Supplementary Information

Annulative coupling of α-substituted acrylic acids and sulfoxonium ylides: Easy access to bioactive γ-butyrolactones

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1. General Information: $^1$H, $^{13}$C{$^1$H} and $^{19}$F{$^1$H} NMR Spectra were recorded on a JEOL ECS and Bruker at 500/126 and 600/151 MHz, respectively. Acrylic acid derivatives 2 were purchased from TCI, Spectrochem, and Merck. Chemical shifts for protons and carbons are reported in parts per million downfield from tetramethylsilane and are referenced to the residual deuterium in the solvent ($^1$H NMR: CDCl$_3$ at 7.26 ppm, DMSO-$d_6$ at 2.50 ppm) and carbon of the solvent peak ($^{13}$C{$^1$H} NMR: CDCl$_3$ at 77.160 ppm, DMSO-$d_6$ at 39.520 ppm), respectively. NMR data are represented as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, brs = broad singlet, and m = multiplet), coupling constant ($J$) (Hz), and integration. A SCIEX X500R QTOF mass spectrometer was used to record the mass spectra. Thin-layer chromatography (TLC) analysis was carried out on Merck Kieselgel 60 GF 254 plates (thickness 0.25 mm). TLC was seen using a UV lamp with a wavelength of 254 nm, and the staining process was carried out in an I$_2$ chamber. Column chromatography using silica gel with a mesh size of 100–200 was used to purify the crude products. All the reactions were carried out in oven-dried open glass vessels.
2. Experimental Section:

Structures of β-Ketosulfoxonium Ylides Used in the Study:

2.1 Preparation of Substituted β-Ketosulfoxonium Ylides, 1

\[
\text{R}^1\text{Cl} + \text{BuOK, THF, } 0^\circ \text{C}, r.t. \rightarrow \text{ArNO} + \text{S}^+ \quad (\text{R} = \text{Aryl, Alkyl})
\]

β-Ketosulfoxonium ylides were synthesized following established literature procedures \((1a^{1a} - 1r^{1a}, 1c^{1b}, 1n^{1b}, 1s^{1c}, 1t^{1d}, 1u^{1e}, 1v^{1f})\). In brief, trimethylsulfoxonium iodide (21 mmol, 3.0 equiv.) was added to a stirred solution of KO'Bu (28 mmol, 4.0 equiv.) in THF (30 mL) at room temperature. The mixture was then refluxed for 2 hours in an oil bath. After cooling to 0 °C, acyl chlorides (7 mmol, 1.0 equiv.) in dry THF (5.0 mL) were added while stirring, and the reaction was allowed to proceed for an additional 3 hours at room temperature. The solvent was evaporated, and the resulting slurry was diluted with ethyl acetate (20 mL) and water (15 mL). The aqueous layer was washed twice with 30 mL of ethyl acetate, and the combined organic layers were separated. The organic solution was filtered through a sintered funnel, dried over anhydrous Na\(_2\)SO\(_4\), and evaporated. The crude product was then purified using flash chromatography with a 95:5 EtOAc/MeOH mixture over silica gel, yielding the desired β-ketosulfoxonium ylides in moderate to high yields.
2.2 Characterization of Compounds, 1

**Representative Data for 2-(Dimethyl(oxo)-λ6-sulfaneylidene)-1-phenylethan-1-one, 1a**

White solid (1.1 g, 80%); mp 117-119 °C; \(^1\)H NMR (600 MHz, CDCl\(_3\)) \(\delta\): 7.79 (d, \(J = 7.8\) Hz, 2H), 7.42 (t, \(J = 7.0\) Hz, 1H), 7.38 (t, \(J = 7.5\) Hz, 2H), 5.02 (s, 1H), 3.49 (s, 6H); \(^{13}\)C\({^1}\)H) NMR (151 MHz, CDCl\(_3\)) \(\delta\): 182.4, 138.9, 130.9, 128.2, 126.6, 68.7, 42.4.

2.3. General Procedure for the Synthesis of Compounds, 3

To a stirred solution of \(\beta\)-ketosulfoxonium ylides 1a (0.5 mmol, 1.0 equiv.) in EtOAc (1.0 mL) was added acrylic acid 2a (1.25 mmol, 2.5 equiv.) and the reaction mixture was stirred at 60 °C for 22-26 hours in a sealed tube on an oil bath. After completion of reaction as monitored by TLC, the reaction mixture was cooled in an ice bath and then diluted with a saturated aqueous solution of NaHCO\(_3\). The reaction mixture was then extracted with DCM (3 x 15 mL), dried over anhydrous Na\(_2\)SO\(_4\), and concentrated under reduced pressure. The crude product was purified by column chromatography (silica gel, 100-200 mesh; ethyl acetate/hexane 10-15% v/v) which afforded the desired product 3a in quantitative yields.

3. Characterization of Compounds, 3

**5-Benzoyldihydrofuran-2(3\(H\))-one, 3a**

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). White solid (90 mg, 95%); m.p. 50–52 °C; \(^1\)H NMR (500 MHz, CDCl\(_3\)) \(\delta\): 7.97 (d, \(J = 8.1\) Hz, 2H), 7.64 (t, \(J = 7.2\) Hz, 1H), 7.51 (t, \(J = 7.6\) Hz, 2H), 5.86 – 5.84 (m, 1H), 2.65 – 2.54 (m, 3H), 2.45–2.39 (m, 1H); \(^{13}\)C\({^1}\)H) NMR (126 MHz, CDCl\(_3\)) \(\delta\): 194.5, 176.5, 134.3, 133.5, 129.0, 128.7, 78.3, 26.8, 25.1.

