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Cycloisomerization – a straightforward way to benzo[*h*]quinolines and benzo[*c*]acridines

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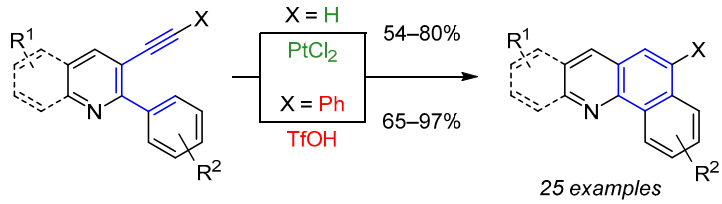


Cycloisomerization of 3-alkynyl-2-arylpyridines and quinolines offers a straightforward approach to benzo[*h*]quinolines and benzo[*c*]-acridines. Substituent at the triple bond governs a choice between transition metal or Brønsted acid catalysis. A direct electrophilic activation by trifluoromethanesulfonic acid induces an almost quantitative cyclization of the *o*-aryl(phenylethynyl) fragment. $PtCl_2$ efficiently catalyzes cyclization of 2-aryl-3-ethynylhetarenes.

Keywords: alkynes, benzo[*c*]acridines, benzo[*h*]quinolines, pyridines, quinolines, cycloisomerization, synthetic methods.

Compounds with the benzo[*h*]quinoline and benzo[*c*]-acridine cores are valuable classes of heterocycles with a wide range of applications exhibiting antibacterial,[1] wound healing,[2] antioxidant,[2] and anticancer activity.[3–7] Their complexes with transition metals and organosilicon compounds were applied in cross-coupling reactions;[8,9] bioactivity[10] and fluorescence properties[11–13] of these complexes have been described as well. Considering the importance of benzoquinoline derivatives, several approaches to their synthesis have been developed. Among them, methods based on the construction of the central benzene ring are quite limited, although they allow utilizing readily available pyridine derivatives.[14–20]

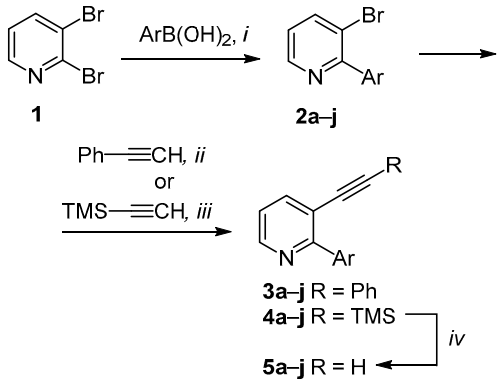
Cycloisomerization of *o*-ethynylbiaryls has emerged as an important tool for the synthesis of fused aromatic systems. Electrophilic activation[21–27] and catalysis with transition metals[28–34] are often used for cyclization. Although substantial work has been done to investigate and improve the efficiency of this transformation, for instance, *via* the utilization of Au-[35–37] or Pt-based[38,39] complexes, or by evaluation of the substrate and catalysts scope and limitations,[40–44] carbocyclic substrates have been involved in these cyclizations almost exclusively. Reports on cycloisomerization of heteroaromatic compounds have appeared in literature only in last years.[45–51] Recently, we have developed a simple and efficient procedure for the Brønsted acid-mediated cyclization of *o*-aryl(ethynyl)-pyrimidines producing benzo[*f*]quinazolines.[52] Here we present our findings in the cycloisomerization of various *o*-aryl(ethynyl)pyridines and quinolines using either transition metal catalysis or by action of Brønsted acid toward benzo[*h*]quinolines and benzo[*c*]acridines.

Starting 2-aryl-3-ethynylpyridines were prepared from 2,3-dibromopyridine **1** by a sequence of two cross-coupling reactions (Scheme 1, Table 1). The difference in reactivity of bromine atoms allows selective arylation in position 2 of the pyridine ring *via* the Suzuki coupling at 50°C.[53] Next, the Sonogashira cross coupling was used for the introduction of the acetylenic moiety. While the reaction with phenylacetylene proceeded smoothly in DMA at 90°C forming compounds **3a**–**j** in high yields after 6 h, trimethylsilylacetylene was completely inert. Solvent and temperature screening revealed that *i*-Pr_2NH and 80°C were optimal conditions for the preparation of 2-aryl-3-(trimethylsilylethynyl)pyridines **4a**–**j**.

TMS group can be easily removed from pyridines **4a**–**j** by treatment with K_2CO_3 in a CH_2Cl_2–MeOH mixture at room temperature to afford pyridines **5a**–**j** with a terminal triple bond. For pyridines **5c**,**h**, we demonstrated that the Sonogashira cross coupling/TMS-deprotection sequence could be performed in a one-pot fashion without affecting the overall yield.

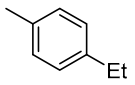
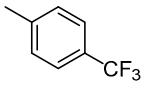
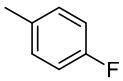
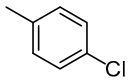
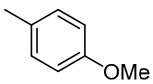
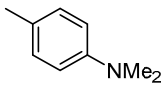
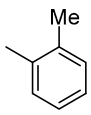
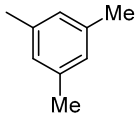
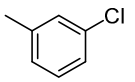
Cycloisomerization of ethynylpyridines **5** was first attempted under conditions reported for *o*-alkynylbiphenyls on pyridine **5a** as a test compound (Scheme 2, Table 2).[28] Pyridine **5a** was heated with $PtCl_2$ in toluene at 80°C for

Scheme 1



i: $Pd(OAc)_2$, PPh_3, K_2CO_3, MeCN/MeOH, 50°C, 24 h
ii: $Pd(PPh_3)_2Cl_2$, CuI, DMA, Et_3N, 90°C, 6 h
iii: $Pd(PPh_3)_2Cl_2$, CuI, *i*-Pr_2NH, 80°C, 4 h
iv: K_2CO_3, CH_2Cl_2, MeOH, rt, 0.5 h

Table 1. Yields of 3-alkynyl-2-arylpyridines **2**–**5** **a**–**j**

	Ar	Yield of compound, %			
		2	**3**	**4**	**5**
a		83	80	85	93
b		78	88	78	94
c		62	83	–	78*
d		84	95	87	95
e		74	91	89	92
f		77	93	90	96
g		65	84	86	94
h		81	78	–	81*
i		81	87	81	93
j		77	84	85	94

* Two-step yield.

Scheme 2

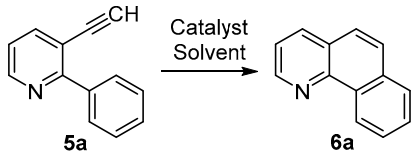


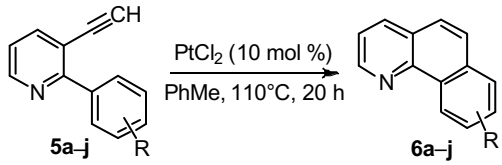
Table 2. Screening of catalysts for the cyclization of pyridine **5a** into quinoline **6a**

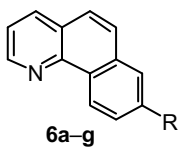
Catalyst (10 mol %)	Solvent	*T*,°C	Time, h	Yield, %
$PtCl_2$	PhMe	80	20	27
$PtCl_2$	PhMe	110	20	67
$InCl_3$	PhMe	110	20	Not detected
$GaCl_3$	PhMe	110	20	Not detected
$Yb(OTf)_3$	PhMe	110	20	14
$PtCl_2$	PhCl	130	12	65
–	TfOH	20	4	Not detected

20 h, however, the cyclization product **6a** was isolated in low yield. Other Lewis acids, such as $InCl_3$, $GaCl_3$, and $Yb(OTf)_3$ were ineffective catalysts, and their use led to slow degradation of the starting material. Treatment of compound **5a** with TfOH also gave no product, but using $PtCl_2$ (10 mol %) at higher reaction temperature (110°C) furnished targeted benzo[*h*]quinoline **6a** in 67% yield. Increasing temperature further to 130°C did not improve the yield.

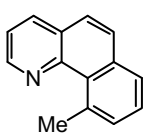
A substrate scope for the $PtCl_2$-catalyzed cyclization of 2-aryl-3-ethynylpyrydines is sufficiently broad and includes compounds with electron-donating and electron-withdrawing substituents along with sterically hindered ones (Scheme 3). Moderately donor alkyl group at the *para* position of the phenyl ring promoted the cyclization: the

Scheme 3

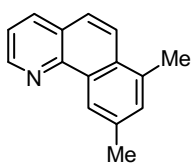




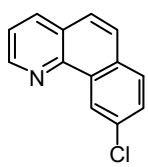
6a R = H (67%)
6b R = Et (80%)
6c R = CF_3 (55%)*
6d R = F (66%)*
6e R = Cl (63%)*
6f R = OMe (60%)
6g R = NMe_2 (54%)**



6h (57%)**



6i (80%)**



6j (69%)

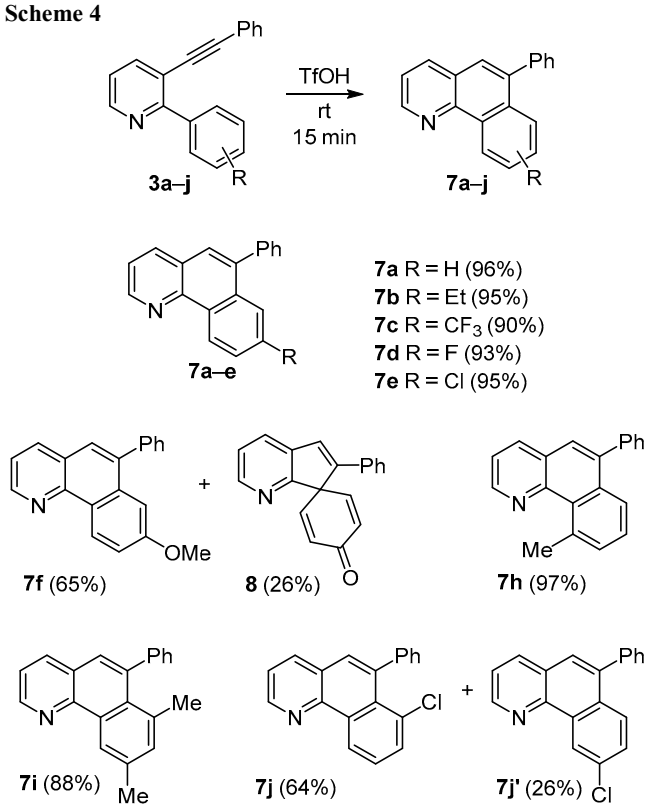
* 48 h.
** 130°C in chlorobenzene.

yield of 8-ethylbenzo[*h*]quinoline **6b** was 80%. Only ca. 50% conversion was observed in 20 h for electron-deficient substrates, but prolonged heating (up to 48 h) allowed isolation of compounds **6c**–**e** in 55–66% yields. This is consistent with the deactivation of electron-deficient aryl ring toward an electrophilic attack. Strong electron-donating methoxy group in 2-aryl-3-ethynylpyrydine **5f** had no influence on the reaction yield. Unexpectedly, dimethylamino-substituted derivative **5g** was almost inert under these conditions and its cyclization occurred only at 130°C, which might be caused by a strong coordination of $PtCl_2$ to the Me_2N group. Sterically hindered pyridines **5h**,**i** required 130°C for the successful cyclization as well. Regioselective cyclization was observed for pyridine **5j** and the single isomer **6j** formed *via* attack of the bulky $PtCl_2$–triple bond complex on the less hindered *ortho* position of the *m*-chloro-substituted phenyl ring.

