HETEROCYCLES, Vol. 98, No. 11, 2019, pp. 1563 - 1573. © 2019 The Japan Institute of Heterocyclic Chemistry
Received, 28th September, 2019, Accepted, 30th October, 2019, Published online, 7th November, 2019
DOI: 10.3987/COM-19-14162

ONE-POT SYNTHESIS OF PYRROLO[2,1-*a*]ISOQUINOLINES VIA TANDEM REACTIONS OF VINYLSELENONIUM SALT, 2-BROMOETHANONES, AND ISOQUINOLINE

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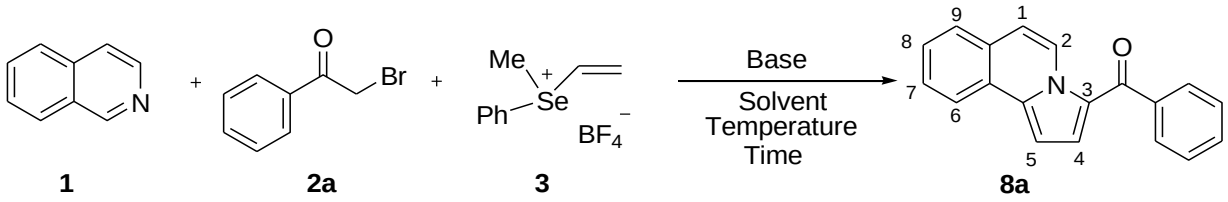
Abstract – An convenient and one-pot synthesis of pyrrolo[2,1-*a*]isoquinolines via the tandem reaction of methyl(phenyl)vinylselenonium salt with isoquinoline and 2-bromoethanones has been developed, which features very mild conditions, available substrates, simple experimental procedures, moderate to good yields, and wide functional group tolerance.

As a class of important nitrogen-containing heterocycles, pyrrolo[2,1-*a*]isoquinoline derivatives are widely found in marine alkaloids[1] such as gephyrotoxin,[1e] lamellarines,[1f] and jamtines,[1g] and exhibit a wide array of biological activities,[2a-d] such as *anti*-inflammatory, cardiovascular, antidepressant, anticancer and HIV-1 integrase inhibiting activities. Pyrrolo[2,1-*a*]isoquinolines also have applications in material science as organic light-emitting devices, biological markers, and dyes.[2e-g] Therefore, pyrrolo[2,1-*a*]isoquinolines with diverse substituents have become important synthetic targets.[3] As a part of our program on developing a convenient and efficient method to valuable pyrrolo[2,1-*a*]isoquinolines using trivalent, tricoordinated selenonium salts, we were particularly interested in finding efficient approaches to 2,3-unsubstituted pyrrolo[2,1-*a*]isoquinolines because they are important precursors of the synthesis of potently cytotoxic analogues of the marine alkaloid lamellarin D.[4] Among the existing synthetic protocols to pyrrolo[2,1-*a*]isoquinolines[5-8] such as cycloadditions,[5] 1,5-electrocyclizations,[6] and transition metal catalyzed carbon-nitrogen bond formation reactions,[7] however, the methodologies to

