

## Supplementary Material

Melting points are uncorrected. Mass spectra were determined at an ionizing voltage of 70eV.

Unless otherwise noted, all reactions were performed in flame dried glassware under an atmosphere of dry nitrogen. Solutions were evaporated under reduced pressure with a rotary evaporator and the residue was chromatographed on a silica gel column using an ethyl acetate-hexane mixture as the eluent unless specified otherwise.

**General Procedure for the Preparation of Diazo Malonic and Malonamic Acid Esters.** To a solution containing 42 mmol of the appropriate carboxylic acid in 250 mL of CH<sub>2</sub>Cl<sub>2</sub> at 0 °C under Ar was added 4.2 mmol of DMAP, 83 mmol of the appropriate alcohol and 46 mmol of 1,3-dicyclohexylcarbodiimide. The reaction mixture was allowed to stir at room temperature for 3 h. The resulting suspension was filtered, the filtrate concentrated under reduced pressure and the crude residue was subjected to silica gel chromatography. To a solution containing 2.1 mmol of the above malonic or malonamic acid ester and 3.1 mmol of 4-nitrobenzenesulfonyl azide in 20 mL of CH<sub>2</sub>Cl<sub>2</sub> at 0 °C under Ar was added 6.7 mmol of triethyl amine. After stirring the solution for 12 h, the solvent was removed under reduced pressure and the residue was subjected to flash silica gel chromatography.

### 2-Diazo-malonic Acid 3-Bromo-1,1-dimethyl-prop-2-ynyl-3-phenyl-but-3-enyl Ester (1).

Esterification of malonic acid mono-(3-bromo-1,1-dimethyl-prop-2-ynyl) ester with 3-phenyl-3-buten-1-ol gave malonic acid 3-bromo-1,1-dimethyl-prop-2-ynyl-3-phenyl-but-3-enyl ester (97%) as light yellow oil; IR (neat) 2117, 1755, 1736, 1254, and 1123 cm<sup>-1</sup>; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 1.68 (s, 6H), 2.87 (dt, 2H, *J* = 7.2 and 1.2 Hz), 3.30 (s, 2H), 4.26 (t, 2H, *J* = 7.2 Hz), 5.15 (dd, 1H, *J* = 1.2 and 1.2 Hz), 5.39 (d, 1H, *J* = 1.2 Hz), and 7.26-7.42 (m, 5H); <sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ 28.8, 34.4, 42.4, 45.9, 64.3, 74.2, 76.9, 114.8, 126.2, 127.9, 128.7, 140.5, 144.1, 164.8, and 166.6; HRMS Calcd. for C<sub>18</sub>H<sub>19</sub>BrO<sub>4</sub>+Li: 385.0627. Found: 385.0622.

Diazo transfer of the above compound gave diazo ester **1** (95%) as a yellow oil; IR (neat) 2203, 2138, 1758, 1736, 1695, and 1328 cm<sup>-1</sup>; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 1.72 (s, 6H), 2.90 (dt, 2H, *J* = 6.8 and 0.8 Hz), 4.34 (t, 2H, *J* = 6.8 Hz), 5.14 (dd, 1H, *J* = 0.8 and 0.8 Hz), 5.38 (d,

1H,  $J = 0.8$  Hz), and 7.27-7.42 (m, 5H);  $^{13}\text{C}$ -NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  29.2, 34.7, 46.3, 64.4, 74.8, 80.3, 115.0, 126.2, 127.9, 128.7, 140.4, 144.2, 159.2, and 160.9.

Diazo ester **1** was used in the next step without further purification.

**6-(2-Bromo-ethyl)-3,3-dimethyl-6-phenyl-5,6-dihydro-3H-isobenzofuran-1,4,7-trione (6).** To a solution of 1.6 g (0.4 mmol) of diazo ester **1** in 5 mL of dry benzene at 80 °C was added 5 mg of  $\text{Rh}_2(\text{OAc})_4$ . The reaction mixture was heated at 80 °C for 15 min. The solvent was removed under reduced pressure to give furan **2** as a clear oil which was used in the next step without further purification;  $^1\text{H}$ -NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  1.60 (s, 6H), 3.00 (t, 2H,  $J = 6.0$  Hz), 4.50 (t, 2H,  $J = 6.0$  Hz), 5.20 (s, 1H), 5.43 (s, 1H), and 7.26-7.42 (m, 5H).

