A Convenient One-Pot Procedure for the Synthesis of 2-Aryl Quinazolines Using Active MnO_2 as Oxidant

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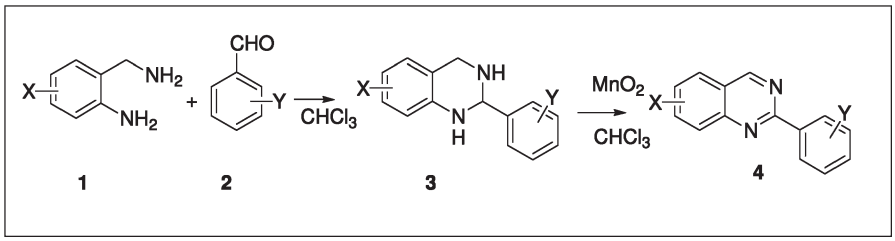
Received December 12, 2009
DOI 10.1002/jhet.444
Published online 26 July 2010 in Wiley Online Library (wileyonlinelibrary.com).



A variety of 2-aryl quinazolines were synthesized from the condensation of 2-aminobenzylamines and aryl aldehydes to form 2-aryl-1,2,3,4-tetrahydroquinazolines and subsequent oxidation of the intermediates with MnO_2.

J. Heterocyclic Chem., **47**, 1240 (2010).

INTRODUCTION

The quinazoline ring is a frequently encountered moiety in organic syntheses as well as in medicinal chemistry [1–10]. Many alkaloids containing a quinazoline skeleton in the molecule exhibit anticonvulsant, antibacterial, antidiabetic, and anticancer activities [6,11–14]. A number of methods for the synthesis of quinazolines are known [15–19]. We found five basic types of synthetic strategies for the synthesis of 2-substitued quinazolines: (1) three-step reaction from aryl azides to form 2-alkylquinazolines [20], (2) reaction of amidines with cyano- or nitro-activated *o*-fluorobenzaldehydes [21], (3) condensation of *o*-phenyl oxime of 2-aminoacetophenone with aldehydes or ketones by irradiation with microwaves to form 4-methylquinazolines [22], (4) reaction of 2-aminobenzaldehyde with an acyl halide and by heating the obtained amide in a sealed tube with saturated alcoholic ammonia [19,23–26], and then dehydrogenation with mercuric EDTA complex or aromatization with alkaline potassium ferricyanide [27,28], (5) condensation of 1,3-diamines **1** with aromatic aldehydes **2** to form 2-aryl-1,2,3,4-tetrahydroquinazolines **3**, and then oxidation of **3** to form the 2-aryl substituted quinazolines **4** (Scheme 1).

The fifth synthetic strategy involves two steps: condensation and oxidation. The condensation products, 2-aryl-1,2,3,4-tetrahydroquinazolines, have been prepared in solvent-free [29] and a number of solvents, including benzene or xylene, methanol or ethanol/acetic acid mixtures [30,31], alkali media [32,33], H_2O [34], and ionic liquids [35]. Vandeneynde et al. reported alternative methods where aldehydes were converted, *in situ*, to *N*-(1-chloroalkyl)pyridinium, which reacted with 2-aminobenzylamine to yield tetrahydroquinazoline hydrochloride salts **3**·**HCl** [36]. Two oxidation regents were used to oxidize 2-aryl-tetrahydroquinazolines to the corresponding quinazolines **4**. One is 2,3-dichloro-5,6-dicyanobenzoquinone (DDQ) and the other tetrachloro-1,4-benzoquinone (TCQ) [36]. More recently, Coskun reported a reaction where the *in situ* formed 2-substituted-1,2,3,4-tetrahydroquinazolines were oxidized to quinazolin-1-oxides [37].

No one-pot reaction to synthesize 2-arylquinazolines was reported. The methods described above to synthesize the 2-arylquinazolines either require multistep preparations of special reagents/reactants, or suffer severe limitations such as tedious experimental procedure and poor yields. Here we report the first one-pot synthesis of 2-aryl substituted quinazolines, from condensation of 1,3-diamines **1** with aryl aldehydes **2** to form 2-aryl-1,2,3,4-tetrahydroquinazolines **3**, and oxidation of **3** to form the 2-aryl substituted quinazolines **4**, using MnO_2 as the oxidant.