directly construct 2,3-unsubstituted pyrrolo[2,1-*a*]isoquinolines are few and conventionally required multiple steps and special alkene substrates such as nitroketene dithioacetals.[5g,h] The 2,3-unsubstituted 1-acylpyrrolo[2,1-*a*]isoquinolines were obtained by Xu's group via a cascade reaction between isoquinolinium ylide and maleic anhydride, including the 1,3-dipolar cycloaddition reaction, the oxidative bisdecarboxylation, and the subsequent dehydrogenative aromatization.[9] However, this elegant method required an excess of oxidant and high temperature. Recently, Jørgensen has reported an efficient synthesis of indolizines via 5-*exo*-dig aza-Conia-ene reaction, but only one example of 2,3-unsubstituted 1-acylpyrrolo[2,1-*a*]isoquinoline was presented.[10] Xiao[11] has reported a synthetic method of 2,3-unsubstituted pyrrolo[2,1-*a*]isoquinolines via 1,3-dipolar cycloaddition of stabilized isoquinolinium *N*-ylides with diphenyl(vinyl)sulfonium salt. Inspired by Xiao's work[11] and considering that vinyl-selenonium salts have the same reaction properties as the vinylsulfonium salts, and this kind of trivalent and tricoordinated selenonium salts have been established as valuable and versatile intermediates;[12] furthermore, the isoquinolinium *N*-ylides are easily formed at room temperature via the *N*-alkylation of isoquinoline with 2-bromoethanones,[11] we envisioned that the *N*-alkylation of isoquinoline and the cascade reactions of vinylselenonium salt could be performed in one-pot procedure to access the 2,3-unsubstituted pyrrolo[2,1-*a*]isoquinolines efficiently. Herein, we report a tandem reaction of the methyl(phenyl)vinylselenonium salt with isoquinoline and 2-bromoethanones to access 2,3-unsubstituted pyrrolo[2,1-*α*]isoquinolines efficiently and conveniently under mild conditions and in moderate to good yields. To the best of our knowledge, this is the first reported one-pot synthesis of the pyrrolo[2,1-*a*]isoquinolines by using the methyl(phenyl)vinylselenonium salt as the Michael acceptors against nucleophiles to produce saturated alkyl ylides, which are among the most important synthons of the carbon-carbon bond.

Initially, isoquinoline **1** and 2-bromo-1-phenylethanone **2a**[13a] were chosen as model substrates with methyl(phenyl)vinylselenonium tetrafluoroborate **3**[13b] as the selenium (Ⅲ) source. As depicted in Table 1, this reaction was rather sluggish in the absence of a base, and pyrrolo[2,1-*a*]isoquinoline **8a** was formed in less than 5% yield when 2.0 equivalents of K_2CO_3 and 1.0 equivalent of 1,4-diazabicyclo[2.2.2]octane (DABCO) were used (Table 1, entries 1, 20, 7, and 14). A survey of several bases and solvents revealed that DMF was optimal and DABCO was confirmed to be better than other bases (Table 1, entries 2-12). We then screened the amount of the base and found that at least 3.0 equivalents of DABCO was needed in the cascade reaction, and the product **8a** was obtained in 65% yield when the reaction was performed in the presence of 3.0 or 5.0 equivalents of DABCO in DMF at room temperature for 34 hours (Table 1, entries 17 and 19). The yield was slightly decreased when the reaction time was extended to 2 days (Table 1, entries 13 and 15) whereas the yield was less than 50% when the reaction was performed at 40 °C for 48 hours or at room temperature for one day (Table 1, entries 16 and 18).



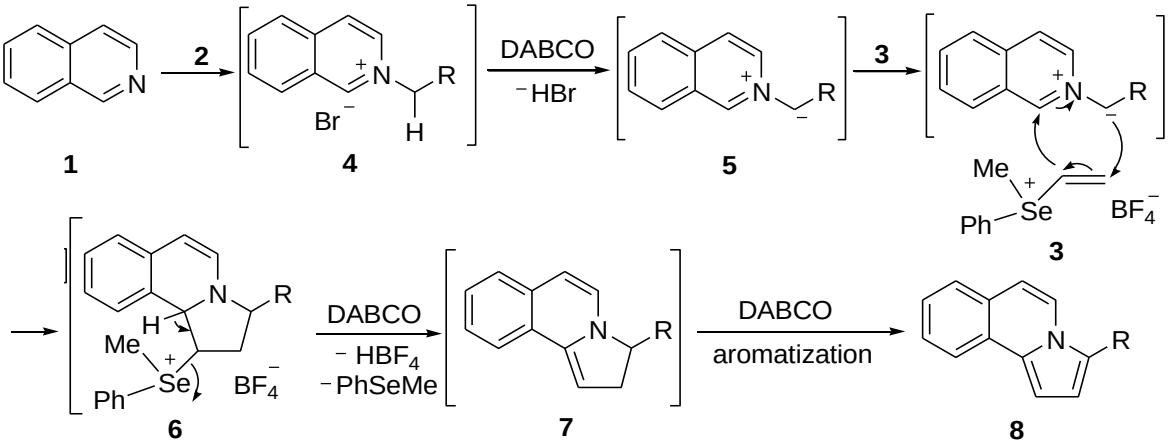
Scheme 1. Synthesis of pyrrolo[2, 1-*a*]isoquinoline **8a**

