(Bromodimethyl)sulfonium Bromide Catalyzed Solvent-Free Friedlander Synthesis of Substituted Quinolines

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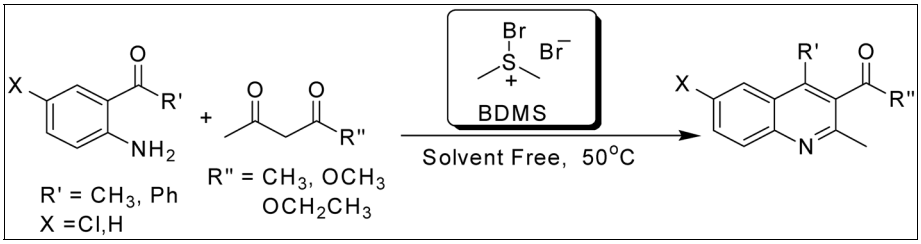

A simple and efficient (bromodimethyl)sulfonium bromide catalyzed synthesis of quinolines, by condensation of α-amino carbonyl, that is, 2-aminobenzophenone and 2-aminoacetophenone with α-methylene containing carbonyl like 1,3-dicarbonyls has been developed. The reaction is versatile, solvent-free protocol for generation of structurally diverse quinolines.

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INTRODUCTION

Qunine identified in 1820 as an active ingredient in Cinchona bark for treatment of malaria is perhaps the first isolated molecule from natural sources to be used as a drug. Similarly, pamaquine [1], again an antimalarial drug, is the first known synthetic drug ever used in humans. Both of them possess quinoline skeleton. Nearly all of the known antimalarial drugs belong to this class [1,2]. Quinolines form major components of a variety of natural products. They are also versatile building blocks of various pharma active molecules. Of late, a number of antituberculosis drugs have evolved based on aryl quinolines like TMC-207 [3] (Fig. 1), exhibiting high potency and novel mode of action, which is in phase-II clinical trials for multidrug-resistant tuberculosis. Quinolines have also been shown to exhibit antiasthmatic [4], antidiabetic [5], *in vitro* antifungal [6], antiviral [7], anti-inflammatory [8], and antiproliferative activities [9]. Further more, as a consequence of their inherent fluorescent nature, they are of great interest as light emitting chromophores [10]. Applications of quinolines as the ligands for transition metals in chiral catalysis are also plentiful [11].

Owing to the wide range of applications, quinoline synthesis has received much attention, and many classical methods for synthesis, such as Skraup, Doebner–Vonmiller, Conrad–Limbach, Combes, Pfitzinger, and Friedlander, are in vogue. Friedlander synthesis of quinoline has proven to be the most versatile, straightforward, and powerful method. It is a Bronsted acid [12] or Lewis acid [13] catalyzed condensation of α-amino carbonyl with carbonyl compound containing a reactive α-methylene group. Recently, heterogenous catalysis has also been employed in Friedlander synthesis [14]. Many of the available methods suffer from several drawbacks like harsh reaction conditions, side reactions or multiple products, and tedious work-up or purification techniques, involving solvents and toxic reagents.

RESULTS AND DISCUSSION

In continuation of our ongoing projects in developing novel solvent-free and environmentally benign synthetic methods for pharmaceutically and agrochemically important heterocycles, we herein report (bromodimethyl)-sulfonium bromide (BDMS) catalyzed Friedlander synthesis of quinoline in solvent-free conditions. BDMS has been proven to be a versatile catalyst for various transformations, which has been frequently employed in our laboratory [15], such as in construction of β-amino ketones and imidazo[1,2-a] pyridines, thia-Michael addition etc.

