Supporting Information

Base-catalyzed cascade synthesis of 2,3-dihydrofuro-[2,3-b]pyridines and 2,3-dihydro-1H-pyrrolo[2,3-b]pyridines from N-propargylic β-enaminones

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General Information

All of the chemicals were obtained from commercially-available sources or prepared according to standard methods. $^1$H, $^{19}$F and $^{13}$C NMR spectra were recorded using a Bruker AV 400 MHz NMR spectrometer. TMS was used as an internal standard. Chemical shifts were reported in ppm downfield from CDCl$_3$ ($\delta = 7.26$ ppm) or DMSO-$d_6$ ($\delta = 2.50$ ppm) for $^1$H NMR and relative to the central CDCl$_3$ or DMSO-$d_6$ resonance ($\delta = 77.0$ ppm or 39.5 ppm) for $^{13}$C NMR spectroscopy. Multiplicities were reported as follows: singlet (s), doublet (d), triplet (t), quartet (q), multiplet (m), doublet of doublets (dd) and doublet of triplets (dt). Coupling constants ($J$) were reported in Hertz (Hz). Melting points were measured on a RY–I apparatus and uncorrected. HRMS were recorded on an IonSpec FT-ICR mass spectrometer with Electron Spray Ionization (ESI) resource.
General Procedure for the Preparation N-propargyl β-enaminones

All the N-propargyl β-enaminones (1) were prepared according to the literature procedure\(^1\).

General procedure for the synthesis of N-sulfonyl imines

All the N-sulfonyl imines (4) were prepared according to the literature procedure\(^2\).

Experimental Procedures and Data for Compounds 3

![Chemical structure](image)

A mixture of N-propargylic β-enaminones 1 (0.4 mmol), arylaldehydes 2 (0.4 mmol), and KOH (8 mg, 0.12 mmol, 0.3 equiv) in DMF (3 mL) was stirred at room temperature under N\(_2\) for 1-4 h. After 1 was disappeared completely (monitored by TLC), the residue dissolved in H\(_2\)O (10 mL) and extracted with EtOAc (3 x 10 mL). The combined EtOAc extracts were dried over Na\(_2\)SO\(_4\) and concentrated. Then the solvent was evaporated and the residue was purified by chromatography (silica gel, 1% EtOAc in PE) to give 3.

2,4,6-Triphenyl-2,3-dihydrofuro[2,3-b]pyridine (3a). Pale yellow solid; 99.2 mg (71% yield); mp 140-141 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 8.08 (d, \(J = 7.2\) Hz, 2H, ArH), 7.56 (d, \(J = 7.0\) Hz, 2H, ArH), 7.50-7.37 (m, 11H, ArH), 7.33 (t, \(J = 7.2\) Hz, 1H, ArH), 5.90 (t, \(J = 8.6\) Hz, 1H, CH), 3.84 (dd, \(J = 16.4, 9.4\) Hz, 1H, CH\(_2\)), 3.39 (dd, \(J = 16.3, 7.8\) Hz, 1H, CH\(_2\)); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \(\delta\) 168.7, 155.9, 147.5, 141.3, 138.9, 138.0, 128.8, 128.8, 128.7, 128.7, 128.6, 128.1, 127.7, 126.8, 125.4, 115.2, 113.5, 81.8, 37.1; HRMS (ESI) \(m/z\) [M + H]\(^+\) calculated for C\(_{25}\)H\(_{20}\)NO: 350.1545, found: 350.1543.
4,6-Diphenyl-2-(4-(trifluoromethyl)phenyl)-2,3-dihydrofuro[2,3-b]pyridine (3b). Yellow solid; 130.2 mg (78% yield); mp 113-114 °C; \( ^1\text{H} \) NMR (CDCl\(_3\), 400 MHz): \( \delta \) 8.07 (dd, \( J = 8.5, 1.5 \) Hz, 2H, ArH), 7.65 (d, \( J = 8.3 \) Hz, 2H, ArH), 7.59 (d, \( J = 8.4 \) Hz, 2H, ArH), 7.54 (dd, \( J = 8.2, 1.5 \) Hz, 2H, ArH), 7.51-7.39 (m, 7H, ArH), 5.96 (t, \( J = 8.5 \) Hz, 1H, CH), 3.90 (dd, \( J = 16.3, 9.5 \) Hz, 1H, CH\(_2\)), 3.35 (dd, \( J = 16.3, 7.7 \) Hz, 1H, CH\(_2\)); \( ^{13}\text{C} \) NMR (CDCl\(_3\), 100 MHz): \( \delta \) 168.5, 156.1, 147.8, 145.4, 138.7, 137.8, 130.2 (q, \( J_{\text{C-F}} = 32.8 \) Hz), 129.0, 128.9, 128.8, 128.6, 127.7, 126.8, 125.7 (q, \( J_{\text{C-F}} = 3.8 \) Hz), 125.7, 124.0 (q, \( J_{\text{C-F}} = 270.6 \) Hz), 114.6, 113.8, 80.8, 37.1; HRMS (ESI) \( m/z \) [M + H]\(^+\) calculated for C\(_{26}\)H\(_{19}\)F\(_3\)NO: 418.1419, found: 418.1421.

Methyl 4-(4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridin-2-yl)benzoate (3c). Pale yellow solid; 123.8 mg (76% yield); mp 157-158 °C; \( ^1\text{H} \) NMR (CDCl\(_3\), 400 MHz): \( \delta \) 8.08-8.04 (m, 4H, ArH), 7.54 (d, \( J = 7.9 \) Hz, 4H, ArH), 7.49-7.38 (m, 7H, ArH), 5.93 (t, \( J = 8.6 \) Hz, 1H, CH), 3.91 (s, 3H, OCH\(_3\)), 3.86 (dd, \( J = 16.4, 9.6 \) Hz, 1H, CH\(_2\)), 3.33 (dd, \( J = 16.3, 7.8 \) Hz, 1H, CH\(_2\)); \( ^{13}\text{C} \) NMR (CDCl\(_3\), 100 MHz): 168.5, 166.6, 156.0, 147.6, 146.3, 138.7, 137.8, 130.0, 129.8, 128.9, 128.8, 128.8, 128.6, 127.6, 126.8, 125.3, 114.7, 113.7, 81.1, 52.1, 37.0; HRMS (ESI) \( m/z \) [M + H]\(^+\) calculated for C\(_{27}\)H\(_{22}\)NO\(_3\): 408.1600, found: 408.1593.

4-(4,6-Diphenyl-2,3-dihydrofuro[2,3-b]pyridin-2-yl)benzamide (3d). Pale yellow solid; 116.1 mg (74% yield); mp 164-165 °C; \( ^1\text{H} \) NMR (DMSO-\( d_6\), 400 MHz) \( \delta \) 8.12 (d, \( J = 7.6 \) Hz, 2H, ArH), 8.01 (s, 1H), 7.92 (d, \( J = 8.0 \) Hz, 2H, ArH), 7.76 (d, \( J = 7.4 \) Hz, 1H, ArH), 7.65 (s, 1H, ArH), 7.55 (d, \( J = 7.8 \) Hz, 2H, ArH), 7.52 (d, \( J = 7.8 \) Hz, 2H, ArH), 7.48 (d, \( J = 7.5 \) Hz, 2H, ArH), 7.44-7.39 (m, 2H, ArH), 5.99 (t, \( J = 8.5 \) Hz,
1H, CH), 3.94 (dd, J = 16.4, 9.4 Hz, 1H, CH₂), 3.38 (dd, J = 16.3, 8.0 Hz, 1H, CH₂);

13C NMR (DMSO-d₆, 100 MHz): δ 168.3, 167.5, 154.5, 146.9, 144.2, 138.3, 137.2, 134.0, 128.9, 128.9, 128.7, 128.0, 127.9, 126.5, 125.5, 115.8, 113.0, 80.9, 36.2;

HRMS (ESI) m/z [M + H]⁺ calculated for C₂₆H₂₁N₂O₂: 393.1603, found: 393.1596.

