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PII: S0040-4020(16)30852-3

DOI: 10.1016/j.tet.2016.08.067

Reference: TET 28048

To appear in: *Tetrahedron*

Received Date: 1 May 2016

Revised Date: 6 August 2016

Accepted Date: 23 August 2016

Please cite this article as: Keivanloo A, Kazemi SS, Nasr-Isfahani H, Bamoniri A, Novel multi-component synthesis of 1,4-disubstituted pyrrolo[1,2-*a*]quinoxalines through palladium-catalyzed coupling reaction/ hetero-annulation in water, *Tetrahedron* (2016), doi: 10.1016/j.tet.2016.08.067.

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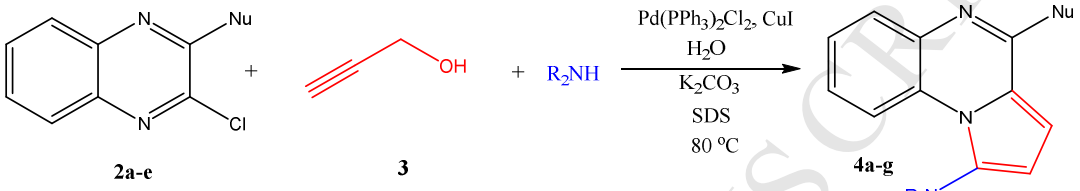

2a-e **3** **4a-g**

NuH: morpholine, pyrrolidine, piperidine, methanol, ethanol

R_2NH: morpholine, piperidine, pyrrolidine

1,4-Disubstituted pyrrolo[1,2-a]quinoxalines were prepared through the one-pot multi-component reactions of 3-substituted-2-chloroquinoxalines, propargyl alcohol, and secondary amines, catalyzed by Pd/Cu, in the presence of K_2CO_3 and sodium dodecyl sulfate (SDS) in water. This process provided a facile, eco-friendly, and highly efficient method for the synthesis of new pyrrolo[1,2-a]quinoxalines in water with good yields.

Novel multi-component synthesis of 1,4-disubstituted pyrrolo[1,2-a]quinoxalines through palladium-catalyzed coupling reaction/hetero-annulation in water

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Abstract- 1,4-Disubstituted pyrrolo[1,2-a]quinoxalines were prepared through the one-pot multi-component reactions of 3-substituted-2-chloroquinoxalines, propargyl alcohol, and secondary amines, catalyzed by Pd/Cu, in the presence of K_2CO_3 and sodium dodecyl sulfate (SDS) in water. This process provided a facile, eco-friendly, and highly efficient method for the synthesis of new pyrrolo[1,2-a]quinoxalines in water with good yields.

1. Introduction

Multi-component reactions[1] (MCRs) are powerful and popular chemical methods for the construction of novel molecular structures and for drug discovery[2] in modern synthetic organic chemistry. The main advantages of MCRs are high atom economy, energy saving, low cost, short reaction time, and avoiding time-consuming purification processes.[3] Typically, MCRs are environmentally friendly, allowing access to a large number of compounds with diverse functionalities, without any

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protection and deprotection steps, for possible combinatorial surveys of structural variations.[4] Therefore, the discovery of new MCRs and improving known MCRs are area of current significant interest.

Nitrogen countaing heterocycles are present in a wide spectrum of organic molecules, and they are foremost in synthetic chemistry. Quinoxalines, which are an important class of nitrogen-containing heterocyclic compounds, have diverse biological properties such as anti-HIV,[5] anti-cancer,[6] and anti-inflammatory[7]. Pyrrolo[1,2-a]quinoxalines and their analogues have outstanding roles in natural products,[8] displaying broad pharmacological activities such as anti-tumor,[9] adenosine A_3 receptor modulator,[10] anti-parasitic,[11] and anti-HIV.[12] Moreover, they are significant intermediates for the construction of 5-HT_3 receptor agonists.[13] Consequently, the progression of novel and highly efficient methods for the synthesis of pyrrolo[1,2-a]quinoxaline derivatives is highly favorable for drug discovery.

Cross-coupling reactions catalyzed by transition metals are important processes for building new carbon-carbon bonds.[14] Recently, the palladium-catalyzed coupling reactions of terminal acetylenic compounds with aromatic halides have been used in the synthesis of different compounds such as heterocycles, a number of natural products,[15] and pharmaceuticals.[16]