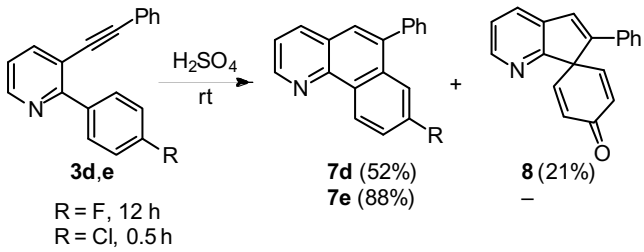
In contrast to ethynylpyridines **5a**–**j**, phenylethynylpyridines **3a**–**j** are more convenient targets for the direct electrophilic activation. Initially we employed TFA–CH_2Cl_2 system which had been previously reported for pyridine-based substrates,[54] however, phenylethynylpyridine **3a** was inert under these conditions and even when heated in pure TFA. Recently, we have described the successful utilization of TfOH for the cyclization of *o*-alkynyl(aryl)-pyrimidines,[52] and this protocol quantitatively provided benzo[*h*]quinoline **7a** within 15 min (Scheme 4). Quinolines **7b**–**e**,**h**,**i** were also isolated in excellent yields regardless of the nature of substituents. 2-(4-Methoxyphenyl)pyridine **3f** gave the mixture of the major benzo[*h*]quinoline **7f** and the minor spiro compound **8**, although similar 5-(4-methoxyphenyl)-4-(phenylethynyl)-pyrimidine gave the single corresponding spiro product.[52] At 0°C, only spiro compound **8** formed from phenylethynylpyridine **3f** in 93% yield (the mechanism of this *ipso* cyclization is analogous to that we described for pyrimidines).[52] Protonation of the Me_2N group in pyridine **3g** appears to cause a complete deactivation of this substrate toward the cyclization; indeed no target product was detected in the complex reaction mixture of phenylethynylpyridine **3g** by ^1H NMR spectroscopy. TfOH-promoted reaction is less sensitive to steric factors than $PtCl_2$-catalyzed process as unsymmetrically substituted pyridine **3j** gave a mixture of isomers **7j** and **7j'** (*cf.* compound **6j**, Scheme 3).

The cyclization of halo-substituted substrates **3d**,**e** with concentrated sulfuric acid instead of TfOH was tested, as the nature of the acid is known to effect the reaction outcome (Scheme 5).[52] Indeed, pyridine **3d** gave a mixture of compounds **7d** and **8** in a ratio 2.5:1 (total yield 73%), whereas benzo[*h*]quinazoline **7e** was a single product for pyridine **3e**. The latter result differs from the reaction of similarly substituted 5-(4-chlorophenyl)-4-(phenylethynyl)-pyrimidine in concentrated sulfuric acid giving an analog of spiro compound **8** only (see the reaction of phenylethynylpyridine **3f** also, Scheme 4). The pyridine core of phenylethynylpyridines **3** disfavors *ipso* cyclization probably because of the close position of an aryl fragment to the nitrogen atom. Fluorine atom as a stronger +M substituent weakens this effect and facilitates formation of spiro compound **8** from phenylethynylpyridine **3d**.

Scheme 4



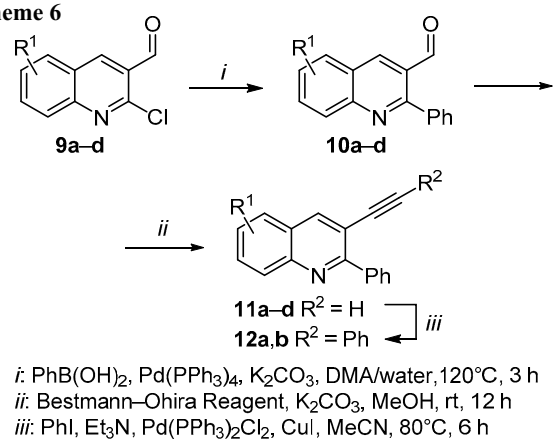
Scheme 5



As a further test of the applicability of this methodology to the synthesis of more complex molecules, several quinoline-based acetylenes were also examined. Substrates **11a**–**d** were prepared from 2-chloroquinoline-3-carbaldehydes[55] **9a**–**d** by the Suzuki cross coupling followed by treatment of 2-phenylquinoline-3-carbaldehydes **10a**–**d** with Bestmann–Ohira reagent (Scheme 6, Table 3). Quinolines **12a**,**b** were obtained by the Sonogashira reaction of compounds **11a**,**b** with iodobenzene.

Fused benzene ring in the heterocyclic core slightly reduced reactivity of quinolines compared to pyridines, though annulated acridines **13** and **14** were obtained in good to excellent yields (Scheme 7). For cycloisomerization of terminal acetylenes **11a**–**d**, $PtCl_2$ catalysis was used at a slightly higher temperature than for compounds **5a**–**j**. TfOH-mediated reaction of phenylethynylquinolines **12a**,**b** was a little slower and completed within 1 h. Further exploration of this reaction and physical properties of the resulting compounds will be reported later.

Scheme 6



Scheme 7

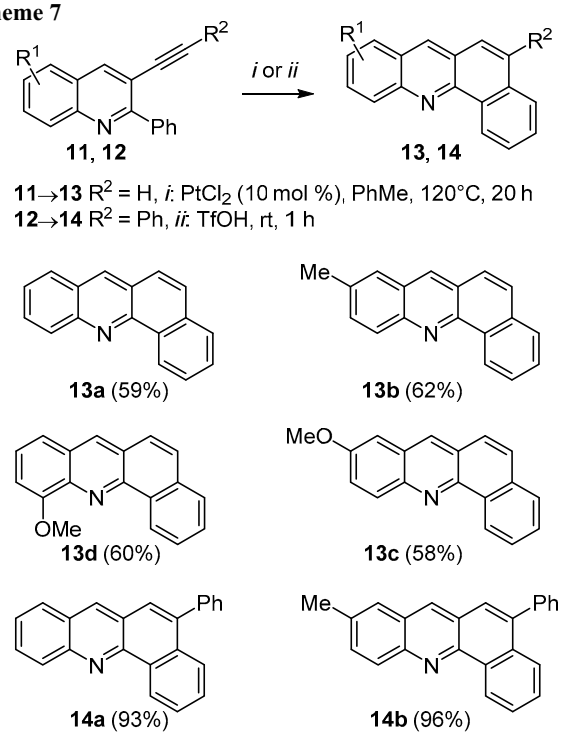


Table 3. Yields of quinoline-based substrates **10**–**12**

	R^1	Yields of compounds, %		
		10	**11**	**12**
a	H	90	53	85
b	6-Me	92	57	84
c	6-OMe	94	42	–
d	8-OMe	93	39	–

In summary, an efficient and simple method to access a variety of benzo[*h*]quinolines and benzo[*c*]acridines by cycloisomerization of *o*-alkynyl(aryl)pyridines and quinolines is described. Two general protocols have been developed depending on the substrate: $PtCl_2$ catalytic conditions are favorable for terminal acetylenes, while TfOH excels with phenylethynyl-substituted heterocycles. Various substituents in aryl fragments are tolerated.

Experimental

^{1}H and ^{13}C NMR spectra were recorded on a Bruker Avance 400 spectrometer 400 and 101 MHz, respectively) in $CDCl_3$ and were referenced to the solvent residual proton (7.26 ppm) and carbon signals (77.16 ppm). High-resolution mass spectra were recorded on a Bruker Maxis HRMS-ESI-qTOF spectrometer (electrospray ionization mode). Melting points were determined on a Stuart SMP30 instrument.

Synthesis of 2-aryl-3-bromopyridines 2a–j (General method). A mixture of MeCN and MeOH (2:1, 15 ml) was added to a mixture of 2,3-dibromopyridine (**1**) (474 mg, 2.0 mmol), arylboronic acid (2.1 mmol), K_2CO_3 (560 mg, 4.0 mmol), PPh_3 (52 mg, 10 mol %) and $Pd(OAc)_2$ (23 mg, 5 mol %) in a screw-cap vial. Reaction mixture was flushed with argon, sealed, and stirred at 50°C for 24 h in an oil bath. Then the reaction mixture was cooled to room temperature and filtered through Celite. Filtrate was concentrated under reduced pressure, the residue was dissolved in CH_2Cl_2 (20 ml), washed with water (3×10 ml) and dried over Na_2SO_4. Solvent was evaporated under reduced pressure, and the residue was purified by column chromatography on silica (hexane–EtOAc, 30:1) to provide pure pyridines **2a**–**j**.

3-Bromo-2-phenylpyridine (2a).[53] Yield 387 mg (83%), colorless oil.

