Supporting Information

Visible-Light-Induced Consecutive C-C Bond Fragmentation and Formation for Synthesis of Elusive Unsymmetric 1, 8-Dicarbonyl Compounds

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1. General experimental details

All reactions were maintained under a nitrogen atmosphere unless otherwise stated. Commercially available reagents were used without further purification. Infrared (FT-IR) spectra were recorded on a BRUKER VERTEX 70, $\nu_{\text{max}}$ in cm$^{-1}$. $^1$H-NMR spectra were recorded on a BRUKER AVANCE III HD (400 MHz) spectrometer. Chemical shifts were reported in ppm from tetramethylsilane with the solvent resonance as internal standard (CDCl$_3$: $\delta$ 7.26, DMSO-d$_6$: $\delta$ 2.50). Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quadruplet, br = broad, m = multiplet), coupling constants (Hz) and integration. $^{13}$C-NMR spectra were recorded on a BRUKER AVANCE III HD (100 MHz) spectrometer with complete proton decoupling. Chemical shifts were reported in ppm from tetramethylsilane with the solvent resonance as the internal standard (CDCl$_3$: $\delta$ 77.00, DMSO-d$_6$: $\delta$ 39.52). $^{19}$F-NMR spectra were recorded on a BRUKER AVANCE III (376 MHz) spectrometer. Mass spectra were measured with an Agilent Technologies 6120 Quadrupole LC/MS. High resolution mass spectrometry (HRMS) were measured with a GCT Premier™ and BRUKER micrOTF-Q III. Melting points were measured using INESA WRR and values were uncorrected.

2. General procedure for preparing cyanohydrins and cyclopropanols

a. Preparation of cyanohydrins

The starting materials cyanohydrins were prepared by the addition of TMSCN to the precursor ketones, according to the reported procedures (reference 1). All cyanohydrins in this paper are known compounds that can be found in reference 2.

b. Preparation of cyclopropanols

The starting materials cyclopropanols were prepared based on the reported procedure (reference 3). Cyclopropanols 1a-g and 1j-l in this paper are known compounds. Cyclopropanols 1a, 1b, 1f, 1g, 1k, and 1l can be found in reference 3a. 1d and 1e can be found in reference 3b. 1c can be found in reference 3c. 1j can be found in reference 3d.

Other cyclopropanols were prepared according to the following procedures.

\[
\begin{align*}
\text{Ar} & \xrightarrow{\text{TMSOTf (1.2 eq), Et}_3\text{N (1.5 eq), dry DCM, 0 }^\circ\text{C}} \text{OTMS} \xrightarrow{\text{Et}_2\text{Zn (1.5 eq), CH}_2\text{I}_2 (1.5 eq), dry DCM, 0 }^\circ\text{C}} \text{Ar} \xrightarrow{\text{TMSCl, MeOH, 0 }^\circ\text{C}} \text{Ar} \xrightarrow{\text{OH}} \text{Ar}
\end{align*}
\]

**Step one:** ketone (5 mmol, 1.0 equiv.) was added to a 100 mL flame-dried round-bottomed flask at 0 \(^\circ\text{C}\) under nitrogen. Anhydrous DCM (20 mL) was added to the flask, followed by adding Et$_3$N (7.5 mmol, 1.5 equiv.). Then TMSOTf (6 mmol, 1.2 equiv.) was added dropwise via syringe over 10 min. The reaction was stirred overnight, which was monitored by TLC. Upon completion, the reaction was quenched with sat. NaHCO$_3$, diluted with DCM, and the phases were separated. The aqueous layer was extracted with DCM (3 x 15 ml). The combined organic layer was washed with brine, dried over Na$_2$SO$_4$, and concentrated in vacuum. The enol ether was used in the next step without further purification.

**Step two:** the enol ether was transferred to a 100 mL flame-dried round-bottomed flask under
nitrogen. The flask was charged with anhydrous DCM (30 mL) and diiodomethane (7.5 mmol, 1.5 equiv.). The mixture was cooled to 0 °C, then neat diethyl zinc (7.5 mmol, 1M in toluene, 1.5 equiv.) was added dropwise to the reaction solution via syringe. The mixture was warmed to RT and stirred for 16 hours. The reaction was quenched with a sat. NH₄Cl at 0 °C. The layers were separated and the aqueous layer was extracted with DCM (3 x 15 mL). The combined organic layer was washed with brine, dried over Na₂SO₄, and concentrated in vacuum. The crude TMS ether also was used in the next step without further purification.

Step three: the crude TMS ether was transferred to a 100 mL flame-dried round-bottomed flask under nitrogen. The flask was charged with methanol (30 mL). A single drop of chlorotrimethylsilane was added via syringe at 0 °C, and the reaction was monitored by TLC. The reaction was completed in about 1 h, then the mixture was concentrated to dryness in vacuum and the residue was purified by flash column chromatography on silica gel.

3. General procedure for synthesis of 1, 8-dicarbonyl compounds

Cyclopropanols 1 (0.5 mmol, 2.5 equiv.), cyanohydrin 2 (0.2 mmol, 1.0 equiv.), Ir(ppy)₂(dtbpy)PF₆ (0.0006 mmol, 3 mol %), and K₂S₂O₈ (0.6 mmol, 3.0 equiv.) were loaded in a flame-dried reaction vial which was subjected to evacuation/ flushing with nitrogen three times. DMSO (1.0 mL) followed by BF₃·Et₂O (0.1 mmol, 0.5 equiv.) was added to the mixture via syringe. The mixture was stirred at RT for 5 min, then H₂O (1.0 mL) was added to the mixture via syringe. The reaction was stirred at RT under 14W blue LEDs irradiation until the cyanohydrin 2 had been consumed as determined by TLC. The mixture was extracted with ethyl acetate (3 x 15 mL). The combined organic extracts were washed with brine, dried over Na₂SO₄, filtered, concentrated, and purified by flash column chromatography on silica gel (eluent: ethyl acetate/petroleum ether) to give the product 3.

4. Characterization of new compounds

**1h**: yellow oil. ¹H NMR (400 MHz, CDCl₃) δ 7.31-7.24 (m, 1H), 7.05-6.99 (m, 2H), 6.94-6.87 (m, 1H), 2.48-2.38 (m, 1H), 1.33-1.27 (m, 2H), 1.08-1.02 (m, 2H); ¹³C NMR (100 MHz, CDCl₃) δ 162.9 (d, Jₐ= 243.4 Hz), 147.3 (d, Jₐ= 7.2 Hz), 129.6 (d, Jₐ= 8.2 Hz), 119.4 (d, Jₐ= 2.7 Hz), 112.9 (d, Jₐ= 21.1 Hz), 111.4 (d, Jₐ= 22.5 Hz), 55.9 (d, Jₐ= 2.2 Hz), 18.3; ¹⁹F NMR (376 MHz, CDCl₃) δ -113.4 (s). FT-IR: ν (cm⁻¹) 3303, 3091, 3010, 1684, 1616, 1587, 1490. HRMS [ESI] calcd for C₉H₃FONa [M+Na]⁺ 175.0530, found 175.0529.

**1i**: yellow oil. ¹H NMR (400 MHz, CDCl₃) δ 7.39 (m, 1H), 7.31-7.23 (m, 1H), 7.13-7.02 (m, 2H), 2.63 (br, 1H), 1.21-1.16 (m, 2H), 1.06-1.00 (m, 2H); ¹³C NMR (100 MHz, CDCl₃) δ 161.4 (d, Jₐ= 245.7 Hz), 129.7 (d, Jₐ= 12.6 Hz), 129.3 (d, Jₐ= 4.1 Hz), 129.0 (d, Jₐ= 8.5 Hz), 123.8 (d, Jₐ= 3.5 Hz), 115.5 (d, Jₐ= 21.6 Hz), 53.5 (d, Jₐ= 0.9 Hz), 13.8 (d, Jₐ= 1.9 Hz); ¹⁹F NMR (376 MHz, CDCl₃) δ -117.2 (s). FT-IR: ν (cm⁻¹) 3342, 3090, 3011, 1683, 1577, 1493, 1417. HRMS [ESI] calcd for C₉H₃FONa
[M+Na]+ 175.0530, found 175.0528.