Furan **2** was taken up in xylene, placed in a sealed tube, the tube was sealed and the mixture was heated at 145 °C for 15 h. The solution was concentrated under reduced pressure, and the residue was subjected to silica gel chromatography to give 0.04 g (23%) of the titled compound **6** as a pale yellow oil; IR (neat) 1780, 1796, 1446, 1390, and 1300  $\text{cm}^{-1}$ ;  $^1\text{H}$ -NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  1.31 (s, 3H), 1.74 (s, 3H), 2.49 (ddd, 1H,  $J = 14.4$ , 10.4 and 6.0 Hz), 2.73 (ddd, 1H,  $J = 16.0$ , 10.4 and 6.0 Hz), 3.08-3.19 (m, 2H), 3.27 (d, 1H,  $J = 16.8$  Hz), 3.72 (d, 1H,  $J = 16.8$  Hz), 7.12-7.15 (m, 2H) and 7.32-7.40 (m, 3H);  $^{13}\text{C}$ -NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  23.9, 25.7, 26.6, 41.0, 47.8, 60.1, 84.2, 126.0, 129.3, 129.5, 130.3, 136.0, 164.5, 168.5, 188.8, and 194.2; Anal. Calcd. for  $\text{C}_{18}\text{H}_{17}\text{BrO}_4$ : C, 57.31; H, 4.54. Found: C, 57.04; H, 4.26.

**Furan-2-carboxylic Acid Allyl-benzylamide (11).** A mixture of furan-2-carboxylic acid benzylamide (**7**)<sup>1</sup> (0.72 g, 3.6 mmol), powdered NaOH (0.6 g, 14 mmol),  $\text{K}_2\text{CO}_3$  (0.5 g, 3.6 mmol), and (*n*-Bu<sub>4</sub>)NHSO<sub>4</sub> (0.02 g, 0.06 mmol) in benzene (20 mL) was stirred for 1 h at rt. Allyl bromide (0.86 g, 7.1 mmol) was added, and the reaction mixture was heated at 80 °C for 48 h. The mixture was cooled, diluted with water, and extracted with EtOAc. The combined organic layers were dried ( $\text{MgSO}_4$ ) and concentrated under reduced pressure. The crude oil was subjected to flash silica gel chromatography to give 0.34 g (40%) of **11** as a yellow oil; IR (neat) 1633, 1574, 1487, 1177, and 1015  $\text{cm}^{-1}$ ;  $^1\text{H}$ -NMR (400 Hz,  $\text{CDCl}_3$ )  $\delta$  4.07 (brs, 2H), 4.74 (brs, 2H), 5.05-5.35 (m, 2H), 5.76-5.98 (m, 1H), 6.43 (s, 1H), 7.02 (brs, 1H), 7.16-7.40 (m, 5H), and

7.44 (s, 1H);  $^{13}\text{C}$ -NMR (100 Hz,  $\text{CDCl}_3$ )  $\delta$  48.5, 49.5, 106.3, 111.1, 116.2, 117.6, 127.3, 128.5, 133.2, 136.8, 143.9, 147.6, and 160.2; Anal. Calcd. for  $\text{C}_{15}\text{H}_{15}\text{NO}_2$ : C, 74.67; H, 6.27; N, 5.80. Found: C, 74.49; H, 6.08; N, 5.63.

This reaction also produced 0.42 g (48%) of cycloadduct **13**.

**3-Benzyl-10-oxa-3-aza-tricyclo[5.2.1.0<sup>1,5</sup>]dec-8-en-2-one (13).** A 0.16 g sample of **11** (0.66 mmol) in toluene (7 mL) was heated at 125 °C for 7 days. The mixture was concentrated under reduced pressure, and the residue was subjected to flash silica gel chromatography to give 0.16 g (98%) of **13** as a white solid: mp 140-141 °C; IR (film) 1690, 1446, 1282, 1158 and 1020  $\text{cm}^{-1}$ ;  $^1\text{H}$ -NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  1.47 (dd,  $J$  = 11.7 and 7.5 Hz, 1H), 1.75-1.90 (m, 1H), 2.21 (ddd,  $J$  = 16.1, 8.1 and 3.0 Hz, 1H), 3.11 (dd,  $J$  = 9.5 and 8.5 Hz, 1H), 3.40 (dd,  $J$  = 9.5 and 8.5 Hz, 1H), 4.48 (s, 2H), 5.10-5.20 (m, 1H), 6.37-6.45 (m, 1H), 6.54-6.62 (m, 1H), and 7.16-7.35 (m, 5H);  $^{13}\text{C}$ -NMR (75 MHz,  $\text{CDCl}_3$ )  $\delta$  31.0, 38.7, 46.7, 51.4, 81.4, 91.8, 127.4, 127.8, 128.6, 133.0, 135.8, 137.1, and 168.1; Anal. Calcd. for  $\text{C}_{15}\text{H}_{15}\text{NO}_2$ : C, 74.67; H, 6.27; N, 5.81. Found: C, 74.51; H, 6.11; N, 5.74.

