Synthesis and *In Vitro* Antibacterial Activities of Novel 2-Aryl-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one Derivatives

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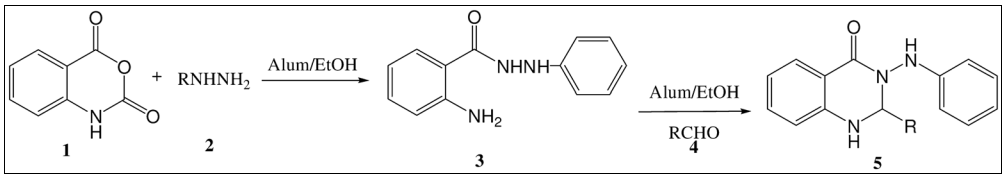
Received May 29, 2011
DOI 10.1002/jhet.1075
Published online 00 Month 2013 in Wiley Online Library (wileyonlinelibrary.com).



An efficient synthesis of novel 2-aryl-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one derivatives using $KAl(SO_4)_2.12H_2O$ (Alum) as a catalyst from an aldehyde and 2-amino-*N*-phenylbenzohydrazine in ethanol is described. All synthesized derivatives were screened for anti-bacterial activity. Some compounds exhibited promising anti-bacterial activity with reference to standard antibiotics.

J. Heterocyclic Chem., **00**, 00 (2013).

INTRODUCTION

During recent years, the use of $KAl(SO_4)_2.12H_2O$ (Alum) compounds as catalysts or promoters in organic synthesis has attracted great interest from many chemists [1–4]. Alum enhances the reactivity and selectivity of many types of reactions such as carbon–carbon bond formation [5], esterification [6], cycloaddition [7], acylation [8], and multicomponent condensations [9].

2,3-Dihydroquinazolinone derivatives have drawn much attention due to their broad range of pharmacological activities such as antibiotic [10], antidefibrillatory [11], antispermatogenic [12], vasodilatory [13], and analgesic [14] ability.

2,3-Dihydroquinazolinone derivatives have been prepared by the reaction of anthranilamides with aldehydes or ketones under either acidic or basic conditions [15–19], by the reductive desulfurization of 2-thioxo-3H-quinazolin-4-ones with nickel boride in dry methanol [20], also by the reductive cyclization of *o*-nitrobenzamides with aldehydes or ketone using $TiCl_4$/Zn in an hydrous THF [21], or $SnCl_2$ in alcohol [22], as well as by the reaction of isatoic anhydride with Schiff bases [23–25]. Also, the reduction of quinazolin-4(3*H*)-ones [26,27], as well as the one-pot reaction of isatoic anhydride, a primary amine, and aromatic aldehyde in the presence of silica sulfuric acid [28], montmorillonite K10 [29], ionic liquids [30], $Ga(OTf)_3$ [31], $Zn(PFO)_2$ [32], I_2 [33], and other routes have been utilized for its synthesis [34,35]. However, none of the 2,3-dihydroquinazolinone compounds prepared by these methods contains 3-phenylamino in 3 position. Here, we report a new synthesis of 2,3-dihydroquinazolinone derivatives with 3-phenyl amino group.

RESULTS AND DISCUSSION

As per our ongoing work to synthesize privileged-class bioactive nitrogen-containing heterocyclic compounds [36–38], and in view of our interest in the $KAl(SO_4)_2.12H_2O$ catalyzed reaction [39,40], we herein report a convenient and rapid methodology for synthesis of some new 2-aryl-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one derivatives **5** in the presence of Alum as a non-toxic, reusable, inexpensive and easily available reagent in ethanol at reflux.

The initial aim of our work was to synthesize 2-amino-*N*-phenylbenzohydrazide **3** followed by the reaction of isatoic anhydride **1** with phenylhydrazine **2** in the presence of Alum using ethanol as a solvent at reflux. The strategy for the synthesis of 2-aryl-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one derivatives **5** has been depicted in Scheme 1. The synthetic methodology commenced with the synthesis of 2-aminophenylbenzohydrazide **3**. Subsequently, the 2-aryl-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one derivatives **5** was prepared by the reaction of 2-aminophenylbenzohydrazide **3** with aldehydes **4**, using alum in ethanol at reflux, in excellent yield and purity (Scheme 1). The completion of the reaction was monitored by TLC at regular intervals, and the disappearance of the starting material was observed within 5 h. The optimized results are summarized in Table 1.