4-(4,6-Diphenyl-2,3-dihydrofuro[2,3-b]pyridin-2-yl)benzonitrile (3e). Yellow solid; 107.8 mg (72% yield); mp 138-139 °C; ¹H NMR (DMSO, 400 MHz) δ 8.06 (d, J = 7.2 Hz, 2H, ArH), 7.67 (d, J = 8.1 Hz, 2H, ArH), 7.57 (d, J = 8.1 Hz, 2H, ArH), 7.54-7.39 (m, 9H, ArH), 5.92 (t, J = 8.5 Hz, 1H, CH), 3.89 (dd, J = 16.2, 9.6 Hz, 1H, CH₂), 3.31 (dd, J = 16.2, 7.6 Hz, 1H, CH₂);

13C NMR (DMSO, 100 MHz): δ 168.3, 156.2, 147.8, 146.6, 138.6, 137.7, 132.5, 129.0, 128.9, 128.9, 128.6, 127.6, 126.8, 126.0, 118.5, 114.3, 113.9, 111.9, 80.5, 36.9; HRMS (ESI) m/z [M + H]⁺ calculated for C₂₆H₁₉N₂O: 375.1497, found: 375.1492.

2-(4-Fluorophenyl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3f). Yellow solid; 107.2 mg (73% yield); mp 129-130 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.07 (d, J = 7.4 Hz, 2H, ArH), 7.55 (d, J = 7.3 Hz, 2H, ArH), 7.51-7.40 (m, 9H, ArH), 7.07 (td, J = 8.4, 1.4 Hz, 2H, ArH), 5.86 (t, J = 8.3 Hz, 1H, CH), 3.81 (dd, J = 16.3, 9.4 Hz, 1H, CH₂), 3.35 (dd, J = 16.3, 7.8 Hz, 1H, CH₂);

13C NMR (CDCl₃, 100 MHz): δ 168.5, 162.5 (d, J_{C:F} = 247.3 Hz), 155.9, 147.5, 138.7, 137.9, 137.0 (d, J_{C:F} = 3.2 Hz), 128.9, 128.8, 128.6, 127.7, 127.3 (d, J_{C:F} = 8.0 Hz), 126.8, 115.5 (d, J_{C:F} = 21.7 Hz), 115.0, 113.6, 81.2, 37.1; HRMS (ESI) m/z [M + H]⁺ calculated for C₂₅H₁₉FNO: 368.1451, found: 368.1450.
2-(4-Chlorophenyl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3g). Yellow solid; 107.4 mg (70% yield); mp 105-106 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.07 (d, $J = 7.5$ Hz, 2H, ArH), 7.55 (d, $J = 7.3$ Hz, 2H, ArH), 7.50-7.39 (m, 9H, ArH), 7.35 (d, $J = 8.4$ Hz, 2H, ArH), 5.86 (t, $J = 8.5$ Hz, 1H, CH), 3.82 (dd, $J = 16.3$, 9.4 Hz, 1H, CH$_2$), 3.32 (dd, $J = 16.3$, 7.7 Hz, 1H, CH$_2$); $^{13}$C NMR (CDCl$_3$, 100 MHz): 168.5, 156.0, 147.6, 139.8, 138.7, 137.8, 133.8, 128.9, 128.8, 128.8, 128.8, 128.6, 127.7, 126.9, 126.8, 114.9, 113.6, 81.0, 37.0; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{25}$H$_{19}$ClNO: 384.1155, found: 384.1162.

2-(4-Ethynylphenyl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3h). Pale yellow solid; 97.1 mg (65% yield); mp 134-135 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.07 (dd, $J = 7.1$, 1.5 Hz, 2H, ArH), 7.55 (dd, $J = 8.2$, 1.3 Hz, 2H, ArH), 7.52-7.49 (m, 4H, ArH), 7.47-7.38 (m, 7H, ArH), 5.90 (t, $J = 8.5$ Hz, 1H, CH), 3.85 (dd, $J = 16.3$, 9.5 Hz, 1H, CH$_2$), 3.35 (dd, $J = 16.3$, 7.7 Hz, 1H, CH$_2$), 3.08 (s, 1H, CH); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.6, 156.0, 147.6, 142.0, 138.0, 137.9, 132.5, 128.9, 128.9, 128.8, 128.6, 127.7, 126.9, 125.4, 121.9, 114.9, 113.7, 83.2, 81.3, 77.5, 37.1; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{27}$H$_{20}$NO: 374.1545, found: 374.1536.

2-([1,1'-Biphenyl]-4-yl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3i). Yellow solid; 110.6 mg (65% yield); mp 154-155 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.09 (dd, $J = 7.2$, 1.4 Hz, 2H, ArH), 7.62-7.53 (m, 8H, ArH), 7.51-7.38 (m, 9H, ArH), 7.35 (tt, $J = 7.3$, 1.9 Hz, 1H, ArH), 5.95 (t, $J = 8.5$ Hz, 1H, CH), 3.87 (dd, $J = 16.4$, 9.4 Hz, 1H, CH$_2$), 3.43 (dd, $J = 16.4$, 7.8 Hz, 1H, CH$_2$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.7, 155.9, 147.5, 141.0, 140.6, 140.3, 138.8, 138.0, 128.8, 128.8, 128.8, 128.7, 128.6, 127.7, 127.4, 127.4, 127.1, 126.8, 125.9, 115.2, 113.5, 81.6, 37.1; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{31}$H$_{24}$NO: 426.1858, found: 426.1851.
4,6-Diphenyl-2-(p-tolyl)-2,3-dihydrofuro[2,3-b]pyridine (3j). Pale yellow solid; 72.7 mg (50% yield); mp 66-67 °C; ^1H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.07 (d, $J = 7.3$ Hz, 2H, ArH), 7.56 (d, $J = 7.0$ Hz, 2H, ArH), 7.50-7.40 (m, 7H, ArH), 7.36 (d, $J = 7.9$ Hz, 2H, ArH), 7.19 (d, $J = 7.8$ Hz, 2H, ArH), 5.87 (t, $J = 8.5$ Hz, 1H, CH), 3.80 (dd, $J = 16.3$, 9.3 Hz, 1H, CH$_2$), 3.38 (dd, $J = 16.3$, 7.8 Hz, 1H, CH$_2$), 2.36 (s, 3H, CH$_3$); ^13C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.8, 155.9, 147.4, 138.9, 138.3, 138.1, 137.9, 129.3, 128.8, 128.7, 128.6, 127.7, 126.8, 125.5, 115.4, 113.4, 81.8, 37.1, 21.1; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{26}$H$_{22}$NO: 364.1701, found: 364.1695.

2-(4-Methoxyphenyl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3k). Yellow solid; 60.7 mg (40% yield); mp 122-123 °C; ^1H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.06 (dd, $J = 7.2$, 1.3 Hz, 2H, ArH), 7.57 (dd, $J = 6.9$, 1.5 Hz, 2H, ArH), 7.50-7.42 (m, 6H, ArH), 7.41-7.38 (m, 3H, ArH), 6.91 (d, $J = 8.7$ Hz, 2H, ArH), 5.84 (t, $J = 8.6$ Hz, 1H, CH), 3.81 (s, 3H, OCH$_3$), 3.78 (dd, $J = 16.4$, 9.3 Hz, 1H, CH$_2$), 3.38 (dd, $J = 16.4$, 7.9 Hz, 1H, CH$_2$); ^13C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.7, 159.5, 155.8, 147.4, 138.9, 138.1, 133.2, 128.8, 128.7, 128.6, 127.7, 127.0, 126.8, 115.4, 114.0, 113.4, 81.8, 55.3, 37.0; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{26}$H$_{22}$NO$_2$: 380.1651, found: 380.1650.

2-(3-Chlorophenyl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3l). Pale yellow solid; 104.5 mg (68% yield); mp 87-88 °C; ^1H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.06 (d, $J = 7.4$ Hz, 2H, ArH), 7.55 (d, $J = 7.4$ Hz, 2H, ArH), 7.51-7.39 (m, 8H, ArH), 7.35-7.30 (m, 3H, ArH), 5.87 (t, $J = 8.6$ Hz, 1H, CH), 3.85 (dd, $J = 16.3$, 9.5 Hz, 1H, CH$_2$), 3.35 (dd, $J = 16.3$, 7.8 Hz, 1H, CH$_2$); ^13C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.5, 156.0, 147.6, 143.4, 138.7, 137.8, 134.6, 130.0, 128.9, 128.9, 128.8, 128.6, 128.2, 127.7, 126.8,
125.6, 123.5, 114.7, 113.7, 80.8, 37.0; HRMS (ESI) m/z [M + H]^+ calculated for C_{25}H_{19}ClNO: 384.1155, found: 384.1160.