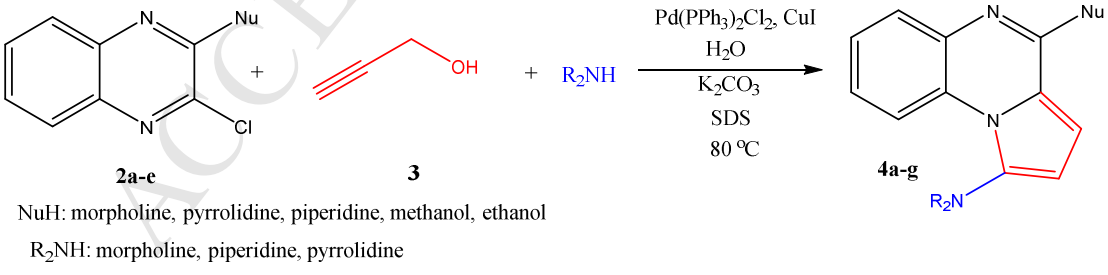
Organic solvents are usually used as the reaction media in most catalytic reactions, mostly causing a great deal of safety, health, and environmental hazards due to their toxicity, flammability, and volatility. Due to the economic and environmental viewpoints, it is favorable to avoid the use of hazardous and expensive organic solvents. One of the most economically and environmentally viable alternatives to organic solvents is the use of water as the solvent or aqueous medium for the reactions catalyzed by palladium salts.[17]

Many methods have been reported for the synthesis of pyrrolo[1,2-a]quinoxaliens such as the 1,3-dipolar cycloaddition reaction,[18] three-component reaction of 1,2-diamines, ethyl pyruvate, and α-bromo ketones,[19] hydroamination and hydroarylation of pyrrolo-substituted anilines and alkynes by gold catalyst,[20] reaction of α-amino acids with 1-(2-halophenyl)-*1H*-pyrroles via a copper catalyst in aerobic oxidative domino reaction,[21] and one-pot coupling/hydrolysis/condensation of 2-halotrifluoroacetanilides with pyrrolo-2-carboxylate esters.[22]

2. Results and discussion

Continuing our studies directed toward efficient and straightforward synthesis of biologically-active molecules based on the quinoxaline ring system through palladium-catalyzed reactions,[23-26] we carried out the synthesis of new derivatives of 1,4-disubstituted pyrrolo[1,2-a]quinoxaline via MCRs of 3-substituted-2-chloroqunoxalines, propargyl alchohol, and secondary amines, catalyzed by Pd/Cu, in water, as the solvent (Scheme 1).

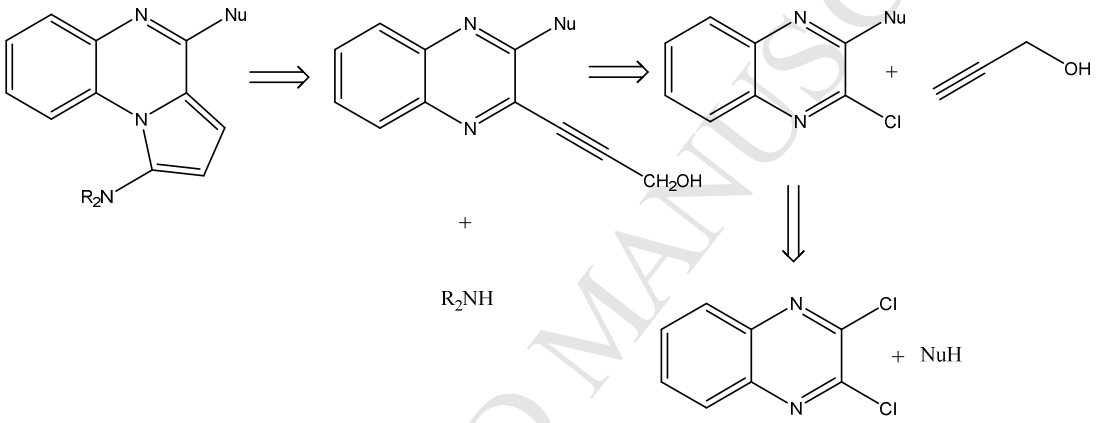
Scheme 1. Palladium-catalyzed coupling reaction/hetero-annulation of 3-substituted 2-chloroquinoxaline with propargyl alcohol and secondary amines in water[a].



[a] Reaction conditions: **2a-e** (1 mmol), **3** (1.2 mmol), a secondary amine (3 mmol), K_2CO_3 (3 mmol), $Pd(PPh_3)_2Cl_2$ (0.05 mmol), CuI (0.1 mmol), SDS (10 mol%), distilled H_2O (5 mL), 80 °C, 18 h, argon atmosphere.

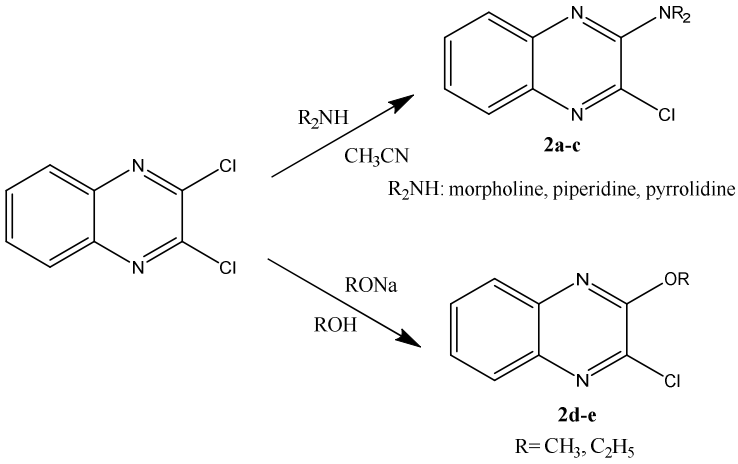
In order to introduce two substituents to the pyrrolo[1,2-a]quinoxaline-fused ring system, our retrosynthetic analysis revealed the use of a 3-substituted 2-chloroquioxaline, propargyl alcohol, and a secondary amine as the starting materials (Scheme 2). The palladium-catalyzed cross-coupling reaction is the key step in this process.

