Regioselective three-component reactions of enaminones, 2-amino pyridines and enals for the synthesis of 1,2-dihydropyridines

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General information

Enaminones were synthesized following literature procedure, and all other chemicals were obtained from commercial sources. Reagents were used directly as obtained without further purification. 1H and 13C NMR spectra were recorded on a 400 MHz apparatus. The frequencies for 1H NMR and 13C NMR experiments are 400 MHz and 100 MHz, respectively. The chemical shifts were recorded in ppm with TMS as internal standard. An X-4A instrument was employed for measuring melting points of all solid products without temperature correction. HRMS results were obtained...
under ESI model.

**General procedure for the three-component synthesis of 1,2-DHPs**

2-Aminopyridine 1 (0.3 mmol), enal 2 (0.3 mmol), enaminone 3 (0.3 mmol), p-TSA (0.3 mmol) and AcOH (0.3 mmol) were charged in a 25 mL round bottom flask equipped with a stirring bar. THF (2ml) were added and the mixture was stirred at reflux for 12 h (TLC). Then, the solvents were directly removed from the mixture under reduced pressure. The residue was subjected to flash silicon column chromatography to provide pure products by using mixed ethyl acetate (EA) and petroleum ether (PE) as eluent ($V_{PE} / V_{EA} = 6:1$).

**Reference**

Phenyl(2-phenyl-1-(pyridin-2-yl)-1,2-dihydropyridin-5-yl)methanone (4a). Yellow solid; m.p. 60-63 °C; \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 8.57 (s, 1H), 8.25 (d, \(J = 6.0\) Hz, 1H), 7.71 (d, \(J = 7.6\) Hz, 2H), 7.50-7.42 (m, 6H), 7.34 (t, \(J = 7.6\) Hz, 2H), 7.28 (d, \(J = 7.2\) Hz, 1H), 6.91 (q, \(J = 4.0\) Hz, 1H), 6.79 (d, \(J = 8.8\) Hz, 2H), 5.97 (d, \(J = 5.2\) Hz, 1H), 5.75 (dd, \(J_1 = 9.6\) Hz, \(J_2 = 4.8\) Hz, 1H); \(^13\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 192.4, 153.4, 148.3, 142.2, 141.8, 139.4, 138.2, 130.8, 129.1, 128.9, 128.2, 128.0, 125.6, 120.1, 119.2, 118.8, 113.5, 110.4, 59.7; ESI-HRMS: Calcd for C\(_{23}\)H\(_{19}\)N\(_2\)O [M+H]\(^+\): 339.1492; Found: 339.1481.

(1-(4-Methylpyridin-2-yl)-2-phenyl-1,2-dihydropyridin-5-yl)(phenyl)methanone (4b). Brown solid; m.p. 64-66°C; \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 8.52 (s, 1H), 8.10 (d, \(J = 4.8\) Hz, 1H), 7.70 (d, \(J = 6.4\) Hz, 2H), 7.48-7.42 (m, 5H), 7.35 (t, \(J = 7.2\) Hz, 2H), 7.27 (d, \(J = 7.2\)Hz, 1H), 6.76 (q, \(J = 8.0\) Hz, 2H), 6.63 (s, 1H), 6.00 (d, \(J = 4.8\) Hz, 1H), 5.73 (dd, \(J_1 = 9.6\) Hz, \(J_2 = 4.8\) Hz, 1H), 2.19 (s, 3H); \(^13\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 192.4, 153.7, 149.7, 147.9, 142.3, 139.5, 130.9, 129.9, 129.1, 129.0, 128.2, 128.0, 125.7, 120.3, 119.9, 119.4, 113.4, 111.1, 59.6, 21.4; ESI-HRMS: Calcd for C\(_{24}\)H\(_{21}\)N\(_2\)O [M+H]\(^+\): 353.1648; Found: 353.1656.
(1-(6-Methylpyridin-2-yl)-2-phenyl-1,2-dihydropyridin-5-yl)(phenyl)methanone (4c). Brown solid; m.p. 61-64°C; \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 8.61 (s, 1H), 7.71 (d, \(J = 6.8\) Hz, 2H), 7.49–7.38 (m, 5H), 7.36–7.24 (m, 4H), 6.78 (d, \(J = 8.4\) Hz, 2H), 6.58 (d, \(J = 8.4\) Hz, 1H), 5.99 (d, \(J = 5.2\) Hz, 1H), 5.71 (dd, \(J_1 = 10.0\) Hz, \(J_2 = 5.6\) Hz, 1H), 2.39 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 192.3, 157.5, 152.7, 142.4, 142.3, 139.5, 138.4, 130.7, 129.0, 128.9, 128.1, 127.9, 125.8, 120.0, 119.2, 118.3, 113.0, 107.2, 59.7, 24.2; ESI-HRMS: Calcd for C\(_{24}\)H\(_{21}\)N\(_2\)O \([M+H]^+\): 353.1648; Found: 353.1657.

