Sequential Michael addition /retro-Claisen condensation of aromatic $\beta$-diketones with $\alpha, \beta$-unsaturated esters: an approach to 1, 5-ketoesters

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I. Experimental Section

General Information

All reactions were carried out using 20 mL sealed tube. All chemicals obtained from commercial suppliers were utilized without further purification unless otherwise noted. NMR Spectra were recorded on a Bruker 600 MHz NMR spectrometer. The chemical shift is given in dimensionless δ values and is frequency referenced relative to TMS in 1H and 13C NMR spectroscopy. Chemical shifts are reported relative to CDCl₃ (δ = 7.26 ppm) for 1H NMR and relative to CDCl₃ (δ = 77 ppm) for 13C NMR. FT-IR spectra were tested by Bruker RFS100/S spectrophotometer (Bio-Rad, Cambridge, MA, USA) using KBr pellets in the 400–4000 cm⁻¹ range. The mass spectra were recorded on LCMS-2010A and the high resolution mass spectra (HRMS) were recorded on an Ion Spec FTICR mass spectrometer with ESI resource.

General experimental procedures for the synthesis of compounds 4 and 7

Aromatic β-diketones (0.5 mmol), acrylates (1 mmol), K₂CO₃ (0.1 mmol, 10 mol %) and dehydrated alcohol (0.5-2 mL) as noted were put into the 20 mL sealed tube. The reaction mixture was stirred at 85 °C for required time. After cooled to room temperature, the mixture was concentrated in vacuo. The desired products 4/7 were obtained in the corresponding yields after purification by flash chromatography on neutral Al₂O₃ with the eluent (EA/PE = 1/15-1/5).

General procedures for the synthesis of compounds 5

1, 3-diphenylpropane-1,3-dione (0.5 mmol), acrylates (1 mmol), K₂CO₃ (0.1 mmol, 10 mol %) and the corresponding alcohol solution (0.5-2 mL) as noted were put into the 20 mL sealed tube. The reaction mixture was stirred at 85 °C for required time. After cooled to room temperature, the mixture was concentrated via vacuum distillation. The desired products 5 were obtained in the corresponding yields after purification by flash chromatography on neutral Al₂O₃ with the eluent (EA/PE = 1/15-1/5).

II. Spectra data of the products

Ethyl 5-oxo-5-phenylpentanoate (4a). The title compound was prepared according to general procedure for the synthesis of compounds 4, the crude product was purified by column chromatography on neutral Al₂O₃ and eluted with ethyl acetate/petroleum ether (1/5) to afford a colourless oily liquid: Rf = 0.47 (EA/PE 1/5). Isolated yield: 107 mg, 98%. 1H NMR (600 MHz, CDCl₃, 25 °C, TMS) δ 7.97 (d, J = 7.6 Hz, 2H), 7.56 (t, J = 7.4 Hz, 1H), 7.46 (t, J = 7.6 Hz, 2H), 52
4.14 (q, $J \approx 7.1$ Hz, 2H), 3.06 (t, $J \approx 7.2$ Hz, 2H), 2.43 (t, $J \approx 7.2$ Hz, 2H), 2.08 (p, $J \approx 7.2$ Hz, 2H), 1.26 (t, $J \approx 7.1$ Hz, 3H); $^{13}$C NMR (151 MHz, CDCl$_3$, 25 °C, TMS) δ 199.45, 173.26, 136.96, 133.06, 128.62, 128.06, 60.37, 37.52, 33.48, 19.50, 14.25; MS (ESI): $m/z$: [M + H]$^+$ 221.1; IR (KBr) ν 3441, 3061, 2980, 2937, 2390, 1731, 1685, 1597, 1580, 1448, 1208, 1002, 691 cm$^{-1}$.

