Supporting Information

Facile Synthesis of Highly Substituted 3-Aminofurans from Thiazolium Salts, Aldehydes, and Dimethyl Acetylenedicarboxylate

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Experimental Section

General

All the solid products were recrystallized from ethyl acetate and hexanes, and the melting points are uncorrected. Thiazolium salts **1d-h** were prepared according to literatures.¹⁻³ Cinnamaldehydes were purchased and not purified prior to use. All reactions were carried out under nitrogen atmosphere with dry, freshly distilled solvents under anhydrous conditions. NMR spectra were measured at 400 or 500 MHz spectrometers in CDCl₃, DMSO-d₆ or D₂O with TMS as the internal standard. High-resolution mass spectral (HRMS) analyses were measured using ESI techniques.

Experimental procedure and analytic data:

Thiazolium salts **1d-h** were prepared according to literatures¹⁻³.

3,4,5-trimethyl thiazolium iodide (**1d**):

¹H NMR (500 MHz, CDCl₃) δ 10.90 (s, 1H), 4.39 (s, 3H), 2.56 (s, 3H), 2.53 (s, 3H) ppm

3,4-dimethyl thiazolium iodide (**1e**):

¹H NMR (500 MHz, CDCl₃) δ 11.04 (d, 1H, *J* = 2.5 Hz), 7.75 (s, 1H), 4.39 (s, 3H), 2.64 (d, 3H, *J* = 1.0 Hz) ppm

3-ethyl-4-methyl thiazolium bromide (**1f**)

¹H NMR (500 MHz, CDCl₃) δ 11.25 (d, 1H, *J* = 2.5 Hz), 8.06 (d, 1H, *J* = 1.05 Hz), 4.76 (q, 2H, *J* = 7.3 Hz), 2.68 (s, 3H), 1.68 (t, 3H, *J* = 7.3 Hz) ppm.

3-butyl-4-methyl thiazolium bromide (**1g**)

¹H NMR (400 MHz, CDCl₃) δ 11.19 (d, 1H, *J* = 2.4 Hz), 8.35 (s, 1H), 4.73 (t, 2H, *J* = 7.8 Hz), 2.72 (s, 3H), 1.97-1.94 (m, 2H), 1.51-1.45 (m, 2H), 0.99 (t, 3H, *J* = 7.2 Hz) ppm.

3-benzyl-4-methyl thiazolium bromide (**1h**)

mp 141-143 °C

¹H NMR (400 MHz, D₂O) δ 11.27 (d, 1H, *J* = 2.0 Hz), 8.03 (s, 1H), 7.37 (s, 5H), 6.06 (s, 2H), 2.54 (s, 3H) ppm

¹³C NMR (125 MHz, D₂O) δ 158.0, 147.1, 132.0, 129.8, 128.8, 121.8, 56.7, 13.2 ppm

General procedure for the reaction of thiazolium salt (1a-c), arylaldehydes, and DMAD:

To a suspension of NaH (1.5 mmol) in anhydrous CH₂Cl₂ (3 ml) was added thiazolium salt **1a-c** (1.0 mmol) in dry CH₂Cl₂ (2 ml) at -78 °C. After 10–15 min, a solution of arylaldehyde (0.5 mmol) and DMAD (0.75 mmol) in CH₂Cl₂ (2 ml) was added over 10 min, then stirred at this temperature for 2 hours. The reaction temperature was then raised slowly to 0 °C within 1h, and kept at 0 °C for additional several hours. On completion of the reaction, the reaction mixture was carefully poured onto a solution of ice cooled NaHCO₃ (sat. solution, 50 ml), then extracted with CH₂Cl₂ (2 × 50 ml). The combined organic phase was washed with brine (2 × 50ml) and dried over anhydrous Na₂SO₄. The solvent was removed under reduced pressure and the resulting oil was purified by column chromatography using appropriate hexane-ethyl acetate solvent mixture to afford the products **3a-p**.

Dimethyl 3-(ethylamino)-2-(4-nitrophenyl) furan-4,5-dicarboxylate (3a): Pale brown crystalline solid; **mp**

134-135 °C; ¹H NMR (500 MHz, CDCl₃) δ 8.28 (d, 2H, *J* = 9.0 Hz), 7.95 (d, 2H, *J* = 9.0 Hz), 3.96 (s, 6H), 2.97 (q, 2H, *J* = 7.1 Hz), 1.15 (t, 3H, *J* = 7.1 Hz) ppm; ¹³C NMR (100 MHz, CDCl₃) δ 163.5, 158.2, 146.4, 142.7, 139.8, 136.6, 135.7, 125.6, 124.0, 119.0, 52.7, 52.5, 43.3, 15.7 ppm; **IR** (KBr) ν 3328, 2955, 1724, 1709, 1595, 1508, 1445, 1335, 1211 cm⁻¹; **HRMS** (ESI) calcd for C₁₆H₁₇N₂O₇ ([M+Na]⁺) 371.0850; found, 371.0855.

Dimethyl 3-(methylamino)-2-(4-nitrophenyl) furan-4,5-dicarboxylate (3b): Pale brown crystalline solid; **mp**

132-133 °C; ¹H NMR (400 MHz, CDCl₃) δ 8.29 (d, 2H, *J* = 7.2 Hz), 7.89 (d, 2H, *J* = 7.6 Hz), 4.25 (bs, 1H), 3.95 (s, 3H), 3.95 (s, 3H), 2.73 (s, 3H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ 163.4, 158.1, 146.2, 142.7, 138.8, 137.9, 135.5, 125.8, 123.9, 117.7, 52.6, 52.5, 35.0 ppm; **IR** (KBr) ν 3448, 1701, 1655, 1597, 1517, 1345, 1219, 1111, 858, 756 cm⁻¹; **HRMS** (ESI) calcd for C₁₅H₁₄N₂O₇ ([M+Na]⁺) 357.0693; found, 357.0689.