RESULTS AND DISCUSSION

The condensation of 2-aminobenzylamine and benzaldehyde was selected as the model reaction. Among the

Scheme 1

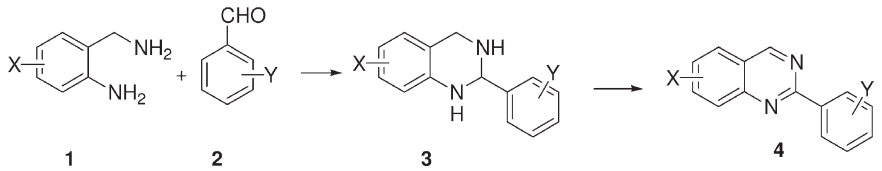


Table 1

The solvent effect on the condensation reaction.

Entry	Solvent	Time (h)	Yield[a] (%)
1	H_2O	4	85
2	$CHCl_3$	10	84
3	THF	16	66
4	CH_3OH	17	73
5	CH_3CN	16	74
6	CH_2Cl_2	18	63

[a] Isolated yield based on 2-aminobenzylamine.

solvents we screened, we found $CHCl_3$ or H_2O was the best solvent to give the product in high yield (Table 1, entries 1 and 2). Other solvents such as THF, CH_3OH, CH_3CN, and CH_2Cl_2 gave lower yields (entries 3–6). This is consistent with the findings of Gawinecki et al. [38].

Several oxidants were evaluated for the transformation of tetrahydroquinazoline **3** to quinazoline **4** in $CHCl_3$ (Table 2). Among the oxidants we used, only DDQ and MnO_2 were effective for the transformation from the tetrahydroquinazoline to the quinazoline (Table 2, entries 4–5).

We then evaluated the solvent effects on the oxidation of the tetrahydroquinazoline to the quinazoline. The reaction did not proceed in water or in CH_3COOH (Table 3, Entries 1 and 2). Moderate yields were obtained in CH_3OH, C_2H_5OH, CH_2Cl_2, CH_3CN, Dioxane, DMF, and THF (Entries 3–9). The best yield was obtained in $CHCl_3$ (Entry 10). Because both condensation and oxidation reactions proceed well in $CHCl_3$, we envisioned that the synthesis of quinazolines might proceed in one pot.

We then investigated the one-pot reactions of 2-aminobenzylamines and benzaldehydes to synthesize 2-arylqunazolines without isolating the tetrahydroquinazoline intermediate. First, the reaction of 2-aminobenzylamine with benzaldehyde gave tetrahydroquinazoline in $CHCl_3$ at room temperature. After TLC indicated the reaction was completed, we added 4.0 mol equivalents of MnO_2. After refluxing for 12 h, the corresponding quinazoline was isolated in 70% yield. To explore the generality and scope of this one-pot reaction, we synthesized 2-arylquinazolines from a variety of 2-aminobenzylamines and aryl aldehydes (Table 4).

A variety of substituents are tolerated on both 2-aminobenzylamines and benzaldehydes. For the 2-aminobenzylamines, ortho F or CF_3 substituents slowed the reaction, probably due to the electronic and steric effect in the first step (entries 15–18). For benzaldehydes, the electron-withdrawing substituents speeded the reaction. Overall the reaction gave 2-arylquinazolines in yields from 26 to 75%.

CONCLUSION

In summary, We have developed an one-pot method to synthesize a variety of 2-arylquinazoline derivatives, from the condensation of 1,3-diamines and aryl aldehydes to form 2-aryl-1,2,3,4-tetrahydroquinazolines and subsequent oxidation of tetrahydroquinazolines with

Table 2

The effect of oxidants on the oxidation of 2-phenyltetrahydroquinazoline to quinazoline.

Entry	Oxidant	Time (h)	Yield[a] (%)
1	NBS	36	0
2	Br_2	36	0
3	$Pb(OAC)_4$	36	0
4	DDQ	36	65
5	MnO_2	36	70

[a] Isolated yield.