The structures of products were characterized by IR, ^{1}H NMR, ^{13}C NMR, MS spectra, and elemental analysis.

The new synthesized compounds were screened *in vitro* for their antibacterial activities against of bacteria *Escherichia coli ATCC 25922, Pseudomonas aeruginusa* ATCC 85327, *Klebsiella pneumonia*, ATCC 29655

(Gram-negative bacteria), *Enterococcus faecalis* ATCC 29737, *Bacillus subtilis* ATCC 465, *Bacillus pumilus* PTCC 1114, *Micrococcus luteus* PTCC 1110, *Staphylococcus aureus* ATCC 25923, *Staphylococcus epidermidis* ATCC 12228, *Sterptococcus mutans* PTCC 1601 (Gram-positive bacteria) by the disk diffusion method (IZ) [41], and subsequently the minimum inhibitory concentration (MIC) [42].

Activities of each compound were compared with tetracycline and gentamicin as standards. MIC and IZ results for bacterial strains are shown on Table 2. The screening results indicate that some of the tested compounds exhibit significant antibacterial activities when compared with the reference drugs. It was observed that the compound containing $N(Me)_2$ substituted group in 4 position of 2-aryl-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one **5f** shows better activity than the other test compounds and the reference, tetracycline and gentamicin, drugs. Meanwhile, 2-aryl-3-(phenylamino)-2,3-dihydroquinazolin-4(1H)-one compounds **5e**, **5f**, **5h**, **5i**, **5j** exhibited good activity, whine the remaining compounds generally showed inferior activities against all the tested strains.

In summary, we have described a successful strategy, efficient and convenient green synthesis for the preparation of 2-aryl-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-ones in valuing cyclocondensation reaction of aldehydes and 2-amino-*N*-phenylbenzohydrazine using the inexpensive, nontoxic and easily available $KAl(SO_4)_2.12H_2O$ (Alum) catalyst. Surprisingly, compounds **5f** and **5j** with the potencies similar to or better than those of tetracycline and gentamicin against *Escherichia coli* ATCC 25922, *Pseudomonas aeruginusa* ATCC 85327, *Klebsiella pneumonia*, ATCC 29655 (Gram-negative bacteria), *Enterococcus faecalis* ATCC 29737, *Bacillus subtilis* ATCC 465, *Bacillus pumilus* PTCC 1114, *Micrococcus luteus PTCC* 1110, *Staphylococcus aureus* ATCC 25923, *Staphylococcus epidermidis* ATCC 12228, *Sterptococcus mutans* PTCC 1601 (Gram-positive bacteria), worth further investigations.

EXPERIMENTAL

General methods. Melting points were obtained in open capillary tubes and were measured on an electro-thermal 9200 apparatus. Mass spectra were recorded on a Shimadzu QP 1100 BX mass spectrometer. The IR spectra were recorded on KBr pellets on a Shimadzu IR-470 spectrophotometer. ^1H and ^{13}C NMR spectra were determined on a Bruker 300 DRX Avance instrument at 300 and 75 MHz. Elemental analysis for C, H, and N were performed using a Heraus CHN rapid analyzer.

General experimental procedure for synthesis of 2-aryl-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one 5a-j. A mixture of 1 mmol **3**, 1 mmol aldehyde **4**, 0.4 g Alum, and 5 mL EtOH in a 20-mL flask was stirred at reflux for periods indicated in Table 1. After completion of the reaction (monitored by TLC, ethyl acetate/*n*-hexane, 1/1), EtOH was removed under reduced pressure, 25 mL H_2O was added to the reaction mixture, the resulting solid was separated by filtration, and recrystallized from ethanol to afford pure product.

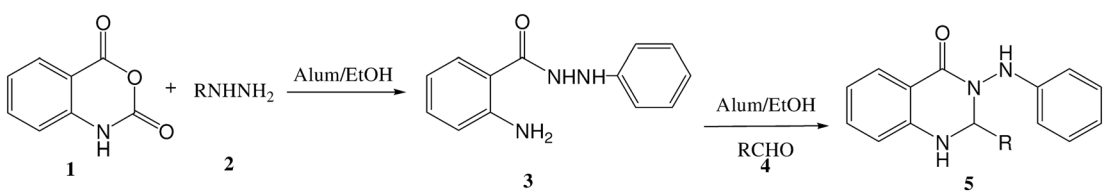
2-Amino-*N′*-phenylbenzohydrazide (3). White powder (99)%; mp 170–172°C; IR (potassium bromide): 3428 (NH), 3335 (NH), 3230 (NH), 1645 (C O); ^1H NMR (DMSO-d_6): δ_H 6.39 (s, 2H, NH_2), 6.56 (t, 1H, J = 7.8, ArH), 6.69–6.75 (m, 2H, ArH), 6.78 (d, 2H, J = 7.7, ArH), 7.13–7.22 (m, 3H, ArH), 7.66 (d, 1H, J = 7.8, ArH), 7.79 (s, 1H, NH), 10.10 (s, 1H, NH); ^{13}C NMR (DMSO-d_6): δ_C 112.75, 113.27, 115.19, 116.86, 119.00, 128.45, 129.18, 132.65, 150.27, 150.34, 169.33.