(1-(4-Chloropyridin-2-yl)-2-phenyl-1,2-dihydropyridin-5-yl)(phenyl)methanone (4d). Brown solid; m.p. 61-64 °C; \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 8.47 (s, 1H), 8.15 (d, \(J = 5.6\) Hz, 1H), 7.71 (d, \(J = 6.8\) Hz, 2H), 7.52 (t, \(J = 7.6\) Hz, 1H), 7.49–7.42 (m, 4H), 7.36 (t, \(J = 7.2\) Hz, 2H), 7.29 (t, \(J = 7.2\) Hz, 1H), 6.91 (d, \(J = 5.2\) Hz, 1H), 6.78 (t, \(J = 8.40\) Hz, 2H), 5.93 (d, \(J = 5.2\) Hz, 1H), 5.77 (dd, \(J_1 = 9.6\) Hz, \(J_2 = 5.2\) Hz, 1H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 192.5, 154.6, 149.0, 145.8, 141.5, 140.7, 139.1, 131.1, 129.2, 128.9, 128.3, 125.6, 120.6, 119.1, 118.9, 114.4, 110.4, 59.6; ESI-HRMS: Calcd for C\(_{23}\)H\(_{18}\)ClN\(_2\)O \([M+H]^+\): 373.1102; Found: 373.1111.
(1-(5-Chloropyridin-2-yl)-2-phenyl-1,2-dihydropyridin-5-yl)(phenyl)methanone (4e). Brown solid; m.p. 89-92°C; 1H NMR (400 MHz, CDCl₃): δ 8.44 (s, 1H), 8.20 (d, J = 2.4 Hz, 1H), 7.69 (d, J = 6.8 Hz, 2H), 7.51 (d, J = 7.6 Hz, 1H), 7.48-7.44 (m, 3H), 7.40 (d, J = 7.2 Hz, 2H), 7.34 (t, J = 7.6 Hz, 2H), 7.28 (d, J = 7.2 Hz, 1H), 6.75 (t, J = 9.6 Hz, 2H), 5.94 (d, J = 5.2 Hz, 1H), 5.76 (dd, J₁ = 9.6 Hz, J₂ = 5.2 Hz, 1H); 13C NMR (100 MHz, CDCl₃): δ 192.4, 151.7, 146.9, 141.7, 141.0, 139.2, 137.9, 131.0, 129.2, 128.9, 128.3, 128.2, 126.3, 125.6, 120.4, 119.1, 113.9, 110.9, 59.9; ESI-HRMS: Calcd for C₂₃H₁₈ClN₂O [M+H]+: 373.1102; Found: 373.1110.