3-Bromo-2-(4-ethylphenyl)pyridine (2b). Yield 409 mg (78%), colorless oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.28 (3H, t, *J* = 7.6, $CH_2C\underline{H}_3$); 2.72 (2H, q, *J* = 7.6, $C\underline{H}_2CH_3$); 7.11 (1H, dd, *J* = 8.0, *J* = 4.6, H Py); 7.30 (2H, d, *J* = 8.0, H Ph); 7.62 (2H, d, *J* = 8.0, H Ph); 7.97 (1H, dd, *J* = 8.0, *J* = 1.4, H Py); 8.61 (1H, dd, *J* = 4.6, *J* = 1.4, H Py). ^{13}C NMR spectrum, δ, ppm: 15.5; 28.9; 119.9; 123.1; 127.6; 129.4; 137.1; 141.4; 145.1; 148.2; 158.4. Found, *m*/*z*: 262.0225 $[M+H]^+$. $C_{13}H_{13}BrN$. Calculated, *m*/*z*: 262.0226.

3-Bromo-2-[4-(trifluoromethyl)phenyl]pyridine (2c). Yield 374 mg (62%), colorless solid, mp 49–50°C (mp 50–51°C[53]).

3-Bromo-2-(4-fluorophenyl)pyridine (2d). Yield 423 mg (84%), colorless solid, mp 72–74°C (mp 73–74°C[53]).

3-Bromo-2-(4-chlorophenyl)pyridine (2e).[56] Yield 395 mg (74%), colorless oil.

3-Bromo-2-(4-methoxyphenyl)pyridine (2f). Yield 405 mg (77%), colorless solid, mp 60–61°C (mp 61–62°C[53]).

4-(3-Bromopyridin-2-yl)-*N*,*N*-dimethylaniline (2g).[57] Yield 360 mg (65%), yellow gum.

3-Bromo-2-(2-methylphenyl)pyridine (2h).[53] Yield 402 mg (81%), colorless oil.

3-Bromo-2-(3,5-dimethylphenyl)pyridine (2i). Yield 423 mg (81%), colorless oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 2.38 (6H, s, CH_3); 7.07 (1H, br. s, H Ph); 7.11 (1H, dd, *J* = 8.0, *J* = 4.6, H Py); 7.27 (2H, br. s, H Ph); 7.97 (1H, dd, *J* = 8.0, *J* = 1.5, H Py); 8.61 (1H, dd, *J* = 4.6, *J* = 1.5, H Py). ^{13}C NMR spectrum, δ, ppm: 21.5; 120.0; 123.2; 127.1; 130.5; 137.6; 139.6; 141.3; 148.1; 158.8. Found, *m*/*z*: 262.0223 $[M+H]^+$. $C_{13}H_{13}BrN$. Calculated, *m*/*z*: 262.0226.

3-Bromo-2-(3-chlorophenyl)pyridine (2j). Yield 413 mg (77%), colorless oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz):

7.16 (1H, dd, *J* = 8.0, *J* = 4.6, H Py); 7.37–7.42 (2H, m, H Ar); 7.56–7.59 (1H, m, H Ar); 7.67–7.69 (1H, m, H Ar); 8.00 (1H, dd, *J* = 8.0, *J* = 1.5, H Py); 8.63 (1H, dd, *J* = 4.6, *J* = 1.5, H Py). ^{13}C NMR spectrum, δ, ppm: 119.9; 123.8; 127.7; 129.0; 129.4; 129.6; 134.1; 141.3; 141.6; 148.3; 156.9. Found, *m/z*: 267.9519 $[M+H]^+$. $C_{11}H_8BrClN$. Calculated, *m/z*: 267.9523.

Synthesis of 2-aryl-3-(phenylethynyl)pyridines 3a–j (General method). DMA (5 ml) was added to a mixture of 2-aryl-3-bromopyridine **2** (0.5 mmol), $Pd(PPh_3)_2Cl_2$ (17.6 mg, 5 mol %), and CuI (4.8 mg, 5 mol %) in a screw-cap vial. Reaction mixture was flushed with argon, phenylacetylene (56 mg, 0.55 mmol) and Et_3N (0.2 ml, 1.4 mmol) were added, the vial was sealed. The reaction mixture was stirred at 90°C in an oil bath for 6 h. Then the reaction mixture was cooled to room temperature, poured into water (40 ml), and extracted with EtOAc (3×10 ml). The combined extracts were washed with water (2×5 ml) and dried over Na_2SO_4. Solvent was evaporated under reduced pressure, and the residue was purified by column chromatography on silica (hexane–EtOAc, 20:1) to provide pure pyridines **3a**–**j**.

2-Phenyl-3-(phenylethynyl)pyridine (3a). Yield 102 mg (80%), brown solid, mp 67–68°C (mp 69°C[58]).

2-(4-Ethylphenyl)-3-(phenylethynyl)pyridine (3b). Yield 125 mg (88%), yellow solid, mp 75–76°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.30 (3H, t, *J* = 7.6, $CH_2C\underline{H}_3$); 2.74 (2H, q, *J* = 7.6, $C\underline{H}_2CH_3$); 7.22 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.31–7.35 (5H, m, H Ar); 7.41–7.45 (2H, m, H Ar); 7.92 (1H, dd, *J* = 7.8, *J* = 1.8, H Py); 7.98–8.01 (2H, m, H Ar); 8.64 (1H, dd, *J* = 4.8, *J* = 1.8, H Py). ^{13}C NMR spectrum, δ, ppm: 15.7; 28.9; 87.9; 94.8; 117.8; 121.2; 123.1; 127.6; 128.5; 128.7; 129.4; 131.5; 137.0; 140.9; 145.3; 148.7; 159.7. Found, *m/z*: 284.1431 $[M+H]^+$. $C_{21}H_{18}N$. Calculated, *m/z*: 284.1434.

3-(Phenylethynyl)-2-[4-(trifluoromethyl)phenyl]pyridine (3c). Yield 134 mg (83%), colorless solid, mp 64–65°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.31 (1H, dd, *J* = 7.9, *J* = 4.6, H Py); 7.33–7.37 (3H, m, H Ph); 7.38–7.42 (2H, m, H Ph); 7.75 (2H, d, *J* = 8.2, H Ar); 7.97 (1H, dd, *J* = 7.9, *J* = 1.7, H Py); 8.16 (2H, d, *J* = 8.2, H Ar); 8.67 (1H, dd, *J* = 4.6, *J* = 1.7, H Py). ^{13}C NMR spectrum, δ, ppm (*J*, Hz): 86.9; 95.4; 118.3; 122.3; 122.6; 124.4 (q, $^1J_{CF}$ = 272.1); 125.0 (q, $^3J_{CF}$ = 3.8); 128.7; 129.1; 129.9; 130.9 (q, $^2J_{CF}$ = 32.4); 131.6; 141.1; 143.0; 148.9; 158.2. Found, *m/z*: 324.0988 $[M+H]^+$. $C_{20}H_{13}F_3N$. Calculated, *m/z*: 324.0995.

2-(4-Fluorophenyl)-3-(phenylethynyl)pyridine (3d). Yield 130 mg (95%), colorless solid, mp 71–72°C (mp 72°C[58]).

2-(4-Chlorophenyl)-3-(phenylethynyl)pyridine (3e). Yield 131 mg (91%), colorless solid, mp 119–121°C (mp 121°C[58]).

2-(4-Methoxyphenyl)-3-(phenylethynyl)pyridine (3f).[58] Yield 133 mg (93%), yellow oil.

***N,N*-Dimethyl-4-[3-(phenylethynyl)pyridin-2-yl]aniline (3g)**. Yield 125 mg (84%), yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.04 (6H, s, $N(CH_3)_2$); 6.79–6.84 (2H, m, H Ar); 7.13 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.31–7.36 (3H, m, H Ph); 7.45–7.52 (2H, m, H Ph); 7.87 (1H, dd, *J* = 7.8, *J* = 1.8, H Py); 8.04–8.12 (2H, m, H Ar); 8.60 (1H, dd, *J* = 4.8, *J* = 1.8, H Py). ^{13}C NMR spectrum, δ, ppm: 40.5; 88.6; 94.2; 111.6; 116.7; 120.2; 123.4; 127.5; 128.5 (2C); 130.5; 131.6; 141.2; 148.6; 151.1; 159.5. Found, *m/z*: 299.1533 $[M+H]^+$. $C_{21}H_{19}N_2$. Calculated, *m/z*: 299.1543.

2-(2-Methylphenyl)-3-(phenylethynyl)pyridine (3h).[58] Yield 105 mg (78%), pale-yellow oil.

2-(3,5-Dimethylphenyl)-3-(phenylethynyl)pyridine (3i). Yield 123 mg (87%), colorless solid, mp 100–101°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 2.42 (6H, s, CH_3); 7.10 (1H, br. s, H Ar); 7.22 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.31–7.35 (3H, m, H Ph); 7.39–7.43 (2H, m, H Ph); 7.67 (2H, br. s, H Ar); 7.92 (1H, dd, *J* = 7.8, *J* = 1.7, H Py); 8.64 (1H, dd, *J* = 4.8, *J* = 1.7, H Py). ^{13}C NMR spectrum, δ, ppm: 21.6; 87.9; 94.7; 117.9; 121.3; 123.1; 127.3; 128.5; 128.7; 130.6; 131.5; 137.4; 139.4; 140.8; 148.6; 160.0. Found, *m/z*: 284.1435 $[M+H]^+$. $C_{21}H_{18}N$. Calculated, *m/z*: 284.1434.

2-(3-Chlorophenyl)-3-(phenylethynyl)pyridine (3j). Yield 122 mg (84%), brown solid, mp 92–93°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.28 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.33–7.37 (3H, m, H Ph); 7.41–7.47 (4H, m, H Ar); 7.91–7.96 (2H, m, H Ar and Py); 8.10–8.11 (1H, m, H Ar); 8.65 (1H, dd, *J* = 4.8, *J* = 1.7, H Py). ^{13}C NMR spectrum, δ, ppm: 87.1; 95.4; 118.2; 122.0; 122.7; 127.7; 128.6; 129.0 (2C); 129.3; 129.6; 131.6; 133.9; 141.0; 141.2; 148.7; 158.1. Found, *m/z*: 290.0735 $[M+H]^+$. $C_{19}H_{13}ClN$. Calculated, *m/z*: 290.0731.

