Supporting Information
for DOI: 10.1055/s-0034-1379935
© Georg Thieme Verlag KG Stuttgart · New York 2015
Supporting Information

Synthesis of 2-Acylated Indoles via Pd-Catalyzed Dehydrogenative Coupling of N-Pyrimidine Protected Indoles with Aldehydes and Ethyl Glyoxylate

Wenduo Wang,* Jidan Liu, Qingwen Gui, Ze Tan**
*State Key Laboratory of Chemo/Biosensing and Chemometrics, College of Chemistry and Chemical Engineering, Hunan University, Changsha 410082, P. R. China.
E-mail: ztanze@gmail.com.

Table of Contents

I General Consideration S 2

II Experimental Section S 2-S3

III Characterization Data for Selected Compounds S 3- S 45
General Consideration:

All solvents and reagents were purchased from the suppliers and used after further dried. $^1$H NMR and $^{13}$C NMR were recorded in CDCl$_3$ at room temperature on the spectrometer (400 MHz $^1$H, 101 MHz $^{13}$C). The chemical-shifts scale is based on internal TMS. Data for $^1$H NMR and $^{13}$C NMR are reported as follows: chemical shift (δ ppm), multiplicity, integration, and coupling constant (Hz). All reactions were carried out under dry nitrogen atmosphere.

Experimental Section:

![Reaction Scheme]

To a 25-mL sealed tube were added indole (0.3 mmol), aldehyde (0.45 mmol), Pd(OAc)$_2$ (6.72 mg, 10 mmol%), TBHP (anhydrous, about 5M in decane) (4 equiv), EtOAc (2.0 mL). The tube was capped and stirred under N$_2$ at 125 °C for 24 h. The reaction mixture was cooled to room temperature and diluted with CH$_2$Cl$_2$, filtered through a short pad of Celite, washed with brine and CH$_2$Cl$_2$. The combined organic extracts were dried over Na$_2$SO$_4$, concentrated in vacuum, and the resulting residue was purified by silica gel column chromatography to afford the desired product. All compounds are characterized by $^1$H NMR, $^{13}$C NMR, LRMS/HRMS and their comparison to literature values.

![Reaction Scheme]

To a 25-mL sealed tube were added indole (0.3 mmol), glyoxylate (0.45 mmol), Pd(OAc)$_2$ (6.72 mg, 10 mmol%), TBHP (anhydrous, about 5M in decane) (4 equiv), EtOAc (2.0 mL). The tube was capped and stirred under N$_2$ at 125 °C for 24 h. The reaction mixture was cooled to room temperature and diluted with CH$_2$Cl$_2$, filtered through a short pad of Celite, washed with brine and CH$_2$Cl$_2$. The combined organic extracts were dried over Na$_2$SO$_4$, concentrated in vacuum, and the resulting residue was purified by silica gel column chromatography to afford the desired product. All compounds are characterized by $^1$H NMR, $^{13}$C NMR, LRMS/HRMS and their comparison to literature values.
To a 25-mL sealed tube were added a mixture of 3ab (51.6 mg, 0.15 mmol), DMSO (1.0 mL) and EtONa (30.6 mg, 0.45 mmol), and the reaction mixture was stirred at 100 °C under nitrogen atmosphere for 24 h. After cooling to ambient temperature, the reaction mixture was diluted with EtOAc and washed with H2O. The aqueous phase was extracted with EtOAc, and the combined organic phase was dried over Na2SO4. After filtration and evaporation under reduced pressure, the residue was purified by flash column chromatography (petroleum ether/ethyl acetate) on silica gel to give the product of 6a.

**Characterization Data for Selected Compounds**

(1-(pyrimidin-2-yl)-1H-indol-2-yl)(p-tolyl)methanone (3aa)<sup>1</sup>

Yield: 83%; Melting Point: 122-123 °C; White solid; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 8.63 (d, J = 4.0 Hz, 2H), 8.39 (d, J = 8.0 Hz, 1H), 7.89 (d, J = 8.0 Hz, 2H), 7.69 (d, J = 8.0 Hz, 1H), 7.43 (t, J = 8.0 Hz, 1H), 7.30-7.23 (m, 3H), 7.10 (s, 1H), 7.05 (t, J = 4.0 Hz, 1H), 2.41 (s, 3H); <sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>) δ 187.3, 157.9, 157.3, 143.5, 138.2, 137.3, 135.3, 129.7, 129.0, 128.0, 126.3, 122.7, 122.4, 117.3, 115.0, 114.1, 21.7; HRMS (APCI) calcd for C<sub>20</sub>H<sub>15</sub>N<sub>3</sub>O (M+H)<sup>+</sup> 314.1288, found 314.1275.