Table 3

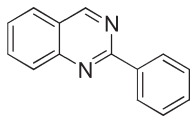
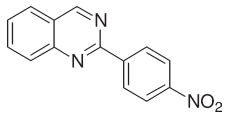
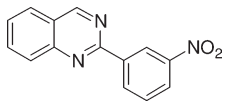
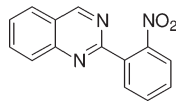
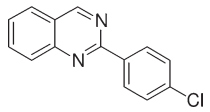
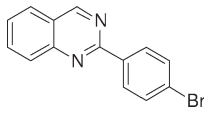
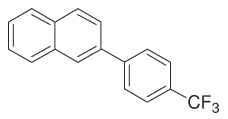
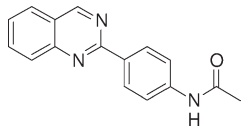
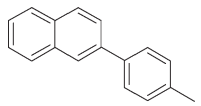
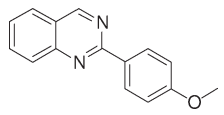
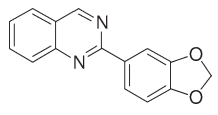
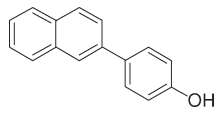
The solvent effect on the oxidation of 2-phenyltetrahydroquinazolin.

Entry	Solvent	$Time_1$ (h)	$Time_2$ (h)	Yield[a] (%)
1	H_2O	5	24	–
2	CH_3COOH	4	12	–
3	CH_3OH	24	12	37
4	C_2H_5OH	24	12	35
5	CH_2Cl_2	36	12	30
6	CH_3CN	16	12	51
7	Dioxane	15	12	54
8	DMF	16	8	54
9	THF	16	12	68
10	$CHCl_3$	10	12	70

[a] Isolated yield.

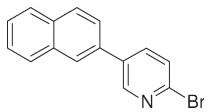
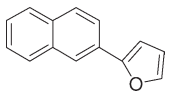
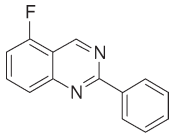
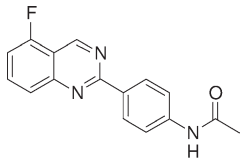
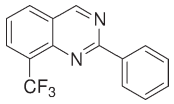
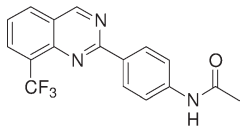
Table 4

One-pot synthesis of 2-arylquinazolines.

Entry	Product	$Time_1$ (h)	$Time_2$ (h)	Yield[a] (%)
1		10	12	70
2		6	12	72
3		5	12	62
4		5	12	52
5		5	12	66
6		5	12	75
7		7	12	50
8		8	12	66
9		10	12	56
10		10	12	48
11		9	12	40
12		10	12	30

(*Continued*)

Table 4
(*Continued*)

Entry	Product	$Time_1$ (h)	$Time_2$ (h)	Yield[a] (%)
13		10	12	50
14		4	13	48
15		20	14	42
16		20	14	40
17		20	12	48
18		20	20	26

[a] Isolated yield based on 2-aminobenzylamines.

MnO_2 in moderate to high yield. This method provided quick access to different quinazolines.

EXPERIMENTAL

Melting points were determined on an Electrothermal 9100 capillary melting point apparatus. ^{1}H NMR spectra were recorded on a Bruker AV400 (400 MHz) spectrometer, and chemical shifts (δ) are reported in parts per million relative to tetramethylsilane. ^{13}C NMR spectra were recorded on a Bruker AV400 spectrometer, and chemical shifts are reported in parts per million relative to solvent resonance as the internal standard ($CDCl_3$, δ 77.16). IR spectra were recorded as solid in pellets on a Perkin-Elmer FTIR 683 spectrometer. Mass spectra were obtained with a TRIO 2 (electronic ionization 70 eV) spectrometer and a Perkin-Elmer Claruss 500 mass spectrometer (electronic ionization 20 eV).

