Supporting Information

Pd/P/dba-Promoted Cascade Annulations to Fused Medium-sized Sulfoximine Polyheterocycles

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1. General remarks.

Unless otherwise noted, commercial reagents were purchased from commercial suppliers and were used as received. All solvents were dried and distilled according to standard procedures before use. The Flash column chromatography was performed using silica gel (60 Å pore size, 32-63 μm, standard grade). Analytical thin-layer chromatography (TLC) was performed using glass plates pre-coated with 0.25 mm 230-400 mesh silica gel impregnated with a fluorescent indicator (254 nm). Organic solutions were concentrated on rotary evaporators at ~20 Torr (house vacuum) at 25-35 °C. Nuclear magnetic resonance (NMR) spectra were recorded in parts per million (ppm) from internal trimethylsilane (TMS) on the δ scale. High resolution mass spectrometry (HRMS) spectra analysis was performed by electrospray ionization (ESI-micrOTOF).
2. General procedure for the synthesis of bridged heterocycles 3-22.

To a screw capped Schlenk tube equipped with a stir bar was charged with ortho-bromo-NH-sulfoximine 1 (0.30 mmol), aryl iodide 2 (0.36 mmol), Pd(dba)$_2$ (10 mol%), ($p$-FC$_6$H$_4$)$_3$P (20 mol%), Norbornadiene (3.0 equiv.), Cs$_2$CO$_3$ (2.1 equiv.), and dry MeCN (4.5 mL). The reaction was purged with N$_2$, and then heated to 85-105 $^\circ$C at oil bath for about 12 h. The reaction was monitored by TLC. Upon completion, the reaction was allowed to cool to room temperature, diluted with ethyl acetate (5.0 mL), then filtered through a short pad of silica. The solid residue was washed with ethyl acetate (~10 mL) unless otherwise noted. Concentration of the filtrate under reduced pressure provided the crude product, which was purified by silica gel column chromatography (petroleum ether/ethyl acetate = 10:1 ~ 2:1, v/v) to afford the desired compounds 3-22.

(1S,4R)-9-Methyl-1,4,4a,14b-tetrahydro-9λ$^4$-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (3a).

Yield: 81%, 92 mg; yellow solid, mp: 198-200 $^\circ$C. Eluent: ethyl acetate/petroleum ether = 1 : 3. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.67 (s, 1H), 7.51 (d, $J$ = 8.1 Hz, 1H), 7.24-7.20 (m, 3H), 7.05-7.01 (m, 1H), 6.71 (d, $J$ = 8.1 Hz, 1H), 6.38 (d, $J$ = 3.9 Hz, 2H), 4.08 (d, $J$ = 9.7 Hz, 1H), 3.73 (s, 3H), 3.44 (s, 3H), 3.29 (d, $J$ = 9.6 Hz, 1H), 3.20 (s, 2H), 2.01 (d, $J$ = 8.5 Hz, 1H), 1.80 (d, $J$ = 8.5 Hz, 1H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 167.2, 151.2, 143.5, 140.1, 139.4, 138.9, 136.5, 132.9, 128.0, 127.8, 127.6, 126.4, 125.3, 124.9, 123.9, 51.9, 46.9, 46.2, 46.1, 45.8, 45.0. HRMS (ESI) calculated for C$_{22}$H$_{22}$NO$_3$S [M+H]$^+$: 380.1315, found: 380.1319.
Methyl(1S,4R)-9-phenyl-1,4,4a,14b-tetrahydro-9\(^{\lambda}4\)-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (3b).

Yield: 75%, 99 mg; white solid, mp: 227-228 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3.

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.24 (s, 2H), 7.86 (s, 1H), 7.78-7.63 (m, 4H), 7.26 (d, \(J = 6.4\) Hz, 1H), 7.20 (t, \(J = 7.5\) Hz, 1H), 7.09 (d, \(J = 8.2\) Hz, 1H), 6.80 (t, \(J = 7.5\) Hz, 1H), 6.50 (d, \(J = 14.1\) Hz, 2H), 6.23 (d, \(J = 7.9\) Hz, 1H), 4.61 (d, \(J = 9.6\) Hz, 1H), 3.82 (s, 3H), 3.47 (d, \(J = 9.6\) Hz, 1H), 3.32 (d, \(J = 9.2\) Hz, 2H), 2.17 (d, \(J = 8.5\) Hz, 1H), 1.91 (d, \(J = 8.3\) Hz, 1H).

\(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 167.2, 152.0, 143.7, 139.8, 139.7, 139.5, 139.3, 138.6, 137.3, 133.8, 132.2, 128.6, 127.9, 126.5, 126.4, 126.2, 125.9, 125.2, 124.5, 51.8, 47.5, 46.7, 45.9, 45.8, 45.6. HRMS (ESI) calculated for C\(_{27}\)H\(_{24}\)NO\(_3\)S [M+H]\(^+\): 442.1471, found: 442.1475.

Methyl(1S,4R)-12-fluoro-9-methyl-1,4,4a,14b-tetrahydro-9\(^{\lambda}4\)-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (4a).

Yield: 60%, 71.5 mg; white solid, mp: 213-214 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3.

\(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.61 (d, \(J = 6.5\) Hz, 1H), 7.33-7.27 (m, 3H), 7.15 (s, 1H), 6.51 6.45 (m, 3H), 4.16 (d, \(J = 8.4\) Hz, 1H), 3.83 (s, 3H), 3.51 (s, 3H), 3.27-3.25 (m, 3H), 2.04 (s, 1H), 1.87 (s, 1H).

\(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 165.1 (d, \(J = 4.0\) Hz), 160.7 (d, \(^{1}\)J = 257 Hz), 152.6, 143.6, 139.9, 139.0, 136.1, 135.2, 133.0, 129.7, 127.5, 126.6, 123.8, 113.6 (d, \(^{2}\)J = 22 Hz), 112.8 (d, \(^{2}\)J = 9.8 Hz), 52.0, 46.5, 46.12, 46.1, 45.8, 45.7, 45.0. HRMS (ESI) calculated for C\(_{22}\)H\(_{21}\)FNO\(_3\)S [M+H]\(^+\): 398.1221, found: 398.1228.
Methyl(1S,4R)-12-fluoro-9-phenyl-1,4,4a,14b-tetrahydro-9\lambda^4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (4b).