Table 1. Optimization of the reaction of selenonium salt **3** with **1** and **2a**[a]

Entry	Base	Amount of Base (equiv)	Solvent[b]	Temperature (°C)	Time (h)	Isolated yield of **8a** (%)
1	-	-	DCM	rt	48	nr
2	DBU	2.0	DCM	rt	48	36
3	NaH	2.0	DCM	rt	48	32
4	*t*-BuOK	2.0	DCM	rt	48	33
5	$CsCO_3$	2.0	DCM	rt	48	27
6	Et_3N	2.0	DCM	rt	48	18
7	K_2CO_3	2.0	DCM	rt	48	<5
8	DABCO	2.0	DCM	rt	48	18
9	DBU	2.0	DMF	rt	48	46
10	DABCO	2.0	DMF	rt	48	52
11	DABCO	2.0	MeCN	rt	48	26
12	DABCO	2.0	THF	rt	48	50
13	DABCO	3.0	DMF	rt	48	60
14	DABCO	1.0	DMF	rt	48	<5
15	DABCO	5.0	DMF	rt	48	61
16	DABCO	3.0	DMF	40	48	42
17	DABCO	3.0	DMF	rt	34	65
18	DABCO	3.0	DMF	rt	24	45
19	DABCO	5.0	DMF	rt	34	65
20	-	-	DMF	rt	48	nr

[a]The reaction was performed on a 0.5 mmol scale in 6 mL solvent, using 1.2 equiv. of selenonium **3**; the ratio of **1** and **2a** is 1:1; the solution of **1** and **2a** was stirred for 10 h to form isoquinolinium bromides **4** in situ. Then the base and selenonium **3** were added and the mixture was stirred for an additional time to obtain the target product **8a**.

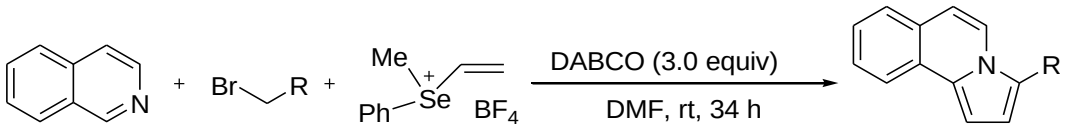
Mechanistically, isoquinolinium bromides **4** are derived in situ from isoquinoline (**1**) and 2-bromoethanones **2**. The deprotonation of the salts **4** with DABCO as a base generates isoquinolinium *N*-ylides **5** which takes part in a 1,3-dipolar cycloaddition with methyl(phenyl)vinylselenonium tetrafluoroborate (**3**) to form the intermediates **6**. The further elimination of methyl phenyl selenide and deprotonation of **6** in the presence of the base yields the intermediates **7** which subsequently undergoes aromatization to access pyrrolo[2,1-*a*]isoquinolines **8** (Scheme 2).



