Supporting information

Synthesis of polysubstituted quinolines via copper(II)-catalyzed annulation of 2-aminoarylketones with alkynoates

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**General.** $^1$H NMR spectra was determined on a Bruker 400 (400 MHz) spectrometer as solutions in CDCl$_3$. Chemical shifts are expressed in parts per million ($\delta$) and are referenced to tetramethylsilane (TMS) as internal standard and the signals were reported as s (singlet), d (doublet), t (triplet), m (multiplet) and coupling constants $J$ were given in Hz. $^{13}$C NMR spectra was recorded at 100 MHz in CDCl$_3$ solution. Elemental analyses were done by a Perkin-Elmer autoanalyzer. TLC was done on silica gel coated glass slide (Merck, Silica gel G for TLC). Silica gel (60-120 mesh, SRL, India) was used for column chromatography. Petroleum ether refers to the fraction boiling in the range of 60-80 °C unless otherwise mentioned. All solvents were dried and distilled before use. Commercially available substrates were freshly distilled before the reaction. All reactions were executed using oven dried glassware.

**Typical procedure for the synthesis of 6-chloro-2,4-diphenylquinoline-3-carboxylic acid ethyl ester (Table 2, 3aa).**

![](image)

2-Amino-5-chlorobenzophenone (231 mg, 1 mmol) and ethyl phenylpropiolate (174 mg, 1 mmol) was mixed in a sealed tube and stirred at room temperature for 10 min. Then copper triflate (36 mg, 0.1 mmol) was added to the reaction mixture and heated at 110 °C. After completion (TLC), the reaction mixture was extracted with dichloromethane (10 mL x 2). Solvent was evaporated to furnish the crude product which was subjected to column chromatography on silica gel using petroleum ether/ethyl acetate as an eluent to obtain the analytically pure product (348 mg, 90 %). Yellow oil. IR (KBr): 1722 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 8.00 (d, $J = 9.2$ Hz, 1H), 7.64-7.62 (m, 2H), 7.61-7.48 (m, 1H), 7.44 (s, 1H), 7.34-7.23 (m, 8H), 3.74 (q, $J = 7.2$ Hz, 2H), 0.65 (t, $J = 7.2$ Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 167.5, 155.9, 146.0,
2,4-Diphenylquinoline-3-carboxylic acid ethyl ester (3ba).<sup>1</sup>

Yellow solid (324 mg, 92%); Mp 86-88 °C; IR (KBr): 1722 cm<sup>-1</sup>; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ 8.15 (d, J = 9.2 Hz, 1H), 7.70-7.66 (m, 3H), 7.54 (d, J = 8.4 Hz, 1H), 7.44-7.32 (m, 9H), 3.79 (q, J = 7.2 Hz, 2H), 0.74 (t, J = 7.2 Hz, 3H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ 168.1, 155.9, 147.8, 147.1, 140.2, 135.5, 130.4, 129.7, 129.3, 128.8, 128.5, 128.4, 128.3, 128.2, 127.1, 127.0, 126.5, 125.5, 61.2, 13.3.

6-Nitro-2,4-diphenylquinoline-3-carboxylic acid ethyl ester (3ca).<sup>1</sup>

Yellow solid (318 mg, 80%); Mp 124-126 °C; IR (KBr): 1722 cm<sup>-1</sup>; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ 8.60 (s, 1H), 8.53 (dd, J<sub>1</sub> = 9.2 Hz, J<sub>2</sub> = 2.4 Hz, 1H), 8.36 (d, J = 9.2 Hz, 1H), 7.81-7.79 (m, 2H), 7.59-7.56 (m, 3H), 7.53-7.50 (m, 3H), 7.46-7.43 (m, 2H), 3.94 (q, J = 7.2 Hz, 2H), 0.86 (t, J = 7.2 Hz, 3H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ 167.2, 159.3, 149.7, 149.0, 145.8, 139.2, 133.9, 131.5, 129.6, 129.3, 129.2, 128.8, 128.6, 128.5, 124.8, 123.8, 123.5, 61.6, 13.3.
6-Chloro-4-(2-chloro-phenyl)-2-phenylquinoline-3-carboxylic acid ethyl ester (3da).

