Supporting Information

Tandem Michael addition/isocyanide insertion into C–C bond: A novel access to 2-acylpyrroles and medium-ring fused pyrroles

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Table of contents

I. General information .............................................................................................................S2
II. Synthetic procedure and analytical data of compounds 3 and 6 .................................S2
III. Crystal data and ORTEP drawing of compound 6a..................................................S12
VI. Copies of $^1$H NMR and $^{13}$C NMR spectra of compounds 3 and 6 .....................S13
I. General information

All reagents were commercial and used without further purification, unless otherwise indicated. Chromatography was carried on flash silica gel (300−400 mesh). All reactions were monitored by TLC, which was performed on precoated aluminum sheets of silica gel 60 (F254). Melting points were uncorrected. The $^1$H NMR and $^{13}$C NMR spectra were determined at 25°C on a 500 MHz and 125 MHz, respectively, and TMS as internal standard. All shifts are given in ppm. High-resolution mass spectra (HRMS) were obtained using a Bruker microTOF II focus spectrometer (ESI). The substrates 1 and 5 were prepared by the similar method as reported references.1,2

II. Synthetic procedures/analytical data of compounds 3 and 6.

**General procedure for the synthesis of 3a-u (taking 3a as an example):** To the mixture of 1a (171.0 mg, 1.0 mmol), tosylmethyl isocyanide (215 mg, 1.1 mmol) and CuCl (10 mg, 0.1 mmol) in CH$_3$CN (5 mL) in ice-bath, a solution of DBU (0.165 mL, 1.1 mmol) in CH$_3$CN (2 mL) was added dropwise in 5 min under stirring. Then the temperature was allowed to rise to room temperature and the reaction was monitored by TLC. After the substrate 1a was consumed, the resulting mixture was poured into brine (20 mL), and extracted with EtOAc (3×10 mL). The combined organic layers were dried over anhydrous MgSO$_4$, and concentrated under reduced pressure. Purification by flash column chromatography on silica gel (eluent: petroleum ether/EtOAc = 6:1) to give 3a (153 mg, 73%) and 4a (40 mg, 24%), respectively.

3a, 2-Acetyl-4-phenyl-1H-pyrrole-3-carbonitrile. White solid. m.p. 112–114 °C. $^1$H NMR (CDCl$_3$, 500 Hz) δ 2.61 (s, 3H), 7.36 (t, $J = 8.0$ Hz, 1H), 7.43 (t, $J = 8.0$ Hz, 2H), 7.49 (d, $J = 2.0$ Hz, 1H), 7.64 (d, $J = 7.5$ Hz 2H), 7.84 (d, $J = 2.0$ Hz, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), δ 22.0, 97.6, 114.8, 116.5, 126.7, 127.7, 128.3, 129.0, 129.3, 131.0, 166.5. HRMS (ESI-TOF) Calcd for C$_{13}$H$_{11}$N$_2$O$^+$ ([M+H]$^+$) 211.0866. Found 211.0861.

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3b, 2-Acetyl-4-(benzo[d][1,3]dioxol-5-yl)-1H-pyrrole-3-carbonitrile. Light yellow solid. m.p. 165–167 °C. 
$^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 2.62 (s, 3H), 6.01 (s, 2H), 6.88 (d, $J = 8.0$ Hz, 1H), 7.07 (d, $J = 2.0$ Hz, 1H), 7.07–7.14 (dd, $J = 8.0$ Hz, $J = 2.0$ Hz, 1H), 7.04 (s, 1H), 7.83 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 22.0, 97.6, 101.3, 107.3, 108.8, 114.8, 116.0, 120.6, 124.9, 127.5, 129.1, 147.8, 148.2, 166.4. HRMS (ESI-TOF) Calcd for C$_{14}$H$_{11}$N$_2$O$_3$ $^{+}$ ([M+H]$^+$) 255.0764 Found 255.0768.

