+$ 217.12276, C$_{14}$H$_{17}$O$_2$ requires 217.12231.

4,4-Diethoxy-1-(4-methoxyphenyl)but-2-yn-1-ol 1c

96% yield; IR (film) ν = 3412, 2976, 2933, 2889, 2243 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) δ = 7.44 (d, J = 8.7 Hz, 2H), 6.89 (d, J = 8.7 Hz, 2H), 5.46 (d, J = 6.0 Hz, 1H), 5.34 (s, 1H), 3.80 (s, 3H), 3.79-3.70 (m, 2H), 3.65-3.55 (m, 2H), 2.53 (br s, 1H), 1.23 (t, J = 7.1 Hz, 6H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) δ = 159.8, 132.4, 128.1,
114.0, 91.4, 85.3, 81.7, 64.0, 61.03, 60.96, 55.3, 15.1 ppm; Found (EI): [M]+ 264.135933, C₁₅H₂₀O₄ requires 264.13561.

1-Cyclopropyl-4,4-diethoxybut-2-yn-1-ol 1d
86% yield; IR (film) ν = 3410, 2978, 2932, 2890, 2248 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 5.26 (s, 1H), 4.18 (t, J = 6.0 Hz, 1H), 3.72-3.65 (m, 2H), 3.57-3.52 (m, 2H), 2.46 (d, J = 6.0 Hz, 1H), 1.25-1.20 (m, 1H), 1.19 (t, J = 7.2 Hz, 6H), 0.56-0.47 (m, 2H), 0.45-0.38 (m, 2H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 91.3, 84.6, 80.2, 65.5, 61.0, 60.9, 17.0, 15.1, 3.34, 1.76 ppm; Found (Cl): [M-OEt]+ 153.10159, C₅H₁₃O₂ requires 153.09101.

4,4-Diethoxy-1-phenylbut-2-yn-1-ol 1e
95% yield; IR (film) ν = 3317, 2977, 1493, 1455 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.57-7.54 (m, 2H), 7.43-7.33 (m, 3H), 5.55 (d, J = 6.2 Hz, 1H), 5.83 (s, 1H), 3.81-3.73 (m, 2H), 3.67-3.58 (m, 2H), 2.43 (d, J = 6.2 Hz, 1H), 1.25 (t, J = 7.1 Hz, 6H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 140.1, 128.7, 128.5, 126.7, 91.4, 85.2, 82.0, 64.5, 61.1, 61.0, 15.1 ppm; data in accordance with the literature.¹

1-(2,6-Dimethylphenyl)-4,4-diethoxybut-2-yn-1-ol 1f
97% yield; IR (film) ν = 3424, 2976, 2930, 2890, 2248 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.10-7.05 (m, 1H), 7.01-6.97 (m, 2H), 5.94 (s, 1H), 5.26 (s, 1H), 3.75-3.65 (m, 2H), 3.60-3.50 (m, 2H), 2.60 (br s, 1H), 2.49 (s, 6H), 1.20 (t, J = 7.1 Hz, 3H), 1.18 (t, J = 7.1 Hz, 3H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 152.4, 143.0, 110.4, 107.9, 91.2, 82.9, 80.9, 61.08, 61.01, 57.8, 15.0 ppm; Found (Cl): [M]+ 261.148379, C₁₆H₂₃O₂ requires 261.14852.

(6R)-1,1-Diethoxy-6,10-dimethylundec-9-en-2-yn-4-ol 1g
88% yield; IR (film) ν = 3388, 2974, 2913, 2236, 1480 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 5.26 (s, 1H), 5.04 (t, J = 5.7 Hz, 1H), 4.46-4.42 (m, 1H), 3.72-3.66 (m, 2H), 3.57-3.51 (m, 2H), 2.54 (d, J = 5.3 Hz, 0.6H), 2.46 (d, J = 5.7 Hz, 0.4H), 2.01-1.88 (m, 2H), 1.77-1.70 (m, 0.5H), 1.69-1.64 (m, 1H), 1.63 (s, 3H), 1.56 (s, 3H), 1.56-1.50 (m, 1H), 1.47-1.42 (m, 0.5H), 1.37-1.27 (m, 1H), 1.19 (t, J = 7.2 Hz, 6H), 1.17-1.10 (m, 1H), 0.88 (dd, J = 6.4, 4.5 Hz, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 131.4, 131.3, 124.7, 124.6, 91.3, 87.2, 86.9, 80.0, 79.7, 61.0, 60.9, 60.3, 44.9, 44.8, 37.2, 37.1, 29.4, 29.0, 25.8, 25.41, 25.38, 19.7, 19.2, 17.7, 15.1 ppm; Found (Cl): [M-OEt]+ 237.184928, C₁₅H₂₅O₂ requires 237.18491. [α]D⁻²⁻⁻⁻⁻¹.7 (c 0.71 in CHCl₃)

4-(4,4-Diethoxy-1-hydroxybut-2-yn-1-yl)benzonitrile 1h
43% yield; IR (film) ν = 3423, 2977, 2932, 2888, 2230 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.67-7.64 (m, 4H), 5.57 (d, J = 5.8 Hz, 1H), 5.32 (s, 1H), 3.78-3.68 (m, 2H), 3.64-3.54 (m, 2H), 3.47 (br s, 1H), 1.22 (t, J = 7.1 Hz, 6H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 154.2, 132.4, 127.2, 118.6, 112.0, 91.2, 84.1, 82.6, 65.8, 63.3, 61.2, 15.0 ppm; Found (ES): [M-H]- 258.1130, C₁₅H₁₆NO₃ requires 258.1130.

4,4-Diethoxy-1-(thiophen-2-yl)but-2-yn-1-ol 1i
51% yield; IR (film) ν = 3395, 2976, 2930, 2888, 2243 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.29-7.26 (m, 1H), 7.16-7.13 (m, 1H), 6.97-6.93 (m, 1H), 5.69 (d, J = 6.7 Hz, 1H), 5.33 (s, 1H), 3.80-3.70 (m, 2H), 3.65-3.55 (m, 2H), 3.44 (br s, 1H), 1.22 (t, J = 7.1 Hz, 6H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 144.1, 126.7, 126.0, 125.7, 91.2,
4,4-Diethoxy-1-(furan-2-yl)but-2-yn-1-ol 1j
94% yield; IR (film) ν = 3404, 2977, 2933, 2890, 2240 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.41-7.39 (m, 1H), 6.44 (d, J = 3.3 Hz, 1H), 6.35-6.32 (m, 1H), 5.51 (d, J = 6.8 Hz, 1H), 5.34 (s, 1H), 3.80-3.70 (m, 2H), 3.65-3.55 (m, 2H), 3.27 (br s, 1H), 1.23 (t, J = 7.1 Hz, 6H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 152.5, 143.0, 110.4, 107.9, 91.2, 82.9, 80.9, 61.08, 61.01, 57.8, 15.0 ppm; Found (EI): [M⁺] 224.104178, C₁₂H₁₅O₄ requires 224.10431.