(1-(pyrimidin-2-yl)-1H-indol-2-yl)(p-tolyl)methanone (3ab)<sup>1</sup>

Yield: 80%; Melting Point: 123-124 °C; White solid; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 8.56 (d, J = 4.0 Hz, 2H), 8.39 (d, J = 8.0 Hz, 1H), 7.95 (d, J = 8.0 Hz, 2H), 7.67 (d, J = 8.0 Hz, 1H), 7.50 (t, J = 8.0 Hz, 1H), 7.41 (q, J = 8.0 Hz, 3H), 7.28-7.22 (m, 1H), 7.10 (s, 1H), 6.97 (t, J = 4.0 Hz, 1H); <sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>) δ 187.4, 157.8, 157.1, 138.1, 137.3, 137.0, 132.6, 129.4, 128.2, 127.8, 126.4, 122.7, 122.4, 117.3, 115.2, 114.1; MS: m/z C<sub>19</sub>H<sub>13</sub>N<sub>3</sub>O 299.1 (M<sup>+</sup>).
Yield: 61%; Melting Point: 125-126 °C White solid. $^1$H NMR (400 MHz, CDCl$_3$) δ 8.68 (d, $J$ = 4.0 Hz, 2H), 8.31 (d, $J$ = 8.0 Hz, 1H), 7.68 (d, $J$ = 8.0 Hz, 1H), 7.51 (d, $J$ = 8.0 Hz, 1H), 7.43 (t, $J$ = 8.0 Hz, 1H), 7.30 – 7.26 (m, 1H), 7.10 – 7.05 (m, 3H), 6.97 (d, $J$ = 8.0 Hz, 1H), 2.54 (s, 3H), 2.35 (s, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) δ 189.1, 157.9, 157.4, 141.6, 139.0, 138.9, 138.5, 135.2, 132.1, 130.5, 127.8, 126.5, 125.7, 122.7, 122.5, 117.5, 115.8, 114.0, 21.4, 20.5; HRMS (ESI) calcd for C$_{21}$H$_{17}$N$_3$O (M+H)$^+$ 328.1444, found 328.1428.

(4-nitrophenyl)(1-(pyrimidin-2-yl)-1H-indol-2-yl)methanone (3ad)

Yield: 52%; Melting Point: 85-86 °C; White solid; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.61 (d, $J$ = 4.0 Hz, 2H), 8.46 (d, $J$ = 8.0 Hz, 1H), 8.26 (d, $J$ = 8.0 Hz, 2H), 8.07 (d, $J$ = 8.0 Hz, 2H), 7.73 (d, $J$ = 8.0 Hz, 1H), 7.49 (t, $J$ = 8.0 Hz, 1H), 7.33 (t, $J$ = 8.0 Hz, 1H), 7.18 (s, 1H), 7.07 (t, $J$ = 4.0 Hz, 1H); $^{13}$C NMR (101 MHz, CDCl$_3$) δ 185.6, 158.0, 157.0, 150.0, 143.1, 138.3, 136.2, 130.0, 127.9, 127.2, 123.6, 123.2, 122.7, 117.5, 116.1, 114.6; HRMS (ESI) calcd for C$_{19}$H$_{12}$N$_4$O$_3$ (M+H)$^+$ 345.0982, found 345.0997.

[1,1'-biphenyl]-4-yl(1-(pyrimidin-2-yl)-1H-indol-2-yl)methanone (3ae)

Yield: 72%; Melting Point: 109-110 °C; White solid; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.65 (d, $J$ = 4.0 Hz, 2H), 8.43 (d, $J$ = 8.0 Hz, 1H), 8.06 (d, $J$ = 8.0 Hz, 2H), 7.73 (d, $J$ = 4.0 Hz, 1H), 7.66 (dd, $J$ = 16.0, 8.0 Hz, 4H), 7.49-7.44 (m, 3H), 7.42 (t, $J$ = 8.0 Hz, 1H), 7.31 (t, $J$ = 7.5 Hz, 1H), 7.17 (s, 1H), 7.06 (t, $J$ = 4.8 Hz, 1H); $^{13}$C NMR (101 MHz, CDCl$_3$) δ 187.2, 158.0, 153.4, 145.4, 140.0, 138.3, 137.3, 136.8, 130.1, 128.9, 128.2, 128.1, 127.3, 127.0, 126.5, 122.8, 122.5, 117.3, 115.2, 114.3; HRMS (APCI) calcd for C$_{25}$H$_{17}$N$_3$O (M+H)$^+$ 376.1444, found 376.1454.
(2-bromophenyl)(1-(pyrimidin-2-yl)-1H-indol-2-yl)methanone (3af)

Yield: 63%; Melting Point: 37-38 °C; White solid; \( ^1 \)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.72 (d, \( J = 4.0 \) Hz, 2H), 8.27 (d, \( J = 8.0 \) Hz, 1H), 7.69 (d, \( J = 8.0 \) Hz, 1H), 7.63 (d, \( J = 7.0 \) Hz, 1H), 7.54-7.52 (m, 1H), 7.45 (t, \( J = 8.0 \) Hz, 1H), 7.28 (t, \( J = 8.0 \) Hz, 3H), 7.15 (s, 1H), 7.10 (t, \( J = 4.0 \) Hz, 1H); \( ^{13} \)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) 186.1, 158.0, 157.2, 139.5, 138.9, 137.2, 133.9, 131.8, 130.6, 127.6, 127.2, 126.7, 122.9, 122.8, 121.3, 117.7, 117.4, 114.0; HRMS (APCI) calcd for C\(_{19}\)H\(_{12}\)N\(_3\)OBr (M+H\(^+\)) 378.0237, found 378.0248.