Scheme 2. Mechanistic hypothesis for the one-pot synthesis of pyrrolo[2,1-*a*]isoquinolines **8** via the tandem reaction of methyl(phenyl)vinylselenonium tetrafluoroborate (**3**) with isoquinoline (**1**) and 2-bromoethanones **2**

With the optimal conditions established, the scope of the substrate **2** was explored. As summarized in Table 2, this one-pot process appeared to be tolerant with respect to significant structural variations in 2-bromoethanones **2**. Various 2-bromoethanones **2** having phenyl group and the phenyl groups with electron-donating substituents, electron-withdrawing substituents, halogen substituents, and phenyl substituent take part in the reaction well and furnish the corresponding pyrrolo[2,1-*a*]isoquinolines **8** in moderate to good yields. (Table 2, entries 1-11, 13). Furthermore, the products **8b**-**8g** were obtained in good yields from the *o*-, *m*-, and *p*-halogen-substituted phenylethanones **2b**-**2h** (Table 2, entries 2-7). In addition, 2-bromo-1-(naphthalen-2-yl)ethanone **2l** could be successfully utilized for this transformation whereas the reaction of 2-bromoactonitrile **2n** only gave the product **8n** in 40% yield and isoquinolinium bromides **4n** was formed as the main by-product in 32% yield. Furthermore, the yield increased slightly when 1.5 equivalents of selenonium **3** was used (Table 2, entry 1).

Table 2. One-pot synthesis of pyrrolo[2,1-*a*]isoquinolines **8**



1 **2** **3** **8**

Entry	R	**2**	Product **8**	Yield of **8** (%)[a]
1	C_6H_5CO	**2a**	**8a**	65 (66[b])
2	2-FC_6H_4CO	**2b**	**8b**	70
3	2-ClC_6H_4CO	**2c**	**8c**	62
4	3-FC_6H_4CO	**2d**	**8d**	68
5	3-ClC_6H_4CO	**2e**	**8e**	60
6	4-FC_6H_4CO	**2f**	**8f**	75
7	4-ClC_6H_4CO	**2h**	**8g**	63
8	4-BrC_6H_4CO	**2g**	**8h**	68
9	4-$MeOC_6H_4CO$	**2i**	**8i**	53
10	4-MeC_6H_4CO	**2j**	**8j**	55
11	2,4-ClC_6H_3CO	**2k**	**8k**	69
12	2-naphthoyl	**2l**	**8l**	62
13	4-PhC_6H_4CO	**2m**	**8m**	67
14	CN	**2n**	**8n**	40

[a]The reaction was performed on a 0.5 mmol scale in 6 mL solvent, using 1.2 equiv. of selenonium **3**; the ratio of **1** and **2** is 1:1; the products **8** were obtained in isolated yields.
[b]1.5 equiv. of selenonium **3** was used.

In conclusion, we have developed an efficient and one-pot synthesis of pyrrolo[2,1-*a*]isoquinolines by a reaction sequence of *N*-alkylation/deprotonation/1,3-dipolar cyclization/deselenenylation/aromatization of isoquinoline, 2-bromoethanones, and methyl(phenyl)vinylselenonium salt. The target products were obtained in moderate to good yields. Furthermore, the easy workup procedure, mild reaction conditions, and the easily available substrates provide an approach that is well-suited for constructing the pyrrolo[2,1-*a*]isoquinoline frameworks. The further modifications of the pyrrolo[2,1-*a*]isoquinolines and the study on their bioactivities are currently ongoing.

EXPERIMENTAL

Melting points were measured with an X-6 micro-melting apparatus and were uncorrected. ^{1}H NMR and ^{13}C NMR spectra were recorded using Bruker Avance 400 MHz spectrometer in $CDCl_3$ with TMS as the internal standard; chemical shifts were quoted in ppm and *J* values were given in Hz. IR spectra were

recorded on a Thermo Nicolet Avatar 360 spectrometer. HRMS were performed on an Agllent LC/Msd TOF instrument. Dry CH_2Cl_2, DMF, and MeCN were distilled from CaH_2. Dry THF was distilled from Na. Acetone was dried over anhydrous $MgSO_4$. Isoquinoline **1** and bromoacetonitrile **1n** were purchased from Aladdin and Tansoole. 2-Bromoacetonphenones **2**[13a] and methyl(phenyl)vinylselenonium tetrafluoroborate **3**[13b] were prepared according to the literatures.