Synthesis of 2-aryl-3-(trimethylsilylethynyl)pyridines 4a–j (General method). Diisopropylamine (2.5 ml) was added to a mixture of 2-aryl-3-bromopyridine **2** (1.0 mmol), $Pd(PPh_3)_2Cl_2$ (35 mg, 5 mol %), and CuI (9.6 mg, 5 mol %) in a screw-cap vial. Reaction mixture was flushed with argon, trimethylsilylacetylene (118 mg, 1.2 mmol) was added, the vial was sealed. The reaction mixture was stirred at 80°C in an oil bath for 4 h. Then the reaction mixture was cooled to room temperature, solvent was evaporated, and the residue was purified by column chromatography on silica (hexane–EtOAc, 20:1) to provide pure pyridines **4a**,**b**,**d**–**g**,**i**,**j**. Pyridines **4c**,**h** were used for the next step without isolation and purification.

2-Phenyl-3-(trimethylsilylethynyl)pyridine (4a).[59] Yield 213 mg (85%), pale-yellow oil.

2-(4-Ethylphenyl)-3-(trimethylsilylethynyl)pyridine (4b). Yield 218 mg (78%), pale-yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.20 (9H, s, CH_3); 1.27 (3H, t, *J* = 7.6, $CH_2C\underline{H}_3$); 2.71 (2H, q, *J* = 7.6, $C\underline{H}_2CH_3$); 7.16 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.25–7.28 (2H, m, H Ar); 7.84 (1H, dd, *J* = 7.8, *J* = 1.4, H Py); 7.92–7.97 (2H, m, H Ar); 8.61 (1H, dd, *J* = 4.8, *J* = 1.4, H Py). ^{13}C NMR spectrum, δ, ppm: –0.3; 15.7; 28.9; 100.7; 103.3; 117.6; 121.0; 127.4; 129.5; 136.7; 141.4; 145.3; 148.8; 160.0. Found, *m/z*: 280.1508 $[M+H]^+$. $C_{18}H_{22}NSi$. Calculated, *m/z*: 280.1516.

2-(4-Fluorophenyl)-3-(trimethylsilylethynyl)pyridine (4d). Yield 234 mg (87%), pale-yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.20 (9H, s, CH_3); 7.08–7.15 (2H, m, H Ar); 7.19 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.85 (1H, dd, *J* = 7.8, *J* = 1.8, H Py); 7.98–8.03 (2H, m, H Ar); 8.60 (1H, dd, *J* = 4.8, *J* = 1.8, H Py). ^{13}C NMR spectrum, δ, ppm (*J*, Hz): –0.3; 101.1; 102.8; 114.8 (d, $^2J_{CF}$ = 21.5); 117.7; 121.4; 131.5 (d, $^3J_{CF}$ = 8.3); 135.4 (d, $^4J_{CF}$ = 3.2);

141.5; 148.8; 158.9; 163.4 (d, $^1J_{CF}$ = 248.4). Found, *m/z*: 270.1106 $[M+H]^+$. $C_{16}H_{17}FNSi$. Calculated, *m/z*: 270.1109.

2-(4-Chlorophenyl)-3-(trimethylsilylethynyl)pyridine (4e). Yield 254 mg (89%), pale-yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.21 (9H, s, CH_3); 7.20 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.38–7.43 (2H, m, H Ar); 7.85 (1H, dd, *J* = 7.8, *J* = 1.8, H Py); 7.94–8.00 (2H, m, H Ar); 8.61 (1H, dd, *J* = 4.8, *J* = 1.8, H Py). ^{13}C NMR spectrum, δ, ppm: –0.3; 101.4; 101.7; 117.7; 121.6; 128.1; 130.9; 135.1; 137.7; 141.6; 148.9; 158.6. Found, *m/z*: 286.0817 $[M+H]^+$. $C_{16}H_{17}ClNSi$. Calculated, *m/z*: 286.0813.

2-(4-Methoxyphenyl)-3-(trimethylsilylethynyl)pyridine (4f). Yield 253 mg (90%), pale-yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.21 (9H, s, CH_3); 3.86 (3H, s, OCH_3); 6.93–6.99 (2H, m, H Ar); 7.14 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.83 (1H, dd, *J* = 7.8, *J* = 1.8, H Py); 7.98–8.05 (2H, m, H Ar); 8.59 (1H, dd, *J* = 4.8, *J* = 1.8, H Py). ^{13}C NMR spectrum, δ, ppm: –0.2; 55.5; 100.6; 103.4; 113.2; 117.2; 120.8; 130.9; 131.9; 141.6; 148.8; 159.5; 160.4. Calculated, *m/z*: 282.1309 $[M+H]^+$. $C_{17}H_{20}NOSi$. Found, *m/z*: 282.1309.

***N,N*-Dimethyl-4-[3-(trimethylsilylethynyl)pyridin-2-yl]-aniline (4g)**. Yield 253 mg (86%), orange oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.23 (9H, s, CH_3); 3.02 (6H, s, $N(CH_3)_2$); 6.73–6.78 (2H, m, H Ar); 7.06 (1H, dd, 7.8, *J* = 4.8, H Py); 7.80 (1H, dd, *J* = 7.8, *J* =1.8, H Py); 8.01–8.09 (2H, m, H Ar); 8.56 (1H, dd, *J* = 4.8, *J* = 1.8, H Py). ^{13}C NMR spectrum, δ, ppm: –0.1; 40.5; 100.0; 104.1; 111.4; 116.4; 119.9; 127.2; 130.5; 141.8; 148.7; 151.1; 159.6. Found, *m/z*: 295.1629 $[M+H]^+$. $C_{18}H_{23}N_2Si$. Calculated, *m/z*: 295.1625.

2-(3,5-Dimethylphenyl)-3-(trimethylsilylethynyl)pyridine (4i). Yield 226 mg (81%), pale-yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.19 (9H, s, CH_3); 2.38 (6H, s, CH_3); 7.05 (1H, br. s, H Ar); 7.17 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.61 (2H, br. s, H Ar); 7.85 (1H, dd, *J* = 7.8, *J* = 1.6, H Py); 8.61 (1H, dd, *J* = 4.8, *J* = 1.6, H Py). ^{13}C NMR spectrum, δ, ppm: –0.2; 21.5; 100.5; 103.1; 117.7; 121.1; 127.2; 130.6; 137.3; 139.1; 141.7; 148.7; 160.2. Found, *m/z*: 280.1514 $[M+H]^+$. $C_{18}H_{22}NSi$. Calculated, *m/z*: 280.1516.

2-(3-Chlorophenyl)-3-(trimethylsilylethynyl)pyridine (4j). Yield 242 mg (85%), yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 0.21 (9H, s, CH_3); 7.22 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.35–7.40 (2H, m, H Ar); 7.85–7.90 (2H, m, H Py and Ar); 8.04–8.06 (1H, m, H Ar); 8.62 (1H, dd, *J* = 4.8, *J* = 1.7, H Py). ^{13}C NMR spectrum, δ, ppm: –0.3; 101.7; 102.3; 118.0; 121.8; 127.7; 129.0; 129.2; 129.6; 133.8; 140.9; 141.5; 148.9; 158.4. Found, *m/z*: 286.0807 $[M+H]^+$. $C_{16}H_{17}ClNSi$. Calculated, *m/z*: 286.0813.

Synthesis of 2-aryl-3-ethynylpyridines 5a–j (General method). A mixture of 2-aryl-3-(trimethylsilylethynyl)-pyridine **4** (0.5 mmol) and K_2CO_3 (70 mg, 0.5 mmol) was stirred in a mixture MeOH–CH_2Cl_2, 2:1 (3 ml) at room temperature for 20 min. Upon completion, the reaction mixture was filtered through Celite, the filtrate was diluted with diethyl ether (20 ml), washed with water (3×10 ml), and dried over Na_2SO_4. Solvent was evaporated, and the residue was purified by column chromatography on silica (hexane–EtOAc, 15:1) to provide pure pyridines **5**.

3-Ethynyl-2-phenylpyridine (5a). Yield 83 mg (93%), colorless solid, mp 70–72°C (mp 72°C[59]).

2-(4-Ethylphenyl)-3-ethynylpyridine (5b). Yield 97 mg (94%), yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.28 (3H, t, *J* = 7.6, $CH_2C\underline{H}_3$); 2.72 (2H, q, *J* = 7.6, $C\underline{H}_2CH_3$); 3.25 (1H, s, ≡CH); 7.19 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.28–7.30 (2H, m, H Ar); 7.87–7.91 (3H, m, H Py and Ar); 8.64 (1H, dd, *J* = 4.8, *J* = 1.8, H Py). ^{13}C NMR spectrum, δ, ppm: 15.5; 28.9; 81.8; 82.9; 116.6; 121.1; 127.6; 129.3; 136.6; 142.0; 145.3; 149.1; 160.4. Found, *m/z*: 208.1125 $[M+H]^+$. $C_{15}H_{14}N$. Calculated, *m/z*: 208.1121.

3-Ethynyl-2-[4-(trifluoromethyl)phenyl]pyridine (5c). Two-step yield 193 mg (78%), colorless solid, mp 78–79°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.28 (1H, s, ≡CH); 7.28 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.72 (2H, d, *J* = 8.1, H Ar); 7.93 (1H, dd, *J* = 7.8, *J* = 1.7, H Py); 8.07 (2H, d, *J* = 8.1, H Ar); 8.68 (1H, dd, *J* = 4.8, *J* = 1.7, H Py). ^{13}C NMR spectrum, δ, ppm (*J*, Hz): 80.9; 83.6; 117.1; 122.0; 124.2 (q, $^1J_{CF}$ = 272.1); 124.9 (q, $^3J_{CF}$ = 3.8); 129.6; 130.8 (q, $^2J_{CF}$ = 32.4); 142.0; 142.4; 149.2; 158.7. Found, *m/z*: 248.0684 $[M+H]^+$. $C_{14}H_9F_3N$. Calculated, *m/z*: 248.0682.

3-Ethynyl-2-(4-fluorophenyl)pyridine (5d). Yield 94 mg (95%), colorless solid, mp 74–75°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.26 (1H, s, ≡CH); 7.11–7.17 (2H, m, H Ar); 7.22 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.90 (1H, dd, *J* = 7.8, *J* = 1.8, H Py); 7.93–7.98 (2H, m, H Ar); 8.64 (1H, dd, *J* = 4.8, *J* = 1.8, H Py). ^{13}C NMR spectrum, δ, ppm (*J*, Hz): 81.5; 83.2; 115.1 (d, $^2J_{CF}$ = 21.6); 116.7; 121.5; 131.4 (d, $^3J_{CF}$ = 8.4); 135.3 (d, $^4J_{CF}$ = 3.2); 142.1; 149.2; 159.3; 163.4 (d, $^1J_{CF}$ = 248.7). Found, *m/z*: 198.0710 $[M+H]^+$. $C_{13}H_9FN$. Calculated, *m/z*: 198.0714.