1-Cyclohexyl-4,4-diethoxybut-2-yn-1-ol 1k
84% yield; IR (film) ν = 3416, 2925, 1450 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 5.29 (s, 1H), 4.19 (br d, J = 6.6 Hz, 1H), 3.75-3.68 (m, 2H), 3.61-3.53 (m, 2H), 2.07 (br s, 1H), 1.25 (m, 2H), 1.18-1.17 (m, 2H), 1.68-1.60 (m, 1H), 1.58-1.50 (m, 1H), 1.27-0.96 (m, 5H), 1.21 (t, J = 7.1 Hz, 6H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 91.4, 85.6, 81.0, 67.1, 61.0, 60.9, 43.9, 28.6, 28.3, 26.4, 25.94, 25.91, 15.2 ppm; Found (EI): [M-H⁺] 239.16446, C₁₄H₂₃O₃ requires 239.16417. Data in accordance with the literature.²

1-(4-Bromophenyl)-4,4-diethoxybut-2-yn-1-ol 1l
48% yield; IR (film) ν = 3397, 2976, 2930, 2887, 2242 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.49 (d, J = 8.3 Hz, 2H), 7.39 (d, J = 8.3 Hz, 2H), 5.47 (br s, 1H), 5.33 (s, 1H), 3.77-3.68 (m, 2H), 3.63-3.55 (m, 2H), 2.76 (br s, 1H), 1.22 (t, J = 7.1 Hz, 6H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 139.0, 131.7, 128.4, 122.5, 91.3, 84.6, 82.2, 63.7, 61.11, 61.06, 15.1 ppm; Found (EI): [M-OEt]⁺ 267.00941, C₁₂H₁₂O₂Br requires 267.00152.

Methyl 3-(4-(4-hydroxybut-2-yn-1-yl)benzoate 1m
67% yield; IR (film) ν = 3429, 2977, 2934, 2888, 2240, 1722 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 8.18 (s, 1H), 8.00-7.94 (m, 1H), 7.75-7.70 (m, 1H), 7.39-7.35 (m, 1H), 5.56 (br s, 1H), 5.32 (s, 1H), 3.90 (s, 3H), 3.79-3.68 (m, 2H), 3.63-3.55 (m, 2H), 2.40 (br s, 1H), 1.21 (t, J = 7.1 Hz, 6H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 166.8, 140.8, 131.2, 130.3, 129.5, 128.7, 127.8, 91.2, 84.9, 81.9, 63.7, 61.1, 61.0, 52.2, 15.0 ppm; Found (Cl): [M-OEt]⁺ 247.095983, C₁₄H₁₄O₂ requires 247.09649.

2-(4-Diethoxy-1-hydroxybut-2-yn-1-yl)phenol 1n
22% yield; IR (film) ν = 3326, 2977, 2931, 2892, 2246 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.70 (s, 1H), 7.30 (d, J = 7.8 Hz, 1H), 7.17 (t, J = 7.8 Hz, 1H), 6.88-6.82 (m, 2H), 5.70 (s, 1H), 5.32 (s, 1H), 4.32 (br s, 1H), 3.78-3.69 (m, 2H), 3.63-3.54 (m, 2H), 1.21 (t, J = 7.1 Hz, 6H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 154.9, 130.0, 127.7, 124.6, 120.2, 116.9, 91.3, 84.1, 82.3, 62.9, 61.27, 61.25, 15.0 ppm; Found (ES): [M-H]⁺ 249.1125, C₁₄H₁₄O₂ requires 249.1127.

2-Bromo-3-(4,4-diethoxy-1-hydroxybut-2-yn-1-yl)benzaldehyde 1o
Obtained in 15% yield as a byproduct during the synthesis of 1p; IR (film) ν = 3408, 2975, 2925, 2248, 1690 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 10.24 (s, 1H), 7.82 (d, J = 7.6 Hz, 1H), 7.68 (d, J = 7.6 Hz, 1H), 7.29 (t, J = 7.6 Hz, 1H), 5.78 (d, J = 4.8 Hz, 1H), 5.13 (s, 1H), 3.60-3.49 (m, 2H), 3.45-3.35 (m, 2H), 2.98 (br d, J = 4.8 Hz, 1H), 1.03 (t, J = 7.1 Hz, 6H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 191.9, 140.7, 134.1,
133.9, 130.1, 128.1, 127.1, 91.2, 83.7, 82.3, 63.2, 61.2, 61.1, 14.1 ppm; Found (Cl): [M+H]^+ 341.07010, C_{15}H_{18}O_{4}Br requires 341.03102.

1,1’-(2-Bromo-1,3-phenylene)bis(4,4-diethoxybut-2-yn-1-ol) 1p
51% yield; IR (film) \( \nu = 3409, 2977, 2931, 2887, 2248 \text{ cm}^{-1} \); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta = 7.73 (d, J = 7.6 \text{ Hz}, 2H), 7.39 (t, J = 7.6 \text{ Hz}, 1H), 5.90 (d, J = 5.5 \text{ Hz}, 2H), 5.32 (s, 2H), 3.77-3.68 (m, 4H), 3.63-3.54 (m, 4H), 3.02 (br d, J = 5.5 \text{ Hz}, 2H), 1.21 (t, J = 7.1 \text{ Hz}, 12H) \text{ ppm}; \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \( \delta = 139.9, 128.6, 128.1, 123.0, 91.3, 84.2, 81.9, 64.1, 61.1, 61.0, 15.0 \text{ ppm}; \) Found (ES): [M+H]^+ 467.1075, C\(_{22}\)H\(_{28}\)O\(_6\)Br requires 467.1069.

1,1-Diethoxy-5,5-dimethyloct-7-en-2-yn-4-ol 1q
78% yield; IR (film) \( \nu = 3466, 2977, 2932, 2892, 2249 \text{ cm}^{-1} \); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 5.75 (m, 1H), 5.25 (s, 1H), 5.02-4.97 (m, 2H), 4.06 (d, J = 5.7 \text{ Hz}, 1H), 3.70-3.64 (m, 2H), 3.55-3.50 (m, 2H), 2.66 (br s, 1H), 2.10 (dd, J = 13.6, 7.5 \text{ Hz}, 1H), 2.03 (dd, J = 13.6, 7.2 \text{ Hz}, 1H), 1.16 (t, J = 7.2 \text{ Hz}, 6H), 0.91 (s, 3H), 0.89 (s, 3H) \text{ ppm}; \(^{13}\)C NMR (150 MHz, CDCl\(_3\)) \( \delta = 134.8, 117.8, 91.3, 85.2, 81.4, 69.7, 61.0, 60.8, 42.7, 38.6, 22.7, 22.5, 15.1 \text{ ppm}; \) Found (Cl): [M-OEt]^+ 195.16034, C\(_{12}\)H\(_{19}\)O\(_2\) requires 195.13796.
2. Furan Synthesis:

Reaction Optimisation

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a 5:1 ratio solvent:EtOH unless otherwise stated. b Yield calculated by 1H NMR using HC₆Cl₅ as an internal standard. c Isolated yield.