Dimethyl 3-(benzylamino)-2-(4-nitrophenyl) furan-4,5-dicarboxylate (3c): Pale brown crystalline solid; **mp**

141-143 °C; ¹H NMR (400 MHz, CDCl₃) δ 8.28-8.01 (m, 4H), 7.27-7.14 (m, 5H), 4.70 (bs, 1H), 4.07 (s, 2H), 3.93 (s, 3H), 3.82 (s, 3H) ppm; ¹³C NMR (100 MHz, CDCl₃) δ 163.1, 158.0, 146.4, 142.4, 140.4, 138.4, 135.7, 135.4, 128.6, 127.6, 125.6, 124.0, 119.4, 52.6, 52.4; **IR** (KBr) ν 3359, 2953, 1722, 1704, 1597, 1518, 1341, 1205, 861, 704 cm⁻¹; **HRMS** (ESI) calcd for C₂₁H₁₈N₂O₇ ([M+Na]⁺) 433.1006; found, 433.1014.

Dimethyl 3-(ethylamino)-2-(4-fluorophenyl) furan-4,5-dicarboxylate (3d): Pale yellow viscous oil; $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 7.82 (q, 2H, $J = 5.6$ Hz), 7.12 (t, 2H, $J = 8.4$ Hz), 3.95 (s, 3H), 3.93 (s, 3H), 3.70 (bs, 1H), 2.92 (q, 2H, $J = 6.8$ Hz), 1.10 (t, 3H, $J = 6.8$ Hz) ppm; $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 163.9 (d, $J_{\text{C-F}} = 24.6$ Hz), 161.2, 158.4, 142.2, 140.7, 133.0, 127.8 (d, $J_{\text{C-F}} = 7.1$ Hz), 126.2 (d, $J_{\text{C-F}} = 4.1$ Hz), 119.7, 115.8 (d, $J_{\text{C-F}} = 22.2$ Hz), 52.4, 52.3, 42.8, 15.6 ppm; **IR** (film) ν 3354, 2954, 2865, 1731, 1604, 1503, 1438, 1331, 1223, 1206 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{16}\text{H}_{16}\text{NO}_5\text{F}$ ($[\text{M}+\text{Na}]^+$) 344.0905; found, 344.0911.

Dimethyl 2-(4-fluorophenyl)-3-(methylamino) furan-4,5-dicarboxylate (3e): Pale yellow crystalline solid; **mp** 76 $^\circ\text{C}$; $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 7.76-7.74 (m, 2H), 7.11 (t, 2H, $J = 8.5$ Hz), 3.93 (s, 3H), 3.91 (s, 3H), 2.66 (s, 3H) ppm; $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 164.0 (d, $J_{\text{C-F}} = 66.6$ Hz), 161.5, 158.5, 141.4, 140.9, 134.6, 128.2 (d, $J_{\text{C-F}} = 8.0$ Hz), 126.3 (d, $J_{\text{C-F}} = 3.0$ Hz), 118.8, 115.8 (d, $J_{\text{C-F}} = 21.6$ Hz), 52.5, 52.5, 34.9 ppm; **IR** (KBr) ν 3371, 2954, 1725, 1704, 1590, 1498, 1443, 1334, 1233, 1204 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{15}\text{H}_{14}\text{FNO}_5$ ($[\text{M}+\text{H}]^+$) 308.0929; found, 308.0924.

Dimethyl 3-(benzylamino)-2-(4-fluorophenyl) furan-4,5-dicarboxylate (3f): Pale yellow crystalline solid; **mp** 90-90.5 $^\circ\text{C}$; $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 7.89-7.86 (m, 2H), 7.28-7.25 (m, 3H), 7.15-7.14 (m, 4H), 4.50 (bs, 1H), 4.03 (s, 2H), 3.91 (s, 3H), 3.82 (s, 3H) ppm; $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 163.6 (d, $J_{\text{C-F}} = 13.3$ Hz), 161.7, 158.5, 142.9, 140.8, 139.1, 132.5, 128.8 (d, $J_{\text{C-F}} = 9.0$ Hz), 128.0, 127.6, 126.2 (d, $J_{\text{C-F}} = 3.6$ Hz), 120.2, 116.1, 115.9, 52.6, 52.5, 52.3 ppm; **IR** (KBr) ν 3369, 2954, 1734, 1729, 1606, 1500, 1437, 1327, 1221, 1202 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{21}\text{H}_{18}\text{FNO}_5$ ($[\text{M}+\text{Na}]^+$) 406.1061; found, 406.1060.

Dimethyl 3-(ethylamino)-2-phenyl furan-4,5-dicarboxylate (3g): Pale yellow viscous oil; ^1H NMR (500 MHz, CDCl_3) δ 7.83-7.81 (m, 2H), 7.44-7.41 (m, 2H), 7.32-7.31 (m, 1H), 3.95 (s, 3H), 3.93 (s, 3H), 2.95 (q, 2H, $J = 7.10$ Hz), 1.11 (t, 3H, $J = 7.10$ Hz) ppm; ^{13}C NMR (125 MHz, CDCl_3) δ 163.9, 158.4, 142.7, 140.7, 133.1, 129.8, 128.5, 128.0, 125.8, 119.5, 52.3, 52.3, 42.7, 15.5 ppm; IR (film) ν 3355, 2953, 1731, 1706, 1541, 1444, 1330, 1228, 767, 698 cm^{-1} ; HRMS (ESI) calcd for $\text{C}_{16}\text{H}_{17}\text{NO}_5$ ($[\text{M}+\text{Na}]^+$) 326.0999; found, 326.0998.