Scheme 2. Retrosynthetic analysis of 1,4-disubstituted-5*H*-pyrrolo[1,2-*a*]quinoxaline system.



Treatment of 2,3-dichloroquinoxaline with secondary amines in acetonitrile at 80 °C or sodium alkoxides in related alcohols at room temperature produced 3-substituted 2-dichloroquioxalines **2a-e** in 70-90% yields.[24,27] The results obtained are shown in Table 1 (Scheme 3).

Scheme 3. Synthesis of 3-substituted 2-chloroquioxalines from 2,3-dichloroquinoxaline and secondary amines or sodium alkoxides[a].



[a] Conditions: 2,3-Dichloroquinoxaline (1 mmol), an amine (2 mmol) at 80 °C in acetonitrile or sodium alkoxide (1 mmol) at room temperature in alcohol.

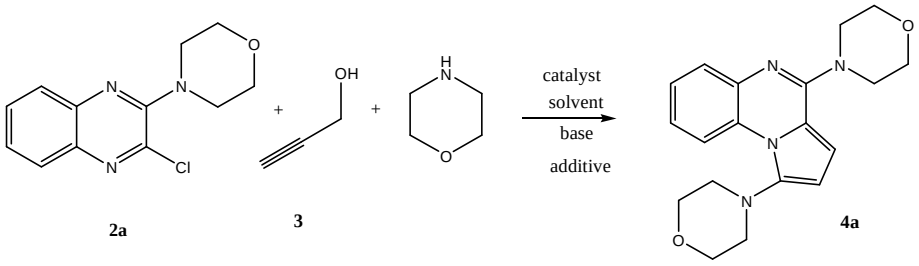
Table 1.
Melting points and yields of 3-substituted 2-chloroquinoxalines **2a-e** obtained from reactions of 2,3-dichloroquinoxaline with secondary amines or alkoxides.[a]

Entry	Amine/Alkoxide	Product	MP (°C)	Yield (%)
1	Morpholine [b]	**2a**	77-79	90
2	Piperidine [b]	**2b**	64-66	85
3	Pyrrolidine [b]	**2c**	71-73	75
4	Methoxide [c]	**2d**	65-67	85
5	Ethoxide [c]	**2e**	52-54	70

[a] Conditions: 2,3-Dichloroquinoxaline (1 mmol), an amine (2 mmol) or sodium alkoxide (1 mmol).
[b] At 80 °C in acetonitrile.
[c] At room temperature in methanol or ethanol.

When 2-chloro-3-morpholinoquinoxaline (**2a**) was reacted with propargyl alcohol (**3**) and morpholine in the presence of bis-triphenylphosphine palladium(II) chloride, copper(I) iodide, and Et_3N at 80 °C in DMF, 1,4-di(morpholin-4yl)pyrrolo[1,2-a]quinoxaline (**4a**) was obtained in 60% yield (Table 2, entry 1).

Table 2: Optimization table for one-pot synthesis of 1-morpholino-4-(piperidin-1-yl)pyrrolo[1,2-a]quinoxaline.[a]



2a **3** **4a**

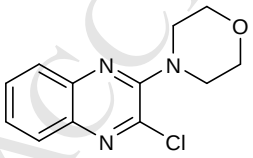
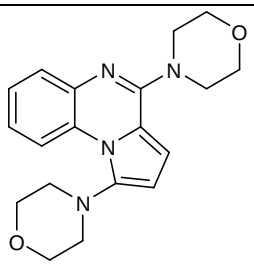
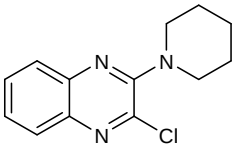
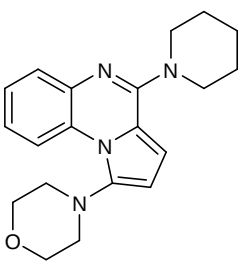
Entry	Solvent	Base	Catalyst	Co-Catalyst	SDS	Yield
1	DMF	Et_3N	$PdCl_2(PPh_3)_2$	CuI	-	60
2	DMF	Morpholine	$PdCl_2(PPh_3)_2$	CuI	-	75
3	DMF	K_2CO_3	$PdCl_2(PPh_3)_2$	CuI	-	45
4	CH_3CN	Et_3N	$PdCl_2(PPh_3)_2$	CuI	-	60
5	CH_3CN	Morpholine	$PdCl_2(PPh_3)_2$	CuI	-	75
6	CH_3CN	DIPEA	$PdCl_2(PPh_3)_2$	CuI	-	55
7	CH_3CN	Et_3N	Pd/C (10 mol%)	CuI	-	30
8	H_2O	K_2CO_3	$PdCl_2(PPh_3)_2$	CuI	5 mol%	66
9	H_2O	K_2CO_3	$PdCl_2(PPh_3)_2$	CuI	10 mol%	87
10	H_2O	K_2CO_3	Pd/C (10 mol%)	CuI	10 mol%	10
11	H_2O	K_2CO_3	$PdCl_2(PPh_3)_2$	-	10 mol%	20
12	H_2O	K_2CO_3	$PdCl_2(PPh_3)_2$	CuI	-	25
13	H_2O	Na_2CO_3	$PdCl_2(PPh_3)_2$	CuI	10 mol%	40