**1m:** yellow oil. $^1$H NMR (400 MHz, CDCl₃) δ 7.28-7.20 (m, 2H), 7.04-6.96 (m, 2H), 1.94 (br, 1H), 1.34-1.29 (m, 3H), 1.23-1.16 (m, 2H), 0.82-0.77 (m, 1H); $^{13}$C NMR (100 MHz, CDCl₃) δ 161.4 (d, $J_{CF} = 242.7$ Hz), 141.0 (d, $J_{CF} = 2.8$ Hz), 125.9 (d, $J_{CF} = 7.9$ Hz), 115.0 (d, $J_{CF} = 21.2$ Hz), 58.9, 23.8, 22.7, 12.5; $^{19}$F NMR (376 MHz, CDCl₃) δ -117.3 (s). FT-IR: ν (cm⁻¹) 3326, 2933, 2875, 1677, 1599, 1510, 1446. HRMS [ESI] calcd for C₈H₆FONa [M+Na]+ 189.0686, found 189.0687.

![Diagram](image1)

**1n:** white solid, m.p. 68-69 °C. $^1$H NMR (400 MHz, CDCl₃) δ 7.10-7.04 (m, 2H), 7.01-6.95 (m, 2H), 3.16 (br, 1H), 1.13 (d, $J = 6.0$ Hz, 3H), 1.08-0.94 (m, 2H), 0.68-0.62 (m, 1H); $^{13}$C NMR (100 MHz, CDCl₃) δ 144.0, 131.5, 128.1, 125.2, 58.4, 24.2, 23.1, 12.4. FT-IR: ν (cm⁻¹) 3322, 2971, 2950, 1677, 1589, 1491, 1400. HRMS [ESI] calcd for C₉H₁₁ClONa [M+Na]+ 205.0931, found 205.0931.

![Diagram](image2)

**Io:** white solid, m.p. 74-75 °C. $^1$H NMR (400 MHz, CDCl₃) δ 7.44-7.36 (m, 2H), 7.13-7.06 (m, 2H), 2.62 (br, 1H), 1.32-1.26 (m, 3H), 1.24-1.13 (m, 2H), 0.86-0.78 (m, 1H); $^{13}$C NMR (100 MHz, CDCl₃) δ 144.6, 131.2, 125.6, 119.6, 58.6, 24.3, 23.3, 12.5. FT-IR: ν (cm⁻¹) 3326, 2926, 2870, 1894, 1679, 1585, 1491. HRMS [ESI] calcd for C₁₀H₁₁BrONa [M+Na]+ 248.9885, found 248.9883.

![Diagram](image3)

**Ip:** yellow oil. $^1$H NMR (400 MHz, CDCl₃) δ 7.40-7.34 (m, 2H), 7.26-7.20 (m, 2H), 2.21 (br, 1H), 1.34 (s, 9H), 1.38-1.30 (m, 3H), 1.26-1.18 (m, 2H), 0.83-0.79 (m, 1H); $^{13}$C NMR (100 MHz, CDCl₃) δ 149.0, 142.4, 125.2, 123.7, 59.0, 34.4, 31.3, 23.8, 22.8, 12.5. FT-IR: ν (cm⁻¹) 3416, 2963, 2906, 2871, 1679, 1605, 1462. HRMS [ESI] calcd for C₁₃H₁₇ONa [M+Na]+ 227.1406, found 227.1407.

![Diagram](image4)

**Iq:** yellow oil. $^1$H NMR (400 MHz, CDCl₃) δ 7.02-6.97 (m, 2H), 6.97-6.91 (m, 2H), 3.02 (br, 1H), 2.17 (s, 3H), 1.13 (d, $J = 6.0$ Hz, 3H), 1.06-0.94 (m, 2H), 0.63-0.58 (m, 1H); $^{13}$C NMR (100 MHz, CDCl₃) δ 142.4, 135.3, 128.7, 123.9, 58.7, 23.6, 22.5, 20.7, 12.4. FT-IR: ν (cm⁻¹) 3406, 2971, 2933, 2875, 1675, 1606, 1447. HRMS [ESI] calcd for C₁₄H₁₉ONa [M+Na]+ 185.0937, found 185.0939.

![Diagram](image5)

**Ir:** yellow oil. $^1$H NMR (400 MHz, CDCl₃) δ 7.05 (t, $J = 7.6$ Hz, 1H), 6.96 (s, 1H), 6.88 (m, 2H), 2.73 (br, 1H), 2.19 (s, 3H), 1.16 (m, 3H), 1.12-0.98 (m, 2H), 0.66-0.61 (m, 1H); $^{13}$C NMR (100 MHz, CDCl₃) δ 145.4, 137.6, 128.0, 126.6, 124.7, 120.9, 58.8, 23.9, 22.9, 21.4, 12.4. FT-IR: ν (cm⁻¹) 3370, 2956, 2926, 2873, 1676, 1607, 1491. HRMS [ESI] calcd for C₁₁H₁₄ONa [M+Na]+ 185.0937, found 185.0940.

![Diagram](image6)

**Is:** yellow oil. $^1$H NMR (400 MHz, CDCl₃) δ 7.16 (d, $J = 7.2$ Hz, 1H), 7.10-7.06 (m, 2H), 7.05-6.99 (m, 1H), 2.37 (s, 3H), 2.03 (br, 1H), 1.26-1.20 (m, 3H), 1.02-0.92 (m, 2H), 0.55-0.48 (m, 1H); $^{13}$C NMR (100 MHz, CDCl₃) δ 141.2, 138.7, 130.5, 128.4, 127.8, 125.5, 59.8, 19.4, 19.2, 18.3, 12.4. FT-IR: ν (cm⁻¹) 3394, 3003, 2927, 2872, 1490, 1456, 1378.
HRMS [ESI] calcd for C_{11}H_{12}ONa [M+Na]^+ 185.0937, found 185.0942.

**1t**: yellow oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.26-7.11 (m, 4H), 7.10-7.04 (m, 1H), 2.71 (br, 1H), 1.58-1.42 (m, 2H), 1.42-1.32 (m, 2H), 1.10-0.98 (m, 2H), 0.85 (t, $J = 7.6$ Hz, 3H), 0.75-0.66 (m, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 145.5, 128.1, 125.9, 124.0, 59.1, 29.9, 28.7, 22.8, 22.7, 13.9. FT-IR: $\nu$ (cm$^{-1}$) 3370, 2997, 2958, 2871, 1677, 1603, 1496. HRMS [ESI] calcd for C$_{12}$H$_{16}$ONa [M+Na]^+ 199.1093, found 199.1093.

**1u**: yellow oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.32-7.22 (m, 4H), 7.20-7.14 (m, 1H), 3.70-3.56 (m, 2H), 2.48 (br, 1H), 2.22-2.12 (m, 1H), 2.10-1.96 (m, 1H), 1.30-1.20 (m, 2H), 0.88-0.84 (m, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 144.5, 128.3, 126.5, 124.5, 59.0, 45.4, 31.1, 26.2, 21.9. FT-IR: $\nu$ (cm$^{-1}$) 3398, 3027, 2959, 2872, 1675, 1603, 1448. HRMS [ESI] calcd for C$_{12}$H$_{17}$ClONa [M+Na]^+ 219.0547, found 219.0553.

**3a**: white solid, m.p. 129-130 °C. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.98-7.93 (m, 4H), 7.61-7.53 (m, 2H), 7.50-7.43 (m, 4H), 3.30-3.15 (m, 2H), 3.05 (t, $J = 7.2$ Hz, 2H), 2.85-2.76 (m, 1H), 2.21-2.10 (m, 1H), 2.06-1.88 (m, 3H), 1.80-1.73 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 199.0, 198.2, 136.6, 136.4, 133.4, 133.1, 128.6, 128.6, 127.9, 127.9, 121.7, 37.5, 35.4, 31.8, 31.0, 26.3, 21.5. FT-IR: $\nu$ (cm$^{-1}$) 3087, 2956, 2853, 2240, 1681, 1595, 1579. HRMS [ESI] calcd for C$_{22}$H$_{23}$NO$_2$Na [M+Na]^+ 342.1456, found 342.1458.