Typical procedure for the synthesis of methyl(phenyl)vinylselenonium tetrafluoroborate 3[13b]

To a THF solution of vinylmagnesium bromide (1.0 mol/L, 30 mL, 30 mmol) was added a solution of benzeneselenenyl bromide (7.08 g, 30.0 mmol) in dry THF (10 mL) dropwise at 0 °C over 1 h. After having been stirred for an additional 1 h the reaction mixture was warmed to room temperature and stirred for 3 h. Then the reaction mixture was diluted with aqueous NH_4Cl and extracted with Et_2O (3 × 50 mL). The ethereal solution was dried over $MgSO_4$ and concentrated under reduced pressure. Purification by column chromatography (silica gel, hexane, R_f = 0.7) gave phenyl vinyl selenide (3.29 g, 60%). To a solution of phenyl vinyl selenide (2.02 g, 11.00 mmol) in MeCN (5 mL) was added methyl iodide (5 mL, 80.32 mmol). The solution was cooled to 0 °C and silver tetrafluoroborate (2.50 g, 12.20 mmol) was added to the solution. The mixture was stirred for 5 h during which time silver iodide was precipitated. The precipitate was filtered and washed with CH_2Cl_2-hexane to give **3** (2.68 g) as a white solid in 85% yield. Mp 81-83 °C. ^{1}H NMR (400 MHz, DMSO-d_6): δ = 8.02-7.77 (m, 2H), 7.71-7.62 (m, 3H), 7.10 (dd, J_1 = 16.5, 9.0 Hz, 1H), 6.48 (dd, J_1 = 9.0, 2.3 Hz, 1H), 6.30 (dd, J_1 = 16.5, 2.3 Hz, 1H), 3.16 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ = 132.85, 132.76, 130.91, 130.84, 129.10, 127.88, 24.95 ppm; IR (KBr): υ_{max} = 3051, 1590, 1482, 1445, 1295, 975, 761 cm^{-1}; HRMS *m/z*: calcd for $C_9H_{11}Se$ $[M]^+$ 199.0020; found 199.0025.

General procedure for the synthesis of 1-acylpyrrolo[2,1-*a*]isoquinolines (8): Isoquinoline **1** (64.6 mg, 0.5 mmol) and 2-bormoethanones (**2a-2m**) or 2-bormoacetonitrile (**2n**) (0.5 mmol, 1.0 equiv) in DMF (0.50 mL) were stirred at room temperature in a test tube with a stopper for 10 h to form isoquinolinium salt **4** in situ. Then further DMF (5.5 mL) and methyl(phenyl)vinylselenonium trifluoroborate (**3**, 159.6 mg, 0.6 mmol) were added to the tube. The mixture was stirred for 5 min and was added DABCO (168.2 mg, 1.50 mmol). After the mixture was stirred for an additional 24 h (TLC monitoring), H_2O (15 mL) was added. Then the resultant mixture was extracted with EtOAc and the combined organic layer was dried over $MgSO_4$. After removal of the solvent in vacuum, the residue was purified by flash chromatography (silica gel, petroleum ether/EtOAc = 10/1) to give the desired products **8**.

Phenyl(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8a)[11]**:** Yellow solid, mp 144-145 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.62 (d, *J* = 7.6 Hz, 1H), 8.22-8.16 (m, 1H), 7.87-7.83 (m, 2H), 7.74 (dd, *J* = 7.4, 1.8

Hz, 1H), 7.61-7.46 (m, 5H), 7.32 (d, *J* = 4.5 Hz, 1H), 7.14 (d, *J* = 7.5 Hz, 1H), 7.06 (d, *J* = 4.5 Hz, 1H) ppm; IR (KBr): υ_{max} = 1611, 1574, 1468, 1450, 878, 751, 722, 690 cm^{-1}; HRMS *m/z*: calcd for $C_{19}H_{14}NO$ $[M+H]^+$ 272.1075; found 272.1080.