2-(3-Methoxyphenyl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3m). White solid; 91.0 mg (60% yield); mp 115-116 °C; 1H NMR (CDCl₃, 400 MHz): δ 8.07 (dd, J = 7.2, 1.4 Hz, 2H, ArH), 7.56 (dd, J = 8.4, 1.6 Hz, 2H, ArH), 7.51-7.39 (m, 7H, ArH), 7.30 (t, J = 7.9 Hz, 1H, ArH), 7.05-7.02 (m, 2H, ArH), 6.86 (dd, J = 8.1, 2.0 Hz, 1H, ArH), 5.88 (t, J = 8.6 Hz, 1H, CH), 3.82 (dd, J = 16.3, 9.4 Hz, 1H, CH₂), 3.81 (s, 3H, OCH₃), 3.38 (dd, J = 16.3, 8.0 Hz, 1H, CH₂); 13C NMR (CDCl₃, 100 MHz): δ 168.7, 159.8, 155.9, 147.4, 143.0, 138.8, 138.0 129.7, 128.8, 128.7, 128.6, 127.7, 126.8, 117.6, 115.2, 113.6, 113.5, 110.8, 81.5, 55.3, 37.1; HRMS (ESI) m/z [M + H]^+ calculated for C_{26}H_{22}NO₂: 380.1651, found: 380.1648.

2-(2-Chlorophenyl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3n). Yellow solid; 112.1 mg (73% yield); mp 163-164 °C; 1H NMR (CDCl₃, 400 MHz): δ 8.07 (d, J = 7.2 Hz, 2H, ArH), 7.69 (dd, J = 7.4, 1.7 Hz, 1H, ArH), 7.54 (dd, J = 7.0, 1.5 Hz, 2H, ArH), 7.49-7.37 (m, 8H, ArH), 7.31-7.22 (m, 2H, ArH), 6.17 (dd, J = 9.5, 7.1 Hz, 1H, CH), 4.04 (dd, J = 16.6, 9.6 Hz, 1H, CH₂), 3.23 (dd, J = 16.6, 7.0 Hz, 1H, CH₂); 13C NMR (CDCl₃, 100 MHz): δ 168.6, 156.0, 147.8, 139.3, 138.5, 137.9, 130.9, 129.5, 129.0, 128.9, 128.8, 128.6, 127.7, 127.1, 126.9, 126.3, 114.8, 113.8, 78.9, 36.2; HRMS (ESI) m/z [M + H]^+ calculated for C_{25}H_{19}ClNO: 384.1155, found: 384.1163.

2-(2-Methoxyphenyl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3o). Pale yellow solid; 75.9 mg (50% yield); mp 152-153 °C; 1H NMR (CDCl₃, 400 MHz): δ 8.08 (dd, J = 7.2, 1.4 Hz, 2H, ArH), 7.59 (dd, J = 7.6, 0.9 Hz, 1H, ArH), 7.55 (dd, J = 7.0, 1.5 Hz, 2H, ArH), 7.29 (dd, J = 8.0, 1.7 Hz, 2H, ArH), 6.87 (dd, J = 8.1, 2.0 Hz, 1H, ArH), 5.87 (t, J = 8.6 Hz, 1H, CH), 3.82 (dd, J = 16.3, 9.4 Hz, 1H, CH₂), 3.81 (s, 3H, OCH₃), 3.38 (dd, J = 16.3, 8.0 Hz, 1H, CH₂); 13C NMR (CDCl₃, 100 MHz): δ 168.7, 155.9, 147.4, 143.0, 138.8, 138.0 129.7, 128.8, 128.7, 128.6, 127.7, 126.8, 117.6, 115.2, 113.6, 113.5, 110.8, 81.5, 55.3, 37.1; HRMS (ESI) m/z [M + H]^+ calculated for C_{25}H_{19}ClNO: 384.1155, found: 384.1163.
Hz, 2H, ArH), 7.49-7.38 (m, 7H, ArH), 7.28 (td, J = 7.8, 1.3 Hz, 1H, ArH), 6.97 (t, J = 7.3 Hz, 1H, ArH), 6.90 (d, J = 8.2 Hz, 1H, ArH), 6.13 (dd, J = 9.3, 7.4 Hz, 1H, CH), 3.90 (dd, J = 16.6, 9.5 Hz, 1H, CH2), 3.84 (s, 3H, OCH3), 3.22 (dd, J = 16.6, 7.2 Hz, 1H, CH2); 13C NMR (CDCl3, 100 MHz): δ 168.8, 155.6, 155.5, 147.4, 138.9, 138.1, 130.0, 128.7, 128.7, 128.5, 128.5, 128.5, 127.7, 126.8, 125.5, 120.5, 115.7, 113.3, 110.1, 77.9, 55.2, 36.2; HRMS (ESI) m/z [M + H]+ calculated for C26H22NO2: 380.1651, found: 380.1644.

4,6-Diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3p). Yellow viscous liquid; 28.4 mg (26% yield); 1H NMR (CDCl3, 400 MHz): δ 8.03 (dd, J = 7.9, 1.4 Hz, 2H, ArH), 7.57 (dd, J = 7.8, 1.5 Hz, 1H, ArH), 7.50 (t, J = 7.3 Hz, 2H, ArH), 7.46-7.37 (m, 5H, ArH), 4.69 (t, J = 8.5 Hz, 2H, CH2), 3.41 (t, J = 8.5 Hz, 2H, CH2); 13C NMR (CDCl3, 100 MHz): 169.3, 155.6, 147.5, 138.9, 138.2, 128.8, 128.8, 128.7, 128.6, 127.7, 126.8, 115.4, 113.2, 69.1, 28.2; HRMS (ESI) m/z [M + H]+ calculated for C19H16NO: 274.1232, found: 274.1231.

2-(Naphthalen-2-yl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3s). Yellow solid; 123.0 mg (77% yield); mp 76-77 °C; 1H NMR (CDCl3, 400 MHz): δ 8.09 (dd, J = 7.1, 1.4 Hz, 2H, ArH), 7.97 (s, 1H, ArH), 7.88 (d, J = 8.6 Hz, 1H, ArH), 7.86-7.83 (m, 2H, ArH), 7.58-7.39 (m, 12H, ArH), 6.07 (t, J = 8.5 Hz, 1H, CH), 3.92 (dd, J = 16.4, 9.5 Hz, 1H, CH2), 3.47 (dd, J = 16.4, 7.8 Hz, 1H, CH2); 13C NMR (CDCl3, 100 MHz): δ 168.8, 155.9, 147.5, 138.8, 138.6, 138.0, 133.1, 133.0, 128.8, 128.8, 128.7, 128.7, 128.6, 128.0, 127.7, 127.7, 126.8, 126.4, 126.1, 124.3, 123.2, 115.2, 113.5, 81.8, 37.1; HRMS (ESI) m/z [M + H]+ calculated for C29H23NO: 400.1701, found: 400.1696.
2-(Furan-2-yl)-4,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3t). Yellow viscous liquid; 76.1 mg (56% yield); ¹H NMR (CDCl₃, 400 MHz): δ 8.05 (d, J = 7.3 Hz, 2H, ArH), 7.59 (d, J = 7.1 Hz, 2H, ArH), 7.51 (t, J = 7.2 Hz, 2H, ArH), 7.47-7.31 (m, 6H, ArH), 6.48 (d, J = 2.8 Hz, 1H, ArH), 6.37 (s, 1H, ArH), 5.85 (t, J = 8.4 Hz, 1H, CH), 3.68 (d, J = 8.4 Hz, 2H, CH₂); ¹³C NMR (CDCl₃, 100 MHz): δ 168.1, 155.8, 152.2, 147.4, 143.2, 138.8, 138.0, 128.9, 128.8, 128.7, 128.5, 127.7, 126.8, 115.0, 113.5, 110.4, 108.7, 75.0, 32.9; HRMS (ESI) m/z [M + H]⁺ calculated for C₂₃H₁₈NO₂: 340.1338, found: 340.1332.

4,6-Diphenyl-2-(thiophen-2-yl)-2,3-dihydrofuro[2,3-b]pyridine (3u). Pale yellow solid; 82.5 mg (58% yield); mp 122-123 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.06 (td, J = 7.0, 1.5 Hz, 2H, ArH), 7.58 (td, J = 8.2, 1.5 Hz, 2H, ArH), 7.51 (tt, J = 7.3, 1.5 Hz, 2H, ArH), 7.48-7.43 (m, 4H, ArH), 7.40 (tt, J = 7.2, 1.4 Hz, 1H, ArH), 7.16 (dt, J = 3.4, 0.9 Hz, 1H, ArH), 7.00 (dd, J = 5.0, 3.6 Hz, 2H, ArH), 6.09 (dd, J = 8.5, 7.8 Hz, 1H, CH), 3.82 (dd, J = 16.4, 9.1 Hz, 1H, CH₂), 3.55 (dd, J = 16.3, 7.5 Hz, 1H, CH₂); ¹³C NMR (CDCl₃, 100 MHz): δ 168.0, 156.0, 147.5, 143.7, 138.7, 137.9, 128.9, 128.8, 128.7, 128.5, 127.7, 126.8, 126.8, 125.7, 125.3, 114.9, 113.6, 78.0, 37.0; HRMS (ESI) m/z [M + H]⁺ calculated for C₂₃H₁₈NOS: 356.1109, found: 356.1102.