**5-Bromo-furan-2-carboxylic Acid Benzylamide (8).** To a solution of 5-bromo-2-furoic acid (10 g, 52 mmol) in  $\text{CH}_2\text{Cl}_2$  (65 mL) at 0 °C was added  $(\text{COCl})_2$  (6.8 mL, 79 mmol) and DMF (50  $\mu\text{L}$ ). The flask was fitted with a drying tube containing  $\text{CaSO}_4$ , and the resulting solution was warmed to rt for 1.5 h. Concentration under reduced pressure afforded the crude acid chloride as a yellow solid that was used directly in the next step without further purification. A solution of this acid chloride in THF (20 mL) was added slowly to solution of benzylamine (6.2 mL, 57 mmol) and  $\text{Et}_3\text{N}$  (15 mL, 100 mmol) in THF (20 mL) at 0 °C. The solution was warmed to rt over 1 h, and then  $\text{H}_2\text{O}$  was added. The layers were separated and the aqueous layer was extracted with ether. The combined organic layers were dried ( $\text{MgSO}_4$ ), filtered, and concentrated under reduced pressure. The yellow oil was subjected to flash silica gel chromatography to give furan amide **8** (15 g, 100%) as a white solid. All of its spectroscopic properties were identical to those reported previously.<sup>2</sup>

**5-Bromo-furan-2-carboxylic Acid Allyl-benzylamide (12).** A mixture of furan **8** (1.0 g, 3.6 mmol), powdered NaOH (0.6 g, 14 mmol), K<sub>2</sub>CO<sub>3</sub> (0.5 g, 3.6 mmol), and (*n*-Bu<sub>4</sub>)NHSO<sub>4</sub> (0.01 g, 0.01 mmol) in benzene (20 mL) was stirred for 1 h at rt. Allyl bromide (0.6 mL, 7.2 mmol) was added, and the reaction mixture was stirred at rt for 22 h. The mixture was diluted with water and the layers were separated. The aqueous layer was extracted with EtOAc, and the combined organic layers were dried (MgSO<sub>4</sub>) and concentrated under reduced pressure. The crude oil was subjected to flash silica gel chromatography to give 1.1 g (99%) of **12** as a colorless oil; IR (neat) 1711, 1624, 1572, 1478, 1414, 1261, and 1013 cm<sup>-1</sup>; <sup>1</sup>H-NMR (400 Hz, CDCl<sub>3</sub>) δ 4.08 (brs, 2H), 4.59-4.88 (m, 2H), 5.08-5.35 (m, 2H), 5.79-5.95 (m, 1H), 6.39 (brs, 1H), 6.83-7.10 (m, 1H), and 7.16-7.45 (m, 5H); <sup>13</sup>C-NMR (100 Hz, CDCl<sub>3</sub>), δ 48.8, 49.7, 113.2, 117.8, 118.7, 124.5, 127.5, 128.6, 132.9 (br), 134.2, 136.7, 149.2, and 159.1; HRMS Calcd. for C<sub>15</sub>H<sub>14</sub>BrNO<sub>2</sub>: 319.0208. Found: 319.0208.

**3-Benzyl-7-bromo-10-oxa-3-aza-tricyclo[5.2.1.0<sup>1,5</sup>]dec-8-en-2-one (14).** A solution of furan **12** (0.2 g, 0.66 mmol) in toluene (7 mL) was heated at 110 °C for 1.5 h. The mixture was concentrated under reduced pressure and the crude oil was subjected to flash silica gel chromatography to give **14** (0.21 g, 99%) as a white solid, mp 120-121; IR (film) 1702, 1485, 1435, and 1283 cm<sup>-1</sup>; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 2.13-2.25 (m, 2H), 2.33-2.42 (m, 1H), 3.26 (dd, *J* = 9.9, 8.4 Hz, 1H), 3.47 (dd, *J* = 9.9, 8.4 Hz, 1H), 4.46 (d, *J* = 15 Hz, 1H), 4.57 (d, *J* = 15 Hz, 1H), 6.50 (d, *J* = 5.4 Hz, 1H), 6.66 (d, *J* = 5.4 Hz, 1H), and 7.24-7.38 (m, 5H); <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>), δ 42.1, 42.9, 47.3, 51.5, 90.8, 90.9, 128.1, 128.3, 129.1, 134.5, 135.7, 141.5, and 166.1; Anal. Calcd. for C<sub>15</sub>H<sub>14</sub>BrNO<sub>2</sub>: C, 56.27; H, 4.41; N, 4.37. Found: C, 56.19; H, 4.20; N, 4.16.

