Supporting Information

CuSO₄-D-glucose an inexpensive and eco-efficient catalytic system: direct access to diverse quinolines through modified Friedländer approach involving S_NAr/reduction/annulation cascade in one-pot

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Experimental Section

1. General Experimental Details

$^1$H and $^{13}$C NMR spectra were recorded at 300 and 75 MHz, respectively. Chemical shift ($\delta$) values are given in parts per million (ppm) with reference to tetramethylsilane (TMS) as the internal standard. Coupling constant ($J$) values are given in Hertz (Hz). The IR spectra were recorded on Varian 3100 FT-IR spectrophotometer. Melting points were determined with Buchi B-540 melting point apparatus and are uncorrected. Commercially obtained reagents were used after further purification when needed. All the reactions were monitored by TLC with silica gel coated plates. Column chromatography was carried out whenever needed, using silica gel of 100/200 mesh. Mixture of hexane/ethyl acetate in appropriate proportion (determined by TLC analysis) was used as eluent.

2. a. General procedure for the synthesis of compound 3

A mixture of 2-bromobenzaldehyde/2-bromoacetophenone 1 (1 mmol), NaN$_3$ (2 mmol) and cyclic/acyclic ketones 2 (1.1 mmol) in H$_2$O + EtOH (3:2, 5 mL) was placed in a 50 mL round bottom flask. To a stirring solution of above mixture added CuSO$_4$ (0.3 mmol), D-glucose (0.3 mmol), L-proline (0.2 mmol) and KOH (1 mmol). The reaction mixture was allowed to stir at 90 °C for 3-10 h. After completion of reaction (monitored on TLC), solvent was removed under reduced pressure and extracted with ethyl acetate. The combined organic layer was dried over anhydrous sodium sulphate, filtered and the solvent was removed under reduced pressure. The crude residue thus obtained was purified by column chromatography to give the desired quinolines 3.
2. b. Characterization of Compounds 3

3-Acetyl-2-methyl quinoline (3aa):
Pale yellow solid, mp 74-75 °C; IR (KBr) cm⁻¹: 3053, 1788, 1624, 1579, 1456, 818 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 8.48 (s, 1H, ArH), 8.05 (d, J = 8.4 Hz, 1H, ArH), 7.87-7.76 (m, 2H, ArH), 7.57-7.52 (m, 1H, ArH), 2.91 (s, 3H, COCH₃) 2.72 (s, 3H, CH₃); ¹³C NMR (75 MHz, CDCl₃): δ 199.9, 157.5, 138.2, 138.1, 131.6, 131.1, 128.5, 128.2, 126.6, 125.5, 29.2, 25.6.

Phenyl(2-phenylquinolin-3-yl)methanone (3ab):
Yellow solid, mp 135-137 °C; IR (KBr) cm⁻¹: 3163, 2960, 1756, 1684, 1562 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 8.23-8.15 (m, 5H, ArH), 8.00 (d, J = 6.9 Hz, 1H, ArH), 7.89-7.81 (m, 2H, ArH), 7.75-7.70 (m, 1H, ArH), 7.55-7.43 (m, 6H, ArH); ¹³C NMR (75 MHz, CDCl₃) δ: 175.7, 157.3, 148.2, 139.6 (2C), 136.7, 132.4, 129.6, 129.2 (2C), 128.8 (3C), 128.6 (3C), 127.4 (2C), 127.1 (2C), 126.2, 118.9.