**5-(4-Methylbenzoyl)dihydrofuran-2(3\(H\))-one, 3b**

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). White solid (95 mg, 93%); m.p. 82–84 °C; \(^1\)H NMR (500 MHz, CDCl\(_3\)) \(\delta\): 7.87 (d, \(J = 7.5\) Hz, 2H), 7.30 (d, \(J = 7.6\) Hz, 2H), 5.82 – 5.80 (m, 1H), 2.64 – 2.54 (m, 3H), 2.43 (s, 4H); \(^{13}\)C\({^1}\)H) NMR (126 MHz, CDCl\(_3\)) \(\delta\): 194.1, 176.5, 145.4, 131.2, 129.7, 128.9, 78.2, 26.9, 25.2, 21.8.

**5-(3-Methylbenzoyl)dihydrofuran-2(3\(H\))-one, 3c**

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 2.5/7.5). Yellow oil (96 mg, 94%); \(^1\)H NMR (500 MHz, CDCl\(_3\)) \(\delta\): 7.66 (d, \(J = 7.7\) Hz, 1H), 7.45 (t, \(J = 7.4\) Hz, 1H), 7.31 (t, \(J = 7.4\) Hz, 2H), 5.74 – 5.72 (m, 1H), 2.60 – 2.54 (m, 3H), 2.51 (s, 3H), 2.37 – 2.31 (m, 1H); \(^{13}\)C\({^1}\)H) NMR (126 MHz, CDCl\(_3\)) \(\delta\): 197.9, 176.5, 139.9, 133.7, 132.6, 132.4, 129.0, 126.0, 79.4, 26.9, 25.2, 21.3.

**5-(4-Methoxybenzoyl)dihydrofuran-2(3\(H\))-one, 3d**

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 2.5/7.5). Yellow oil (96 mg, 94%); \(^1\)H NMR (500 MHz, CDCl\(_3\)) \(\delta\): 7.66 (d, \(J = 7.7\) Hz, 1H), 7.45 (t, \(J = 7.4\) Hz, 1H), 7.31 (t, \(J = 7.4\) Hz, 2H), 5.74 – 5.72 (m, 1H), 2.60 – 2.54 (m, 3H), 2.51 (s, 3H), 2.37 – 2.31 (m, 1H); \(^{13}\)C\({^1}\)H) NMR (126 MHz, CDCl\(_3\)) \(\delta\): 197.9, 176.5, 139.9, 133.7, 132.6, 132.4, 129.0, 126.0, 79.4, 26.9, 25.2, 21.3.
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). White solid (106 mg, 96%); m.p. 111–113 °C; $^1$H NMR (500 MHz, CDCl$_3$) δ: 7.97 (d, $J = 8.4$ Hz, 2H), 6.98 (d, $J = 9.1$ Hz, 2H), 5.76 – 5.74 (m, 1H), 3.89 (s, 3H), 2.62 – 2.54 (m, 3H), 2.49 – 2.44 (m, 1H); $^{13}$C{$_^1$H} NMR (126 MHz, CDCl$_3$) δ: 192.9, 176.5, 164.6, 131.4, 126.8, 114.4, 78.3, 55.7, 27.1, 25.1.

5-(3-Methoxybenzoyl)dihydrofuran-2(3H)-one, 3e

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). Yellow oil (104 mg, 95%); $^1$H NMR (600 MHz, CDCl$_3$) δ: 7.52 (d, $J = 7.8$ Hz, 1H), 7.47 (s, 1H), 7.41 (t, $J = 8.0$ Hz, 1H), 7.18 – 7.15 (m, 1H), 5.88 – 5.86 (m, 1H), 3.84 (s, 3H), 2.70 – 2.63 (m, 1H), 2.58 – 2.52 (m, 2H), 2.39–2.33 (m, 1H).; $^{13}$C{$_^1$H} NMR (151 MHz, CDCl$_3$) δ: 194.4, 176.5, 159.8, 134.5, 129.9, 120.9, 120.4, 112.8, 78.2, 55.3, 26.6, 25.2.

5-(4-Fluorobenzoyl)dihydrofuran-2(3H)-one, 3f

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). White solid (97 mg, 93%); m.p. 96–98 °C; $^1$H NMR (500 MHz, CDCl$_3$) δ: 8.05 – 8.02 (m, 2H), 7.22 – 7.15 (m, 2H), 5.78 – 5.75 (m, 1H), 2.63 – 2.57 (m, 3H), 2.51 – 2.46 (m, 1H).; $^{13}$C{$_^1$H} NMR (126 MHz, CDCl$_3$) δ: 193.0, 176.2, 166.4 (d, $J = 254.6$ Hz), 131.75 (d, $J = 9.7$ Hz), 130.2, 116.8, 113.8 (d, $J = 12.2$ Hz), 78.3, 26.9, 24.8.; $^{19}$F NMR {$_^1$H} (471 MHz, CDCl$_3$) δ: –102.49.