Dimethyl 3-(methylamino)-2-phenyl furan-4,5-dicarboxylate (3h): Pale yellow crystalline solid; mp 67-68 $^\circ\text{C}$; ^1H NMR (500 MHz, CDCl_3) δ 7.77 (d, 2H, $J = 7.51\text{ Hz}$), 7.44-7.31 (m, 3H), 3.94 (s, 3H), 3.92 (s, 3H), 2.69 (s, 3H) ppm; ^{13}C NMR (125 MHz, CDCl_3) δ 164.2, 158.6, 142.0, 140.9, 134.9, 130.0, 128.7, 128.2, 126.3, 118.7, 52.6, 52.5, 34.9 ppm; IR (KBr) ν 3379, 2948, 1728, 1702, 1608, 1443, 1232, 1207 cm^{-1} ; HRMS (ESI) calcd for $\text{C}_{15}\text{H}_{15}\text{NO}_5$ ($[\text{M}+\text{Na}]^+$) 312.0842; found, 312.0842.

Dimethyl 3-(ethylamino)-2-(4-methylphenyl) furan-4,5-dicarboxylate (3i): Pale yellow viscous oil; ^1H NMR (500 MHz, CDCl_3) δ 7.71 (d, 2H, $J = 8.1\text{ Hz}$), 7.23 (d, 2H, $J = 8.0\text{ Hz}$), 4.20 (bs, 1H), 3.93 (s, 3H), 3.91 (s, 3H), 2.94 (q, 2H, $J = 7.1\text{ Hz}$), 2.37 (s, 3H), 1.09 (t, 3H, $J = 7.1\text{ Hz}$) ppm; ^{13}C NMR (125 MHz, CDCl_3) δ 164.2, 158.6, 143.3, 140.4, 138.3, 132.9, 129.4, 127.3, 125.9, 119.9, 52.5, 52.4, 42.9, 21.5, 15.8 ppm; IR (film) ν 3355, 2952, 2863, 1728, 1608, 1504, 1438, 1330, 1227, 1205 cm^{-1} ; HRMS (ESI) calcd for $\text{C}_{17}\text{H}_{19}\text{NO}_5$ ($[\text{M}+\text{Na}]^+$) 340.1155; found, 340.1158.

Dimethyl 3-(methylamino)-2-(4-methylphenyl) furan-4,5-dicarboxylate (3j): Pale yellow solid; **mp** 81-82 °C; ^1H NMR (500 MHz, CDCl_3) δ 7.66 (d, 2H, J = 8.1 Hz), 7.22 (d, 2H, J = 7.9 Hz), 3.93 (s, 3H), 3.91 (s, 3H), 2.68 (s, 3H), 2.37 (s, 3H) ppm; ^{13}C NMR (125 MHz, CDCl_3) δ 164.1, 158.5, 142.5, 140.5, 138.1, 134.3, 129.3, 127.2, 126.2, 118.9, 52.4, 52.3, 34.8, 21.5 ppm; **IR** (KBr) ν 3369, 2951, 1726, 1703, 1608, 1509, 1445, 1335, 1236, 1211 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{16}\text{H}_{17}\text{NO}_5$ ($[\text{M}+\text{H}]^+$) 304.1179; found, 304.1176.

Dimethyl 3-(ethylamino)-2-(3-nitrophenyl) furan-4,5-dicarboxylate (3k): Pale yellow solid; **mp** 109-110 °C; ^1H NMR (500 MHz, CDCl_3) δ 8.68 (s, 1H), 8.13 (d, 2H, J = 7.6 Hz), 7.61 (t, 1H, J = 8.0 Hz), 3.96 (s, 6H), 2.95 (q, 2H, J = 7.0 Hz), 1.16 (t, 3H, J = 7.1 Hz) ppm; ^{13}C NMR (125 MHz, CDCl_3) δ 163.7, 158.4, 148.8, 142.2, 140.1, 135.4, 131.5, 131.0, 129.8, 122.4, 120.4, 119.4, 52.8, 52.7, 43.4, 15.8 ppm; **IR** (KBr) ν 3345, 2960, 2869, 1730, 1701, 1608, 1528, 1439, 1352, 1232, 1209 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{16}\text{H}_{16}\text{N}_2\text{O}_7$ ($[\text{M}+\text{Na}]^+$) 371.0850; found, 371.0856.

Dimethyl 2-(2-chlorophenyl)-3-(ethylamino) furan-4,5-dicarboxylate (3l): Pale yellow viscous oil; ^1H NMR (500 MHz, CDCl_3) δ 7.52-7.31 (m, 4H), 4.25 (bs, 1H), 3.94 (s, 3H), 3.91 (s, 3H), 2.75 (q, 2H, J = 7.1 Hz), 1.02 (t, 3H, J = 7.1 Hz) ppm; ^{13}C NMR (125 MHz, CDCl_3) δ 164.3, 158.5, 142.4, 135.7, 135.2, 135.0, 132.6, 130.7, 130.0, 129.9, 126.5, 115.6, 52.6, 52.4, 40.8, 15.5 ppm; **IR** (film) ν 3384, 2952, 2870, 1735, 1620, 1541, 1438, 1331, 1209, 1140 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{16}\text{H}_{16}\text{NO}_5\text{Cl}$ ($[\text{M}+\text{Na}]^+$) 360.0609; found, 360.0601.