General procedure for the synthesis of 2-aryltetrahydroquinazolines. A mixture of 2-aminobenzylamine (1.1 mmol), aryl aldehyde (1.0 mmol), and 10 mL of solvent were stirred at room temperature. The reaction was followed by TLC. When the reaction was completed, 4 mmol of active MnO_2 was added and refluxed. After the reaction was completed, the organic material was extracted with ethyl acetate. The organic layer was dried over Na_2SO_4, and the solvents were removed. The residue was purified by flash chromatography on silica gel column, using petroleum/ethyl acetate as eluate to give products.

2-Phenylquinazoline.[37] This compound was obtained as yellow solid, mp 91–92°C; ^{1}H NMR (dimethyl sulfoxide d_6): δ 7.53–7.56 (m, 3H, Ar—H), 7.69–7.73 (m, 1H, Ar—H), 8.00–8.04 (m, 2H, Ar—H), 8.13 (d, J = 8.0 Hz, 1H), 8.54–8.56 (m, 2H, Ar—H), 9.67 (s, 1H); ^{13}C NMR (deuteriochloroform): δ 123.6, 127.1, 127.3, 128.6, 128.7, 130.6, 134.1, 138.0, 150.8, 160.5, 161.1.

2-(4-Nitro-phenyl)quinazoline.[33] This compound was obtained as yellow solid, mp 197–198°C; ^{1}H NMR (deuteriochloroform): δ 7.70 (t, 1H, J = 7.2 Hz), 7.89–7.96 (m, 1H), 8.38 (d, 2H, J = 8.8 Hz), 8.83 (d, 2H, J = 8.8 Hz), 9.50 (s, 1H); ^{13}C NMR (deuteriochloroform): δ 123.8, 123.9, 127.2, 128.3, 128.9, 129.4, 134.6, 143.8, 149.2, 150.6, 158.8, 160.7.

2-(3-Nitro-phenyl)quinazoline.[33] This compound was obtained as yellow solid, mp 194–195°C; ^{1}H NMR (deuteriochloroform): δ 7.68–7.73 (m, 2H), 7.98 (t, J = 8.0 Hz, 2H), 8.14 (d, J = 8.0 Hz, 1H), 8.34 (d, J = 8.0 Hz, 1H), 8.98 (d, J

= 7.6 Hz, 1H), 9.51 (s, 2H); ^{13}C NMR (deuteriochloroform): δ 123.6, 123.9, 125.1, 127.3, 128.1, 128.8, 129.6, 134.2, 134.6, 139.9, 150.6, 158.7, 160.8.

2-(2-Nitro-phenyl)quinazoline.[37] This compound was obtained as yellow solid, mp 91–92°C; ^{1}H NMR (deuteriochloroform): δ 7.68–7.73 (m, 2H), 7.98 (t, J = 8.0 Hz, 2H), 8.14 (d, J = 8.0 Hz, 1H), 8.34 (d, J = 8.0 Hz, 1H), 8.98 (d, J = 7.6 Hz, 1H), 9.51 (s, 2H); ^{13}C NMR (deuteriochloroform): δ 123.6, 124.0, 125.1, 127.2, 128.1, 128.8, 129.6, 134.2, 134.6, 139.8, 148.9, 150.6, 158.7, 160.8.

2-(4-Chloro-phenyl)quinazoline.[33] This compound was obtained as yellow solid, mp 116–117°C; ^{1}H NMR (deuteriochloroform): δ 7.49 (d, J = 7.6 Hz, 2H), 7.62–7.65 (m, 1H, Ar—H), 7.90–7.95 (m, 2H, Ar—H), 8.07 (d, J = 8.4 Hz, 1H), 8.58 (d, J = 8.8 Hz, 2H, Ar—H), 9.46 (s, 1H); ^{13}C NMR (deuteriochloroform): δ 123.6, 127.2, 127.5, 128.6, 128.9, 129.9, 134.3, 136.5, 136.9, 150.7, 160.1, 160.6.