3,4-Dihydroacridin-1(2H)-one (3ac):
White solid, mp 103-105 °C; IR (KBr) cm⁻¹: 3463, 2926, 1737, 1452, 1230, 835 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 8.85 (s, 1H, ArH), 8.06 (d, J = 8.4 Hz, 1H, ArH), 7.94 (d, J = 8.1 Hz, 1H, ArH), 7.83-7.78 (m, 1H, ArH), 7.57 (t, J = 7.2 Hz, 1H, ArH), 3.34 (t, J = 6.0 Hz, 2H, CH₂), 2.82 (t, J = 6.0 Hz, 2H, CH₂), 2.32 (dd, J₁ = 6.0 Hz, J₂ = 12.6 Hz, 2H, CH₂); ¹³C NMR (75 MHz, CDCl₃) δ: 197.8, 161.9, 137.1, 132.3, 129.7, 128.4, 126.7, 126.6, 126.2, 39.0, 33.3, 21.7.
3,3-Dimethyl-3,4-dihydroacridin-1(2H)-one (3ad)\(^1\): White solid, mp 116-118 °C; IR (KBr) cm\(^{-1}\): 3062, 1768, 1594, 1488, 1231 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\): 8.82 (s, 1H, ArH), 8.06 (d, \(J = 8.7\) Hz, 1H, ArH), 7.94 (d, \(J = 8.1\) Hz, 1H, ArH), 7.82-7.77 (m, 1H, ArH), 7.57-7.52 (m, 1H, ArH), 3.20 (s, 2H, CH\(_2\)), 2.65 (s, 2H, CH\(_2\)), 1.15 (s, 6H, 2xCH\(_3\)); \(^13\)C NMR (75 MHz, CDCl\(_3\)) \(\delta\): 197.9, 160.7, 149.9, 136.4, 132.1, 129.7, 128.5, 126.6 (2C), 125.2, 52.4, 47.1, 32.7, 28.3(2C).

7-Methoxy-3,3-dimethyl-3,4-dihydroacridin-1(2H)-one (3bd)\(^3\): Yellow solid, mp 98-100 °C; IR (KBr) cm\(^{-1}\): 3062, 1768, 1594, 1488, 1231 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\): 8.73 (s, 1H, ArH), 7.97 (d, \(J = 9.0\) Hz, 1H, ArH), 7.47-7.43 (m, 1H, ArH), 7.167 (s, 1H, ArH), 3.93 (s, 3H, OCH\(_3\)), 3.16 (s, 2H, CH\(_2\)), 2.63 (s, 2H, CH\(_2\)), 1.14 (s, 6H, 2xCH\(_3\)); \(^13\)C NMR (75 MHz, CDCl\(_3\)) \(\delta\): 198.1, 158.2, 157.7, 146.1, 135.0, 129.8 (2C), 127.7, 125.3, 106.3, 55.6, 52.4, 46.7, 32.8, 28.3(2C).

3-Acetyl-2-methyl-4-phenyl quinoline (3ca)\(^4\): Yellow solid, mp 112-114 °C; IR (KBr) cm\(^{-1}\): 3053, 1788, 1624, 1579, 1456, 818 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\): 8.08 (d, \(J = 8.4\) Hz, 1H, ArH), 7.72-7.67 (m, 1H, ArH), 7.62 (d, \(J = 8.4\) Hz, 1H, ArH), 7.49-7.44 (m, 3H, ArH), 7.42-7.34 (m, 3H, ArH), 2.70 (s, 3H, CH\(_3\)), 2.00 (s, 3H, CH\(_3\)); \(^13\)C NMR (75 MHz, CDCl\(_3\)) \(\delta\): 205.5, 153.3, 147.3, 143.7, 135.0, 134.6, 129.9, 129.8 (2C), 128.8, 128.7, 128.5
9-Phenyl-3,4-dihydroacridin-1(2H)-one (3cc): Pale yellow solid, mp 153-156 °C; IR (KBr) cm⁻¹: 3407, 3048, 2924, 1737, 1498, 1230, 749 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 8.08 (d, J = 8.4 Hz, 1H, ArH), 7.78 (m, 1H, ArH), 7.50-7.37 (m, 5H, ArH), 7.19-7.16 (m, 2H, ArH), 3.40 (t, J = 6.3 Hz, 2H, CH₂), 2.72 (t, J = 6.3 Hz, 2H, CH₂), 2.29 (dd, J₁ = 6.6 Hz, J₂ = 12.6 Hz, 2H, CH₂); ¹³C NMR (75 MHz, CDCl₃) δ: 197.9, 162.2, 151.4, 148.5, 137.5, 131.7, 128.4 (2C), 128.1, 128.0 (2C), 127.9, 127.5 (2C), 126.4, 123.8, 40.6, 34.5, 21.3.