**3b**: white solid, m.p. 139-141 °C. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.01-7.94 (m, 2H), 7.88-7.83 (m, 2H), 7.62-7.55 (m, 1H), 7.51-7.44 (m, 2H), 7.29-7.23 (m, 2H), 3.30-3.15 (m, 2H), 3.03 (t, $J = 6.8$ Hz, 2H), 2.85-2.75 (m, 1H), 2.41 (s, 3H), 2.21-2.10 (m, 1H), 2.05-1.88 (m, 3H), 1.80-1.72 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 198.7, 198.3, 143.9, 136.4, 134.2, 133.4, 129.3, 128.7, 128.1, 128.0, 121.7, 37.4, 35.5, 31.9, 31.0, 26.3, 21.6, 21.6. FT-IR: $\nu$ (cm$^{-1}$) 2958, 2923, 2854, 2241, 1680, 1603, 1573. HRMS [ESI] calcd for C$_{22}$H$_{23}$NO$_2$Na [M+Na]^+ 356.1621, found 356.1632.

**3c**: white solid, m.p. 90-91 °C. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.00-7.96 (m, 2H), 7.92-7.87 (m, 2H), 7.61-7.56 (m, 1H), 7.51-7.45 (m, 4H), 3.30-3.15 (m, 2H), 3.04 (t, $J = 7.2$ Hz, 2H), 2.85-2.76 (m, 1H), 2.22-2.11 (m, 1H), 2.06-1.88 (m, 3H), 1.81-1.72 (m, 2H), 1.34 (s, 9H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 198.8, 198.3, 156.9, 136.4, 134.1, 133.4, 128.7, 128.0, 127.9, 125.6, 121.7, 37.4, 35.5, 35.1, 31.9, 31.0, 26.3, 21.7. FT-IR: $\nu$ (cm$^{-1}$) 2953, 2907, 2868, 2237, 1675, 1604, 1579. HRMS [ESI] calcd for C$_{23}$H$_{29}$NO$_3$Na [M+Na]^+ 398.2091, found 398.2090.
3d: white solid, m.p. 120-121 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 8.05-7.93 (m, 4H), 7.63-7.55 (m, 1H), 7.52-7.43 (m, 2H), 7.18-7.08 (m, 2H), 3.30-3.15 (m, 2H), 3.03 (t, $J = 6.8$ Hz, 2H), 2.85-2.75 (m, 1H), 2.21-2.10 (m, 1H), 2.06-1.88 (m, 3H), 1.82-1.73 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 198.3, 197.4, 165.7 (d, $J_{CF} = 253.3$ Hz), 136.4, 133.4, 133.1 (d, $J_{CF} = 3.0$ Hz), 130.6 (d, $J_{CF} = 9.3$ Hz), 128.7, 128.0, 121.7, 115.7 (d, $J_{CF} = 21.8$ Hz), 37.4, 35.5, 31.9, 31.0, 26.3, 21.5; $^{19}$F NMR (376 MHz, CDCl$_3$) δ -105.1 (s). FT-IR: ν (cm$^{-1}$) 2958, 2900, 2242, 1680, 1595, 1505, 1459. HRMS [ESI] calcd for C$_{21}$H$_{20}$FNO$_3$Na [M+Na]$^+$ 360.1370, found 360.1389.

3e: white solid, m.p. 122-123 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.99-7.95 (m, 2H), 7.92-7.87 (m, 2H), 7.62-7.56 (m, 1H), 7.51-7.46 (m, 2H), 7.46-7.41 (m, 2H), 3.30-3.15 (m, 2H), 3.03 (t, $J = 6.8$ Hz, 2H), 2.86-2.75 (m, 1H), 2.22-2.11 (m, 1H), 2.06-1.88 (m, 3H), 1.80-1.73 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 198.3, 197.8, 139.6, 136.4, 135.0, 133.4, 129.4, 128.9, 128.7, 128.0, 121.6, 37.5, 35.5, 31.8, 31.0, 26.3, 21.5. FT-IR: ν (cm$^{-1}$) 3060, 2922, 2856, 2240, 1679, 1587, 1572. HRMS [ESI] calcd for C$_{22}$H$_{28}$FNO$_3$Na [M+Na]$^+$ 376.1075, found 376.1097.

3f: white solid, m.p. 124-126 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 8.00-7.94 (m, 2H), 7.84-7.79 (m, 2H), 7.64-7.56 (m, 3H), 7.52-7.44 (m, 2H), 3.28-3.16 (m, 2H), 3.02 (t, $J = 7.2$ Hz, 2H), 2.85-2.75 (m, 1H), 2.21-2.10 (m, 1H), 2.05-1.88 (m, 3H), 1.80-1.72 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 198.3, 198.0, 136.4, 135.4, 133.4, 131.9, 129.5, 128.7, 128.3, 128.0, 121.6, 37.5, 35.5, 31.8, 31.0, 26.3, 21.4. FT-IR: ν (cm$^{-1}$) 2958, 2924, 2854, 2240, 1680, 1596, 1584. HRMS [ESI] calcd for C$_{23}$H$_{30}$BrNO$_3$Na [M+Na]$^+$ 420.0570, found 420.0599.

3g: white solid, m.p. 125-126 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 8.18-8.08 (m, 2H), 8.06-7.92 (m, 4H), 7.63-7.54 (m, 1H), 7.52-7.44 (m, 2H), 3.95 (s, 3H), 3.30-3.16 (m, 2H), 3.09 (t, $J = 6.8$ Hz, 2H), 2.88-2.74 (m, 1H), 2.24-2.10 (m, 1H), 2.10-1.86 (m, 3H), 1.84-1.70 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 198.5, 198.3, 166.1, 139.8, 136.4, 133.9, 133.4, 129.9, 128.7, 128.0, 127.9, 121.6, 52.5, 37.9, 35.5, 31.8, 31.0, 26.3, 21.4. FT-IR: ν (cm$^{-1}$) 2954, 2923, 2239, 1722, 1677, 1597. HRMS [ESI] calcd for C$_{23}$H$_{28}$NO$_4$Na [M+Na]$^+$ 400.1519, found 400.1521.

3h: white solid, m.p. 81-82 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 8.00-7.95 (m, 2H), 7.76-7.72 (m, 1H), 7.66-7.62 (m, 1H), 7.62-7.56 (m, 1H), 7.52-7.42 (m, 3H), 7.30-7.24 (m, 1H), 3.31-3.16 (m, 2H), 3.04 (t, $J = 7.2$ Hz, 2H), 2.86-2.76 (m, 1H), 2.22-2.12 (m, 1H), 2.08-1.88 (m, 3H), 1.82-1.72 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 198.3, 197.4, 165.7 (d, $J_{CF} = 253.3$ Hz), 136.4, 133.4, 133.1 (d, $J_{CF} = 3.0$ Hz), 130.6 (d, $J_{CF} = 9.3$ Hz), 128.7, 128.0, 121.7, 115.7 (d, $J_{CF} = 21.8$ Hz), 37.4, 35.5, 31.9, 31.0, 26.3, 21.5. FT-IR: ν (cm$^{-1}$) 2958, 2900, 2242, 1680, 1595, 1505, 1459. HRMS [ESI] calcd for C$_{21}$H$_{20}$FNO$_3$Na [M+Na]$^+$ 360.1370, found 360.1389.
MHz, CDCl$_3$) $\delta$ 198.3, 197.7 (d, $J_{CF} = 2.0$ Hz), 162.9 (d, $J_{CF} = 246.5$ Hz), 138.8 (d, $J_{CF} = 6.0$ Hz), 136.4, 133.4, 130.3 (d, $J_{CF} = 7.6$ Hz), 128.7, 128.0, 123.7 (d, $J_{CF} = 3.0$ Hz), 121.6, 120.2 (d, $J_{CF} = 21.4$ Hz), 114.7 (d, $J_{CF} = 22.1$ Hz), 37.7, 35.5, 31.8, 31.1, 26.3, 21.4; $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$ -111.7 (s). FT-IR: $\nu$ (cm$^{-1}$) 2921, 2871, 2852, 2238, 1684, 1674, 1590. HRMS [ESI] calcd for $C_{21}H_{20}FNO_2Na$ [M+Na]$^+$ 360.1370, found 360.1368.