4,6-Diphenyl-2-(pyridin-2-yl)-2,3-dihydrofuro[2,3-b]pyridine (3v). Yellow solid; 112.1 mg (80% yield); mp 127-128 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.60 (d, J = 4.7 Hz, 1H, ArH), 8.06 (dd, J = 7.1, 1.4 Hz, 2H, ArH), 7.75-7.69 (m, 2H, ArH), 7.58 (dd, J = 6.9, 1.5 Hz, 2H, ArH), 7.50-7.38 (m, 7H, ArH), 7.23 (tt, J = 6.7, 1.6 Hz, 1H, ArH), 5.99 (dd, J = 9.8, 6.8 Hz, 1H, CH), 3.95 (dd, J = 16.6, 9.9 Hz, 1H, CH₂), 3.66 (dd, J = 16.6, 6.8 Hz, 1H, CH₂); ¹³C NMR (CDCl₃, 100 MHz): δ 168.6, 160.3, 155.8, 149.3,
147.6, 138.8, 137.8, 136.9, 128.8, 128.7, 128.6, 127.7, 126.8, 122.8, 120.3, 115.0, 113.7, 81.5, 35.1; HRMS (ESI) m/z [M + H]^+ calculated for C_{24}H_{19}N_{2}O: 351.1497, found: 351.1497.

2,6-Diphenyl-4-(4-(trifluoromethyl)phenyl)-2,3-dihydrofuro[2,3-b]pyridine (3w).
Yellow solid; 83.4 mg (50% yield); mp 173-174 °C; 1H NMR (CDCl_{3}, 400 MHz): δ 8.06 (d, J = 7.2 Hz, 2H, ArH), 7.74 (d, J = 8.2 Hz, 2H, ArH), 7.66 (d, J = 8.1 Hz, 2H, ArH), 7.49-7.37 (m, 8H, ArH), 7.33 (t, J = 7.2 Hz, 1H, ArH), 5.92 (t, J = 8.5 Hz, 1H, CH), 3.82 (dd, J = 16.4, 9.4 Hz, 1H, CH\textsubscript{2}), 3.37 (dd, J = 16.4, 7.8 Hz, 1H, CH\textsubscript{2}); 13C NMR (CDCl_{3}, 100 MHz): δ 168.8, 156.3, 146.0, 141.6, 141.1, 138.5, 130.7 (q, J\textsubscript{C-F} = 32.5 Hz), 129.1, 128.7, 128.6, 128.2, 128.1, 126.8, 125.8 (q, J\textsubscript{C-F} = 3.5 Hz), 125.4, 123.9 (q, J\textsubscript{C-F} = 271.1 Hz), 115.5, 113.2, 81.8, 36.9; HRMS (ESI) m/z [M + H]^+ calculated for C_{26}H_{19}F\textsubscript{3}NO: 418.1419, found: 418.1425

4-(4-Chlorophenyl)-2,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3x). Pale yellow solid; 95.0 mg (62% yield); mp 111-112 °C; 1H NMR (CDCl_{3}, 400 MHz): δ 8.06 (d, J = 7.2 Hz, 2H, ArH), 7.49-7.38 (m, 12H, ArH), 7.33 (t, J = 7.2 Hz, 1H, ArH), 5.90 (t, J = 8.5 Hz, 1H, CH), 3.79 (dd, J = 16.3, 9.4 Hz, 1H, CH\textsubscript{2}), 3.35 (dd, J = 16.3, 7.8 Hz, 1H, CH\textsubscript{2}); 13C NMR (CDCl_{3}, 100 MHz): δ 168.8, 156.0, 146.2, 141.1, 138.6, 136.4, 134.8, 129.0, 129.0, 128.9, 128.7, 128.6, 128.1, 126.8, 125.4, 115.1, 113.1, 81.7, 37.0; HRMS (ESI) m/z [M + H]^+ calculated for C_{25}H_{19}ClNO: 384.1155, found: 384.1160.
4-(4-Methoxyphenyl)-2,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3y). Yellow solid; 83.4 mg (55% yield); mp 75-76 °C; $^1$H NMR (CDCl$_3$, 400 MHz): δ 8.07 (dd, $J$ = 7.2, 1.4 Hz, 2H, ArH), 7.51 (d, $J$ = 8.8 Hz, 2H, ArH), 7.49-7.44 (m, 4H, ArH), 7.41-7.37 (m, 11H, ArH), 7.32 (tt, $J$ = 7.2, 2.4 Hz, 1H, ArH), 7.00 (dd, $J$ = 8.8 Hz, 2H, ArH), 5.89 (t, $J$ = 8.5 Hz, 1H, CH), 3.86 (s, 3H, OCH$_3$), 3.83 (dd, $J$ = 16.2, 9.4 Hz, 1H, CH$_2$), 3.38 (dd, $J$ = 16.2, 7.8 Hz, 1H, CH$_2$); $^{13}$C NMR (CDCl$_3$, 100 MHz): δ 168.8, 160.0, 155.8, 147.0, 141.4, 139.0, 130.3, 129.0, 128.7, 128.6, 126.6, 128.0, 126.8, 125.4, 114.7, 114.2, 113.2, 81.7, 55.4, 37.3; HRMS (ESI) m/z [M + H]$^+$ calculated for C$_{26}$H$_{22}$NO$_2$: 380.1651, found: 380.1648.

4-(3-Bromophenyl)-2,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3z). White solid; 114.7 mg (66% yield); mp 125-126 °C; $^1$H NMR (CDCl$_3$, 400 MHz): δ 8.13 (d, $J$ = 7.2 Hz, 2H, ArH), 7.69 (s, 1H, ArH), 7.56 (d, $J$ = 7.7 Hz, 1H, ArH), 7.47-7.33 (m, 4H, ArH), 5.91 (t, $J$ = 8.5 Hz, 1H, CH), 3.82 (dd, $J$ = 16.4, 9.4 Hz, 1H, CH$_2$), 3.36 (dd, $J$ = 16.4, 7.8 Hz, 1H, CH$_2$); $^{13}$C NMR (CDCl$_3$, 100 MHz): δ 168.8, 156.2, 146.0, 141.1, 140.1, 138.6, 131.7, 130.7, 130.4, 129.0, 128.9, 128.7, 128.6, 128.2, 126.9, 126.3, 125.5, 123.0, 115.3, 113.2, 81.9, 37.0; HRMS (ESI) m/z [M + H]$^+$ calculated for C$_{25}$H$_{19}$BrNO: 428.0650, found: 428.0652.
2,6-Diphenyl-4-(m-tolyl)-2,3-dihydrofuro[2,3-b]pyridine (3aa). Pale yellow viscous liquid; 95.9mg (67% yield); $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.02 (d, $J$ = 7.5 Hz, 2H, ArH), 7.40 (t, $J$ = 7.3 Hz, 4H, ArH), 7.37-7.24 (m, 8H, ArH), 7.19-7.17 (m, 1H, ArH), 5.82 (t, $J$ = 8.6 Hz, 1H, CH), 3.76 (dd, $J$ = 16.3, 9.4 Hz, 1H, CH$^2$), 3.31 (dd, $J$ = 16.3, 7.8 Hz, 1H, CH$^2$), 2.37 (s, 3H, CH$_3$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.7, 155.8, 147.6, 141.3, 138.9, 138.5, 137.9, 129.4, 128.8, 128.7, 128.6, 128.5, 128.3, 128.0, 126.8, 125.4, 124.8, 115.2, 113.5, 81.8, 37.1, 21.5; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{26}$H$_{22}$NO: 364.1701, found: 364.1699.