2,3-Dihydro-1H-cyclopenta[b]quinoline (3ae): White solid, mp 55-57 °C; IR (KBr) cm⁻¹: 3053, 1646, 1562, 1212 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 8.02 (d, J = 8.4 Hz, 1H, ArH), 7.70 (s, 1H, ArH), 7.67-7.64 (m, 1H, ArH), 7.60-7.55 (m, 1H, ArH), 7.43-7.38 (m, 1H, ArH), 3.14 (t, J = 7.5 Hz, 2H, CH₂), 3.02 (t, J = 7.2 Hz, 2H, CH₂), 2.19-2.11 (dd, J₁ = 7.5 Hz, J₂ = 15.0 Hz, 2H, CH₂); ¹³C NMR (75 MHz, CDCl₃) δ: 157.6, 147.2, 135.3, 130.0, 128.3, 128.2, 128.0, 127.1, 125.2, 34.3, 30.2, 23.3.

1,2,3,4-Tetrahydroacridine (3af): White solid, mp 85-87 °C; IR (KBr) cm⁻¹: 3058, 1624, 1557, 1453, 1214 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 7.97 (d, J = 8.4 Hz, 1H, ArH), 7.70 (s, 1H, ArH), 7.67-7.64 (m, 1H, ArH), 7.60-7.55 (m, 1H, ArH), 7.42-7.37 (m, 1H, ArH), 3.13 (t, 23.3.
J = 6.3 Hz, 2H, CH$_2$), 2.96 (t, J = 6.3 Hz, 2H, CH$_2$), 1.99-1.95 (m, 2H, CH$_2$), 1.88-1.84 (m, 2H, CH$_2$); $^{13}$C NMR (75 MHz, CDCl$_3$) δ: 159.1, 146.4, 134.8, 130.8, 128.3, 128.1, 127.0, 126.7, 125.3, 33.4, 29.1, 23.1, 22.7.

*5,6-Dihydrobenzo[a]acridine (3ag)*: Yellow solid, mp 63-65 °C; IR (KBr) cm$^{-1}$: 3417, 2929, 1498, 1278, 1033, 789 cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ: 8.58 (d, J = 7.5 Hz, 1H, ArH), 8.13 (d, J = 8.4 Hz, 1H, ArH), 7.84 (s, 1H, ArH), 7.69-7.59 (m, 2H, ArH), 7.45-7.31 (m, 3H, ArH), 7.24 (d, J = 7.2 Hz, 1H, ArH), 3.08-3.04 (m, 2H, CH$_2$), 2.97-2.93 (m, 2H, CH$_2$); $^{13}$C NMR (75 MHz, CDCl$_3$) δ: 153.2, 147.5, 139.3, 134.6, 133.6, 130.4, 129.5, 129.3, 128.5, 127.8, 127.7, 127.2, 126.8, 126.0, 125.9, 28.7, 28.3.

*7-Methoxy-2,3-dihydro-1H-cyclopenta[b]quinoline (3be)*: White solid, mp 97-99 °C; IR (KBr) cm$^{-1}$: 3407, 3048, 2924, 1595, 1498, 1230, 749 cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ: 7.91 (d, J = 9.3 Hz, 1H, ArH), 7.77 (s, 1H, ArH), 7.28-7.24 (m, 1H, ArH), 7.00 (d, J = 2.7 Hz, 1H, ArH), 3.90 (s, 3H, OCH$_3$), 3.24 (t, J = 7.5 Hz, 2H, CH$_2$), 3.14-3.02 (m, 2H, 2xCH$_2$), 2.23-2.13 (m, 2H, CH$_2$); $^{13}$C NMR (75 MHz, CDCl$_3$) δ: 165.2, 157.0, 143.3, 135.9, 129.7, 129.3, 128.2, 120.4, 105.5, 55.4, 34.2, 30.5, 23.6.
9-Phenyl-2,3-dihydro-1-cyclopenta[b]quinoline (3ce): Yellow solid, mp 133-135 °C; IR (KBr) cm⁻¹: 3053, 1625, 1586, 1230, 1033, 836 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 8.09 (d, J = 8.4 Hz, 1H, ArH), 7.63 (m, 2H, ArH), 7.51-7.45 (m, 3H, ArH), 7.37-7.34 (m, 3H, ArH), 3.24 (t, J = 7.5 Hz, 2H, CH₂), 2.90 (t, J = 7.2 Hz, 2H, CH₂), 2.21-2.11 (m, 2H, CH₂); ¹³C NMR (75 MHz, CDCl₃) δ: 167.3, 147.7, 142.8, 136.7, 133.6, 129.2 (2C), 128.6, 128.4, 128.2, 127.9 (2C), 126.2, 125.6, 125.5, 35.1, 30.3, 23.5.