At the outset, the amino carbonyl, 2-amino benzophenone was reacted with ethylacetoacetate in the presence of BDMS at 50°C in solvent-free conditions (Scheme 1). The product, 3-methyl-4-phenylquinoline-3-carboxylic acid ethyl ester, was obtained by simply filtering the precipitated product from reaction mixture. Then, efforts were focused on the optimization of catalyst concentration. The reaction does not progress in the absence of catalyst. It was found to be sluggish as well as low yielding with 5 mol % BDMS (Table 1). Catalyst (10 mol %) was

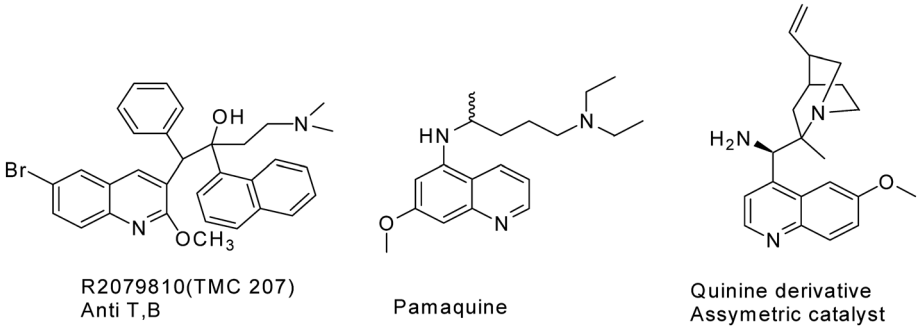


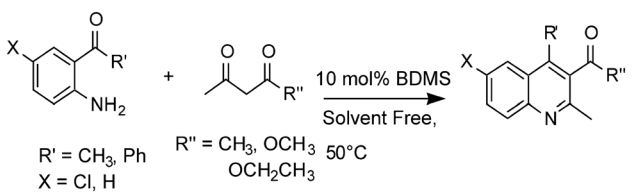
Figure 1. Quinolines with applications in pharmaceutical and synthetic chemistry.

ideal for the quinoline synthesis. Further increase in catalyst concentration does not improve reaction yield or time. The generality of method was investigated by employing 1,3-diketones, cyclic ketones, ketones, aldehydes, and so forth, and results are presented in Table 2. In all cases, reactions are facile and pure products were obtained without involving any additional purification. This method is general and tolerant to substitutions on the amino benzophenone as well as changes in the carbonyls (entries 1–20, Table 2). Heterocyclic aldehydes/ketones gave lower yields, and reactions were time consuming. Aliphatic and aromatic aldehydes were not good substrates and reactions did not progress. The yields were also poor with aliphatic carbonyls. The same was the case when carbonyls with electron donating substitutions were employed. The reaction does not proceed with triflouro ethylacetoacetate.

Encouraged by the results 2-amino benzophenone was replaced by 2-amino acetophenone to effect of R^1 on the reaction protocol. Condensation of 2-amino acetophenone with ethylacetoacetate and 10 mol % BDMS was sluggish and low yielding. However, when the catalyst concentration was enhanced to 40 mol %, the reaction was effective yielding corresponding quinoline in 81% in 20 min. The reaction was extendable with 2-amino benzophenone and other diketones without any hassles (entries 19–21, Table 2).

The Friedlander synthesis mechanism goes *via* an imine formation and an aldol condensation, either of which can be the first step. A rate limiting aldol reaction, followed by elimination of water and imine formation with further loss of water leads to quinolines. Alternately, Schiff's base formation followed by aldol reaction and water elimination also leads to the same product. In this case, the aldol formation seems to be the first step, because the reaction does not proceed at low temperatures and stops at simple Schiff's base formation. Aldol condensation, being an equilibration reaction, can be propelled only by heating. BDMS has a role in both enolization of the carbonyl compound with α-methylene group as well as the final Schiff's base formation and cyclization. The plausible mechanism is given in Figure 2.

Scheme 1. BDMS catalyzed synthesis of quinolines.



CONCLUSIONS

To the best of our knowledge, this is the first report of BDMS catalyzed Friedlander synthesis of quinoline starting from 2-amino carbonyls, that is, 2-aminobenzophenone and 2-aminoacetophenone. The reaction is a versatile, solvent-free protocol for generation of structurally diverse quinolines. Several advantages offered by this protocol include operational simplicity, inexpensive reagents, short reaction times, and hassle-free work-up and purification.