2-(4-Bromo-phenyl)-quinazoline. This compound was obtained as yellow solid, mp 131–132°C; IR (potassium bromide): 2925, 1693, 1618, 1582, 1546, 1405, 1369, 1067 cm^{-1}. ^{1}H NMR (deuteriochloroform): δ 7.62–7.68 (m, 3H, Ar—H), 7.91–7.95 (m, 2H), 8.08 (d, 1H, J = 8.4 Hz), 8.51 (d, 2H, J = 8.4 Hz), 9.46 (s, 1H); ^{13}C NMR (deuteriochloroform): δ 123.7, 125.5, 127.2, 127.6, 128.6, 130.2, 131.8, 134.4, 136.9, 150.7, 160.1, 160.6. HRMS calcd. for $C_{14}H_9BrN_2$: 283.9949, found: 283.9951.

2-(4-Trifluoromethyl-phenyl)quinazoline. This compound was obtained as brown-yellow solid, mp 120–122°C; IR (potassium bromide): 2925, 2854, 1621, 1553, 1326, 1163, 1116 cm^{-1}. ^{1}H NMR (deuteriochloroform): δ 7.68 (t, J = 7.6 Hz, 1H), 7.78 (d, J = 8.4 Hz, 2H), 7.94–7.98 (m, 2H, Ar—H), 8.12 (d, J = 8.4 Hz, 1H), 8.75 (d, J = 8.4 Hz, 2H), 9.51 (s, 1H); ^{13}C NMR (deuteriochloroform): δ 122.7 (q, J = 262.0 Hz), 123.7, 123.9, 127.2, 128.3, 128.9, 129.4, 134.6, 143.8, 149.2, 150.6, 158.8, 160.7. HRMS calcd. for $C_{15}H_9F_3N_2$: 274.0718, found: 274.0720.

2-(4-Acetamido-phenyl)quinazoline. This compound was obtained as brown-yellow solid, mp 136–139°C; IR (potassium bromide): 3445, 3259, 2925, 1697, 1602, 1532, 1408, 1312, 799 cm^{-1}. ^{1}H NMR (deuteriochloroform): δ 2.23 (s, 3H), 7.39 (br s, 1H), 7.60 (t, J = 7.6 Hz, 1H), 7.68 (d, J = 8.4 Hz, 2H), 7.88–7.93 (m, 2H), 8.06 (d, J = 8.4 Hz, 1H), 8.59 (d, J = 8.4 Hz, 2H), 9.44 (s, 1H); ^{13}C NMR (deuteriochloroform): δ 24.8, 119.4, 123.5, 127.1, 128.5, 129.5, 131.1, 133.9, 134.1, 140.2, 150.8, 160.5, 168.4. HRMS calcd. for $C_{16}H_{13}N_3O$: 263.1059, found: 263.1057.

2-(4-Methyl-phenyl)quinazoline.[36] This compound was obtained as yellow solid, mp 99–101°C; IR (potassium bromide): 3027, 2922, 2854, 1620, 1610, 1589, 1552, 1402, 1380, 797, 726 cm^{-1}. ^{1}H NMR (deuteriochloroform): δ 2.44 (s, 3H), 7.33 (d, J = 7.2 Hz, 2H), 7.57–7.60 (m, 1H), 7.87–7.91 (m, 2H), 8.05 (d, J = 8.8 Hz, 1H), 8.50 (d, J = 7.2 Hz), 9.44 (d, J = 0.8 Hz); ^{13}C NMR (deuteriochloroform): δ 21.5, 123.5, 127.1, 128.6, 129.4, 134.1, 135.3, 140.9, 150.8, 160.5.

2-(4-Methoxyl-phenyl)quinazoline.[36] This compound was obtained as yellow solid, mp 85–86°C; ^{1}H NMR (deuteriochloroform): δ 3.89 (s, 3H), 7.03 (d, J = 8.8 Hz, 2H), 7.56 (t, J = 7.6 Hz, 1H), 7.82–7.89 (m, 2H, Ar—H), 8.02 (d, J = 8.4 Hz, 1H), 8.56 (d, J = 8.8 Hz, 2H), 9.41(s, 1H); ^{13}C NMR (deuteriochloroform): δ 55.4, 113.9, 123.3, 126.8, 127.1, 128.4, 130.2, 130.7, 134.0, 150.8, 160.4, 160.8, 161.8.

