Rong-Zhang Jin, Yu-Ling Li and Xiang-Shan Wang*

An efficient synthesis of 11-aryl-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo [4′,5′:3,4]benzo[1,2-*b*][1,6]naphthyridine derivatives under catalyst-free conditions

DOI 10.1515/hc-2015-0050
Received March 26, 2015; accepted August 3, 2015; previously published online November 5, 2015

Abstract: A three-component reaction of an aromatic aldehyde, 1*H*-benzo[*d*][1,2,3]triazol-5-amine and *tert*-butyl 2,4-dioxopiperidine-1-carboxylate in refluxing EtOH under catalyst-free conditions furnishes the title compounds in high yields.

Keywords: catalyst-free; three-component reaction; triazolobenzonaphthyridine.

Introduction

Naphthyridines are an important class of heterocycles with significant pharmacological and biological activities, especially antibacterial activity [1–5]. Many triazoles are also bioactive [6]. To the best of our knowledge, only one example of a triazolobenzonaphthyridine has been described in the literature concerning the synthesis and potential application as an antimicrobial agent [7]. As a continuation of our research devoted to the development of new methods for preparing heterocycles via multicomponent reactions [8–12], we now report the synthesis of a series of substituted triazolobenzonaphthyridines **4** by a three-component reaction of an aromatic aldehyde, 1*H*-benzo[*d*][1,2,3]triazol-5-amine and *tert*-butyl 2,4-dioxopiperidine-1-carboxylate (Scheme 1).

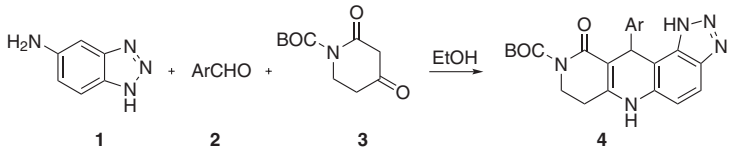
***Corresponding author: Xiang-Shan Wang,** School of Chemistry and Chemical Engineering, Jiangsu Key Laboratory of Green Synthetic Chemistry for Functional Materials, Jiangsu Normal University, Xuzhou, Jiangsu 221116, P.R. China, e-mail: xswang1974@yahoo.com
Rong-Zhang Jin and Yu-Ling Li: School of Chemistry and Chemical Engineering, Jiangsu Key Laboratory of Green Synthetic Chemistry for Functional Materials, Jiangsu Normal University, Xuzhou, Jiangsu 221116, P.R. China

Results and discussion

The required benzotriazolamine **1** was prepared in a two-step procedure starting with commercially available 4-nitrobenzene-1,2-diamine as described in the literature [13]. Subsequently, the amine **1** was allowed to react with equimolar amounts of aromatic aldehyde **2** and *tert*-butyl 2,4-dioxopiperidine-1-carboxylate (**3**) in ethanol under reflux conditions. This reaction produced the desired product **4** in high yield (Scheme 1).

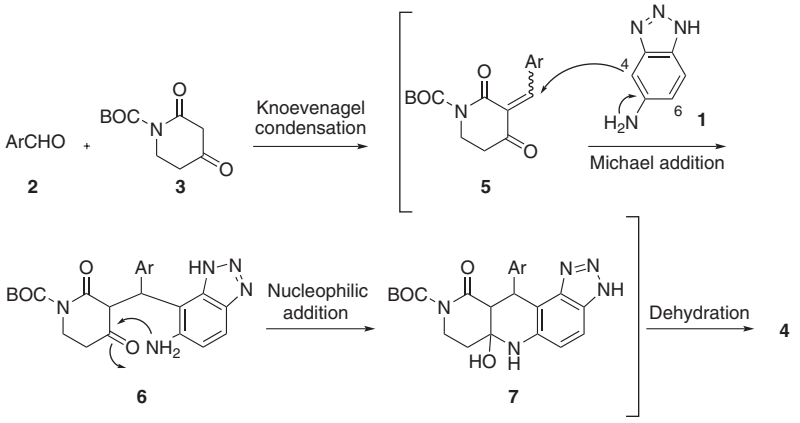
Synthesis of product **4a** from the amine **1**, 4-chlorobenzaldehyde (**2a**) and *tert*-butoxycarbonyl (BOC) derivative **3** was used as a model reaction for optimization. Several reaction parameters including temperature, catalysts and solvents were varied. Only trace amount of **4a** was detected by TLC for the reaction conducted at room temperature. The reaction could not be catalyzed by bases (5 mol%), such as DBU, Et_3N, piperidine and $NaHCO_3$ using a variety of solvents, including alcohols, *N,N*-dimethylformamide, acetonitrile, dioxane and tetrahydrofuran. The highest yield of **4a** of 92% was obtained for the reaction conducted in ethanol without any additive under reflux conditions. After cooling, the resulting precipitate of **4a** was filtered. By using this simple workup, compound **4a** was obtained in an analytically pure form. Crystallization was not necessary. The remaining products **4b–l** were synthesized in high yields under similar conditions. As can be seen from Scheme 1, benzaldehydes substituted with an electron-withdrawing or electron-donating group can successfully be used. The steric hindrance of an ortho-substitution does not hinder the product formation, as evidenced by synthesis of **4i** and **4l** in the respective yields of 94% and 91%. All products were characterized by IR, ^1H NMR and HRMS.