EXPERIMENTAL

General procedure for the preparation of substituted quinolines: a mixture of 2-amino aryl ketone (1 mmol), enolizable ketone (1 mmol), and (bromodimethyl)sulfonium bromide (BDMS) 10 mol % was stirred at 50°C under solvent-free condition till the completion of the reaction as indicated by TLC (Table 2). After completion of the reaction, the reaction mixture was triturated with 2–3 mL of ethyl acetate and

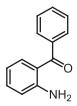
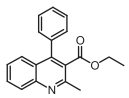
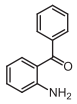
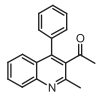
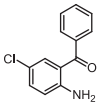
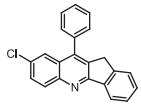
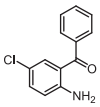
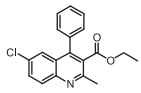
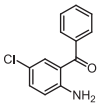
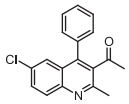
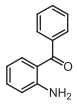
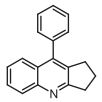
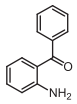
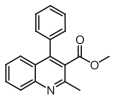
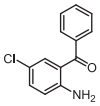
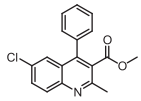
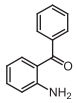
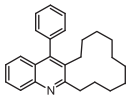
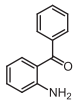
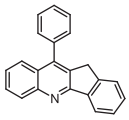
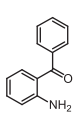
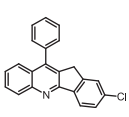
Table 1

Optimization of BDMS concentration for quinoline synthesis (2-amino benzophenone and ethylacetoacetate).

S. No.	BDMS	Yield (%)	Time
1	0	Traces	>24 h
2	5	50	2 h
3	10	80	50 min
4	20	80	50 min

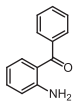
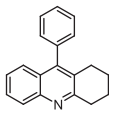
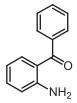
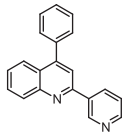
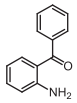
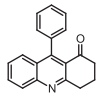
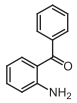
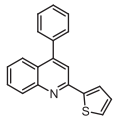
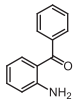
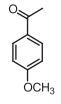
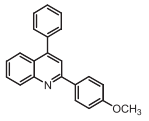
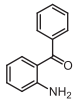
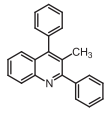
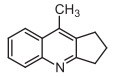
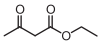
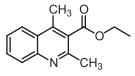
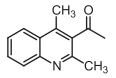
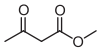
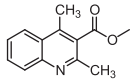
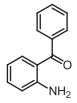
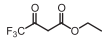
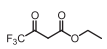
Table 2

BDMS catalyzed synthesis of substituted quinolines.

Entry	2-Amino carbonyl	α-Methylene carbonyl	Product	Yield (isolated, %)	Time
1				80	50 min
2				81	45 min
3				84	35 min
4				81	55 min
5				80	55 min
6				92	30 min
7				85	50 min
8				81	50 min
9				72	75 min
10				93	20 min
11				81	20 min

(*Continued*)

Table 2
(Continued)

Entry	2-Amino carbonyl	α-Methylene carbonyl	Product	Yield (isolated, %)	Time
12				88	10 min
13				64	12 h
14				80	50 min
15				40	12 h
16				32	10 h
17				41	10 h
18				60	12 h
19				81	20 min
20				62	5 h
21				83	20 min
22			No reaction	–	–
23			No reaction	–	–

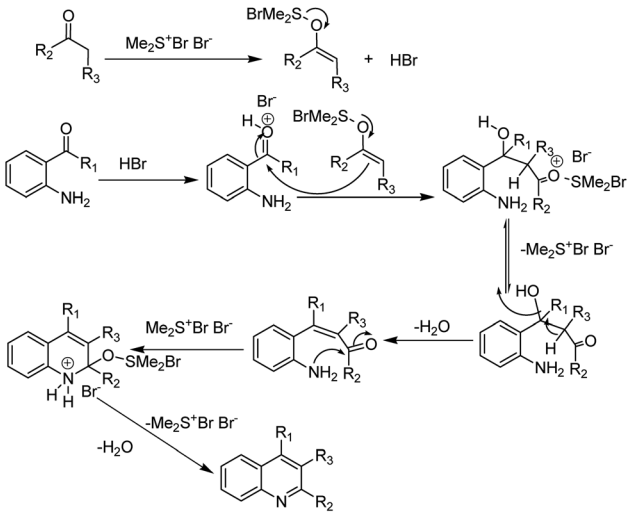


Figure 2. Plausible mechanism of BDMS catalyzed quinoline synthesis.

precipitated solid filtered. The product so obtained was pure enough for all practical purposes. Compounds were characterized by spectral data given below.