**5-Chloro-furan-2-carboxylic Acid Benzylamide (9).** Following the general procedure outlined above, 5-chloro-furan-2-carboxylic acid<sup>3</sup> (0.12 g, 0.85 mmol), DMF (5 μL), oxalyl chloride (0.11 mL, 1.28 mmol), benzylamine (0.12 mL, 0.94 mmol), and Et<sub>3</sub>N (0.24 mL, 1.7 mmol) afforded 0.17 g (84%) of **9** as a white solid; mp 58-59 °C; IR (film) 1655, 1599, 1527, 1480, 1301, 1144, and 1013 cm<sup>-1</sup>; <sup>1</sup>H-NMR (600 Hz, CDCl<sub>3</sub>) δ 4.56 (d, *J* = 6.0 Hz, 2H), 6.26 (d, *J* = 4.2 Hz, 1H),

6.85 (brs, 1H), 7.08 (d, 1 H,  $J = 4.2$  Hz), and 7.24-7.37 (m, 5H);  $^{13}\text{C}$ -NMR (150 Hz,  $\text{CDCl}_3$ )  $\delta$  43.0, 108.9, 116.3, 127.5, 127.7, 128.6, 137.7, 138.2, 146.9, and 157.1; Anal. Calcd. for  $\text{C}_{12}\text{H}_{10}\text{ClNO}_2$ : C, 61.16; H, 4.28; N, 5.94. Found: C, 61.26; H, 4.18; N, 5.89.

**3-Benzyl-7-chloro-10-oxa-3-aza-tricyclo[5.2.1.0<sup>1,5</sup>]dec-8-en-2-one (15).** Following the general procedure outlined above, furan **9** (0.16 g, 0.69 mmol), powdered NaOH (0.11 g, 2.8 mmol),  $\text{K}_2\text{CO}_3$  (0.096 g, 0.69 mmol), (*n*-Bu<sub>4</sub>)NHSO<sub>4</sub> (0.005 g, 0.015 mmol), and allyl bromide (0.12 mL, 1.4 mmol) gave 0.12 g (62%) of **15** as a white solid; mp 117-118 °C; IR (film) 1704, 1484, 1436, 1287, 1244, 1012, 991, 728, and 700  $\text{cm}^{-1}$ ;  $^1\text{H}$ -NMR (400 Hz,  $\text{CDCl}_3$ )  $\delta$  2.01-2.17 (m, 2H), 2.33-2.44 (m, 1H), 3.25 (dd,  $J = 7.5$  and 6.6 Hz, 1H), 3.46 (dd,  $J = 7.5$  and 6.6 Hz, 1H), 4.50 (dd,  $J = 18$  and 11 Hz, 2H), 6.42 (d,  $J = 4.2$  Hz, 1H), 6.73 (d,  $J = 4.2$  Hz, 1H), and 7.18-7.42 (m, 5H);  $^{13}\text{C}$ -NMR (100 Hz,  $\text{CDCl}_3$ ),  $\delta$  40.9, 41.8, 47.0, 51.2, 89.9, 100.9, 127.7, 128.0, 128.8, 134.5, 135.4, 139.7, and 166.1; Anal. Calcd. for  $\text{C}_{15}\text{H}_{14}\text{ClNO}_2$ : C, 65.34; H, 5.12; N, 5.08. Found C, 65.46; H, 5.37; N, 4.91.

**5-Iodo-furan-2-carboxylic Acid Benzylamide (10).** Following the general procedure outlined above, 5-iodo-furan-2-carboxylic acid (0.75 g, 3.2 mmol), DMF (10  $\mu\text{L}$ ), oxalyl chloride (0.4 mL, 4.7 mmol), benzylamine (0.4 mL, 3.4 mmol) and Et<sub>3</sub>N (0.9 mL, 6.3 mmol) afforded 0.98 g (95%) of **10** as a white solid; mp 91-93 °C; IR (film) 1653, 1593, 1522, 1456, 1297, and 1013  $\text{cm}^{-1}$ ;  $^1\text{H}$ -NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  4.60 (d,  $J = 6.0$  Hz, 2H), 6.65 (d,  $J = 3.6$  Hz, 1H), 6.70 (brs, 1H), 7.02 (d,  $J = 3.6$  Hz, 1H), and 7.27-7.40 (m, 5H);  $^{13}\text{C}$ -NMR (75 MHz,  $\text{CDCl}_3$ )  $\delta$  43.0, 91.2, 116.8, 122.8, 127.7, 127.9, 128.7, 137.7, 152.9, and 156.9; Anal. Calcd. for  $\text{C}_{12}\text{H}_{10}\text{INO}_2$ : C, 44.06; H, 3.08; N, 4.28. Found: C, 44.39; H, 3.10; N, 4.23.