2-(4-Nitrophenyl)-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one (5a). Cream powder (92)%; mp 220–222°C; IR (potassium bromide): 3374 (NH), 3238 (NH), 1660 (C O); ^1H NMR (DMSO-d_6): δ_H 6.09 (s, 1H, CH), 6.70–6.86 (m, 5H, ArH), 7.18 (t, 2H, J = 7.6, ArH), 7.30 (t, 1H, J = 7.7, ArH), 7.63 (d, 1H, J = 7.7, ArH), 7.69 (d, 1H, J = 8.3, ArH), 7.76 (s, 1H, NH), 8.20 (d, 2H, J = 8.3, ArH), 8.50 (s, 1H, NH); ^{13}C NMR (DMSO-d_6): δ_C 73.22, 112.88, 114.61, 115.24, 118.34, 119.94, 124.02, 128.13, 129.24, 129.43, 134.51, 146.87, 147.92, 148.08, 148.45, 162.88; MS (70 eV, electron impact) *m/z*: 360 (M^+, 50), 312 (20), 268 (35), 237 (40), 206 (25), 178 (25), 120 (50), 91 (100), 77 (20), 65 (45), 51 (30), 39 (30); Anal. Calcd for $C_{20}H_{16}N_4O_3$: C, 66.66; H, 4.48; N, 15.55; Found: C, 66.56; H, 4.37; N, 15.44.

2,4-Dichlorophenyl)-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one (5b). Cream powder (90)%; mp 196–198°C; IR (potassium bromide): 3365 (NH), 3258 (NH), 1656 (C O); ^1H NMR (DMSO-d_6): δ_H 6.24 (s, 1H, CH), 6.72–6.80 (m, 5H, ArH), 7.15 (t, 2H, J = 7.7, ArH), 7.30 (t, 1H, J = 7.4, ArH), 7.43–7.49 (m, 2H, ArH), 7.52 (s, 1H, ArH), 7.66 (d, 1H, J = 6.4, ArH), 7.70 (s, 1H, NH), 8.28 (s, 1H, NH); ^{13}C NMR (DMSO-d_6): δ_C 71.03, 112.72, 114.05, 115.32, 118.31, 119.83, 128.06, 129.30, 129.40, 129.72, 133.51, 134.42, 134.54, 136.69, 146.51, 147.95, 163.21; MS (70 eV, electron impact) *m/z*: 308 (M^+, 50), 291 (50), 252 (35), 237 (40), 222 (25), 193 (25), 165 (30), 119 (75), 106 (50), 90 (60), 77 (20), 65 (100), 51 (30), 39 (30); Anal. Calcd for $C_{20}H_{15}Cl_2N_3O$: C, 62.51; H, 3.93; N, 10.94; Found: C, 62.42; H, 4.01; N, 10.82.

2-(4-Bromophenyl)-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one (5c). Cream powder (91)%; mp 178–180°C; IR (potassium bromide): 3337 (NH), 3269 (NH), 1626 (C O); ^1H

Scheme 1



1 2 3 4 5

Table 1

The synthesis of 2-aryl-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one **5a–j**.

Product	R	Time (h)	Yield[a] (%)	m.p. (°C)	Lit. m.p. (°C)
5a	*p*-$NO_2C_6H_4$	6	92	220–222	–
5b	2,4-di-ClC_6H_3	7	90	196–198	–
5c	*p*-BrC_6H_4	7	91	178–180	–
5d	Ph	5	93	198–200	–
5e	*o*-HOC_6H_4	7	91	191–193	–
5f	*p*-$N(Me)_2C_6H_4$	6	93	222–224	–
5g	*m*-$NO_2C_6H_4$	7	91	177–179	–
5h	*p*-$MeOC_6H_4$	7	94	217–219	–
5i	*p*-MeC_6H_4	6	94	162–164	–
5j	*p*-FC_6H_4	6	93	205–207	–

[a]Yields of pure isolated product based on isatoic anhydride.