(3-chlorophenyl)(1-(pyrimidin-2-yl)-1H-indol-2-yl)methanone (3ag)

Yield: 65%; Melting Point: 85-86 °C; White solid; \( ^1 \)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.65 (d, \( J = 4.0 \) Hz, 2H), 8.41 (d, \( J = 8.0 \) Hz, 1H), 7.98 (s, 1H), 7.83 (d, \( J = 8.0 \) Hz, 1H), 7.72 (d, \( J = 8.0 \) Hz, 1H), 7.52 (d, \( J = 8.0 \) Hz, 1H), 7.46 (t, \( J = 8.0 \) Hz, 1H), 7.37 (t, \( J = 8.0 \) Hz, 1H), 7.31 (t, \( J = 8.0 \) Hz, 1H), 7.14 (s, 1H), 7.09 (t, \( J = 4.0 \) Hz, 1H); \( ^{13} \)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) 186.1, 158.0, 157.1, 139.6, 138.3, 136.5, 134.6, 132.6, 129.6, 129.4, 127.9, 127.6, 126.8, 122.9, 122.6, 117.4, 115.7, 114.3; HRMS (ESI) calcd for C\(_{19}\)H\(_{12}\)N\(_3\)OCl (M+H\(^+\)) 334.0742, found 334.0757.

(2-fluorophenyl)(1-(pyrimidin-2-yl)-1H-indol-2-yl)methanone (3ah)

Yield: 61%; Melting Point: 96-97 °C; White solid; \( ^1 \)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.67 (d, \( J = 4.0 \) Hz, 2H), 8.34 (d, \( J = 8.0 \) Hz, 1H), 7.71 (t, \( J = 8.0 \) Hz, 2H), 7.46 (q, \( J = 8.0 \) Hz, 2H), 7.29 (d, \( J = 8.0 \) Hz, 1H), 7.19-7.14 (m, 2H), 7.12-7.06 (m, 2H); \( ^{13} \)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) 184.0, 162.1, 159.6, 157.9, 157.2, 138.5, 137.9, 133.6 (d, \( J_{C,F} = 8.1 \) Hz), 131.1 (d, \( J_{C,F} = 2.0 \) Hz), 127.8, 127.2 (d, \( J_{C,F} = 12.1 \) Hz), 126.9, 123.8 (d, \( J_{C,F} = 4.0 \) Hz), 122.7 (d, \( J_{C,F} = 14.1 \) Hz), 117.5, 116.6, 116.3, 115.8 (d, \( J_{C,F} = 1.0 \) Hz), 114.2; HRMS (ESI) calcd for C\(_{19}\)H\(_{12}\)N\(_3\)OF (M+H\(^+\)) 318.1037, found 318.1033.
naphthalen-1-yl(1-(pyrimidin-2-yl)-1H-indol-2-yl)methanone (3ai)

Yield: 62%; Melting Point: 137-138 °C; White solid; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.70 (d, \(J = 8.0\) Hz, 1H), 8.51 (d, \(J = 4.0\) Hz, 2H), 8.37 (d, \(J = 8.0\) Hz, 1H), 7.88 (dd, \(J = 20.0, 8.0\) Hz, 2H), 7.71 (dd, \(J = 20.0, 7.5\) Hz, 2H), 7.56 (dt, \(J = 28.0, 8.0\) Hz, 2H), 7.45 (t, \(J = 8.0\) Hz, 1H), 7.36 (t, \(J = 8.0\) Hz, 1H), 7.27 (dd, \(J = 16.0, 8.0\) Hz, 1H), 7.14 (s, 1H), 6.93 (t, \(J = 4.0\) Hz, 1H); \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 188.8, 157.8, 157.3, 138.9, 138.4, 136.0, 133.6, 132.2, 131.0, 129.0, 128.2, 127.9, 127.6, 126.7, 126.4, 126.0, 124.1, 122.8, 122.6, 117.3, 116.2, 114.2; HRMS (APCI) calcd for C\(_{23}\)H\(_{15}\)N\(_3\)O (M+H)+ 350.1288, found 350.1270.

tetrahydrofuran-2-yl(1-(pyrimidin-2-yl)-1H-indol-2-yl)methanone (3aj)

Yield: 78%; Melting Point: 123-124 °C; White solid; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.68 (d, \(J = 4.0\) Hz, 2H), 8.35 (d, \(J = 8.0\) Hz, 1H), 7.72 (d, \(J = 8.0\) Hz, 1H), 7.63 (s, 1H), 7.44 (t, \(J = 8.0\) Hz, 1H), 7.37 (s, 1H), 7.32-7.26 (m, 2H), 7.10 (t, \(J = 4.0\) Hz, 1H), 6.54 (dd, \(J = 3.5, 1.7\) Hz, 1H); \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 174.2, 158.0, 157.2, 152.4, 146.9, 138.4, 135.9, 127.7, 126.6, 122.7, 122.5, 119.4, 117.5, 115.2, 113.9, 112.2; HRMS (APCI) calcd for C\(_{17}\)H\(_{11}\)N\(_3\)O\(_2\) (M+H)+ 290.0924, found 290.0896.