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\begin{array}{c}
\text{F}_3\text{C} \\
\text{N} \\
\text{Cl} \\
\end{array}
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(1-(5-Chloropyridin-2-yl)-2-phenyl-1,2-dihydropyridin-5-yl)(4-(trifluoromethyl)phenyl)methanone (4f). Brown solid; m.p. 70-73°C; 1H NMR (400 MHz, CDCl₃): δ 8.44 (s, 1H), 7.99 (d, J = 5.6 Hz, 1H), 7.66 (d, J = 8.0 Hz, 2H), 7.58 (d, J = 8.0 Hz, 2H), 7.28 (d, J = 7.6 Hz, 2H), 7.22 (t, J = 7.2 Hz, 2H), 7.15 (d, J = 8.0 Hz, 1H), 6.77 (d, J = 4.8 Hz, 1H), 6.69 (s, 1H), 6.61 (d, J = 10.0 Hz, 1H), 5.77 (d, J = 5.2 Hz, 1H), 5.64 (dd, J₁ = 10.0 Hz, J₂ = 5.2 Hz, 1H); 13C NMR (100 MHz, CDCl₃): δ 191.0, 154.2, 149.0, 145.9, 142.5, 141.4, 141.3, 132.7, 131.3, 119.1, 128.4, 125.5, 125.3 (q, J = 3.5 Hz), 121.0, 119.3, 118.5, 113.8, 110.6, 59.9; ESI-HRMS: Calcd for C₂₄H₁₇ClF₃N₂O [M+H]+: 441.0976; Found: 441.0981.

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\begin{array}{c}
\text{MeO} \\
\text{N} \\
\text{Cl} \\
\end{array}
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(2-(2-Chlorophenyl)-1-(5-chloropyridin-2-yl)-1,2-dihydropyridin-5-yl)(4-methoxyphenyl)methanone (4g). Brown solid; m.p. 63-65°C; 1H NMR (400 MHz,
CDCl$_3$: $\delta$ 8.69 (s, 1H), 8.15 (d, $J = 5.2$ Hz, 1H), 7.74 (d, $J = 8.0$ Hz, 2H), 7.47 (t, $J = 4.8$ Hz, 1H), 7.42 (t, $J = 4.4$ Hz, 1H), 7.23 (dd, $J_1 = 10.0$ Hz, $J_2 = 6.0$ Hz, 2H), 6.99 (d, $J = 8.0$ Hz, 2H), 6.92 (d, $J = 5.2$ Hz, 1H), 6.70 (d, $J = 10.4$ Hz, 2H), 6.28 (d, $J = 5.2$ Hz, 1H), 5.86 (dd, $J_1 = 10.0$ Hz, $J_2 = 4.8$ Hz, 1H), 3.88 (s, 3H);

$^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 191.4, 162.2, 154.1, 149.1, 146.0, 139.8, 139.1, 131.6, 131.1, 130.0, 129.5, 129.4, 128.2, 127.0, 119.9, 118.9, 118.5, 113.7, 113.6, 109.7, 57.0, 55.4; ESI-HRMS: Calcd for C$_{24}$H$_{19}$Cl$_2$N$_2$O$_2$ [M+H]$^+$: 437.0818; Found: 437.0813.

(2-(2-Chlorophenyl)-1-(5-chloropyridin-2-yl)-1,2-dihydropyridin-5-yl)(4-chlorophenyl)methanone (4h). Yellow solid; m.p. 98-101 °C; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.72 (s, 1H), 8.16 (d, $J = 5.2$ Hz, 1H), 7.67 (d, $J = 8.4$ Hz, 2H), 7.47-7.41 (m, 4H), 7.24 (dd, $J_1 = 8.8$ Hz, $J_2 = 4.8$ Hz, 2H), 6.94 (d, $J = 5.6$ Hz, 1H), 6.70 (d, $J = 10.0$ Hz, 2H), 6.27 (d, $J = 4.8$ Hz, 1H), 5.86 (dd, $J_1 = 10.0$ Hz, $J_2 = 4.8$ Hz, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 191.1, 153.8, 149.1, 146.1, 140.8, 138.8, 137.4, 137.2, 130.3, 130.0, 129.6, 129.5, 128.6, 128.3, 127.0, 119.2, 118.8, 113.2, 109.9, 57.2; ESI-HRMS: Calcd for C$_{23}$H$_{16}$Cl$_3$N$_2$O [M+H]$^+$: 441.0323; Found: 441.0310.