General procedure for furan synthesis: [Ph₃PAuNTf₂]₂.PhMe (2 mol%) was added to a solution of propargylic alcohol in alcohol (8-10 mL/g) and the solution stirred magnetically at room temperature until starting material had disappeared (TLC). The solvent was removed in vacuo (cold water bath – heating during solvent evaporation can promote aerobic oxidation of the 3-alkoxyfuran) and the crude product purified by column chromatography. The product was then stored at 0-5 °C to avoid decomposition.

(E)-1,1-Diethoxy-4-(4-(trifluoromethyl)phenyl)but-3-en-2-one 2a

Procedure: [Ph₃PAuNTf₂]₂.PhMe (2 mol%) was added to a solution of propargylic alcohol in CH₂Cl₂ (10 mL/g) and the solution stirred magnetically at room temperature until starting material had disappeared (TLC). The solvent was removed in vacuo and the crude product purified by column chromatography.

IR (film) ν = 2980, 2933, 2884, 1702, 1615, 1321 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.77 (d, J = 16.2 Hz, 1H), 7.70 (d, J = 8.7 Hz, 2H), 7.64 (d, J = 8.7 Hz, 2H), 7.17 (d, J = 16.2 Hz, 1H), 4.80 (s, 1H), 3.75 (q, J = 7.2 Hz, 2H), 3.63 (q, J = 7.2 Hz, 2H), 1.28 (t, J = 7.2 Hz, 6H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 194.0, 142.9, 138.1, 128.8, 125.9 (q, J = 32.1 Hz), 123.8 (q, J = 32.1 Hz), 129.2, 102.7, 63.5, 15.3 ppm; Found (Cl): [M-OEt]⁺ 257.09021, C₁₃H₁₂F₃O₂ requires 257.07839.

3-Ethoxy-2-(4-(trifluoromethyl)phenyl)furan 3a

IR (film) ν = 2979, 2929, 1615, 1322 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.88 (d, J = 7.9 Hz, 2H), 7.60 (d, J = 7.9 Hz, 2H), 7.32 (d, J = 2.3 Hz, 1H), 6.42 (d, J = 2.3 Hz, 1H), 4.12 (q, J = 6.8 Hz, 2H), 1.45 (t, J = 6.8 Hz, 3H) ppm; ¹³C NMR (150 MHz,
3-Ethoxy-2-phenylfuran 3b
IR (film) ν = 2979, 2930, 1636, 1275 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.29-7.23 (m, 2H), 7.20-7.15 (m, 3H), 7.12 (d, J = 2.1 Hz, 1H), 6.21 (d, J = 2.1 Hz, 1H), 3.78 (q, J = 7.0 Hz, 2H), 2.97-2.85 (m, 4H), 1.23 (t, J = 7.0 Hz, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 142.2, 141.6, 139.9, 139.1, 128.5, 128.3, 125.9, 104.1, 67.9, 34.3, 27.1, 15.1 ppm; Found (EI): [M]+ 217.121850, C₁₃H₁₁O₂F₃ requires 217.122285.

2-Cyclopropyl-3-ethoxyfuran 3d
IR (film) ν = 2958, 2927, 2870, 1667, 1219 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.02 (d, J = 1.8 Hz, 1H), 6.22 (d, J = 1.8 Hz, 1H), 3.95 (q, J = 7.2 Hz, 2H), 1.89-1.83 (m, 1H), 1.33 (t, J = 7.2 Hz, 3H), 0.85-0.81 (m, 4H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 142.3, 140.7, 138.3, 104.5, 67.9, 15.3, 6.6, 5.6 ppm; Found (EI): [M]+ 218.094297, C₉H₁₂O requires 218.09429.

3-Ethoxy-2-phenylfuran 3e
IR (film) ν = 2980, 1612, 1510, 1391, 1291, 1259 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.81 (d, J = 7.7 Hz, 2H), 7.37 (t, J = 7.7 Hz, 2H), 7.27 (d, J = 1.6 Hz, 1H), 7.17 (t, J = 7.7 Hz, 1H), 6.40 (d, J = 1.6 Hz, 1H), 4.10 (q, J = 7.0 Hz, 2H), 1.44 (t, J = 7.0 Hz, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 144.4, 140.2, 136.9, 131.1, 128.5, 125.8, 123.1, 104.1, 67.3, 15.4 ppm; Found (CI): [M]+ 188.0831, C₁₂H₁₂O₂ requires 188.0831.

2-(2,6-Dimethylphenyl)-3-ethoxyfuran 3f
IR (film) ν = 2979, 2925, 1623, 1283 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.35 (br s, 1H), 7.19 (t, J = 7.5 Hz, 1H), 7.09 (d, J = 7.5 Hz, 2H), 6.40 (br s, 1H), 3.92 (q, J = 7.2 Hz, 2H), 2.23 (s, 6H), 1.27 (t, J = 7.2 Hz, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 143.6, 140.6, 139.2, 136.5, 129.6, 128.8, 127.4, 103.8, 67.0, 20.4, 15.3 ppm; Found (Cl): [M]+ 216.113848, C₁₄H₁₄O₂ requires 216.11448.

(3R)-2-(2,6-Dimethylhept-5-en-1-yl)-3-ethoxyfuran 3g
IR (film) ν = 2966, 2914, 1634, 1278 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.11 (d, J = 1.9 Hz, 1H), 6.24 (d, J = 1.9 Hz, 1H), 5.09 (m, 1H), 3.92 (q, J = 7.2 Hz, 2H), 2.56 (dd, J = 14.7, 6.0 Hz, 1H), 2.42 (dd, J = 14.7, 7.9 Hz, 1H), 2.08-1.93 (m, 2H), 1.86-1.77 (m, 1H), 1.68 (s, 3H), 1.60 (s, 3H), 1.41-1.32 (m, 1H), 1.31 (t, J = 7.2 Hz, 3H), 1.23-1.13 (m, 1H), 0.88 (d, J = 6.4 Hz, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 142.7, 140.2, 139.0, 131.2, 124.9, 103.8, 67.8, 36.8, 32.4, 32.3, 25.9, 25.7, 19.7, 17.8, 15.3 ppm; Found (Cl): [M]+ 236.177040, C₁₅H₂₆O₂ requires 236.17708; [α]D²⁰ -1.0 (c 0.71 in CHCl₃).

C₆D₆ δ = 146.3, 141.4, 135.5, 134.2, 127.0 (q, J = 32.1 Hz), 125.5 (q, J = 4.0 Hz), 124.5 (q, J = 271 Hz), 122.8, 103.9, 67.3, 15.3 ppm; Found (Cl): [M]+ 256.070568, C₁₃H₁₁O₂F₃ requires 256.07057.
4-(3-Ethoxyfuran-2-yl)benzonitrile 3h
IR (film) \( \nu = 2986, 2971, 2899, 2219 \text{ cm}^{-1} \); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 7.84 \) (d, \( J = 8.7 \) Hz, 2H), 7.60 (d, \( J = 8.7 \) Hz, 2H), 7.34 (d, \( J = 1.9 \) Hz, 1H), 6.42 (d, \( J = 1.9 \) Hz, 1H), 4.13 (q, \( J = 7.2 \) Hz, 2H), 1.46 (t, \( J = 7.2 \) Hz, 3H) ppm; \(^{13}\)C NMR (150 MHz, CDCl\(_3\)) \( \delta = 147.4, 142.2, 135.0, 134.9, 132.4, 122.9, 119.7, 108.0, 103.8, 67.4, 15.3 \) ppm; Found (Cl): [M+H]+ 214.085614, C\(_{13}\)H\(_{12}\)NO\(_2\) requires 214.08626.