**3-Benzyl-7-iodo-10-oxa-3-aza-tricyclo[5.2.1.0<sup>1,5</sup>]dec-8-en-2-one (16).** Following the general procedure outlined above, furan **10** (0.3 g, 0.9 mmol), powdered NaOH (0.15 g, 3.7 mmol),  $\text{K}_2\text{CO}_3$  (0.13 g, 0.9 mmol), (*n*-Bu<sub>4</sub>)NHSO<sub>4</sub> (0.01 g, 0.03 mmol), and allyl bromide (0.16 mL, 1.8 mmol) afforded the title compound **16** (0.32 g, 94%) as a white solid; mp 134-135 °C; IR (film) 1703, 1483, 1283, 1046, 758 and 700  $\text{cm}^{-1}$ ;  $^1\text{H}$ -NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  2.12-2.40 (m, 3H), 3.23 (dd,  $J = 9.9$ , 8.1 Hz, 1H), 3.45 (dd,  $J = 9.9$ , 8.1 Hz, 1H), 4.41 (d,  $J = 15$  Hz, 1H), 4.59 (d,  $J$

= 15 Hz, 1H), 6.48 (d,  $J$  = 5.5 Hz, 1H), 6.56 (d,  $J$  = 5.5 Hz, 1H), and 7.20-7.40 (m, 5H);  $^{13}\text{C}$ -NMR (75 MHz,  $\text{CDCl}_3$ )  $\delta$  41.6, 46.1, 47.0, 51.1, 64.9, 91.2, 127.8, 128.1, 128.8, 133.6, 135.5, 144.2, and 165.7; Anal. Calcd. for  $\text{C}_{15}\text{H}_{14}\text{INO}_2$ : C, 49.07; H, 3.84; N, 3.81. Found: 49.06; H, 3.74; N, 3.90.

**Furan-2-carboxylic Acid Benzyl-(2-methyl-allyl)amide (17).** To a solution of 4.0 g (20 mmol) of furan-2-carboxylic acid benzylamide in 80 mL of benzene was added 3.2 g (80 mmol) of powdered sodium hydroxide, 2.8 g (20 mmol) of potassium carbonate, and 0.08 g (0.24 mmol) of tetrabutyl-ammoniumhydrogen sulfate and the mixture stirred for 1 h at rt. A 5.4 g (40 mmol) sample of 3-bromo-2-methylpropene was added, and the reaction mixture was heated at 80 °C for 24 h. The mixture was then diluted with water, extracted with EtOAc and the combined organic layers dried over  $\text{MgSO}_4$ , filtered and the solvent removed under reduced pressure. The crude oil was subjected to silica gel chromatography to give 2.9 g (57%) of **17** as a pale yellow oil which was immediately used in the next step;  $^1\text{H}$ -NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  1.74 (s, 3H), 4.05 (s, 2H), 4.72-4.98 (m, 4H), 6.46 (dd, 1H,  $J$  = 3.3 and 1.8 Hz), 7.02 (d, 1H,  $J$  = 3.3 Hz), 7.23-7.34 (m, 5H), and 7.48 (d, 1H,  $J$  = 1.8 Hz).

**3-Benzyl-5-methyl-10-oxa-3-aza-tricyclo[5.2.1.0<sup>1,5</sup>]dec-8-en-2-one (19).** A sample of furan **17** (0.1 g, 0.4 mmol) in 5 mL of benzene was heated at 80 °C for 6 days. The solution was concentrated under reduced pressure to give a yellow oil whose NMR revealed the presence of recovered starting material and compound **19**;  $^1\text{H}$ -NMR (400 Hz,  $\text{CDCl}_3$ )  $\delta$  0.96 (s, 3H), 1.62 (d,  $J$  = 5.2 Hz, 1H), 2.21 (dd,  $J$  = 5.2, 1.8 Hz, 1H), 3.01 (d,  $J$  = 5.6 Hz, 1H), 3.40 (d,  $J$  = 5.6 Hz, 1H), 4.43 (d,  $J$  = 16.0 Hz, 1H), 4.61 (d,  $J$  = 16.0 Hz, 1H), 5.13 (m, 1H), 6.51 (d,  $J$  = 3.2 Hz, 1H), 6.62 (d,  $J$  = 3.2 Hz, 1H), and 7.24-7.39 (m, 5H).

**5-Bromo-furan-2-carboxylic Acid Benzyl-(2-methyl-allyl)-amide (18).** A mixture of 5-bromo-furan-2-carboxylic acid benzylamide (**8**) (1.0 g, 3.6 mmol), powdered NaOH (0.57 g, 14 mmol),  $\text{K}_2\text{CO}_3$  (0.5 g, 3.6 mmol), and (*n*-Bu<sub>4</sub>)NHSO<sub>4</sub> (0.02 g, 0.06 mmol) in benzene (20 mL) was stirred for 1 h at rt. 3-Bromo-2-methylpropene (0.86 g, 7.1 mmol) was added, and the reaction mixture was heated at 70 °C for 24 h. The mixture was diluted with water, and the

layers were separated. The aqueous layer was extracted with EtOAc, and the combined organic layers were dried (MgSO<sub>4</sub>) and concentrated under reduced pressure. The crude oil was subjected to silica gel chromatography to give **18** (0.86 g, 71%) as a yellow oil which was used in the next step without further purification; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 1.74 (s, 3H), 4.04 (s, 2H), 4.71-4.92 (m, 3H), 4.98 (s, 1H), 6.39 (s, 1H), 7.03 (s, 1H), and 7.29-7.34 (m, 5H). This reaction also produced 0.28 g (23%) of compound **20**.