3c, 2-Acetyl-4-p-tolyl-1H-pyrrole-3-carbonitrile. White solid. m.p. 116–118 °C. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 2.39 (s, 3H), 2.62 (s, 3H), 7.25 (d, $J = 8.0$ Hz, 2H), 7.46 (s, 1H), 7.53 (d, $J = 8.0$ Hz, 2H), 7.84 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 21.2, 22.0, 97.5, 114.9, 116.0, 126.6, 127.6, 128.0, 129.3, 129.6, 138.2, 166.4. HRMS (ESI-TOF) Calcd for C$_{14}$H$_{13}$N$_2$O$^+$ ([M+H]$^+$) 225.1022, Found 225.1019.

3d, 2-Acetyl-4-(4-methoxyphenyl)-1H-pyrrole-3-carbonitrile. White solid. m.p. 145–147 °C. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 2.61 (s, 3H), 3.84 (s, 3H), 6.96 (d, $J = 8.5$ Hz, 2H), 7.42 (s, 1H), 7.57 (d, $J = 8.5$ Hz, 2H), 7.82 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 22.0 55.3, 87.6, 114.4, 115.0, 115.7, 123.5, 127.5, 128.0, 129.1, 159.7, 166.5. HRMS (ESI-TOF) Calcd for C$_{14}$H$_{13}$N$_2$O$_2$ $^{+}$ ([M+H]$^+$) 241.0972, Found 241.0970.
3e, 2-Acetyl-4-(4-chlorophenyl)-1H-pyrrole-3-carbonitrile. White solid. m.p. 182–184 °C. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 2.63 (s, 3H), 7.41 (d, $J$ = 8.5 Hz, 2H), 7.50 (s, 1H), 7.57 (d, $J$ = 8.5 Hz, 2H), 7.85 (d, $J$ = 2.0 Hz, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 22.1, 94.5, 114.7, 116.6, 127.8, 128.0, 128.2, 129.3, 134.3, 166.4. HRMS (ESI-TOF) Calcd for C$_{13}$H$_9$ClN$_2$O$^+$ ([M+Na]$^+$) 267.0296, Found 267.0285.

3f, 2-Acetyl-4-(4-bromophenyl)-1H-pyrrole-3-carbonitrile. White solid. m.p. 165–167 °C. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 2.64 (s, 3H), 7.51 (s, 1H), 7.52 (d, $J$ = 8.5 Hz, 2H), 7.57 (d, $J$ = 8.5 Hz, 2H), 7.86 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 22.0, 97.4, 114.6, 116.6, 122.4, 127.8, 128.2, 129.3, 129.9, 132.2, 166.3. HRMS (ESI-TOF) Calcd for C$_{13}$H$_{10}$BrN$_2$O$^+$ ([M+H]$^+$) 288.9971, Found 288.9980.

3g, 2-Acetyl-4-(furan-2-yl)-1H-pyrrole-3-carbonitrile. White solid. m.p. 154–156 °C. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 2.62 (s, 3H), 6.49 (s, 1H), 6.88 (s, 1H), 7.44 (s, 1H), 7.54 (s, 1H), 7.82 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 22.0, 95.6, 107.3, 111.6, 114.3, 114.9, 120.1, 127.2, 142.0, 145.7, 166.3. HRMS (ESI-TOF) Calcd for C$_{11}$H$_9$N$_2$NaO$_2$$^+$ ([M+Na]$^+$) 223.0478, Found 223.0467.
3h, 2-Acetyl-4-(thiophen-2-yl)-1H-pyrrole-3-carbonitrile. Light pink solid. m.p. 162–164 °C. ¹H NMR (CDCl₃, 500 Hz) δ 2.62 (s, 3H), 7.10 (dd, J = 5.0 Hz, J = 3.5 Hz, 1H), 7.30 (dd, J = 5.0 Hz, J = 1.0 Hz, 1H), 7.47 (s, 1H), 7.52 (dd, J = 4.0 Hz, J = 1.0 Hz, 1H), 7.83 (s, 1H). ¹³C NMR (CDCl₃, 125 Hz), δ 22.0, 97.2, 114.5, 115.9, 123.1, 125.1, 125.3, 127.5, 128.1, 132.7, 166.3. HRMS (ESI-TOF) Caled for C₁₁H₉N₂O₂S⁺ ([M+H]+) 217.0430, Found 217.0424.