(2-(2-Chlorophenyl)-1-(5-chloropyridin-2-yl)-1,2-dihydropyridin-5-yl)(4-nitrophenyl)methanone (4i). Brown solid; m.p. 115-118 °C; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.75 (s, 1H), 8.34 (d, $J = 8.4$ Hz, 2H), 8.15 (d, $J = 5.2$ Hz, 1H), 7.84 (d, $J = 8.8$ Hz, 2H), 7.45-7.40 (m, 2H), 7.27-7.25 (m, 2H), 6.97 (dd, $J_1 = 5.6$ Hz, $J_2 = 1.6$ Hz, S6
(1-(4-Chloropyridin-2-yl)-2-(4-methoxyphenyl)-1,2-dihydropyridin-5-yl)(p-tolyl) methanone (4j). Brown solid; m.p. 71-74°C; ¹H NMR (400 MHz, CDCl₃): δ 8.40 (s, 1H), 8.16 (d, J = 5.2 Hz, 1H), 7.62 (d, J = 8.0 Hz, 2H), 7.37 (d, J = 8.8 Hz, 2H), 7.26 (d, J = 7.6 Hz, 1H), 6.92~6.87 (m, 3H), 6.82 (s, 1H), 6.76 (d, J = 9.6 Hz, 1H), 5.90 (d, J = 5.2 Hz, 1H), 5.74 (dd, J₁ = 9.6 Hz, J₂ = 5.2 Hz, 1H), 3.78 (s, 3H), 2.43 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 192.3, 159.5, 154.7, 148.9, 145.7, 141.6, 140.1, 136.4, 133.8, 129.2, 129.0, 127.2, 120.8, 119.1, 118.8, 114.5, 110.4, 58.8, 55.3, 21.6; ESI-HRMS: Calcd for C₂₅H₂₂ClN₂O₂ [M+H]⁺: 417.1364; Found: 417.1369.

(1-(Pyridin-2-yl)-2-m-tolyl-1,2-dihydropyridin-5-yl)(4-nitrophenyl) methanone (4k). Brown solid; m.p. 81-83°C; ¹H NMR (400 MHz, CDCl₃): δ 8.68 (s, 1H), 8.33 (d, J = 8.8 Hz, 2H), 8.28 (d, J = 5.6 Hz, 1H), 7.84 (d, J = 8.8 Hz, 2H), 7.54 (t, J = 8.8 Hz, 1H), 7.24 (d, J = 6.4 Hz, 1H), 7.18 (s, 2H), 7.11 (d, J = 7.2 Hz, 1H), 6.98 (q, J = 4.0 Hz, 1H), 6.83 (d, J = 8.4 Hz, 1H), 6.73 (d, J = 10.0 Hz, 1H), 5.88 (d, J = 4.8 Hz, 1H), 5.75 (dd, J₁ = 9.6 Hz, J₂ = 5.2 Hz, 1H), 2.35 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 190.0, 152.9, 149.0, 148.4, 145.4, 142.9, 141.8, 139.1, 138.5, 129.6, 129.2, 129.1,
125.9, 123.5, 122.4, 120.8, 119.5 118.0, 112.7, 110.7, 60.4, 21.6; ESI-HRMS: Calcd for C_{24}H_{20}N_{3}O_{3} [M+H]^+: 398.1499; Found: 398.1497.