Yield: 64%, 88 mg; white solid, mp: 220-221 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3. ¹H NMR (400 MHz, CDCl₃) δ 8.14-8.19 (m, 2H), 7.78-7.69 (m, 4H), 7.28-7.22 (m, 2H), 6.88-6.78 (m, 2H), 6.54-6.46 (m, 2H), 6.25 (d, J = 7.8 Hz, 1H), 4.58 (d, J = 9.6 Hz, 1H), 3.85 (s, 3H), 3.41 (d, J = 9.6 Hz, 1H), 3.31 (s, 2H), 2.13 (d, J = 8.6 Hz, 1H), 1.90 (d, J = 8.6 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ 165.1, 160.6 (d, J = 256 Hz), 153.5, 143.8, 139.9, 139.3, 138.9, 137.1, 134.6, 134.0, 132.4, 130.5, 129.1, 126.5, 126.0, 125.2, 114.2 (d, J = 22 Hz), 112.5 (d, J = 21 Hz), 52.0, 47.7, 46.6, 45.8, 45.6, 45.2. HRMS (ESI) calculated for C₂₇H₂₃FNO₃S [M+H]⁺: 460.1377, found: 460.1367.

Methyl(1S,4R)-12-chloro-9-methyl-1,4,4a,14b-tetrahydro-9\lambda^4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (5a).

Yield: 82%, 102 mg; white solid, mp: 209-210 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3. ¹H NMR (400 MHz, CDCl₃) δ 7.58 (s, 1H), 7.37-7.31 (m, 3H), 7.17 (d, J = 6.7 Hz, 1H), 6.81 (s, 1H), 6.45 (s, 2H), 4.15 (d, J = 12.0 Hz, 1H), 3.83 (s, 3H), 3.52 (s, 3H), 3.28-3.22 (m, 3H), 2.02 (d, J = 8.1 Hz, 1H), 1.86 (d, J = 7.8 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ 166.0, 150.9, 143.3, 139.8, 139.1, 137.9, 136.1, 133.1, 131.8, 129.8, 127.9, 127.5, 126.7, 123.8, 52.1, 46.4, 46.3, 46.1, 45.9, 45.7, 45.0. HRMS (ESI) calculated for C₂₂H₂₀ClNO₃S [M+H]⁺: 414.1025, found: 414.1038.
Methyl(1S,4R)-12-chloro-9-phenyl-1,4,4α,14b-tetrahydro-9λ4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (5b).

Yield: 71%, 101 mg; white solid, mp: 233-234 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3. $^1$H NMR (400 MHz, CDCl$_3$) δ 8.21 (s, 2H), 7.78-7.71 (m, 4H), 7.28-7.22 (m, 2H), 7.11 (s, 1H), 6.88-6.84 (m, 1H), 6.53 (m, 1H), 6.48-6.45 (m, 1H), 6.26 (d, $J$ = 7.9 Hz, 1H), 4.60 (d, $J$ = 9.7 Hz, 1H), 3.85 (s, 3H), 3.40 (d, $J$ = 9.7 Hz, 1H), 3.31 (d, $J$ = 10.1 Hz, 2H), 2.10 (d, $J$ = 8.6 Hz, 1H), 1.90 (d, $J$ = 8.6 Hz, 1H). $^{13}$C NMR (100 MHz, CDCl$_3$) δ 166.1, 151.7, 143.6, 140.0, 139.2, 138.8, 137.3, 137.1, 134.0, 132.4, 131.8, 130.6, 129.4, 128.5, 126.4, 126.2, 125.2, 123.3, 52.1, 47.5, 46.8, 45.8, 45.6, 45.4. HRMS (ESI) calculated for C$_{27}$H$_{23}$ClNO$_3$S [M+H]$^+$: 476.1082, found: 476.1082.

((1S,4R)-9-Methyl-13-(trifluoromethyl)-1,4,4α,14b-tetrahydro-9λ4-1,4-methanotribenzo[c,e,g][1,2]thiazocine 9-oxide (6).

Yield: 71%, 83 mg; white solid, mp: 209-210 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.35-7.26 (m, 4H), 7.13 (t, $J$ = 7.4 Hz, 2H), 6.81 (d, $J$ = 8.1 Hz, 1H), 6.45 (s, 2H), 4.18 (d, $J$ = 9.6 Hz, 1H), 3.51 (s, 3H), 3.38 (d, $J$ = 9.6 Hz, 1H), 3.29 (s, 1H), 3.22 (s, 1H), 2.03 (d, $J$ = 8.4 Hz, 1H), 1.87 (d, $J$ = 8.4 Hz, 1H). $^{13}$C NMR (100 MHz, CDCl$_3$) δ 149.4, 143.3, 140.1, 140.0, 139.0, 136.4, 132.9, 127.5, 126.6, 125.5, 125.0, 123.9, 123.4 (q, $J$ = 258.0 Hz), 123.3, 123.2, 46.9, 46.1, 46.2, 45.9, 45.6, 45.0. HRMS (ESI) calculated for C$_{21}$H$_{19}$F$_3$NOS [M+H]$^+$: 390.1134, found: 390.1142.
1-((1S,4R)-9-Methyl-9-oxido-1,4,4a,14b-tetrahydro-9λ4-1,4-methanotribenzo[c,e,g][1,2] thiazocin-13-yl)ethan-1-one (7).

Yield: 63%, 69 mg; white solid, mp: 230-231 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.71 (d, \(J = 1.5\) Hz, 1H), 7.51-7.49 (m, 1H), 6.79 (d, \(J = 8.1\) Hz, 1H), 6.46-6.45 (m, 2H), 4.18 (d, \(J = 9.6\) Hz, 1H), 3.52 (s, 3H), 3.37 (d, \(J = 9.7\) Hz, 1H), 3.28 (s, 2H), 2.45 (s, 3H), 2.08 (d, \(J = 8.6\) Hz, 1H), 1.88 (d, \(J = 8.6\) Hz, 1H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 197.4, 151.6, 143.5, 140.1, 139.5, 139.0, 136.5, 132.9, 132.4, 127.6, 127.3, 126.5, 126.4, 125.3, 123.8, 46.9, 46.2, 46.1, 45.9, 45.8, 45.1, 26.4. HRMS (ESI) calculated for C\(_{22}\)H\(_{22}\)NO\(_2\)S [M+H]\(^+\): 364.1366, found: 364.1361.