2-(4-Chlorophenyl)-3-ethynylpyridine (5e). Yield 98 mg (92%), colorless solid, mp 85–86°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.27 (1H, s, ≡CH); 7.23 (1H, dd, *J* = 7.8, *J* = 4.8); 7.40–7.46 (2H, m, H Ar); 7.88–7.94 (3H, m, H Ar and Py); 8.65 (1H, dd, *J* = 4.8, *J* = 1.7, H Py). ^{13}C NMR spectrum, δ, ppm: 81.3; 83.4; 116.8; 121.7; 128.3; 130.8; 135.2; 137.6; 142.1; 149.3; 159.1. Found, *m/z*: 214.0421 $[M+H]^+$. $C_{13}H_9ClN$. Calculated, *m/z*: 214.0418.

3-Ethynyl-2-(4-methoxyphenyl)pyridine (5f). Yield 100 mg (96%), colorless solid, mp 59–60°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.25 (1H, s, ≡CH); 3.86 (3H, s, OCH_3); 6.96–7.01 (2H, m, H Ar); 7.17 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.87 (1H, dd, *J* = 7.8, *J* = 1.8, H Py); 7.92–7.98 (2H, m, H Ar); 8.62 (1H, dd, *J* = 4.8, *J* = 1.8, H Py). ^{13}C NMR spectrum, δ, ppm: 55.4; 81.9; 82.8; 113.5; 116.3; 120.9; 130.8; 131.8; 142.1; 149.1; 159.9; 160.4. Found, *m/z*: 210.0910 $[M+H]^+$. $C_{14}H_{12}NO$. Calculated, *m/z*: 210.0913.

4-(3-Ethynylpyridin-2-yl)-*N,N*-dimethylaniline (5g). Yield 104 mg (94%), yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.02 (6H, s, $N(CH_3)_2$); 3.27 (1H, s, ≡CH); 6.75–6.81 (2H, m, H Ar); 7.10 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.84 (1H, dd, *J* = 7.8, *J* = 1.8, H Py); 7.93–8.00 (2H, m, H Ar); 8.60 (1H, dd, *J* = 4.8, *J* = 1.8, H Py). ^{13}C NMR spectrum, δ, ppm: 40.4; 82.4; 82.5; 111.5; 115.6; 120.1; 127.0; 130.4; 142.2; 149.1; 151.0; 160.2. Found, *m/z*: 223.1235 $[M+H]^+$. $C_{15}H_{15}N_2$. Calculated, *m/z*: 223.1230.

3-Ethynyl-2-(2-methylphenyl)pyridine (5h). Two-step yield 156 mg (81%), yellow oil. ^{1}H NMR spectrum, δ, ppm

(*J*, Hz): 2.23 (3H, s, CH_3); 3.07 (1H, s, ≡CH); 7.23–7.34 (5H, m, H Ar and Py); 7.89 (1H, dd, *J* = 7.8, *J* = 1.7, H Py); 8.65 (1H, dd, *J* = 4.8, *J* = 1.7, H Py). ^{13}C NMR spectrum, δ, ppm: 19.7; 80.7; 82.7; 118.7; 121.6; 125.5; 128.6; 129.3; 130.2; 136.1; 139.4; 140.6; 148.8; 162.6. Found, *m*/*z*: 194.0965 $[M+H]^+$. $C_{14}H_{12}N$. Calculated, *m*/*z*: 194.0964.

2-(3,5-Dimethylphenyl)-3-ethynylpyridine (5i). Yield 96 mg (93%), yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 2.39 (6H, s, CH_3); 3.23 (1H, s, ≡CH); 7.07 (1H, br. s, H Ar); 7.20 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.55 (2H, br. s, H Ar); 7.89 (1H, d, *J* = 7.8, H Py); 8.64 (1H, d, *J* = 4.8, H Py). ^{13}C NMR spectrum, δ, ppm: 21.5; 81.7; 82.8; 116.9; 121.3; 127.1; 130.7; 137.6; 139.1; 141.9; 149.1; 160.8. Found, *m*/*z*: 208.1125 $[M+H]^+$. $C_{15}H_{14}N$. Calculated, *m*/*z*: 208.1121.

2-(3-Chlorophenyl)-3-ethynylpyridine (5j). Yield 100 mg (94%), colorless solid, mp 54–55°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.29 (1H, s, ≡CH); 7.25 (1H, dd, *J* = 7.8, *J* = 4.8, H Py); 7.36–7.42 (2H, m, H Ar); 7.83–7.86 (1H, m, H Ar); 7.91 (1H, dd, *J* = 7.8, *J* = 1.7, H Py); 7.94–7.97 (1H, m, H Ar); 8.66 (1H, dd, *J* = 4.8, *J* = 1.7, H Py). ^{13}C NMR spectrum, δ, ppm: 81.1; 83.6; 117.0; 121.9; 127.6; 129.1; 129.3; 129.5; 134.1; 140.8; 142.1; 149.3; 158.8. Found, *m*/*z*: 214.0419 $[M+H]^+$. $C_{13}H_9ClN$. Calculated, *m*/*z*: 214.0418.

Synthesis of benzo[*h*]quinolines 6a–j (General method). $PtCl_2$ (5.3 mg, 10 mol %) was added to a solution of pyridine **5a–j** (0.2 mmol) in toluene (chlorobenzene for pyridines **5g–i**) (0.5 ml) in a screw-cap vial. Reaction mixture was flushed with argon, the vial was sealed and heated with stirring in an oil bath at 110°C (130°C for pyridines **5g–i**) for 20 h (48 h for pyridines **5c–e**). Solvent was evaporated under reduced pressure, and the residue was purified by column chromatography on silica (hexane–EtOAc, 15:1) to provide pure quinolines **6**.

Benzo[*h*]quinoline (6a). Yield 24 mg (67%), colorless solid, mp 50–51°C (mp 51–52°C[60]).

8-Ethylbenzo[*h*]quinoline (6b). Yield 33 mg (80%), yellowish oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.39 (3H, t, *J* = 7.6, $CH_2C\underline{H}_3$); 2.90 (2H, q, *J* = 7.6, $C\underline{H}_2CH_3$); 7.48 (1H, dd, *J* = 8.0, *J* = 4.3, H benzoquinoline); 7.60–7.66 (2H, m, H benzoquinoline); 7.71 (1H, br. s, H benzoquinoline); 7.77 (1H, d, *J* = 8.8, H benzoquinoline); 8.14 (1H, dd, *J* = 8.0, *J* = 1.3, H benzoquinoline); 8.99 (1H, dd, *J* = 4.3, *J* = 1.3, H benzoquinoline); 9.21 (1H, d, *J* = 8.4, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 15.7; 29.1; 121.5; 124.5; 125.4; 126.2; 126.3; 127.8; 128.0; 129.8; 134.0; 135.8; 144.6; 146.8; 148.9. Found, *m*/*z*: 208.1118 $[M+H]^+$. $C_{15}H_{14}N$. Calculated, *m*/*z*: 208.1121.

8-(Trifluoromethyl)benzo[*h*]quinoline (6c). Yield 27 mg (55%), colorless solid, mp 75–76°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.58 (1H, dd, *J* = 8.0, *J* = 4.4, H benzoquinoline); 7.76 (1H, d, *J* = 8.9, H benzoquinoline); 7.84 (1H, d, *J* = 8.9, H benzoquinoline); 7.92 (1H, d, *J* = 8.6, H benzoquinoline); 8.17–8.22 (2H, m, H benzoquinoline); 9.04 (1H, dd, ^3J = 4.4, *J* = 1.5, H benzoquinoline); 9.41 (1H, d, *J* = 8.6, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm (*J*, Hz): 122.9; 123.0 (q, $^3J_{CF}$ = 3.3); 124.5 (q, $^1J_{CF}$ = 272.2); 125.3 (q, $^3J_{CF}$ = 4.3); 125.7; 127.0; 127.3; 127.6; 130.1 (q, $^2J_{CF}$ = 32.4); 133.0; 133.6; 136.1; 146.0; 149.6. Found, *m*/*z*: 248.0686 $[M+H]^+$. $C_{14}H_9F_3N$. Calculated, *m*/*z*: 248.0682.

8-Fluorobenzo[*h*]quinoline (6d). Yield 26 mg (66%), colorless solid, mp 63–64°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.44–7.54 (3H, m, H benzoquinoline); 7.68–7.75 (2H, m, H benzoquinoline); 8.15 (1H, dd, *J* = 8.0, *J* = 1.7, H benzoquinoline); 8.99 (1H, dd, *J* = 4.4, *J* = 1.7, H benzoquinoline); 9.30 (1H, dd, *J* = 9.1, $^4J_{HF}$ = 5.8, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm (*J*, Hz): 112.0 (d, $^2J_{CF}$ = 20.9); 116.2 (d, $^2J_{CF}$ = 23.6); 121.8; 125.9 (d, $^5J_{CF}$ = 1.1); 126.9; 127.1 (d, $^4J_{CF}$ = 3.8); 127.3 (d, $^3J_{CF}$ = 9.0); 128.3 (d, $^5J_{CF}$ = 1.7); 135.1 (d, $^3J_{CF}$ = 9.2); 136.0; 146.7; 149.3; 162.7 (d, $^1J_{CF}$ = 247.9). Found, *m*/*z*: 198.0716 $[M+H]^+$. $C_{13}H_9FN$. Calculated, *m*/*z*: 198.0714.