3-Methoxy-2-(4-(trifluoromethyl)phenyl)furan 4a
IR (film) \( \nu = 2944, 1677, 1270 \text{ cm}^{-1} \); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 7.85 \) (d, \( J = 8.2 \) Hz, 2H), 7.59 (d, \( J = 8.2 \) Hz, 2H), 7.33 (d, \( J = 2.1 \) Hz, 1H), 6.45 (d, \( J = 2.1 \) Hz, 1H), 3.91 (s, 3H) ppm; \(^{13}\)C NMR (150 MHz, CDCl\(_3\)) \( \delta = 147.4, 141.4, 135.2, 135.4, 127.1 \) (q, \( J = 32.1 \) Hz), 125.5 (q, \( J = 4.0 \) Hz), 124.4 (q, \( J = 270 \) Hz), 122.8, 103.2, 58.7 ppm; Found (EI): [M]+ 242.055390, C\(_{12}\)H\(_{9}\)O\(_2\)F\(_3\) requires 242.05546.

3-Methoxy-2-phenethylfuran 4b
IR (film) \( \nu = 2980, 2931, 1638, 1277 \text{ cm}^{-1} \); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 7.32-7.28 \) (m, 2H), 7.24-7.18 (m, 3H), 7.17 (d, \( J = 2.1 \) Hz, 1H), 6.29 (d, \( J = 2.1 \) Hz, 1H), 3.64 (s, 3H), 2.98-2.90 (m, 4H) ppm; \(^{13}\)C NMR (150 MHz, CDCl\(_3\)) \( \delta = 141.5, 139.21, 139.18, 128.6, 128.4, 128.3, 125.9, 103.2, 59.5, 34.3, 27.1 \) ppm; Found (EI): [M]+ 202.099153, C\(_{13}\)H\(_{14}\)O\(_2\) requires 202.09938.

3-Methoxy-2-(4-methoxyphenyl)furan 4c
IR (film) \( \nu = 2979, 2935, 2838, 1672, 1247 \text{ cm}^{-1} \); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 7.13 \) (d, \( J = 8.9 \) Hz, 2H), 7.23 (d, \( J = 2.1 \) Hz, 1H), 6.92 (d, \( J = 8.9 \) Hz, 2H), 6.41 (d, \( J = 2.1 \) Hz, 1H), 3.86 (s, 3H), 3.82 (s, 3H) ppm; \(^{13}\)C NMR (150 MHz, CDCl\(_3\)) \( \delta = 144.1, 139.4, 136.8, 124.6, 124.2, 114.1, 103.5, 58.9, 55.4 \) ppm; Found (EI): [M]+ 204.077876, C\(_{12}\)H\(_{12}\)O\(_3\) requires 204.07864.

2-Cyclopropyl-3-methoxyfuran 4d
IR (film) \( \nu = 2957, 2924, 2855, 1667, 1230 \text{ cm}^{-1} \); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 7.03 \) (br s, 1H), 6.25 (br s, 1H), 3.75 (s, 3H), 1.85 (q, \( J = 7.2 \) Hz, 1H), 0.85-0.82 (m, 4H) ppm; \(^{13}\)C NMR (150 MHz, CDCl\(_3\)) \( \delta = 143.7, 139.9, 138.3, 103.5, 59.5, 6.4, 5.5 \) ppm; Found (Cl): [M]+ 138.07201, C\(_{9}\)H\(_{10}\)O\(_2\) requires 138.06808.

2-(2,6-Dimethylphenyl)-3-methoxyfuran 4f
IR (film) \( \nu = 2979, 2942, 1626, 1282 \text{ cm}^{-1} \); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 7.33 \) (d, \( J = 2.1 \) Hz, 1H), 7.17 (d, \( J = 7.5 \) Hz, 1H), 7.07 (d, \( J = 7.5 \) Hz, 2H), 6.40 (d, \( J = 2.1 \) Hz, 1H), 3.70 (s, 3H), 3.19 (s, 6H) ppm; \(^{13}\)C NMR (150 MHz, CDCl\(_3\)) \( \delta = 144.7, 140.7, 139.3, 136.0, 129.4, 128.9, 127.4, 103.0, 58.8, 20.3 \) ppm; Found (EI): [M]+ 202.098693, C\(_{13}\)H\(_{14}\)O\(_2\) requires 202.09938.

(R)-2-(2,6-Dimethylhept-5-en-1-yl)-3-methoxyfuran 4g
IR (film) \( \nu = 2958, 2913, 1635, 1279 \text{ cm}^{-1} \); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 7.12 \) (d, \( J = 2.1 \) Hz, 1H), 6.28 (d, \( J = 2.1 \) Hz, 1H), 5.09 (m, 1H), 3.73 (s, 3H), 2.56 (dd, \( J = 14.8, 6.1 \) Hz, 1H), 2.42 (dd, \( J = 14.8, 7.8 \) Hz, 1H), 2.08-1.93 (m, 2H), 1.86-1.77 (m, 1H), 1.68 (s, 3H), 1.60 (s, 3H), 1.41-1.31 (m, 1H), 1.23-1.14 (m, 1H), 0.88 (d, \( J = 6.7 \) Hz, 3H) ppm; \(^{13}\)C NMR (150 MHz, CDCl\(_3\)) \( \delta = 144.0, 139.4, 139.0, 131.3, 124.9, 102.9, 59.5, 36.8, 32.4, 32.3, 25.9, 25.7, 19.6, 17.7 \) ppm; Found (Cl): [M]+ 222.161292, C\(_{14}\)H\(_{22}\)O\(_2\) requires 222.16143.
4-(3-Methoxyfuran-2-yl)benzonitrile 4h
IR (film) ν = 2944, 2232, 1601, 1225 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.83 (d, J = 8.6 Hz, 2H), 7.61 (d, J = 8.6 Hz, 2H), 7.36 (d, J = 2.1 Hz, 1H), 6.46 (d, J = 2.1 Hz, 1H), 3.92 (s, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 148.4, 142.2, 134.8, 134.7, 132.4, 122.9, 119.7, 108.1, 103.3, 58.8 ppm; Found (Cl): [M+H]^+ 200.069819, C₁₂H₁₀NO₂ requires 200.07061.

3-Methoxy-2-(thiophen-2-yl)furan 4i
IR (film) ν = 2937, 1624, 1283 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.27-7.24 (m, 1H), 7.22 (d, J = 2.1 Hz, 1H), 7.18 (dd, J = 4.9, 1.1 Hz, 1H), 7.04 (dd, J = 4.9, 3.6 Hz, 1H), 6.40 (d, J = 2.1 Hz, 1H), 3.88 (s, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 143.9, 140.0, 134.4, 132.5, 127.4, 122.7, 120.8, 103.3, 59.0 ppm; Found (El): [M]^+ 180.24207, C₉H₈O₂S requires 180.22362.