5-(2-Fluorobenzoyl)dihydrofuran-2(3H)-one, 3g

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). White solid (94 mg, 90%); m.p. 89–91°C; $^1$H NMR (500 MHz, CDCl$_3$) δ: 7.96 (t, $J = 7.1$ Hz, 1H), 7.64 (d, $J = 5.5$ Hz, 1H), 7.32 (t, $J = 7.2$ Hz, 1H), 7.20 (t, $J = 9.8$ Hz, 1H), 5.80 – 5.64 (m, 1H), 2.73 – 2.65 (m, 1H), 2.58 – 2.52 (m, 2H), 2.40 – 2.32 (m, 1H); $^{13}$C{$_^1$H} NMR (126 MHz, CDCl$_3$) δ: 193.3, 176.5, 163.0 (d, $J = 254.4$ Hz), 136.2 (d, $J = 9.1$ Hz), 131.3, 125.2, 122.1 (d, $J = 13.8$ Hz), 116.8 (d, $J = 22.7$ Hz), 81.2 (d, $J = 10.5$ Hz), 26.3, 24.8.; $^{19}$F NMR {$_^1$H} (471 MHz, CDCl$_3$) δ: –114.18.

5-(4-Bromobenzoyl)dihydrofuran-2(3H)-one, 3h

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). White solid (123 mg, 92%); m.p. 101–104 °C; $^1$H NMR (500 MHz, CDCl$_3$) δ: 7.84 (d, $J = 9.0$ Hz, 2H), 7.65 (d, $J = 8.1$ Hz, 2H), 5.79 – 5.77 (m, 1H), 2.63 – 2.56 (m, 3H), 2.46 – 2.41 (m, 1H); $^{13}$C{$_^1$H} NMR (126 MHz, CDCl$_3$) δ: 193.7, 176.2, 132.8, 130.3, 129.6, 78.3, 26.8, 24.8.

5-(2-Bromobenzoyl)dihydrofuran-2(3H)-one, 3i

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). Yellow liquid (126 mg, 94%); $^1$H NMR (600 MHz, CDCl$_3$) δ: 7.65 (d, $J = 7.9$ Hz, 1H), 7.47 (d, $J = 7.5$ Hz, 1H), 7.62 (d, $J = 8.1$ Hz, 2H), 5.79 – 5.77 (m, 1H), 2.63 – 2.56 (m, 3H), 2.46 – 2.41 (m, 1H).
7.43 (t, J = 7.4 Hz, 1H), 7.38 (t, J = 7.7 Hz, 1H), 5.67 – 5.64 (m, 1H), 2.61 – 2.53 (m, 3H), 2.46 – 2.41 (m, 1H); 13C{1H} NMR (151 MHz, CDCl3) δ: 199.2, 176.2, 137.8, 134.0, 132.9, 129.4, 127.7, 119.7, 80.2, 26.9, 24.9.; HRMS (ESI-TOF) m/z: [M + H]⁺ calcd. for C11H10BrO2 268.9808, found 268.9811.

5-(4-Nitrobenzoyl)dihydrofuran-2(3H)-one, 3j
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). Yellow solid (106 mg, 90%); m.p. 112 – 116 °C; 1H NMR (500 MHz, CDCl3) δ: 8.35 (d, J = 8.9 Hz, 2H), 8.18 (d, J = 9.0 Hz, 2H), 5.82 – 5.79 (m, 1H), 2.69 – 2.61 (m, 3H), 2.57 – 2.52 (m, 1H).; 13C{1H} NMR (126 MHz, CDCl3) δ: 193.4, 175.8, 150.9, 138.3, 130.2, 124.1, 78.7, 26.8, 24.4.; HRMS (ESI-TOF) m/z: [M + H]⁺ calcd. for C11H10NO5 236.0554, found 236.0554.

5-(4-(Trifluoromethyl)benzoyl)dihydrofuran-2(3H)-one, 3k
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). White solid (117 mg, 91%); m.p. 52 – 55 °C; 1H NMR (500 MHz, CDCl3) δ: 8.11 (d, J = 8.1 Hz, 2H), 7.78 (d, J = 8.2 Hz, 2H), 5.81 – 5.78 (m, 1H), 2.66 – 2.58 (m, 3H), 2.53 – 2.48 (m, 1H).; 13C{1H} NMR (126 MHz, CDCl3) δ: 193.8, 176.0, 136.6, 135.5 (q, J = 33.1 Hz), 129.4, 126.12 (d, J = 3.1 Hz), 123.5 (d, J = 273.1 Hz), 78.6, 26.9, 24.6.

5-(Furan-2-carbonyl)dihydrofuran-2(3H)-one, 3l
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). Black solid (79 mg, 88%); m.p. 64 – 65 °C; 1H NMR (500 MHz, CDCl3) δ: 7.71 (s, 1H), 7.44 (d, J = 3.3 Hz, 1H), 6.64 (d, J = 4.3 Hz, 1H), 5.61–5.58 (m, 1H), 2.66 – 2.58 (m, 3H), 2.44 – 2.40 (m, 1H); 13C{1H} NMR (126 MHz, CDCl3) δ: 183.8, 176.4, 149.9, 147.9, 120.3, 112.9, 78.5, 26.7, 25.2; HRMS (ESI-TOF) m/z: [M + H]⁺ calcd. for C9H9O4 181.0496, found 181.0493.

5-(Thiophene-2-carbonyl)dihydrofuran-2(3H)-one, 3m
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). Brown solid (84 mg, 86%); m.p. 63–65 °C; 1H NMR (500 MHz, CDCl3) δ: 7.91 (d, J = 3.8 Hz, 1H), 7.78 (d, J = 4.9 Hz, 1H), 7.20 (t, J = 4.4 Hz, 1H), 5.60–5.58 (m, 1H), 2.65 – 2.58 (m, 3H), 2.44 – 2.40 (m, 1H); 13C{1H} NMR (126 MHz, CDCl3) δ: 188.1, 176.2, 140.2, 135.7, 134.0, 128.8, 79.3, 26.9, 25.5.