Spectral data. ***10-Phenyl-11H-indeno[1,2-b]quinoline ($C_{22}H_{15}N$, Table 1, entry 10).*** Pale yellow solid (M.p. 144–148°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.47 (t, 2H, J = 4.9 Hz), 8.35 (t, 1H, J = 7.8 Hz), 7.74 (d, 1H, J = 8.8 Hz), 7.63–7.48 (m, 9H), 3.96 (s, 2H); ^{13}C NMR (75 MHz, DMSO-d_6): 146.23, 145.47, 144.86, 137.69, 135.00, 133.58, 131.32, 130.18, 129.27, 128.90, 127.81, 126.65, 126.06, 125.78, 128.65, 122.35, 33.86; MS (ESI): m/z = 294 $[M+H]^+$; HRMS (ESI) Calculated for $C_{22}H_{16}N$ $[M+H]^+$ 294.1282 found 294.1291; I.R. (KBr, cm^{-1}) : 3384, 3036, 2608, 1524, 763.

4-Phenyl-2-pyridine-3-yl-quinoline ($C_{20}H_{14}N_2$, Table 1, entry 13). Pale brown solid (M.p. 116–118°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 9.63 (d, 1H, J = 10.8 Hz), 9.08 (d, 1H, J = 8.1 Hz), 8.91 (d, 1H, J = 5.1 Hz), 8.20 (d, 1H, J = 8.3 Hz), 8.13–8.07 (m, 1H), 7.97–7.76 (m, 3H), 7.62–7.52 (m, 6H); ^{13}C NMR (75 MHz, DMSO-d_6): 151.82, 149.41, 147.91, 146.25, 144.70, 139.47, 137.06, 135.61, 133.42, 132.04, 130.48, 129.74, 129.65, 128.99, 127.78, 125.67, 125.39, 119.00; MS (ESI): m/z = 283 $[M+H]^+$; HRMS (ESI) Calculated for $C_{20}H_{15}N_2$ $[M+H]^+$ 283.1235 found 283.1234; I.R. (KBr, cm^{-1}) : 3440, 3060, 2047, 1587, 1482, 766, 699.

2-Chloro-10-phenyl-11H-indeno[1,2-b]quinoline ($C_{22}H_{14}$NCl, Table 1, entry 11). Pale yellow solid (M.p. 315–318°C);^{1}H NMR (300 MHz, DMSO-d_6): δ 8.88 (d, 1H, J = 8.8 Hz), 8.69 (d, 1H, J = 7.8 Hz), 7.99 (t, 1H, J = 7.8 Hz), 7.92 (s, 1H), 7.86 (t, 1H, J = 7.8 Hz), 7.74–7.62 (m, 4H), 7.58 (t, 2H, J = 7.8 Hz), 7.52 (t, 1H, J = 8.8 Hz), 4.10 (s, 2H); ^{13}C NMR (75 MHz, DMSO-d_6): 149.11, 141.28, 137.34, 135.64, 132.58, 134.30, 138.11, 131.87, 129.50, 129.24, 129.05, 128.54, 128.04, 126.33, 125.75, 124.98, 123.75, 123.45, 34.25; MS (ESI): m/z = 328 $[M+H]^+$; HRMS (ESI) Calculated for $C_{22}H_{15}$NCl $[M+H]^+$ 328.0893 found 328.0890; I.R. (KBr, cm^{-1}): 3421, 3051, 2897, 2462, 1635, 1597, 1341.