![2,6-Diphenyl-4-(m-tolyl)-2,3-dihydrofuro[2,3-b]pyridine (3aa)](image)

2,6-Diphenyl-4-(o-tolyl)-2,3-dihydrofuro[2,3-b]pyridine (3ab). Pale yellow solid; 88.7 mg (61% yield); mp 44-45 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.04 (d, $J$ = 7.4 Hz, 2H, ArH), 7.46-7.30 (m, 10H, ArH), 7.24 (d, $J$ = 8.1 Hz, 2H, ArH), 7.19 (d, $J$ = 7.3 Hz, 1H, ArH), 5.89 (t, $J$ = 8.6 Hz, 1H, CH), 3.52 (dd, $J$ = 16.4, 9.5 Hz, 1H, CH$_2$), 3.07 (dd, $J$ = 16.4, 7.8 Hz, 1H, CH$_2$), 2.23 (s, 3H, CH$_3$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.3, 155.3, 148.5, 141.4, 138.8, 137.9, 134.9, 130.5, 128.8, 128.7, 128.6, 128.4, 128.3, 128.0, 126.8, 125.9, 125.4, 116.7, 114.8, 81.8, 36.4, 19.8; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{26}$H$_{22}$NO: 364.1701, found: 364.1696.

![2,6-Diphenyl-4-(o-tolyl)-2,3-dihydrofuro[2,3-b]pyridine (3ab)](image)

4-(Tert-butyl)-2,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3ac). Yellow viscous liquid; 54.0mg (41% yield); $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.02 (d, $J$ = 7.2 Hz, 2H, ArH), 7.48-7.33 (m, 9H, ArH), 5.81 (t, $J$ = 8.7 Hz, 1H, CH), 3.88 (dd, $J$ = 16.0, 9.4 Hz, 1H, CH$_2$), 3.38 (dd, $J$ = 16.0, 8.2 Hz, 1H, CH$_2$), 1.39 (s, 9H, 3×CH$_3$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.9, 157.9, 155.4, 141.5, 139.3, 128.6, 128.6, 128.5, 128.0, 126.8, 125.5, 114.5, 111.4, 81.1, 38.8, 35.7, 29.7; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{26}$H$_{22}$NO: 364.1701, found: 364.1696.

![4-(Tert-butyl)-2,6-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3ac)](image)
calculated for C$_{23}$H$_{24}$NO: 330.4428, found: 330.4421.

6-(4-Chlorophenyl)-2,4-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3ad). Yellow solid; 99.8 mg (65% yield); mp 118-119 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.02 (d, $J = 8.6$ Hz, 2H, ArH), 7.55 (dd, $J = 8.4$, 1.5 Hz, 2H, ArH), 7.51-7.37 (m, 10H, ArH), 7.32 (tt, $J = 7.2$, 2.4 Hz, 1H, ArH), 5.91 (t, $J = 8.65$ Hz, 1H, CH), 3.84 (dd, $J = 16.4$, 9.4 Hz, 1H, CH$_2$), 3.39 (dd, $J = 16.4$, 7.8 Hz, 1H, CH$_2$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.7, 154.5, 147.5, 141.1, 137.7, 137.2, 134.8, 128.8, 128.8, 128.7, 128.6, 128.1, 128.0, 127.6, 125.4, 115.6, 113.2, 81.8, 37.0; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{25}$H$_{19}$ClNO: 384.1155, found: 384.1159.

6-(4-Methoxyphenyl)-2,4-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3ae). Yellow solid; 78.9 mg (52% yield); mp 132-133 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.04 (d, $J = 8.7$ Hz, 2H, ArH), 7.55 (d, $J = 7.2$ Hz, 2H, ArH), 7.50-7.35 (m, 8H, ArH), 7.32 (t, $J = 7.1$ Hz, 1H, ArH), 6.99 (d, $J = 8.7$ Hz, 2H, ArH), 5.88 (t, $J = 8.6$ Hz, 1H, CH), 3.86 (s, 3H, OCH$_3$), 3.81 (dd, $J = 16.2$, 9.5 Hz, 1H, CH$_2$), 3.37 (dd, $J = 16.2$, 7.8 Hz, 1H, CH$_2$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.6, 160.3, 155.6, 147.4, 141.4, 138.1, 131.5, 128.8, 128.6, 128.1, 128.0, 127.7, 125.4, 114.3, 113.9, 112.6, 81.7, 55.3, 37.1; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{26}$H$_{22}$NO$_2$: 380.1651, found: 380.1646.

2,4-Diphenyl-6-(m-tolyl)-2,3-dihydrofuro[2,3-b]pyridine (3af). Pale yellow viscous
liquid; 88.7 mg (61% yield); $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.04 (d, $J = 7.4$ Hz, 2H, ArH), 7.44-7.23 (m, 12H, ArH), 7.19 (d, $J = 7.3$ Hz, 1H, ArH), 5.89 (t, $J = 8.6$ Hz, 1H, CH), 3.52 (dd, $J = 16.4$, 9.5 Hz, 1H, CH$_2$), 3.07 (dd, $J = 16.4$, 7.8 Hz, 1H, CH$_2$), 2.23 (s, 3H, CH$_3$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.3, 155.3, 148.5, 141.4, 138.8, 137.9, 134.9, 130.5, 128.8, 128.7, 128.6, 128.4, 128.3, 128.0, 126.8, 125.9, 125.4, 116.7, 114.8, 81.8, 36.4, 19.8; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{26}$H$_{22}$NO: 364.1701, found: 364.1697.

6-(2-Fluorophenyl)-2,4-diphenyl-2,3-dihydrofuro[2,3-b]pyridine (3ag). Pale yellow solid; 79.5 mg (54% yield); mp 92-93 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.14 (td, $J = 7.9$, 1.8 Hz, 1H, ArH), 7.57-7.55 (m, 3H, ArH), 7.50-7.31 (m, 9H, ArH), 7.27 (td, $J = 7.6$, 1.0 Hz, 1H, ArH), 7.16 (ddd, $J = 11.6$, 8.2, 0.9 Hz, 1H, ArH), 5.91 (t, $J = 8.6$ Hz, 1H, CH), 3.86 (dd, $J = 16.4$, 9.4 Hz, 1H, CH$_2$), 3.41 (dd, $J = 16.4$, 7.8 Hz, 1H, CH$_2$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 168.6, 160.4 (d, $J_{C-F} = 248.4$ Hz), 151.1, 151.1 (d, $J_{C-F} = 2.7$ Hz), 147.2, 141.2, 137.8, 131.0 (d, $J_{C-F} = 2.7$ Hz), 130.1 (d, $J_{C-F} = 8.7$ Hz), 128.8, 128.7, 128.1, 127.8, 126.9 (d, $J_{C-F} = 10.9$ Hz), 125.4, 124.3 (d, $J_{C-F} = 3.4$ Hz), 117.6 (d, $J_{C-F} = 10.7$ Hz), 116.1 (d, $J_{C-F} = 23.3$ Hz), 115.6, 81.7, 37.2; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{25}$H$_{19}$FNO: 368.1451, found: 368.1448.

4,6-Bis(4-chlorophenyl)-2-phenyl-2,3-dihydrofuro[2,3-b]pyridine (3ah). Yellow solid; 110.3 mg (66% yield); mp 157-158 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.00 (d, $J = 7.6$ Hz, 2H, ArH), 7.49-7.33 (m, 12H, ArH), 5.90 (t, $J = 8.5$ Hz, 1H, CH), 3.80 (dd, $J = 16.3$, 9.4 Hz, 1H, CH$_2$), 3.35 (dd, $J = 16.3$, 7.7 Hz, 1H, CH$_2$); $^{13}$C NMR (CDCl$_3$, 100
MHz): δ 168.8, 154.8, 146.4, 141.0, 137.1, 136.0, 135.0, 129.1, 129.0, 128.8, 128.7, 128.2, 128.1, 125.4, 115.5, 113.0, 81.9, 37.0; HRMS (ESI) m/z [M + H]+ calculated for C_{25}H_{18}Cl_{2}NO: 418.0765, found: 418.0770.

4-(4-Chlorophenyl)-6-(4-methoxyphenyl)-2-phenyl-2,3-dihydrofuro[2,3-b]pyridine (3ai). Brick red solid; 99.3 mg (60% yield); mp 126-127 °C; 1H NMR (CDCl$_3$, 400 MHz): δ 8.01 (d, J = 8.7 Hz, 1H, ArH), 7.49-7.43 (m, 6H, ArH), 7.39 (t, J = 7.4 Hz, 1H, ArH), 7.33 (d, J = 7.2 Hz, 1H, ArH), 7.31 (s, 1H, ArH), 6.98 (d, J = 8.7 Hz, 1H, ArH), 5.89 (t, J = 8.5 Hz, 1H, CH), 3.86 (s, 3H, OCH$_3$), 3.78 (dd, J = 16.3, 9.4 Hz, 1H, CH$_2$), 3.34 (dd, J = 16.2, 7.8 Hz, 1H, CH$_2$); 13C NMR (CDCl$_3$, 100 MHz): δ 168.7, 160.4, 155.8, 146.2, 141.2, 136.6, 134.8, 131.3, 129.0, 129.0, 128.7, 128.1, 128.1, 125.4, 114.2, 114.0, 112.3, 81.8, 55.3, 37.1; HRMS (ESI) m/z [M + H]+ calculated for C$_{26}$H$_{21}$ClNO$_2$: 414.1261, found: 414.1260.