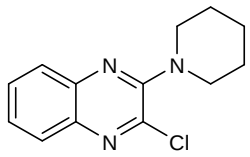
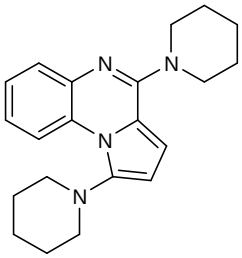
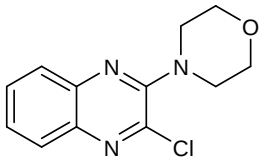
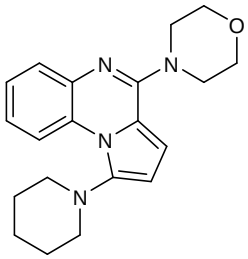
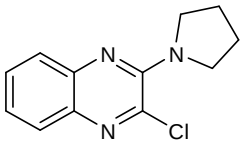
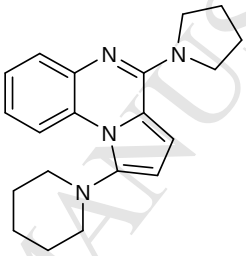
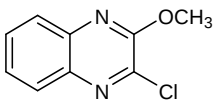
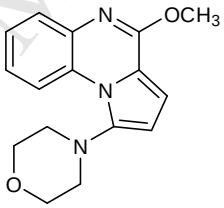
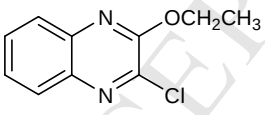
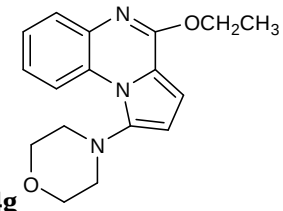
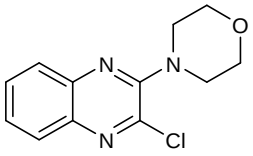
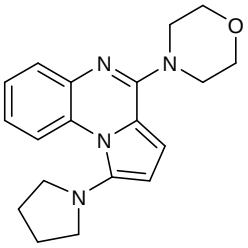
[a] Reaction conditions: **2a** (1 mmol), **3** (1.2 mmol), secondary amine (3 mmol), morpholine (3 mmol), catalyst (0.05 mmol), CuI (0.1 mmol), SDS, distilled solvent (5 mL), 80 ºC, 18 h, argon atmosphere.

The effects of the solvent, base, and catalyst used were studied, and the results obtained were tabulated in Table 2. We screened DMF, CH_3CN, and water as the solvent in the presence of an organic or inorganic base such as Et_3N, morpholine, DIPEA, and carbonate salts. Surprisingly, we found that water was an efficient

solvent for the reaction in the presence of sodium dodecyl sulfate (SDS). Potassium carbonate was found to be the most suitable base, giving a cleaner product and a better yield. The $Pd(PPh_3)_2Cl_2$-CuI catalytic system was found to be the optimal. Moreover, the use of CuI was found to be essential for the reaction progress; the reaction carried out without CuI led to only a 20% product. The effect of surfactant was also studied, and the surfactant inclusion was found to be critical for the success of the reaction; the product yield decreased significantly when no surfactant was used. In order to explore the scope and generality of this protocol, compounds **2a-e** were reacted with propargyl alcohol (**3**) and various secondary amines in the presence of bis-triphenylphosphine palladium(II) chloride, copper(I) iodide, sodium dodecyl sulfate (SDS), and potassium carbonate at 80 °C in water. 1,4-disubstituted pyrrolo[1,2-a]quinoxalines **4a-h** were obtained in moderate to high yields. The results obtained are shown in Table 3. The reactions were performed under an argon atmosphere and degassed water.

Table 3: Synthesis of 1,4-disubstituted pyrrolo[1,2-a]quinoxalines.