Yellow gummy mass (345 mg, 82%); IR (KBr): 1722 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 8.17 (m, 1H), 7.77-7.31 (m, 11H), 3.88 (m, 2H), 0.80 (m, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 167.2, 156.4, 145.9, 143.9, 139.6, 133.8, 133.5, 133.2, 131.5, 131.4, 130.8, 130.3, 129.5, 129.0, 128.4, 128.3, 127.7, 126.6, 125.7, 124.7, 61.3, 13.2. Anal. Calcd for C\(_{24}\)H\(_{17}\)Cl\(_2\)NO\(_2\): C, 68.26; H, 4.06; N, 3.32. Found: C, 68.17; H, 4.01; N 3.23.

4-Methyl-2-phenylquinoline-3-carboxylic acid ethyl ester (3ea).\(^1\)

Yellow oil (265 mg, 91%); IR (KBr): 1717 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 7.98 (d, \(J = 8.4\) Hz, 1H), 7.77 (d, \(J = 8.4\) Hz, 1H), 7.56-7.48 (m, 3H), 7.33-7.21 (m, 4H), 3.97 (q, \(J = 7.2\) Hz, 2H), 2.52 (s, 3H), 0.81 (t, \(J = 7.2\) Hz, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 168.6, 155.7, 146.8, 142.3, 140.3, 129.9, 129.8, 128.3, 128.0, 127.9, 127.0, 126.5, 125.6, 123.6, 61.1, 15.2, 13.2.

6-Chloro-2-methyl-4-phenylquinoline-3-carboxylic acid ethyl ester (3ab).

Yellow gummy mass (286 mg, 88%); IR (KBr): 1714 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 7.87 (d, \(J = 9.2\) Hz, 1H), 7.50 (dd, \(J_1 = 8.8\) Hz, \(J_2 = 2.4\) Hz, 1H), 7.42 (d, \(J = 2.4\) Hz, 1H), 7.38-7.35 (m, 3H), 7.24-7.21 (m,
2H), 3.95 (q, J = 7.2 Hz, 2H), 2.65 (s, 3H), 0.82 (t, J = 7.2 Hz, 3H); \(^{13}\text{C}\) NMR (100 MHz, CDCl\(_3\)): \(\delta\) 167.8, 154.7, 145.8, 145.1, 134.8, 132.1, 130.9, 129.1, 128.5, 128.2, 127.9, 125.7, 124.9, 13.4.

Anal. Calcd for C\(_{19}\)H\(_{16}\)ClNO\(_2\): C, 70.05; H, 4.95; N, 4.30. Found: C, 70.01; H, 4.87; N 4.19.

2,4-Dimethylquinoline-3-carboxylic acid ethyl ester (3eb).

Yellow oil (204 mg, 89%); IR (KBr): 1714 cm\(^{-1}\); \(^1\text{H}\) NMR (400 MHz, CDCl\(_3\)): \(\delta\) 7.88 (d, J = 8.0 Hz, 1H), 7.79 (d, J = 8.4 Hz, 1H), 757-7.52 (m, 1H), 7.37-7.33 (m, 1H), 4.35 (q, J = 7.2 Hz, 2H), 2.58 (s, 3H), 2.48 (s, 3H), 1.29 (t, J = 7.2 Hz, 3H); \(^{13}\text{C}\) NMR (100 MHz, CDCl\(_3\)): \(\delta\) 168.8, 154.0, 146.7, 141.1, 129.7, 128.9, 127.7, 126.0, 125.4, 123.7, 61.4, 23.5, 15.4, 13.9. Anal. Calcd for C\(_{14}\)H\(_{15}\)NO\(_2\): C, 73.34; H, 6.59; N, 6.11. Found: C, 73.24; H, 6.48; N, 6.05.