(5-fluoro-1-(pyrimidin-2-yl)-1H-indol-2-yl)(naphthalen-2-yl)methanone (3ak)

Yield: 61%; Melting Point: 129-130 °C; White solid; \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.59 (d, \(J = 3.5\) Hz, 2H), 8.46 (d, \(J = 12.0\) Hz, 2H), 8.06 (d, \(J = 8.0\) Hz, 1H), 7.89 (t, \(J = 8.0\) Hz, 3H), 7.56 (dt, \(J = 28.0, 8.0\) Hz, 2H), 7.37 (d, \(J = 8.0\) Hz, 1H), 7.20 (t, \(J = 8.0\) Hz, 1H), 7.11 (s, 1H), 7.02 (s, 1H); \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 187.6, 160.4, 158.0 (d, \(J_{C-F} = 6.1\) Hz), 157.0, 138.5, 135.5, 135.1, 134.4, 132.3, 131.5, 129.6, 128.7 (d, \(J_{C-F} = 10.1\) Hz), 128.4 (d, \(J_{C-F} = 3.0\) Hz), 127.8, 126.7, 124.9, 117.4, 115.8 (d, \(J_{C-F} = 9.1\) Hz).
(5-bromo-1-(pyrimidin-2-yl)-1H-indol-2-yl)(4-chlorophenyl)methanone (3al)

Yield: 59%; Melting Point: 90-91 °C; White solid; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.61 (d, $J = 4.0$ Hz, 2H), 8.35 (d, $J = 8.0$ Hz, 1H), 7.88 (d, $J = 8.0$ Hz, 1H), 7.82 (d, $J = 4.0$ Hz, 1H), 7.52 (dd, $J = 8.0, 1.9$ Hz, 1H), 7.41 (d, $J = 8.0$ Hz, 2H), 7.08 (t, $J = 4.0$ Hz, 1H), 7.01 (s, 1H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 186.2, 158.0, 156.7, 139.3, 137.5, 136.6, 136.0, 130.8, 129.6, 129.3, 128.8, 124.8, 117.6, 116.1, 116.0, 113.6; HRMS (APCI) calcd for C$_{19}$H$_{11}$N$_3$OBrCl (M+H)$_+$ 411.9847, found 411.9851.

(2-bromophenyl)(5-chloro-1-(pyrimidin-2-yl)-1H-indol-2-yl)methanone (3am)

Yield: 63%; Melting Point: 92-93 °C; White solid; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.69 (d, $J = 4.0$ Hz, 2H), 8.26 (d, $J = 8.0$ Hz, 1H), 7.65-7.62 (m, 2H), 7.49 (t, $J = 4.0$ Hz, 1H), 7.38 (d, $J = 8.0$ Hz, 1H), 7.27 (t, $J = 4.0$ Hz, 2H), 7.09-7.07 (m, 2H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 186.0, 158.0, 156.7, 139.0, 138.1, 136.8, 134.0, 132.0, 130.6, 128.7, 128.3, 127.2, 126.7, 121.9, 121.3, 117.8, 115.7, 115.5; HRMS (APCI) calcd for C$_{19}$H$_{11}$N$_3$OBrCl (M+H)$_+$ 411.9847, found 411.9851.

2-(2,4-dimethylbenzoyl)-1-(pyrimidin-2-yl)-1H-indole-5-carbonitrile (3an)

Yield: 76%; Melting Point: 138-139 °C; White solid; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.69 (d, $J = 4.0$ Hz, 2H), 8.41 (d, $J = 8.0$ Hz, 1H), 8.01 (d, $J = 4.0$ Hz, 1H), 7.62 (dd, $J = 8.0, 4.0$ Hz, 1H), 7.48 (d, $J = 8.0$ Hz, 1H), 7.16 (t, $J = 4.0$ Hz, 1H), 7.08 (s, 1H), 7.04 (s, 1H), 6.98 (d, $J = 8.0$ Hz, 1H), 2.54 (s, 3H), 2.34 (s,
$^{13}$C NMR (101 MHz, CDCl$_3$) δ 188.5, 158.1, 156.6, 142.3, 140.6, 139.5, 139.3, 134.3, 132.4, 130.7, 128.7, 127.6, 127.6, 125.9, 119.6, 118.3, 115.1, 114.0, 105.9, 21.4, 20.6; HRMS (APCI) calcd for C$_{22}$H$_{16}$N$_4$O (M+H)$^+$ 353.1406, found 353.1406.