Experimental Procedures and Data for Compounds 5

A mixture of N-propargylic β-enaminones 1 (0.4 mmol), N-sulfonyl imines 4 (0.8 mmol), and KOH (8 mg, 0.12 mmol, 0.3 equiv) in DMF (3 mL) was stirred at 100 °C under N$_2$ for 3 h. After 1 was disappeared completely (monitored by TLC), the residue dissolved in H$_2$O (10 mL) and extracted with EtOAc (3 x 10 mL). The combined EtOAc extracts were dried over Na$_2$SO$_4$ and concentrated. Then solvent was evaporated and the residue was purified by chromatography (silica gel, 2%
EtOAc in PE) to give 5.

2,4,6-Triphenyl-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5a). Yellow solid; 130.7 mg (65% yield); mp 209-210 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 8.08 (d, \(J = 7.3\) Hz, 2H, ArH), 7.70 (d, \(J = 8.2\) Hz, 2H, ArH), 7.49 (t, \(J = 7.4\) Hz, 2H, ArH), 7.44-7.36 (m, 7H, ArH), 7.26-7.23 (m, 5H, ArH), 7.09 (d, \(J = 8.2\) Hz, 2H, ArH), 5.74 (dd, \(J = 10.3, 3.1\) Hz, 1H, CH), 3.85 (dd, \(J = 16.8, 10.4\) Hz, 1H, CH\(_2\)), 3.10 (dd, \(J = 16.8, 3.1\) Hz, 1H, CH\(_2\)); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \(\delta\) 156.7, 155.7, 146.9, 143.6, 142.3, 138.9, 137.8, 136.9, 128.9, 128.8, 128.7, 128.6, 128.4, 128.0, 127.8, 126.9, 126.2, 118.6, 114.6, 63.3, 36.0, 21.5; HRMS (ESI) \(m/z\) [M + H]\(^+\) calculated for C\(_{32}\)H\(_{27}\)N\(_2\)O\(_2\)S: 503.1793, found: 503.1789.

2,4,6-Triphenyl-1-(phenylsulfonyl)-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5b). Yellow solid; 97.7 mg (50% yield); mp 248-249 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 8.07 (d, \(J = 7.6\) Hz, 2H, ArH), 7.83 (d, \(J = 7.6\) Hz, 2H, ArH), 7.50-7.37 (m, 10H, ArH), 7.29 (t, \(J = 7.8\) Hz, 2H, ArH), 7.25-7.19 (m, 5H, ArH), 5.75 (dd, \(J = 10.3, 3.0\) Hz, 1H, CH), 3.86 (dd, \(J = 16.8, 10.4\) Hz, 1H, CH\(_2\)), 3.11 (dd, \(J = 16.8, 3.0\) Hz, 1H, CH\(_2\)); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \(\delta\) 156.7, 155.8, 147.0, 142.1, 139.8, 138.9, 137.8, 132.7, 128.9, 128.8, 128.7, 128.6, 128.3, 128.1, 128.1, 128.7, 128.6, 126.9, 126.2, 118.6, 114.7, 63.33, 36.00; HRMS (ESI) \(m/z\) [M + H]\(^+\) calculated for C\(_{31}\)H\(_{25}\)N\(_2\)O\(_2\)S: 489.1637, found: 489.1623.
1-(Methylsulfonyl)-2,4,6-triphenyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5c).
White solid; 90.4 mg (53% yield); mp 228-229 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 8.10 (d, \(J = 7.2\) Hz, 2H, ArH), 7.51-7.41 (m, 9H, ArH), 7.35-7.29 (m, 5H, ArH), 5.69 (dd, \(J = 10.2, 3.1\) Hz, 1H, CH), 3.90 (dd, \(J = 16.8, 10.2\) Hz, 1H, CH\(_2\)), 3.31 (s, 3H, CH\(_3\)), 3.15 (dd, \(J = 16.8, 3.1\) Hz, 1H, CH\(_2\)); \(^1^3\)C NMR (CDCl\(_3\), 100 MHz): \(\delta\) 157.0, 155.8, 147.4, 142.3, 138.6, 137.7, 129.1, 129.0, 128.9, 128.8, 128.7, 128.2, 127.8, 126.8, 125.7, 118.9, 114.7, 62.5, 41.9, 36.0; HRMS (ESI) \(m/z\) [M + H]\(^+\) calculated for C\(_{26}\)H\(_{23}\)N\(_2\)O\(_2\)S: 427.1480, found: 427.1468.

4,6-Diphenyl-1-tosyl-2-(4-(trifluoromethyl)phenyl)-2,3-dihydro-1H-pyrrolo[2,3-b]-pyridine (5d). Yellow solid; 102.7 mg (45% yield); mp 198-199 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 8.10 (d, \(J = 7.2\) Hz, 2H, ArH), 7.76 (d, \(J = 8.3\) Hz, 2H, ArH), 7.52-7.39 (m, 11H, ArH), 7.35 (d, \(J = 8.0\) Hz, 2H, ArH), 7.12 (d, \(J = 8.1\) Hz, 2H, ArH), 5.76 (dd, \(J = 10.4, 3.4\) Hz, 1H, CH), 3.86 (dd, \(J = 16.8, 10.4\) Hz, 1H, CH\(_2\)), 3.06 (dd, \(J = 16.8, 3.5\) Hz, 1H, CH\(_2\)), 2.34 (s, 3H, CH\(_3\)); \(^1^3\)C NMR (CDCl\(_3\), 100 MHz): \(\delta\) 156.6, 156.0, 147.3, 146.2, 144.0, 138.7, 137.6, 136.6, 130.2 (q, \(J_{C-F} = 32.3\) Hz), 129.1, 128.9, 129.0, 128.8, 128.7, 128.3, 127.7, 126.9, 126.5, 125.7 (q, \(J_{C-F} = 3.6\) Hz), 123.9 (q, \(J_{C-F} = 270.4\) Hz), 118.0, 114.8, 62.7, 35.9, 21.5; HRMS (ESI) \(m/z\) [M + H]\(^+\) calculated for C\(_{33}\)H\(_{26}\)F\(_3\)N\(_2\)O\(_2\)S: 571.1667, found: 571.1661.

2-(4-Fluorophenyl)-4,6-diphenyl-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5e).
Pale yellow solid; 102.0 mg (49% yield); mp 211-212 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.09 (d, J = 8.0 Hz, 2H, ArH), 7.74 (d, J = 8.1 Hz, 2H, ArH), 7.50 (t, J = 7.3 Hz, 2H, ArH), 7.44-7.39 (m, 7H, ArH), 7.21 (dd, J = 7.9, 5.5 Hz, 2H, ArH), 7.13 (d, J = 8.0 Hz, 2H, ArH), 6.93 (t, J = 8.5 Hz, 2H, ArH), 5.73 (dd, J = 10.2, 2.7 Hz, 1H, CH), 3.85 (dd, J = 16.8, 10.4 Hz, 1H, CH₂), 3.06 (dd, J = 16.8, 2.9 Hz, 1H, CH₂), 2.34 (s, 3H, CH₃); ¹³C NMR (CDCl₃, 100 MHz): δ 162.4 (d, J_{C-F} = 245.2 Hz), 156.5, 155.8, 147.0, 143.7, 138.8, 138.2 (d, J_{C-F} = 3.1 Hz), 137.7, 136.8, 128.9, 128.8, 128.2, 128.6, 128.3, 128.0 (d, J_{C-F} = 8.2 Hz), 127.7, 126.9, 118.3, 115.5 (d, J_{C-F} = 21.5 Hz), 114.7, 62.6, 36.0, 21.5; HRMS (ESI) m/z [M + H]⁺ calculated for C₃₂H₂₆FN₂O₂S: 521.1699, found: 521.1692.

2-(4-Chlorophenyl)-4,6-diphenyl-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5f).

