Metal free synthesis of 2,4-Diarylquinoline Derivatives with Enamides and Imines

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General Remarks:

All reactions were carried out in oven-dried glassware. Products were purified by flash chromatography on 200–300 mesh silica gels. Progresses of the reactions were monitored by TLC. $^1$H NMR spectra were recorded on 400 MHz in CDCl$_3$ and $^{13}$C NMR spectra were recorded on 100 MHz in CDCl$_3$. All chemical shifts are given as $\delta$ value (ppm) with reference to tetramethylsilane (TMS) as an internal standard. All compounds were further characterized by mass spectrometer; Copies of their $^1$H NMR and $^{13}$CNMR spectra are provided. Commercially available reagents and solvents were used without further purification.

General procedure for the preparation of 2,4-diarylquinolines.

An oven-dried test tube was charged with 0.2 mmol of enamides, 0.15 mmol of imines, 0.02 mmol of I$_2$ and 2 mL chlorobenzene. The reaction was stirred at 100 °C under air for 1h and the product formation was monitored by TLC. After cooling to room temperature, the solvent was diluted with 20 mL ethyl acetate then the combined organics were concentrated on rotary evaporator. After the solvents were evaporated in vacuo, the residues were purified by column chromatography, eluting with petroleum ether/EtOAc to afford the desired pure quinolines.

Characterization data of 2,4-diarylquinolines.

2,4-diphenylquinoline 3aa.
Yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.24 (d, $J = 8.4$ Hz, 1H), 8.19 (d, $J = 7.3$ Hz, 2H), 7.89 (d, $J = 8.3$ Hz, 1H), 7.81 (s, 1H), 7.75 – 7.68 (m, 1H), 7.57 – 7.41 (m, 9H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 156.85, 149.12, 148.79, 139.63, 138.38, 130.11, 129.63, 129.47, 129.30, 128.80, 128.55, 128.36, 127.55, 126.29, 125.60, 119.31; MS (EI) m/z: 281.

2-phenyl-4-(p-tolyl)quinoline 3ab.
Colourless oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.23 (d, $J = 8.4$ Hz, 1H), 8.19 (d, $J = 8.3$ Hz, 2H), 7.93 (d, $J = 8.4$ Hz, 1H), 7.80 (s, 1H), 7.74 – 7.70 (m, 1H), 7.55 – 7.49 (m, 2H), 7.49 – 7.43 (m, 4H), 7.36 (m, 2H), 2.48 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 156.89, 149.19, 148.84, 139.74, 138.31, 135.48, 130.11, 129.47, 129.42, 128.80, 127.57, 126.20, 125.88, 125.70, 119.31, 21.30; MS (EI) m/z: 295.

2-phenyl-4-(m-tolyl)quinoline 3ac.

Colourless oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.24 (d, $J = 8.5$ Hz, 1H), 8.21 – 8.17 (m, 2H), 7.91 (d, $J = 8.4$ Hz, 1H), 7.81 (s, 1H), 7.76 – 7.69 (m, 1H), 7.56 – 7.40 (m, 5H), 7.39 – 7.29 (m, 3H), 2.47 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 156.86, 149.32, 148.80, 139.71, 138.37, 138.32, 130.20, 130.10, 129.44, 129.29, 129.10, 128.81, 128.43, 127.57, 126.67, 126.23, 125.83, 125.72, 119.28, 21.50; MS (EI) m/z: 295.

4-(2-methoxyphenyl)-2-phenylquinoline 3ae.

Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.22 (d, $J = 8.4$ Hz, 1H), 8.18 (d, $J = 8.3$ Hz, 2H), 7.81 (s, 1H), 7.72 – 7.65 (m, 1H), 7.60 (d, $J = 8.2$ Hz, 1H), 7.54 – 7.38 (m, 5H), 7.34 – 7.30 (m, 1H), 7.14 – 7.05 (m, 2H), 3.71 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 156.84, 148.44, 146.44, 139.84, 131.28, 129.93, 129.23, 129.14, 128.73, 127.60, 127.17, 126.42, 126.07, 125.89, 120.68, 120.15, 111.13, 55.50; MS (EI) m/z: 311.

4-(3-methoxyphenyl)-2-phenylquinoline 3af.

Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.24 (d, $J = 8.4$ Hz, 1H), 8.21 – 8.16 (m, 2H), 7.92 (d, $J = 8.4$ Hz, 1H), 7.82 (s, 1H), 7.76 – 7.69 (m, 1H), 7.55 – 7.41 (m, 5H), 7.16 – 7.01 (m, 3H), 3.86 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 159.66, 156.83, 148.98, 148.78, 139.74, 139.62, 130.10, 129.61,
4-(4-methoxyphenyl)-2-phenylquinoline 3ag.
Pale yellow oil. \(^1H\) NMR (400 MHz, CDCl\(_3\)): \(\delta 8.23\) (d, \(J = 8.4\) Hz, 1H), \(8.19\) (d, \(J = 7.3\) Hz, 2H), \(7.95\) (d, \(J = 8.3\) Hz, 1H), \(7.79\) (s, 1H), \(7.74 - 7.69\) (m, 1H), \(7.55 - 7.43\) (m, 6H), \(7.08\) (m, 2H), \(3.91\) (s, 3H). \(^{13}C\) NMR (100 MHz, CDCl\(_3\)): \(\delta 159.86, 156.90, 148.90, 148.84, 139.77, 130.80, 130.71, 130.14, 129.40, 129.26, 128.80, 127.57, 126.18, 125.96, 125.66, 119.28, 114.08, 55.41; MS (EI) m/z: 311.

4-(biphenyl-4-yl)-2-phenylquinoline 3ah.
White solid. mp 105-107°C. \(^1H\) NMR (400 MHz, CDCl\(_3\)): \(\delta 8.28 - 8.23\) (m, 1H), \(8.23 - 8.18\) (m, 2H), \(7.98\) (d, \(J = 8.4\) Hz, 1H), \(7.86\) (s, 1H), \(7.79 - 7.61\) (m, 7H), \(7.56 - 7.37\) (m, 7H). \(^{13}C\) NMR (100 MHz, CDCl\(_3\)): \(\delta 156.90, 148.85, 148.76, 141.32, 140.32, 139.64, 137.30, 130.17, 130.02, 129.53, 129.33, 128.91, 128.83, 127.65, 127.60, 127.29, 127.15, 126.36, 125.72, 125.61, 119.30; MS (EI) m/z: 357.

4-(naphthalen-2-yl)-2-phenylquinoline 3ai.
Pale yellow oil. \(^1H\) NMR (400 MHz, CDCl\(_3\)): \(\delta 8.27\) (d, \(J = 8.1\) Hz, 1H), \(8.22\) (m, 2H), \(8.05 - 7.98\) (m, 2H), \(7.97 - 7.89\) (m, 4H), \(7.78 - 7.71\) (m, 1H), \(7.67\) (d, \(J = 8.4\) Hz, 1H), \(7.59 - 7.43\) (m, 6H). \(^{13}C\) NMR (100 MHz, CDCl\(_3\)): \(\delta 156.90, 149.11, 148.86, 139.36, 135.89, 133.25, 133.03, 130.19, 129.54, 129.34,
4-(4-fluorophenyl)-2-phenylquinoline 3aj.
Yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.24 (d, $J = 8.5$ Hz, 1H), 8.21 – 8.17 (m, 2H), 7.85 (d, $J = 8.4$ Hz, 1H), 7.79 (s, 1H), 7.76 – 7.71 (m, 1H), 7.56 – 7.44 (m, 6H), 7.27 – 7.22 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 162.92 (d, $J = 247$ Hz), 156.88, 148.83, 148.06, 139.54, 134.35 (d, $J = 3.4$ Hz), 131.25 (d, $J = 8.1$ Hz), 130.23, 129.50 (d, $J = 19.6$ Hz), 128.85, 127.56, 126.46, 125.73, 125.34, 119.37, 115.77, 115.55; MS (EI) m/z: 331.

4-(4-chlorophenyl)-2-phenylquinoline 3ak.
Yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.24 (d, $J = 8.4$ Hz, 1H), 8.21 – 8.15 (m, 2H), 7.84 (d, $J = 8.2$ Hz 1H), 7.78 (s, 1H), 7.76 – 7.70 (m, 1H), 7.56 – 7.44 (m, 8H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 156.87, 148.81, 147.84, 139.47, 136.79, 134.62, 130.85, 130.25, 130.25, 129.65, 129.43, 128.85, 127.54, 126.52, 125.50, 125.24, 119.22; MS (EI) m/z: 315.

4-(3,4-dichlorophenyl)-2-phenylquinoline 3al.
Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.25 (d, $J = 8.1$ Hz, 1H), 8.20 – 8.15 (m, 2H), 7.81 (d, $J = 8.1$ Hz 1H), 7.79 – 7.72 (m, 2H), 7.67 (d, $J = 2.0$ Hz, 1H), 7.62 (d, $J = 8.2$ Hz, 1H), 7.56 – 7.45 (m, 4H), 7.40 (dd, $J = 8.2$, 2.0 Hz, 1H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 156.86, 148.76, 146.47, 139.25,
138.28, 132.95, 132.84, 131.30, 130.61, 130.32, 129.83, 129.54, 128.89, 128.85, 127.52, 126.79, 125.16, 124.93, 119.17; MS (EI) m/z: 349.