5-(2-Naphthoyl)dihydrofuran-2(3H)-one, 3n
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 3/7). White solid (108 mg, 90%); m.p. 60–62 °C; 1H NMR (500 MHz, CDCl3) δ: 8.59 (d, J = 8.7 Hz, 1H), 8.00 (d, J = 8.2 Hz, 1H), 7.86 (dd, J = 12.4, 7.8 Hz, 2H), 7.58 (t, J = 7.7 Hz, 1H), 7.52 (t, J = 7.4 Hz, 1H), 7.47 (t, J = 7.8 Hz,
1H), 5.82–5.80 (m, 1H), 2.60 – 2.48 (m, 3H), 2.37 – 2.30 (m, 1H); $^{13}$C {\textsuperscript{1}H} NMR (126 MHz, CDCl\textsubscript{3}) δ: 198.1, 176.5, 134.2, 134.0, 131.5, 130.6, 128.70, 128.66, 126.9, 125.3, 124.4, 79.6, 26.9, 25.3.

5-(Cyclopropanecarbonyl)dihydrofuran-2(3H)-one, 3o
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 2/8). Colourless oil (65 mg, 85%); $^1$H NMR (500 MHz, CDCl\textsubscript{3}) δ: 5.05 – 5.00 (m, 1H), 2.60 – 2.53 (m, 3H), 2.36 – 2.30 (m, 1H), 2.25–2.20 (m, 1H), 1.16 – 1.12 (m, 2H), 1.08 – 1.05 (m, 2H); $^{13}$C {\textsuperscript{1}H} NMR (126 MHz, CDCl\textsubscript{3}) δ: 207.1, 176.2, 82.0, 77.3, 27.1, 24.9, 16.8, 12.3, 12.2; HRMS (ESI-TOF) m/z: [M + H$^+$] calcd. for C\textsubscript{8}H\textsubscript{11}O\textsubscript{3} 155.0703, found 155.0703.

5-(Cyclohexanecarbonyl)dihydrofuran-2(3H)-one, 3p
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 1.5/8.5). Colourless oil (85 mg, 87%); $^1$H NMR (500 MHz, CDCl\textsubscript{3}) δ: 4.98 – 4.95 (m, 1H), 2.75 – 2.70 (m, 1H), 2.56 – 2.47 (m, 3H), 2.29 – 2.23 (m, 1H), 1.91 (d, J = 10.5 Hz, 1H), 1.80 (d, J = 10.0 Hz, 3H), 1.71–1.70 (m, 1H), 1.39 – 1.23 (m, 5H); $^{13}$C {\textsuperscript{1}H} NMR (151 MHz, CDCl\textsubscript{3}) δ: 209.9, 176.3, 80.6, 46.9, 28.3, 28.0, 27.3, 25.7, 25.6, 25.4, 24.6.; HRMS (ESI-TOF) m/z: [M + H$^+$] calcd. for C\textsubscript{11}H\textsubscript{17}O\textsubscript{3} 197.1172, found 197.1171.

5-((3r,5r,7r)-Adamantane-1-carbonyl)dihydrofuran-2(3H)-one, 3q
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 2/8). Colourless oil (106 mg, 86%); $^1$H NMR (500 MHz, CDCl\textsubscript{3}) δ: 5.38 – 5.36 (m, 1H), 2.62 – 2.54 (m, 1H), 2.52 – 2.39 (m, 2H), 2.18 – 2.12 (m, 1H), 2.08 (br, 3H), 1.92 – 1.89 (m, 3H), 1.84 – 1.77 (m, 6H), 1.71 (d, J = 12.3 Hz, 3H); $^{13}$C {\textsuperscript{1}H} NMR (126 MHz, CDCl\textsubscript{3}) δ: 209.7, 176.7, 76.0, 45.7, 37.5, 36.3, 27.6, 26.7, 25.1; HRMS (ESI-TOF) m/z: [M + H$^+$] calcd. for C\textsubscript{15}H\textsubscript{21}O\textsubscript{3} 249.1485, found 249.1482.

5-Pivaloyldihydrofuran-2(3H)-one, 3r
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 1.5/8.5). Colourless oil (72 mg, 85%); $^1$H NMR (500 MHz, CDCl\textsubscript{3}) δ: 5.35–5.32 (m, 1H), 2.64 – 2.57 (m, 1H), 2.53 – 2.42 (m, 2H), 2.21 – 2.15 (m, 1H), 1.22 (s, 9H); $^{13}$C {\textsuperscript{1}H} NMR (126 MHz, CDCl\textsubscript{3}) δ: 210.6, 176.6, 76.6, 38.9, 31.3, 27.5, 24.7, 22.6, 22.5, 14.0.

5-Heptanoyldihydrofuran-2(3H)-one, 3s
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 1.5/8.5). Colourless oil (83 mg, 90%); $^1$H NMR (600 MHz, CDCl\textsubscript{3}) δ: 4.83 (t, J = 7.3 Hz, 1H), 2.64 – 2.22 (m, 5H), 2.27 – 2.22 (m, 1H), 1.64 – 1.59 (m, 2H), 1.33 – 1.28 (s, 9H); $^{13}$C {\textsuperscript{1}H} NMR (151 MHz, CDCl\textsubscript{3}) δ: 207.9, 176.2, 81.9, 38.9, 31.3, 27.5, 24.7, 22.6, 22.5, 14.0.