(1S,4R)-9-Methyl-12-nitro-1,4,4a,14b-tetrahydro-9λ4-1,4-methanotribenzo[c,e,g][1,2]thiazocine 9-oxide (8).

Yield: 67%, 73 mg; yellow solid, mp: 207-210 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.69-7.66 (m, 1H), 7.56 (d, \(J = 2.4\) Hz, 1H), 7.36-7.31 (m, 3H), 7.20-7.14 (m, 2H), 6.47 (s, 2H), 4.23 (d, \(J = 8.0\) Hz, 1H), 3.56 (s, 3H), 3.41 (d, \(J = 10.0\) Hz, 1H), 3.30 (s, 1H), 3.22 (s, 1H), 2.03 (d, \(J = 8.0\) Hz, 1H), 1.88 (d, \(J = 8.0\) Hz, 1H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 148.1, 147.3, 146.4, 142.9, 139.8, 139.1, 136.2, 133.0, 127.5, 126.9, 126.7, 124.2, 120.1, 118.3, 47.5, 46.2, 46.1, 46.0, 45.6, 44.9. HRMS (ESI) calculated for C\(_{20}\)H\(_{19}\)N\(_2\)O\(_3\)S [M+H]\(^+\): 367.1111, found: 367.1110.
(1S,4R)-9-Methyl-1,4,4α,14b-tetrahydro-9λ^4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carbonitrile 9-oxide (9).

Yield: 43%, 45 mg; white solid, mp: 218-219 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3. ^1H NMR (400 MHz, CDCl₃) δ 7.38 (t, J = 7.5 Hz, 1H), 7.31 (t, 3H), 7.18-7.13 (m, 2H), 6.78 (d, J = 8.1 Hz, 1H), 6.45 (s, 2H), 4.19 (d, J = 9.6 Hz, 1H), 3.52 (s, 3H), 3.34-3.29 (m, 2H), 3.17 (s, 1H), 2.00 (d, J = 8.6 Hz, 1H), 1.87 (d, J = 8.5 Hz, 1H). ^13C NMR (100 MHz, CDCl₃) δ 151.3, 143.2, 140.8, 139.8, 139.2, 136.2, 133.1, 130.5, 130.4, 127.5, 126.7, 126.2, 123.8, 119.6, 106.4, 46.6, 46.2, 46.1, 45.9, 45.6, 45.1. HRMS (ESI) calculated for C₂₁H₁₉N₂O₅S [M+H]^+: 347.1213, found: 347.1232.

Ethyl(1S,4R)-9-methyl-1,4,4α,14b-tetrahydro-9λ^4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (10a).

Yield: 63%, 74 mg; white solid, mp: 174-173 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3. ^1H NMR (400 MHz, CDCl₃) δ 7.68 (s, 1H), 7.51 (m, 1H), 7.25-7.19 (m, 3H), 7.05-7.02 (m, 1H), 6.70 (d, J = 8.2 Hz, 1H), 6.39-6.36 (m, 2H), 4.19 (q, J = 7.1 Hz, 2H), 4.10-4.08 (m, 1H), 3.43 (s, 3H), 3.29 (d, J = 9.7 Hz, 1H), 3.20 (d, 2H), 2.02 (d, J = 8.6 Hz, 1H), 1.79 (d, J = 8.6 Hz, 1H), 1.24 (t, J = 7.1 Hz, 3H). ^13C NMR (100 MHz, CDCl₃) δ 166.7, 151.1, 143.5, 140.1, 139.3, 138.9, 136.6, 132.8, 127.9, 127.8, 127.6, 126.3, 125.3, 125.2, 123.9, 60.6, 46.9, 46.2, 46.1, 45.9, 45.7, 45.0, 45.3. HRMS (ESI) calculated for C₂₃H₂₄NO₅S [M+H]^+: 394.1471, found: 394.1470.
Ethyl(1S,4R)-9-phenyl-1,4,4α,14b-tetrahydro-9λ^4-1,4-methanotriphenol[1,2]thiazocine-13-carboxylate 9-oxide (10b).

Yield: 65%, 89 mg; white solid, mp: 176-177 °C. Eluent: ethyl acetate/petroleum ether =1: 3. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.24 (s, 2H), 7.87 (s, 1H), 7.78-7.63 (m, 4H), 7.27 (d, \(J = 6.3\) Hz, 1H), 7.21 (t, \(J = 7.5\) Hz, 1H), 7.09 (d, \(J = 8.2\) Hz, 1H), 6.80 (t, \(J = 7.6\) Hz, 1H), 6.54-6.47 (m, 2H), 6.23 (d, \(J = 7.9\) Hz, 1H), 4.60 (d, \(J = 9.7\) Hz, 1H), 4.29 (q, \(J = 7.1\) Hz, 2H), 3.47 (d, \(J = 9.7\) Hz, 1H), 3.34-3.42 (m, 2H), 2.18 (d, \(J = 8.6\) Hz, 1H), 1.91 (d, \(J = 8.6\) Hz, 1H), 1.33 (t, \(J = 7.1\) Hz, 3H). \(^1\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 166.7, 151.8, 143.9, 139.8, 139.5, 139.4, 138.5, 137.3, 133.8, 132.2, 130.6, 128.7, 127.8, 126.5, 126.1, 125.8, 125.2, 124.8, 60.6, 47.5, 46.7, 45.8, 45.6, 14.4. HRMS (ESI) calculated for C\(_{28}\)H\(_{26}\)NO\(_3\)S [M+H]\(^+\): 456.1628, found: 456.1626.

Methyl(1S,4R)-9,12-dimethyl-1,4,4α,14b-tetrahydro-9λ^4-1,4-methanotriphenol[1,2]thiazocine-13-carboxylate 9-oxide (11).