Dimethyl 2-(4-chlorophenyl)-3-(ethylamino) furan-4,5-dicarboxylate (3m): Pale yellow solid; **mp** 64-66 °C; ^1H NMR (500 MHz, CDCl_3) δ 7.77-7.36 (m, 4H), 3.94-3.91 (m, 6H), 2.93-2.90 (m, 2H), 1.12-1.07 (m, 3H) ppm; ^{13}C NMR (125 MHz, CDCl_3) δ 163.8, 158.4, 141.8, 141.0, 133.8, 129.7, 128.8, 128.7, 126.9, 119.6, 52.4, 42.9, 15.6 ppm; **IR** (KBr) ν 3357, 2955, 2871, 1730, 1701, 1611, 1538, 1441, 1335, 1232, 1209 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{16}\text{H}_{16}\text{NO}_5\text{Cl}$ ($[\text{M}+\text{Na}]^+$) 360.0609; found, 360.0613.

Dimethyl 2-(4-chlorophenyl)-3-(methylamino) furan-4,5-dicarboxylate (3n): Pale yellow viscous oil; $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 7.71 (d, 2H, $J = 8.0$ Hz), 7.40 (d, 2H, $J = 9.0$ Hz), 4.25 (bs, 1H), 3.94 (s, 3H), 3.92 (s, 3H), 2.67 (s, 3H) ppm; $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 164.7, 159.2, 141.9, 141.7, 136.0, 134.6, 129.6, 129.1, 128.1, 119.3, 53.3, 53.3, 35.7 ppm; **IR** (film) ν 3375, 2953, 1722, 1704, 1567, 1484, 1291, 1206, 1077, 1057, 847, 802, 776 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{15}\text{H}_{14}\text{NO}_5\text{Cl}$ ($[\text{M}+\text{H}]^+$) 324.0633; found, 324.0637.

Dimethyl 3-(ethylamino)-2-(4-methoxyphenyl) furan-4,5-dicarboxylate (3o): Pale yellow viscous oil; $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 7.77 (d, 2H, $J = 8.8$ Hz), 6.95 (d, 2H, $J = 8.8$ Hz), 3.94 (s, 3H), 3.91 (s, 3H), 3.84 (s, 3H), 2.93 (q, 2H, $J = 7.1$ Hz), 1.09 (t, 3H, $J = 7.1$ Hz) ppm; $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 164.2, 159.7, 158.6, 143.6, 140.0, 132.1, 127.5, 122.8, 120.2, 114.2, 55.5, 52.5, 52.4, 42.9, 15.7 ppm; **IR** (film) ν 3354, 2953, 2839, 1727, 1606, 1504, 1439, 1331, 1251 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{17}\text{H}_{19}\text{NO}_6$ ($[\text{M}+\text{Na}]^+$) 356.1105; found, 356.1105.

Dimethyl 2-(3,4-dimethoxyphenyl)-3-(methylamino) furan-4,5-dicarboxylate (3p): Pale yellow crystalline solid; mp 115-117 $^{\circ}\text{C}$; $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 7.37-7.36 (m, 2H), 6.92 (d, 1H, $J = 9.0$ Hz), 3.95 (s, 6H), 3.93 (s, 3H), 3.92 (s, 3H), 2.69 (s, 3H) ppm; $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 164.2, 158.7, 149.3, 149.2, 142.9, 140.3, 133.8, 122.9, 119.5, 119.1, 111.2, 109.5, 56.2, 56.2, 52.6, 52.5, 35.1 ppm; **IR** (KBr) ν 3376, 2953, 2841, 1727, 1711, 1510, 1439, 1341, 1242, 1142, 803, 765 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{17}\text{H}_{19}\text{NO}_7$ ($[\text{M}+\text{H}]^+$) 350.1234; found, 350.1237.

General procedure for the reaction of thiazolium salt (1d-h), aldehydes, and DMAD:

To a suspension of NaH (1.0 mmol) in anhydrous CH₂Cl₂ (3 ml) was added thiazolium salt **1d-h** (1.0 mmol) in dry CH₂Cl₂ (2 ml) at -78 °C. After 10–15 min, a solution of aldehyde (0.5 mmol) and DMAD (0.75 mmol) in CH₂Cl₂ (2 ml) was added over 10 min, then stirred at this temperature for 2 hours. The reaction temperature was then raised slowly to 0 °C within 1h, and kept at 0 °C for additional several hours. On completion of the reaction, the reaction mixture was carefully poured onto a solution of ice cooled NaHCO₃ (sat. solution, 50 ml), then extracted with CH₂Cl₂ (2 × 50 ml). The combined organic phase was washed with brine (2 × 50ml) and dried over anhydrous Na₂SO₄. The solvent was removed under reduced pressure and the resulting oil was purified by column chromatography using appropriate hexane-ethyl acetate solvent mixture to afford the products **3b**, **3c**, **3h**, **3n**, **3p**, **3q-u**, **6a**, **6b**, and **7**.