NMR (DMSO-d_6): δ_H 5.91 (s, 1H, CH), 6.69–6.84 (m, 5H, ArH), 7.16 (t, 2H, *J* = 7.5, ArH), 7.26 (t, 1H, *J* = 7.0, ArH), 7.40 (d, 2H, *J* = 8.3, ArH), 7.53 (d, 2H, *J* = 8.4, ArH), 7.62 (d, 1H, *J* = 8.3, ArH), 7.64 (s, 1H, NH), 8.39 (s, 1H, NH); ^{13}C NMR (DMSO-d_6): δ_C 73.48, 112.84, 114.63, 115.13, 118.09, 119.79, 122.05, 128.06, 129.13, 129.39, 131.69, 134.39, 140.52, 147.11, 148.19, 163.01; MS (70 eV, electron impact) *m/z*: 395 (M^++2, 30), 393 (M^+, 30), 301 (35), 250 (20), 214 (100), 178 (45), 118 (50), 90 (80), 77 (60), 63 (45), 51 (65), 39 (60); Anal. Calcd for $C_{20}H_{16}BrN_3O$: C, 60.93; H, 4.09; N, 10.66; Found: C, 60.82; H, 4.02; N, 10.54.

2-Phenyl-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one (5d). Creampowder(93)%;mp198–200°C;IR(potassiumbromide): 3311 (NH), 3250 (NH), 1648 (C O); ^{1}H NMR (DMSO-d_6): δ_H 5.89 (s, 1H, CH), 6.68–6.80 (m, 3H, ArH), 6.84 (d, 2H, *J* = 7.7, ArH), 7.17 (t, 2H, *J* = 7.4, ArH), 7.25–7.37 (m, 4H, ArH), 7.42 (d, 2H, *J* = 6.4, ArH), 7.63 (d, 1H, *J* = 7.3, ArH), 7.65 (s, 1H, NH), 8.38 (s, 1H, NH); ^{13}C NMR (DMSO-d_6): δ_C 74.05, 112.86, 114.71, 115.07, 117.86, 119.70, 126.84, 128.01, 128.79, 129.36, 134.26, 141.22, 147.31, 148.31, 163.06; MS (70 eV, electron impact) *m/z*: 315 (M^+, 25), 242 (25), 210 (35), 118 (30), 91 (100), 77 (20), 63 (45), 51 (30), 39 (30); Anal. Calcd for $C_{20}H_{17}N_3O$: C, 76.17; H, 5.43; N, 13.32; Found: C, 76.22; H, 5.32; N, 13.21.

2-(2-Hydroxyphenyl)-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one (5e). Cream powder (91)%; mp 191–193°C; IR (potassium bromide): 3385 (OH), 3315 (NH), 3269 (NH),

Table 2

Antibiotic activity of the synthesized compounds and standard antibiotics against some gram positive and gram negative bacteria, as determined by disc diffusion test (IZ) and minimum inhibitory concentration (MIC) methods.

	Tetracycline (30 µg/disc)		Gentamicin (10 µg/disc)		**5a,b,c,d,g**		**5e**		**5f**		**5i**		**5j**		**5h**	
Microorganisms	IZ[a]	MIC[b]	IZ	MIC	IZ	MIC	IZ	IZ	MIC	MIC	IZ	MIC	IZ	MIC	IZ	MIC
Bacillus subtilis (ATCC 465)	21	4	0	NT[c]	0	NT	22	7	512	4	41	<2	18	16	24	<2
Bacillus pumilus (PTCC 1114)	17	8	0	NT	0	NT	24	10	256	<2	38	<2	20	8	28	<2
Micrococcus luteus (PTCC 1110)	19	4	0	NT	0	NT	12	0	NT	128	24	<2	14	32	20	4
Staphylococcus aureus (ATCC 25923)	20	4	0	NT	0	NT	19	14	128	8	35	<2	15	16	24	<2
Staphylococcus epidermidis (ATCC 12228)	34	<2	0	NT	0	NT	17	12	128	4	38	<2	15	32	24	4
Streptococcus mutans (PTCC 1601)	24	2	0	NT	0	NT	22	16	32	4	34	<2	14	64	30	<2
Escherichia coli (ATCC 25922)	0	NT	23	4	0	NT	18	0	NT	8	28	<2	12	64	16	8
Enterococcus faecalis (ATCC 29737)	9	8	0	NT	0	NT	13	0	NT	256	26	<2	12	256	14	8
Pseudomonas aeruginosa (ATCC 85327)	0	NT	12	8	0	NT	14	0	NT	256	22	<2	0	NT	0	NT
Klebsiella pneumonia (ATCC 29655)	8	16	0	NT	0	NT	15	0	NT	128	15	8	0	NT	0	NT

[a]Inhibition zone (mm).
[b]Minimum inhibitory concentration (µg/mL).
[c]Not tested.