Yield: 72%, 85 mg; white solid, mp: 223-224 °C. Eluent: ethyl acetate/petroleum ether =1: 3. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.64 (s, 1H), 7.36-7.29 (m, 3H), 7.12 (t, \(J = 6.2\) Hz, 1H), 6.60 (s, 1H), 6.44 (s, 2H), 4.15 (d, \(J = 8.0\) Hz, 1H), 3.79 (s, 3H), 3.51 (s, 3H), 3.31 (d, \(J = 9.7\) Hz, 1H), 3.26 (d, \(J = 9.8\) Hz, 2H), 2.36 (s, 3H), 2.06 (d, \(J = 8.4\) Hz, 1H), 1.85 (d, \(J = 8.2\) Hz, 1H). \(^1\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 168.0, 150.1, 143.7, 140.1, 138.9, 138.8, 136.5, 136.1, 132.8, 129.1, 128.6, 127.5, 126.4, 124.0, 123.9, 51.5, 46.4, 46.3, 46.0, 45.9, 45.7, 45.1, 21.4. HRMS (ESI) calculated for C\(_{23}\)H\(_{24}\)NO\(_3\)S [M+H]\(^+\): 394.1471, found: 394.1462.
(1S,4R)-12-Methoxy-9-methyl-1,4,4a,14b-tetrahydro-9\(^\lambda_4\)-1,4-methanotribenzo[c,e,g][1,2]thiazocine 9-oxide (12).

Yield: 69%, 73 mg; white solid, mp: 186-189 °C. Eluent: ethyl acetate/petroleum ether =1: 4. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.35-7.26 (m, 3H), 7.13-7.09 (m, 1H), 6.91 (d, \(J = 8.4\) Hz, 1H), 6.46-6.44 (m, 1H), 6.41-6.35 (m, 3H), 4.09 (d, \(J = 9.5\) Hz, 1H), 3.64 (s, 3H), 3.48 (s, 3H), 3.32 (d, \(J = 9.5\) Hz, 1H), 3.26 (s, 1H), 3.17 (s, 1H), 2.03 (d, \(J = 8.4\) Hz, 1H), 1.79 (d, \(J = 8.4\) Hz, 1H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 158.0, 147.1, 144.0, 140.3, 138.6, 136.8, 132.5, 131.2, 127.4, 126.4, 126.2, 124.3, 111.3, 108.6, 55.2, 46.3, 46.2, 46.0, 45.7, 45.6, 44.9. HRMS (ESI) calculated for C\(_{21}\)H\(_{22}\)NO\(_2\)S [M+H]\(^+\): 352.1366, found: 352.1360.

Ethyl(1S,4R)-12-acetamido-9-methyl-1,4,4a,14b-tetrahydro-9\(^\lambda_4\)-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (13a).

Yield: 79%, 107 mg; white solid, mp: 283-284 °C. Eluent: ethyl acetate/petroleum ether =1: 3. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 10.83 (s, 1H), 8.06 (s, 1H), 7.61 (s, 1H), 7.25-7.05 (m, 3H), 7.05-7.03 (m, 1H), 6.39-6.34 (m, 2H), 4.20-4.16 (m, 2H), 4.05 (d, \(J = 9.5\) Hz, 1H), 3.45 (s, 3H), 3.26 (d, \(J = 9.6\) Hz, 1H), 3.20 (s, 1H), 3.13 (s, 1H), 2.05 (s, 3H), 1.94 (d, \(J = 8.4\) Hz, 1H), 1.77 (d, \(J = 8.4\) Hz, 1H), 1.28 (t, \(J = 7.1\) Hz, 3H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 168.7, 168.2, 152.5, 143.3, 140.3, 140.0, 138.8, 136.8, 133.5, 132.7, 128.3, 127.5, 126.5, 124.3, 116.9, 110.1, 61.0, 46.4, 46.2, 46.0, 45.7, 45.5, 44.9, 25.5, 14.2. HRMS (ESI) calculated for C\(_{25}\)H\(_{27}\)N\(_2\)O\(_4\)S [M+H]\(^+\): 451.1686, found: 451.1684.
Methyl(1S,4R)-12-acetamido-9-phenyl-1,4,4a,14b-tetrahydro-9λ4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (13b).

Yield: 75%, 115 mg; white solid, mp: 273-274 °C. Eluent: ethyl acetate/petroleum ether =1: 3. \[^1\]H NMR (400 MHz, CDCl$_3$) $\delta$ 10.94 (s, 1H), 8.50 (s, 2H), 7.81 (s, 1H), 7.74 (d, $J = 5.0$ Hz, 3H), 7.27-7.23 (m, 2H), 6.83 (t, $J = 7.5$ Hz, 1H), 6.53-6.46 (m, 2H), 6.29 (d, $J = 7.8$ Hz, 1H), 4.57 (d, $J = 9.6$ Hz, 1H), 4.33-4.28 (m, 2H), 3.44 (d, $J = 9.6$ Hz, 1H), 3.30 (d, $J = 16.4$ Hz, 2H), 2.17 (s, 3H), 2.10 (d, $J = 8.4$ Hz, 1H), 1.88 (d, $J = 8.4$ Hz, 1H), 1.70 (s, 1H), 1.38 (t, $J = 7.1$ Hz, 3H). \[^{13}\]C NMR (100 MHz, CDCl$_3$) $\delta$ 168.9, 168.3, 153.3, 143.7, 140.2, 139.8, 139.3, 139.2, 137.5, 133.8, 132.8, 132.1, 130.7, 129.4, 129.2, 126.3, 126.0, 125.5, 117.6, 109.8, 61.0, 47.4, 46.6, 45.6, 45.5, 45.3, 25.5, 14.2. HRMS (ESI) calculated for C$_{30}$H$_{29}$N$_2$O$_4$S [M+H]$^+$: 513.1843, found: 513.1849.

(1S,4R)-9-Methyl-12-(trifluoromethyl)-1,4,4a,14b-tetrahydro-9λ4-1,4-methanotribenzo[c,e,g][1,2]thiazocine 9-oxide (14).