3-Methoxy-2,2'-bifuran 4j
IR (film) ν = 2972, 1741, 1370 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.43 (br s, 1H), 7.26 (d, J = 2.1 Hz, 1H), 6.48-6.45 (m, 2H), 6.40 (d, J = 2.1 Hz, 1H), 3.87 (s, 3H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 145.5, 144.3, 141.1, 140.5, 130.8, 112.4,104.4, 103.1, 59.0 ppm; Found (El): [M]^+ 164.04811, C₉H₈O₂ requires 164.04734.

2-Cyclohexyl-3-methoxyfuran 4k
IR (film) ν = 2927, 2852, 1629, 1274 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.09 (d, J = 1.9 Hz, 1H), 6.26 (d, J = 1.9 Hz, 1H), 3.72 (s, 3H), 2.73-2.66 (m, 1H), 1.85-1.65 (m, 5H), 1.38-1.20 (m, 5H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 144.1, 142.1, 138.6, 103.2, 59.7, 35.4, 31.3, 26.5, 26.1 ppm; Found (Cl): [M]^+ 180.114359, C₁₁H₁₆O₂ requires 180.114857.

2-(4-Bromophenyl)-3-methoxyfuran 4l
IR (film) ν = 2939, 2850, 1672, 1217 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.64 (d, J = 8.6 Hz, 2H), 7.47 (d, J = 8.6 Hz, 2H), 7.28 (d, J = 2.1 Hz, 1H), 6.42 (d, J = 2.1 Hz, 1H), 3.88 (s, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 145.9, 140.5, 135.6, 131.5, 129.8, 124.5, 119.1, 103.3, 58.7 ppm; Found (El): [M]^+ 251.977808, C₁₁H₇O₂Br requires 251.97859.

Methyl 3-(3-methoxyfuran-2-yl)benzoate 4m
IR (film) ν = 2953, 2846, 1721, 1673, 1206 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 8.42 (br s, 1H), 7.96 (d, J = 7.8 Hz, 1H), 7.83 (d, J = 7.8 Hz, 1H), 7.43 (t, J = 7.8 Hz, 1H), 7.30 (d, J = 2.1 Hz, 1H), 6.45 (d, J = 2.1 Hz, 1H), 3.93 (s, 3H), 3.90 (s, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 167.3, 146.2, 140.6, 135.5, 131.2, 130.4, 128.5, 127.2, 126.6, 124.0, 103.2, 58.7, 52.1 ppm; Found (El): [M+H]^+ 233.08138, C₁₃H₁₂O₄ requires 233.08084.

2-(3-Methoxyfuran-2-yl)phenol 4n
IR (film) ν = 3333, 2968, 2944, 1606, 1287 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.99 (s, 1H), 7.37 (d, J = 2.1 Hz, 1H), 7.26 (s, 1H), 7.21-7.16 (m, 1H), 6.98-6.92 (m, 2H), 6.46 (d, J = 2.1 Hz, 1H), 3.94 (s, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 152.1, 142.7, 141.5, 136.1, 128.9, 126.2, 120.4, 117.9, 117.3, 103.5, 60.2 ppm; Found (El): [M+H]^+ 190.062865, C₁₁H₁₀O₃ requires 190.06299.

2-(2-Bromo-3-(dimethoxymethyl)phenyl)-3-methoxyfuran 4o
IR (film) ν = 2935, 2832, 1668, 1235 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.58 (dd, J = 7.6, 1.7 Hz, 1H), 7.45 (dd, J = 7.6, 1.7 Hz, 1H), 7.39-7.33 (m, 2H), 6.43 (d, J = 2.1 Hz, 1H), 5.66 (s, 1H), 3.77 (s, 3H), 3.41 (s, 6H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 145.5, 141.0, 138.1, 136.1, 132.3, 131.9, 127.8, 126.8, 123.7, 103.5, 103.1, 58.8, 54.1 ppm; Found (CI): [M]+ 326.014436, C₁₄H₁₅BrO₄ requires 326.01482

2,2’-(2-Bromo-1,3-phenylene)bis(3-methoxyfuran) 4p
IR (film) ν = 2960, 2932, 1245 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.44 (d, J = 7.2 Hz, 2H), 7.37-7.33 (m, 1H), 7.36 (d, J = 2.1 Hz, 2H), 6.43 (d, J = 2.1 Hz, 2H), 3.78 (s, 6H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 145.5, 140.9, 136.4, 132.9, 131.1, 126.7, 123.5, 103.2, 58.9 ppm; Found (CI): [M]+ 347.999242, C₁₆H₁₃BrO₄ requires 347.99917.

3-Phenethoxy-2-phenethylfuran 5b
IR (film) ν = 2979, 2869, 1636, 1275 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.32-7.12 (m, 10H), 7.13 (d, J = 1.9 Hz, 1H), 6.20 (d, J = 1.9 Hz, 1H), 3.92 (t, J = 7.5 Hz, 2H), 2.92-2.82 (m, 4H), 2.91 (t, J = 7.5 Hz, 2H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 142.4, 141.6, 140.0, 139.3, 138.4, 129.0, 128.6, 128.5, 128.4, 126.5, 126.0, 104.1, 73.1, 36.2, 34.4, 27.2 ppm; Found (CI): [M+H]+ 293.153275, C₂₀H₂₁O₂ requires 293.15415.

3-(Allyloxy)-2-phenethylfuran 6b
IR (film) ν = 2926, 2858, 1636, 1276 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.29-7.23 (m, 2H), 7.20-7.15 (m, 3H), 7.13 (d, J = 2.1 Hz, 1H), 6.22 (d, J = 2.1 Hz, 1H), 5.90 (dd, J = 17.4, 10.6, 1.5 Hz, 1H), 5.28 (dd, J = 17.4, 1.5 Hz, 1H), 5.19 (dd, J = 10.6, 1.5 Hz, 1H), 4.23 (dt, J = 5.5, 1.5 Hz, 2H), 2.96-2.86 (m, 4H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 142.3, 141.5, 140.0, 139.1, 133.9, 128.5, 128.3, 125.9, 117.5, 104.2, 73.1, 34.3, 27.1 ppm; Found (CI): [M+H]+ 229.12213, C₁₅H₁₇O₂ requires 229.12285.

2-((2-Phenethylfuran-3-yl)oxy)ethanol 7b
IR (film) ν = 3420, 2928, 2871, 1660, 1275 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.30-7.24 (m, 2H), 7.19 (t, J = 7.2 Hz, 1H), 7.15 (d, J = 1.9 Hz, 1H), 7.12 (d, J = 7.2 Hz, 2H), 6.22 (d, J = 1.9 Hz, 1H), 3.78-3.69 (m, 4H), 2.96-2.88 (m, 4H), 1.79 (br s, 1H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 142.4, 141.5, 139.9, 139.4, 128.6, 128.4, 126.1, 104.0, 73.6, 61.7, 34.4, 27.2 ppm; Found (CI): [M+H]+ 233.116954, C₁₄H₁₇O₃ requires 233.11722.