3i, 2-Acetyl-4-styryl-1H-pyrrole-3-carbonitrile. Light yellow solid. m.p. 167–169 °C. ¹H NMR (CDCl₃, 500 Hz) δ 2.60 (s, 3H), 6.93 (d, J = 16.5 Hz, 1H), 7.29 (t, J = 8.0 Hz, 1H), 7.30 (d, J = 16.5 Hz, 1H), 7.36 (t, J = 8.0 Hz, 2H), 7.41 (s, 1H), 7.49 (d, J = 8.0 Hz, 2H), 7.78 (s, 1H). ¹³C NMR (CDCl₃, 125 Hz), δ 22.0, 97.1, 114.8, 117.2, 117.3, 126.5, 127.5, 128.2, 128.7, 131.0, 136.5, 166.3. HRMS (ESI-TOF) Caled for C₁₅H₁₃N₂O⁺ ([M+H]+) 237.1022, Found 237.1022.

3j, 2-Acetyl-4-cyclohexyl-1H-pyrrole-3-carbonitrile. White solid. Light yellow oil. ¹H NMR (CDCl₃, 500 Hz) δ 1.21–1.27 (m, 1H), 1.30–1.44 (m, 4H), 1.74 (d, J = 14.0 Hz, 1H), 1.82 (d, J = 14.0 Hz, 2H), 1.99 (d, J = 14.0 Hz, 2H), 2.53 (s, 3H), 2.53–2.58 (m, 1H), 7.05 (s, 1H), 7.70 (s, 1H). ¹³C NMR (CDCl₃, 125 Hz), δ 22.0, 25.8, 26.2, 33.1, 35.5, 98.5, 114.7, 115.3, 126.4, 135.8, 166.6. HRMS (ESI-TOF) Caled for
C_{13}H_{17}N_{2}O^{+} ([M+H]^{+}) 217.1355, Found 217.1340.

3k, 4-tert-Butyl-2-acetyl-1H-pyrrole-3-carbonitrile. Colorless oil. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 1.36 (s, 9H), 2.55 (s, 3H), 7.06 (s, 1H), 7.74 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 22.0, 28.6, 31.3, 97.4, 114.9, 115.6, 128.0, 139.4, 166.6. HRMS (ESI-TOF) Calcd for C$_{11}$H$_{15}$N$_2$O$^+$ ([M+H]$^+$) 191.1179, Found 191.1169.

3l, 2-Benzoyl-4-(4-methoxyphenyl)-1H-pyrrole-3-carbonitrile. White solid. m.p. 126–128 °C. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 3.84 (s, 3H), 6.96 (d, $J$ = 9.0 Hz, 2H), 7.47 (d, $J$ = 2.5 Hz, 1H), 7.56–7.60 (m, 4H), 7.70 (t, $J$ = 7.5 Hz, 1H), 7.77 (s, 1H), 7.78 (d, $J$ = 7.5 Hz, 2H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 55.3, 97.3, 114.4, 115.1, 117.5, 123.5, 128.0, 128.8, 128.9, 129.7, 129.8, 131.1, 133.5, 159.6, 166.4. HRMS (ESI-TOF) Calcd for C$_{19}$H$_{14}$N$_2$NaO$_2$$^+$ ([M+Na]$^+$) 325.0947, Found 325.0941.

3m, Methyl 2-acetyl 4-(4-methoxyphenyl)-1H-pyrrole-3-carboxylate. White solid. m.p. 134–136 °C. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 2.59 (s, 3H), 3.77 (s, 3H), 3.83 (s, 3H), 6.91 (d, $J$ = 8.5 Hz, 2H), 7.27 (s, 1H), 7.40 (d, $J$ = 8.5 Hz, 2H), 7.93 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 22.0, 51.3, 55.3, 113.4, 118.0, 125.4, 125.5, 129.2, 130.2, 159.1, 164.2, 167.3. HRMS (ESI-TOF) Calcd for C$_{15}$H$_{15}$NNaO$_4$$^+$ ([M+Na]$^+$) 296.0893, Found 296.0897.
3n, 2,3-Diacetyl-4-(4-methoxyphenyl)pyrrole. Yellowish solid, m.p. 138–140 °C. $^1$H NMR (CDCl$_3$ 500 Hz) δ 2.36 (s, 3H), 2.59 (s, 3H), 3.83 (s, 3H), 6.91 (d, $J = 7.5$ Hz, 2H), 7.21 (s, 1H), 7.33 (d, $J = 7.5$ Hz, 2H), 7.91 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), δ 22.1, 28.7, 55.2, 113.5, 118.6, 124.8, 125.6, 127.0, 128.7, 130.2, 159.1, 167.4, 194.1. HRMS (ESI-TOF) Calcd for C$_{15}$H$_{15}$NNaO$_3^+$ ([M+Na]$^+$) 280.0944, Found 280.0951.