Yield: 44%, 51 mg; yellow solid, mp: 146-147 °C. Eluent: ethyl acetate/petroleum ether =1: 3. \[^1\]H NMR (400 MHz, CDCl$_3$) $\delta$ 7.29-7.18 (m, 3H), 7.05 (m, 2H), 6.97 (d, $J = 8.2$ Hz, 1H), 6.90 (s, 1H), 6.38-6.36 (m, 2H), 4.11 (d, $J = 9.7$ Hz, 1H), 3.43 (s, 3H), 3.31 (d, $J = 9.8$ Hz, 1H), 3.20 (s, 1H), 3.12 (s, 1H), 1.95 (d, $J = 8.5$ Hz, 1H), 1.77 (d, $J = 8.5$ Hz, 1H). \[^{13}\]C NMR (100 MHz, CDCl$_3$) $\delta$ 146.8, 143.5, 143.2, 140.0, 138.9, 136.4, 132.8, 132.7, 127.4, 126.6, 126.5 (q, $J = 262$ Hz), 125.4, 124.1, 122.7, 121.9, 119.9, 47.1, 46.1, 46.1, 45.9, 45.6, 44.9, 29.7. HRMS (ESI) calculated for C$_{21}$H$_{19}$F$_3$NOS [M+H]$^+$: 390.1134, found: 390.1137.
Methyl(1S,4R)-9-methyl-1,4,4a,14b-tetrahydro-9β,1,4-methanotribenzo[c,e,g][1,2]thiazocine-12-carboxylate 9-oxide (15).

Yield: 46%, 52 mg; white solid, mp: 190-189 °C. Eluent: ethyl acetate/petroleum ether =1: 3. 1H NMR (400 MHz, CDCl₃) δ 7.48 (d, J = 8.0 Hz, 1H), 7.40 (s, 1H), 7.31 (d, J = 5.9 Hz, 2H), 7.27 (d, J = 3.8 Hz, 1H), 7.10 (d, J = 8.0 Hz, 2H), 6.46-6.44 (m, 2H), 4.18 (d, J = 9.7 Hz, 1H), 3.81 (s, 3H), 3.52 (s, 3H), 3.42 (d, J = 9.7 Hz, 1H), 3.25 (d, J = 22.9 Hz, 2H), 2.04 (d, J = 8.4 Hz, 1H), 1.85 (d, J = 8.4 Hz, 1H). 13C NMR (100 MHz, CDCl₃) δ 167.0, 146.3, 145.4, 143.2, 140.1, 138.8, 136.7, 132.7, 128.2, 127.5, 126.5, 126.2, 126.1, 124.6, 124.3, 51.9, 47.5, 46.2, 45.9, 45.6, 44.9. HRMS (ESI) calculated for C₂₂H₂₂NO₃S [M+H]+: 380.1315, found: 380.1308.

Ethyl(1S,4R)-9-methyl-1,4,4a,14b-tetrahydro-9β,1,4-methanotribenzo[c,e,g][1,2]thiazocine-12-carboxylate 9-oxide (16).

Yield 65%, 77 mg; white solid, mp: 169-170 °C. Eluent: ethyl acetate/petroleum ether =1: 3. 1H NMR (400 MHz, CDCl₃) δ 7.50-7.48 (m, 1H), 7.40 (d, J = 1.7 Hz, 1H), 7.32-7.28 (m, 3H), 7.12-7.09 (m, 2H), 6.47-6.43 (m, 2H), 4.29-4.25 (m, 2H), 4.18 (d, J = 9.7 Hz, 1H), 3.52 (s, 3H), 3.41 (d, J = 9.7 Hz, 1H), 3.27 (s, 1H), 3.21 (s, 1H), 2.04 (d, J = 8.5 Hz, 1H), 1.85 (d, J = 8.5 Hz, 1H), 1.32 (t, J = 7.1 Hz, 3H). 13C NMR (100 MHz, CDCl₃) δ 166.6, 146.3, 145.2, 143.2, 140.1, 138.8, 136.7, 132.6, 128.6, 127.5, 126.5, 126.2, 126.0, 124.5, 124.3, 60.7, 47.4, 46.2, 45.94, 45.92, 45.6, 44.9, 14.3. HRMS (ESI) calculated for C₂₃H₂₄NO₃S [M+H]+: 394.1472, found: 394.1470.
Methyl(1S,4R)-9-ethyl-6-methyl-1,4,4a,14b-tetrahydro-9\(\lambda^4\)-1,4-methanotribenzo\[c,e,g\][1,2]thiazocine-13-carboxylate 9-oxide (17).

Yield: 82%, 100 mg; white solid, mp: 168-169 °C. Eluent: ethyl acetate/petroleum ether = 1: 3. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.76 (s, 1H), 7.57 (d, \(J = 8.1\) Hz, 1H), 7.10-7.07 (m, 2H), 6.87 (d, \(J = 7.9\) Hz, 1H), 6.73 (d, \(J = 8.2\) Hz, 1H), 6.44 (s, 2H), 4.23 (d, \(J = 9.6\) Hz, 1H), 3.81 (s, 3H), 3.75-3.63 (m, 1H), 3.54-3.48 (m, 1H), 3.35 (d, \(J = 9.6\) Hz, 1H), 3.26 (s, 3H), 2.25 (s, 3H), 2.08 (d, \(J = 8.5\) Hz, 1H), 1.86 (d, \(J = 8.4\) Hz, 1H), 1.67 (t, \(J = 7.2\) Hz, 3H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 167.3, 151.9, 143.9, 143.0, 139.9, 139.2, 139.1, 132.5, 128.2, 128.0, 127.9, 126.8, 125.8, 124.4, 123.5, 51.8, 50.7, 46.6, 46.5, 45.9, 45.8, 21.7, 7.4. HRMS (ESI) calculated for C\(_{24}\)H\(_{25}\)NO\(_3\)S \([M+H]^+\): 408.1628, found: 408.1635.

Ethyl(1S,4R)-9-Ethyl-6-methyl-1,4,4a,14b-tetrahydro-9\(\lambda^4\)-1,4-methanotribenzo\[c,e,g\][1,2]thiazocine-13-carboxylate 9-oxide (18).

Yield: 47%, 59.3 mg; white solid, mp: 166-167 °C. Eluent: ethyl acetate/petroleum ether = 1: 3. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.77 (s, 1H), 7.59-7.56 (m, 1H), 7.09 (d, \(J = 8.6\) Hz, 2H), 6.87 (d, \(J = 7.9\) Hz, 1H), 6.72 (d, \(J = 8.2\) Hz, 1H), 6.44 (s, 2H), 4.28-4.21 (m, 3H), 3.73-3.66 (m, 1H), 3.54-3.49 (m, 1H), 3.35 (d, \(J = 9.7\) Hz, 1H), 3.27 (s, 2H), 2.26 (s, 3H), 2.08 (d, \(J = 8.5\) Hz, 1H), 1.86 (d, \(J = 8.4\) Hz, 1H), 1.67 (t, \(J = 7.2\) Hz, 3H), 1.33 (t, \(J = 7.1\) Hz, 3H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 166.9, 151.8, 143.9, 143.0, 139.9, 139.1, 132.5, 128.2, 128.0, 127.8, 126.7, 125.7, 124.8, 123.5, 60.6, 50.7, 46.6, 46.5, 46.0, 45.8, 21.7, 14.3, 7.5. HRMS (ESI) calculated for C\(_{25}\)H\(_{28}\)NO\(_3\)S \([M+H]^+\): 422.1784, found: 422.1779.
(1S,4R)-9-ethyl-6-methyl-1,4,4a,14b-tetrahydro-9λ^4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carbonitrile 9-oxide (19).