Entry	3-Substituted 2-chloroquinoxaline	Product	Mp (°C)	Yield (%)
1		 **4a**	133-135	87
2		 **4b**	116-117	65

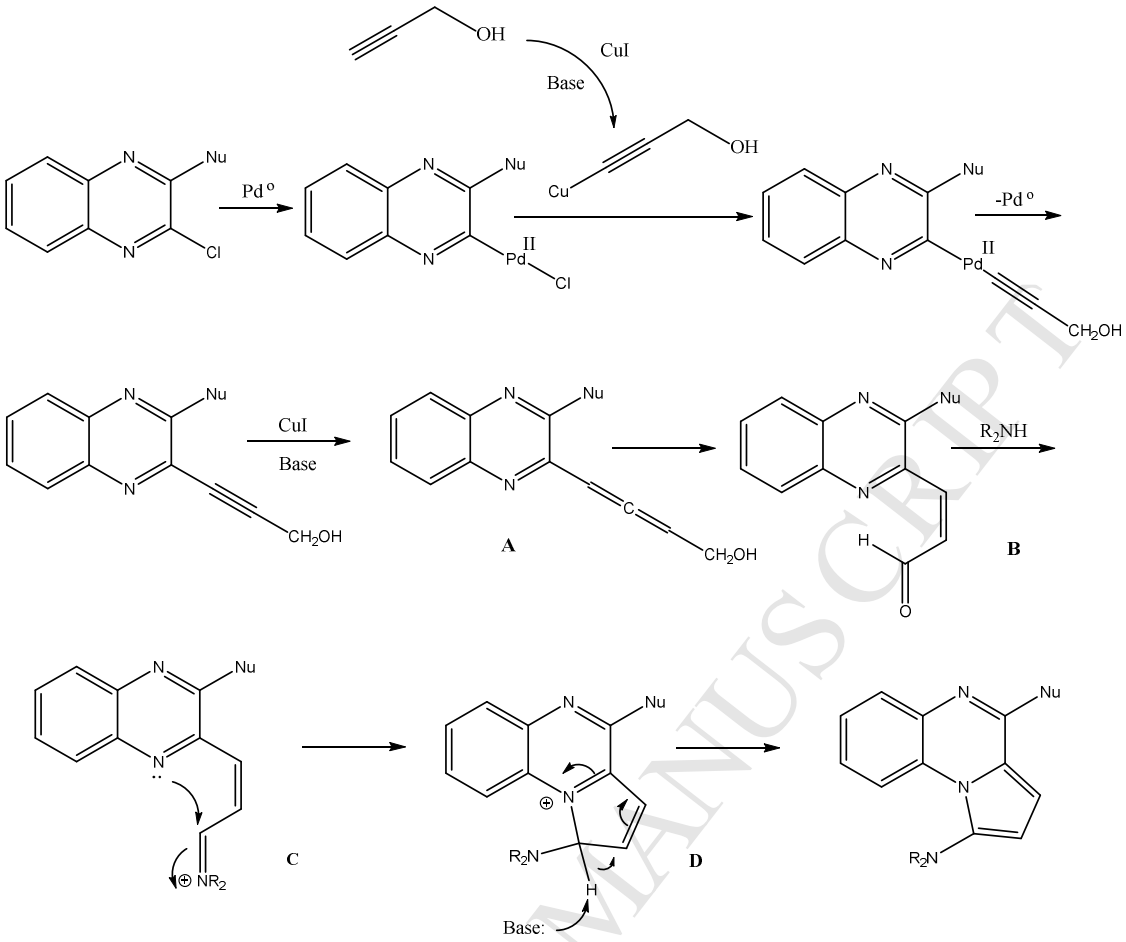
3		 **4c**	119-120	71
4		 **4d**	122-123	68
5		 **4e**	121-122	70
6		 **4f**	116-118	75
7		 **4g**	123-125	70
8		 **4h**	119-121	78

[a] Reaction conditions: **2** (1 mmol), **3** (1.2 mmol), secondary amine (3 mmol), K_2CO_3 (3 mmol), $Pd(PPh_3)_2Cl_2$ (0.05 mmol), CuI (0.1 mmol), SDS (10 mol%), distilled H_2O (5 mL), 80 ºC, 18 h, argon atmosphere.

The structural assignments of compounds **4a-h** were based on the NMR spectroscopic data and mass analysis. The ^{1}H NMR spectrum for 1,4-di(morpholin-4yl)pyrrolo[1,2-a]quinoxaline (**4a)** showed a doublet at δ 9.05, which is characteristic of an aromatic proton at position 9 of the heterocyclic system; it was deshielded by the diamagnetic pyrrole ring current. The other three aromatic protons in the quinoxaline ring appeared at δ 7.25-7.67. The two doublets at δ 6.71 and δ 6.38 were assigned to the two protons at positions 2 and 3 of the fused pyrrole ring. In the aliphatic region, we observed 16 protons of two morpholine substituents at positions 1 and 4 of this heterocyclic system at δ 2.92-4.03.

A plausible multi-step mechanism can be suggested for the reaction (Scheme 4). First a standard Sonogashira coupling takes place by a Pd^0/Cu^I catalyzed reaction, followed by a Cu(I)-catalyzed isomerization to the allene intermediate **A**, continuing to an enone aldehyde **B**, an iminium ion **C**, the intramolecular cyclization to the fused ring system **D**, and finally, a base-induced aromatization to afford the product.