3i: white solid, m.p. 95-96 °C. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.01-7.95 (m, 2H), 7.87 (dd, $J = 9.2, 9.2, 1.6$ Hz, 1H), 7.62-7.56 (m, 1H), 7.56-7.44 (m, 3H), 7.28-7.20 (m, 1H), 7.14 (ddd, $J = 11.2, 8.0, 0.8$ Hz, 1H), 3.30-3.14 (m, 2H), 3.10-3.02 (m, 2H), 2.86-2.74 (m, 1H), 2.22-2.10 (m, 1H), 2.08-1.84 (m, 3H), 1.84-1.73 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 198.3, 197.4 (d, $J_{CF} = 4.2$ Hz), 162.0 (d, $J_{CF} = 252.7$ Hz), 136.4, 134.6 (d, $J_{CF} = 9.0$ Hz), 133.4, 130.6 (d, $J_{CF} = 2.6$ Hz), 128.7, 128.0, 125.4 (d, $J_{CF} = 2.9$ Hz), 124.5 (d, $J_{CF} = 3.3$ Hz), 121.7, 116.7 (d, $J_{CF} = 23.8$ Hz), 42.6 (d, $J_{CF} = 7.4$ Hz), 35.5, 31.9, 31.1, 26.3, 21.4 (d, $J_{CF} = 2.1$ Hz); $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$ -109.3 (s). FT-IR: $\nu$ (cm$^{-1}$) 2951, 2919, 2869, 2237, 1674, 1608, 1577. HRMS [ESI] calcd for $C_{21}H_{20}FNO_2Na$ [M+Na]$^+$ 360.1370, found 360.1364.

3j: white solid, m.p. 47-49 °C. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.00-7.95 (m, 2H), 7.62-7.56 (m, 1H), 7.51-7.44 (m, 2H), 3.30-3.13 (m, 2H), 2.80-2.70 (m, 1H), 2.48 (t, $J = 6.8$ Hz, 2H), 2.40 (t, $J = 7.6$ Hz, 2H), 2.18-2.08 (m, 1H), 2.02-1.90 (m, 1H), 1.88-1.72 (m, 2H), 1.70-1.63 (m, 2H), 1.62-1.52 (m, 3H), 1.36-1.20 (m, 6H), 0.89 (t, $J = 7.0$ Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 210.2, 198.3, 136.4, 133.4, 128.7, 128.0, 121.7, 42.8, 41.6, 35.5, 31.8, 31.4, 31.0, 26.3, 23.5, 22.4, 21.2, 13.9. FT-IR: $\nu$ (cm$^{-1}$) 3067, 2927, 2871, 2244, 1705, 1672, 1597. HRMS [ESI] calcd for $C_{20}H_{22}FNO_2Na$ [M+Na]$^+$ 336.1349, found 336.1342.

3k: white solid, m.p. 142-143 °C. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.49 (s, 1H), 8.03 (dd, $J = 8.8, 1.6$ Hz, 1H), 8.01-7.96 (m, 3H), 7.90 (t, $J = 8.6$ Hz, 2H), 7.66-7.54 (m, 3H), 7.52-7.44 (m, 2H), 3.32-3.24 (m, 2H), 3.21 (t, $J = 6.8$ Hz, 2H), 2.90-2.80 (m, 1H), 2.24-2.14 (m, 1H), 2.12-1.94 (m, 3H), 1.86-1.78 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 199.0, 198.3, 136.4, 135.6, 134.0, 133.4, 132.5, 129.7, 129.6, 128.7, 128.5, 128.0, 127.8, 126.8, 123.7, 121.7, 37.6, 35.5, 32.0, 31.1, 26.3, 21.8. FT-IR: $\nu$ (cm$^{-1}$) 2923, 2869, 2237, 1681, 1626, 1607. HRMS [ESI] calcd for $C_{25}H_{24}NO_2Na$ [M+Na]$^+$ 392.1621, found 392.1609.

3l ($d.r = 1:1$): white solid, m.p. 66-68 °C. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.00-7.92 (m, 4H, two isomers), 7.62-7.54 (m, 2H, two isomers), 7.51-7.43 (m, 4H, two isomers), 3.34-3.16 (m, 2H, two isomers), 3.08-2.97 (m, 1H, two isomers), 2.96-2.82 (m, 2H, two isomers), 2.56-2.40 (m, 1H, two isomers), 2.26-2.10 (m, 1H, two isomers), 2.02-1.91 (m, 1H, two isomers), 1.91-1.83 (m, 0.5H, one isomer), 1.82-1.64 (m, 1H, two isomers), 1.51-1.39 (m, 1H, two isomers).
1.57-1.48 (m, 0.5H, one isomer), 1.16-1.03 (m, 3H, two isomers); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 199.0 & 198.9 (two isomers), 198.4 & 198.3 (two isomers), 137.0 & 136.9 (two isomers), 136.4 & 136.4 (two isomers), 133.4 & 133.3 (two isomers), 133.2 & 133.1 (two isomers), 128.7 (two isomers), 128.6 (two isomers), 128.0 & 128.0 (two isomers), 128.0 & 127.9 (two isomers), 122.1 & 121.6 (two isomers), 45.5 & 45.0 (two isomers), 39.4 (two isomers), 35.5 & 35.3 (two isomers), 29.0 & 28.7 (two isomers), 27.8 & 27.5 (two isomers), 26.9 & 26.2 (two isomers), 19.9 & 19.4 (two isomers). FT-IR: $\nu$ (cm$^{-1}$) 2969, 2922, 2851, 2360, 2341, 1684, 1597, 1466. HRMS [ESI] calcd for C$_{22}$H$_{23}$NO$_2$Na [M+Na]$^+$ 356.1621, found 356.1612.

3m ($d.r = 1:1$): white solid, m.p. 91-92 °C. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.04-7.94 (m, 4H, two isomers), 7.63-7.56 (m, 1H, two isomers), 7.51-7.45 (m, 2H, two isomers), 7.18-7.10 (m, 2H, two isomers), 3.34-3.18 (m, 2H, two isomers), 3.04-2.96 (m, 1H, two isomers), 2.94-2.78 (m, 2H, two isomers), 2.56-2.38 (m, 1H, two isomers), 2.26-2.08 (m, 1H, two isomers), 2.00-1.90 (m, 1H, two isomers), 1.90-1.82 (m, 0.5H, one isomer), 1.82-1.66 (m, 1H, two isomers), 1.56-1.46 (m, 0.5H, one isomer), 1.12-1.02 (m, 3H, two isomers); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 198.4 & 198.3 (two isomers), 197.4 & 197.2 (two isomers), 165.7 (d, $J_{C-F} = 253.3$ Hz) & 165.7 (d, $J_{C-F} = 253.3$ Hz) (two isomers), 136.4 & 136.4 (two isomers), 133.4 & 133.4 (two isomers), 130.6 (d, $J_{C-F} = 9.2$ Hz, two isomers), 128.7 (two isomers), 128.0 (two isomers), 122.1 & 121.6 (two isomers), 115.7 (d, $J_{C-F} = 21.7$ Hz, two isomers), 45.4 & 44.8 (two isomers), 39.4 & 39.3 (two isomers), 35.4 & 35.2 (two isomers), 29.0 & 28.7 (two isomers), 27.8 & 27.5 (two isomers), 26.9 & 26.2 (two isomers), 19.9 & 19.4 (two isomers); $^{19}$F NMR (376 MHz, CDCl$_3$) $\delta$ -105.1 & -105.2 (s, two isomers). FT-IR: $\nu$ (cm$^{-1}$) 3061, 2928, 2238, 1741, 1676, 1597. HRMS [ESI] calcd for C$_{22}$H$_{23}$FNO$_2$Na [M+Na]$^+$ 374.1527, found 374.1523.