3o, 2,3-Diacetyl-4-phenylpyrrole. White solid, m.p. 93–95 °C. $^1$H NMR (CDCl$_3$, 500 Hz) δ 2.36 (s, 3H), 2.61 (s, 3H), 7.26 (s, 1H), 7.33–7.41 (m, 5H), 7.93 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), δ 22.1, 28.7, 119.1, 124.9, 127.5, 128.0, 129.0, 129.1, 133.3, 167.5, 194.1. HRMS (ESI-TOF) Calcd for C$_{14}$H$_{13}$NNaO$_2^+$ ([M+Na]$^+$) 250.0838, Found 250.0841.

3p, (4-(Methoxyphenyl)-1H-pyrrole-2,3-diyl)bis(phenylmethanone). White solid. m.p. 186–188 °C. $^1$H NMR (CDCl$_3$, 500 Hz) δ 3.76 (s, 3H), 6.80 (d, $J = 8.5$ Hz, 2H), 7.14 (d, $J = 8.5$ Hz, 2H), 7.15 (d, $J = 8.5$ Hz, 2H), 7.23 (d, $J = 2.5$ Hz, 1H), 7.27–7.29 (m, 4H), 7.32–7.35 (m, 1H), 7.37–7.41 (m, 3H), 9.59 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), δ 55.2, 113.9, 121.9, 125.7, 127.6, 127.9, 128.0, 128.5, 129.0, 129.5, 131.0, 131.8, 132.6, 138.7, 139.2, 158.7, 186.7, 194.2. HRMS (ESI-TOF) Calcd for C$_{25}$H$_{19}$NNaO$_3^+$ ([M+Na]$^+$) 404.1257, Found 404.1257.
3q, (4-(p-Tolyl)-1H-pyrrole-2,3-diyl)bis(phenylmethanone). White solid. m.p. 179–181 °C. $^1$H NMR (CDCl$_3$, 500 Hz) δ 2.28 (s, 3H), 7.06 (d, $J = 8.0$ Hz, 2H), 7.14–7.16 (m, 4H), 7.22–7.25 (m, 3H), 7.33 (t, $J = 8.0$ Hz, 2H), 7.38–7.42 (m, 4H), 9.89 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), δ 21.0, 122.1, 127.7, 127.9, 128.0, 128.1, 128.3, 128.5, 129.0, 129.1, 130.2, 130.8, 131.8, 132.5, 136.6, 138.6, 139.1, 186.7, 194.1. HRMS (ESI-TOF) Calcd for C$_{25}$H$_{19}$NNaO$_2^+$ ([M+Na]$^+$) 388.1308, Found 388.1310.

3r, (4-Phenyl-1H-pyrrole-2,3-diyl)bis(phenylmethanone). White solid. m.p. 150–152 °C. $^1$H NMR (CDCl$_3$, 500 Hz) δ 7.15 (t, $J = 7.5$ Hz, 4H), 7.21 (d, $J = 7.5$ Hz, 1H), 7.24–7.29 (m, 3H), 7.33 (dd, $J = 7.0$, 3.5 Hz, 4H), 7.39–7.43 (m, 4H), 9.70 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), δ 122.1, 126.9, 127.9, 128.1, 128.2, 128.3, 128.4, 128.5, 129.7, 129.1, 131.0, 131.9, 132.6, 133.2, 138.6, 139.1, 186.7, 194.0. HRMS (ESI-TOF) Calcd for C$_{24}$H$_{17}$NNaO$_2^+$ ([M+Na]$^+$) 374.1151, Found 374.1157.