1634 (C O); ^{1}H NMR (DMSO-d_6): δ_H 6.08 (s, 1H, CH), 6.66–6.89 (m, 7H, ArH), 7.10–7.22 (m, 1H, NH, 4H, ArH), 7.67 (d, 1H, *J* = 7.7, ArH), 8.29 (s, 1H, NH), 10.00 (s, 1H, OH); ^{13}C NMR (DMSO-d_6): δ_C 69.41, 112.73, 114.46, 115.33, 115.92, 117.68, 119.11, 119.74, 126.58, 126.74, 127.86, 129.44, 129.77, 134.05, 147.19, 148.17, 155.14, 163.53; MS (70 eV, electron impact) *m/z*: 331 (M^+, 40), 236 (65), 221 (40), 207 (35), 178 (40), 118 (50), 91 (100), 77 (55), 77 (60); 65 (45), 51 (30), 44 (30); Anal. Calcd for $C_{20}H_{17}N_3O_2$: C, 72.49; H, 5.17; N, 12.68; Found: C, 72.38; H, 5.05; N, 12.74.

2-(4-(Dimethylamino)phenyl)-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one (5f). Cream powder (93)%; mp 222–224°C; IR (potassium bromide): 3309 (NH), 3260 (NH), 1654 (C O); ^{1}H NMR (DMSO-d_6): δ_H 2.84 (s, 6H, $2CH_3$), 5.76 (s, 1H, CH), 6.64–6.77 (m, 5H, ArH), 6.82 (d, 2H, *J* = 7.7, ArH), 7.13–7.29 (m, 5H, ArH), 7.45 (s, 1H, NH), 7.61 (d, 1H, *J* = 7.6, ArH), 8.23 (s, 1H, NH); ^{13}C NMR (DMSO-d_6): δ_C 40.70, 74.00, 112.44, 114.83, 113.30, 114.72, 115.01, 117.62, 119.56, 127.63, 127.97, 129.32, 134.11, 147.55, 148.41, 150.82, 163.23; MS (70 eV, electron impact) *m/z*: 358 (M^+, 20), 313 (20), 266 (35), 237 (55), 206 (25), 178 (20), 118 (95), 90 (100), 77 (70), 65 (45), 51 (50), 39 (30); Anal. Calcd for $C_{22}H_{22}N_4O$: C, 73.72; H, 6.19; N, 15.63; Found: C, 73.63; H, 6.08; N, 15.64.

2-(3-Nitrophenyl)-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one (5g). Cream powder (91)%; mp 177–179°C; IR (potassium bromide): 3301 (NH), 2352 (NH), 1652 (C O); ^{1}H NMR (DMSO-d_6): δ_H 6.14 (s, 1H, CH), 6.71–6.85 (m, 5H, ArH), 7.71 (t, 2H, *J* = 8.1, ArH), 7.31 (t, 1H, *J* = 7.1, ArH), 7.66 (t, 2H, *J* = 7.8, ArH), 7.79 (s, 1H, ArH), 7.88 (d, 1H, *J* = 7.6, ArH), 8.16 (d, 1H, *J* = 8.1, ArH), 8.32 (s, 1H, NH), 8.54 (s, 1H, NH); ^{13}C NMR (DMSO-d_6): δ_C 73.14, 112.87, 114.63, 115.27, 118.37, 119.89, 121.77, 123.80, 128.13, 129.41, 130.44, 133.53, 134.53, 143.37, 146.88, 148.10, 148.19, 162.96; MS (70 eV, electron impact) *m/z*: 360 (M^+, 30), 268 (35), 237 (40), 206 (45), 178 (45), 120 (50), 91 (100), 77 (40), 65 (35), 51 (30), 39 (30); Anal. Calcd for $C_{20}H_{16}N_4O_3$: C, 66.66; H, 4.48; N, 15.55; Found: C, 66.53; H, 4.39; N, 15.61.