5-Tridecanoyldihydrofuran-2(3H)-one, 3t
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 1.5/8.5). Colourless oil (120 mg, 85%); $^1$H NMR (600 MHz, CDCl\textsubscript{3}) δ: 4.83 – 4.81 (m, 1H), 2.66 – 2.48 (m, 5H), 2.27 – 2.21 (m, 1H), 1.61 –
1.59 (m, 3H), 1.29 – 1.24 (m, 17H), 0.88 (t, J = 7.0 Hz, 3H); $^{13}$C{H} NMR (151 MHz, CDCl$_3$) $\delta$: 207.9, 176.1, 81.9, 39.0, 32.0, 29.78, 29.76, 29.6, 29.5, 29.2, 27.5, 24.7, 23.0, 22.8, 14.3.

**Ethyl 5-oxotetrahydrofuran-2-carboxylate, 3u**

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 1.5/8.5). Colourless oil (70 mg, 85%); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$: 4.95 – 4.92 (m, 1H), 4.27 (dd, J = 6.7, 2.6 Hz, 2H), 2.63 – 2.51 (m, 3H), 2.34 – 2.29 (m, 1H), 1.32 (t, J = 6.8 Hz, 3H); $^{13}$C{H} NMR (126 MHz, CDCl$_3$) $\delta$: 176.0, 169.9, 75.84, 62.0, 26.8, 25.9, 14.1.

**Benzyl 5-oxotetrahydrofuran-2-carboxylate, 3v**

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 1.5/8.5). Colourless oil (97 mg, 88%); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$: 7.37 – 7.31 (m, 5H), 5.20 (s, 2H), 4.95 – 4.93 (m, 1H), 2.54 – 2.47 (m, 3H), 2.28 – 2.22 (m, 1H); $^{13}$C{H} NMR (126 MHz, CDCl$_3$) $\delta$: 175.9, 169.7, 134.9, 128.65, 128.62, 128.3, 75.7, 67.4, 26.6, 25.6.

**5-Benzoyl-3-phenyldihydrofuran-2(3H)-one, 3w**

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 2/8). White solid (106 mg, 80%); m.p. 120 – 122 °C; $^1$H NMR (500 MHz, CDCl$_3$) $\delta$: 8.02 (d, J = 8.2 Hz, 2H), 7.66 (t, J = 7.5 Hz, 1H), 7.53 (t, J = 7.4 Hz, 2H), 7.37 (t, J = 7.6 Hz, 2H), 7.39 – 7.28 (m, 3H), 5.92 – 5.89 (m, 1H), 3.97 – 3.90 (m, 1H), 2.99 – 2.93 (m, 1H), 2.80 – 2.73 (m, 1H); $^{13}$C{H} NMR (126 MHz, CDCl$_3$) $\delta$: 194.4, 176.4, 137.8, 134.5, 133.8, 133.3, 129.9, 129.2, 129.0, 128.0, 76.3, 43.7, 34.3, 21.2.; HRMS (ESI-TOF) m/z: [M + H]$^+$ calcd. for C$_{17}$H$_{15}$O$_3$ 267.1016, found 267.1014.

**5-Benzoyl-3-(p-tolyl)dihydrofuran-2(3H)-one, 3x**

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 2/8). White solid (106 mg, 76%); m.p. 122 – 124 °C; $^1$H NMR (500 MHz, CDCl$_3$) $\delta$: 8.01 (d, J = 8.1 Hz, 2H), 7.65 (t, J = 7.4 Hz, 1H), 7.53 (t, J = 7.4 Hz, 2H), 7.18 (s, 4H), 5.90 – 5.87 (m, 1H), 3.92 – 3.88 (m, 1H), 2.97 – 2.92 (m, 1H), 2.77 – 2.70 (m, 1H), 2.34 (s, 3H); $^{13}$C{H} NMR (126 MHz, CDCl$_3$) $\delta$: 194.5, 176.5, 137.8, 134.5, 133.8, 133.3, 129.9, 129.2, 129.0, 128.0, 76.4, 43.7, 34.3, 21.2.; HRMS (ESI-TOF) m/z: [M + H]$^+$ calcd. for C$_{18}$H$_{17}$O$_3$ 281.1172, found 281.1171.

**5-Benzoyl-3-(3-methoxyphenyl)dihydrofuran-2(3H)-one, 3y**

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 1.5/8.5). Yellow oil (206 mg, 81%); $^1$H NMR (500 MHz, CDCl$_3$) $\delta$: 8.01 (d, J = 8.1 Hz, 2H), 7.65 (t, J = 7.5 Hz, 1H), 7.53 (t, J = 7.5 Hz, 2H), 7.28 (t, J = 8.1 Hz, 1H), 6.87 – 6.84 (m, 3H), 5.90 – 5.88 (m, 1H), 3.93 – 3.88 (m, 1H), 3.80 (s, 3H), 2.97 – 2.91 (m, 1H), 2.79 – 2.72 (m, 1H); $^{13}$C{H} NMR (126 MHz, CDCl$_3$) $\delta$: 207.9, 176.1, 81.9, 39.0, 32.0, 29.78, 29.76, 29.6, 29.5, 29.2, 27.5, 24.7, 23.0, 22.8, 14.3.
δ: 194.4, 176.2, 160.2, 137.8, 134.5, 133.8, 130.2, 129.0, 129.3, 114.1, 113.4, 76.3, 55.4, 44.0, 34.2. HRMS (ESI-TOF) m/z: [M + H]+ calcd. for C_{18}H_{17}O_{4} 297.1122, found 297.1122.