**3-Benzyl-7-bromo-5-methyl-10-oxa-3-aza-tricyclo[5.2.1.0<sup>1,5</sup>]dec-8-en-2-one (20)**. A solution of **18** (0.84 g, 2.5 mmol) in benzene (18 mL) was heated at 80 °C for 36 h. The solution was concentrated under reduced pressure, and the residue was subjected to flash silica gel chromatography to give **20** (0.68 g, 82%) as a white solid; mp 79-80 °C; IR (film) 1704, 1453, 1432, 1300, and 1056 cm<sup>-1</sup>; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 0.94 (s, 3H), 1.80 (d, *J* = 12 Hz, 1H), 2.50 (d, *J* = 12 Hz, 1H), 3.07 (d, *J* = 9.6 Hz, 1H), 3.51 (d, *J* = 9.6 Hz, 1H), 4.37 (d, *J* = 14.8 Hz, 1H), 4.66 (d, *J* = 14.8 Hz, 1H), 6.55 (d, *J* = 6.0 Hz, 1H), 6.64 (d, *J* = 6.0 Hz, 1H), and 7.24-7.37 (m, 5H); <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>) δ 22.1, 47.3, 48.7, 50.3, 58.7, 91.1, 93.3, 128.1, 128.3, 129.0, 132.9, 135.8, 141.4, and 165.7; Anal. Calcd. for C<sub>16</sub>H<sub>16</sub>BrNO<sub>2</sub>: C, 57.50; H, 4.83; N, 4.19. Found: C, 57.64; H, 4.85; N, 4.15.

**5-Bromo-furan-2-carboxylic Acid (2-Benzofuran-3-yl-ethyl)-tert-butyl-amide (29a)**. To a solution of 2-benzofuran-3-yl-ethanol<sup>4</sup> (6.2 g, 38 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (200 mL) at 0 °C was added Et<sub>3</sub>N (8.0 mL, 57 mmol) and TsCl (8.4 g, 44 mmol). The resulting solution was allowed to warm slowly to rt and was then stirred for 12 h. The reaction mixture was washed with H<sub>2</sub>O, dried (Na<sub>2</sub>SO<sub>4</sub>), and concentrated under reduced pressure to afford the crude tosylate (10.1 g, 84%) that was immediately carried forward in the next step. The crude tosylate (10.1 g) was dissolved in MeCN (160 mL) and was treated sequentially with NaHCO<sub>3</sub> (8.1 g, 96 mmol) and *tert*-butylamine (8.4 mL, 80 mmol). The resulting suspension was warmed to 50-55 °C for 2h. The mixture was cooled to rt and treated with additional NaHCO<sub>3</sub> (8.1 g, 96 mmol) and *tert*-butylamine (8.4 mL, 80 mmol). After heating for an additional 8 h at 50-55 °C, the suspension was cooled to rt, filtered through a pad of Celite<sup>®</sup>, and concentrated to afford a tan oil. The crude

(2-benzofuran-3-yl-ethyl)-*tert*-butyl-amine (**27**) solidified upon standing in the freezer (5.0 g, 72%) and was used directly in the next step without further purification.

To a solution of **27** (0.44 g, 2.0 mmol) and Et<sub>3</sub>N (0.5 mL, 3.6 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (15 mL) at 0 °C was added a cooled solution of 5-bromo-2-furoyl chloride (0.4 g, 2.0 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (5 mL) dropwise. After warming to rt over 1 h, the reaction mixture was subjected to the normal aqueous workup. The crude product was purified by flash silica gel chromatography to give **29a** (0.84 g, 73%) as a tan oil; IR (neat) 1639, 1476, 1452, 1012 and 744 cm<sup>-1</sup>; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 1.61 (s, 9H), 3.07 (t, *J* = 8.1 Hz, 2H), 3.83 (t, *J* = 8.1 Hz, 2H), 6.32 (d, *J* = 3.4 Hz, 1H), 6.86 (d, *J* = 3.4 Hz, 1H), 7.17-7.34 (m, 2H), 7.40 (d, *J* = 8.1 Hz, 1H), 7.46 (d, *J* = 7.5 Hz, 1H), and 7.51 (s, 1H); <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>) δ 26.8, 28.7, 45.7, 58.2, 111.5, 113.2, 116.8, 118.0, 119.2, 122.4, 123.0, 124.3, 127.6, 141.8, 151.7, 155.2, and 160.7; HRMS Calcd. for C<sub>19</sub>H<sub>20</sub>BrNO<sub>3</sub>+Li<sup>+</sup>: 396.0787. Found: 396.0787.