2-phenyl-4-(4-(trifluoromethyl)phenyl)quinoline 3am.
Yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.27 (d, $J = 8.4$ Hz, 1H), 8.22 – 8.16 (m, 2H), 7.85 – 7.73 (m, 5H), 7.69 (m, 2H), 7.57 – 7.45 (m, 4H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 156.89, 148.77, 147.61, 142.08, 139.34, 130.65 (q, $J = 32.4$ Hz), 130.32, 129.95, 129.82, 129.54, 128.91, 127.56, 126.74, 125.60 (q, $J = 3.7$ Hz), 124.08 (q, $J = 271$ Hz), 125.31, 125.10, 119.26; MS (EI) m/z: 349.

6-methoxy-2,4-diphenylquinoline 4ba.
Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.18 – 8.11 (m, 3H), 7.76 (s, 1H), 7.58 – 7.45 (m, 7H), 7.45 – 7.35 (m, 2H), 7.18 (d, $J = 2.8$ Hz, 1H), 3.77 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 157.74, 154.57, 147.72, 144.86, 139.70, 138.69, 131.57, 129.31, 128.91, 128.74, 128.64, 128.28, 127.25, 126.60, 121.75, 119.59, 103.65, 55.39; MS (EI) m/z: 311.

8-methoxy-2,4-diphenylquinoline 4ca.
Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.22 (d, $J = 7.1$ Hz, 2H), 7.85 (s, 1H), 7.58 – 7.41 (m, 9H), 7.41 – 7.35 (m, 1H), 7.08 (d, $J = 6.9$ Hz, 1H), 4.13 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 155.79, 155.66, 149.10, 140.72, 139.72, 138.71, 129.53, 129.17, 128.73, 128.48, 128.29, 127.67, 126.88, 126.25, 119.86, 117.49, 107.88, 56.23; MS (EI) m/z: 311.
6-methyl-2,4-diphenylquinoline 4da.
Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.24 – 8.16 (m, 3H), 7.77 (s, 1H), 7.64 (s, 1H), 7.59 – 7.48 (m, 8H), 7.44 (t, $J = 7.3$ Hz, 1H), 2.47 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 155.99, 148.41, 147.36, 139.74, 138.61, 136.24, 131.73, 129.83, 129.53, 129.12, 128.77, 128.55, 128.26, 127.45, 125.68, 124.36, 119.39, 21.81; MS (EI) m/z: 295.

5,8-dimethyl-2,4-diphenylquinoline 4ea.
Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.26 (d, $J = 8.0$ Hz, 2H), 7.70 (s, 1H), 7.51 – 7.30 (m, 9H), 7.11 (d, $J = 7.1$ Hz, 1H), 2.90 (s, 3H), 1.95 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 153.28, 149.61, 148.53, 143.16, 139.40, 136.16, 132.94, 129.21, 129.16, 128.86, 128.68, 127.85, 127.55, 127.33, 125.16, 120.47, 24.35, 18.80; MS (EI) m/z: 309.

6-chloro-2,4-diphenylquinoline 4fa
Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.19 – 8.10 (m, 3H), 7.84 (d, $J = 2.3$ Hz, 1H), 7.80 (s, 1H), 7.62 (dd, $J = 9.0$, 2.3 Hz, 1H), 7.56 – 7.41 (m, 8H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 156.94, 148.32, 147.15, 139.10, 137.67, 132.12, 131.67, 130.34, 129.51, 129.37, 128.81, 128.74, 128.62, 127.45, 126.40, 124.39, 119.91; MS (EI) m/z: 315.

6-fluoro-2,4-diphenylquinoline 4ga
Yellow oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.23 (m, 1H), 8.17 (m, 2H), 7.83 (s, 1H), 7.59 – 7.43 (m, 10H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 160.56 (d, $J = 246$ Hz), 156.29 (d, $J = 2.8$ Hz), 148.69, 148.64, 145.92, 139.34, 137.94, 132.52 (d, $J = 9.1$ Hz), 129.39, 129.34, 128.81 (d, $J = 8.9$ Hz), 128.626, 127.44, 119.85, 119.65 (d, $J = 25.5$ Hz), 109.04 (d, $J = 23.0$ Hz); MS (EI) m/z: 299.

![Structure](image)

**2-(4-chlorophenyl)-4-phenylquinoline 4ha**
Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.21 (d, $J = 8.4$ Hz, 1H), 8.16 – 8.09 (m, 2H), 7.89 (d, $J = 8.4$ Hz, 1H), 7.75 (s, 1H), 7.75 – 7.70 (m, 1H), 7.57 – 7.43 (m, 8H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 155.45, 149.35, 148.71, 138.19, 137.96, 135.50, 130.03, 129.64, 129.49, 128.95, 128.77, 128.58, 128.45, 126.49, 125.77, 125.63, 118.84; MS (EI) m/z: 315.