3s, (4-(Methylbenzoyl)-1H-pyrrole-2,3-diyl)bis(phenylmethanone). White solid. m.p. 162–164 °C. $^1$H NMR (CDCl$_3$, 500 Hz) δ 2.37 (s, 3H), 7.10 (t, $J = 7.5$ Hz, 2H), 7.17 (t, $J = 7.5$ Hz, 4H), 7.29–7.35 (m, 2H), 7.39 (d, $J = 3.0$ Hz, 1H), 7.42 (d, $J = 8.0$ Hz, 2H), 7.51 (d, $J = 7.5$ Hz, 2H), 7.65 (d, $J = 8.0$ Hz, 2H), 11.03 (s,
1H). $^1$H NMR (CDCl$_3$, 500 Hz) δ 7.11 (t, $J = 8.0$ Hz, 2H), 7.19 (t, $J = 8.0$ Hz, 2H), 7.33–7.38 (m, 4H), 7.41–7.47 (m, 3H), 7.48 (d, $J = 7.0$ Hz, 2H), 7.69 (d, $J = 8.5$ Hz, 2H), 10.9, (s, 1H). $^{13}$C NMR (DMSO-$d_6$, 125 Hz), δ 125.9, 128.1, 128.5, 128.7, 128.8, 128.9, 130.9, 131.0, 132.5, 132.9, 136.4, 137.5, 138.0, 138.1, 187.0, 188.1, 192.8. HRMS (ESI-TOF) Calcd for C$_{25}$H$_{17}$ClNO$_3$ $^+ ([M+H]^+)$ 414.0891, Found 414.0888.

3u, (4-(Chlorobenzoyl)-1H-pyrrole-2,3-diyl)bis(phenylmethanone). White solid. m.p. 161–163 °C. $^1$H NMR (CDCl$_3$, 500 Hz) δ 7.12 (t, $J = 8.0$ Hz, 2H), 7.19 (t, $J = 8.0$ Hz, 2H), 7.33–7.38 (m, 4H), 7.41–7.47 (m, 3H), 7.48 (d, $J = 7.0$ Hz, 2H), 7.69 (d, $J = 8.5$ Hz, 2H), 10.9, (s, 1H). $^{13}$C NMR (DMSO-$d_6$, 125 Hz), δ 125.9, 128.1, 128.5, 128.7, 128.8, 130.5, 130.9, 131.0, 132.5, 132.9, 136.4, 137.5, 138.0, 138.1, 187.0, 188.1, 192.8. HRMS (ESI-TOF) Calcd for C$_{25}$H$_{17}$ClNO$_3$ $^+ ([M+H]^+)$ 414.0891, Found 414.0888.

General procedure for the synthesis of 6 (taking 6a as an example): To the mixture of 5a (272.0 mg, 1.0 mmol) and tosylmethyl isocyanide 2a (215 mg, 1.1 mmol) in CH$_3$CN (10 mL) was added K$_2$CO$_3$ (207 mg, 1.5 mmol) in one portion at room temperature. The reaction mixture was then heated to reflux under stirring, and the reaction mixture was monitored by TLC. After the substrate 5a was consumed, the
resulting mixture was poured into brine ice (30 mL) under stirring and neutralized with diluted hydrochloric acid, extracted with EtOAc (3 x 10 mL). The combined organic layers were dried over anhydrous MgSO4, and concentrated under reduced pressure. Purification by flash column chromatography on silica gel (petroleum ether: EtOAc = 6:1) gave 6a (332 mg, 82%).

6a, 3-(Ethylthio)-6,7-dihydro-6,6-dimethyl-2-tosylcyclohepta[b]pyrrole-4,8(1H,5H)-dione. Yellowish solid, m.p. 139–141 °C. 1H NMR (CDCl3, 500 Hz) δ 1.01 (t, J = 7.5 Hz, 3H), 1.13 (s, 6H), 2.43 (s, 3H), 2.77 (q, J = 7.5 Hz, 2H), 2.86 (s, 2H), 2.88 (s, 2H), 7.33 (d, J = 8.0 Hz, 2H), 7.98 (d, J = 8.5 Hz, 2H), 10.2 (s, 1H). 13C NMR (CDCl3, 125 Hz), δ 13.8, 21.6, 29.0, 30.4, 31.5, 56.3, 58.4, 120.3, 128.4, 128.6, 129.6, 132.2, 136.6, 137.0, 145.3, 189.9, 193.6. HRMS (ESI-TOF) Calcd for C20H22NO4S2- ([M-H]−) 404.0996. Found 404.0994.