Dimethyl 3-(buthylamino)-2-(4-nitrophenyl) furan-4,5-dicarboxylate (3q): Pale brown crystalline solid; mp 137-138 °C; ¹H NMR (500 MHz, CDCl₃) δ 8.27 (d, 2H, *J* = 9.0 Hz), 7.92 (d, 2H, *J* = 9.0 Hz), 4.25 (bs, 1H), 3.96 (s, 6H), 2.92 (t, 2H, *J* = 7.0 Hz), 1.51-1.48 (m, 2H), 1.35-1.31 (m, 2H), 0.89 (t, 3H, *J* = 7.25 Hz) ppm; ¹³C NMR (125 MHz, CDCl₃) δ 163.6, 158.4, 146.4, 142.9, 139.7, 137.0, 135.8, 125.7, 124.2, 118.8, 52.8, 52.7, 48.5, 32.7, 20.1, 14.0 ppm; IR (KBr) ν 3359, 2953, 2860, 1736, 1705, 1523, 1442, 1345, 1289, 1204, 863, 855 cm⁻¹; HRMS (ESI) calcd for C₁₈H₂₀N₂O₇ ([M+H]⁺) 377.1343; found, 377.1347.

Dimethyl 3-(buthylamino)-2-phenyl furan-4,5-dicarboxylate (3r): Pale yellow viscous oil; ¹H NMR (500 MHz, CDCl₃) δ 7.79 (d, 2H, *J* = 8.0 Hz), 7.39 (t, 2H, *J* = 7.5 Hz), 7.27 (t, 1H, *J* = 7.0 Hz), 4.05 (bs, 1H), 3.92 (s, 3H), 3.89 (s, 3H), 2.88 (t, 2H, *J* = 7.0 Hz), 1.47-1.41 (m, 2H), 1.30-1.26 (m, 2H), 0.84 (t, 3H, *J* = 7.25 Hz) ppm; ¹³C NMR (125 MHz, CDCl₃) δ 164.1, 158.6, 142.6, 140.9, 133.7, 130.1, 128.7, 128.2, 126.0, 119.6, 52.5, 52.5, 48.0, 32.6, 20.1, 14.0 ppm; IR (film) ν 3363, 2955, 2873, 1732, 1713, 1611, 1541, 1444, 1332, 1206, 1075, 767, 698 cm⁻¹; HRMS (ESI) calcd for C₁₈H₂₁NO₅ ([M+Na]⁺) 354.1312; found, 354.1305.

Dimethyl 3-(methylamino)-2-(1-naphthyl) furan-4,5-dicarboxylate (3s): Pale yellow viscous oil; ¹H NMR (500 MHz, CDCl₃) δ 7.92-7.88 (m, 3H), 7.67 (d, 1H, *J* = 6.0 Hz), 7.55-7.50 (m, 3H), 4.25 (bs, 1H), 3.97 (s, 3H), 3.91 (s, 3H), 2.35 (s, 3H) ppm; ¹³C NMR (125 MHz, CDCl₃) δ 164.5, 158.6, 142.3, 137.6, 136.3, 133.6, 132.6, 129.9, 129.3,

128.5, 128.0, 127.0, 126.4, 126.0, 125.1, 115.7, 52.6, 52.6, 33.4 ppm; **IR** (film) ν 3399, 2952, 1732, 1703, 1614, 1538, 1439, 1327, 1211, 800, 780 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{19}\text{H}_{17}\text{NO}_5$ ($[\text{M}+\text{H}]^+$) 340.1179; found, 340.1178.

Dimethyl 3-(methylamino)-2-(thiophene-2-yl) furan-4,5-dicarboxylate (3t): Pale yellow viscous oil; ^1H NMR (500 MHz, CDCl_3) δ 7.39-7.36 (m, 2H), 7.11-7.09 (m, 1H), 3.94 (s, 3H), 3.92 (s, 3H), 3.80 (bs, 1H), 2.75 (s, 3H) ppm; ^{13}C NMR (125 MHz, CDCl_3) δ 164.1, 158.4, 140.6, 138.2, 133.9, 131.0, 127.5, 126.5, 126.3, 118.8, 52.7, 52.6, 34.5 ppm; **IR** (film) ν 3380, 2952, 1728, 1711, 1553, 1438, 1316, 1203, 1062, 802, 702 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{13}\text{H}_{13}\text{NO}_5\text{S}$ ($[\text{M}+\text{H}]^+$) 296.0587; found, 296.0584.

Dimethyl 3-(ethylamino)-2-(furan-2-yl) furan-4,5-dicarboxylate (3u): Pale yellow viscous oil; ^1H NMR (500 MHz, CDCl_3) δ 7.50 (s, 1H), 6.64 (d, 1H, $J = 3.5$ Hz), 6.51 (t, 1H, $J = 1.75$ Hz), 4.25 (bs, 1H), 3.94 (s, 3H), 3.91 (s, 3H), 3.10 (q, 2H, $J = 7.0$ Hz), 1.16 (t, 3H, $J = 7.25$ Hz) ppm; ^{13}C NMR (125 MHz, CDCl_3) δ 164.3, 158.4, 145.1, 142.6, 140.7, 133.1, 133.1, 118.3, 111.7, 108.5, 52.8, 52.6, 41.7, 15.8 ppm; **IR** (film) ν 3389, 2954, 1732, 1711, 1531, 1439, 1328, 1207, 1136, 796, 733 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{14}\text{H}_{15}\text{NO}_6$ ($[\text{M}+\text{H}]^+$) 294.0972; found, 294.0976.