(2-Fluorophenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8b)[11]: Yellow solid, mp 161-162 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.66 (d, *J* = 7.6 Hz, 1H), 8.19 (dd, J_1 = 6.0, J_2 = 3.2 Hz, 1H), 7.78-7.72 (m, 1H), 7.63-7.47 (m, 4H), 7.29-7.17 (m, 5H), 7.05 (d, *J* = 4.5 Hz, 1H) ppm; IR (KBr): υ_{max} = 1601, 1484, 1469, 1452, 882, 746 cm^{-1}; HRMS *m/z*: calcd for $C_{19}H_{13}FNO$ $[M+H]^+$ 290.0981; found 290.0982.

(2-Chlorophenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8c)[11]: Yellow solid, mp 206-207 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.56 (d, *J* = 7.6 Hz, 1H), 8.22-8.18 (m, 1H), 7.80 (d, *J* = 2.0 Hz, 1H), 7.79 (d, *J* = 2.0 Hz, 1H), 7.76-7.73 (m, 1H), 7.62-7.56 (m, 2H), 7.50-7.46 (m, 2H), 7.29 (d, *J* = 4.6 Hz, 1H), 7.16 (d, *J* = 7.6 Hz, 1H), 7.07 (d, *J* = 4.5 Hz, 1H) ppm; IR (KBr): υ_{max} = 1612, 1468, 1450, 786, 746 cm^{-1}; HRMS *m/z*: calcd for $C_{19}H_{13}ClNO$ $[M+H]^+$ 306.0686; found 306.0685.

(3-Fluorophenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8d): Yellow solid, mp 168-169 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.59 (d, *J* = 7.5 Hz, 1H), 8.41-8.07 (m, 1H), 7.74 (dd, *J* = 6.7, 2.4 Hz, 1H), 7.66-7.51 (m, 4H), 7.51-7.40 (m, 1H), 7.32 (d, *J* = 4.6 Hz, 1H), 7.26 (d, *J* = 3.1 Hz, 1H), 7.15 (d, *J* = 7.6 Hz, 1H), 7.07 (d, *J* = 4.5 Hz, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ = 183.64, 162.46 (d, *J* = 247.5 Hz), 142.72, 137.40, 129.88, 129.84 (d, *J* = 7.7 Hz), 128.27, 127.88, 126.99, 125.93 (d, *J* = 25.4 Hz), 124.86, 124.83, 124.61, 123.76, 118.04 (d, *J* = 21.1 Hz), 116.16, 115.93, 113.67, 102.27 ppm; IR (KBr): υ_{max} = 1600, 1484, 1465, 1451, 880, 790, 706 cm^{-1}; HRMS *m/z*: calcd for $C_{19}H_{13}FNO$ $[M+H]^+$ 290.0981; found 290.0977.

(3-Chlorophenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8e)[11]: Yellow solid, mp 195-196 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.59 (d, *J* = 7.5 Hz, 1H), 8.22-8.16 (m, 1H), 7.83-7.80 (m, 1H), 7.75-7.70 (m, 2H), 7.62-7.52 (m, 3H), 7.45-7.41 (m, 1H), 7.30 (d, *J* = 4.5 Hz, 1H), 7.15 (d, *J* = 7.6 Hz, 1H), 7.07 (d, *J* = 4.5 Hz, 1H) ppm; IR (KBr): υ_{max} = 1611, 1560, 1465, 806, 790, 726 cm^{-1}; HRMS *m/z*: calcd for $C_{19}H_{13}ClNO$ $[M+H]^+$ 306.0686; found 306.0680.