![Structure](image)

**2-(4-fluorophenyl)-4-phenylquinoline 4ia**
Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.23 – 8.15 (m, 3H), 7.75 (s, 1H), 7.75 – 7.70 (m, 1H), 7.57 – 7.43 (m, 6H), 7.23 – 7.16 (m, 2H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 163.79 (d, $J = 248$ Hz), 149.30, 148.73, 138.29, 135.76 (d, $J = 3.1$ Hz), 130.00, 129.61, 129.51, 129.39 (d, $J = 8.4$ Hz), 128.59, 128.44, 126.36, 125.64, 118.93, 115.73 (d, $J = 22$ Hz); MS (EI) m/z: 299.

![Structure](image)

**4-phenyl-2-(p-tolyl)quinoline 4ja**
Colourless oil. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.22 (d, $J = 8.4$ Hz, 1H), 8.09 (d, $J = 8.2$ Hz, 2H), 7.87 (d, $J = 8.4$ Hz, 1H), 7.78 (s, 1H), 7.73 – 7.67 (m, 1H), 7.56 – 7.46 (m, 5H), 7.46 – 7.40 (m, 1H), 7.31 (m, 2H), 2.41 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 156.78, 148.97, 148.78, 139.36, 138.45, 136.79, 130.00, 129.52, 129.38, 128.52, 128.30, 127.40, 126.07, 125.65, 125.56, 119.13, 21.31; MS (EI) m/z: 295.
**2-(4-methoxyphenyl)-4-phenylquinoline 4ka**
Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.18 (m, 3H), 7.87 (d, $J = 8.4$ Hz, 1H), 7.77 (s, 1H), 7.70 (t, $J = 7.6$ Hz, 1H), 7.58 – 7.47 (m, 5H), 7.43 (t, $J = 7.6$ Hz, 1H), 7.04 (m, 2H), 3.87 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 160.79, 156.39, 148.95, 148.78, 138.48, 132.19, 129.87, 129.52, 129.40, 128.87, 128.53, 128.31, 125.92, 125.58, 125.48, 118.86, 114.18, 55.36; MS (EI) m/z: 311.

**2-(3,4-dimethylphenyl)-4-phenylquinoline 4la**
Pale yellow oil. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.23 (d, $J = 8.4$ Hz, 1H), 8.01 (s, 1H), 7.89 (t, $J = 7.8$ Hz, 2H), 7.80 (s, 1H), 7.74 – 7.68 (m, 1H), 7.58 – 7.41 (m, 6H), 7.30 – 7.22 (m, 1H), 2.38 (s, 3H), 2.33 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 157.00, 148.92, 148.79, 138.51, 138.10, 137.19, 137.04, 130.09, 130.00, 129.55, 129.36, 128.66, 128.53, 128.30, 126.03, 125.65, 125.58, 124.95, 119.26, 19.94, 19.67; MS (EI) m/z: 309.

**methyl 2,4-diphenylquinoline-6-carboxylate 4ma**
White solid. mp 188-190°C. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.67 (d, $J = 1.6$ Hz, 1H), 8.34 – 8.20 (m, 4H), 7.88 (s, 1H), 7.60 – 7.47 (m, 8H), 3.93 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 166.84, 158.77, 150.76, 150.52, 139.08, 137.72, 130.38, 129.87, 129.55, 129.56, 128.86, 128.91, 128.89, 128.84, 128.79, 127.70, 124.99, 120.00, 52.32; MS (EI) m/z: 339.
methyl 4-(4-phenylquinolin-2-yl)benzoate 4na
White solid. mp 120-122°C. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.30 – 8.22 (m, 3H), 8.18 (d, $J$ = 8.5 Hz, 2H), 7.91 (d, $J$ = 8.4 Hz, 1H), 7.84 (s, 1H), 7.77 – 7.71 (m, 1H), 7.58 – 7.46 (m, 6H), 3.95 (s, 3H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 166.85, 155.48, 149.41, 148.76, 143.68, 138.12, 130.59, 130.20, 130.03, 129.71, 129.49, 128.60, 128.50, 127.44, 126.77, 125.96, 125.65, 119.24, 52.16; MS (EI) m/z: 339.

4-(4-phenylquinolin-2-yl)benzonitrile 4oa
White solid. mp 160-162°C. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.35 – 8.30 (m, 2H), 8.24 (d, $J$ = 8.0 Hz, 1H), 7.93 (dd, $J$ = 8.0, 0.7 Hz, 1H), 7.84 – 7.74 (m, 4H), 7.58 – 7.50 (m, 6H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 154.43, 149.79, 148.76, 143.68, 137.95, 132.58, 130.25, 129.97, 129.48, 128.69, 128.65, 128.06, 127.15, 126.11, 125.74, 118.94, 118.81, 112.73; MS (EI) m/z: 306.