8-Chlorobenzo[*h*]quinoline (6e). Yield 27 mg (63%), colorless solid, mp 109–110°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.52 (1H, dd, *J* = 8.0, *J* = 4.4, H benzoquinoline); 7.64–7.70 (3H, m, H benzoquinoline), 7.86 (1H, d, *J* = 2.1, H benzoquinoline); 8.15 (1H, dd, *J* = 8.0, *J* = 1.7, H benzoquinoline); 8.99 (1H, dd, *J* = 4.4, *J* = 1.7, H benzoquinoline); 9.22 (1H, d, *J* = 8.8, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 122.1; 126.3; 126.4; 126.8 (2C); 126.9; 127.7; 130.0; 134.4; 134.6; 136.0; 146.3; 149.3. Found, *m*/*z*: 214.0423 $[M+H]^+$. $C_{13}H_9ClN$. Calculated, *m*/*z*: 214.0418.

8-Methoxybenzo[*h*]quinoline (6f). Yield 25 mg (60%), yellow oil. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.98 (3H, s, OCH_3); 7.00 (1H, d, *J* = 2.4, H benzoquinoline); 7.27 (1H, dd, *J* = 9.0, *J* = 2.4, H benzoquinoline); 7.37 (1H, dd, *J* = 7.9, *J* = 4.4, H benzoquinoline); 7.57 (1H, d, *J* = 8.9, H benzoquinoline); 7.66 (1H, d, *J* = 8.9, H benzoquinoline); 8.07 (1H, dd, *J* = 7.9, *J* = 1.7, H benzoquinoline); 8.91 (1H, dd, *J* = 4.4, *J* = 1.7, H benzoquinoline); 9.10 (1H, d, *J* = 9.0, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 40.7; 107.6; 115.0; 120.1; 122.4; 124.9; 125.6; 125.7; 127.8; 135.6; 136.0; 147.1; 148.6; 150.6. Found, *m*/*z*: 210.0907 $[M+H]^+$. $C_{14}H_{12}NO$. Calculated, *m*/*z*: 210.0913.

***N*,*N*-Dimethylbenzo[*h*]quinolin-8-amine (6g)**. Yield 24 mg (54%), orange solid, mp 110–111°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.12 (6H, s, $N(CH_3)_2$); 7.26 (1H, d, *J* = 2.8, H benzoquinoline); 7.37 (1H, dd, *J* = 9.0, *J* = 2.8, H benzoquinoline); 7.45 (1H, dd, *J* = 8.0, *J* = 4.4, H benzoquinoline); 7.65 (1H, d, *J* = 8.8, H benzoquinoline); 7.73 (1H, d, *J* = 8.8, H benzoquinoline); 8.13 (1H, dd, *J* = 8.0, *J* = 1.8, H benzoquinoline); 8.96 (1H, dd, *J* = 4.4, *J* = 1.8, H benzoquinoline); 9.20 (1H, d, *J* = 9.0, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 55.6; 108.1; 117.6; 121.0; 125.4; 126.1; 126.2; 126.3; 127.4; 135.3; 135.9; 146.8; 149.1; 159.8. Found, *m*/*z*: 223.1224 $[M+H]^+$. $C_{15}H_{15}N_2$. Calculated, *m*/*z*: 223.1230.

10-Methylbenzo[*h*]quinoline (6h). Yield 22 mg (57%), colorless solid, mp 73–74°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.37 (3H, s, CH_3); 7.48 (1H, dd, *J* = 8.0, *J* = 4.3, H benzoquinoline); 7.55–7.59 (2H, m, H benzoquinoline); 7.66 (1H, d, *J* = 8.7, H benzoquinoline); 7.78–7.81 (2H, m, H benzoquinoline); 8.16 (1H, dd, *J* = 8.0, *J* = 1.8, H benzoquinoline); 9.03 (1H, dd, *J* = 4.3, *J* = 1.8, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 27.3; 120.7; 125.6;

126.8; 127.4; 127.6; 128.9; 130.1; 131.3; 135.3; 135.4; 138.9; 147.3; 149.2. Found, *m/z*: 194.0966 $[M+H]^+$. $C_{14}H_{12}N$. Calculated, *m/z*: 194.0964.

7,9-Dimethylbenzo[*h*]quinoline (6i). Yield 33 mg (80%), colorless solid, mp 77–78°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 2.62 (3H, s, CH_3); 2.74 (3H, s, CH_3); 7.39 (1H, br. s, H benzoquinoline), 7.50 (1H, dd, *J* = 8.0, *J* = 4.4, H benzoquinoline); 7.65 (1H, d, *J* = 9.1, H benzoquinoline); 7.98 (1H, d, *J* = 9.1, H benzoquinoline); 8.16 (1H, dd, *J* = 8.0, *J* = 1.7, H benzoquinoline); 8.98–9.02 (2H, m, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 19.7; 22.0; 121.7; 122.1; 123.9; 124.1; 126.3; 130.6; 131.3; 131.9; 134.3; 135.9; 136.8; 146.8; 148.7. Found, *m/z*: 208.1114 $[M+H]^+$. $C_{15}H_{14}N$. Calculated, *m/z*: 208.1121.

9-Chlorobenzo[*h*]quinoline (6j). Yield 26 mg (61%), colorless solid, mp 118–119°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.52 (1H, dd, *J* = 8.0, *J* = 4.4, H benzoquinoline); 7.60–7.66 (2H, m, H benzoquinoline); 7.74 (1H, d, *J* = 8.8, H benzoquinoline); 7.80 (1H, d, *J* = 8.5, H benzoquinoline); 8.14 (1H, dd, *J* = 8.0, *J* = 1.3, H benzoquinoline); 8.98 (1H, dd, *J* = 4.4, *J* = 1.3, H benzoquinoline); 9.26 (1H, d, *J* = 1.9, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 122.4; 124.1; 125.7; 126.8; 127.1; 128.8; 129.3; 131.9; 132.7; 133.4; 135.9; 145.7; 149.2. Found, *m/z*: 214.0411 $[M+H]^+$. $C_{13}H_9ClN$. Calculated, *m/z*: 214.0418.

Cyclization of 2-aryl-3-(phenylethynyl)pyridines 3a–j (General method). A solution of pyridine **3a–j** (0.2 mmol) in TfOH (0.5 ml) was stirred at room temperature for 15 min. The reaction mixture was poured into cold water (20 ml) and extracted with CH_2Cl_2 (2×5 ml). The combined extracts were washed with water (2×5 ml) and dried over Na_2SO_4. Solvent was evaporated under reduced pressure, and the residue was purified by column chromatography on silica (hexane–EtOAc, 15:1) to provide pure products.

6-Phenylbenzo[*h*]quinoline (7a). Yield 49 mg (96%), colorless solid, mp 139–140°C (mp 140–141°C[61]).

8-Ethyl-6-phenylbenzo[*h*]quinoline (7b). Yield 54 mg (95%), colorless solid, mp 95–96°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.29 (3H, t, *J* = 7.6, $CH_2C\underline{H}_3$); 2.81 (2H, q, *J* = 7.6, $C\underline{H}_2CH_3$); 7.46–7.59 (7H, m, H Ph and benzoquinoline); 7.64 (1H, dd, *J* = 8.4, *J* = 1.6, H benzoquinoline); 7.72 (1H, br. s, H benzoquinoline); 8.14 (1H, dd, *J* = 8.0, *J* = 1.7, H benzoquinoline); 9.00 (1H, dd, *J* = 4.4, *J* = 1.7, H benzoquinoline); 9.35 (1H, d, *J* = 8.4, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 15.8; 29.4; 121.8; 124.9 (2C); 125.7; 126.0; 127.7(2C); 128.5; 130.1 (2C); 133.0; 135.9; 139.8; 140.6; 144.6; 146.4; 148.8. Found, *m/z*: 284.1430 $[M+H]^+$. $C_{21}H_{18}N$. Calculated, *m/z*: 284.1434.

6-Phenyl-8-(trifluoromethyl)benzo[*h*]quinoline (7c). Yield 58 mg (90%), yellowish solid, mp 120–121°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.49–7.62 (6H, m, H Ph and benzoquinoline); 7.72 (1H, s, H benzoquinoline); 7.95 (1H, dd, *J* = 8.6, *J* = 1.5, H benzoquinoline); 8.18–8.23 (2H, m, H benzoquinoline); 9.05 (1H, dd, *J* = 4.4, *J* = 1.7, H benzoquinoline); 9.55 (1H, d, *J* = 8.6, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm (*J*, Hz): 122.9 (q, $^3J_{CF}$ = 3.0); 123.2; 123.8 (q, $^3J_{CF}$ = 4.3); 124.5 (q, $^1J_{CF}$ = 272.4); 126.0; 126.9; 127.3; 128.3; 128.8; 130.0 (2C, q, $^2J_{CF}$ = 32.2); 132.2; 134.0; 136.1; 139.4; 139.9; 145.5; 149.5. Found, *m/z*: 324.0986 $[M+H]^+$. $C_{20}H_{13}F_3N$. Calculated, *m/z*: 324.0995.

8-Fluoro-6-phenylbenzo[*h*]quinoline (7d). Yield 51 mg (93%), colorless solid, mp 115–116°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.45–7.57 (8H, m, H Ph and benzoquinoline); 7.66 (1H, s, H benzoquinoline); 8.17 (1H, dd, *J* = 8.0, *J* = 1.7, H benzoquinoline); 9.00 (1H, dd, *J* = 4.4, *J* = 1.7, H benzoquinoline); 9.55 (1H, dd, *J* = 8.0, $^4J_{HF}$ = 6.0, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm (*J*, Hz): 111.1 (d, $^2J_{CF}$ = 22.6); 116.0 (d, $^2J_{CF}$ = 23.7); 122.1; 125.5 (d, $^5J_{CF}$ = 1.0); 127.1; 127.5 (d, $^3J_{CF}$ = 9.0); 128.0; 128.6 (d, $^5J_{C\text{-}F}$ = 1.6); 128.7; 129.9; 134.5 (d, $^3J_{CF}$ = 8.8); 136.0; 139.3 (d, $^4J_{CF}$ = 3.8); 139.8; 146.0; 149.3; 162.8 (d, $^1J_{CF}$ = 247.3). Found, *m/z*: 274.1030 $[M+H]^+$. $C_{19}H_{13}FN$. Calculated, *m/z*: 274.1027.