Yield: 60%, 67 mg; white solid, mp: 183-184 °C. Eluent: ethyl acetate/petroleum ether =1: 3. ¹H NMR (400 MHz, CDCl₃) δ 7.33 (s, 1H), 7.17-7.14 (m, 1H), 7.09 (d, J = 8.4 Hz, 2H), 6.91 (d, J = 8.0 Hz, 1H), 6.74 (d, J = 8.1 Hz, 1H), 6.44 (q, J = 5.5 Hz, 2H), 4.25 (d, J = 9.7 Hz, 1H), 3.75-3.66 (m, 1H), 3.55-3.11 (m, 1H), 3.32-3.28 (m, 2H), 2.30 (s, 3H), 2.01 (d, J = 8.5 Hz, 1H), 1.99 (d, J = 8.6 Hz, 1H), 1.86 (d, J = 8.6 Hz, 1H), 1.66 (t, J = 7.3 Hz, 3H). ¹³C NMR (100 MHz, CDCl₃) δ 152.0, 143.6, 143.4, 140.5, 139.5, 139.4, 132.1, 130.7, 130.3, 128.1, 127.0, 126.7, 123.4, 119.9, 105.8, 50.8, 46.6, 46.3, 46.0, 45.7, 45.6, 21.7, 7.5. HRMS (ESI) calculated for C₂₃H₂₃N₂O₅ [M+H]⁺: 375.1526, found: 375.1497.

Methyl(1S,4R)-12-chloro-9-ethyl-6-methyl-1,4,4a,14b-tetrahydro-9λ^4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (20).

Yield: 65%, 86 mg; white solid, mp: 205-206 °C. Eluent: ethyl acetate/petroleum ether =1: 3. ¹H NMR (400 MHz, CDCl₃) δ 7.59 (s, 1H), 7.12-7.07 (m, 2H), 6.93 (d, J = 8.0 Hz, 1H), 6.77 (s, 1H), 6.43 (s, 2H), 4.23 (d, J = 9.6 Hz, 1H), 3.84 (s, 3H), 3.74-3.68 (m, 1H), 3.55-3.50 (m, 1H), 3.27 (d, J = 8.3 Hz, 2H), 3.22 (s, 1H), 2.29 (s, 3H), 2.01 (d, J = 8.5 Hz, 1H), 1.85 (d, J = 8.5 Hz, 1H), 1.66 (t, J = 7.2 Hz, 3H). ¹³C NMR (100 MHz, CDCl₃) δ 166.2, 151.7, 143.7, 143.3, 139.5 139.4, 137.7, 132.1, 131.7, 130.0, 128.2, 128.1, 127.1, 123.4, 123.2, 52.1, 50.8, 46.7, 46.1, 45.9, 45.8, 21.7, 7.5.
HRMS (ESI) calculated for C_{24}H_{25}ClNO_{3}S [M+H]^+: 442.1238, found: 442.1234.

Methyl(1S,4R)-9-ethyl-12-fluoro-6-methyl-1,4,4a,14b-tetrahydro-9\lambda^4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (21).

Yield: 85%, 108 mg; white solid, mp: 171-172 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3. \textbf{1H NMR (400 MHz, CDCl}_3) \delta 7.62 (d, J = 8.3 Hz, 1H), 7.12-7.07 (m, 2H), 6.92 (d, J = 7.9 Hz, 1H), 6.46 (d, J = 12.2 Hz, 3H), 4.22 (d, J = 9.6 Hz, 1H), 3.84 (s, 3H), 3.73-3.68 (m, 1H), 3.55-3.50 (m, 1H), 3.26 (t, J = 10.2 Hz, 3H), 2.28 (s, 3H), 2.04 (d, J = 8.5 Hz, 1H), 1.86 (d, J = 8.5 Hz, 1H), 1.65 (t, J = 7.3 Hz, 3H). \textbf{13C NMR (100 MHz, CDCl}_3) \delta 165.3, 160.7 (d, J = 257 Hz), 153.5, 143.9, 143.3, 139.7, 139.3, 135.0, 132.1, 129.8, 128.2, 126.9, 123.4, 113.9 (d, J = 22 Hz), 112.3 (d, J = 19 Hz), 52.0, 50.8, 46.9, 45.9, 45.8, 45.8, 45.7, 21.7, 7.5. HRMS (ESI) calculated for C_{24}H_{25}FNO_{3}S [M+H]^+: 426.1534, found: 426.1510.

Methyl(1S,4R)-9-ethyl-6,12-dimethyl-1,4,4a,14b-tetrahydro-9\lambda^4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (22).

Yield: 71%, 90 mg; white solid, mp: 207-208 °C. Eluent: ethyl acetate/petroleum ether = 1 : 3. \textbf{1H NMR (400 MHz, CDCl}_3) \delta 7.65 (s, 1H), 7.11-7.09 (m, 2H), 6.88 (d, J = 8.0 Hz, 1H), 6.56 (s, 1H), 6.43 (s, 2H), 4.21 (d, J = 9.6 Hz, 1H), 3.80 (s, 3H), 3.73-3.26 (m, 1H), 3.54-3.49 (m, 1H), 3.30-3.24 (m, 3H), 2.36 (s, 3H), 2.27 (s, 3H), 2.05 (d, J = 8.4 Hz, 1H), 1.84 (d, J = 8.4 Hz, 1H), 1.66 (t, J = 7.3 Hz, 3H). \textbf{13C NMR}
(100 MHz, CDCl$_3$) δ 168.2, 150.8, 144.1, 142.9, 139.8, 139.1, 138.7, 135.9, 132.5, 129.3, 129.0, 128.1, 126.7, 123.6, 123.5, 51.5, 50.8, 46.8, 46.0, 45.9, 45.8, 45.7, 21.7, 21.3, 7.6. **HRMS (ESI)** calculated for C$_{25}$H$_{27}$NO$_3$S [M+H]$^+$: 422.1785, found: 422.1770.