**methyl 2-(4-methylbenzoyl)-1-(pyrimidin-2-yl)-1H-indole-5-carboxylate (3ao)**

![Structure of methyl 2-(4-methylbenzoyl)-1-(pyrimidin-2-yl)-1H-indole-5-carboxylate (3ao)]

Yield: 85%; Melting Point: 111-112 °C; White solid; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.67 (d, J = 4.0 Hz, 2H), 8.45 (d, J = 0.8 Hz, 1H), 8.40 (d, J = 8.0 Hz, 1H), 8.11 (dd, J = 8.0, 4.0 Hz, 1H), 7.90 (d, J = 8.0 Hz, 2H), 7.27 (d, J = 8.0 Hz, 2H), 7.16 (s, 1H), 7.13 (t, J = 4.0 Hz, 1H), 3.96 (s, 3H), 2.42 (s, 3H); 13C NMR (101 MHz, CDCl$_3$) δ 187.0, 167.3, 158.1, 156.9, 143.9, 140.4, 138.4, 134.8, 129.7, 129.1, 127.2, 125.0, 124.6, 117.9, 115.0, 113.9, 52.1, 21.7; HRMS (APCI) calcd for C$_{22}$H$_{17}$N$_3$O$_3$ (M+H)$^+$ 372.1343, found 372.1340.

**(6-fluoro-1-(pyrimidin-2-yl)-1H-indol-2-yl)(phenyl)methanone (3ap)**

![Structure of (6-fluoro-1-(pyrimidin-2-yl)-1H-indol-2-yl)(phenyl)methanone (3ap)]

Yield: 70%; Melting Point: 126-127 °C; White solid; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.64 (d, J = 4.0 Hz, 2H), 8.14 (dd, J = 8.0, 4.0 Hz, 1H), 7.98 (d, J = 8.0 Hz, 2H), 7.63 (dd, J = 8.0, 4.0 Hz, 1H), 7.56 (t, J = 8.0 Hz, 1H), 7.45 (t, J = 7.6 Hz, 2H), 7.10 – 7.03 (m, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 187.00, 162.2 (d, $J_{C,F} = 244.4$ Hz), 158.0, 156.9, 138.6 (d, $J_{C,F} = 13.1$ Hz), 137.6, 137.5 (d, $J_{C,F} = 4.0$ Hz), 132.8, 129.5, 128.3, 124.2, 123.4 (d, $J_{C,F} = 10.1$ Hz), 117.6, 115.4, 111.7 (d, $J_{C,F} = 25.3$ Hz), 101.1 (d, $J_{C,F} = 29.3$ Hz). HRMS (ESI) calcd for C$_{19}$H$_{12}$N$_3$OF (M+H)$^+$ 318.1037, found 318.1033.

**(6-chloro-1-(pyrimidin-2-yl)-1H-indol-2-yl)(naphthalen-1-yl)methanone (3aq)**

![Structure of (6-chloro-1-(pyrimidin-2-yl)-1H-indol-2-yl)(naphthalen-1-yl)methanone (3aq)]

Yield: 85%; Melting Point: 85-86 °C; White solid; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.67 (d, J = 4.0 Hz, 2H), 8.45 (d, J = 0.8 Hz, 1H), 8.40 (d, J = 8.0 Hz, 1H), 8.11 (dd, J = 8.0, 4.0 Hz, 1H), 7.90 (d, J = 8.0 Hz, 2H), 7.27 (d, J = 8.0 Hz, 2H), 7.16 (s, 1H), 7.13 (t, J = 4.0 Hz, 1H), 3.96 (s, 3H), 2.42 (s, 3H); 13C NMR (101 MHz, CDCl$_3$) δ 187.00, 167.3, 158.1, 156.9, 143.9, 140.4, 138.4, 134.8, 129.7, 129.1, 127.2, 125.0, 124.6, 117.9, 115.0, 113.9, 52.1, 21.7; HRMS (APCI) calcd for C$_{22}$H$_{17}$N$_3$O$_3$ (M+H)$^+$ 372.1343, found 372.1340.
Yield: 72%; Melting Point: 131-132 oC; White solid; ¹H NMR (400 MHz, CDCl₃) δ 8.71 (d, J = 8.0 Hz, 1H), 8.53 (d, J = 4.0 Hz, 2H), 8.44 (d, J = 1.7 Hz, 1H), 7.93 (d, J = 8.0 Hz, 1H), 7.87 (d, J = 8.0 Hz, 1H), 7.74 (d, J = 8.0 Hz, 1H), 7.62-7.53 (m, 3H), 7.38 (t, J = 8.0 Hz 1H), 7.27 (d, J = 8.0 Hz, 1H), 7.11 (s, 1H), 6.97 (t, J = 4.0 Hz, 1H); ¹³C NMR (101 MHz, CDCl₃) δ 188.6, 157.9, 156.9, 139.4, 138.6, 135.7, 133.6, 132.6, 132.5, 131.0, 129.1, 128.2, 127.7, 126.5, 126.4, 125.9, 124.1, 123.6, 123.4, 117.6, 115.6, 114.4; HRMS (APCI) calcd for C₂₃H₁₉N₃OCl (M+H)+ 384.0898, found 384.0912.