Pale yellow solid; 122.4 mg (57% yield); mp 120-121 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.08 (d, J = 7.4 Hz, 2H, ArH), 7.76 (d, J = 8.2 Hz, 2H, ArH), 7.49 (t, J = 7.4 Hz, 2H, ArH), 7.45-7.39 (m, 7H, ArH), 7.22-7.13 (m, 6H, ArH), 5.70 (dd, J = 10.3, 3.2 Hz, 1H, CH), 3.83 (dd, J = 16.8, 10.4 Hz, 1H, CH₂), 3.03 (dd, J = 16.8, 3.3 Hz, 1H, CH₂), 2.35 (s, 3H, CH₃); ¹³C NMR (CDCl₃, 100 MHz): δ 156.5, 155.8, 147.1, 143.8, 140.9, 138.7, 137.6, 136.7, 133.7, 128.9, 128.9, 128.8, 128.8, 128.7, 128.6, 128.3, 127.7, 127.6, 126.9, 118.2, 114.7, 62.6, 36.0, 21.5; HRMS (ESI) m/z [M + H]⁺ calculated for C₃₂H₂₆ClN₂O₂S: 537.1404, found: 537.1403.

2-(4-(tert-Butyl)phenyl)-4,6-diphenyl-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5g).

Yellow solid; 120.7 mg (54% yield); mp 224-225 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.11 (dd, J = 7.2, 1.3 Hz, 2H, ArH), 7.64 (d, J = 8.3 Hz, 2H, ArH), 7.50 (t, J = 7.4 Hz, 2H, ArH), 7.45-7.36 (m, 7H, ArH), 7.23 (d, J = 8.4 Hz, 2H, ArH), 7.12 (d, J = 8.0 Hz, 2H, ArH).
= 8.4 Hz, 2H, ArH), 7.04 (d, J = 8.2 Hz, 2H, ArH), 5.71 (dd, J = 10.2, 2.7 Hz, 1H, CH), 3.84 (dd, J = 16.7, 10.3 Hz, 1H, CH₂), 3.13 (dd, J = 10.2, 2.7 Hz, 1H, CH₂), 2.31 (s, 3H, CH₃), 1.29 (s, 9H, 3×CH₃); ¹³C NMR (CDCl₃, 100 MHz): δ 156.7, 155.6, 151.0, 146.8, 143.3, 139.0, 138.9, 137.8, 136.9, 128.8, 128.8, 128.6, 128.6, 128.6, 128.4, 127.8, 126.9, 126.0, 125.5, 118.9, 114.4, 63.2, 35.8, 34.5, 31.3, 21.5; HRMS (ESI) m/z [M + H]⁺ calculated for C₃₆H₃₅N₂O₂S: 559.2419, found: 559.2406.

2-(4-Methoxyphenyl)-4,6-diphenyl-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5h). Pale yellow solid; 134.2 mg (63% yield); mp 216-217 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.08 (d, J = 7.4 Hz, 2H, ArH), 7.70 (d, J = 8.2 Hz, 2H, ArH), 7.49 (t, J = 7.4 Hz, 2H, ArH), 7.44-7.39 (m, 7H, ArH), 7.15 (d, J = 8.6 Hz, 2H, ArH), 7.10 (d, J = 8.1 Hz, 2H, ArH), 6.76 (d, J = 8.6 Hz, 2H, ArH), 5.71 (dd, J = 10.3, 2.8 Hz, 1H, CH), 3.83 (dd, J = 16.8, 10.3 Hz, 1H, CH₂), 3.79 (s, 3H, OCH₃), 3.09 (dd, J = 16.8, 2.8 Hz, 1H, CH), 2.33 (s, 3H, CH₃); ¹³C NMR (CDCl₃, 100 MHz): δ 159.3, 156.6, 155.7, 146.9, 143.5, 138.9, 137.8, 137.0, 134.5, 128.8, 128.8, 128.7, 128.6, 128.6, 128.4, 127.8, 127.6, 126.9, 118.7, 114.5, 113.9, 62.9, 55.3, 36.1, 21.5; HRMS (ESI) m/z [M + H]⁺ calculated for C₃₃H₂₉N₂O₂S: 533.1899, found: 533.1890.

2-(Benzo[d][1,3]dioxol-5-yl)-4,6-diphenyl-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]-pyridine (5i). Pale yellow solid; 146.5 mg (67% yield); mp 203-204 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.09 (dd, J = 7.2, 1.4 Hz, 2H, ArH), 7.78 (d, J = 8.3 Hz, 2H, ArH), 7.49 (t, J = 7.4 Hz, 2H, ArH), 7.44-7.37 (m, 7H, ArH), 7.13 (d, J = 8.1 Hz, 2H, ArH), 6.76 (d, J = 8.0, 1.5 Hz, 1H, ArH), 6.69 (d, J = 8.0 Hz, 1H, ArH), 6.59 (d, J = 1.5 Hz, 1H, ArH), 5.89 (d, J = 5.2 Hz, 2H, ArH), 5.65 (dd, J = 10.2, 3.0 Hz, 1H, CH), 3.81 (dd, J = 16.8, 10.3 Hz, 1H, CH₂), 3.06 (dd, J = 16.8, 3.1 Hz, 1H, CH₂), 2.34 (s,
3H, CH$_3$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 156.6, 155.8, 147.9, 147.3, 147.0, 143.7, 138.9, 137.8, 137.0, 136.3, 128.9, 128.8, 128.7, 128.6, 128.4, 127.8, 126.9, 120.0, 118.5, 114.6, 108.2, 106.4, 101.0, 63.3, 36.1, 21.6; HRMS (ESI) m/z [M + H]$^+$ calculated for C$_{33}$H$_{27}$N$_2$O$_4$S: 547.1692, found: 547.1683.

![Chemical Structure](image)

2,6-Diphenyl-1-tosyl-4-(4-(trifluoromethyl)phenyl)-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5j). Pale yellow solid; 152.9 mg (67% yield); mp 103-104 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.08 (dd, $J = 8.5, 1.4$ Hz, 2H, ArH), 7.70 (dd, $J = 8.4, 1.9$ Hz, 4H, ArH), 7.54 (d, $J = 8.1$ Hz, 2H, ArH), 7.50 (t, $J = 7.3$ Hz, 2H, ArH), 7.44 (t, $J = 7.2$ Hz, 1H, ArH), 7.39 (s, 1H, ArH), 7.28-7.19 (m, 5H, ArH), 7.10 (d, $J = 8.2$ Hz, 2H, ArH), 5.76 (dd, $J = 10.4, 3.2$ Hz, 1H, CH), 3.83 (dd, $J = 16.8, 10.4$ Hz, 1H, CH$_2$), 3.07 (dd, $J = 16.8, 3.2$ Hz, 1H, CH$_2$), 2.33 (s, 3H, CH$_3$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 156.8, 156.0, 145.4, 143.7, 142.0, 141.3, 138.5, 136.7, 130.6 (q, $J_{C,F} = 32.5$ Hz), 129.0, 128.8, 128.7, 128.6, 128.4, 128.2, 128.0, 126.8, 126.1, 125.7 (q, $J_{C,F} = 3.7$ Hz), 123.8 (q, $J_{C,F} = 270.7$ Hz), 118.7, 114.2, 63.3, 35.8, 21.4; HRMS (ESI) m/z [M + H]$^+$ calculated for C$_{33}$H$_{28}$F$_3$N$_2$O$_2$S: 571.1667, found: 571.1660.

![Chemical Structure](image)

4-(3-Bromophenyl)-2,6-diphenyl-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5k). Pale yellow solid; 141.9 mg (61% yield); mp 205-206 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.08 (d, $J = 7.3$ Hz, 2H, ArH), 7.70 (d, $J = 8.2$ Hz, 2H, ArH), 7.56 (s, 1H, ArH), 7.52-7.47 (m, 3H, ArH), 7.43 (t, $J = 7.2$ Hz, 1H, ArH), 7.36 (s, 1H, ArH), 7.34 (d, $J = 7.9$ Hz, 1H, ArH), 7.29 (t, $J = 7.7$ Hz, 1H, ArH), 7.27-7.20 (m, 5H, ArH), 7.09 (d, $J = 8.1$ Hz, 2H, ArH), 5.74 (dd, $J = 10.3, 3.1$ Hz, 1H, CH), 3.83 (dd, $J = 16.8, 10.4$ Hz, 1H, CH)$_2$. The remaining data follows with similar format as above.
Hz, 1H, CH$_2$), 3.06 (dd, $J = 16.8$, 3.2 Hz, 1H, CH$_2$), 2.32 (s, 3H, CH$_3$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 156.8, 156.0, 145.4, 143.6, 142.1, 139.8, 138.6, 136.7, 131.7, 130.7, 130.3, 129.0, 128.8, 128.7, 128.6, 128.4, 128.1, 126.9, 126.4, 126.2, 122.9, 118.6, 114.2, 63.3, 35.9, 21.5; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{32}$H$_{26}$BrN$_2$O$_2$S: 581.0898, found: 581.0898.