**Ethyl 2-methyl-5-oxo-5-phenylpentanoate (4b):** The title compound was prepared according to general procedure for the synthesis of compounds 4 from 1,3-diphenylpropane-1,3-dione (112 mg, 0.5 mmol) and tert-butyl methacrylate (126 μL, 1 mmol), the crude product was purified by column chromatography on neutral Al$_2$O$_3$ and eluted with ethyl acetate/petroleum ether (1/10) to afford a colourless oily liquid: $R_t = 0.62$ (EA/PE 1/10). Isolated yield: 84 mg, 72%. $^1$H NMR (600 MHz, CDCl$_3$, 25 °C, TMS): δ 7.95 (d, $J \approx 7.2$ Hz, 2H), 7.55 (t, $J \approx 7.4$ Hz, 1H), 7.46 (t, $J \approx 7.7$ Hz, 2H), 4.14 (q, $J \approx 7.1$ Hz, 2H), 3.10-2.92 (m, 2H), 2.56 (dq, $J \approx 14.0$, 7.0 Hz, 1H), 2.13-1.87 (m, 2H), 1.30-1.17 (m, 6H); $^{13}$C NMR (151 MHz, CDCl$_3$, 25 °C, TMS) δ 199.47, 176.17, 136.93, 132.98, 128.57, 128.01, 60.29, 38.93, 36.05, 27.98, 17.28, 14.21; HRMS (ESI-TOF) m/z: [M+H]$^+$ Calcd for C$_{14}$H$_{19}$O$_3$ 235.1334; Found 235.1329; IR (KBr) ν 3440, 3062, 2977, 2936, 2390, 1729, 1686, 1449, 1159, 744, 658 cm$^{-1}$.

**Ethyl 5-(4-methoxyphenyl)-5-oxopentanoate (4d):** The title compound was prepared according to general procedure for the synthesis of compounds 4 from 1,3-bis(4-methoxyphenyl) propane-1,3-dione (142 mg, 0.5 mmol) and ethyl acrylate (108 μL, 1 mmol), the crude product was purified by column chromatography on neutral Al$_2$O$_3$ and eluted with ethyl acetate/petroleum ether (1/5) to afford a white solid: $R_t = 0.31$ (EA/PE =1/5). Isolated yield: 175 mg, 70%; Melting point: 58-59 °C. $^1$H NMR (600 MHz, CDCl$_3$, 25 °C, TMS) δ 7.95 (d, $J \approx 8.6$ Hz, 2H), 6.93 (d, $J \approx 8.6$ Hz, 2H), 4.14 (q, $J \approx 7.1$ Hz, 2H), 3.86 (s, 3H), 2.99 (t, $J \approx 7.2$ Hz, 2H), 2.42 (t, $J \approx 7.2$ Hz, 2H), 2.06 (p, $J \approx 7.2$ Hz, 2H), 1.25 (t, $J \approx 7.1$ Hz, 3H); $^{13}$C NMR (151 MHz, CDCl$_3$, 25 °C, TMS) δ 197.99, 173.27, 163.47, 130.27, 130.01, 113.72, 60.28, 55.42, 37.13, 33.49, 19.67, 14.20; HRMS (ESI-TOF) m/z: [M+H]$^+$ Calcd for C$_{14}$H$_{19}$O$_4$ 251.1283; Found 251.1277; IR (KBr) ν 3440, 3062, 2977, 2936, 2390, 1729, 1686, 1449, 1159, 744, 658 cm$^{-1}$.

**Ethyl 5-oxo-5-(pyridine-2-yl)pentanoate (4e):** The title compound was prepared according to general procedure for the synthesis of compounds 4, the crude product was purified by column chromatography on neutral Al$_2$O$_3$ and eluted with ethyl acetate/petroleum ether (1/5) to afford a colourless oily liquid: $R_t = 0.28$ (EA/PE =1/5). Isolated yield: 83 mg, 75%. $^1$H NMR (600 MHz,
CDCl₃, 25 °C, TMS) δ 8.67 (d, J = 4.7 Hz, 1H), 8.04 (d, J = 7.8 Hz, 1H), 7.84 (t, J = 7.7 Hz, 1H), 7.51-7.44 (m, 1H), 4.14 (q, J = 7.1 Hz, 2H), 3.29 (t, J = 7.3 Hz, 2H), 2.44 (t, J = 7.4 Hz, 2H), 2.08 (p, J = 7.3 Hz, 2H), 1.25 (t, J = 7.1 Hz, 3H); ¹³C NMR (151 MHz, CDCl₃, 25 °C, TMS) δ 201.08, 173.20, 153.33, 148.91, 136.83, 127.06, 121.69, 60.24, 36.80, 33.61, 19.22, 14.19; MS (ESI) m/z: [M]⁺ 221.0; IR (KBr) ν 3444, 3056, 2938, 2390, 1732, 1697, 1583, 1439, 1373, 994, 682 cm⁻¹.