(5-methoxy-1-(pyrimidin-2-yl)-1H-indol-2-yl)(phenyl)methanone (3ar)¹

Yield: 78%; Melting Point: 134-135 oC; White solid; ¹H NMR (400 MHz, CDCl₃) δ 8.58 (d, J = 4.0 Hz, 2H), 8.34 (d, J = 8.0 Hz, 1H), 7.95 (d, J = 8.0 Hz, 2H), 7.52 (t, J = 8.0 Hz, 1H), 7.42 (t, J = 8.0 Hz, 2H), 7.12-7.05 (m, 3H), 7.00 (t, J = 4.0 Hz, 1H), 3.87 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 187.5, 157.8, 157.1, 155.9, 138.0, 137.5, 133.1, 132.6, 129.4, 128.6, 128.2, 117.1, 116.4, 115.3, 114.9, 103.4, 55.6; HRMS (ESI) calcd for C₂₀H₁₅N₃O₂ (M+H)+ 330.1237, found 330.1234.

(3-methyl-1-(pyrimidin-2-yl)-1H-indol-2-yl)(phenyl)methanone (3as)¹

Yield: 82%; Melting Point: 153-154 oC; White solid; ¹H NMR (400 MHz, CDCl₃) δ 8.63 (d, J = 8.0 Hz, 1H), 8.44 (d, J = 4.0 Hz, 2H), 7.77 (d, J = 8.0 Hz, 2H), 7.68 (d, J = 8.0 Hz, 1H), 7.48-7.40 (m, 2H), 7.32 (q, J = 8.0 Hz, 3H), 6.84 (t, J = 4.0 Hz, 1H), 2.37 (s, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 189.4, 157.5, 157.0, 139.2, 136.4, 133.2, 132.2, 130.2, 128.5, 128.3, 126.1, 122.5, 121.7, 120.1, 116.1, 115.2, 9.3; HRMS calcd for C₂₀H₁₅N₃O (M)+ 313.1207, found 313.1210.

(7-methyl-1-(pyrimidin-2-yl)-1H-indol-2-yl)(phenyl)methanone (3at)¹
Yield: 80%; Melting Point: 36-37 °C; Yellow solid; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.85 (d, $J = 4.0$ Hz, 2H), 7.92 (d, $J = 8.0$ Hz, 2H), 7.60-7.55 (m, 2H), 7.48-7.45 (m, 2H), 7.39 (t, $J = 4.0$ Hz, 1H), 7.20 (s, 1H), 7.13-7.11 (m, 2H), 1.96 (s, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 187.0, 159.7, 158.1, 138.3, 138.2, 136.0, 132.4, 129.6, 129.2, 128.2, 127.2, 121.9, 121.1, 120.1, 116.4, 19.3; HRMS calcd for C$_{20}$H$_{15}$N$_3$O (M)$^+$ 313.1207, found 313.1210.

(4-methoxyphenyl)(1-(pyrimidin-2-yl)-1H-indol-2-yl)methanone (3au)$^1$

Yield: 76%; Melting Point: 39-40 °C; White solid; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.61 (d, $J = 4.0$ Hz, 2H), 8.39 (d, $J = 8.0$ Hz, 1H), 7.97 (d, $J = 8.0$ Hz, 2H), 7.68 (d, $J = 8.0$ Hz, 1H), 7.41 (t, $J = 8.0$ Hz, 1H), 7.27 (t, $J = 8.0$ Hz, 1H), 7.07 (s, 1H), 7.02 (t, $J = 4.0$ Hz, 1H), 6.91 (d, $J = 8.0$ Hz, 2H), 3.83 (s, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 186.4, 163.3, 157.9, 157.2, 138.0, 137.2, 131.8, 130.7, 127.9, 126.1, 122.6, 122.2, 117.3, 114.5, 114.1, 113.5, 55.4; HRMS calcd for C$_{20}$H$_{15}$N$_3$O$_2$ (M)$^+$ 329.1152, found 329.1159.

N-(4-(1-(pyrimidin-2-yl)-1H-indole-2-carbonyl)phenyl)acetamide (3av)

Yield: 67%; Melting Point: 138-139 °C; Yellow solid; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 9.11 (s, 1H), 8.56 (d, $J = 4.0$ Hz, 2H), 8.37 (d, $J = 8.0$ Hz, 1H), 7.89 (d, $J = 8.0$ Hz, 2H), 7.68-7.61 (m, 3H), 7.41 (t, $J = 8.0$ Hz, 1H), 7.26 (t, $J = 8.0$ Hz, 1H), 7.07 (s, 1H), 6.99 (t, $J = 4.0$ Hz, 1H), 2.09 (s, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 186.8, 169.4, 157.8, 157.0, 142.9, 138.0, 136.9, 132.7, 130.7, 127.8, 126.4, 122.7, 122.3, 118.7, 117.3, 115.1, 114.1, 24.28; HRMS calcd for C$_{21}$H$_{16}$N$_4$O$_2$ (M)$^+$ 356.1273, found 356.1268.