2-Phenylquinoline (3ah): White solid, mp 85-87 °C; IR (KBr) cm⁻¹: 3056, 1612, 1598, 1557, 1478 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 8.21-8.14 (m, 3H, ArH), 7.88-7.80 (m, 2H, ArH), 7.74-7.69 (m, 1H, ArH), 7.55-7.43 (m, 5H, ArH); ¹³C NMR (75 MHz, CDCl₃) δ: 157.3, 148.2, 139.6, 129.6, 129.2 (2C), 128.8 (2C), 127.5 (2C), 127.4, 127.1, 126.2, 118.9.

2-(2-Chlorophenyl)quinoline (3ai): White solid, mp 72-75 °C; IR (KBr) cm⁻¹: 3063, 1614, 1574, 1512, 1423 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 8.20-8.17 (m, 2H, ArH), 8.13-8.08 (m, 2H, ArH), 7.81-7.69 (m, 2H, ArH), 7.54-7.45 (m, 3H, ArH); ¹³C NMR (75 MHz, CDCl₃) δ: 155.9, 148.1, 137.9, 136.9, 135.5, 129.9, 129.8, 128.9 (2C), 128.7 (2C), 127.4, 127.1, 126.4, 118.6.
2-(2-Chlorophenyl)quinoline (3aj): White solid, mp 65-67 °C; IR (KBr) cm\(^{-1}\): 3025, 2915, 1664, 1574, 1497, 1431, 815 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) δ: 8.24-8.16 (m, 3H, ArH), 8.03-7.97 (m, 1H, ArH), 7.85-7.71 (m, 3H, ArH), 7.56-7.51 (m, 2H, ArH); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) δ: 155.7, 137.0, 134.9, 132.6, 130.8, 130.2, 129.9, 129.7, 129.3, 128.5, 127.7, 127.4, 126.6, 125.6, 118.6.

2-(4-Chlorophenyl)quinoline (3ak): White solid, mp 110-113 °C; IR (KBr) cm\(^{-1}\): 3065, 1610, 1553, 1525, 1412 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) δ: 8.20-8.08 (m, 4H, ArH), 7.81-7.69 (m, 3H, ArH), 7.54-7.46 (3H, ArH); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) δ: 155.9, 148.1, 138.0, 136.9, 135.5, 129.7, 129.6, 128.9 (2C), 128.7 (2C), 127.4, 127.1, 126.4, 118.4.

2-p-Tolylquinoline (3al): White solid, mp 80-82 °C; IR (KBr) cm\(^{-1}\): 3422, 2915, 1668, 1618, 1596, 1497, 815, 788 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) δ: 8.15 (d, J = 8.4 Hz, 2H, ArH), 8.06 (d, J = 8.1 Hz, 2H, ArH), 7.83-7.68 (m, 3H, ArH), 7.49-7.47 (m, 1H, ArH), 7.32 (d, J = 7.8 Hz, 2H, ArH), 2.41 (s, 3H, CH\(_3\)); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) δ: 157.2, 148.2, 139.3, 136.8, 136.5, 129.6 (2C), 129.4 (2C), 127.3 (3C), 127.0, 126.0, 118.7, 21.2.
2-(3-Methoxyphenyl)quinoline (3am): Yellow oil, IR (Neat) cm⁻¹: 3152, 1604, 1563, 1498 cm⁻¹; \(^1^H\) NMR (300 MHz, CDCl₃) δ: 8.17 (d, \(J = 8.4\) Hz, 1H, ArH), 8.10 (d, \(J = 8.7\) Hz, 1H, ArH), 7.78-7.65 (m, 5H, ArH), 7.47-7.35 (m, 2H, ArH), 6.99 (d, \(J = 8.1\) Hz, 1H, ArH), 3.86 (s, 3H, OCH₃); \(^1^3^C\) NMR (75 MHz, CDCl₃) δ: 160.0, 156.8, 148.0, 140.9, 136.5, 129.6, 129.5, 129.4, 127.3, 127.1, 126.1, 119.8, 118.8, 115.2, 112.6, 55.2.