6b, 3-(Ethylthio)-6,7-dihydro-2-tosylcyclohepta[b]pyrrole-4,8(1H,5H)-dione. Yellowish solid, m.p. 140–142 °C. 1H NMR (CDCl3, 500 Hz) δ 1.02 (t, J = 7.5 Hz, 3H), 2.10 (m, 2H), 2.43 (s, 3H), 2.77 (q, J = 7.5 Hz, 2H), 2.88 (m, 4H), 7.33 (d, J = 8.0 Hz, 2H), 7.98 (d, J = 8.0 Hz, 2H), 10.3 (s, 1H). 13C NMR (CDCl3, 125 Hz), δ 13.8, 18.4, 21.7, 30.5, 42.0, 44.5, 120.8, 127.8, 128.8, 129.7, 131.6, 136.6, 137.6, 145.5, 191.1, 194.9. HRMS (ESI-TOF) Calcd for C18H18NO4S2- ([M-H]−) 376.0683. Found 376.0677.

6c, Ethyl 3-(ethylthio)-1,4,5,6,7,8-hexahydr-6,6-dimethyl-4,8-dioxycyclohepta[b]pyrrole-2-carboxylate. Yellowish solid, m.p. 98–100 °C. 1H NMR (CDCl3, 500 Hz) δ 1.15 (s, 6H), 1.20 (t, J = 7.5 Hz, 3H), 1.41 (t, J = 7.5 Hz, 3H), 2.88 (s, 2H), 2.92 (s, 2H), 2.97 (q, J = 7.0 Hz, 2H), 4.42 (q, J = 7.0 Hz, 2H), 10.0 (s,
$^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 14.3, 14.4, 29.1, 30.1, 31.7, 56.5, 58.5, 61.7, 124.6, 127.4, 128.5, 128.5, 131.9, 159.1, 190.1, 193.9. HRMS (ESI-TOF) Calcd for C$_{16}$H$_{20}$NO$_4$S$^-$ ([M-H]$^-$) 322.1119. Found 322.1090.

**6d.** Ethyl 3-(ethylthio)-1,4,5,6,7,8-hexahydri-4,8-dioxocyloheptal[b]pyrrole-2-carboxyate. Yellow oil. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 1.18 (t, $J$ = 7.5 Hz, 3H), 1.42 (t, $J$ = 7.5 Hz, 3H), 2.13 (m, 2H), 2.88 (m, 2H), 2.93 (m, 2H), 2.97 (q, $J$ = 7.5 Hz, 2H), 4.43 (q, $J$ = 7.5 Hz, 2H), 10.2 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 14.2, 21.5, 21.7, 25.2, 32.2, 37.7, 43.4, 117.7, 128.5, 129.7, 131.1, 133.2, 136.7, 137.2, 145.4, 190.7, 202.6. HRMS (ESI-TOF) Calcd for C$_{14}$H$_{16}$NO$_4$S$^-$ ([M-H]$^-$) 294.0806. Found 294.0801.

**6e.** 3-(Ethylthio)-2-tosyl-5,6,7,8-tetrahydro-1H-cycloocta[b]pyrrole-4,9-dione. White solid. m.p. 181–183 $^\circ$C. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 1.11 (t, $J$ = 7.5 Hz, 3H), 1.88 (br, 4H), 2.43 (s, 3H), 2.66 (br, 4H), 2.79 (q, $J$ = 7.5 Hz, 2H), 7.33 (d, $J$ = 8.0 Hz, 2H), 7.98 (d, $J$ = 8.0 Hz, 2H), 10.2 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 14.2, 21.5, 21.7, 25.2, 32.2, 37.7, 43.4, 117.7, 128.5, 129.7, 131.1, 133.2, 136.7, 137.2, 145.4, 190.7, 202.6. HRMS (ESI-TOF) Calcd for C$_{19}$H$_{22}$NO$_4$S$_2$ $^+$ ([M+H]$^+$) 392.0985. Found 392.0993.