ethyl 1-(pyrimidin-2-yl)-1H-indole-2-carboxylate (5aa)$^2$

Yield: 82%; Oil; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.79 (d, $J = 4.0$ Hz, 2H), 8.14 (d, $J = 8.0$ Hz, 1H), 7.69 (d, $J = 8.0$ Hz, 1H), 7.39 (t, $J = 8.0$ Hz, 1H), 7.34 (s, 1H), 7.25 (t, $J = 8.0$ Hz, 1H), 7.21 (t, $J = 4.0$ Hz,
1H, 4.31 (q, J = 8.0 Hz, 2H), 1.27 (t, J = 8.0 Hz, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 162.1, 158.1, 157.6, 138.5, 130.4, 127.6, 126.2, 122.5, 122.3, 118.0, 114.0, 113.4, 61.0, 14.1; MS: m/z C$_{15}$H$_{13}$N$_3$O$_2$ 267.1 (M$^+$).

ethyl 5-fluoro-1-(pyrimidin-2-yl)-1H-indole-2-carboxylate (5ab)

Yield: 67%; Oil; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.78 (d, J = 4.0 Hz, 2H), 8.15 (t, J = 8.0 Hz, 1H), 7.33 (d, J = 8.0 Hz, 1H), 7.27 (s, 1H), 7.23 (s, 1H), 7.13 (t, J = 8.0 Hz, 1H), 4.32 (q, J = 8.0 Hz, 2H), 1.28 (t, J = 8.0 Hz, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 161.9, 160.2, 158.1, 158.8, 157.3, 134.8, 131.8, 128.1 (d, $J_{C-F}$ = 10.1 Hz), 118.1, 114.7 (t, $J_{C-F}$ = 9.1 Hz), 114.4, 113.3 (d, $J_{C-F}$ = 4.0 Hz), 107.2, 106.9, 61.2, 14.1; MS: m/z C$_{15}$H$_{12}$FN$_3$O$_2$ 285.9 (M$^+$).

ethyl 5-bromo-1-(pyrimidin-2-yl)-1H-indole-2-carboxylate (5ac)

Yield: 68%; Oil; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.78 (d, J = 4.0 Hz, 2H), 8.05 (d, J = 8.0 Hz, 1H), 7.81 (d, J = 4.0 Hz, 1H), 7.45 (dd, J = 8.0, 4.0 Hz, 1H), 7.23-7.22 (m, 2H), 4.31 (q, J = 8.0 Hz, 2H), 1.28 (t, J = 8.0 Hz, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 161.8, 158.2, 157.2, 136.9, 131.4, 129.2, 129.0, 124.7, 118.2, 115.7, 115.2, 112.7, 61.3, 14.1; MS: m/z C$_{15}$H$_{12}$BrN$_3$O$_2$ 345.0 (M$^+$).

ethyl 5-chloro-1-(pyrimidin-2-yl)-1H-indole-2-carboxylate (5ad)

Yield: 72%; Oil; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.78 (d, J = 4.0 Hz, 2H), 8.10 (d, J = 8.0 Hz, 1H), 7.65 (d, J = 2.0 Hz, 1H), 7.32 (dd, J = 8.0, 4.0 Hz, 1H), 7.24 – 7.21 (m, 2H), 4.31 (q, J = 8.0 Hz, 2H), 1.28 (t, J = 8.0 Hz, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 161.8, 158.1, 157.2, 136.6, 131.5, 128.6, 128.1, 126.4, 121.5, 118.2, 114.8, 112.8, 61.2, 14.1; HRMS (APCI) calcd for C$_{15}$H$_{12}$ClN$_3$O$_2$ (M+H)$^+$ 302.0691, found 302.0692.

ethyl 5-cyano-1-(pyrimidin-2-yl)-1H-indole-2-carboxylate (5ae)
Yield: 65%; Oil; \( ^1 \text{H NMR (400 MHz, CDCl}_3) \delta 8.83 \) (d, \( J = 4.0 \text{ Hz, 2H} \)), 8.20 (d, \( J = 8.0 \text{ Hz, 1H} \)), 8.04 (d, \( J = 0.9 \text{ Hz, 1H} \)), 7.59 (dd, \( J = 8.0, 1.6 \text{ Hz, 1H} \)), 7.34 -7.30 (m, 2H), 4.32 (q, \( J = 8.0 \text{ Hz, 2H} \)), 1.29 (t, \( J = 8.0 \text{ Hz, 3H} \)); \( ^1 \text{C NMR (101 MHz, CDCl}_3) \delta 161.4, 158.3, 156.7, 139.5, 132.5, 128.6, 127.6, 127.3, 119.6, 118.9, 114.6, 112.9, 105.9, 61.5, 14.0; HRMS (APCI) caled for C\(_8\)H\(_7\)N\(_4\)O\(_2\) (M+H\(^+\)) 293.1033, found 293.1027.