Ethyl 5-(4-(tert-butyl)phenyl)-5-oxopentanoate (4f): The title compound was prepared according to general procedure for the synthesis of compounds 4, the crude product was purified by column chromatography on neutral Al₂O₃ and eluted with ethyl acetate/petroleum ether (1/5) to afford a colourless oily liquid: R_f = 0.53 (EA/PE =1/5). Isolated yield: 55 mg, 40%. ¹H NMR (600 MHz, CDCl₃, 25 °C, TMS) δ 7.91 (d, J = 8.1 Hz, 2H), 7.47 (d, J = 8.1 Hz, 2H), 4.14 (q, J = 7.1 Hz, 2H), 3.03 (t, J = 7.1 Hz, 2H), 2.42 (t, J = 7.2 Hz, 2H), 2.07 (p, J = 7.1 Hz, 2H), 1.34 (s, 9H), 1.25 (t, J = 7.1 Hz, 3H); ¹³C NMR (151 MHz, CDCl₃, 25 °C, TMS) δ 199.08, 173.24, 156.76, 134.36, 128.01, 125.51, 60.29, 37.38, 35.07, 33.48, 31.07, 19.57, 14.22; HRMS (ESI-TOF) m/z: [M+H]⁺ Caled for C₁₇H₂₅O₃ 277.1804; Found 277.1799; IR (KBr) ν 3349, 3055, 2964, 2907, 1733, 1682, 1605, 1566, 1407, 1191, 1028, 988, 734, 545 cm⁻¹.

Methyl 5-oxo-5-phenylpentanoate (5a): The title compound was prepared according to general procedure for the synthesis of compounds 5, the crude product was purified by column chromatography on neutral Al₂O₃ and eluted with ethyl acetate/petroleum ether (1/5) to afford a colourless oily liquid: R_f = 0.50 (EA/PE =1/5). Isolated yield: 77 mg, 75%. ¹H NMR (600 MHz, CDCl₃, 25 °C, TMS) δ 7.96 (d, J = 7.8 Hz, 2H), 7.56 (t, J = 7.4 Hz, 1H), 7.46 (t, J = 7.7 Hz, 2H), 3.68 (s, 3H), 3.06 (t, J = 7.2 Hz, 2H), 2.45 (t, J = 7.2 Hz, 2H), 2.08 (p, J = 7.2 Hz, 2H); ¹³C NMR (151 MHz, CDCl₃, 25 °C, TMS) δ 199.37, 173.68, 136.94, 133.07, 128.62, 128.05, 51.54, 37.49, 33.19, 19.43; MS (ESI) m/z: [M + H]⁺ 207.1; IR (KBr) ν 3450, 3353, 3061, 2917, 2870, 1733, 1682, 1605, 1566, 1407, 1191, 1028, 988, 734, 545 cm⁻¹.

Butyl 5-oxo-5-phenylpentanoate (5b): The title compound was prepared according to general procedure for the synthesis of compounds 5, the crude product was purified by column chromatography on neutral Al₂O₃ and eluted with ethyl acetate/petroleum ether (1/5) to afford a colourless oily liquid: R_f = 0.47 (EA/PE =1/5). Isolated yield: 99 mg, 80%. ¹H NMR (600 MHz, CDCl₃, 25 °C, TMS) δ 7.96 (d, J = 8.3 Hz, 2H), 7.56 (t, J = 7.4 Hz, 1H), 7.46 (t, J = 7.7 Hz, 2H), 4.09 (t, J = 6.7 Hz, 2H), 3.05 (t, J = 7.2 Hz, 2H), 2.44 (t, J = 7.2 Hz, 2H), 2.08 (p, J = 7.2 Hz, 2H),
1.64-1.54 (m, 2H), 1.42-1.32 (m, 2H), 0.93 (t, J = 7.4 Hz, 3H); $^{13}$C NMR (151 MHz, CDCl$_3$, 25 °C, TMS) δ 199.41, 173.33, 136.96, 133.05, 128.62, 128.05, 64.31, 37.52, 33.47, 30.73, 19.52, 19.17, 13.69; HRMS (ESI-TOF) m/z: [M+H]$^+$ Calcd for C$_{15}$H$_{21}$O$_3$ 249.1491; Found 249.1489; IR (KBr) υ 3440, 3159, 2961, 2873, 2254, 1730, 1686, 1598, 1450, 1209, 1067, 912, 733 cm$^{-1}$.