5-Benzoyl-3-(4-methoxyphenyl)dihydrofuran-2(3H)-one, 3z
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 1.5/8.5). White solid (120 mg, 81%); m.p. 122–124 °C; 1H NMR (500 MHz, CDCl$_3$) δ: 8.01 (d, J = 7.9 Hz, 2H), 7.65 (t, J = 7.4 Hz, 1H), 7.53 (t, J = 7.4 Hz, 2H), 7.20 (d, J = 8.1 Hz, 2H), 6.90 (d, J = 9.0 Hz, 2H), 5.90 – 5.89 (m, 1H), 3.90 – 3.85 (m, 1H), 3.79 (s, 3H), 2.94 – 2.90 (m, 1H), 2.76 – 2.69 (m, 1H).; 13C{1H} NMR (126 MHz, CDCl$_3$) δ: 194.4, 176.7, 159.3, 134.5, 133.7, 129.2, 128.9, 128.2, 114.6, 76.3, 55.4, 43.2, 34.3. HRMS (ESI-TOF) m/z: [M + H]+ calcd. for C_{18}H_{17}O_{4} 297.1122, found 297.1119.

5-Benzoyl-3-(4-fluorophenyl)dihydrofuran-2(3H)-one, 3aa
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 1.5/8.5). White solid (108 mg, 76%); m.p. 126–128 °C; 1H NMR (600 MHz, CDCl$_3$) δ: 8.01 (d, J = 7.8 Hz, 2H), 7.66 (t, J = 7.3 Hz, 1H), 7.54 (t, J = 7.6 Hz, 2H), 7.26 (t, J = 6.6 Hz, 2H), 7.05 (t, J = 8.5 Hz, 2H), 5.92 (d, J = 9.0 Hz, 1H), 3.98 – 3.86 (m, 1H), 3.00 – 2.89 (m, 1H), 2.74 (dt, J = 22.0, 11.1 Hz, 1H); 13C{1H} NMR (151 MHz, CDCl$_3$) δ 194.3, 176.3, 162.4 (d, J = 246.1 Hz), 134.6, 133.5, 131.9 (d, J = 2.8 Hz), 129.8 (d, J = 8.2 Hz), 129.2, 128.9, 116.1 (d, J = 21.1 Hz), 76.1, 43.1, 34.2; 19F NMR{1H} (471 MHz, CDCl$_3$) δ: −114.22.; HRMS (ESI-TOF) m/z: [M + H]+ calcd. for C$_{17}$H$_{14}$FO$_3$ 285.0922, found 285.0919.

5-Benzoyl-3-(3-chlorophenyl)dihydrofuran-2(3H)-one, 3ab
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 2/8). White solid (117 mg, 78%); m.p. 130–132 °C; 1H NMR (500 MHz, CDCl$_3$) δ: 8.01 (d, J = 7.6 Hz, 2H), 7.66 (t, J = 7.4 Hz, 1H), 7.54 (t, J = 7.8 Hz, 2H), 7.34 – 7.27 (m, 3H), 7.19 (d, J = 6.2 Hz, 1H), 5.93 – 5.89 (m, 1H), 3.94 – 3.90 (m, 1H), 2.99 – 2.94 (m, 1H), 2.78 – 2.71 (m, 1H); 13C{1H} NMR (151 MHz, CDCl$_3$) δ 194.3, 175.7, 138.1, 135.0, 134.6, 133.6, 130.4, 129.3, 129.0, 128.3, 128.2, 126.3, 76.2, 43.5, 33.9.; HRMS (ESI-TOF) m/z: [M + H]+ calcd. for C$_{17}$H$_{14}$ClO$_3$ 301.0626, found 301.0627.

5-Benzoyl-3-(8-aphthalene-1-yl)dihydrofuran-2(3H)-one, 3ac
Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 2/8). Brown solid (118 mg, 75%); m.p. 140–142 °C; 1H NMR (500 MHz, CDCl$_3$) δ: 8.00 (d, J = 8.0 Hz, 2H), 7.87 – 7.79 (m, 3H), 7.62 (t, J = 7.5 Hz, 1H), 7.53 – 7.46 (m, 4H), 7.46 – 7.41 (m, 2H), 5.94 – 5.91 (m, 1H), 4.62 (t, J = 9.5 Hz, 1H), 3.07 – 3.02 (m, 1H), 2.78 – 2.71 (m, 1H);
\[^{13}\text{C}\{^1\text{H}\}\text{ NMR}\ (126\text{ MHz, } \text{CDCl}_3) \ \delta: \ 194.4, \ 176.5, \ 134.5, \ 134.2, \ 133.7, \ 132.8, \ 131.3, \ 129.3, \ 129.2, \ 129.0, \ 128.8, \ 126.8, \ 126.1, \ 125.7, \ 125.6, \ 122.9, \ 76.5, \ 41.7, \ 34.2; \ HRMS (ESI-TOF) m/z: [M + H]^+ \text{ calcd. for C}_{21}\text{H}_{17}\text{O}_3 \ 317.1172, \text{ found } 317.1180.\]