3-Methyl-2,4-diphenylquinoline ($C_{22}H_{17}N$, Table 1, entry 17). White solid (M.p. 188–191°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 9.37 (d, 1H, J = 8.7 Hz), 7.83 (t, 3H, J = 6.2 Hz), 7.68–7.50 (m, 8H), 7.42 (d, 2H, J = 6.8 Hz), 2.29 (s, 3H); ^{13}C NMR (75 MHz, DMSO-d_6): 156.67, 154.81, 138.29, 135.08, 133.77, 132.73, 130.74, 129.55, 129.23, 129.17, 129.09, 128.77, 128.63, 127.02, 126,50, 122.44, 18.04; MS (ESI): m/z = 296 $[M+H]^+$; HRMS (ESI) Calculated for $C_{22}H_{18}N$ $[M+H]^+$ 296.1433 found 296.1451; I.R. (KBr, cm^{-1}) : 3458, 3049, 2833, 2511, 1626, 759, 704.

16-Phenyl-6,7,8,9,10,11,12,13,14,15-decahydro-5-azacyclododeca[b]naphtha lene($C_{25}H_{29}N$ Table 1, entry 9). White solid (M.p. 217–220°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.76 (d, 1H, J = 8.1 Hz), 8.00 (t, 1H, J = 7.9 Hz), 7.71–7.59 (m, 4H), 7.43 (d, 1H, J = 8.3 Hz), 7.32–7.27 (q, 2H), 3.49 (t, 2H, J = 7.5 Hz), 2.76 (t, 2H, J = 7.7 Hz), 2.20–2.10 (m, 2H), 1.97–1.25 (m, 14H); ^{13}C NMR (75 MHz, DMSO-d_6): 160.25, 156.62, 136.37, 134.48, 134.26, 133.38, 129.30, 128.81, 128.53, 128.29, 128.14, 126.95, 126.73, 120.00, 29.92, 28.24, 27.66, 27.49, 27.29, 26.75, 26.59, 22.20, 21.77; MS (ESI): m/z = 344 $[M+H]^+$; HRMS (ESI) Calculated for $C_{22}H_{18}N$ $[M+H]^+$ 344.2378 found 344.2366; I.R. (KBr, cm^{-1}): 3412, 3054, 2926, 2850, 2483, 1930.

2-Chloro-11-phenyl-6H-indeno[2,1-b]quinoline ($C_{22}H_{14}$NCl, Table 1, entry 3). Pale yellow solid (M.p. 178–180°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.54 (d, 1H, J = 4.1 Hz), 8.43 (d, 1H, J = 8.9 Hz), 7.70 (dd, 1H, J = 9.1 Hz), 7.66–7.59 (m, 4H), 7.56–7.46 (m, 5H), 3.94 (s, 2H); ^{13}C NMR (75 MHz, DMSO-d_6): 183.77, 181.68, 175.19, 172.05, 169.02, 168.62, 167.80, 166.76, 166.70, 166.64, 166.58, 165.36, 163.61, 161.81, 159.81, 71.39; MS (ESI): m/z = 328 $[M+H]^+$; HRMS (ESI) Calculated for $C_{22}H_{14}$NCl$[M+H]^+$ 328.0893 found 328.0887; I.R. (KBr, cm^{-1}): 3448, 3056, 2902, 2454, 1339.

6-Chloro-2-methyl-4-phenyl-quinoline-3-carboxylic acid ethylester ($C_{19}H_{16}NO_2Cl$, Table 1, entry 4, ref. 13d). White solid (M.p. 105–107°C); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.99 (d, 1H, J = 9.1 Hz), 7.63 (dd, 1H, J = 9.1 Hz), 7.51–746 (m, 4H), 7.35–7.31 (m, 2H), 4.06–3.98 (q, 2H), 2.74 (s, 3H), 0.93 (t, 3H, J = 6.8 Hz); MS (ESI): m/z = 325 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3423, 2927, 1719, 1220, 1070.

1–(6-Chloro-2-methyl-4-phenyl-quinoline-3-yl)-ethanone ($C_{18}H_{14}$NOCl, Table 1, entry 5, ref. 13d). White solid (M.p. 153–156°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.03 (d, 1H, J = 8.9 Hz), 7.67 (d, 1H, J = 8.9 Hz), 7.56 (t, 3H, J = 3.9 Hz), 7.51 (d, 1H, J = 2.1 Hz), 3.75 (m, 2H), 2.65 (s, 3H), 1.97 (s, 3H); MS (ESI): m/z = 296 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3420, 2925, 1700.