2-ethyl 5-methyl 1-(pyrimidin-2-yl)-1H-indole-2,5-dicarboxylate (5af)

Yield: 70%; Oil; \( ^1 \text{H NMR (400 MHz, CDCl}_3) \delta 8.83 \) (d, \( J = 4.0 \text{ Hz, 2H} \)), 8.45 (s, 1H), 8.14 (d, \( J = 8.0 \text{ Hz, 1H} \)), 8.07 (dd, \( J = 8.0, 1.6 \text{ Hz, 1H} \)), 7.40 (s, 1H), 7.28 (dd, \( J = 8.0, 4.0 \text{ Hz, 1H} \)), 4.32 (q, \( J = 8.0 \text{ Hz, 2H} \)), 3.95 (s, 3H), 1.29 (t, \( J = 8.0 \text{ Hz, 3H} \)); \( ^1 \text{C NMR (101 MHz, CDCl}_3) \delta 167.3, 161.7, 158.2, 157.1, 140.7, 131.6, 127.1, 125.0, 124.5, 118.5, 114.2, 113.1, 61.3, 52.1, 14.1; MS: m/z C\(_{17}\)H\(_{15}\)N\(_3\)O\(_4\) 325.1 (M\(^+\)).

ethyl 6-fluoro-1-(pyrimidin-2-yl)-1H-indole-2-carboxylate (5ag)

Yield: 73%; Oil; \( ^1 \text{H NMR (400 MHz, CDCl}_3) \delta 8.79 \) (d, \( J = 4.0 \text{ Hz, 2H} \)), 7.31 (s, 1H), 7.23 (t, \( J = 4.0 \text{ Hz, 1H} \)), 7.02 (t, \( J = 8.0 \text{ Hz, 1H} \)), 4.31 (q, \( J = 8.0 \text{ Hz, 2H} \)), 1.28 (t, \( J = 8.0 \text{ Hz, 3H} \)); \( ^1 \text{C NMR (101 MHz, CDCl}_3) \delta 163.3, 161.8, 160.9, 158.1, 157.3, 138.8 \) (d, \( J = 13.0 \text{ Hz} \)), 130.9 (d, \( J = 4.0 \text{ Hz} \)), 124.0, 123.3 (d, \( J = 10.1 \text{ Hz} \)), 118.1, 113.9, 111.7, 111.4, 100.6, 100.3, 61.1, 14.1; MS: m/z C\(_{15}\)H\(_{12}\)FN\(_3\)O\(_2\) 285.9 (M\(^+\)).

ethyl 6-chloro-1-(pyrimidin-2-yl)-1H-indole-2-carboxylate (5ah)
Yield: 78%; Oil; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.80 (d, $J = 4.0$ Hz, 2H), 8.20 (s, 1H), 7.59 (d, $J = 8.0$ Hz, 1H), 7.29 (s, 1H), 7.24 (t, $J = 4.0$ Hz, 2H), 4.31 (q, $J = 8.0$ Hz, 2H), 1.28 (t, $J = 8.0$ Hz, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 161.8, 158.2, 157.2, 138.7, 132.1, 131.0, 126.1, 123.4, 123.1, 118.2, 113.7, 113.6, 61.2, 14.1; HRMS (APCI) calcd for C$_{15}$H$_{12}$ClN$_3$O$_2$ (M+H)$^+$ 302.0691, found 302.0692.

**ethyl 5-methoxy-1-(pyrimidin-2-yl)-1H-indole-2-carboxylate (5ai)**

Yield: 64%; Oil; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.76 (d, $J = 4.0$ Hz, 2H), 8.09 (d, $J = 8.0$ Hz, 1H), 7.25 (d, $J = 4.0$ Hz, 1H), 7.18 (t, $J = 4.0$ Hz, 1H), 7.10 (s, 1H), 7.03 (d, $J = 8.0$ Hz, 1H), 4.31 (q, $J = 8.0$ Hz, 2H), 3.86 (s, 3H), 1.27 (t, $J = 8.0$ Hz, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 162.2, 158.0, 157.5, 155.8, 133.5, 130.8, 128.2, 117.7, 116.4, 114.6, 113.7, 103.3, 61.0, 55.6, 14.1; MS: m/z C$_{16}$H$_{15}$N$_3$O$_3$ 297.2 (M$^+$).

**(1H-indol-2-yl)(phenyl)methanone (6a)**

Yield: 80%; White solid; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 9.83 (s, 1H), 8.01 (d, $J = 8.0$ Hz, 2H), 7.71 (d, $J = 8.0$ Hz, 1H), 7.62 (t, $J = 7.4$ Hz, 1H), 7.52 (dd, $J = 15.0$, 7.9 Hz, 3H), 7.37 (t, $J = 8.0$ Hz, 1H), 7.16 (m, 2H).

**References:**
S31