Hexyl 5-oxo-5-phenylpentanoate ($5c$): The title compound was prepared according to general procedure for the synthesis of compounds 5, the crude product was purified by column chromatography on neutral Al$_2$O$_3$ and eluted with ethyl acetate/petroleum ether (1/5) to afford a colourless oily liquid: R$_f$ = 0.47 (EA/PE =1/5). Isolated yield: 83 mg, 75%. $^1$H NMR (600 MHz, CDCl$_3$, 25 °C, TMS) δ 7.96 (d, J = 8.0 Hz, 2H), 7.57 (dd, J = 17.8,10.4 Hz, 1H), 7.46 (t, J = 7.5 Hz, 2H), 4.07 (t, J = 6.7 Hz, 2H), 3.06 (t, J=7.2Hz, 2H), 2.44 (t, J = 7.2 Hz, 2H), 2.12-2.03 (m, 2H), 1.65-1.57 (m, 2H), 1.37-1.24 (m, 6H), 0.88 (t, J = 6.7 Hz, 3H); $^{13}$C NMR (151 MHz, CDCl$_3$, 25 °C, TMS) δ 199.38, 173.29, 136.89, 132.99, 128.55, 127.99, 64.57, 37.46, 33.41, 31.38, 28.58, 25.56, 22.47, 19.45, 13.91; MS (ESI) m/z: [M+H]$^+$ 277.2; IR (KBr) υ 3029, 2921, 2857, 1734, 1684, 1958, 1540, 1452, 1235, 1071, 1015, 812, 693 cm$^{-1}$.

Benzyl 5-oxo-5-phenylpentanoate ($5d$): The title compound was prepared according to general procedure for the synthesis of compounds 5, the crude product was purified by column chromatography on neutral Al$_2$O$_3$ and eluted with ethyl acetate/petroleum ether (1/10) to afford a colourless oily liquid: R$_f$ = 0.38 (EA/PE 1/10). Isolated yield: 69 mg, 49%. $^1$H NMR (600 MHz, CDCl$_3$, 25 °C, TMS) δ 7.92 (d, J = 7.3 Hz, 2H), 7.55 (t, J = 7.4 Hz, 1H), 7.44 (t, J = 7.7 Hz, 2H), 7.37-7.28 (m, 5H), 5.13 (s, 2H), 3.03 (t, J = 7.2 Hz, 2H), 2.49 (t, J = 7.2 Hz, 2H), 2.09 (p, J = 7.2 Hz, 2H); $^{13}$C NMR (151 MHz, CDCl$_3$, 25 °C, TMS) δ 199.32, 173.03, 136.90, 136.04, 133.03, 128.59, 128.57, 128.22, 128.03, 66.23, 37.40, 33.42, 19.45; HRMS (ESI-TOF) m/z: [M+H]$^+$ Calcd for C$_{18}$H$_{19}$O$_3$ 283.1334; Found 283.1332; IR (KBr) υ 3443, 3063, 2941, 1734, 1540, 1257, 1211, 1074, 745, 694 cm$^{-1}$.

tert-Butyl 5-oxo-5-phenylpentanoate ($5e$): The title compound was prepared according to general procedure for the synthesis of compounds 5, the crude product was purified by column chromatography on neutral Al$_2$O$_3$ and eluted with ethyl acetate/petroleum ether (1/10) to afford a colourless oily liquid: R$_f$ = 0.63 (EA/PE 1/10). Isolated yield: 112 mg, 90%. $^1$H NMR (600 MHz, CDCl$_3$, 25 °C, TMS) δ 7.96 (d, J = 8.4 Hz, 2H), 7.56 (t, J = 8.5 Hz, 1H), 7.46 (t, J = 7.7 Hz, 2H), 3.04 (t, J = 7.2 Hz, 2H), 2.34 (t, J = 7.2 Hz, 2H), 2.03 (p, J = 7.2 Hz, 2H), 1.45 (s, 9H); $^{13}$C NMR
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(151 MHz, CDCl3, 25 °C, TMS) δ 199.54, 172.57, 136.95, 132.98, 128.57, 128.02, 80.26, 37.51, 34.69, 28.12, 19.69; MS (ESI) m/z: [M + Na]+ 271.1; IR (KBr) υ 3435, 3354, 3062, 2977, 2934, 1726, 1686, 1597, 1450, 1147, 751, 691, 658, 590 cm⁻¹.