2-(4-Methoxyphenyl)quinoline (3an): White solid, mp 117-120 ºC; IR (KBr) cm⁻¹: 3039, 2921, 2840, 1604, 1499, 1251, 1029, 818 cm⁻¹; \(^1^H\) NMR (300 MHz, CDCl₃) δ: 8.14-8.11 (m, 4H, ArH), 7.80-7.75 (m, 2H, ArH), 7.71-7.65 (m, 1H, ArH), 7.49-7.44 (m, 1H, ArH), 7.03 (d, \(J = 8.7\) Hz, 2H, ArH), 3.85 (s, 3H, OCH₃); \(^1^3^C\) NMR (75 MHz, CDCl₃) δ: 160.7, 156.8, 148.2, 136.5, 132.1, 129.5, 129.4, 128.8, 127.3, 126.8, 125.8, 118.4, 114.1 (2C), 55.3.

2-(Naphthalen-2-yl)quinoline (3ao): White solid, mp 163-165 ºC; IR (KBr) cm⁻¹: 3058, 1622, 1567 cm⁻¹; \(^1^H\) NMR (300 MHz, CDCl₃) δ: 8.59 (s, 1H, ArH), 8.37 (d, \(J = 8.7\) Hz, 1H, ArH), 8.22 (d, \(J = 8.4\) Hz, 2H, ArH), 8.00-7.96 (m, 3H, ArH), 7.89-7.86 (m, 1H, ArH), 7.82 (d, \(J = 8.1\) Hz, 1H, ArH), 7.75-7.70 (m, 1H, ArH), 7.53-7.49 (m, 2H, ArH); \(^1^3^C\) NMR (75 MHz, CDCl₃) δ: 157.1, 148.3, 136.7, 133.8, 133.4, 129.6, 128.9, 128.7 (2C), 128.5, 127.6, 127.4, 127.2, 127.1, 126.6, 126.2 (2C), 125.0, 119.0.
2-(Furan-2-yl)quinoline (3ap)\(^6\): White solid, mp 90-92 °C; IR (KBr) cm\(^{-1}\): 3152, 1618, 1523 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\): 8.15-8.12 (m, 2H, ArH), 7.81-7.61 (m, 4H, ArH), 7.47 (t, \(J = 7.5\) Hz, 1H, ArH), 7.22-7.21 (m, 1H, ArH), 6.57 (bs, 1H, ArH); \(^13\)C NMR (75 MHz, CDCl\(_3\)) \(\delta\): 153.6, 148.9, 148.0, 144.0, 136.6, 129.8, 129.3, 127.5, 127.1, 126.1, 117.4, 112.1, 110.0.

2-(Thiophen-2-yl)quinoline (3aq)\(^6\): White solid, mp 125-128 °C; IR (KBr) cm\(^{-1}\): 3101, 3054, 1624, 1578, 1223 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\): 8.11-8.06 (m, 2H, ArH), 7.77-7.65 (m, 4H, ArH), 7.48-7.43 (m, 2H, ArH), 7.15-7.12 (m, 1H, ArH); \(^13\)C NMR (75 MHz, CDCl\(_3\)) \(\delta\): 152.2, 148.0, 145.3, 136.5, 129.7, 129.2, 128.5, 128.0, 127.4, 127.1, 126.0, 125.7, 117.5.

2-(Pyridin-3-yl)quinoline (3ar)\(^{10}\): White solid, mp 93-95 °C; IR (KBr) cm\(^{-1}\): 3059, 2924, 1599, 1095, 787 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\): 8.51 (d, \(J = 7.8\) Hz, 1H, ArH), 8.25 (d, \(J = 8.7\) Hz, 1H, ArH), 8.18 (d, \(J = 8.4\) Hz, 1H, ArH), 7.86-7.71 (m, 4H, ArH), 7.56-7.47 (m, 3H, ArH); \(^13\)C NMR (75 MHz, CDCl\(_3\)) \(\delta\): 154.5, 150.0, 148.6, 148.2, 137.0 (2C), 134.8, 129.9, 129.6, 127.4, 127.2, 126.7 (2C), 118.4.
2,4-Diphenylquinoline (3ch): White solid, mp 112-115 °C; IR (KBr) cm⁻¹: 3423, 3086, 2955, 1589, 1095, 846 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 7.81 (d, J = 7.2 Hz, 4H, ArH), 7.67-7.56 (m, 4H, ArH), 7.51-7.38 (m 5H, ArH), 7.35-7.31 (m, 2H, ArH); ¹³C NMR (75 MHz, CDCl₃) δ: 163.1, 140.5, 137.5, 136.2, 136.0, 133.6, 133.0, 132.3, 131.8, 131.0, 130.0, 129.9, 129.0, 128.8, 128.5, 128.2, 128.1, 127.1, 119.4, 118.5, 118.5.