Dimethyl 3-(ethylamino)-2-(4-formylphenyl) furan-4,5-dicarboxylate (6a): ⁴ Pale yellow viscous oil; ^1H NMR (500 MHz, CDCl_3) δ 10.02 (s, 1H), 7.96 (d, 2H, $J = 8.50$ Hz), 7.93 (d, 2H, $J = 8.50$ Hz), 3.96 (s, 3H), 3.95 (s, 3H), 2.97 (q, 2H, $J = 7.0$ Hz), 1.60 (bs, 1H), 1.13 (t, 3H, $J = 7.25$ Hz) ppm. **HRMS** (ESI) calcd for $\text{C}_{17}\text{H}_{17}\text{NO}_6$ ($[\text{M}+\text{H}]^+$) 331.1050; found, 331.1054.

Dimethyl 3-(ethylamino)-2-{4-[3-(ethylamino)-4,5-bis(methoxycarbonyl)-2-furyl]phenyl}-4,5-furan-dicarboxylate (6b): Pale yellow crystalline solid; **mp** 158-160 °C; $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 7.90 (s, 4H), 3.96-3.95 (m, 14H), 2.99 (q, 4H, $J = 7.0$ Hz), 1.14 (t, 6H, $J = 6.75$ Hz) ppm; $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 164.1, 158.6, 142.5, 141.1, 134.1, 129.2, 125.8, 119.8, 52.6, 52.6, 43.1, 15.8 ppm; **IR** (KBr) ν 3352, 2958, 1729, 1700, 1609, 1556, 1444, 1306, 1232, 1138, 967, 831 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{26}\text{H}_{28}\text{N}_2\text{O}_{10}$ ($[\text{M}+\text{H}]^+$) 529.1817; found, 529.1822.

Dimethyl 3-(ethylamino)-2-isopropyl furan-4,5-dicarboxylate (7): Pale yellow viscous oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 3.76 (s, 3H), 3.74 (s, 3H), 3.37 (bs, 1H), 3.03-3.00 (m, 1H), 2.90 (q, 2H, $J = 6.8$ Hz), 1.14 (d, 6H, $J = 6.8$ Hz), 1.00 (t, 3H, $J = 7.2$ Hz) ppm; $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 163.9, 158.0, 150.6, 139.3, 129.9, 118.8, 51.8, 51.6, 43.3, 26.2, 20.6, 15.2 ppm; **IR** (film) ν 3362, 2971, 2875, 1731, 1707, 1548, 1439, 1340, 1208, 1144, 831, 772 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{13}\text{H}_{19}\text{NO}_5$ ($[\text{M}+\text{H}]^+$) 270.1336; found, 270.1334.

General procedure for the reaction of α , β -unsaturated aldehydes with DMAD and thiazolium salt (1e-g)

To a suspension of NaH (1.2 mmol) in anhydrous CH_2Cl_2 (3 ml) was added thiazolium salt **1e-g** (1.0 mmol) in dry CH_2Cl_2 (2 ml) at -78 °C. After 10–15 min, a solution of aldehyde (0.5 mmol) and DMAD (0.75 mmol) in CH_2Cl_2 (2 ml) was added over 10 min, then stirred at this temperature for 2 hours. The reaction temperature was then raised slowly to 0 °C within 1h, and kept at 0 °C for additional several hours. On completion of the reaction, the reaction mixture was carefully poured onto a solution of ice cooled NaHCO_3 (sat. solution, 50 ml), then extracted with CH_2Cl_2 (2 $\times$ 50 ml). The combined organic phase was washed with brine (2 $\times$ 50ml) and dried over anhydrous Na_2SO_4 . The solvent was removed under reduced pressure and the resulting oil was purified by column chromatography using appropriate hexane-ethyl acetate solvent mixture to afford the products **8a-j**.

(E)-dimethyl 3-(methylamino)-2-styryl furan-4,5-dicarboxylate (8a): Pale yellow viscous oil; $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 7.46 (d, 2H, $J = 8.0$ Hz), 7.34 (t, 2H, $J = 7.75$ Hz), 7.23 (t, 1H, $J = 7.75$ Hz), 7.13 (d, 1H, $J = 16.0$ Hz), 6.99 (d, 1H, $J = 16.0$ Hz), 3.94 (s, 3H), 3.91 (s, 3H), 3.05 (s, 3H) ppm; $^{13}\text{C NMR}$ (125 MHz, CDCl_3) δ 164.4, 158.8, 141.9, 138.7, 137.4, 135.6, 129.0, 127.8, 126.4, 126.3, 115.4, 114.9, 52.7, 52.5, 34.2 ppm; **IR** (film) ν 3406, 2952, 1731, 1703, 1593, 1439, 1323, 1225, 927, 751 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{17}\text{H}_{17}\text{NO}_5$ ($[\text{M}+\text{H}]^+$) 316.1179; found, 316.1178.

(E)-dimethyl 3-(ethylamino)-2-styryl furan-4,5-dicarboxylate (8b): Pale yellow solid; **mp** 118-119 °C; **¹H NMR** (400 MHz, CDCl₃) δ 7.46 (d, 2H, *J* = 7.2 Hz), 7.36 (t, 2H, *J* = 7.6 Hz), 7.29-7.23 (m, 1H), 7.05 (s, 2H), 4.60 (bs, 1H), 3.95 (s, 3H), 3.93 (s, 3H), 3.31 (q, 2H, *J* = 6.80 Hz), 1.29 (t, 3H, *J* = 6.80 Hz) ppm; **¹³C NMR** (100 MHz, CDCl₃) δ 164.0, 158.3, 141.3, 138.9, 137.1, 134.3, 128.7, 127.4, 126.3, 126.1, 115.7, 114.5, 52.3, 52.1, 41.9, 15.4 ppm; **IR** (KBr) ν 3375, 2977, 2867, 1733, 1689, 1593, 1529, 1442, 1304, 1224, 1146, 1071, 940, 749 cm⁻¹; **HRMS** (ESI) calcd for C₁₈H₁₉NO₅ ([M+Na]⁺) 352.1155; found, 352.1150.