2-(Benzo[1,3]dioxol-5-yl)quinazoline. This compound was obtained as yellow solid, mp 123–125°C; IR (potassium bromide): 2921, 2850, 1618, 1584, 1568, 1502, 1460, 1256, 1099, 1039, 793 cm^{-1}. ^{1}H NMR (deuteriochloroform): δ 6.06 (s, 2H, OCH_2O), 6.97 (d, 1H, J = 8.4 Hz, Ar—H), 7.59 (s, 1H, Ar—H), 7.91–7.89 (m, 2H, Ar—H), 8.04–8.03 (m, 1H, Ar—H), 8.20 (s, 1H, Ar—H), 8.23 (d, 1H, J = 7.0 Hz, Ar—H), 9.41 (s, 1H, Ar—H); ^{13}C NMR (deuteriochloroform): δ 29.7, 46.5, 69.4, 101.2, 107.1, 108.3, 115.0, 118.2, 120.1, 121.3, 126.2, 127.3, 135.8, 143.7, 147.7. HRMS calcd. for $C_{15}H_{10}N_2O_2$: 250.0742, found: 250.0740.

2-(4-Hydroxyl-phenyl)quinazoline. This compound was obtained as yellow solid, mp 210–212°C; IR (potassium bromide): 3168, 1670, 1606, 1555, 1457, 1405, 1385, 1240, 1165, 799 cm^{-1}. ^{1}H NMR (deuteriochloroform): δ 6.92 (d, J = 8.4 Hz, 3H), 7.64–7.69 (m, 1H), 7.97 (d, J = 3.2 Hz, 2H), 8.09 (d, J = 8.0 Hz, 1H), 8.41 (d, J = 8.8 Hz, 2H), 9.61 (s, 1H); ^{13}C NMR (deuteriochloroform): δ 115.9, 116.3, 123.4, 127.4, 128.1, 128.2, 128.9, 130.4, 135.1, 150.4, 160.5, 161.5. HRMS calcd. for $C_{14}H_{10}N_2O$: 222.0793, found: 222.0795.

2-(6-Bromo-pyridin-3-yl)-quinazoline. This compound was obtained as black solid, mp 158–160°C; IR (potassium bromide): 3061, 2924, 1619, 1572, 1448, 1404, 1088, 734 cm^{-1}. ^{1}H NMR (deuteriochloroform): δ 7.61–7.69 (m, 2H, Ar—H), 7.92–7.96 (m, 2H), 8.07 (d, J = 8.8 Hz, 1H), 8.73 (dd, 1H, J = 1.6, 8.4Hz), 9.45 (s, 1H), 9.55 (d, J = 1.6 Hz, 1H); ^{13}C NMR (deuteriochloroform): δ 123.9, 127.2, 127.9, 128.0, 128.7, 133.0, 134.6, 138.2, 144.2, 150.6, 150.7, 158.3, 160.7. HRMS calcd. for $C_{13}H_8BrN_3$: 284.9902, found: 284.9905.

2-(2-Furyl)quinazoline.[37] This compound was obtained as black solid, mp 131–132°C; ^{1}H NMR (deuteriochloroform): δ 6.63 (dd, J = 2.0, 3.6 Hz, 1H), 7.46 (d, J = 3.2 Hz, 1H), 7.59–7.63 (m, 1H), 7.70 (d, J = 0.8 Hz, 1H), 7.89–7.93 (m, 2H), 8.09 (d, J = 9.2 Hz, 1H), 9.39 (s, 1H); ^{13}C NMR (deuteriochloroform): δ 112.4, 114.1, 123.4, 127.3, 128.4, 134.6, 145.4, 150.4, 152.5, 154.1, 160.8.

2-Phenyl-5-flouroquinazoline. This compound was obtained as yellow solid, mp 111–113°C; IR (potassium bromide): 3058, 2925, 1635, 1582, 1555, 1465, 1398, 1240, 790, 699 cm^{-1}. ^{1}H NMR (deuteriochloroform): δ 7.22 (t, 1H, J = 8.4 Hz), 7.53–7.56 (m, 3H, Ar—H), 7.83–7.90 (m, 2H, Ar—H), 8.62–8.63 (m, 2H, Ar—H), 9.74 (s, 1H); ^{13}C NMR (deuteriochloroform): δ 110.9 (d, J = 19.0 Hz), 114.1, 124.6 (d, J = 4.0 Hz), 128.7 (d, J = 6.0 Hz), 131.0, 134.1 (d, J = 10.0 Hz), 137.6, 152.0, 154.9 (d, J = 3.0 Hz), 157.0 (d, J = 257.0 Hz), 161.2. HRMS calcd. for $C_{14}H_9FN_2$: 224.0750, found: 224.0752.