3-Methyl-2-phenylquinoline (3as): Yellow oil; IR (Neat) cm⁻¹: 3052, 1618, 1553, 1431, 1097, 756 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 8.13 (d, J = 8.4 Hz, 1H, ArH), 7.96 (s, 1H, ArH), 7.74 (d, J = 8.1 Hz, 1H, ArH), 7.65-7.56 (m, 3H, ArH), 7.46-7.40 (m, 4H, ArH), 2.43 (s, 3H, CH₃); ¹³C NMR (75 MHz, CDCl₃) δ: 160.4, 146.5, 140.8, 136.6, 129.2, 129.0, 128.7 (2C), 128.6, 128.1 (2C), 128.0, 127.5, 126.6, 126.2, 20.5.

3-Ethyl-2-phenylquinoline (3at): Yellow oil. IR (Neat) cm⁻¹: 3048, 2924, 1595, 1432, 749 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ: 8.14 (d, J = 8.4 Hz, 1H, ArH), 8.01 (s, 1H, ArH), 7.79 (d, J = 7.8 Hz, 1H, ArH), 7.66-7.61 (m, 1H, ArH), 7.54-7.52 (m, 2H, ArH), 7.48-7.41 (m, 4H, ArH), 2.81-2.73 (m, 2H, CH₂), 1.19 (t, J = 7.8 Hz, 3H, CH₃); ¹³C NMR (75 MHz, CDCl₃) δ: 160.5, 146.2, 140.8, 135.1, 134.8, 129.1, 128.7, 128.6, 128.1, 127.9, 127.6, 126.8, 126.2, 25.9, 14.6.
3. References


$^1$H NMR of 3aa

$^{13}$C NMR of 3aa
$^1$H NMR of 3ab

$^{13}$C NMR of 3ab
$^1$H NMR of 3ac

$^{13}$C NMR of 3ac
$^1$H NMR of 3ad

$^{13}$C NMR of 3ad
$^1$H NMR of 3bd

$^{13}$C NMR of 3bd
$^1$H NMR of 3ca

$^{13}$C NMR of 3ca
$^1$H NMR of 3cc

$^{13}$C NMR of 3cc
$^1$H NMR of 3ae

$^{13}$C NMR of 3ae
$^1$H NMR of 3af

$^{13}$C NMR of 3af
$^1$H NMR of 3ag

$^{13}$C NMR of 3ag
$^1$H NMR of 3be

$^{13}$C NMR of 3be
$^1$H NMR of 3ce

$^{13}$C NMR of 3ce
$^1$H NMR of 3ah

$^{13}$C NMR of 3ah
$^1$H NMR of 3ai

$^{13}$C NMR of 3ai
$^{1}H$ NMR of 3aj

$^{13}C$ NMR of 3aj
$^1$H NMR of 3ak

$^{13}$C NMR of 3ak
\(^1\)H NMR of 3al

\(^{13}\)C NMR of 3al
$^1$H NMR of 3am

$^{13}$C NMR of 3am
$^1$H NMR of 3an

$^{13}$C NMR of 3an
$^{1}H$ NMR of 3ao

$^{13}C$ NMR of 3ao
$^1$H NMR of 3ap

$^{13}$C NMR of 3ap
$^1$H NMR of 3aq

13C NMR of 3aq
$^1$H NMR of 3ar

$^{13}$C NMR of 3ar
\(^1\)H NMR of 3ch

\(^13\)C NMR of 3ch
$^1$H NMR of 3as

$^{13}$C NMR of 3as
$^{1}$H NMR of $^{3}$at

$^{13}$C NMR of $^{3}$at