(E)-dimethyl 3-(buthylamino)-2-styryl furan-4,5-dicarboxylate (8c): Pale yellow solid; **mp** 121-122 °C; **¹H NMR** (400 MHz, CDCl₃) δ 7.43 (d, 2H, *J* = 7.6 Hz), 7.33 (t, 2H, *J* = 7.8 Hz), 7.24-7.22 (m, 1H), 7.02 (s, 2H), 4.70 (bs, 1H), 3.93 (s, 3H), 3.90 (s, 3H), 3.25 (t, 2H, *J* = 7.0 Hz), 1.63-1.60 (m, 2H), 1.46-1.41 (m, 2H), 0.96 (t, 3H, *J* = 7.2 Hz) ppm; **¹³C NMR** (100 MHz, CDCl₃) δ 164.0, 158.3, 141.3, 138.8, 137.1, 134.5, 128.7, 127.4, 126.2, 126.1, 115.6, 114.5, 52.3, 52.2, 47.0, 32.1, 20.0, 13.8 ppm; **IR** (KBr) ν 3365, 2951, 2869, 1736, 1691, 1540, 1439, 1302, 1217, 1198, 937, 746 cm⁻¹; **HRMS** (ESI) calcd for C₂₀H₂₃NO₅ ([M+H]⁺) 358.1649; found, 358.1644.

(E)-dimethyl 3-(ethylamino)-2-(4-fluorostyryl) furan-4,5-dicarboxylate (8d): Pale yellow crystalline solid; **mp** 124-126 °C; **¹H NMR** (500 MHz, CDCl₃) δ 7.40 (s, 2H), 7.02 (t, 2H, *J* = 7.25 Hz), 6.95-6.91 (m, 2H), 4.25 (bs, 1H), 3.93 (s, 3H), 3.91 (s, 3H), 3.30 (q, 2H, *J* = 6.8 Hz), 1.27 (t, 3H, *J* = 7.2 Hz) ppm; **¹³C NMR** (125 MHz, CDCl₃) δ 164.2, 163.4, 161.4, 158.5, 141.5, 139.1, 134.5, 133.6, 127.8 (d, *J*_{C-F} = 7.75 Hz), 125.3, 115.9 (d, *J*_{C-F} = 21.85 Hz), 114.5, 52.6, 52.4, 42.2, 15.7 ppm; **IR** (KBr) ν 3381, 2951, 2871, 1727, 1693, 1540, 1442, 1306, 1231, 1152, 928, 850 cm⁻¹; **HRMS** (ESI) calcd for C₁₈H₁₈FO₅ ([M+H]⁺) 348.1242; found, 348.1250.

(E)-dimethyl 3-(butylamino)-2-(4-fluorostyryl) furan-4,5-dicarboxylate (8e): Pale yellow crystalline solid; **mp** 126-127 °C; **¹H NMR** (400 MHz, CDCl₃) δ 7.40 (s, 2H), 7.03 (t, 2H, *J* = 8.0 Hz), 6.94 (d, 2H, *J* = 8.0 Hz), 4.50 (bs, 1H), 3.93 (s, 3H), 3.91 (s, 3H), 3.25 (t, 2H, *J* = 5.60 Hz), 1.61-1.60 (m, 2H), 1.46-1.43 (m, 2H), 0.96 (t, 3H, *J* = 6.6 Hz) ppm; **¹³C NMR** (100 MHz, CDCl₃) δ 164.0, 163.4, 160.9, 158.3, 141.3, 138.7, 134.5, 133.3 (d, *J*_{C-F} = 2.90 Hz), 127.6 (d, *J*_{C-F} = 7.5 Hz), 124.9, 115.5 (d, *J*_{C-F} = 22.3 Hz), 114.3, 52.3, 52.1, 47.0, 32.1, 20.0, 13.8; **IR** (KBr) ν 3380, 2955, 2873, 1735, 1692, 1596, 1509, 1439, 1306, 1228, 1053, 852, 796 cm⁻¹; **HRMS** (ESI) calcd for C₂₀H₂₂FNO₅ ([M+Na]⁺) 398.1374; found, 398.1367.

(E)-dimethyl 3-(ethylamino)-2-(4-methylstyryl) furan-4,5-dicarboxylate (8f): Pale yellow crystalline solid; **mp** 131-132 °C; **¹H NMR** (500 MHz, *d*₆-DMSO) δ 7.47 (d, 2H, *J* = 8.0 Hz), 7.27 (d, 1H, *J* = 16.0 Hz), 7.17 (d, 2H, *J* = 7.50 Hz), 6.83 (d, 1H, *J* = 16.0 Hz), 5.20 (t, 1H, *J* = 7.50 Hz), 3.84 (s, 3H), 3.83 (s, 3H), 3.06 (t, 2H, *J* = 6.50 Hz), 2.31 (s, 3H), 1.13 (t, 3H, *J* = 6.75 Hz) ppm; **¹³C NMR** (125 MHz, *d*₆-DMSO) δ 164.4, 157.9, 139.9, 139.0, 137.5, 134.6, 133.4, 129.8, 126.7, 125.7, 119.5, 113.4, 53.1, 52.7, 40.9, 21.3, 15.7 ppm; **IR** (KBr) ν 3440, 2253, 1735, 1682, 1662, 1531, 1442, 1307, 1027, 824, 762 cm⁻¹; **HRMS** (ESI) calcd for C₁₉H₂₁NO₅ ([M+H]⁺) 344.1492; found, 344.1482.