4-Phenylquinoline-2,3-dicarboxylic acid diethyl ester (3bc).\(^2\)

Pale yellow solid (304 mg, 87%); Mp 94-96 °C; IR (KBr): 1740 cm\(^{-1}\); \(^1\text{H}\) NMR (400 MHz, CDCl\(_3\)): \(\delta\) 8.23 (d, J = 8.4 Hz, 1H), 7.71 (t, J = 7.2 Hz, 1H), 7.53 (d, J = 8.4 Hz, 1H), 7.48 (d, J = 7.2 Hz, 1H), 7.41-7.28 (m, 3H), 7.27-7.26 (m, 2H), 4.45 (q, J = 7.2 Hz, 2H), 4.01 (q, J = 7.2 Hz, 2H), 1.37 (t, J = 7.2 Hz, 3H), 0.90 (t, J = 7.2 Hz, 3H); \(^{13}\text{C}\) NMR (100 MHz, CDCl\(_3\)): \(\delta\) 167.0, 165.1, 147.8, 147.0, 145.7, 134.6, 130.8, 130.5, 129.3, 128.9, 128.6, 128.1, 127.4, 126.9, 126.5, 62.5, 61.4, 14.1, 13.5.
6-Chloro-4-phenylquinoline-2,3-dicarboxylic acid diethyl ester (3ac).\textsuperscript{2}

White solid (321 mg, 84%); Mp 154-156 °C; IR (KBr): 1738 cm\textsuperscript{-1}; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}): \(\delta\) 8.28 (s, 1H), 7.76 (s, 1H), 7.64-7.48 (m, 4H), 7.36-7.38 (m, 2H), 4.70-4.40 (m, 2H), 4.30-4.00 (m, 2H), 1.47 (m, 3H), 1.01-0.98 (m, 3H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}): \(\delta\) 166.7, 165.0, 147.1, 145.9, 145.3, 135.3, 134.0, 132.1, 131.9, 129.2, 129.0, 128.4, 125.3, 62.7, 61.6, 14.1, 13.5.

![Chemical structure of 3ac](image)

4-Methylquinoline-2,3-dicarboxylic acid diethyl ester (3ec).\textsuperscript{2}

Brown oil (250 mg, 87%); IR (KBr): 1740 cm\textsuperscript{-1}; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}): \(\delta\) 8.17 (d, \(J = 8.8\) Hz, 1H), 7.99 (d, \(J = 8.4\) Hz, 1H), 7.71 (t, \(J = 7.2\) Hz, 1H), 7.62-7.59 (m, 1H), 4.46-4.36 (m, 4H), 2.67 (s, 3H), 1.39-1.31 (m, 6H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}): \(\delta\) 167.6, 165.2, 146.0, 145.6, 143.6, 130.7, 130.4, 128.6, 127.6, 126.8, 123.8, 62.2, 61.6, 15.2, 13.9, 13.8.

![Chemical structure of 3ec](image)

4-Phenylquinoline-2,3-dicarboxylic acid dimethyl ester (3bd).\textsuperscript{2}

Brown solid (273 mg, 85%); Mp 124-126 °C; IR (KBr): 1730 cm\textsuperscript{-1}; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}): \(\delta\) 8.24 (d, \(J = 8.4\) Hz, 1H), 7.75-7.70 (m, 1H), 7.56-7.47 (m, 2H), 7.42-7.40 (m, 3H), 7.28-7.26 (m, 2H), 3.98 (s, 3H), 3.55 (s, 3H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}): \(\delta\) 167.5, 165.4, 147.9, 146.9, 144.7, 134.4, 130.9, 130.5, 129.2, 129.1, 128.7, 128.2, 127.5, 127.1, 126.5, 53.3, 52.3.

![Chemical structure of 3bd](image)
6-Chloro-4-phenylquinoline-2,3-dicarboxylic acid dimethyl ester (3ad). 