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\begin{align*}
\text{(1-(5-Bromopyridin-2-yl)-2-(4-nitrophenyl)-1,2-dihydropyridin-5-yl)(4-bromophenyl)methanone (4l).} \\
\text{Brown solid; m.p. 72-75\degree C; } ^1\text{H NMR (400 MHz, CDCl}_3): \delta 8.31 (d, J = 2.4 Hz, 1H), 8.23 (s, 1H), 8.19 (d, J = 8.8 Hz, 2H), 7.67 (dd, J_1 = 8.8 Hz, J_2 = 2.8 Hz, 1H), 7.60 (d, J = 8.4 Hz, 3H), 7.55 (t, J = 7.2 Hz, 3H), 6.76 (q, J = 9.6 Hz, 2H), 6.21 (d, J = 5.2 Hz, 1H), 5.77 (dd, J_1 = 9.6 Hz, J_2 = 5.2 Hz, 1H); ^{13}\text{C NMR (100 MHz, CDCl}_3): \delta 190.9, 151.7, 149.3, 148.4, 147.6, 141.0, 140.3, 137.5, 131.7, 130.4, 126.8, 126.0, 124.4, 120.4, 119.3, 114.9, 114.2, 111.3, 58.7; ESI-HRMS: Calcd for C_{23}H_{16}Br_2N_3O_3 [M+H]^+: 539.9553; Found: 539.9546.
\end{align*}
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\begin{align*}
\text{(1-(4-Chloropyridin-2-yl)-2-(4-methoxyphenyl)-1,2-dihydropyridin-5-yl)(2-methylphenyl)methanone (4m).} \\
\text{Brown solid; m.p. 135-138\degree C; } ^1\text{H NMR (400 MHz, CDCl}_3): \delta 8.22 (s, 1H), 8.11 (d, J = 4.8 Hz, 1H), 7.31 (d, J = 8.8 Hz, 4H), 7.23 (d, J = 8.4 Hz, 2H), 6.90-6.84 (m, 3H) , 6.74 (d, J = 12.8 Hz, 2 H) , 5.87 (d, J = 4.8 Hz, 1H), 5.70 (dd, J_1 = 9.6 Hz, J_2 = 5.2 Hz, 1H), 3.76 (s, 3H), 2.37 (s, 3H); ^{13}\text{C NMR (100 MHz, CDCl}_3): \delta 194.3, 159.5, 154.5, 148.9, 145.7, 141.3, 139.4, 135.8, 133.7, 130.8, 129.3, 127.5, 127.2, 125.3, 120.9, 119.0, 118.0, 115.3, 114.5, 110.5, 59.1, 55.3, 19.7 ESI-HRMS: Calcd for C_{25}H_{22}ClN_2O_2 [M+H]^+: 417.1364; Found: 417.1350.
\end{align*}
\]
(1-(4-Methylpyridin-2-yl)-2-(4-nitrophenyl)-1,2-dihydropyridin-5-yl)(4-bromophenyl)methanone (4n). Brown solid; m.p. 101-104°C; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.30 (s, 1H), 8.20 (d, $J = 8.4$ Hz, 2H), 8.14 (d, $J = 4.8$ Hz, 1H), 7.62~7.54 (m, 6H), 6.82 (t, $J = 8.8$ Hz, 2H), 6.63 (s, 1H), 6.27 (d, $J = 5.2$ Hz, 1H), 5.75 (dd, $J_1 = 10.0$ Hz, $J_2 = 5.6$ Hz, 1H), 2.27 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 190.8, 153.4, 150.1, 149.0, 148.1, 147.5, 141.3, 137.9, 131.6, 130.4, 126.8, 125.8, 124.3, 120.8, 118.5, 113.6, 110.9, 58.4, 21.4. ESI-HRMS: Calcd for C$_{24}$H$_{19}$BrN$_3$O$_3$ [M+H]$^+$: 476.0604; Found: 476.0588.