2-Methoxyethyl 5-oxo-5-phenylpentanoate (5g):⁹ The title compound was prepared according to general procedure for the synthesis of compounds 5, the crude product was purified by column chromatography on neutral Al₂O₃ and eluted with ethyl acetate/petroleum ether (1/10) to afford a colourless oily liquid: Rf = 0.42 (EA/PE =1/10). Isolated yield: 100 mg, 80%. ¹H NMR (600 MHz, CDCl₃, 25 °C, TMS) δ 7.96 (d, J = 7.3 Hz, 2H), 7.56 (t, J = 7.4 Hz, 1H), 7.46 (t, J = 7.7 Hz, 2H), 4.24 (t, 2H), 3.59 (t, 2H), 3.37 (s, 3H), 3.06 (t, J = 7.2 Hz, 2H), 2.49 (t, J = 7.2 Hz, 2H), 2.09 (p, J = 7.2 Hz, 2H); ¹³C NMR (151 MHz, CDCl₃, 25 °C, TMS) δ 199.33, 173.16, 136.87, 133.00, 128.55, 127.99, 70.42, 63.56, 58.88, 37.39, 33.23, 19.37; HRMS (ESI-TOF) m/z: [M+H]+ Calcd for C₁₄H₁₉O₄ 251.1283; Found 251.1276; IR (KBr) υ 3451, 3353, 3061, 2934, 2893, 2821, 2393, 1733, 1684, 1580, 1449, 1179, 1100, 985, 749, 692, 658, 569 cm⁻¹.

(Tetrahydrofuran-2-yl)ethyl-5-oxo-5-phenylpentanoate (5h): The title compound was prepared according to general procedure for the synthesis of compounds 5, the crude product was purified by column chromatography on neutral Al₂O₃ and eluted with ethyl acetate/petroleum ether (1/10) to afford a colourless oily liquid: Rf = 0.35 (EA/PE =1/10). Isolated yield: 125 mg, 91%. ¹H NMR (600 MHz, CDCl₃, 25 °C, TMS) δ 7.96 (d, J = 7.8 Hz, 2H), 7.55 (t, J = 7.3 Hz, 1H), 7.46 (t, J = 7.6 Hz, 2H), 4.17 (dd, J = 11.3, 3.4 Hz, 1H), 4.11 (dt, J = 6.9, 5.2 Hz, 1H), 4.03 (dd, J = 11.3, 6.8 Hz, 1H), 3.87 (dd, J = 14.5, 7.3 Hz, 1H), 3.06 (t, J = 7.2 Hz, 2H), 2.49 (t, J = 7.1 Hz, 2H), 2.08 (p, J = 7.1 Hz, 2H), 1.99 (dt, J = 12.4, 7.5 Hz, 1H), 1.95 – 1.83 (m, 2H), 1.60 (dt, J = 19.6, 7.5 Hz, 1H); ¹³C NMR (151 MHz, CDCl₃, 25 °C, TMS) δ 199.40, 173.19, 136.93, 133.04, 128.60, 128.05, 76.51, 68.42, 66.46, 37.47, 33.30, 28.02, 25.67, 19.45; HRMS (ESI-TOF) m/z: [M+H]+ Calcd for C₁₆H₂₁O₄ 277.1440; Found 277.1431; IR (KBr) υ 3749, 3442, 3061, 2950, 2874, 2391, 2347, 1734, 1684, 1449, 1209, 1076, 999, 750, 692, 659, 570 cm⁻¹.