5-Benzoyl-3-methyldihydrofuran-2(3\text{H})-one, 3ad\(^1\)

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 2/8). White solid (87 mg, 85\%); m.p. 53–55 \(^\circ\text{C};\) \(^1\text{H}\) NMR (500 MHz, CDCl\(_3\)) \(\delta: \ 7.98 \ (d, \ J = 7.8 \text{ Hz}, 2H), \ 7.64 \ (t, \ J = 7.4 \text{ Hz}, 1H), \ 7.52 \ (t, \ J = 7.6 \text{ Hz}, 2H), \ 5.76 \ (d, \ J = 9.5 \text{ Hz}, 1H), \ 2.74 – 2.67 \ (m, 2H), \ 2.30 – 2.23 \ (m, 1H), \ 1.31 \ (d, \ J = 6.5 \text{ Hz}, 3H); \)^{13}\text{C}\{^1\text{H}\}\text{ NMR (126 MHz, } \text{CDCl}_3) \ \delta: \ 194.6, \ 179.0, \ 134.4, \ 133.8, \ 129.1, \ 128.9, \ 33.4, \ 32.7, \ 15.5.

5-Benzoyl-3-benzyldihydrofuran-2(3\text{H})-one, 3ae\(^5\)

Purified by column chromatography (silica gel 100-200 mesh, ethyl acetate/hexane, v/v = 1/9). Colourless oil (105 mg, 75\%); \(^1\text{H}\) NMR (500 MHz, CDCl\(_3\)) \(\delta: \ 7.90 \ (d, \ J = 7.7 \text{ Hz}, 2H), \ 7.61 \ (t, \ J = 7.4 \text{ Hz}, 1H), \ 7.48 \ (t, \ J = 7.6 \text{ Hz}, 2H), \ 7.30 \ (t, \ J = 7.4 \text{ Hz}, 2H), \ 7.26 – 7.22 \ (m, 1H), \ 7.19 \ (d, \ J = 7.4 \text{ Hz}, 2H), \ 5.65 – 5.63 \ (m, 1H), \ 3.27 – 3.24 \ (m, 1H), \ 3.01 – 2.94 \ (m, 1H), \ 2.84 – 2.79 \ (m, 1H), \ 2.45 – 2.41 \ (m, 1H), \ 2.37 – 2.30 \ (m, 1H); \)^{13}\text{C}\{^1\text{H}\}\text{ NMR (126 MHz, } \text{CDCl}_3) \ \delta: \ 194.5, \ 177.7, \ 138.0, \ 134.4, \ 129.12, \ 127.07, \ 128.9, \ 128.8, \ 127.0, \ 76.4, \ 39.4, \ 36.3, \ 30.9.

4. Synthesis of L-Factor, 4\(^1\)

To a stirred solution of 5-heptanoyldihydrofuran-2(3\text{H})-one 3s (1.0 mmol, 1.0 equiv.) in a 9:1 mixture of DCM/MeOH, BH\(_3\cdot\text{NH}_3\) (1.5 mmol, 1.5 equiv.) was added. The reaction mixture was stirred at \(-10 ^\circ\text{C}\) for 1 hour. Upon completion, as monitored by TLC, the reaction was quenched with a saturated NH\(_4\)Cl solution. The mixture was then extracted with EtOAc (3 x 10 mL), dried over anhydrous Na\(_2\)SO\(_4\), and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (100-200 mesh) using ethyl acetate/hexane (3:7 v/v) as the eluent, yielding the L-Factor 4 as a colorless oil in 75\% yield (134 mg) with a diastereomeric ratio of >99:1; \(^1\text{H}\) NMR (500 MHz, CDCl\(_3\)) \(\delta: \ 4.46 – 4.42 \ (m, 1H), \ 3.93 – 3.92 \ (m, 1H), \ 2.63 – 2.47 \ (m, 3H), \ 2.31 – 2.23 \ (m, 1H), \ 2.18 – 2.11 \ (m, 1H), \ 1.57 – 1.51 \ (m, 1H), \ 1.44 – 1.40 \ (m, 2H), \ 1.36 – 1.28 \ (m, 5H), \ 0.90 \ (t, \ J = 6.6 \text{ Hz}, 3H);\) \(^{13}\text{C}\{^1\text{H}\}\text{ NMR (126 MHz, } \text{CDCl}_3) \ \delta: \ 177.8, \ 83.1, \ 71.5, \ 32.0, \ 31.8, \ 28.8, \ 25.4, \ 22.6, \ 21.2, \ 14.1.

5. Synthesis of Muricatacin, 5\(^5\)

To a stirred solution of 5-heptanoyldihydrofuran-2(3\text{H})-one 3t (1.0 mmol, 1.0 equiv.) in a 9:1 mixture of DCM/MeOH, BH\(_3\cdot\text{NH}_3\) (1.5 mmol, 1.5 equiv.) was added. The reaction mixture was stirred at \(-10 ^\circ\text{C}\) for 1 hour. Upon completion, as monitored by TLC, the reaction was quenched with a saturated NH\(_4\)Cl solution. The mixture was then extracted with EtOAc (3 x 10 mL), dried over anhydrous Na\(_2\)SO\(_4\),
and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (100-200 mesh) using ethyl acetate/hexane (3:7 v/v) as the eluent, yielding Muricatacin 5 as a white solid in 78% yield (211 mg) with a diastereomeric ratio of >99:1. m.p. 72–74 °C; 1H NMR (500 MHz, CDCl₃) δ: 4.45 – 4.40 (m, 1H), 3.93 – 3.91 (m, 1H), 2.64 – 2.46 (m, 3H), 2.31 – 2.22 (m, 1H), 2.17 – 2.10 (m, 1H), 1.55 – 1.54 (m, 2H), 1.48 – 1.40 (m, 2H), 1.28 – 1.26 (m, 17H), 0.88 (t, J = 6.7 Hz, 3H).