Scheme 4. Proposed mechanism for formation of 1,4-disubstituted pyrrolo[1,2-a]quinoxalines from 3-substituted 2-chloroquinoxalines, propargyl alcohol, and secondary amines.



Conclusion

We have demonstrated an efficient and successful process for the synthesis of 1,4-disubstituted pyrrolo[1,2-a]quinoxalines via the multi-component reactions of 3-substituted-2-chloroqunoxalines, propargyl alcohol, and secondary amines, catalyzed by Pd/Cu, in water, as the solvent. Since water-based syntheses are safer and environmentally-friendly, the method described may hold promise in organic chemistry.

3. Experimental

3.1. General method

Palladium(II) chloride and propargyl alcohol were purchased from Sigma Aldrich Chemical Company. Triphenylphosphine, *N*,*N*-dimethylformamide, triethylamine, secondary amines, thin-layer chromatography (TLC) plates, silica gel (particle size,

100-200 mesh), and all the solvents used for the reactions were purchased from Merck. NMR spectra were recorded on Bruker 400 MHz ^{1}H NMR, 100 MHz ^{13}C NMR, 300 MHz ^{1}H NMR, and 75 MHz ^{13}C NMR spectrometers. ^{1}H NMR spectra were reported relative to Me_4Si (δ 0.0) or residual $CHCl_3$ (δ 7.26). ^{13}C NMR spectra were reported relative to $CDCl_3$ (δ 77.16). IR spectra were recorded on a Shimadzu IR-435 grating spectrophotometer. Mass spectra were recorded on a 5975C spectrometer manufactured by Agilent Technologies Company. Elemental analyses were performed on a Eager 300 for EA1112 microanalyzer.

1.1. Experimental procedures

*Synthesis of 2-chloro-3-amino quinoxalines **2a-c***

A mixture of 2,3-dichloroquinoxaline (1 mmol, 0.199 g) and a secondary amine (2 mmol) in acetonitrile was refluxed for 5 h. The complete consumption of the starting materials was monitored by TLC. After evaporation of the solvent, the resulting precipitate was washed with H_2O; it did not require any further purification.

*Synthesis of 2-chloro-3-alkoxyquinoxalines **2d-e***

A mixture of sodium (1 mmol, 0.023 g) and alcohol (3 mL) was stirred for 15 min at room temperature. Then 2,3-dichloroquinoxaline (1 mmol, 0.199 g) was added to the mixture until the complete consumption of the starting materials, monitored by TLC. After evaporation of the solvent, the resulting precipitate was washed with H_2O; it did not require any further purification.

*Synthesis of 1,4-disubstituted pyrrolo[1,2-a]quinoxalines **4a-h***

A mixture of a 3-substituted-2-chloroquinoxaline **2** (1 mmol), a secondary amine (3 mmol), $Pd(PPh_3)_2Cl_2$ (0.05 mmol, 0.036 g), CuI (0.1 mmol, 0.019 g), sodium dodecyl sulfate (0.1 mmol, 0.029 g), and K_2CO_3 (3 mmol, 0.414 g) was stirred in H_2O (5 mL) at room temperature under an argon atmosphere. Propargyl alcohol (1.2 mmol, 0.067 g) was then added, and the resulting mixture was stirred at 80 °C for 18 h. After completion of the reaction, the mixture was filtered, and the resulting solid was washed with H_2O and dried. The crude product was purified by column chromatography (silica gel 100) using $CHCl_3$–CH_3OH (99:1) as the eluent.

1,4-di(morpholin-4yl)pyrrolo[1,2-a]quinoxaline ***4a***

Yellow solid; mp 133-135 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.92-3.05 (m, 4H, $2NCH_2$), 3.67-4.03 (m, 12H, $2NCH_2$, $4OCH_2$), 6.38 (d, *J* = 4.4 Hz, 1H, CH of pyrrole), 6.71 (d, *J* = 4.4 Hz, 1H, CH of pyrrole), 7.25-7.46 (m, 2H, 2CH of quinoxaline), 7.67 (m, 1H, CH of quinoxaline), 9.05 (d, *J* = 7.6 Hz, 1H, CH of quinoxaline); ^{13}C NMR (75 MHz, $CDCl_3$): δ 49.2, 52.8, 66.8, 66.8, 67.0, 101.1, 105.5, 115.9, 116.9, 123.6, 124.8, 127.3, 127.6, 136.9, 153.5; IR (KBr): 2950, 2840, 1610, 1500, 1120 cm^{-1}; MS (EI), m/z $[M]^+$ 338; Anal. Calcd for $C_{19}H_{22}N_4O_2$: C, 67.44; H, 6.55; N, 16.56%. Found: C, 67.32; H, 6.52; N, 16.50%.