(E)-dimethyl 3-(butylamino)-2-(4-methylstyryl) furan-4,5-dicarboxylate (8g): Pale yellow crystalline solid; **mp** 127-129 °C; **¹H NMR** (400 MHz, CDCl₃) δ 7.33 (d, 2H, *J* = 8.0 Hz), 7.15 (d, 2H, *J* = 7.60 Hz), 6.99 (s, 1H), 6.98 (s, 1H), 4.60 (bs, 1H), 3.92 (s, 3H), 3.91 (s, 3H), 3.24 (t, 2H, *J* = 7.0 Hz), 2.35 (s, 3H), 1.63-1.59 (m, 2H), 1.46-1.40 (m, 2H), 0.96 (t, 3H, *J* = 7.20 Hz) ppm; **¹³C NMR** (100 MHz, CDCl₃) δ 164.1, 158.3, 141.1, 139.4, 137.5, 134.3, 134.1, 129.4, 126.5, 126.1, 115.9, 113.6, 52.3, 52.2, 47.2, 32.1, 21.2, 20.0, 13.8 ppm; **IR** (KBr) ν 3374, 2955, 2868, 1735, 1687, 1537, 1439, 1218, 1198, 1052, 847, 796 cm⁻¹; **HRMS** (ESI) calcd for C₂₁H₂₅NO₅ ([M+H]⁺)

372.1816; found, 372.1818.

(E)-dimethyl 3-(ethylamino)-2-(1-phenylprop-1-en-2-yl) furan-4,5-dicarboxylate (8h): Pale yellow viscous oil; $^1\text{H NMR}$ (400 MHz, d_6 -DMSO) δ 7.39-7.38 (m, 4H), 7.27-7.24 (m, 1H), 6.99 (s, 1H), 4.50 (bs, 1H), 3.84 (s, 3H), 3.80 (s, 3H), 2.95 (t, 2H, $J = 6.4$ Hz), 2.21 (d, 3H, $J = 1.2$ Hz), 1.04 (t, 3H, $J = 7.0$ Hz) ppm; $^{13}\text{C NMR}$ (100 MHz, d_6 -DMSO) δ 164.1, 157.9, 144.4, 137.8, 137.0, 132.3, 129.5, 128.8, 128.7, 127.5, 126.7, 121.7, 53.0, 52.6, 41.5, 15.7, 15.5 ppm; **IR** (film) ν 3442, 2976, 1724, 1666, 1529, 1441, 1333, 1213, 1028, 822, 760 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{19}\text{H}_{21}\text{NO}_5$ ($[\text{M}+\text{H}]^+$) 344.1492; found, 344.1494.

(E)-dimethyl 3-(buthylamino)-2-(1-phenylprop-1-en-2-yl) furan-4,5-dicarboxylate (8i): Pale yellow viscous oil; $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.35-7.34 (m, 4H), 7.23-7.22 (m, 1H), 6.99 (d, 1H, $J = 1.20$ Hz), 3.90 (s, 3H), 3.87 (s, 3H), 3.86 (s, 1H), 2.97 (t, 2H, $J = 7.0$ Hz), 2.28 (d, 3H, $J = 1.20$ Hz), 1.47-1.43 (m, 2H), 1.33-1.28 (m, 2H), 0.86 (t, 3H, $J = 7.20$ Hz) ppm; $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 164.1, 158.4, 144.8, 139.6, 137.0, 133.3, 129.8, 129.1, 128.3, 127.0, 126.9, 119.0, 52.3, 52.2, 47.1, 32.3, 20.0, 15.3, 13.8 ppm; **IR** (film) ν 3362, 2955, 2872, 1731, 1713, 1596, 1526, 1439, 1313, 1209, 917, 734 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{21}\text{H}_{25}\text{NO}_5$ ($[\text{M}+\text{H}]^+$) 372.1816; found, 372.1815.

(E)-dimethyl 3-(methylamino)-2-(prop-1-enyl) furan-4,5-dicarboxylate (8j): Pale yellow viscous oil; $^1\text{H NMR}$ (500 MHz, CDCl_3) δ 6.42 (d, 1H, 14.5 Hz), 6.23-6.19 (m, 1H), 3.89 (s, 3H), 3.89 (s, 3H), 3.75 (bs, 1H), 2.91 (s, 3H), 1.88 (dd, 3H, $J_1 = 1.25$ Hz, $J_2 = 6.75$ Hz) ppm; $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 164.3, 158.6, 140.7, 139.6, 133.4, 125.5, 118.1, 116.3, 52.4, 52.4, 34.5, 18.9 ppm; **IR** (film) ν 3406, 2954, 1735, 1706, 1619, 1541, 1439, 1341, 1213, 1146, 1055, 775 cm^{-1} ; **HRMS** (ESI) calcd for $\text{C}_{12}\text{H}_{15}\text{NO}_5$ ($[\text{M}+\text{H}]^+$) 254.1023; found, 254.1027.

References and Notes

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2. Moteshare, K.; Myles, D. C. *J. Am. Chem. Soc.* **1997**, *119*, 6674.
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4. Product **6a** is extremely unstable; we couldn't get a clear ^{13}C -NMR spectrum.

AVANCE DMX500 Zhejiang University
 1H NMR sample.org125 in CDCl3

3f

AVANCE DMX500 Zhejiang University
 13C NMR sample.org125 in CDCl3

3f