![Chemical structure](Image)

Methyl-6,9-dimethyl-1,4,4$\alpha$,14$\beta$-tetrahydro-9$\lambda^4$-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (23).

Yield 66%, 78 mg; white solid; mp: 199-200 °C. Eluent: ethyl acetate/petroleum ether =1: 2. **$^1$H NMR (400 MHz, CDCl$_3$)** δ 7.75 (s, 1H), 7.60-7.58 (m, 1H), 7.16 (d, $J$ = 8.2 Hz, 1H), 7.07 (s, 1H), 6.88 (d, $J$ = 8.0 Hz, 1H), 6.78 (d, $J$ = 8.0 Hz, 1H), 6.47-6.41 (m,2H), 4.11 (d, $J$ = 9.6 Hz, 1H), 3.81 (s, 3H), 3.48 (s, 3H), 3.35 (d, $J$ = 9.6 Hz, 1H), 3.27 (s, 2H), 2.26 (s, 3H), 2.07 (d, $J$ = 8.4 Hz, 1H), 1.87 (d, $J$ = 8.6 Hz, 1H). **$^{13}$C NMR (100 MHz, CDCl$_3$)** δ 167.3, 151.4, 143.4, 143.3, 140.1, 139.5, 138.7, 133.7, 128.2, 128.0, 127.9, 126.9, 125.3, 124.8, 124.1, 51.8, 46.8, 46.2, 46.1, 45.8, 45.7, 45.1, 21.7. **HRMS (ESI)** calculated for C$_{23}$H$_{24}$NO$_3$S [M+H]$^+$: 394.1471, found: 394.1473.

![Chemical structure](Image)

Methyl-6-chloro-9-methyl-1,4,4$\alpha$,14$\beta$-tetrahydro-9$\lambda^4$-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (24)
Yield 52%, 65 mg; white solid; mp: 200-201 °C. Eluent: ethyl acetate/petroleum ether =1: 2. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.76 (s, 1H), 7.62 (d, \(J = 8.0\) Hz, 1H), 7.27-7.24 (m, 2H), 7.08 (d, \(J = 8.4\) Hz, 1H), 6.79 (d, \(J = 8.2\) Hz, 1H), 6.48-6.42 (m, 2H), 4.12 (d, \(J = 9.6\) Hz, 1H), 3.83 (s, 3H), 3.50 (s, 3H), 3.36 (d, \(J = 9.6\) Hz, 1H), 3.26 (d, \(J = 16.0\)Hz, 2H), 2.04 (d, \(J = 8.8\)Hz, 1H), 1.89 (d, \(J = 8.6\) Hz, 1H). \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 167.0, 150.8, 145.8, 140.3, 139.1, 138.9, 138.7, 135.2, 128.2, 127.9, 127.9, 126.5, 125.3, 125.3, 51.9, 47.0, 46.3, 46.1, 46.0, 45.7, 45.2. HRMS (ESI) calculated for C\(_{22}\)H\(_{21}\)ClNO\(_3\)S [M+H]\(^+\): 414.0925, found:414.0927.
3. General procedure for the oxidation reaction of bridged heterocycles 3a.

![Reaction Scheme]

To a stirred solution of 3a (75.8 mg, 0.20 mmol) in DCM (3.0 mL) at 0 °C was added \( m \)-chloroperbenzoic acid (98.7 mg, 0.40 mmol), and the resulting light yellow solution was kept stirring for 12 h at room temperature. After diluting with DCM, the reaction was quenched with 1 M aq. KOH solution. The water layer was extracted with DCM and the combined organic layers were washed with brine, dried over \( \text{Na}_2\text{SO}_4 \), and concentrated in vacuo. The residue was purified by column chromatography (PE/EA = 4:1) to give compound 26 as a yellow solid.

**Methyl(2S,13R)-7-methyl-1a,2,2a,12b,13,13a-hexahydro-7\( \lambda \)-2,13-methanobenzo[c]benzo[g]oxireno[2',3':4,5]benzo[1,2-e][1,2]thiazocine-11-carboxylate 7-oxide (26)**

Yield: 71%, 55.8 mg; yellow solid, mp: 186-187 °C. Eluent: ethyl acetate/petroleum ether = 1 : 5. ¹H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.01 (d, \( J \) = 1.2 Hz, 1H), 7.88-7.86 (m, 2H), 7.59 (d, \( J \) = 8.4 Hz, 1H), 7.22-7.18 (m, 1H), 7.11-7.07 (m, 1H), 6.58 (d, \( J \) = 7.9 Hz, 1H), 4.12 (d, \( J \) = 9.2 Hz, 1H), 3.99 (d, \( J \) = 9.2 Hz, 1H), 3.90 (s, 3H), 3.53-3.52 (m, 1H), 3.41-3.40 (m, 1H), 3.09 (s, 3H), 3.03 (s, 1H), 2.62 (s, 1H), 1.62-1.58 (m, 2H).

¹³C NMR (100 MHz, CDCl\(_3\)) \( \delta \) 165.1, 152.8, 140.3, 139.5, 136.8, 133.5, 132.6, 130.6, 130.1, 129.4, 128.5, 127.3, 124.9, 52.8, 52.1, 51.7, 46.4, 46.1, 45.4, 44.8, 42.3, 23.9.

HRMS (ESI) calculated for C\(_{22}\)H\(_{22}\)NO\(_4\)S [M+H]\(^+\): 396.1264, found: 396.1241.

Bromine (119.8 mg, 0.75 mmol) in DCM (3.0 mL) was added to a solution of compound 3a (57.0 mg, 0.15 mmol) in DCM (3.0 mL) at 0 °C. The reaction was kept stirring for 3 h at room temperature and then quenched with Na$_2$S$_2$O$_3$ solution. The reaction was extracted with DCM. The aqueous layer was washed with DCM and brine, dried over anhydrous MgSO$_4$, and solvent was removed under reduced pressure. The obtained residue was purified by column chromatography (PE/EA = 3:1) to give product 24 (50.7 mg, 55% yield) as a white solid.