(4-Fluorophenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8f)[11]: Yellow solid, mp 189-190 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.56 (d, *J* = 7.6 Hz, 1H), 8.19 (d, *J* = 7.2 Hz, 1H), 7.87 (dd, *J* = 5.6, 8.0 Hz, 2H), 7.76-7.72 (m, 1H), 7.62-7.54 (m, 2H), 7.29 (d, *J* = 4.5 Hz, 1H), 7.22-7.12 (m, 3H), 7.07 (d, *J* = 4.5 Hz, 1H) ppm; IR (KBr): υ_{max} = 1610, 1589, 1450, 885 cm^{-1}; HRMS *m/z*: calcd for $C_{19}H_{13}FNO$ $[M+H]^+$ 290.0981; found 290.0979.

(4-Chlorophenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8g)[11]: Yellow solid, mp 206-208 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.58 (d, *J* = 7.6 Hz, 1H), 8.20-8.17 (m, 1H), 7.79 (d, *J* = 8.4 Hz, 2H), 7.76-7.72 (m, 1H), 7.61-7.54 (m, 2H), 7.48 (d, *J* = 8.0 Hz, 2H), 7.28 (d, *J* = 4.5 Hz, 1H), 7.14 (d, *J* = 7.6 Hz, 1H), 7.06 (d, *J* = 4.5 Hz, 1H) ppm; IR (KBr): υ_{max} = 1610, 1465, 878 cm^{-1}; HRMS *m/z*: calcd for

$C_{19}H_{13}ClNO$ $[M+H]^+$ 306.0686; found 306.0689.

(4-Bromophenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8h)[11]**:** Yellow solid, mp 215-216 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.57 (d, *J* = 7.6 Hz, 1H), 8.20-8.16 (m, 1H), 7.75-7.61 (m, 5H), 7.59-7.55 (m, 2H), 7.27 (d, *J* = 4.5 Hz, 1H), 7.14 (d, *J* = 7.6 Hz, 1H), 7.06 (d, *J* = 4.5 Hz, 1H) ppm; IR (KBr): υ_{max} = 1606, 1467, 878, 796 cm^{-1}; HRMS *m/z*: calcd for $C_{19}H_{13}BrNO$ $[M+H]^+$ 350.0181; found 350.0180.

(4-Methoxyphenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8i)[11]**:** Yellow solid, mp 186-188 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.53 (d, *J* = 7.6 Hz, 1H), 8.16 (d, *J* = 7.6 Hz, 1H), 7.86 (d, *J* = 8.4 Hz, 2H), 7.72-7.70 (m, 1H), 7.56-7.51 (m, 2H), 7.31 (d, *J* = 4.4 Hz, 1H), 7.09 (d, *J* = 7.6 Hz, 1H), 7.04 (d, *J* = 4.4 Hz, 1H), 7.00 (d, *J* = 8.8 Hz, 2H), 3.89 (s, 3H) ppm; IR (KBr): υ_{max} = 1604, 1451, 1175, 841, 796 cm^{-1}; HRMS *m/z*: calcd for $C_{20}H_{16}NO_2$ $[M+H]^+$ 302.1181; found 302.1180.

(4-Methylphenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8j)[11]**:** Yellow solid, mp 168-170 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.58 (d, *J* = 7.6 Hz, 1H), 8.18-8.16 (m, 1H), 7.76 (d, *J* = 8.0 Hz, 2H), 7.73-7.70 (m, 1H), 7.59-7.53 (m, 2H), 7.33-7.28 (m, 3H), 7.11 (d, *J* = 7.6 Hz, 1H), 7.04 (d, *J* = 4.5 Hz, 1H), 2.45 (s, 3H) ppm; IR (KBr): υ_{max} = 1601, 1466, 1452, 1348, 879 cm^{-1}; HRMS *m/z*: calcd for $C_{20}H_{16}NO$ $[M+H]^+$ 286.1232; found 286.1230.