2-(4-Acetamido-phenyl)-5-flouroquinazoline. This compound was obtained as yellow solid, mp 207–208°C; IR (potassium bromide): 3536, 3283, 3126, 2926, 1633, 1656, 1580, 1556, 1463, 1397, 1376, 1347, 1237, 1089, 822. ^{1}H NMR (dimethyl sulfoxide d_6): δ 2.10 (s, 3H), 7.49 (t, J = 8.8 Hz, 1H), 7.77 (d, J = 8.4 Hz, 2H), 7.85 (d, J = 8.4 Hz, 1H), 7.97–8.03 (m, 1H), 8.48 (d, J = 8.8 Hz, 2H), 9.78 (s, 1H), 10.23 (br s, 1H); ^{13}C NMR (deuteriochloroform): δ 24.5, 111.7 (d, J = 18.0 Hz), 113.9 (d, J = 16.0 Hz), 119.1 (d, J = 8.0 Hz), 124.6 (d, J = 4.0 Hz), 129.6, 131.9, 135.7 (d, J = 10.0Hz), 142.6, 151.2, 155.6, 156.8 (d, J = 246 Hz), 160.7 169.2. HRMS calcd. for $C_{16}H_{12}FN_3O$: 281.0964, found: 281.0967.

2-Phenyl-8-trifluoromethylquinazoline. This compound was obtained as yellow solid, mp 94–96°C; IR (potassium

bromide): 3070, 1621, 1590, 1568, 1468, 1475, 1410, 1343, 1281, 1159, 1078, 773 cm^{-1}. ^1H NMR (dimethyl sulfoxide d_6): δ 7.54 (d, $J = 4.0$ Hz, 3H), 7.66 (t, $J = 7.6$ Hz, 1H), 8.10 (d, $J = 7.6$ Hz, 1H), 8.23 (d, $J = 7.2$ Hz, 1H), 8.68 (d, $J = 4.0$ Hz, 2H), 9.52 (s, 1H); ^{13}C NMR (dimethyl sulfoxide d_6): δ 123.7(q, $J = 242.2$ Hz), 125.8, 128.7, 129.0, 131.3, 131.4, 132.1, 132.2, 137.4, 147.7, 160.7, 161.4. HRMS calcd. for $C_{15}H_9F_3N_2$: 274.0718, found: 274.0721.

2-(4-Acetamido-phenyl)-8-trifluoromethylquinazoline. This compound was obtained as yellow solid, mp 166–168°C; IR (potassium bromide): 3265, 3121, 2926, 2853, 1675, 1601, 1596, 1471, 1327, 1286, 1139, 833, 775 cm^{-1}. ^1H NMR (dimethyl sulfoxide d_6): δ 2.23 (s, 3H), 7.56–7.72 (m, 3H), 7.84 (d, $J = 7.6$ Hz, 1H), 8.08 (d, $J = 8.0$ Hz, 1H), 8.22 (d, $J = 6.8$ Hz, 1H), 8.64 (d, $J = 8.0$ Hz, 1H), 9.49 (s, 1H). ^{13}C NMR (dimethyl sulfoxide d_6): δ 24.3, 113.0, 113.2, 116.3, 121.7 (q, $J = 248.3$), 124.9, 127.1, 129.1, 129.8, 131.1, 131.8, 136.7, 138.5, 144.3, 169.5. HRMS calcd. for $C_{17}H_{12}F_3N_3O$: 331.09325, found: 331.09367.

Acknowledgments. We are grateful to the support from the National Science Foundation of China (No. 20462003, 20862009, and 20962010) and the National Science Foundation of Jiangxi province (No. 2008GQH0026).

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