Pale yellow solid (295 mg, 83%); Mp 164-165 °C; IR (KBr): 1730 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 8.17 (d, \(J = 8.8\) Hz, 1H), 7.67-7.64 (m, 1H), 7.50 (d, \(J = 2.0\) Hz, 1H), 7.44-7.42 (m, 3H), 7.27-7.25 (m, 2H), 3.98 (s, 3H), 3.55 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 167.1, 165.1, 147.1, 145.3, 144.8, 135.5, 133.6, 132.0, 129.1, 129.0, 128.4, 128.3, 127.9, 125.3, 53.4, 52.4.

![Chemical structure of 6-Chloro-4-phenylquinoline-2,3-dicarboxylic acid dimethyl ester](image)

4-Methylquinoline-2,3-dicarboxylic acid dimethyl ester (3ed).

Brown oil (218 mg, 84%); IR (KBr): 1730 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 8.12 (d, \(J = 8.4\) Hz, 1H), 7.92 (d, \(J = 8.8\) Hz, 1H), 7.69-7.65 (m, 1H), 7.56-7.52 (m, 1H), 3.94 (s, 3H), 3.90 (s, 3H), 2.59 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 168.1, 165.5, 146.1, 144.7, 143.6, 130.7, 130.6, 128.8, 127.7, 126.9, 123.8, 53.1, 52.6, 15.3. Anal. Calcd for C\(_{14}\)H\(_{13}\)NO\(_4\): C, 64.86; H, 5.05; N, 5.40. Found: C, 64.78; H, 5.01; N, 5.34.

![Chemical structure of 4-Methylquinoline-2,3-dicarboxylic acid dimethyl ester](image)

6-Chloro-4-phenylquinoline-3-carboxylic acid methyl ester (3be).

Yellow gummy mass (196 mg, 66%); IR (KBr): 1718 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 9.31 (s, 1H), 8.22-8.10 (m, 1H), 7.72-7.69 (m, 1H), 7.53-7.49 (m, 1H), 7.44-7.42 (m, 3H), 7.23-7.21 (m, 2H), 3.61 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 166.7, 150.1, 149.9, 136.3, 131.0, 129.5, 128.7, 128.3, 128.1, 128.0, 127.5, 127.2, 52.1. Anal. Calcd for C\(_{17}\)H\(_{12}\)ClNO\(_2\): C, 68.58; H, 4.06; N, 4.70. Found: C, 68.52; H, 4.01; N, 4.62.

![Chemical structure of 6-Chloro-4-phenylquinoline-3-carboxylic acid methyl ester](image)
4-Methylquinoline-3-carboxylic acid methyl ester (3ee).

Yellow gummy mass (137 mg, 68%); IR (KBr): 1722 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 9.24 (s, 1H), 8.17 (d, \(J = 8.4\) Hz, 1H), 8.12 (d, \(J = 8.4\) Hz, 1H), 7.79 (t, \(J = 6.8\) Hz, 1H), 7.62 (t, \(J = 6.8\) Hz, 1H), 4.00 (s, 3H), 2.99 (s, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 167.1, 150.2, 148.4, 147.8, 130.8, 130.0, 127.6, 127.1, 124.9, 122.9, 52.3, 15.3. Anal. Calcd for C\(_{12}\)H\(_{11}\)NO\(_2\): C, 71.63; H, 5.51; N, 6.96. Found: C, 71.54; H, 5.43; N, 6.87.

![Chemical structure](attachment:image.png)

6-Chloro-4-(2-chloro-phenyl)-quinoline-3-carboxylic acid methyl ester (3de).