1-(morpholin-4-yl)-4-(piperidin-1-yl)pyrrolo[1,2-a]quinoxaline ***4b***

Yellow solid; mp 116-117 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 1.63-2.05 (m, 6H, $3CH_2$), 2.94-3.00 (m, 2H, NCH_2), 3.16-3.19 (m, 2H, NCH_2), 3.61-3.79 (m, 4H, $2NCH_2$), 3.90-4.01 (m, 4H, $2OCH_2$), 6.35 (d, *J* = 4.0 Hz, 1H, CH of pyrrole), 6.72 (d, *J* = 4.0 Hz, 1H, CH of pyrrole), 7.20-7.31 (m, 2H, 2CH of quinoxaline), 7.64-7.73 (m, 1H, CH of quinoxaline), 9.03 (d, *J* = 7.6 Hz, 1H, CH of quinoxaline); ^{13}C NMR (75

MHz, $CDCl_3$): δ 25.1, 26.1, 49.8, 52.8, 66.8, 100.8, 105.6, 115.9, 117.3, 122.9, 124.7, 126.9, 127.4, 137.2, 142.7, 154.1; IR (KBr): 2940, 2850, 1600, 1510, 1100 cm^{-1}; MS (EI), m/z $[M]^+$ 336; Anal. Calcd for $C_{20}H_{24}N_4O$: C, 71.40; H, 7.19; N, 16.65%. Found: C, 71.19; H, 7.14; N, 16.68%.

1,4-di(piperidin-1-yl)pyrrolo[1,2-a]quinoxaline ***4c***

Light brown solid; mp 119-120 °C; ^1H NMR (400 MHz, $CDCl_3$): δ 1.95-2.10 (m, 12H, $6CH_2$), 2.91-2.97 (m, 2H, NCH_2), 3.16-3.19 (m, 2H, NCH_2), 3.93-3.99 (m, 4H, $2NCH_2$), 6.33 (d, *J* = 4.0 Hz, 1H, CH of pyrrole), 6.79 (d, *J* = 4.4 Hz, 1H, CH of pyrrole), 7.07-7.11 (m, 1H, CH of quinoxaline), 7.22-7.30 (m, 1H, CH of quinoxaline), 7.47-7.54 (m, 1H, CH of quinoxaline), 9.01 (d, *J* = 8.4 Hz, 1H, CH of quinoxaline); ^{13}C NMR (75 MHz, $CDCl_3$): δ 24.0, 25.1, 25.7, 26.2, 49.9, 53.8, 100.4, 105.7, 116.2, 116.8, 122.8, 124.4, 126.6, 127.7, 137.0, 144.5, 154.1; IR (KBr): 2930, 2850, 1615, 1510, 1490 cm^{-1}; MS (EI), m/z $[M]^+$ 334; Anal. Calcd for $C_{21}H_{26}N_4$: C, 75.41; H, 7.84; N, 16.75%. Found: C, 75.25; H, 7.79; N, 16.66%.

4-(morpholin-4-yl)-1-(piperidin-1-yl)pyrrolo[1,2-a]quinoxaline ***4d***

Brown solid; mp 133-135 °C; ^1H NMR (300 MHz, $CDCl_3$): δ 1.82-1.95 (m, 6H, $3CH_2$), 2.62-2.70 (m, 2H, NCH_2), 3.28-3.36 (m, 2H, NCH_2), 3.71-3.72 (m, 4H, NCH_2), 3.91-3.92 (m, 4H, $2OCH_2$), 6.33 (d, *J* = 3.6 Hz, 1H, CH of pyrrole), 6.71 (d, *J* = 3.9 Hz, 1H, CH of pyrrole), 7.26-7.34 (m, 2H, 2CH of quinoxaline), 7.66-7.68 (m,1H, CH of quinoxaline), 9.06 (d, *J* = 7.8 Hz, 1H, CH of quinoxaline); ^{13}C NMR (75 MHz, $CDCl_3$): δ 24.0, 25.7, 49.2, 53.8, 67.0, 100.5, 105.47, 116.2, 116.4, 123.4, 124.5, 127.0, 127.9, 136.8, 144.7, 153.6; IR (KBr): 2950, 2850, 1615, 1520, 1105

cm^{-1}; MS (EI), m/z $[M]^+$ 336; Anal. Calcd for $C_{20}H_{24}N_4O$: C, 71.40; H, 7.19; N, 16.65%. Found: C, 71.63; H, 7.23; N, 16.53%.

1-(piperidin-1-yl)-4-(pyrrolidin-1-yl)pyrrolo[1,2-a]quinoxaline ***4e***

Yellow solid; mp 121-122 °C; ^1H NMR (300 MHz, $CDCl_3$): δ 1.90-1.94 (m. 10H, $5CH_2$), 2.78-2.95 (m, 2H, NCH_2), 3.06-3.10 (m, 2H, NCH_2), 3.81-3.87 (m, 4H, $2NCH_2$), 6.23 (d, *J* = 4.5 Hz, 1H, CH of pyrrole), 6.81 (d, *J* = 4.6 Hz, 1H, CH of pyrrole), 6.97-7.03 (m, 1H, CH of quinoxaline), 7.12-7.20 (m, 1H, CH of quinoxaline), 7.47 (m, 1H, CH of quinoxaline), 8.90-8.94 (d, *J* = 7.5 Hz, 1H, CH of quinoxaline); ^{13}C NMR (75 MHz, $CDCl_3$): δ 25.5, 40.6, 45.8, 49.1, 52.6, 100.5, 106.8, 115.9, 116.8, 121.0, 124.8, 125.5, 126.3, 138.1, 143.0, 150.0; IR (KBr): 2950, 2850, 1600, 1510, 1330 cm^{-1}; MS (EI), m/z $[M]^+$ 320; Anal. Calcd for $C_{20}H_{24}N_4$: C, 74.97; H, 7.55; N, 17.48%. Found: C, 75.10; H, 7.59; N, 17.50%.