![6-(4-Chlorophenyl)-2,4-diphenyl-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5l).](image)

Yellow solid; 118.1 mg (55% yield); mp 241-242 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 8.01 (d, $J = 8.4$ Hz, 2H, ArH), 7.66 (d, $J = 8.1$ Hz, 2H, ArH), 7.45-7.37 (m, 8H, ArH), 7.25-7.22 (m, 5H, ArH), 7.09 (d, $J = 8.1$ Hz, 2H, ArH), 5.74 (dd, $J = 10.3$, 2.9 Hz, 1H, CH), 3.84 (dd, $J = 16.9$, 10.4 Hz, 1H, CH$_2$), 3.09 (dd, $J = 16.9$, 2.9 Hz, 1H, CH$_2$), 2.32 (s, 3H, CH$_3$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 156.7, 154.4, 147.0, 143.7, 142.1, 137.6, 137.3, 136.8, 134.8, 128.8, 128.7, 128.7, 128.7, 128.3, 128.1, 128.0, 127.7, 126.2, 119.0, 114.4, 63.3, 36.0, 21.5; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{32}$H$_{26}$ClN$_2$O$_2$S: 537.1404, found: 537.1397.

![2,4-Diphenyl-6-(m-tolyl)-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5m).](image)

Yellow solid; 121.9 mg (59% yield); mp 197-198°C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 7.87-7.85 (m, 2H, ArH), 7.71 (d, $J = 8.1$ Hz, 2H, ArH), 7.43-7.35 (m, 7H, ArH), 7.26-7.23 (m, 6H, ArH), 7.11 (d, $J = 8.0$ Hz, 2H, ArH), 5.75 (dd, $J = 10.3$, 2.9 Hz, 1H, CH), 3.85 (dd, $J = 16.8$, 10.4 Hz, 1H, CH$_2$), 3.10 (dd, $J = 16.8$, 3.0 Hz, 1H, CH$_2$), 2.47 (s, 3H, CH$_3$), 2.33 (s, 3H, CH$_3$); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ 156.7, 155.9, 146.9, 143.5, 142.3, 138.9, 138.0, 137.8, 136.9, 129.6, 128.8, 128.8, 128.7, 128.6, 128.5, 128.0, 127.8, 127.6, 126.2, 124.1, 118.5, 114.6, 63.2, 36.0, 21.6, 21.5; HRMS (ESI) $m/z$ [M + H]$^+$ calculated for C$_{33}$H$_{29}$N$_2$O$_2$S: 517.1950, found: 517.1945.
6-(2-Fluorophenyl)-2,4-diphenyl-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5n).
Yellow solid; 104.1 mg (50% yield); mp 143-144 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.19 (t, J = 7.4 Hz, 1H, ArH), 7.66 (d, J = 7.8 Hz, 2H, ArH), 7.56 (s, 1H, ArH), 7.43-7.13 (m, 13H, ArH), 7.07 (d, J = 7.8 Hz, 2H, ArH), 5.74 (d, J = 8.5 Hz, 1H, CH), 3.87 (dd, J = 16.7, 10.4 Hz, 1H, CH₂), 3.12 (d, J = 16.9 Hz, 1H, CH₂), 2.32 (s, 3H, CH₃);
¹³C NMR (CDCl₃, 100 MHz): δ 167.7, 160.6 (d, J_C-F = 248.6 Hz), 156.5, 151.1 (d, J_C-F = 3.0 Hz), 146.6, 143.6, 142.1, 137.6, 136.7, 131.3 (d, J_C-F = 2.6 Hz), 130.2 (d, J_C-F = 8.5 Hz), 128.8, 128.7, 128.7, 128.6, 128.4, 128.0, 127.8, 126.9 (d, J_C-F = 10.6 Hz), 126.2, 124.3 (d, J_C-F = 3.4 Hz), 118.9, 118.7 (d, J_C-F = 11.3 Hz), 116.1 (d, J_C-F = 23.3 Hz), 63.2, 36.1, 21.5; HRMS (ESI) m/z [M + H]⁺ calculated for C₃₂H₂₆FN₂O₂S: 521.1699, found: 521.1696.

**Synthetic Transformations**

To a solution of 2,4,6-triphenyl-2,3-dihydrofuro[2,3-b]pyridine (3a; 104.8 mg, 0.3 mmol, 1.0 equiv) in anhydrous 1,4-dioxane (3 mL) was added 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (204.3 mg, 0.9 mmol, 3.0 equiv) and the reaction mixture was stirred under reflux for 20 h. Then it was quenched with a sat. aq. NaHCO₃ solution and
extracted with EtOAc (3 × 15 mL). The combined organic layers were washed with a sat. aq. NaCl solution, dried over Na₂SO₄ and concentrated in vacuo. Purification of the crude product by flash chromatography (SiO₂, 1% EtOAc in PE) afforded 6a.

2,4,6-Triphenylfuro[2,3-b]pyridine (6a). White solid; 90.7 mg (87% yield); mp 176-177 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.16 (d, J = 7.5 Hz, 2H, ArH), 7.94 (d, J = 7.5 Hz, 2H, ArH), 7.79 (s, 1H, ArH), 7.76 (d, J = 7.4 Hz, 2H, ArH), 7.58 (t, J = 7.2 Hz, 2H, ArH), 7.53-7.44 (m, 6H, ArH), 7.38 (t, J = 7.0 Hz, 1H, ArH), 7.20 (s, 1H, ArH); ¹³C NMR (CDCl₃, 100 MHz): δ 162.7, 155.9, 152.5, 143.6, 139.0, 137.9, 129.6, 129.1, 129.0, 128.9, 128.8, 128.7, 128.2, 127.0, 125.0, 118.2, 115.6, 99.7; HRMS (ESI) m/z [M + H]⁺ calculated for C₂₅H₁₈NO: 348.1388, found: 348.1383.

To a solution of 2,4,6-triphenyl-1-tosyl-2,3-dihydro-1H-pyrrolo[2,3-b]pyridine (5a; 150.8 mg, 0.3 mmol, 1.0 equiv) in anhydrous DCE (4 mL) was added DDQ (204.3 mg, 0.9 mmol, 3.0 equiv) and the reaction mixture was stirred under reflux for 24 h. Then it was quenched with a sat. aq. NaHCO₃ solution and extracted with CH₂Cl₂ (3 × 15 mL). The combined organic layers were washed with a sat. aq. NaCl solution, dried over Na₂SO₄ and concentrated in vacuo. Purification of the crude product by flash chromatography (SiO₂, 2% EtOAc in PE) afforded 7a.

2,4,6-Triphenyl-1-tosyl-1H-pyrrolo[2,3-b]pyridine (7a). White solid; 129.2 mg (86% yield); mp 194-195 °C; ¹H NMR (CDCl₃, 400 MHz): δ 8.25 (dd, J = 7.3, 1.2 Hz, 2H, ArH), 7.94 (d, J = 8.3 Hz, 2H, ArH), 7.77 (s, 1H, ArH), 7.67-7.60 (m, 4H, ArH), 7.55 (t, J = 7.6 Hz, 2H, ArH), 7.52-7.43 (m, 7H, ArH), 7.18 (d, J = 8.2 Hz, 2H, ArH), 6.72 (s, 1H, ArH), 2.32 (s, 3H, CH₃); ¹³C NMR (CDCl₃, 100 MHz): δ 152.5, 150.6, 144.7, 142.7, 142.4, 139.2, 137.9, 135.9, 133.0, 129.7, 129.2, 129.0, 128.8, 128.7, 128.7, 128.4, 128.2, 127.7, 127.0, 119.0, 115.4, 108.3, 21.57; HRMS (ESI) m/z [M + H]⁺ calculated for C₃₂H₂₅N₂O₂S: 501.1637, found: 501.1633.
References


X-Ray Structure of 3a

Crystal data
Crystallographic data for compound 3a (CCDC-1544842) has been deposited with the Cambridge Crystallographic Data Centre, Copies of the data can be obtained, free of charge, on application to CCDC (Email:deposit@ccdc.cam.ac.uk).

Datablock: 3a

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Npar = 244

Figure 1. Ortep view of the complex 3a (Color scheme: C, gray; N, blue; O, red)
$^1$H and $^{13}$C NMR spectra
3i

3j
3z

3aa
3ab

3ac
3ah

3ai