13C{1H} NMR (126 MHz, CDCl₃) δ: 177.7, 83.1, 73.7, 71.5, 33.1, 32.13, 32.01, 29.72, 29.66, 29.1, 29.4, 2.8, 25.8, 25.6, 24.2, 22.8, 21.2, 14.2.

6. Synthesis of Cytosporanone A, 6

To a stirred solution of 5-benzoyldihydrofuran-2(3H)-one 3a (1.0 mmol, 1.0 equiv.) in a 9:1 mixture of DCM/MeOH, BH₃·NH₃ (1.5 mmol, 1.5 equiv.) was added. The reaction mixture was stirred at −10 °C for 1 hour. Upon completion, as monitored by TLC, the reaction was quenched with a saturated NH₄Cl solution. The mixture was then extracted with EtOAc (3 x 10 mL), dried over anhydrous Na₂SO₄, and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (100-200 mesh) using ethyl acetate/hexane (3:7 v/v) as the eluent, yielding Cytosporanone A 6 as a white solid in 80% yield (154 mg); m.p. 98–100 °C; 1H NMR (500 MHz, CDCl₃) δ: 7.39 – 7.34 (m, 4H), 7.31 – 7.28 (m, 1H), 5.10 – 5.08 (m, 1H), 4.70 – 4.66 (m, 1H), 3.32 (d, J = 3.8 Hz, 1H), 2.57 – 2.50 (m, 1H), 2.44 – 2.37 (m, 1H), 2.30 – 2.22 (m, 1H), 1.94 – 1.86 (m, 1H); 13C{1H} NMR (126 MHz, CDCl₃) δ: 178.2, 138.8, 128.6, 128.0, 126.2, 83.6, 73.4, 28.7, 20.7.

7. References:


$^1$H NMR (600 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (151 MHz, CDCl$_3$), 1a
$^1$H NMR (600 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (151 MHz, CDCl$_3$), 3a
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C($^1$H) NMR (126 MHz, CDCl$_3$), 3b
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{${}^1$H} NMR (126 MHz, CDCl$_3$), 3c
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C-$^1$H NMR (126 MHz, CDCl$_3$), 3d
$^1$H NMR (600 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (151 MHz, CDCl$_3$), 3e
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3f
\(^1\)H NMR (500 MHz, CDCl\(_3\)) and \(^{13}\)C\(^{\text{\(1\)H}}\) NMR (126 MHz, CDCl\(_3\)), 3g
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3h
$^{1}H$ NMR (600 MHz, CDCl$_3$) and $^{13}C\{}^{1}H\} NMR (151 MHz, CDCl$_3$), 3i
\(^1\)H NMR (500 MHz, CDCl\(_3\)) and \(^{13}\)C\(^{1}\)H NMR (126 MHz, CDCl\(_3\)), 3j
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3k
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3l
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C\{$^1$H\} NMR (126 MHz, CDCl$_3$), 3m
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3n
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{${^1}$H} NMR (126 MHz, CDCl$_3$), 3o
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3p
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3q
\(^1H\) NMR (500 MHz, CDCl\(_3\)) and \(^{13}C\{^1H\}\) NMR (126 MHz, CDCl\(_3\)), 3r
$^1$H NMR (600 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (151 MHz, CDCl$_3$), 3s
$^1$H NMR (600 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (151 MHz, CDCl$_3$), 3t
$^1$H NMR (600 MHz, CDCl$_3$) and $^{13}$C-$^1$H NMR (151 MHz, CDCl$_3$), 3u
$^1$H NMR (600 MHz, CDCl$_3$) and $^{13}$C{$_^1$H} NMR (151 MHz, CDCl$_3$), 3v
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3w
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C {$^1$H} NMR (126 MHz, CDCl$_3$), 3x
^1H NMR (500 MHz, CDCl₃) and ^13C{^1H} NMR (126 MHz, CDCl₃), 3y
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3z
$^1$H NMR (600 MHz, CDCl$_3$) and $^{13}$C\textsubscript{\text{\text{1}}H} NMR (151 MHz, CDCl$_3$), 3aa
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C$\{^1$H$\}$ NMR (126 MHz, CDCl$_3$), 3ab
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3ac
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{${^1}$H} NMR (126 MHz, CDCl$_3$), 3ad
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C{$^1$H} NMR (126 MHz, CDCl$_3$), 3ae
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C($^1$H) NMR (126 MHz, CDCl$_3$), 4
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C($^1$H) NMR (126 MHz, CDCl$_3$), 5
$^1$H NMR (500 MHz, CDCl$_3$) and $^{13}$C({$^1$H}) NMR (126 MHz, CDCl$_3$), 6
$^{19}$F NMR ($^1$H) (471 MHz, CDCl$_3$), 3f and 3g
$^{19}$ F NMR ($^1$H) (471 MHz, CDCl$_3$), 3aa
NOESY NMR of 3y
HRMS data of intermediate, II

$[\text{M+H}]_{\text{observed}} = 191.0703$

$[\text{M+H}]_{\text{calculated}} = 191.0706$