8-Chloro-6-phenylbenzo[*h*]quinoline (7e). Yield 55 mg (95%), colorless solid, mp 129–130°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.47–7.58 (6H, m, H Ph and benzoquinoline); 7.64 (1H, s, H benzoquinoline); 7.69 (1H, dd, *J* = 8.8, *J* = 2.1, H benzoquinoline); 7.87 (1H, d, *J* = 2.1, H benzoquinoline); 8.16 (1H, dd, *J* = 8.0, *J* = 1.7, H benzoquinoline); 9.00 (1H, dd, *J* = 4.4, *J* = 1.7, H benzoquinoline); 9.36 (1H, d, *J* = 8.8, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 122.4; 125.6; 126.0; 126.6; 127.1; 127.6; 128.1; 128.7; 130.0; 130.2; 133.9; 134.7; 136.1; 139.1; 139.6; 145.8; 149.3. Found, *m/z*: 290.0723 $[M+H]^+$. $C_{19}H_{13}ClN$. Calculated, *m/z*: 290.0731.

8-Methoxy-6-phenylbenzo[*h*]quinoline (7f). Yield 37 mg (65%), colorless solid, mp 86–87°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.83 (3H, s, OCH_3); 7.30 (1H, d, *J* = 2.5, H benzoquinoline); 7.39 (1H, dd, *J* = 9.0, *J* = 2.5, H benzoquinoline); 7.45–7.59 (6H, m, H Ph and benzoquinoline); 7.61 (1H, s, H benzoquinoline); 8.15 (1H, dd, *J* = 8.0, *J* = 1.4, H benzoquinoline); 8.98 (1H, dd, *J* = 4.4, *J* = 1.4, H benzoquinoline); 9.34 (1H, d, *J* = 9.0, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 55.5; 107.7; 116.9; 121.3; 125.1; 126.6; 126.7; 127.8; 128.6; 129.9; 134.5; 136.1; 139.5; 140.4; 148.8; 159.9. Found, *m/z*: 286.1222 $[M+H]^+$. $C_{20}H_{16}NO$. Calculated, *m/z*: 286.1226.

6'-Phenyl-4*H*-spiro[cyclohexa-2,5-diene-1,7'-cyclopenta-[*b*]pyridin]-4-one (8). Yield 14 mg (26%), 38 mg (93%, isolated as a single product when the reaction was carried out at 0°C on 0.15 mmol scale), colorless solid, mp 184–85°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 6.56–6.60 (2H, m, =CH); 6.68–6.72 (2H, m, =CHCO); 7.24 (1H, dd, *J* = 7.6, *J* = 5.0, H Py); 7.30–7.36 (3H, m, H Ph); 7.46 (1H, s, C$\underline{H}$=CPh); 7.56–7.59 (2H, m, H Ph); 7.71 (1H, dd, *J* = 7.6, *J* = 1.5, H Py); 8.40 (1H, dd, *J* = 5.0, *J* = 1.5, H Py). ^{13}C NMR spectrum, δ, ppm: 61.0; 123.5; 126.1; 127.7; 128.9; 129.0; 129.2; 132.6; 134.0; 138.3; 147.4; 147.6; 147.7; 162.6; 186.1. Found, *m/z*: 272.1079 $[M+H]^+$. $C_{19}H_{14}NO$. Calculated, *m/z*: 272.1070.

10-Methyl-6-phenylbenzo[*h*]quinoline (7h). Yield 52 mg (97%), yellowish solid, mp 145–146°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.45 (3H, s, CH_3); 7.47–7.55 (7H, m, H Ph and benzoquinoline); 7.59–7.61 (2H, m, H benzoquinoline); 7.80 (1H, d, *J* = 8.0, H benzoquinoline); 8.15 (1H, dd, *J* = 8.0, *J* = 1.9, H benzoquinoline); 9.06 (1H, dd, *J* = 4.3, *J* = 1.9, H benzoquinoline). ^{13}C NMR spectrum,

δ, ppm: 27.8; 120.9; 125.3; 126.4; 127.0; 127.2; 127.6; 128.4; 130.2; 130.4; 131.3; 134.4; 135.4; 139.1; 140.5; 141.3; 147.2; 148.7. Found, *m*/*z*: 270.1270 $[M+H]^+$. $C_{20}H_{16}N$. Calculated, *m*/*z*: 270.1277.

7,9-Dimethyl-6-phenylbenzo[*h*]quinoline (7i). Yield 50 mg (88%), colorless solid, mp 172–173°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 2.04 (3H, s, CH_3); 2.62 (3H, s, CH_3); 7.30 (1H, br. s, H benzoquinoline); 7.38–7.44 (5H, m, H Ph); 7.46 (1H, s, H benzoquinoline); 7.50 (1H, dd, *J* = 8.0, *J* = 4.4, H benzoquinoline); 8.09 (1H, dd, *J* = 8.0, *J* = 1.7, H benzoquinoline); 8.99 (1H, dd, *J* = 4.4, *J* = 1.7, H benzoquinoline); 9.22 (1H, br. s, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 21.7; 25.0; 122.1; 122.8; 125.3; 127.1; 127.3; 128.0; 129.4; 129.6; 133.2; 134.3; 135.5; 135.6; 136.7; 140.0; 144.9; 146.4; 148.6. Found, *m*/*z*: 284.1430 $[M+H]^+$. $C_{21}H_{18}N$. Calculated, *m*/*z*: 284.1434.

7-Chloro-6-phenylbenzo[*h*]quinoline (7j). Yield 37 mg (64%), colorless solid, 140–141°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.38–7.45 (5H, m, H Ph); 7.55 (1H, dd, *J* = 8.0, *J* = 4.4, H benzoquinoline); 7.61 (1H, s, H benzoquinoline); 7.62–7.66 (1H, m, H benzoquinoline); 7.71 (1H, dd, *J* = 7.6, *J* = 1.5, H benzoquinoline); 8.12 (1H, dd, *J* = 8.0, *J* = 1.7, H benzoquinoline); 9.02 (1H, dd, *J* = 4.4, *J* = 1.7, H benzoquinoline); 9.50 (1H, dd, *J* = 8.1, *J* = 1.5, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 122.8; 124.3; 125.4; 127.1; 127.2; 127.8; 129.4; 129.5; 130.0; 131.8; 131.9; 134.6; 135.7; 138.5; 143.3; 146.0; 149.4. Found, *m*/*z*: 290.0733 $[M+H]^+$. $C_{19}H_{13}ClN$. Calculated, *m*/*z*: 290.0731.

9-Chloro-6-phenylbenzo[*h*]quinoline (7j'). Yield 15 mg (26%), colorless solid, mp 158–159°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 7.48–7.58 (7H, m, H Ph and benzoquinoline); 7.62 (1H, s, H benzoquinoline); 7.84 (1H, d, *J* = 8.8, H benzoquinoline); 8.18 (1H, dd, *J* = 8.0, *J* = 1.5, H benzoquinoline); 8.99–9.02 (1H, m, H benzoquinoline); 9.40 (1H, d, *J* = 2.2, H benzoquinoline). ^{13}C NMR spectrum, δ, ppm: 122.8; 124.3; 126.1; 126.5; 128.0; 128.1; 128.7 (2C); 130.0; 131.1; 133.1; 133.5; 136.0; 139.6; 139.9; 145.3; 149.1. Found, *m*/*z*: 290.0730 $[M+H]^+$. $C_{19}H_{13}ClN$. Calculated, *m*/*z*: 290.0731.

Treatment of 2-aryl-3-(phenylethynyl)pyridines with sulfuric acid (General method). A solution of pyridine **3d**,**e** (0.2 mmol) in concentrated H_2SO_4 (98%, 0.5 ml) was stirred at room temperature for 12 h (compound **3d**) or 0.5 h (compound **3e**). The reaction mixture was poured into cold water (20 ml) and extracted with CH_2Cl_2 (2×5 ml). The combined extracts were washed with water (2×5 ml) and dried over Na_2SO_4. Solvent was evaporated under reduced pressure, and the residue was purified by column chromatography on silica (hexane–EtOAc, 15:1) to provide pure products. Mixture of quinoline **7d** (52%) and compound **8** (21%) was obtained from pyridine **3d**; quinoline **7e** (88%) formed as a single product from pyridine **3e**.

Synthesis of 2-phenylquinoline-3-carbaldehydes 10a–d (General method). A mixture of DMA and water (4:1, 10 ml) was added to a mixture of 2-chloroquinoline-3-carbaldehyde **9a**–**d** (1 mmol), phenylboronic acid (128 mg, 1.05 mmol), K_2CO_3 (280 mg, 2.0 mmol), and $Pd(PPh_3)_4$ (56 mg, 5 mol %) in a screw-cap vial. Reaction mixture was flushed with argon, sealed, and stirred at 120°C for 3 h in an oil bath. Then the reaction mixture was cooled to room temperature, poured into water (50 ml), and extracted with EtOAc (3×10 ml). Extracts were washed with water (2×15 ml) and dried over Na_2SO_4. Solvent was evaporated under reduced pressure, and the residue was purified by column chromatography on silica (hexane–$CHCl_3$, 10:1) to provide pure carbaldehydes **10a**–**d**.

2-Phenylquinoline-3-carbaldehyde (10a). Yield 210 mg (90%), colorless solid, mp 96–97°C (mp 98°C[62]).

6-Methyl-2-phenylquinoline-3-carbaldehyde (10b). Yield 227 mg (92%), yellowish solid, mp 119–121°C (mp 120–121°C[62]).

6-Methoxy-2-phenylquinoline-3-carbaldehyde (10c). Yield 247 mg (94%), yellowish solid, mp 129–131°C (mp 130°C[62]).

8-Methoxy-2-phenylquinoline-3-carbaldehyde (10d). Yield 245 mg (93%), yellowish solid, mp 159–160°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 4.10 (3H, s, OCH_3); 7.19–7.22 (1H, m, H quinoline); 7.48–7.60 (5H, m, H Ph and quinoline); 7.68–7.72 (2H, m, H Ph); 8.81 (1H, s, H quinoline); 10.19 (1H, s, CHO). ^{13}C NMR spectrum, δ, ppm: 56.4; 110.7; 121.1; 127.7; 127.8; 128.2; 128.8; 129.4; 130.7; 138.0 (2C); 141.6; 155.6; 159.3; 191.8. Found, *m*/*z*: 264.1017 $[M+H]^+$. $C_{17}H_{14}NO_2$. Calculated, *m*/*z*: 264.1019.