Methyl(1S,4R)-8-bromo-9-methyl-1,4,4a,14b-tetrahydro-9λ4-1,4-methanotribenzo[c,e,g][1,2]thiazocine-13-carboxylate 9-oxide (27)

Yield: 54%, 49 mg; white solid, mp: 157-158 °C. Eluent: ethyl acetate/petroleum ether 1:4. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.90 (d, $J$ = 1.7 Hz, 1H), 7.64 (d, $J$ = 1.3 Hz, 1H), 7.39-7.33 (m, 2H), 7.19 (t, $J$ = 8.5 Hz, 2H), 4.67 (t, $J$ = 3.8 Hz, 1H), 4.58 (d, $J$ = 9.8 Hz, 1H), 4.29 (s, 1H), 4.19 (d, $J$ = 9.9 Hz, 1H), 3.82 (s, 3H), 3.80 (s, 3H), 3.00-2.97 (m, 2H), 2.46 (d, $J$ = 11.2 Hz, 1H), 2.31 (d, $J$ = 10.9 Hz, 1H). $^{13}$C NMR (100 MHz, CDCl$_3$) δ 165.8, 149.7, 140.0, 138.9, 135.4, 133.1, 131.8, 127.4, 126.4, 126.3, 125.3, 123.5, 122.0, 59.7, 59.5, 52.2, 51.2, 49.5, 48.0, 45.4, 34.5. HRMS (ESI) calculated for C$_{22}$H$_{21}$Br$_3$NO$_3$S [M+H]$^+$: 615.8714, found: 615.8720.
5. $^1$H and $^{13}$C NMR spectra of all new compounds (S23-S51)

$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 3a

$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 3a
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 3b

$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 3b
$^{1}H$ NMR spectrum (400 MHz, CDCl$_{3}$) of 4a

$^{13}C$ NMR spectrum (100 MHz, CDCl$_{3}$) of 4a
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 4b
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 4b
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 5a
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 5a
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 5b

$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 5b
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 6

$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 6
$^{1}$H NMR spectrum (400 MHz, CDCl$_3$) of 7

$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 7
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 8
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 8
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 9

$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 9
\(^1\)H NMR spectrum (400 MHz, CDCl\(_3\)) of 10a

\(^{13}\)C NMR spectrum (100 MHz, CDCl\(_3\)) of 10a
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 10b
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 10b
$^{1}H$ NMR spectrum (400 MHz, CDCl$_3$) of 11

$^{13}C$ NMR spectrum (100 MHz, CDCl$_3$) of 11
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 12
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 12
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 13a

$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 13a
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 13b
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 13b
\textsuperscript{1}H NMR spectrum (400 MHz, CDCl\textsubscript{3}) of 14

\textsuperscript{13}C NMR spectrum (100 MHz, CDCl\textsubscript{3}) of 14
$^{1}H$ NMR spectrum (400 MHz, CDCl$_3$) of 15

$^{13}C$ NMR spectrum (100 MHz, CDCl$_3$) of 15
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 16
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 16
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 17

$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 17
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 18
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 18
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 19
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 19
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 20
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 20
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 21
$^{13}$CNMR spectrum (100 MHz, CDCl$_3$) of 21
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 22
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 22

$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 23
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 23
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 24
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 24
$^1$H NMR spectrum (400 MHz, CDCl$_3$) of 26
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 26
$^{1}$H NMR spectrum (400 MHz, CDCl$_3$) of 27
$^{13}$C NMR spectrum (100 MHz, CDCl$_3$) of 27
6. X-ray ORTEP illustration of compound 3a.
Crystal data and structure refinement for compound 3a.

<table>
<thead>
<tr>
<th>Bond precision:</th>
<th>C-C - 0.0032 Å</th>
<th>Wavelength-0.71073</th>
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</thead>
<tbody>
<tr>
<td>Cell:</td>
<td>a=19.5977(12)</td>
<td>b=8.1238(4)</td>
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<tr>
<td>alpha=90</td>
<td>beta=90.182(5)</td>
<td>gamma=90</td>
</tr>
<tr>
<td>Temperature:</td>
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<tr>
<td>Volume</td>
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<td>3709.5(3)</td>
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<tr>
<td>Space group</td>
<td>C 2/c</td>
<td>C 2/c</td>
</tr>
<tr>
<td>Hall group</td>
<td>-C 2yc</td>
<td>-C 2yc</td>
</tr>
<tr>
<td>Moisture formula</td>
<td>C22 H21 N O3 S</td>
<td>?</td>
</tr>
<tr>
<td>Sum formula</td>
<td>C22 H21 N O3 S</td>
<td>C22 H21 N O3 S</td>
</tr>
<tr>
<td>Mr</td>
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<tr>
<td>Dx,g cm-3</td>
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<td>1.359</td>
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<tr>
<td>Mu (mm-1)</td>
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<tr>
<td>F000</td>
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<td>h,k,lmax</td>
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<tr>
<td>Nref</td>
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<td>3319</td>
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<td>0.765,1.000</td>
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<tr>
<td>Tm'n</td>
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Correction method- # Reported T Limits: Tmin-0.765 Tmax-1.000
AbsCorr - MULTI-SCAN

Data completeness= 0.955     Theta(max)= 25.593
R(reflections)= 0.0412( 2968) WR2(reflections)= 0.1121( 3319)
S = 1.007                  Npar= 244
7. X-ray ORTEP illustration of compound **27 (S46-S47)**.
Crystal data and structure refinement for compound 24.

<table>
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<tr>
<td>Hall group</td>
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<td>-P 1</td>
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<tr>
<td>Moiety formula</td>
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<td>?</td>
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<tr>
<td>Sum formula</td>
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<td>C23 H22 Br3 Cl2 N O3 S</td>
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<tr>
<td>Mu (mm⁻¹)</td>
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<tr>
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<td>692.0</td>
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<tr>
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Correction method: # Reported T Limits: Tmin-0.026 Tmax-1.000
AbsCorr = MULTI-SCAN

Data completeness= 0.985       Theta(max)= 25.098
R(reflections)= 0.1666( 2341)   WR2(reflections)= 0.3351( 4471)
S = 1.094          Npar= 299