2,2,2-Trifluoroethyl 5-oxo-5-phenylpentanoate (5i):¹⁰ The title compound was prepared according to general procedure for the synthesis of compounds 5, the crude product was purified by column chromatography on neutral Al₂O₃ and eluted with ethyl acetate/petroleum ether (1/10) to afford a colourless oily liquid: Rf = 0.49 (EA/PE =1/10). Isolated yield: 22 mg, 16%. ¹H NMR (600 MHz, CDCl₃, 25 °C, TMS) δ 7.96 (d, J = 7.2 Hz, 2H), 7.57 (t, J = 7.4 Hz, 1H), 7.47 (t, J = 7.7 Hz, 2H),
4.48 (q, J = 8.5 Hz, 2H), 3.07 (t, J = 7.1 Hz, 2H), 2.57 (t, J = 7.2 Hz, 2H), 2.12 (p, J = 7.1 Hz, 2H); \[ 1^3 \text{C} \text{ NMR (151 MHz, CDCl}_3, 25 \degree \text{C, TMS)} \delta 199.04, 171.65, 136.83, 133.19, 128.67, 128.02, 125.75, 123.92, 122.08, 120.24, 60.65, 60.40, 60.16, 59.92, 37.13, 32.78, 19.10; \text{HRMS (ESI-TOF)} \text{ m/z: [M+H]}^+ \text{ Calcd for C}_{13}\text{H}_{14}\text{F}_3\text{O}_3 275.0895; \text{ Found 275.0891; IR (KBr) } \nu 3491, 3395, 3336, 3075, 3012, 2849, 2811, 1756, 1676, 1451, 1290, 1273, 1183, 1149, 991, 736, 658, 572 \text{ cm}^{-1}. \]

**Benzyl 2-methyl-5-oxo-5-phenylpentanoate (5k):** The title compound was prepared according to general procedure for the synthesis of compounds 5, the crude product was purified by column chromatography on neutral Al$_2$O$_3$ and eluted with ethyl acetate/petroleum ether (1/10) to afford a white solid : R$_f$ = 0.45 (EA/PE =1/10). Isolated yield: 66 mg, 45%, melting point: 50-51 °C. \[ ^1\text{H} \text{ NMR (600 MHz, CDCl}_3, 25 \degree \text{C, TMS)} \delta 7.87 (d, J = 7.8 Hz, 2H), 7.54 (t, J = 7.3 Hz, 1H), 7.42 (t, J = 7.4 Hz, 2H), 7.36-7.27 (m, 5H), 5.18-5.09 (m, 2H), 3.03-2.86 (m, 2H), 2.68-2.57 (m, 1H), 2.06 (td, J = 14.3, 8.5 Hz, 1H), 1.95 (td, J = 14.3, 6.1 Hz, 1H), 1.24 (d, J = 7.0 Hz, 3H); ^{13}\text{C} \text{ NMR (151 MHz, CDCl}_3, 25 \degree \text{C, TMS)} \delta 199.40, 175.99, 136.85, 136.12, 132.98, 128.54, 128.16, 128.01, 66.16, 38.94, 35.95, 28.00, 17.29; \text{HRMS (ESI-TOF)} \text{ m/z: [M+H]}^+ \text{ Calcd for C}_{19}\text{H}_{21}\text{O}_3 297.1491; \text{ Found 297.1489; IR (KBr) } \nu 3342, 3354, 3088, 2972, 2936, 2878, 2391, 1732, 1686, 1497, 1097, 695, 659 \text{ cm}^{-1}. \]

### III. References

IV. Spectra
$\text{Supporting Information}$

**$4b$**

$^1H$ NMR (500 MHz, CDCl$_3$): $\delta$ 7.05 (d, $J = 7.4$ Hz, 2H), 7.57 (t, $J = 7.4$ Hz, 2H), 7.36 (t, $J = 7.7$ Hz, 2H), 3.19 (t, $J = 2.8$ Hz, 2H), 3.06 (d, $J = 1.6$ Hz, 2H), 1.10 (t, $J = 1.0$ Hz, 3H).