3n ($d.r = 1:1$): white solid, m.p. 89-90 °C. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.00-7.94 (m, 2H, two isomers), 7.92-7.85 (m, 2H, two isomers), 7.58 (t, $J = 7.2$ Hz, 1H, two isomers), 7.52-7.40 (m, 4H, two isomers), 3.34-3.16 (m, 2H, two isomers), 3.04-2.94 (m, 1H, two isomers), 2.92-2.78 (m, 2H, two isomers), 2.54-2.38 (m, 1H, two isomers), 2.26-2.08 (m, 1H, two isomers), 2.00-1.88 (m, 1H, two isomers), 1.88-1.80 (m, 0.5H, one isomer), 1.80-1.66 (m, 1H, two isomers), 1.56-1.48 (m, 0.5H, one isomer), 1.12-1.02 (m, 3H, two isomers); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 198.3 & 198.3 (two isomers), 197.7 & 197.5 (two isomers), 139.5 & 139.5 (two isomers), 136.4 & 136.3 (two isomers), 135.2 & 135.2 (two isomers), 133.4 & 133.4 (two isomers), 129.4 (two isomers), 128.9 (two isomers), 128.6 (two isomers), 127.9 (two isomers), 122.1 & 121.5 (two isomers), 45.4 & 44.8 (two isomers), 39.3 & 39.3 (two isomers), 35.4 & 35.2 (two isomers), 28.9 & 28.6 (two isomers), 27.7 & 27.4 (two isomers), 26.8 & 26.2 (two isomers), 19.8 & 19.4 (two isomers). FT-IR: $\nu$ (cm$^{-1}$) 2956, 2925, 2884, 2236, 1724, 1679, 1587. HRMS [ESI] calcd for C$_{22}$H$_{23}$ClNO$_2$Na [M+Na]$^+$ 390.1231, found 390.1224.
**3o** (d.r = 1:1): white solid, m.p. 102-103 °C. ¹H NMR (400 MHz, CDCl₃) δ 8.02-7.94 (m, 2H, two isomers), 7.86-7.78 (m, 2H, two isomers), 7.64-7.56 (m, 3H, two isomers), 7.52-7.4 (m, 2H, two isomers), 3.34-3.16 (m, 2H, two isomers), 3.04-2.94 (m, 1H, two isomers), 2.92-2.78 (m, 2H, two isomers), 2.54-2.38 (m, 1H, two isomers), 2.26-2.08 (m, 1H, two isomers), 2.00-1.90 (m, 1H, two isomers), 1.90-1.82 (m, 0.5H, one isomer), 1.80-1.66 (m, 1H, two isomers), 1.56-1.46 (m, 0.5H, one isomer), 1.12-1.02 (m, 3H, two isomers); ¹³C NMR (100 MHz, CDCl₃) δ 198.4 & 198.3 (two isomers), 197.9 & 197.8 (two isomers), 136.4 & 136.4 (two isomers), 135.7 & 135.7 (two isomers), 133.4 & 133.4 (two isomers), 131.9 (two isomers), 129.6 (two isomers), 128.7 (two isomers), 128.4 & 128.3 (two isomers), 128.0 (two isomers), 122.1 & 121.5 (two isomers), 45.5 & 44.9 (two isomers), 39.4 & 39.3 (two isomers), 35.4 & 35.3 (two isomers), 29.0 & 28.6 (two isomers), 27.7 & 27.5 (two isomers), 26.9 & 26.2 (two isomers), 19.9 & 19.4 (two isomers). FT-IR: ν (cm⁻¹) 2957, 2922, 2878, 2235, 1681, 1583. HRMS [ESI] calcd for C₂₉H₂₂BrNO₂Na [M+Na]⁺ 434.0726, found 434.0730.

**3p** (d.r = 1:1): white solid, m.p. 82-83 °C. ¹H NMR (400 MHz, CDCl₃) δ 8.01-7.94 (m, 2H, two isomers), 7.92-7.86 (m, 2H, two isomers), 7.62-7.55 (m, 1H, two isomers), 7.52-7.44 (m, 4H, two isomers), 3.34-3.16 (m, 2H, two isomers), 3.06-2.94 (m, 1H, two isomers), 2.94-2.79 (m, 2H, two isomers), 2.56-2.38 (m, 1H, two isomers), 2.26-2.08 (m, 1H, two isomers), 2.02-1.90 (m, 1H, two isomers), 1.90-1.82 (m, 0.5H, one isomer), 1.82-1.66 (m, 1H, two isomers), 1.58-1.46 (m, 0.5H, one isomer), 1.34 (s, 9H, two isomers), 1.12-1.02 (m, 3H, two isomers); ¹³C NMR (100 MHz, CDCl₃) δ 198.7 & 198.6 (two isomers), 198.4 & 198.3 (two isomers), 156.9 & 156.9 (two isomers), 136.5 & 136.4 (two isomers), 134.4 (two isomers), 133.4 & 133.4 (two isomers), 128.7 (two isomers), 128.0 (two isomers), 128.0 & 128.0 (two isomers), 125.6 (two isomers), 122.2 & 121.6 (two isomers), 45.5 & 44.9 (two isomers), 39.4 (two isomers), 35.5 & 35.3 (two isomers), 31.0 (two isomers), 29.0 & 28.7 (two isomers), 27.9 & 27.6 (two isomers), 26.9 & 26.2 (two isomers), 19.9 & 19.4 (two isomers). FT-IR: ν (cm⁻¹) 2963, 2872, 2237, 1680, 1604, 1580. HRMS [ESI] calcd for C₂₆H₂₃NO₂Na [M+Na]⁺ 412.2247, found 412.2261.

**3q** (d.r = 1:1): white solid, m.p. 98-99 °C. ¹H NMR (400 MHz, CDCl₃) δ 8.02-7.94 (m, 2H, two isomers), 7.88-7.82 (m, 2H, two isomers), 7.62-7.55 (m, 1H, two isomers), 7.52-7.44 (m, 2H, two isomers), 7.30-7.22 (m, 2H, two isomers), 3.32-3.16 (m, 2H, two isomers), 3.04-2.94 (m, 1H, two isomers), 2.92-2.79 (m, 2H, two isomers), 2.54-2.42 (m, 1H, two isomers), 2.41 (s, 3H, two isomers), 2.26-2.10 (m, 1H, two isomers), 2.02-1.90 (m, 1H, two isomers), 1.90-1.80 (m, 0.5H, one isomer), 1.80-1.60 (m, 1H, two isomers), 1.56-1.46 (m, 0.5H, one isomer), 1.12-1.02 (m, 3H, two isomers); ¹³C NMR (100 MHz, CDCl₃) δ 198.7 & 198.5 (two isomers), 198.3 & 198.3 (two isomers), 143.9 & 143.8 (two isomers), 136.4 & 136.3 (two isomers), 134.5 (two isomers), 133.4 & 133.3 (two isomers), 129.3 (two isomers), 128.6 (two isomers), 128.1 (two isomers), 127.9 (two isomers), 122.1 & 121.6 (two isomers), 45.4 & 44.8 (two isomers), 39.4 (two isomers), 35.5 & 35.3 (two isomers), 28.9 & 28.7 (two isomers), 27.8 &
27.6 (two isomers), 26.9 & 26.2 (two isomers), 21.6 (two isomers), 19.9 & 19.4 (two isomers). FT-IR: ν (cm\(^{-1}\)) 2967, 2922, 2360, 2341, 1676, 1598, 1580. HRMS [ESI] calcd for C\(_{23}\)H\(_{25}\)NO\(_2\)Na [M+Na]\(^+\) 370.1778, found 370.1784.