**6f.** Ethyl 3-(ethylthio)-4,9-dioxo-4,5,6,7,8,9-hexahydro-1H-cycloocta[b]pyrrole-2-carboxylate. Colorless oil. $^1$H NMR (CDCl$_3$, 500 Hz) $\delta$ 1.18 (t, $J$ = 7.5 Hz, 3H), 1.42 (t, $J$ = 7.5 Hz, 3H), 1.89 (br, 4H), 2.68 (br, 4H), 2.88 (q, $J$ = 7.5 Hz, 2H), 4.42 (q, $J$ = 7.5 Hz, 2H), 10.04 (s, 1H). $^{13}$C NMR (CDCl$_3$, 125 Hz), $\delta$ 14.2, 14.6, 21.6, 25.4, 30.8, 37.6, 43.6, 61.6, 120.2, 128.2, 131.0, 133.1, 159.1, 190.8, 203.3. HRMS (ESI-TOF) Calcd for C$_{15}$H$_{20}$NO$_4$S$^+$ ([M+H]$^+$) 310.1108. Found 310.1099.
III. Crystal data and ORTEP drawing of compound 6a

6a: C$_{20}$H$_{23}$N$_1$O$_4$S$_2$, $M = 405.51$, monoclinic, space group P21/n, $a = 15.619(2)$, $b = 5.9270(8)$, $c = 22.055(3)$ Å, $V = 2003.3(5)$ Å$^3$, $\alpha = 90.0 \beta = 101.129(2)$, $\gamma = 90.00$, $Z = 4$, $T = 273(2)$ K, $F000 = 856$, 9573 reflections collected, 2366 unique, $R_1 = 0.0805$, $wR_2 = 0.1023$ ($I > 2\sigma(I)$).

![Fig 1. ORTEP diagram of 6a (30% probability displacement ellipsoids and all hydrogen atoms are omitted).](image-url)
VI. Copies of $^1$H NMR and $^{13}$C NMR spectra of compounds 3 and 6
STANDARD CARBON PARAMETERS

Archive directory: /export/home/ougy/vnmrsys/data
Sample directory:

Pulse Sequence: s2pul
Solvent: CDCl3
Ambient temperature
User: 1-26-87
File: p070
INOVA-500 "NERU500"

Relax. delay 6.500 sec
Pulse 45.0 degrees
Acc. time 1.800 sec
Width 31421.0 Hz
128 repetitions
OBSERVE C13, 129.6754666 MHz
DECOUPLE HO, 499.8059085 MHz
Power 40 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.5 Hz
FT size 131072
Total time 3 hr, 56 sec
STANDARD CARBON PARAMETERS

Archive directory: /export/home/cagy/vnmrs/ncrdata
Sample directory:

Pulse Sequence: zgip1
Solvent: CDC13
Ambient temperature
User: I=1,6-87
File: t091
INova-500 "Wenu500"

Relax. delay 0.500 sec
Pulse 45.0 degrees
Acq. time 1.250 sec
Sweep width 21442.0 Hz
5022 repetitions

Observe G13, 125.8754753 MHz
Decoupling ft, 499.9059059 MHz
Power 42 dB
Continuously on
WALTZ-16 modulated

Data Processing
Line broadening 1.5 Hz
FT size 131072

Total time 10 hr, 3 min, 7 sec
STANDARD PROTON PARAMETERS
Archive directory: /export/home/cryy/vvewsys/data
Sample directory:
Pulse Sequence: s2pu1
Solvent: CDCl3
Ambient temperature
file: p935

ID: "MEN506"
Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.992 sec
Width 0.008 Hz
8 Repetitions
OBSERVE: 400.0025906 MHz
DATA PROCESSING
FT size 65536
Total time 6 min, 23 sec
STANDARD CARBON PARAMETERS

Archive directory: /export/home/quy/vnmrsys/data
Sample directory:
Pulse Sequence: s2pul
Solvent: CDC13
Ambient temperature
User: 1-14-07
File: ph66
INOVAS-500 "HANG500"

Relax. delay 0.500 sec
Pulse 45.0 degrees
Acq. time 1.380 sec
Width 3121.8 Hz
350 repetitions.