3-(tert-Butoxy)-2-phenethylfuran 8b
IR (film) ν = 2977, 2933, 1624, 1273 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.31-7.24 (m, 2H), 7.22-7.17 (m, 3H), 7.15 (d, J = 2.1 Hz, 1H), 6.15 (d, J = 2.1 Hz, 1H), 2.96-2.83 (m, 4H), 1.25 (s, 9H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ = 144.8, 141.7, 138.7, 137.1, 128.4, 128.3, 126.0, 109.3, 78.5, 34.1, 28.4, 27.3 ppm; Found (CI): [M+H]+ 245.15352, C₁₅H₂₁O₂ requires 245.15415.

3-Isopropoxy-2-phenethylfuran 9b
IR (film) ν = 2975, 2933, 1634, 1274 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ = 7.30-7.23 (m, 2H), 7.20-7.15 (m, 3H), 7.14 (d, J = 2.1 Hz, 1H), 6.19 (d, J = 2.1 Hz, 1H), 3.98 (septet, J = 6.2 Hz, 1H), 2.95-2.84 (m, 4H), 1.18 (d, J = 6.2 Hz, 6H) ppm; ¹³C NMR
11

(100 MHz, CDCl₃) δ = 141.6, 141.2, 140.9, 139.1, 128.4, 128.3, 125.9, 105.3, 74.4, 34.4, 27.0, 22.2 ppm; Found (Cl): [M+H]⁺ 231.136913, C₁₅H₁₉O₂ requires 231.13850.

5-Methoxy-7,7-dimethyl-4,5,6,7-tetrahydrobenzofuran 10a
IR (film) ν = 2964, 2928, 2863, 1161 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.24 (d, J = 1.9 Hz, 1H), 6.14 (d, J = 1.9 Hz, 1H), 3.69-3.62 (m, 1H), 3.40 (s, 3H), 2.86 (dd, J = 14.8, 5.4 Hz, 1H), 2.32 (dd, J = 14.8, 9.1 Hz, 1H), 1.94 (br d, J = 12.0 Hz, 1H), 1.67 (app t, J = 12.0 Hz, 1H), 1.30 (s, 3H), 1.26 (s, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 156.5, 141.2, 112.5, 110.2, 75.2, 56.2, 44.4, 32.8, 28.9, 28.4, 28.3 ppm; Found (Cl): [M⁺] 180.114054, C₁₁H₁₆O₂ requires 180.11448.

5-Ethoxy-7,7-dimethyl-4,5,6,7-tetrahydrobenzofuran 10b
IR (film) ν = 2967, 2929, 2867, 1161 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.23 (d, J = 1.9 Hz, 1H), 6.13 (d, J = 1.9 Hz, 1H), 3.78-3.72 (m, 1H), 3.63-3.53 (m, 2H), 2.85 (dd, J = 15.1, 5.3 Hz, 1H), 2.33 (dd, J = 15.1, 9.0 Hz, 1H), 1.93 (br d, J = 12.0 Hz, 1H), 1.69 (app t, J = 12.0 Hz, 1H), 1.29 (s, 3H), 1.25 (s, 3H), 1.23 (t, J = 7.2 Hz, 3H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 156.6, 141.2, 112.8, 110.3, 73.5, 63.9, 45.1, 32.9, 29.5, 28.5, 28.3, 15.9 ppm; Found (Cl): [M⁺] 194.130165, C₁₂H₁₈O₂ requires 194.13013.

**Control Experiments**

Reaction of alcohol 1b with gold catalyst and ethanol in the presence of one equivalent of the hindered base 2,6-di-tert-butylpyridine led to the formation of furan 3b, although a longer reaction time was required to achieve full conversion. Treatment of alcohol 1b with 1 mol% Tf₂NH did not lead to furan formation, however. With larger quantities of acid catalyst, complete decomposition of the starting alcohol was observed. Taken together, these experiments suggest that the furan formation is not a simple acid-catalysed process. Treatment of alcohol 1b with catalytic AgNTf₂ in EtOH also did not lead to furan formation, demonstrating that this reaction is not likely to be mediated by silver impurities in the gold catalyst.
3. Reactions of Furan Products

(E)-3-Ethoxy-4-oxo-4-phenylbut-2-enal A

![Chemical Structure]

Procedure: Toluene (2.0 mL) was added to 3-ethoxy-2-phenylfuran (103 mg, 0.548 mmol) and the solution heated at reflux under an atmosphere of air for 24 h. The reaction was then allowed to cool before it was concentrated in vacuo to give the crude product. This was purified by column chromatography to give 3-cyclohexyl-2-phenylfuran 16 as a white crystalline solid (61 mg, 0.30 mmol, 55%); m.p. 52 – 54 °C; IR (film) \( \nu = 2981, 1665, 1594, 1447 \) cm\(^{-1}\); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 9.51 (d, J = 7.8 \) Hz, 1H), 7.93 (d, \( J = 7.6 \) Hz, 2H), 7.66 (t, \( J = 7.6 \) Hz, 1H), 7.52 (t, \( J = 7.6 \) Hz, 2H), 5.73 (d, \( J = 7.8 \) Hz, 1H), 4.12 (q, \( J = 7.1 \) Hz, 1H), 1.44 (t, \( J = 7.1 \) Hz, 3H) ppm; \(^13\)C NMR (100 MHz, CDCl\(_3\)) \( \delta = 14.1, 66.3, 107.8, 129.1, 130.1, 134.7, 134.9, 172.0, 189.6, 189.8 \) ppm; Found (CI): [M+H]\(^+\) 205.0859, C\(_{12}\)H\(_{13}\)O\(_3\) requires 205.0859.

(3aS,4R,7R,7aR)-5-methoxy-2-methyl-4-phenethyl-3a,4,7,7a-tetrahydro-1H-4,7-epoxyisoindole-1,3(2H)-dione 16

3-methoxy furan 4b and N-methylmaleimide were dissolved in CH\(_2\)Cl\(_2\) and stirred overnight at rt. The product was purified by column chromatography. 