Brown gummy mass (199 mg, 60%); IR (KBr): 1720 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 9.47 (s, 1H), 8.17 (d, \(J = 9.2\) Hz, 1H), 7.76 (dd, \(J_1 = 8.8\) Hz, \(J_2 = 2.4\) Hz, 1H), 7.60 (d, \(J = 8.0\) Hz, 1H), 7.50-7.45 (m, 2H), 7.39 (d, \(J = 2.2\) Hz, 1H), 7.22-7.20 (m, 1H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 165.4, 150.5, 147.8, 146.9, 134.8, 133.7, 132.7, 132.3, 131.3, 130.0, 130.0, 129.5, 127.4, 126.7, 125.6, 123.0, 52.4. Anal. Calcd for C\(_{17}\)H\(_{11}\)Cl\(_2\)NO\(_2\): C, 61.47; H, 3.34; N, 4.22. Found: C, 61.41; H, 3.24; N, 4.15.

Typical procedure for the synthesis of 6-chloro-2,4-diphenylquinoline (5af).\(^2\)

![Chemical structure](attachment:image.png)

2-Amino-5-chlorobenzophenone (231 mg, 1 mmol) and phenylpropioloic acid (146 mg, 1 mmol) was mixed in a sealed tube and stirred at room temperature for 10 min. Then copper triflate (36 mg, 0.1 mmol) was added to the reaction mixture and heated at 110 °C. After completion (TLC), the reaction mixture was extracted with dichloromethane (10 mL x 2). Solvent was evaporated to furnished the crude product which
was subjected to column chromatography on silica gel to obtain the analytically pure product using petroleum ether/ethyl acetate as an eluent (white solid, 277 mg, 88%); Mp 124-125 °C; IR (KBr): 1620 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ 8.08-8.05 (m, 3H), 7.76 (d, J = 2.4 Hz, 1H), 7.71 (s, 1H), 7.54 (dd, J₁ = 9.2 Hz, J₂ = 2.4 Hz, 1H), 7.47-7.33 (m, 8H); ¹³C NMR (100 MHz, CDCl₃): δ 157.0, 148.3, 147.1, 139.1, 137.6, 132.1, 131.6, 130.3, 129.5, 129.3, 128.8, 128.7, 128.6, 127.4, 126.4, 124.4, 119.9.

4-Methyl-2-phenylquinoline (5ef).²

White oil (184 mg, 84%); IR (KBr): 1640 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ 8.08-8.02 (m, 3H), 7.86-7.82 (m, 1H), 7.61-7.75 (m, 2H), 7.43-7.32 (m, 4H), 2.61 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 157.1, 148.1, 144.9, 139.8, 130.3, 129.4, 129.2, 128.8, 127.6, 127.3, 126.1, 123.7, 119.8, 19.0.

(4-Methyl-2-phenyl-quinolin-3-yl)-phenyl-methanone (7eg).³

Yellow oil (281 mg, 87%); ¹H NMR (400 MHz, CDCl₃): δ 8.13 (d, J = 8.4 Hz, 1H), 7.97 (d, J = 8.0 Hz, 1H), 7.67 (t, J = 8.0 Hz, 1H), 7.5-7.48 (m, 3H), 7.43 (dd, J₁ = 1.6 Hz, J₂ = 7.6 Hz, 2H), 7.29 (t, J = 7.6 Hz, 1H), 7.17-7.08 (m, 5H), 2.49 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 198.4, 156.1, 147.3, 142.5, 140.0, 137.5, 133.5, 132.5, 130.3, 130.2, 129.3, 129.2, 128.6, 128.5, 128.2, 127.0, 126.3, 124.0, 15.8.
2,8-Dichloro-6,12-diphenyldibenzo[b,f][1,5]diazocine (8).^2

Yellow solid, 230 mg, 54%; Mp 210-212 °C; IR (KBr): 1586 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta\) 7.54 (d, \(J = 7.2\) Hz, 4H), 7.45-7.24 (m, 8H), 6.91-6.87 (m, 4H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)): \(\delta\) 168.9, 150.2, 13.2, 131.7, 130.2, 129.5, 129.2, 128.9, 128.2, 127.3, 122.6.

References:

3de

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