\[ \text{3r (d.r = 1:1): white solid, m.p. 67-68 °C. } ^{1}\text{H NMR (400 MHz, CDCl}_3) \delta 8.02-7.94 (m, 2H, two isomers), 7.78-7.72 (m, 2H, two isomers), 7.62-7.55 (m, 1H, two isomers), 7.52-7.44 (m, 2H, two isomers), 7.40-7.32 (m, 2H, two isomers), 3.34-3.16 (m, 2H, two isomers), 3.06-2.96 (m, 1H, two isomers), 2.94-2.80 (m, 2H, two isomers), 2.60-2.42 (m, 1H, two isomers), 2.41 (s, 3H, two isomers), 2.26-2.10 (m, 1H, two isomers), 2.00-1.90 (m, 1H, two isomers), 1.90-1.82 (m, 0.5H, one isomer), 1.82-1.66 (m, 1H, two isomers), 1.56-1.44 (m, 0.5H, one isomer), 1.12-1.02 (m, 3H, two isomers); 13\(^{1}\)C NMR (100 MHz, CDCl\(_3\)) δ 199.2 & 199.1 (two isomers), 198.4 & 198.3 (two isomers), 138.4 & 138.4 (two isomers), 138.1 & 138.3 (two isomers), 134.4 & 133.4 (two isomers), 128.7 (two isomers), 128.5 (two isomers), 128.5 & 128.5 (two isomers), 128.0 & 128.0 (two isomers), 125.2 & 125.2 (two isomers), 122.1 & 121.6 (two isomers), 45.6 & 45.0 (two isomers), 39.4 (two isomers), 35.5 & 35.3 (two isomers), 29.0 & 28.7 (two isomers), 27.8 & 27.6 (two isomers), 26.9 & 26.2 (two isomers), 21.3 & 21.3 (two isomers), 19.9 & 19.4 (two isomers). FT-IR: ν (cm\(^{-1}\)) 2958, 2922, 2236, 1724, 1680, 1598. HRMS [ESI] calcd for C\(_{23}\)H\(_{25}\)NO\(_2\)Na [M+Na]\(^+\) 370.1778, found 370.1774.

\[ \text{3s (d.r = 1:1): yellow oil. } ^{1}\text{H NMR (400 MHz, CDCl}_3) \delta 8.02-7.94 (m, 2H, two isomers), 7.64-7.54 (m, 2H, two isomers), 7.52-7.44 (m, 2H, two isomers), 7.37 (ddd, J = 8.8, 8.8, 1.2 Hz, 1H, two isomers), 7.29-7.22 (m, 2H, two isomers), 3.34-3.16 (m, 2H, two isomers), 3.00-2.90 (m, 1H, two isomers), 2.90-2.74 (m, 2H, two isomers), 2.50 (d, J = 2.0 Hz, 3H, two isomers), 2.46-2.38 (m, 1H, two isomers), 2.26-2.08 (m, 1H, two isomers), 2.02-1.88 (m, 1H, two isomers), 1.88-1.80 (m, 0.5H, one isomer), 1.80-1.64 (m, 1H, two isomers), 1.56-1.46 (m, 0.5H, one isomer), 1.12-1.00 (m, 3H, two isomers); 13\(^{1}\)C NMR (100 MHz, CDCl\(_3\)) δ 203.2 & 203.1 (two isomers), 198.4 & 198.3 (two isomers), 138.1 & 138.0 (two isomers), 138.0 & 137.9 (two isomers), 136.5 & 136.4 (two isomers), 133.4 & 133.4 (two isomers), 132.0 & 132.0 (two isomers), 131.3 & 131.3 (two isomers), 128.7 & 128.7 (two isomers), 128.4 & 128.3 (two isomers), 128.0 (two isomers), 125.7 & 125.7 (two isomers), 122.1 & 121.5 (two isomers), 48.5 & 47.9 (two isomers), 39.3 & 39.3 (two isomers), 35.5 & 35.3 (two isomers), 29.0 & 28.7 (two isomers), 27.9 & 27.6 (two isomers), 26.9 & 26.2 (two isomers), 21.2 & 21.2 (two isomers), 19.8 & 19.3 (two isomers). FT-IR: ν (cm\(^{-1}\)) 2962, 2926, 2238, 1682, 1598, 1580. HRMS [ESI] calcd for C\(_{23}\)H\(_{25}\)NO\(_2\)Na [M+Na]\(^+\) 370.1778, found 370.1774.

\[ \text{3t (d.r = 1:1): yellow oil. } ^{1}\text{H NMR (400 MHz, CDCl}_3) \delta 8.00-7.92 (m, 4H, two isomers), 7.62-7.52 (m, 2H, two isomers), 7.50-7.42 (m, 4H, two isomers), 3.32-3.14 (m, 2H, two isomers), 3.12-2.88 (m, 2H, two isomers), 2.88-2.80 (m,
1H, two isomers), 2.46-2.26 (m, 1H, two isomers), 2.22-2.08 (m, 1H, two isomers), 2.00-1.86 (m, 1H, two isomers), 1.86-1.74 (m, 1H, two isomers), 1.74-1.58 (m, 1H, two isomers), 1.52-1.32 (m, 4H, two isomers), 0.92 (t, J = 6.8 Hz, 3H, two isomers); 13C NMR (100 MHz, CDCl3) δ 199.4 & 199.3 (two isomers), 198.3 & 198.3 (two isomers), 137.0 & 137.0 (two isomers), 136.4 & 136.4 (two isomers), 133.3 & 133.3 (two isomers), 133.1 & 133.1 (two isomers), 128.6 & 128.6 (two isomers), 128.0 & 128.0 (two isomers), 128.0 (two isomers), 122.1 & 121.8 (two isomers), 42.6 & 42.4 (two isomers), 37.1 & 37.0 (two isomers), 36.2 & 35.7 (two isomers), 35.4 & 35.3 (two isomers), 32.1 & 32.1 (two isomers), 28.8 & 28.8 (two isomers), 26.8 & 26.7 (two isomers), 19.7 & 19.6 (two isomers), 14.2 & 14.1 (two isomers). FT-IR: ν (cm⁻¹) 3065, 2924, 2872, 2237, 1724, 1681, 1597. HRMS [ESI] calc'd for C₂₄H₂₇NO₂Na [M+Na]+ 384.1934, found 384.1927.

3u (d.r = 1:1): yellow oil. 1H NMR (400 MHz, CDCl3) δ 8.02-7.90 (m, 4H, two isomers), 7.62-7.54 (m, 2H, two isomers), 7.52-7.44 (m, 4H, two isomers), 3.68-3.54 (m, 2H, two isomers), 3.32-3.16 (m, 2H, two isomers), 3.16-3.02 (m, 2H, two isomers), 2.94-2.84 (m, 1H, two isomers), 2.66-2.52 (m, 1H, two isomers), 2.24-2.12 (m, 1H, two isomers), 2.06-1.90 (m, 3H, two isomers), 1.90-1.72 (m, 2H, two isomers); 13C NMR (100 MHz, CDCl3) δ 198.6 & 198.5 (two isomers), 198.3 & 198.3 (two isomers), 136.8 & 136.8 (two isomers), 136.4 & 136.4 (two isomers), 133.4 & 133.4 (two isomers), 128.7 & 128.7 (two isomers), 128.0 & 128.0 (two isomers), 121.8 & 121.6 (two isomers), 42.3 (two isomers), 41.9 & 41.5 (two isomers), 36.8 & 36.8 (two isomers), 36.7 & 36.2 (two isomers), 35.4 & 35.3 (two isomers), 30.4 & 30.3 (two isomers), 28.8 & 28.8 (two isomers), 26.7 & 26.6 (two isomers). FT-IR: ν (cm⁻¹) 3061, 2924, 2237, 1682, 1597, 1448. HRMS [ESI] calc'd for C₂₃H₂₅ClNO₂Na [M+Na]+ 404.1388, found 404.1406.

3v: white solid, m.p. 115-116 °C. 1H NMR (400 MHz, CDCl₃) δ 7.98-7.94 (m, 2H), 7.89-7.85 (m, 2H), 7.60-7.54 (m, 1H), 7.50-7.44 (m, 2H), 7.29-7.26 (m, 2H), 3.25-3.15 (m, 2H), 3.06 (t, J = 7.2 Hz, 2H), 2.85-2.75 (m, 1H), 2.42 (s, 3H), 2.01-2.09 (m, 1H), 2.06-1.88 (m, 3H), 1.81-1.72 (m, 2H); 13C NMR (100 MHz, CDCl₃) δ 199.0, 197.9, 144.3, 136.7, 134.0, 133.1, 129.3, 128.6, 128.1, 128.0, 121.7, 37.5, 35.3, 31.9, 31.1, 26.4, 21.6, 21.6. FT-IR: ν (cm⁻¹) 3086, 2923, 2871, 2243, 1679, 1669, 1608. HRMS [ESI] calc'd for C₂₃H₂₅NO₂Na [M+Na]+ 356.1621, found 356.1608.