(2,4-Dichlorophenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8k)[13]**:** Yellow solid, mp 175-176 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.65 (d, *J* = 7.6 Hz, 1H), 8.18-8.16 (m, 1H), 7.76-7.74 (m, 1H), 7.63-7.56 (m, 2H), 7.50 (d, *J* = 2.0 Hz, 1H), 7.42 (d, *J* = 8.4 Hz, 1H), 7.35 (dd, J_1 = 8.4, 2.0 Hz, 2H), 7.19 (d, *J* = 7.6 Hz, 1H), 7.04-7.00 (m, 2H) ppm; IR (KBr): υ_{max} = 1606, 1464, 1451, 849, 733 cm^{-1}; HRMS *m/z*: calcd for $C_{19}H_{12}Cl_2NO$ $[M+H]^+$ 340.0296; found 340.0299.

(2-Naphthalenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8l)[9]**:** Yellow solid, mp 215-216 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.64 (d, *J* = 7.6 Hz, 1H), 8.39 (s, 1H), 8.28-8.23 (m, 1H), 7.94-8.02 (m, 4H), 7.81-7.75 (m, 1H), 7.57-7.65 (m, 4H), 7.41 (d, *J* = 4.4 Hz, 1H), 7.20 (d, *J* = 7.6 Hz, 1H), 7.12 (d, *J* = 4.4 Hz, 1H) ppm; IR (KBr):. IR (KBr): υ_{max} = 1605, 1591, 1450, 1112, 752 cm^{-1}; HRMS *m/z*: calcd for $C_{23}H_{16}NO$ $[M+H]^+$ 322.1232; found 322.1230.

(4-Phenylphenyl)(pyrrolo[2,1-*a*]isoquinolin-3-yl)methanone (8m)[9]**:** Yellow solid, mp 236-238 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 9.63 (d, *J* = 7.6 Hz, 1H), 8.24-8.17 (m, 1H), 7.95 (d, *J* = 8.0 Hz, 2H), 7.66-7.76 (m, 5H), 7.56-7.62 (m, 2H), 7.53-7.50 (m, 2H), 7.44 (d, *J* = 7.2 Hz, 1H), 7.40 (d, *J* = 4.4 Hz, 1H), 7.17 (d, *J* = 7.6 Hz, 1H), 7.11 (d, *J* = 4.4 Hz, 1H) ppm; IR (KBr): υ_{max} = 1610, 1578, 1469, 1450, 879, 760, 736 cm^{-1}; HRMS *m/z*: calcd for $C_{25}H_{18}NO$ $[M+H]^+$ 348.1388; found 348.1385.

Pyrrolo[2,1-*a*]isoquinoline-3-carbonitrile (8n)[9]**:** White solid, mp 98-99 °C. ^1H NMR (400 MHz, $CDCl_3$): δ = 8.09 (d, *J* = 7.6 Hz, 1H), 8.06 (d, *J* = 7.2 Hz, 1H), 7.68 (d, *J* = 7.6 Hz, 1H), 7.61-7.50 (m, 2H), 7.30 (d, *J* = 4.4 Hz, 1H), 7.06 (d, *J* = 7.2 Hz, 1H), 6.97 (d, *J* = 4.4 Hz, 1H) ppm; IR (KBr): υ_{max} = 2217, 1455, 790, 739 cm^{-1}; HRMS *m/z*: calcd for $C_{13}H_9N_2$ $[M+H]^+$ 193.0766; found 193.0765.

ACKNOWLEDGEMENTS

This work was supported by the Program for Changjiang Scholars and Innovative Research Team in University (IRT13095), the Natural Science Foundation of China (NSFC 21762046), the Program for Young and Middle-Aged Academic and Technical Leaders in Yunnan Province (2014HB001), Yunnan University Youth Talent, the Program for Yunnan Province Department of Science and Technology-Yunnan University Joint Fund (2018FY001).

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