4*-methoxy-1-(morpholin-4-yl)pyrrolo[1,2-a]quinoxaline* ***4f***

Light brown solid; mp 116-118 °C; ^1H NMR (300 MHz, $CDCl_3$): δ 2.85-2.92 (m, 2H, NCH_2), 3.06-3.10 (m, 2H, NCH_2), 3.60-3.81 (m, 4H, $2OCH_2$), 3.88 (s, 3H, OCH_3), 6.28 (d, *J* = 3.6 Hz, 1H, CH of pyrrole), 6.61 (d, *J* = 3.9 Hz, 1H, CH of pyrrole), 7.15-7.25 (m, 2H, 2CH of quinoxaline), 7.56-7.59 (m, 1H, CH of quinoxaline), 8.96 (d, *J* = 7.8 Hz, 1H, CH of quinoxaline); ^{13}C NMR (75 MHz, $CDCl_3$): δ 52.8, 55.2, 66.6, 101.3, 105.6, 115.7, 116.9, 123.5, 124.9, 127.3, 127.6, 136.8, 143.0, 153.5; IR (KBr): 2940, 2850, 1610, 1500, 1110 cm^{-1}; M (EI), m/z $[M]^+$ 283, Anal. Calcd for $C_{16}H_{17}N_3O_2$: C, 67.83; H, 6.05; N, 14.83%. Found: C, 67.65; H, 6.01; N, 14.75%.

4-ethoxy-1-(morpholin-4-yl)pyrrolo[1,2-a]quinoxaline ***4g***

Dark yellow solid; mp 123-125 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 1.17-1.26 (m, 3H, CH_3), 2.87-2.88 (m, 2H, NCH_2), 3.06-3.10 (m, 2H, NCH_2), 3.55-3.91 (m, 6H, $3OCH_2$), 6.28 (d, *J* = 4.2 Hz, 1H, CH of pyrrole), 6.62 (d, *J* = 4.2 Hz, 1H, CH of pyrrole), 7.16-7.24 (m, 1H, CH of quinoxaline), 7.30-7.40 (m, 1H, CH of quinoxaline), 7.44-7.64 (m, 1H, CH of quinoxaline), 8.95 (d, *J* = 8.2 Hz, 1H, CH of quinoxaline); ^{13}C NMR (75 MHz, $CDCl_3$): δ 14.8, 52.8, 66.4, 66.9, 101.1, 105.8, 115.9, 116.9, 123.6, 124.8, 127.2, 127.5, 136.6, 143.1, 153.1; IR (KBr): 2950, 2850, 1610, 1500, 1115 cm^{-1}; MS (EI) m/z $[M]^+$ 297; Anal. Calcd for $C_{17}H_{19}N_3O_2$: C, 68.67; H, 6.44; N, 14.13%. Found: C, 68.46; H, 6.42; N, 14.21%.

1-morpholino-4-(pyrrolidin-1-yl)pyrrolo[1,2-a]quinoxaline ***4h***

Yellow solid; mp 119-121 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 1.89-1.94 (m, 4H, $2CH_2$), 2.80-2.88 (m, 2H, NCH_2), 3.06-3.10 (m, 2H, NCH_2), 3.80-3.87 (m, 8H, $2NCH_2$, $2OCH_2$), 6.23 (d, *J* = 4.2 Hz, 1H, CH of pyrrole), 6.80 (d, *J* = 4.2 Hz, 1H, CH of pyrrole), 6.97-7.03 (m, 1H, CH of quinoxaline), 7.12-7.18 (m, 1H, CH of quinoxaline), 7.44-7.47 (m, 1H, CH of quinoxaline), 8.91 (d, *J* = 7.8 Hz, 1H, CH of quinoxaline); ^{13}C NMR (75 MHz, $CDCl_3$): δ 25.6, 49.1, 52.6, 66.81, 100.4, 106.6, 115.9, 116.9, 121.0, 124.8, 125.6, 126.4, 138.3, 142.9, 150.1; IR (KBr): 2940, 2850, 1615, 1520, 1110 cm^{-1}; MS (EI), m/z $[M]^+$ 322; Anal. Calcd for $C_{19}H_{22}N_4O$: C, 70.78; H, 6.88; N, 17.38%. Found: C, 70.85; H, 6.82; N, 17.44%.

Acknowledgment

We wish to express our thanks to the Research Council of the Shahrood University of Technology for the financial support of this work.

Supporting Information

Supporting information for this article is available. Copies of the ^{1}H and ^{13}C spectra of all new compounds were provided.

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