endo-16: IR (film) \( \nu = 2931, 1774, 1699, 1625, 1433 \) cm\(^{-1}\); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 7.29 (t, J = 7.5 \) Hz, 2H), 7.24 (d, \( J = 7.5 \) Hz, 1H), 7.19 (t, \( J = 7.5 \) Hz, 1H), 5.20 (dd, \( J = 5.3, 1.9 \) Hz, 1H), 5.02 (br s, 1H), 3.70 (dd, \( J = 7.5, 5.3 \) Hz, 1H), 3.53 (s, 3H), 3.21 (d, \( J = 7.5 \) Hz, 1H), 2.85 (s, 3H), 2.80 (t, \( J = 8.5 \) Hz, 2H), 2.62-2.55 (m, 1H), 2.29-2.22 (m, 1H) ppm; \(^13\)C NMR (150 MHz, CDCl\(_3\)) \( \delta = 175.6, 174.3, 165.4, 141.6, 128.52, 128.49, 126.1, 96.9, 89.7, 78.2, 58.2, 51.3, 49.8, 31.9, 30.5, 24.6 ppm;

exo-16: IR (film) \( \nu = 2922, 1764, 1698, 1633, 1440 \) cm\(^{-1}\); \(^1\)H NMR (600 MHz, CDCl\(_3\)) \( \delta = 7.28 (t, J = 7.5 \) Hz, 2H), 7.23 (d, \( J = 7.5 \) Hz, 1H), 7.18 (t, \( J = 7.5 \) Hz, 1H), 5.19 (d, \( J = 1.9 \) Hz, 1H), 5.16 (br s, 1H), 3.66 (s, 3H), 3.14 (d, \( J = 6.4 \) Hz, 1H), 2.96 (s, 3H), 2.93 (d, \( J = 6.4 \) Hz, 1H), 2.83-2.73 (m, 2H), 2.39-2.33 (m, 1H), 2.29-2.20 (m, 1H) ppm; \(^13\)C NMR (150 MHz, CDCl\(_3\)) \( \delta = 176.4, 174.9, 168.4, 141.9, 128.5, 128.4, 126.0, 99.6, 89.3, 79.9, 58.3, 54.4, 49.2, 30.8, 29.4, 25.0 ppm;

Found (CI): [M+H]\(^+\) 313.132190, C\(_{18}\)H\(_{19}\)NO\(_4\) requires 313.13086.

(3aS,3bR,9bS,11R,11aR)-9b-Methoxy-2-methyl-4,5,9b,10,11,11a-hexahydro-3b,11-epoxynaphtho[2,1-e]isoindole-1,3(2H,3aH)-dione 17

![Chemical Structure]

Trifluoroacetic acid (0.5 mL) was added to a stirring solution of endo-16 (46 mg, 0.15 mmol) in CH\(_2\)Cl\(_2\) (1.0 mL) at -78°C. The reaction was allowed to reach room
temperature and stirred for 16 h before the reaction was quenched withaq. sat. NaHCO₃ (10 mL) and diluted with CH₂Cl₂ (10 mL). The aqueous extract was washed with CH₂Cl₂ (3 × 10 mL) and the combined organic extracts washed with brine (20 mL), dried (MgSO₄) and the solvent removed in vacuo to give the crude product. This was partially purified by column chromatography to give a mixture of 17 and B (3:1). The mixture of products was then dissolved in hot methanol (2 mL), cooled to 0 °C and treated with sodium borohydride (10 mg, 0.31 mmol). The resulting suspension was stirred at 0 °C for 4 h before the reaction was diluted with CH₂Cl₂ (10 mL) and treated with Amberlyte IRA743 boron scavenger resin. The mixture was filtered and the solution concentrated in vacuo to give 17 as a white crystalline solid (32 mg, 0.10 mmol, 69% yield) and side product C.

17: m.p. 174–176 °C; IR (film) ν = 2934, 1771, 1693, 1434 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 7.27–7.22 (m, 2H), 7.19 (t, J = 7.1 Hz, 1H), 7.10 (d, J = 7.7 Hz, 1H), 4.77 (t, J = 6.2 Hz, 1H), 3.71 (1H, dd, J = 9.8, 6.2 Hz, 1H), 3.16 (d, J = 9.8 Hz, 1H), 3.02–2.96 (m, 4H), 2.85 (dd, J = 16.6, 5.7 Hz, 1H), 2.76 (s, 3H), 2.53 (dd, J = 13.8, 6.2 Hz, 1H), 2.43 (td, J = 14.2, 6.0 Hz, 1H), 2.34 (dd, J = 14.2, 6.0 Hz, 1H), 2.25 (d, J = 13.8 Hz, 1H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 175.5, 174.7, 172.3, 171.7, 138.3, 135.8, 128.5, 127.6, 127.5, 102.1387; C₁₈H₂₀NO₄ requires 314.1387.

(3aS,4R,7R,7aR)-2-Methyl-4-phenethyltetrahydro-1H-4,7-epoxyisoindole-1,3,5(2H,6H)-trione B
¹H NMR (600 MHz, CDCl₃) δ = 7.31–7.28 (m, 2H), 7.23–7.18 (m, 3H), 5.17 (t, J = 6.2 Hz, 1H), 3.79 (dd, J = 9.3, 6.2 Hz, 1H), 3.33 (d, J = 9.3 Hz, 1H), 2.92 (s, 3H), 2.81–2.75 (m, 1H), 2.73–2.65 (m, 2H), 2.51–2.45 (m, 1H), 2.31–2.25 (m, 1H), 2.21 (d, J = 18.3 Hz, 1H) ppm; ¹³C NMR (150 MHz, CDCl₃) δ = 207.2, 174.3, 172.3, 140.9, 128.6, 128.5, 126.4, 90.1, 75.2, 51.5, 51.0, 42.2, 30.8, 30.0, 21.2 ppm;

3aS,4R,5R,7R,7aR)-5-Hydroxy-2-methyl-4-phenethylhexahydro-1H-4,7-epoxyisoindole-1,3(2H)-dione C
IR (film) ν = 3445, 2927, 1771, 1691, 1434 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) 7.31 (t, J = 7.4 Hz, 2H), 7.27 (d, J = 7.4 Hz, 2H), 7.22 (t, J = 7.2 Hz, 1H), 4.77 (t, J = 6.1 Hz, 1H), 4.23 (m, 1H), 3.64 (dd, J = 9.7, 6.1 Hz, 1H), 3.20 (d, J = 9.7 Hz, 1H), 3.00–2.88 (m, 4H), 2.42–2.27 (m, 3H), 1.98–1.95 (m, 1H), 1.49 (dd, J = 13.8, 3.0, 1H), 1.25 (m, 1H) ppm; ¹³C NMR (150 MHz, CDCl₃) 175.8, 175.7, 141.2, 128.8, 128.4, 126.4, 90.8, 77.7, 75.5, 52.8, 51.9, 36.8, 35.0, 30.0, 24.9 ppm; Found (Cl): [M+H]+ 302.1385; C₁₈H₂₀NO₄ requires 302.1387.

1-(5-Ethoxy-7,7-dimethyl-4,5,6,7-tetrahydrobenzofuran-2-yl)-N,N-dimethylmethanamine 18
Procedure: N-Methyl-N-methylenemethanaminium iodide (Eschenmoser’s salt, 2 eq.) was added to a solution of 10b (20 mg, 0.103 mmol) in DMF (1 mL). The resulting solution was stirred at rt for 12 h. The reaction was then concentrated in vacuo to give the crude product. This was purified by column chromatography to give 18 (24 mg, 0.095 mmol 92%).
IR (film) ν = 2964, 2926, 2866, 1456, 1362 cm⁻¹; ¹H NMR (600 MHz, CDCl₃) δ = 5.97 (s, 1H), 3.77–3.70 (m, 1H), 3.62–3.53 (m, 2H), 3.47 (d, J = 14.0 Hz, 1H), 3.43 (d, J = 14.0 Hz, 1H), 2.80 (dd, J = 15.1, 4.9 Hz, 1H), 2.29 (dd, J = 15.1, 9.4, 1H), 2.27 (s, 6H), 1.91 (br d, J = 12.0 Hz, 1H), 1.66 (t, J = 12.1 Hz, 1H), 1.28 (s, 3H), 1.24 (s, 3H),
1.22 (t, J = 7.2 Hz, 3H) ppm; $^{13}$C NMR (150 MHz, CDCl$_3$) δ = 156.5, 150.1, 113.4, 109.9, 73.4, 63.9, 55.9, 45.1, 44.9, 32.9, 29.5, 28.5, 28.3, 15.8 ppm; Found (Cl): [M]$^+$ 251.187845, C$_{15}$H$_{26}$NO$_2$ requires 251.18798.