$\text{C NMR (125 MHz, CDCl}_3$): 199.47 (s), 173.17 (s), 136.59 (s), 132.98 (s), 128.57 (s), 120.41 (s), 60.29 (s), 38.73 (s), 30.06 (s), 27.98 (s), 17.25 (s), 14.23 (s).
**4f**

\[
\begin{align*}
\text{\(^{1}H\) NMR (600 MHz, CDCl}_3): & \ 7.94 (d, J = 8.1 Hz, 2H), 7.67 (d, J = 7.1 Hz, 2H), 6.14 (t, J = 7.1 Hz, 2H), 2.13 (s, J = 7.1 Hz, 2H), 2.07 (q, J = 7.1 Hz, 2H), 1.34 (s, J = 7.1 Hz, 2H). \\
\text{\(^{13}C\) NMR (151 MHz, CDCl}_3): & \ 156.26, 154.24, 135.8, 128.9, 126.5, 58.1, 37.8, 29.07, 31.07, 19.57, 14.22. 
\end{align*}
\]
$^1$H NMR (600 MHz, CDCl$_3$): $\delta$ 7.96 (d, $J = 8.0$ Hz, 2H), 7.57 (d, $J = 17.8$, 8.0 Hz, 2H), 7.46 (d, $J = 7.5$ Hz, 2H), 4.07 (t, $J = 6.7$ Hz, 2H), 3.46 (s, $J = 7.2$ Hz, 6H), 2.46 (s, $J = 7.2$ Hz, 2H), 2.12 - 2.10 (m, 2H), 1.09 - 1.07 (m, 3H), 1.37 - 1.28 (m, 6H), 0.93 (s, $J = 6.7$ Hz, 3H).
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5d

$^1$H NMR (600 MHz, CDCl₃): δ 7.93 (d, J = 7.7 Hz, 2H), 7.55 (d, J = 7.7 Hz, 2H), 7.44 (d, J = 7.7 Hz, 2H), 7.37 - 7.28 (m, 5H), 5.0 (s, 2H), 3.94 (s, J = 7.2 Hz, 2H), 2.49 (s, J = 7.2 Hz, 2H), 2.09 (s, J = 7.2 Hz, 2H).

$^{13}$C NMR (150 MHz, CDCl₃): δ 199.12 (s), 173.05 (s), 130.44 (s), 130.09 (s), 130.07 (s), 128.69 (s), 128.64 (s), 128.57 (s), 128.54 (s), 128.03 (s), 128.01 (s), 127.5 (s), 127.4 (s), 126.5 (s), 126.0 (s), 125.0 (s), 60.23 (s), 37.40 (s), 37.40 (s), 19.49 (s).
$^1$H NMR (600 MHz, CDCl$_3$): δ 7.16 (d, J = 7.7 Hz, 2H), 7.06 (d, J = 7.7 Hz, 2H), 7.00 (d, J = 7.1 Hz, 2H), 7.02 (d, J = 7.4 Hz, 2H), 2.93 (t, J = 7.2 Hz, 2H), 2.80 (q, J = 7.2 Hz, 2H).

$^13$C NMR (151 MHz, CDCl$_3$): δ 190.33 (s), 175.16 (s), 174.73 (s), 173.0 (s), 128.59 (s), 127.91 (s), 127.32 (s), 126.59 (s), 70.42 (s), 70.36 (s), 70.88 (s), 70.24 (s), 51.37 (s), 29.37 (s).
Supporting Information

[Image of a mass spectrum and an infrared spectrum with molecular structures labeled '5h']
$^1$H NMR (600 MHz, CDCl$_3$) δ 7.87 (d, $J=7.8$ Hz, 2H), 7.54 (t, $J=7.3$ Hz, 2H), 7.42 (t, $J=7.4$ Hz, 2H), 7.36 - 7.27 (m, 9H), 5.08 - 5.09 (m, 2H), 3.86 - 3.85 (m, 2H), 2.68 - 2.57 (m, 1H), 2.06 (s, $J=14.3$, 8.5 Hz, 1H), 1.95 (dt, $J=14.3$, 6.1 Hz, 1H), 1.24 (d, $J=7.0$ Hz, 3H).

$^{13}$C NMR (151 MHz, CDCl$_3$) δ 199.40 (s), 175.99 (s), 136.85 (s), 136.70 (s), 132.98 (s), 128.54 (s), 128.36 (s), 128.01 (s), 66.36 (s), 26.94 (q, $J=35.8$ Hz), 26.09 (s), 17.29 (s).