2-(4-Methoxyphenyl)-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one (5h). Cream powder (94)%; Cream powder; mp 216–218°C; IR (potassium bromide): 3266 (NH), 3262 (NH), 1641 (C O); ^{1}H NMR (DMSO-d_6): δ_H 4.24 (s. 1H, OCH_3), 5.97 (s, 1H, CH), 6.72–6.86 (m, 5H, ArH), 7.14 (t, 2H, *J* = 7.7, ArH), 7.23 (d, 1H, *J* = 8.4, ArH), 7.42 (d, 2H, *J* = 8.4, ArH), 7.53 (d, 2H, *J* = 7.8, ArH), 7.60 (s, 1H, ArH), 7.65 (s, 1H, NH), 8.37 (s, 1H, NH); ^{13}C NMR (DMSO-d_6): δ_C 60.12, 74.38, 111.94, 113.95, 114.18, 116.95, 118.96, 127.07, 127.18, 128.95, 129.65, 137.05, 138.12, 138.42, 146.93, 147.63, 149.03, 164.09; MS (70 eV, electron impact) *m/z*: 345 (M^+, 35), 237 (100), 208 (50), 177 (45), 120 (50), 92 (85), 77 (65), 63 (55), 50 (25), 44 (35); 39 (65); Anal. Calcd for $C_{21}H_{19}N_3O_2$: C, 73.03; H, 5.54; N, 12.17; Found: C, 73.10; H, 5.46; N, 12.06.

3-(Phenylamino)-2-*p*-tolyl-2,3-dihydroquinazolin-4(1*H*)-one (5i). Cream powder (95)%; mp 162–164°C; IR (potassium bromide): 3269 (NH), 3264 (NH), 1640 (C O); ^{1}H NMR (DMSO-d_6): δ_H 2.24 (s. 1H, CH_3), 5.92 (s, 1H, CH), 6.71–6.84 (m, 5H, ArH), 7.16 (t, 2H, *J* = 7.8, ArH), 7.29 (d, 1H, *J* = 8.5, ArH), 7.40 (d, 2H, *J* = 8.5, ArH), 7.56 (d, 2H, *J* = 78.5, ArH), 7.62 (s, 1H, ArH), 7.64 (s, 1H, NH), 8.39 (s, 1H, NH); ^{13}C NMR (DMSO-d_6): δ_C 21.11, 73.88, 112.84, 114.75, 115.08, 117.80, 119.66, 126.77, 127.98, 129.29, 129.35, 134.20, 138.06, 138.25, 147.33, 147.33, 148.33, 163.12; MS (70 eV, electron impact) *m/z*: 329 (M^+, 30), 237 (100), 207 (50), 178 (45), 120 (60), 91 (90), 77 (60), 63 (45), 51 (20), 44 (35); 39 (60); Anal. Calcd for $C_{21}H_{19}N_3O$: C, 76.57; H, 5.81; N, 12.76; Found: C, 76.50; H, 5.71; N, 12.65.

2-(4-Folorophenyl)-3-(phenylamino)-2,3-dihydroquinazolin-4(1*H*)-one (5j). Cream powder (93)%; mp 205–207°C; IR (potassium bromide): 3327 (NH), 3262 (NH), 1626 (C O); ^{1}H NMR (DMSO-d_6): δ_H 5.92 (s, 1H, CH), 6.68–6.83 (m, 5H, ArH), 7.13–7.20 (m, 4H, ArH), 7.26 (t, 1H, *J* = 7.0, ArH), 7.44–7.49 (m, 2H, ArH), 7.61 (m, 2H, NH and ArH), 8.36 (s, 1H, NH); ^{13}C NMR (DMSO-d_6): δ_C 73.45, 112.83, 114.61, 115.10, 115.42, 115.70, 117.99, 119.71, 128.04, 128.97, 129.09, 129.35, 134.34, 137.41, 147.22, 148.25, 163.03; MS (70 eV, electron impact) *m/z*: 333 (M^+, 40), 241 (40), 178 (40), 120 (65), 92 (65), 77 (100), 77 (100), 51 (30), 39 (30); Anal. Calcd for $C_{20}H_{16}FN_3O$: C, 72.06; H, 4.84; N, 12.61; Found: C, 72.10; H, 4.73; N, 12.54.

Acknowledgments. We gratefully acknowledge the financial support from the Research Council of Islamic Azad University, Sabzevar Branch.

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