3w: white solid, m.p. 102-104 °C. 1H NMR (400 MHz, CDCl₃) δ 7.98-7.93 (m, 2H), 7.85-7.81 (m, 2H), 7.64-7.60 (m, 2H), 7.60-7.54 (m, 1H), 7.50-7.44 (m, 2H), 3.25-3.13 (m, 2H), 3.06 (t, J = 7.2 Hz, 2H), 2.84-2.75 (m, 1H), 2.20-2.09 (m, 1H), 2.05-1.88 (m, 3H), 1.80-1.72 (m, 2H); 13C NMR (100 MHz, CDCl₃) δ 199.0, 197.2, 136.7, 135.1, 133.2, 132.0, 129.5, 128.6, 128.0, 121.6, 37.5, 35.5, 31.8, 31.0, 26.2, 21.5. FT-IR: ν (cm⁻¹) 3065, 2923, 2854, 2242, 1679, 1671, 1584. HRMS [ESI] calc'd for C₂₂H₂₀BrNO₂Na [M+Na]+ 420.0570, found 420.0581.
3x: white solid, m.p. 94-95 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 8.10-8.05 (m, 2H), 7.98-7.92 (m, 2H), 7.77-7.71 (m, 2H), 7.60-7.54 (m, 1H), 7.50-7.44 (m, 2H), 3.34-3.17 (m, 2H), 3.07 (t, $J = 6.8$ Hz, 2H), 2.86-2.77 (m, 1H), 2.22-2.12 (m, 1H), 2.09-1.88 (m, 3H), 1.82-1.73 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 199.0, 197.3, 139.0 (q, $J_{CF} = 0.8$ Hz), 136.7, 134.7 (q, $J_{CF} = 32.6$ Hz), 133.2, 128.6, 128.3, 127.9, 125.8 (q, $J_{CF} = 3.7$ Hz), 123.5 (d, $J_{CF} = 271.1$ Hz), 121.5, 37.4, 35.8, 31.8, 31.0, 26.1, 21.5; $^{19}$F NMR (376 MHz, CDCl$_3$) δ -63.2 (s). FT-IR: ν (cm$^{-1}$) 2934, 2243, 1681, 1599, 1581. HRMS [ESI] calcd for C$_{22}$H$_{38}$F$_3$NO$_2$Na [M+Na]$^+$ 410.1338, found 410.1342.

3y: white solid, m.p. 108-109 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 8.06-8.01 (m, 2H), 7.98-7.94 (m, 2H), 7.61-7.55 (m, 1H), 7.51-7.45 (m, 2H), 7.34-7.28 (m, 2H), 3.27-3.17 (m, 2H), 3.07 (t, $J = 7.2$ Hz, 2H), 2.85-2.76 (m, 1H), 2.22-2.12 (m, 1H), 2.07-1.90 (m, 3H), 1.82-1.73 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 199.0, 196.7, 152.8 (q, $J_{CF} = 1.7$ Hz), 136.7, 134.6, 133.2, 130.0, 128.7, 128.0, 121.6, 120.5 (q, $J_{CF} = 0.7$ Hz), 120.2 (q, $J_{CF} = 257.2$ Hz), 37.5, 35.6, 31.9, 31.0, 26.2, 21.5; $^{19}$F NMR (376 MHz, CDCl$_3$) δ -57.6 (s). FT-IR: ν (cm$^{-1}$) 2954, 2924, 2854, 2244, 1681, 1599, 1507. HRMS [ESI] calcd for C$_{22}$H$_{38}$F$_3$NO$_2$Na [M+Na]$^+$ 426.1287, found 426.1296.

3z: white solid, m.p. 100-102 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.99-7.94 (m, 2H), 7.80-7.75 (m, 2H), 7.60-7.55 (m, 1H), 7.50-7.44 (m, 2H), 7.42-7.33 (m, 2H), 3.27-3.15 (m, 2H), 3.07 (t, $J = 7.2$ Hz, 2H), 2.85-2.76 (m, 1H), 2.42 (s, 3H), 2.20-2.10 (m, 1H), 2.07-1.88 (m, 3H), 1.81-1.73 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 199.1, 198.5, 138.5, 136.7, 136.5, 134.2, 133.2, 128.6, 128.6, 128.5, 128.0, 125.2, 121.7, 37.5, 35.5, 31.9, 31.1, 26.3, 21.6, 21.3. FT-IR: ν (cm$^{-1}$) 3061, 2949, 2856, 2236, 1677, 1598, 1580. HRMS [ESI] calcd for C$_{22}$H$_{32}$NO$_2$Na [M+Na]$^+$ 356.1621, found 356.1609.

3aa: white solid, m.p. 70-72 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.99-7.94 (m, 2H), 7.70 (dd, $J = 7.6$, 0.8 Hz, 1H), 7.60-7.55 (m, 1H), 7.50-7.44 (m, 2H), 7.42-7.36 (m, 1H), 7.31-7.24 (m, 2H), 3.18-3.13 (m, 2H), 3.07 (t, $J = 6.8$ Hz, 2H), 2.84-2.76 (m, 1H), 2.50 (s, 3H), 2.19-2.09 (m, 1H), 2.06-1.88 (m, 3H), 1.81-1.73 (m, 2H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 202.1, 199.1, 138.3, 137.1, 136.7, 133.2, 132.1, 131.7, 128.6, 128.6, 128.0, 125.8, 121.7, 38.2, 37.5, 31.9, 31.0, 26.5, 21.6, 21.5. FT-IR: ν (cm$^{-1}$) 3076, 2927, 2867, 2240, 1685, 1680, 1488. HRMS [ESI] calcd for C$_{22}$H$_{32}$NO$_2$Na [M+Na]$^+$ 356.1621, found 356.1620.

3ab: white solid, m.p. 58-59 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.98-7.93 (m, 2H), 7.60-7.54 (m, 1H), 7.50-7.44 (m, 2H), 3.04 (t, $J = 7.2$ Hz, 2H), 2.72-2.64 (m, 3H), 2.40-2.31 (m, 1H), 2.03-1.74 (m, 8H), 1.72-1.63 (m, 3H), 1.40-1.15 (m, 5H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 212.4, 199.1, 136.7, 133.2, 128.6, 128.0, 121.6, 50.9, 37.5, 37.3, 31.8,

![Chemical structure of 3ac](image)

3ac: yellow oil. ¹H NMR (400 MHz, CDCl₃) δ 7.97-7.93 (m, 2H), 7.59-7.54 (m, 1H), 7.49-7.44 (m, 2H), 3.04 (t, J = 7.2 Hz, 2H), 2.74-2.60 (m, 3H), 2.42 (t, J = 7.6 Hz, 2H), 2.03-1.85 (m, 3H), 1.82-1.74 (m, 1H), 1.73-1.66 (m, 2H), 1.62-1.53 (m, 2H), 1.35-1.22 (m, 4H), 0.89 (t, J = 7.2 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 209.4, 199.0, 136.7, 133.1, 128.6, 127.9, 121.6, 42.9, 39.4, 37.5, 31.8, 31.3, 30.9, 25.8, 23.5, 22.4, 21.5, 13.9. FT-IR: v (cm⁻¹) 2950, 2931, 2868, 2236, 1714, 1678, 1597. HRMS [ESI] calcd for C₂₀H₂₅NO₂Na [M+Na]^+ 336.1934, found 336.1959.

![Chemical structure of 3ad-1](image)

3ad-1: yellow oil. ¹H NMR (400 MHz, CDCl₃) δ 7.99-7.93 (m, 2H), 7.59-7.54 (m, 1H), 7.50-7.44 (m, 2H), 3.04 (t, J = 7.2 Hz, 2H), 2.96-2.87 (m, 1H), 2.67-2.58 (m, 1H), 2.43-2.33 (m, 2H), 2.17-2.08 (m, 2H), 2.05-1.85 (m, 4H), 1.81-1.60 (m, 4H), 1.47-1.28 (m, 2H); ¹³C NMR (100 MHz, CDCl₃) δ 212.3, 199.2, 136.8, 133.1, 128.6, 128.0, 122.3, 48.5, 42.4, 37.5, 35.5, 32.9, 32.4, 30.1, 28.2, 25.3, 21.4. FT-IR: v (cm⁻¹) 3052, 2944, 2860, 2237, 1709, 1683, 1597. HRMS [ESI] calcd for C₁₀H₂₃NO₂Na [M+Na]^+ 320.1621, found 320.1627.