2-Methyl-4-phenyl-quinoline-3-carboxylic acid methyl ester ($C_{18}H_{15}NO_2$, Table 1, entry 7, 13b). White solid (M.p. 94–95°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.58 (m, 1H), 8.03 (t, 1H, J = 6.8 Hz), 7.77–7.71 (m, 2H). 7.61–7.54 (m, 3H), 7.40–7.33 (m, 2H), 3.60 (s, 3H), 3.0 (s, 3H); MS (ESI): m/z = 278 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3447, 2942, 2494, 1735, 1230.

1-(2-Methyl-4-phenyl-quinoline-3-yl)-ethanone ($C_{18}H_{15}$NO, Table 1, entry 2, ref. 13d). White solid (M.p. 114–116°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 7.99 (d, 1H, J = 8.3 Hz), 7.70 (t, 1H, J = 8.1 Hz), 7.58 (d, 1H, J = 8.3 Hz), 7.55–7.50 (m,3H), 7.44 (t, 1H, J = 7.2 Hz), 7.36–7.31 (m, 2H), 2.63 (s, 3H), 1.97 (s, 3H); MS (ESI): m/z = 262 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3424, 2922, 1688.

9-Phenyl-2,3-dihydro-1H-cylopenta[b]quinoline ($C_{18}H_{15}N$, Table 1, entry 6, ref. 13a). Lite dark solid (M.p. 130–132°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.69–8.61 (q, 1H), 7.98 (t, 1H, J = 7.5 Hz), 7.85 (d, 1H, J = 8.5 Hz), 7.72 (t, 1H, J = 7.4 Hz), 7.62 (d, 3H, J = 6.0 Hz), 7.43 (d, 2H, J = 6.8 Hz), 3.77(q, 2H), 3.08 (t, 2H, J = 7.2 Hz), 2.45–2.35 (q, 2H); MS (ESI): m/z = 246 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3432, 2906, 2465, 1590.

2-Methyl-4-phenyl-quinoline-3-carboxylic acid ethylester ($C_{19}H_{17}NO_2$, Table 1, entry 1, ref. 13d). White solid (M.p. 98–100°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.05 (d, 1H, J = 8.3 Hz), 7.72–7.65 (m, 1H), 7.54 (d, 1H, J = 8.3 Hz), 7.48–7.41 (m, 3H), 7.40–7.33 (m, 3H), 4.06–3.99 (q, 2H), 2.77 (s, 3H), 0.93 (t, 3H, J = 6.8 Hz); MS (ESI): m/z = 292 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3399, 2977, 1719, 1235, 1068.

9-Phenyl-3,4-dihydro-2H-acridin-1-one ($C_{19}H_{15}NO$, Table 1, entry 14, ref. 13a). White solid (M.p. 154–157°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.40 (d, 1H, J = 8.5 Hz), 8.01 (t, 1H, J = 8.1 Hz), 7.64 (t, 1H, J = 8.2 Hz), 7.57–7.48 (m, 4H), 7.22–7.16 (q, 2H), 2.75 (t, 2H, J = 6.4 Hz), 2.54 (s, 2H), 2.37–2.27 (q, 2H); MS (ESI): m/z = 274 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3387, 2935, 1699, 1631, 1382.

6-Chloro-2-methyl-4-phenyl-quinoline-3-carboxylic acid methylester ($C_{18}H_{14}NO_3Cl$, Table 1, entry 8, ref. 13b). White solid (M.p. 196–198°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 9.23 (d, 1H, J = 9.1 Hz), 7.99 (dd, 1H, J = 9.1 Hz), 7.70 (d, 1H, J = 1.5 Hz), 7.65–7.60 (m, 3H), 7.39–7.35 (m, 2H), 3.62 (s, 3H), 3.25 (s, 3H); MS (ESI): m/z = 312 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3432, 2955, 2374, 1727.

2-(4-Methoxy-phenyl)-4-phenyl-quinoline ($C_{22}H_{17}NO$, Table 1, entry 16, ref. 14). Yellow solid (M.p. 74–76°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.79 (d, 1H, J = 8.5 Hz), 8.33 (d, 2H, J = 8.9 Hz), 8.18 (s, 1H), 8.11–8.02 (m, 2H), 7.79 (t, 1H, J = 7.4 Hz), 7.70–7.62 (m, 5H), 7.19 (d, 2H, J = 8.9 Hz), 3.96 (s, 3H); MS (ESI): m/z = 312 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3408, 3052, 2844, 1629, 1595, 1244, 1186.