Synthesis of 3-ethynyl-2-phenylquinolines 11a–d (General method). A mixture of 2-phenylquinoline-3-carbaldehyde **10a**–**d** (1 mmol), K_2CO_3 (280 mg, 2 mmol) and diethyl 1-diazo-2-oxopropylphosphonate (264 mg, 1.2 mmol) in MeOH (8 ml) was stirred at room temperature overnight. Solvent was evaporated under reduced pressure, and the residue was purified by column chromatography on silica (hexane–$CHCl_3$, 20:1) to provide pure quinolines **11a**–**d**.

3-Ethynyl-2-phenylquinoline (11a). Yield 121 mg (53%), colorless solid, mp 99–100°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.27 (1H, s, ≡CH); 7.47–7.58 (4H, m, H Ph and quinoline); 7.72–7.76 (1H, m, H quinoline); 7.80 (1H, d, *J* = 8.1, H quinoline); 8.00–8.03 (2H, m, H Ph); 8.16 (1H, d, *J* = 8.5, H quinoline); 8.44 (1H, s, H quinoline). ^{13}C NMR spectrum, δ, ppm: 81.9; 82.8; 115.1; 126.2; 127.2 (2C); 128.1; 129.2; 129.7 (2C); 130.8; 139.5; 142.4; 147.2; 159.6. Found, *m*/*z*: 230.0970 $[M+H]^+$. $C_{17}H_{12}N$. Calculated, *m*/*z*: 230.0964.

3-Ethynyl-6-methyl-2-phenylquinoline (11b). Yield 138 mg (57%), colorless solid, mp 107–108°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 2.55 (3H, s, CH_3); 3.25 (1H, s, ≡CH); 7.45–7.58 (5H, m, H Ph and quinoline); 7.98–8.01 (2H, m, H Ph); 8.04 (1H, d, *J* = 8.5, H quinoline); 8.34 (1H, s, H quinoline). ^{13}C NMR spectrum, δ, ppm: 22.7; 82.1; 82.6; 115.0; 125.9; 126.2; 128.1; 129.0; 129.4; 129.6; 133.1; 137.2; 139.6; 141.7; 145.9; 158.7. Found, *m*/*z*: 244.1119 $[M+H]^+$. $C_{18}H_{14}N$. Calculated, *m*/*z*: 244.1121.

3-Ethynyl-6-methoxy-2-phenylquinoline (11c). Yield 109 mg (42%), yellow solid, mp 109–110°C. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 3.26 (1H, s, ≡CH); 3.94 (3H, s, OCH_3); 7.04 (1H, d, *J* = 2.7, H quinoline); 7.39 (1H, dd, *J* = 9.2, *J* = 2.7, H quinoline); 7.44–7.51 (3H, m, H Ph); 7.97–8.00 (2H, m, H Ph); 8.04 (1H, d, *J* = 9.2, H quinoline); 8.32 (1H, s, H quinoline). ^{13}C NMR spectrum,

δ, ppm: 55.7; 82.1; 82.7; 104.4; 115.3; 123.6; 127.2; 128.1; 128.9; 129.6; 131.2; 139.6; 141.0; 143.5; 157.2; 158.3. Found, *m*/*z*: 260.1063 $[M+H]^+$. $C_{18}H_{14}NO$. Calculated, *m*/*z*: 260.1070.

3-Ethynyl-8-methoxy-2-phenylquinoline (11d). Yield 101 mg (39%), yellow solid, mp 101–103°C. ^1H NMR spectrum, δ, ppm (*J*, Hz): 3.27 (1H, s, ≡CH); 4.06 (3H, s, OCH_3); 7.07 (1H, d, *J* = 7.7, H quinoline); 7.36 (1H, d, *J* = 8.1, H quinoline); 7.43–7.49 (4H, m, H Ph and quinoline); 8.01–8.04 (2H, m, H Ph); 8.39 (1H, s, H quinoline). ^{13}C NMR spectrum, δ, ppm: 56.2; 81.9; 83.0; 109.1; 115.7; 118.9; 127.3; 127.4; 128.0; 129.0; 129.9; 139.0; 139.6; 142.3; 155.6; 158.4. Found, *m*/*z*: 260.1065 $[M+H]^+$. $C_{18}H_{14}NO$. Calculated, *m*/*z*: 260.1070.

Synthesis of 2-phenyl-3-(phenylethynyl)quinolines 12a,b (General method). MeCN (5 ml) was added to a mixture of 3-ethynyl-2-phenylquinoline **11a**,**b** (0.5 mmol), $Pd(PPh_3)_2Cl_2$ (17.6 mg, 5 mol %) and CuI (4.8 mg, 5 mol %) in a screw-cap vial. Reaction mixture was flushed with argon, iodobenzene (112 mg, 0.55 mmol) and Et_3N (0.17 ml, 1.25 mmol) were added, the vial was sealed; and the reaction mixture was stirred at 80°C in an oil bath for 6 h. Then it was cooled to room temperature, poured into water (40 ml) and extracted with EtOAc (3×10 ml). The combined extracts were washed with water (2×5 ml) and dried over Na_2SO_4. Solvent was evaporated under reduced pressure, and the residue was purified by column chromatography on silica (hexane–$CHCl_3$, 15:1) to provide pure quinolines **12a**,**b**.

2-Phenyl-3-(phenylethynyl)quinoline (12a).[63] Yield 130 mg (85%), dark-yellow amorphous solid.

6-Methyl-2-phenyl-3-(phenylethynyl)quinoline (12b). Yield 134 mg (84%), yellow solid, mp 131–132°C. ^1H NMR spectrum, δ, ppm (*J*, Hz): 2.56 (3H, s, CH_3); 7.30–7.44 (5H, m, H Ph); 7.46–7.58 (5H, m, H Ph and quinoline); 8.02–8.09 (3H, m, H Ph and quinoline); 8.35 (1H, s, H quinoline). ^{13}C NMR spectrum, δ, ppm: 22.8; 88.3; 94.5; 116.2; 123.2; 126.0; 126.5; 128.0; 128.6; 128.7; 129.0; 129.4; 129.7; 131.5; 132.8; 137.1; 139.6; 140.1; 145.7; 158.6. Found, *m*/*z*: 320.1437 $[M+H]^+$. $C_{24}H_{18}N$. Calculated, *m*/*z*: 320.1434.

Synthesis of benzo[*c*]acridines 13a–d (General method). A mixture of quinoline **11a**–**d** (0.2 mmol) and $PtCl_2$ (5.3 mg, 10 mol %) in toluene (0.5 ml) was flushed with argon in screw-cap vial, sealed, and heated with stirring in an oil bath at 120°C for 20 h. Solvent was evaporated under reduced pressure, and the residue was purified by column chromatography on silica (hexane–$CHCl_3$, 15:1) to provide pure acridines **13a**–**d**.

Benzo[*c*]acridine (13a). Yield 27 mg (59%), colorless solid, mp 107–109°C (mp 108°C[64]).

9-Methylbenzo[*c*]acridine (13b). Yield 30 mg (62%), yellowish solid, mp 126–127°C (mp 126°C[65]).

9-Methoxybenzo[*c*]acridine (13c). Yield 30 mg (58%), yellow solid, mp 154–155°C (mp 155°C[66]).

11-Methoxybenzo[*c*]acridine (13d). Yield 31 mg (60%), colorless solid, mp 115–117°C. ^1H NMR spectrum, δ, ppm (*J*, Hz): 4.21 (3H, s, OCH_3); 7.10–7.14 (1H, m, H benzoacridine); 7.48–7.53 (1H, m, H benzoacridine); 7.60–7.63 (1H, m, H benzoacridine); 7.67–7.74 (3H, m, H benzoacridine); 7.75–7.80 (1H, m, H benzoacridine); 7.85–7.89 (1H, m, H benzoacridine); 8.63 (1H, s, H benzoacridine); 9.55–9.58 (1H, m, H benzoacridine). ^{13}C NMR spectrum, δ, ppm: 56.5; 107.3; 119.9; 125.6(2C); 125.8; 126.2; 127.4; 127.9; 128.2; 128.3; 129.1; 131.9; 134.0; 135.1; 140.4; 146.8; 155.6. Found, *m*/*z*: 260.1063 $[M+H]^+$. $C_{18}H_{14}NO$. Calculated, *m*/*z*: 260.1070.

Synthesis of 5-phenylbenzo[*c*]acridines 14a,b (General method). A solution of quinoline **12a**,**b** (0.2 mmol) in TfOH (0.5 ml) was stirred at room temperature for 1 h. The reaction mixture was poured into cold water (20 ml) and extracted with CH_2Cl_2 (2×5 ml). The combined extracts were washed with water (2×5 ml) and dried over Na_2SO_4. Solvent was evaporated under reduced pressure, and the residue was purified by column chromatography on silica (hexane–$CHCl_3$, 15:1) to provide pure acridines **14a**,**b**.

5-Phenylbenzo[*c*]acridine (14a). Yield 57 mg (93%), yellowish solid, mp 110–112°C (mp 111–112°C[61]).

9-Methyl-5-phenylbenzo[*c*]acridine (14b). Yield 61 mg (96%), yellowish solid, mp 131–132°C. ^1H NMR spectrum, δ, ppm (*J*, Hz): 2.60 (3H, s, CH_3); 7.47–7.68 (8H, m, H Ph and benzoacridine); 7.74–7.81 (2H, m, H benzoacridine); 7.87 (1H, d, *J* = 8.0, H benzoacridine); 8.30 (1H, d, *J* = 8.7, H benzoacridine); 8.51 (1H, s, H benzoacridine); 9.63 (1H, d, *J* = 8.0, H benzoacridine). ^{13}C NMR spectrum, δ, ppm: 21.9; 124.9; 125.5; 126.2; 126.3; 126.6; 127.2; 127.5; 127.7; 128.5; 128.8; 129.6; 130.0; 132.1; 132.5; 133.3; 134.1; 135.9; 139.4; 140.4; 146.7; 146.9. Found, *m*/*z*: 320.1441 $[M+H]^+$. $C_{24}H_{18}N$. Calculated, *m*/*z*: 320.1434.

The Supplementary information file containing optimization of the Sonogashira reaction between pyridine **2a** and TMS-acetylene and copies of ^1H and $^{13}C\{^1H\}$ NMR spectra of all compounds is available from the journal website at http://link.springer.com/journal/10593.

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