**5-Nitro-furan-2-carboxylic Acid (2-Benzofuran-3-yl-ethyl)-*tert*-butylamide (29b).**

Following the acylation procedure described above, a sample of **27** (1.0 g, 4.6 mmol), Et<sub>3</sub>N (1.2 mL, 8.3 mmol), and 5-nitro-2-furoyl chloride<sup>5</sup> (0.8 g, 4.6 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (40 mL) afforded **29b** (1.1 g, 70%) as a white solid: mp 126-127 °C; IR (film) 1635, 1526, 1396, 1351, 1018, and 752 cm<sup>-1</sup>; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 1.62 (s, 9H), 3.03 (t, *J* = 7.2 Hz, 2H), 3.94 (t, *J* = 7.2 Hz, 2H), 6.67 (d, *J* = 3.9 Hz, 1H), 6.90 (d, *J* = 3.9 Hz, 1H), 7.05-7.14 (m, 1H), 7.16-7.26 (m, 1H), 7.29 (d, *J* = 7.5 Hz, 1H), 7.38 (d, *J* = 8.1 Hz, 1H), and 7.43 (s, 1H); <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>) δ 26.1, 28.6, 45.0, 58.7, 111.5, 111.6, 115.9, 116.4, 118.7, 122.2, 124.4, 127.1, 142.4, 150.2, 155.1, and 159.4; Anal. Calcd. for C<sub>19</sub>H<sub>20</sub>N<sub>2</sub>O<sub>4</sub>: C, 64.06; H, 5.66; N, 7.86. Found: C, 63.99; H, 5.66; N, 7.78.

***N*-(5-Bromo-furan-2-ylmethyl)-*N*-*tert*-butyl-2-(7-methoxy-benzofuran-3-yl)acetamide (33a).**

Following the procedure for reductive amination described by Abdel-Magid,<sup>6</sup> 5-bromo-2-furfural (2.0 g, 11.4 mmol), *tert*-butylamine (1.2 mL, 11.4 mmol), and NaBH(OAc)<sub>3</sub> (3.6 g, 17.1 mmol) were stirred in dichloroethane (41 mL) until the reaction was complete. After the described workup, (5-bromo-furan-2-ylmethyl)-*tert*-butyl-amine (**31a**) was isolated as an orange solid



(3.1 g, 100%) that was essentially pure; mp 25-26 °C; IR (neat) 1507, 1364, 1125, 1012, and 785  $\text{cm}^{-1}$ ;  $^1\text{H}$ -NMR (400 Hz,  $\text{CDCl}_3$ )  $\delta$  1.19 (s, 9H), 3.78 (s, 2H), 4.91 (s, 1H), and 6.30-6.38 (m, 2H);  $^{13}\text{C}$ -NMR (75 MHz,  $\text{CDCl}_3$ )  $\delta$  28.3, 40.3, 52.8, 111.6, 113.4, 122.0, and 156.6.

A solution of (7-methoxy-benzofuran-3-yl)-acetic acid<sup>7</sup> (2.5 g, 12.1 mmol) and  $(\text{COCl})_2$  (3.2 mL, 36.4 mmol) in  $\text{CH}_2\text{Cl}_2$  (80 mL) was treated with DMF (0.1 mL). A drying tube ( $\text{CaSO}_4$ ) was added, and the mixture was stirred for 3 h. The mixture was concentrated under reduced pressure to give the crude acid chloride **32**. To this acid chloride in  $\text{CH}_2\text{Cl}_2$  (50 mL) at 0 °C was added a cooled solution of **31a** (2.8 g, 12.1 mmol) and pyridine (1.8 mL, 24.2 mmol) in  $\text{CH}_2\text{Cl}_2$  (80 mL). After stirring for 1 h at rt, the reaction mixture was subjected to aqueous workup, and the residue was chromatographed on a silica gel column to give the title compound **33a** (1.4 g, 27%) as a white solid: mp 120-122 °C; IR (film) 1653, 1624, 1504, 1392, 1269, and 735  $\text{cm}^{-1}$ ;  $^1\text{H}$ -NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  1.45 (s, 9H), 3.79 (s, 2H), 4.00 (s, 3H), 4.52 (s, 2H), 6.20 (d,  $J$  = 6.6 Hz, 1H), 6.28 (d,  $J$  = 3.3 Hz, 1H), 6.81 (dd,  $J$  = 3.3, 2.7 Hz, 1H), 7.10-7.20 (m, 2H), and 7.56 (brs, 1H);  $^{13}\text{C}$ -NMR (75 MHz,  $\text{CDCl}_3$ )  $\delta$  28.6, 32.3, 42.6, 56.1, 58.1, 106.6, 109.6, 112.1, 112.2, 115.0, 121.1, 123.3, 129.5, 142.4, 145.5, 154.4, and 170.8; Anal. Calcd. for  $\text{C}_{20}\text{H}_{22}\text{BrNO}_4$ : C, 57.15; H, 5.28; N, 3.33. Found: C, 57.36; H, 5.21; N, 3.29.