2-Allyl-2-phenethylfuran-3(2H)-one 19
Furan 6b (50 mg, 0.219 mmol) was dissolved in toluene (2 mL) and heated to reflux for 6 h. The reaction was then allowed to cool before it was concentrated in vacuo to give the crude product. This was purified by column chromatography to give 19 as a colourless oil (40 mg, 0.176 mmol 80%);

IR (film) ν = 3064, 3028, 2920, 1697, 1559 cm$^{-1}$; $^1$H NMR (600 MHz, CDCl$_3$) δ = 8.25 (d, J = 2.3 Hz, 1H), 7.26 (d, J = 7.5 Hz, 2H), 7.18 (d, J = 7.5 Hz, 1H), 7.14 (d, J = 7.5 Hz, 2H), 5.70 (d, J = 2.3 Hz, 1H), 5.69-5.63 (m, 1H), 5.13 (d, J = 18.8 Hz, 1H), 5.11 (d, J = 11.3 Hz, 1H), 2.58-2.44 (m, 2H), 2.50 (d, J = 7.2 Hz, 1H), 2.10-2.05 (m, 2H) ppm; $^{13}$C NMR (150 MHz, CDCl$_3$) δ = 206.4, 177.3, 141.0, 130.4, 128.6, 128.4, 126.2, 119.9, 107.7, 91.5, 40.4, 37.2, 29.1 ppm; Found (Cl): [M]$^+$ 229.122392, C$_{15}$H$_{17}$O$_2$ requires 229.12231.

5-Bromo-2-(2,6-dimethylphenyl)-3-ethoxyfuran 20
N-Bromo-succinimide (2 eq.) was added to a solution of 3e (20 mg, 0.09 mmol) in DMF (1 mL). The solution was stirred at rt for 6 h. The reaction was then concentrated in vacuo to give the crude product. This was purified by flash column chromatography to give 20 (18 mg, 0.061 mmol, 68%);

IR (film) ν = 2954, 2924, 2853, 1626 cm$^{-1}$; $^1$H NMR (600 MHz, CDCl$_3$) δ = 7.20 (t, J = 7.5 Hz, 1H), 7.02 (d, J = 7.5 Hz, 2H), 6.27 (s, 1H), 3.80 (q, J = 7.2 Hz, 2H), 2.27 (s, 6H), 1.16 (t, J = 7.2 Hz, 3H) ppm; $^{13}$C NMR (150 MHz, CDCl$_3$) δ = 144.7, 139.3, 139.0, 129.2, 128.5, 127.5, 119.7, 105.6, 67.3, 20.4, 15.2 ppm; Found (El): [M]$^+$ 294.024760, C$_{14}$H$_{15}$BrO$_2$ requires 294.02499.
4. $^1$H and $^{13}$C NMR Spectra

*(E)-1,1-Diethoxy-4-(4-(trifluoromethyl)phenyl)but-3-en-2-one 2a*
3-Ethoxy-2-(4-(trifluoromethyl)phenyl)furan 3a
3-Ethoxy-2-phenethylfuran 3b

Chemical Shift (ppm)

Electronic Supplementary Material (ESI) for Chemical Communications
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3-Ethoxy-2-(4-methoxyphenyl)furan 3c
2-Cyclopropyl-3-ethoxyfuran 3d

Electronically Supplemnetary Material (ESI) for Chemical Communications
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2-(2,6-Dimethylphenyl)-3-ethoxyfuran 3f
(R)-2-(2,6-Dimethylhept-5-en-1-yl)-3-ethoxyfuran 3g
4-(3-Ethoxyfuran-2-yl)benzonitrile 3h
3-Methoxy-2-(4-(trifluoromethyl)phenyl)furan 4a
3-Methoxy-2-phenethylfuran 4b
3-Methoxy-2-(4-methoxyphenyl)furan 4c
2-Cyclopropyl-3-methoxyfuran 4d
2-(2,6-Dimethylphenyl)-3-methoxyfuran 4f

Electronic Supplementary Material (ESI) for Chemical Communications
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\((R)-2-(2,6\text{-Dimethylhept-5-en-1-yl})-3\text{-methoxyfuran} \ 4g\)
4-(3-Methoxyfuran-2-yl)benzonitrile 4h
3-Methoxy-2-(thiophen-2-yl)furan 4i
3-Methoxy-2,2'-bifuran 4j

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2-Cyclohexyl-3-methoxyfuran 4k
2-(4-Bromophenyl)-3-methoxyfuran 4I
Methyl 3-(3-methoxyfuran-2-yl)benzoate 4m
2-(3-methoxyfuran-2-yl)phenol 4n

Chemical Shift (ppm)

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2-(2-Bromo-3-(dimethoxymethyl)phenyl)-3-methoxfuran 4o
2,2’-(2-Bromo-1,3-phenylene)bis(3-methoxyfuran) 4p
3-Phenethoxy-2-phenethylfuran 5b

Chemical Shift (ppm)

200 180 160 140 120 100 80 60 40 20 0

Electronic Supplementary Material (ESI) for Chemical Communications
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3-(Allyloxy)-2-phenethylfuran 6b
2-((2-Phenethylfuran-3-yl)oxy)ethanol 7b
3-(tert-Butoxy)-2-phenethylfuran 8b
3-Isopropoxy-2-phenethylfuran 9b
5-Methoxy-7,7-dimethyl-4,5,6,7-tetrahydrobenzofuran 10a
5-Ethoxy-7,7-dimethyl-4,5,6,7-tetrahydrobenzofuran 10b
(E)-3-Ethoxy-4-oxo-4-phenylbut-2-enal A
exo-16 (also contains endo-16)
(3aR,3bS,11S,11aS)-9b-methoxy-2-methyl-4,5,9b,10,11,11a-hexahydro-3b,11-epoxynaphtho[2,1-e]isoindole-1,3(2H,3aH)-dione 17
1-(5-Ethoxy-7,7-dimethyl-4,5,6,7-tetrahydrobenzofuran-2-yl)-N,N-dimethylmethanamine 18

Electronic Supplementary Material (ESI) for Chemical Communications
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2-Allyl-2-phenethylfuran-3(2H)-one 19
5-Bromo-2-(2,6-dimethylphenyl)-3-ethoxyfuran 20
5. References