RESOLVE C13, 125.675649 MHz
DECUPLE H1, 499.605005 MHz
Power 40 dB
continuously on

VALTE-16 modulated
DATA PROCESSING
Line broadening 1.5 Hz
FT size 151872
Total time 3 hr, 58 sec
STANDARD CARBON PARAMETERS

Archive directory: /export/home/pvuu/nmrsys/data
Sample directory:
Pulse Sequence: s2pul
Solvent: CDCl3
Ambient temperature
User: 1-14-07
File: 1552
INOVA-500 "MEN0590"

Relax. delay 0.500 sec
Pulse 45.0 degrees
Acq. time 1.300 sec
Width 33.013 8 Hz
256 repetitions

OBSEVE CL, 125.675 MHz
DECouple CL, 49.895 MHz
Power 42 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.5 Hz
FT size 131072
Total time 2 hr, 3 min, 31 sec

3f

220 200 180 160 140 120 100 80 60 40 20 0 ppm
STANDARD CARBON PARAMETERS

Archive directory: /export/home/omuy/wmsys/data
Sample directory:
Pulse Sequence: 2pul
Solvent: CDC13
Ambient temperature
User: L. LI
File: 3268
INNOVA 500 "RENOVIA"

Relax. delay 0.500 sec
Pulse 45.9 degrees
Acq. time 1.300 sec
Width 31421.8 Hz
4096 repetitions

ODDPROXY C13, 125.6754600 MHz
DECOUPLING H1, 499.8050915 MHz
Power 40 dB
continuously on
WALTZ=16 accumulated

DATA PROCESSING

Line broadening 1.5 Hz
FT size 121072
Total time 2 hr, 3 min, 31 sec

3j
STANDARD CARBON PARAMETERS

Archive directory: /export/home/owyy/vnmrsyndata
Sample directory:
Pulse Sequence: ezpul
Solvent: CDCl3
Ambient temperature
User: 1-14-37
File: 1977
INNOVA-500 "HEMUS500"

Relax. delay 0.500 sec
Pulse 5.0 deg
Acq. time 1.50 sec
Width 31421.6 Hz
4996 repetitions
OBSERVE C13, 125.6754684 MHz
DECOUPLE H1, 499.6605939 MHz
Power 40 dB
continuously on
WALTZ-16 modulated
Data PROCESSING
Line broadening 1.5 Hz
FT size 121672
Total time 2 hr, 3 min, 31 sec

[Chemical spectrum image]
STANDARD PROTON PARAMETERS

Archive directory: /export/home/pogy/vnmrtsg/data
Sample directory:

Pulse Sequence: zgul
Solvent: CDCl3
Ambient temperature
File: 3Q
Spectrometer: "RENOVA 500"

Relay delay 1000 sec
Pulse 220.4 degrees
Acq. time 1.455 sec
Width 3052.8 Hz
8 repetitions

OBSERVE HF: 400.100798 MHz
DATA PROCESSING
FT size 65536
Total time 0 min, 19 sec
STANDARD CARBON PARAMETERS
Archive directory: /export/home/sxuy/vnmrsy/data
Sample directory:
Pulse Sequence: s2pul
Solvent: CDCl3
Ambient temperature
User: L-14-87
file: p465
INOMA-300 "RENN569"
Relax. delay 6.569 sec
Pulse 45.0 degrees
Acq. time 1.080 sec
Width 31421.8 Hz
364 repetitions
OBSERVE Cl2, 125.675655 MHz
DECUPLE H2, 498.805806 MHz
Power 2.1 dB
continuously cm
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.5 Hz
FF size 131072
Total time 3 hr, 56 sec
STANDARD PROTON PARAMETERS

- Pulse Sequence: s2pul
- Solvent: CDCl3
- Ambient temperature: 25°C
- Field: 500 MHz
- Spectrometer: "MERV-500"

- Relax. delay 1.000 sec
- Pulse 45.0 degree
- Acq. time 1.832 sec
- Width 3271.3 Hz
- 8 Repetitions

- OBSERVE: H1, 499.8025799 MHz
- DATA PROCESSING: FT 6120 95503B
- Total time 9 min, 23 sec