4-Phenyl-2-thiophene-2-yl-quinoline ($C_{19}H_{13}NS$, Table 1, entry 15, ref. 14). Pale yellow solid (M.p. 90–92°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.33 (d, 1H, J = 4.5 Hz), 8.13 (d, 1H, J = 3.8 Hz), 7.92–7.79 (m, 3H), 7.68 (d, 1H, J = 5.1 Hz), 7.61–7.52 (m, 6H), 7.24 (t, 1H, J = 3.8 Hz); MS (ESI): m/z = 288 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3418, 3028, 2851, 2697, 1626, 1595, 1407, 1367.

9-Phenyl-1,2,3,4-tetrahydro-acridine ($C_{19}H_{17}N$, Table 1, entry 12, ref. 13d). White solid (M.p. 136–138°C); ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.55 (d, 1H, J = 9.8 Hz), 8.00 (t,1H, J = 7.5 Hz), 7.70 (t, 1H, J = 7.7 Hz), 7.65–7.58 (m, 3H), 7.55 (d, 1H, J = 8.7 Hz), 7.29 (d, 2H, J = 6.2 Hz), 3.56 (t, 2H, J = 5.7 Hz), 2.71 (t, 2H, J = 6.2 Hz), 2.09–2.0 (q, 2H), 1.93–1.85 (q, 2H); MS (ESI): m/z = 259 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3412, 3055, 2930, 2563, 1909, 761, 707.

2,4-Dimethyl-quinoline-3-carboxylicacid methylester ($C_{13}H_{13}NO_2$, Table 1, entry 21, ref. 13b). Yellow oil ^{1}H NMR (300 MHz, DMSO-d_6): δ 5.92 (d, 1H, J = 8.3 Hz), 5.73 (d, 1H, J = 8.3 Hz), 5.62 (t, 1H, J = 6.8 Hz), 5.41 (t, 1H, J = 7.5 Hz), 1.52 (s, 3H), 0.33 (s, 6H); MS (ESI): m/z = 216 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3463, 2945, 2514, 1738, 1230.

2,4-Dimethyl-quinoline-3-carboxylic acid ethylester ($C_{14}H_{15}NO_2$, Table 1, entry 19, ref. 13b). Yellow oil ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.45 (d, 2H, J = 8.5 Hz), 8.13 (t, 1H, J = 7.4 Hz), 7.94 (t, 1H, J = 7.7 Hz), 4.57–4.47 (m, 2H), 2.97 (s, 3H), 2.91 (s, 3H), 1.45 (t, 3H, J = 7.0 Hz); m/z = 230 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3448, 2982, 2509, 1731, 1300.

1-(2,4-Dimethyl-quinolin-3-yl)-ethanone($C_{13}H_{13}NO$, Table 1, entry 20, ref. 13b). Yellow oil ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.39 (t, 2H, J = 9.1 Hz), 8.06 (t, 1H, J = 7.2 Hz), 7.89 (t, 1H, J = 7.9 Hz), 2.89 (s, 3H), 2.83 (s, 3H), 2.71 (s, 3H); m/z = 200 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3391, 2629, 2601, 1860, 1704, 1637.

9-Methyl-2,3-dihydro-1H-cyclopenta[b]quinoline ($C_{13}H_{13}N$, Table 1, entry 18, ref. 14). Yellow oil ^{1}H NMR (300 MHz, DMSO-d_6): δ 8.44–9.35 (m, 1H), 8.24 (d, 1H, J = 7.5 Hz), 7.95 (t, 1H, J = 7.4 Hz), 7.85–7.77 (m, 1H), 3.57 (t, 2H, J = 7.5 Hz), 3.24 (t, 2H, J = 7.2 Hz), 2.84 (s, 3H), 2.47–2.36 (m, 2H); m/z = 184 $[M+H]^+$; I.R. (KBr, cm^{-1}): 3326, 2928, 2521, 1595.

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