![Chemical structure of 3ad-2](image)

3ad-2: white solid, m.p. 59-61 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.98-7.93 (m, 2H), 7.60-7.54 (m, 1H), 7.50-7.44 (m, 2H), 3.04 (t, J = 7.2 Hz, 2H), 2.73-2.64 (m, 1H), 2.61-2.51 (m, 1H), 2.46-2.30 (m, 2H), 2.26-2.08 (m, 3H), 2.05-1.86 (m, 3H), 1.80-1.62 (m, 4H), 1.53-1.44 (m, 1H), 1.40-1.32 (m, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 211.5, 199.1, 136.7, 133.2, 128.6, 128.0, 121.6, 47.9, 42.1, 37.6, 33.4, 31.9, 31.6, 28.8, 27.8, 25.1, 21.6. FT-IR: v (cm⁻¹) 3062, 2934, 2858, 2235, 1708, 1683, 1580. HRMS [ESI] calcd for C₁₀H₂₃NO₂Na [M+Na]^+ 320.1621, found 320.1631.

![Chemical structure of 3ae](image)

3ae: white solid, m.p. 133-134 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.98 (d, J = 8.0 Hz, 1H), 7.94-7.89 (m, 2H), 7.89-7.83 (m, 3H), 7.56-7.49 (m, 2H), 7.49-7.32 (m, 6H), 3.42-3.30 (m, 1H), 3.10-2.90 (m, 4H), 2.42-2.30 (m, 1H), 2.28-2.16 (m, 1H), 2.08-1.92 (m, 2H), 1.92-1.73 (m, 2H); ¹³C NMR (100 MHz, CDCl₃) δ 199.7, 199.4, 175.5, 153.0, 136.8, 136.7, 134.7, 133.0, 123.9, 128.5, 128.0, 125.9, 124.8, 122.7, 121.7, 44.5, 38.1, 36.0, 36.0, 30.3, 22.0. FT-IR: v (cm⁻¹) 2938, 2925, 2851, 1677, 1598, 1508, 1247. HRMS [ESI] calcd for C₂₇H₂₉NO₂SNa [M+Na]^+ 450.1498, found 450.1483.

![Chemical structure of 3af](image)

3af: yellow solid, m.p. 118-120 °C. ¹H NMR (400 MHz, CDCl₃) δ 9.67 (d, J = 2.4 Hz, 1H), 7.98-7.92 (m, 4H), 7.60-7.53 (m, 2H), 7.50-7.42 (m, 4H), 3.12-2.94 (m, 4H), 2.50-2.40 (m, 1H), 2.16-2.04 (m, 1H), 2.04-1.93 (m, 1H), 1.88-1.76 (m, 3H), 1.66-1.58 (m, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 204.5, 199.5, 199.3, 136.9, 136.7, 133.2, 133.1, 128.6, 128.0, 128.0, 128.0, 128.0, 51.1, 38.1, 35.6, 28.5, 22.7, 21.5. FT-IR: v (cm⁻¹) 3067, 2924,
4: white solid, m.p. 120-121 °C. 1H NMR (400 MHz, CDCl₃) δ 8.00-7.90 (m, 4H), 7.58-7.52 (m, 2H), 7.48-7.40 (m, 4H), 3.16-2.96 (m, 4H), 2.62-2.52 (m, 1H), 2.10-2.00 (m, 2H), 1.90-1.76 (m, 3H), 1.74-1.60 (m, 1H); 13C NMR (100 MHz, CDCl₃) δ 199.8, 199.4, 181.2, 136.8, 136.7, 133.1, 133.0, 128.6, 128.6, 128.1, 128.0, 44.5, 38.1, 36.0, 31.7, 26.0, 21.8. FT-IR: ν (cm⁻¹) 3059, 2955, 2923, 1696, 1676, 1581. HRMS [ESI] calcd for C₂₁H₂₃O₃Na [M+Na]^+ 345.1461, found 345.1462.

5: white solid, m.p. 149-150 °C. 1H NMR (400 MHz, CDCl₃) δ 7.98-7.88 (m, 4H), 7.59-7.51 (m, 2H), 7.48-7.40 (m, 4H), 5.99 (s, 1H), 5.58 (s, 1H), 3.18-3.06 (m, 1H), 3.06-2.92 (m, 3H), 2.44-2.34 (m, 1H), 2.08-1.90 (m, 2H), 1.86-1.68 (m, 3H), 1.62-1.50 (m, 1H); 13C NMR (100 MHz, CDCl₃) δ 200.1, 200.0, 177.5, 136.8, 136.7, 133.2, 133.1, 128.6, 128.6, 128.1, 128.0, 45.6, 38.2, 35.8, 32.4, 27.3, 22.0. FT-IR: ν (cm⁻¹) 3181, 2988, 2931, 2901, 1682, 1645, 1597. HRMS [ESI] calcd for C₂₁H₂₃NO₃ [M+H]^+ 338.1751, found 338.1752.

6: white solid, m.p. 97-98 °C. 1H NMR (400 MHz, CDCl₃) δ 8.00-7.92 (m, 2H), 7.59-7.52 (m, 1H), 7.50-7.43 (m, 2H), 7.43-7.30 (m, 5H), 7.11 (br, 1H), 5.46-5.40 (m, 1H), 3.04 (t, J = 7.2 Hz, 2H), 2.68-2.58 (m, 1H), 2.58-2.48 (m, 1H), 2.38-2.26 (m, 1H), 2.08-1.76 (m, 3H), 1.62-1.54 (m, 1H); 13C NMR (100 MHz, CDCl₃) δ 200.0, 136.9, 136.6, 134.9, 133.0, 128.9, 128.7, 128.6, 128.0, 124.8, 102.1, 39.6, 38.4, 29.3, 26.1, 21.7. FT-IR: ν (cm⁻¹) 3060, 2924, 1740, 1672, 1580. HRMS [ESI] calcd for C₂₁H₂₃NO₃ [M+Na]^+ 342.1465, found 342.1461.

7: white solid, m.p. 104-106 °C. 1H NMR (400 MHz, CDCl₃) δ 7.89-7.82 (m, 4H), 7.30-7.22 (m, 4H), 3.26-3.12 (m, 2H), 3.02 (t, J = 7.2 Hz, 2H), 2.84-2.74 (m, 1H), 2.42 (s, 3H), 2.41 (s, 3H), 2.20-2.10 (m, 1H), 2.06-1.86 (m, 3H), 1.80-1.71 (m, 2H); 13C NMR (100 MHz, CDCl₃) δ 198.8, 197.9, 144.2, 143.9, 134.2, 134.0, 129.3, 129.3, 128.1, 121.7, 37.4, 35.3, 31.9, 31.1, 26.4, 21.7, 21.6, 21.6. FT-IR: ν (cm⁻¹) 2924, 2857, 2238, 1674, 1605, 1267. HRMS [ESI] calcd for C₂₃H₂₅NO₃ [M+Na]^+ 377.1778, found 377.1771.

8: white solid, m.p. >200 °C. 1H NMR (400 MHz, DMSO-d₆) δ 9.91 (s, 1H), 9.81 (s, 1H), 7.50-7.42 (m, 4H), 7.08 (d, J = 8.0 Hz, 4H), 2.94-2.84 (m, 1H), 2.48-2.38 (m, 2H), 2.34 (t, J = 7.2 Hz, 2H), 2.24 (s, 6H), 2.00-1.56 (m, 6H); 13C NMR (100 MHz, DMSO-d₆) δ 170.4, 169.6,
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![Chemical Structure 1](image1)

![Chemical Structure 2](image2)

![1H NMR Spectrum](image3)

![13C NMR Spectrum](image4)
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![Chemical Structure](image1)

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![Graph](image4)
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