(1-(4-Methylpyridin-2-yl)-2-(4-nitrophenyl)-1,2-dihydropyridin-5-yl)(3,4-dichlorophenyl)methanone (4o). Brown solid; m.p. 80-83°C; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.32 (s, 1H), 8.20 (d, $J = 8.4$ Hz, 2H ), 8.16 (d, $J = 4.8$ Hz, 1H ), 7.78 (s, 1H), 7.57 (t, $J = 10.0$ Hz, 3H ), 7.49 (d, $J = 8.0$ Hz, 1H ), 6.85 (d, $J = 5.2$ Hz, 1H ), 6.78 (d, $J = 10.0$ Hz, 1H ), 6.64 (s, 1H), 6.27 (d, $J = 5.6$ Hz, 1H ), 5.74 (dd, $J_1 = 9.6$ Hz, $J_2 = 5.2$ Hz, 1H), 2.28 (s, 3 H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 189.3, 153.3, 150.2, 148.8, 148.1, 141.6, 138.8, 135.4, 132.9, 130.8, 130.4, 127.9, 126.7, 124.3, 121.0, 120.6, 118.7, 113.3, 111.0, 58.6, 21.4 ESI-HRMS: Calcd for C$_{24}$H$_{18}$Cl$_2$N$_3$O$_3$ [M+H]$^+$: 466.0720; Found: 466.0721.
(1-(5-Chloropyridin-2-yl)-2-(4-nitrophenyl)-1,2-dihydropyridin-5-yl)(\rho-tolyl)methanone (4p). Brown solid; m.p. 98-101°C; \(^1\)H NMR (400 MHz, CDCl\(_3\)): δ 8.21 (d, \(J = 9.2\) Hz, 3H), 8.16 (s, 1H), 7.61 (d, \(J = 3.6\) Hz, 4H), 7.58 (d, \(J = 2.8\) Hz, 2H), 7.27 (d, \(J = 9.6\) Hz, 1H), 6.83 (d, \(J = 10.0\) Hz, 1H), 6.77 (d, \(J = 8.8\) Hz, 1H), 6.24 (d, \(J = 5.2\) Hz, 1H), 5.77 (dd, \(J_1 = 9.2\) Hz, \(J_2 = 5.2\) Hz, 1H), 2.44 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): δ 191.9, 151.5, 148.7, 147.5, 147.0, 141.9, 139.8, 138.1, 136.0, 129.1, 129.0, 126.9, 126.7, 124.3, 121.0, 119.0, 114.8, 110.7, 58.4, 21.6. ESI-HRMS: Calcd for C\(_{24}\)H\(_{19}\)ClN\(_3\)O\(_3\) [M+H]\(^+\): 432.1109; Found: 432.1118.

(1-(4-Chloropyridin-2-yl)-2-(4-nitrophenyl)-1,2-dihydropyridin-5-yl)(3,4-dichlorophenyl)methanone (4q). Brown solid; m.p. 83-86°C; \(^1\)H NMR (400 MHz, CDCl\(_3\)): δ 8.29 (s, 1H), 8.21 (d, \(J = 7.6\) Hz, 3H), 7.77 (s, 1H), 7.56 (t, \(J = 8.0\) Hz, 3H), 7.49 (t, \(J = 4.0\) Hz, 1H), 7.01 (d, \(J = 4.8\) Hz, 1H), 6.78 (t, \(J = 9.2\) Hz, 2H), 6.19 (d, \(J = 4.8\) Hz, 1H), 5.79 (dd, \(J_1 = 10.0\) Hz, \(J_2 = 5.6\) Hz, 1H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): δ 189.4, 154.0, 149.2, 148.1, 147.7, 146.3, 140.2, 138.4, 135.8, 133.1, 130.8, 130.4, 127.9, 126.7, 124.5, 120.3, 119.8, 119.5, 114.3, 110.4, 58.6, ESI-HRMS: Calcd for C\(_{23}\)H\(_{15}\)Cl\(_3\)N\(_3\)O\(_3\) [M+H]\(^+\): 486.0174; Found: 486.0153.
$^1$H and $^{13}$C NMR of all synthesized substrates and products

$^1$H and $^{13}$C NMR of $4a$
$^1$H and $^{13}$C NMR of 4b
$^1$H and $^{13}$C NMR of 4e
$^1$H and $^{13}$C NMR of 4d
\(^1\)H and \(^{13}\)C NMR of 4e
$^1\text{H}$ and $^{13}\text{C}$ NMR of 4f
$^1$H and $^{13}$C NMR of 4g
$^1$H and $^{13}$C NMR of $4h$
$^1$H and $^{13}$C NMR of 4i

[Diagram of NMR spectra and chemical structure]

S19
$^1$H and $^{13}$C NMR of 4j
$^1$H and $^{13}$C NMR of 4k
$^1$H and $^{13}$C NMR of 4l
$^1$H and $^{13}$C NMR of 4m
$^1$H and $^{13}$C NMR of 4n
$^1\text{H}$ and $^{13}\text{C}$ NMR of 4o
$^1$H and $^{13}$C NMR of 4p
$^1$H and $^{13}$C NMR of 4q