***N*-tert-Butyl-2-(7-methoxy-benzofuran-3-yl)-*N*-(5-nitro-furan-2-ylmethyl)-acetamide (33b).**

Following the procedure for reductive amination described by Abdel-Magid,<sup>6</sup> 5-nitro-2-furfural (3.0 g, 21 mmol), *tert*-butylamine (2.2 mL, 21 mmol), and  $\text{NaBH}(\text{OAc})_3$  (6.8 g, 32 mmol), and dichloroethane (72 mL) gave *tert*-butyl-(5-nitro-furan-2-ylmethyl)amine (**31b**) as an orange solid that was essentially pure; mp 25-26 °C; IR (neat) 1593, 1529, 1390, 1356, 1229, 1017, and 739  $\text{cm}^{-1}$ ;  $^1\text{H}$ -NMR (400 Hz,  $\text{CDCl}_3$ )  $\delta$  1.16 (s, 9H), 1.62 (brs, 1H), 3.82 (s, 2H), 6.46 (d,  $J$  = 3.6 Hz, 1H), and 7.24 (d,  $J$  = 3.6 Hz, 1H);  $^{13}\text{C}$ -NMR (100 Hz,  $\text{CDCl}_3$ )  $\delta$  28.8, 40.1, 50.9, 109.9, 112.8 (br), and 159.5.

Following the acylation procedure described above, (7-methoxy-benzofuran-3-yl)-acetic acid<sup>7</sup> (0.21 g, 1.0 mmol),  $(\text{COCl})_2$  (0.26 mL, 3.0 mmol), DMF (0.05 mL), **31b** (0.2 g, 1.0 mmol) and pyridine (0.15 mL, 2.0 mmol) afforded the title compound **33b** (0.16 g, 41%) as a yellow

solid: mp 140-142 °C; IR (film) 1654, 1629, 1625, 1497, and 1359 cm<sup>-1</sup>; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 1.48 (s, 9H), 3.75 (d, *J* = 1.2 Hz, 1H), 3.99 (s, 3H), 4.65 (s, 2H), 6.41 (d, *J* = 3.6 Hz, 1H), 6.82 (dd, *J* = 6.0, 1.5 Hz, 1H), 7.05-7.20 (m, 2H), 7.22-7.31 (m, 1H), and 7.55 (s, 1H); <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>) δ 28.7, 32.5, 42.9, 56.1, 58.5, 106.8, 110.2, 111.9, 112.3, 114.5, 123.5, 129.2, 142.4, 144.5, 145.5, 156.4, and 170.7; Anal. Calcd. for C<sub>20</sub>H<sub>22</sub>N<sub>2</sub>O<sub>6</sub>: C, 62.17; H, 5.74; N, 7.25. Found: C, 62.30; H, 5.71; N, 5.65.

**2-tert-Butyl-1-furan-2-yl-8-methoxy-1,4-dihydro-2H-benzo[4,5]furo[2,3-c]pyridin-3-one**

**(34).** A 10 mL glass microwave reaction vessel containing **33b** (0.07 g, 0.18 mmol), dry 1-methyl-2-pyrrolidinone (NMP, 2 mL) and a magnetic stir bar was sealed with a septum and irradiated for 15 min using a power of 300 W with continuous cooling (60 psi of compressed air). After cooling to rt, the mixture was subjected to the normal aqueous workup, and the residue was purified by preparative plate chromatography to give **34** (0.022 g, 36%) as a yellow solid: mp 164-166 °C; IR (film) 1678, 1654, 1620, 1498, 1207, and 731 cm<sup>-1</sup>; <sup>1</sup>H-NMR (600 Hz, CDCl<sub>3</sub>) δ 1.44 (s, 9H), 3.70 (d, *J* = 20.4 Hz, 1H), 3.98 (dd, *J* = 20.4 and 1.8 Hz, 1H), 3.98 (s, 3H), 6.04 (s, 1H), 6.27-6.31 (m, 1H), 6.33 (d, *J* = 3.6 Hz, 1H), 6.80 (d, *J* = 7.8 Hz, 1H), 7.06 (d, *J* = 7.2 Hz, 1H), 7.17 (t, *J* = 7.8 Hz, 1H), and 7.30 (s, 1H); <sup>13</sup>C-NMR (150 Hz, CDCl<sub>3</sub>) δ 28.3, 31.7, 50.7, 56.0, 58.9, 106.7, 107.7, 110.3, 110.5, 111.6, 123.9, 128.2, 142.6, 144.3, 145.4, 148.4, 152.0, and 170.0; Anal. Calcd. for C<sub>20</sub>H<sub>21</sub>NO<sub>4</sub>: C, 70.78; H, 6.24; N, 4.13. Found: C, 70.63; H, 6.13; N, 4.06.

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## Ortep of Compound 34