The mechanism of the formation of **4** is suggested in Scheme 2. As can be seen, the initial Knoevenagel condensation product **5** undergoes Michael addition with **1**. The resultant adduct **6** undergoes an intramolecular cyclization to **7** which is a direct precursor to **4**. The observed



4a: Ar = 4-ClC_6H_4 **4d**: Ar = 4-FC_6H_4 **4g**: Ar = 3-ClC_6H_4 **4j**: Ar = 3-$MeOC_6H_4$
4b: Ar = 4-BrC_6H_4 **4e**: Ar = 4-$O_2NC_6H_4$ **4h**: Ar = 3-BrC_6H_4 **4k**: Ar = 3,4-$Cl_2C_6H_3$
4c: Ar = 4-NCC_6H_4 **4f**: Ar = 3,5-$(MeO)_2C_6H_3$ **4i**: Ar = 2,3-$Cl_2C_6H_3$ **4l**: 2,4-$Cl_2C_6H_3$

Scheme 1



Scheme 2

regioselectivity for the addition reaction of **1** is apparently a result of a higher reactivity of the position 4 in comparison to the position 6. More specifically, the electron density at position 4 is greater than that at position 6 because the position 4 is *ortho* to the amino group and α to the nitrogen atom of the adjacent triazole.

Conclusion

A mild, facile, efficient and environmentally benign method was developed for the synthesis of 1*H*-[1,2,3]triazolo[4′,5′:3,4]benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate derivatives **4** under catalyst-free conditions.

Experimental

Melting points were determined in open capillaries and are uncorrected. IR spectra were recorded on a Tensor 27 spectrometer in KBr pellets. ^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) spectra were taken in DMSO-d_6 with Me_4Si as internal standard using a Bruker-400 spectrometer. HR-MS analyses were carried out using a Bruker-micro-TOF-Q-MS analyzer. 1*H*-Benzo[*d*][1,2,3]triazol-5-amine (**2**) was prepared by a two-step procedure from the 4-nitrobenzene-1,2-diamine according to the literature [13].

General procedure for the synthesis of compounds 4

A dry flask (50 mL) was charged with 1*H*-benzo[*d*][1,2,3]triazol-5-amine (**1**, 134 mg, 1.0 mmol), aromatic aldehyde **2** (1.0 mmol), *tert*-butyl 2,4-dioxopiperidine-1-carboxylate (**3**, 213 mg, 1.0 mmol), and EtOH (10.0 mL). The reaction mixture was stirred at 80°C for 6–10 h until the starting material **1** was consumed as monitored by TLC. Product **4** was obtained directly by simple filtration after cooling the mixture to room temperature.

***tert*-Butyl 11-(4-chlorophenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo [4′,5′:3,4]benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4a)** This compound was obtained in 92% yield (0.415 g) as a pale yellow solid; mp 234–236°C; IR: ν 3423, 3281, 2974, 2889, 2824, 1735, 1639, 1546, 1519, 1492, 1467, 1369, 1321, 1247, 1212, 1158, 1138, 1050, 1013, 945, 850, 810, 779 cm^{-1}; ^{1}H NMR: δ_H 1.41 (s, 9H, $3CH_3$), 2.64–2.68 (m, 1H, CH), 2.76–2.84 (m, 1H, CH), 3.47–3.52 (m, 1H, CH), 3.99–4.02 (m, 1H, CH), 5.55 (s, 1H, CH), 7.10 (s, 1H, ArH), 7.24 (d, J = 8.4 Hz, 2H, ArH), 7.37 (d, J = 8.4 Hz, 2H, ArH), 7.81 (s, 1H, ArH), 9.96 (s, 1H, NH), 15.55 (s, 1H, NH); ^{13}C NMR: δ_C 164.5, 162.8, 152.9, 149.1, 145.8, 142.3, 135.3, 131.3, 129.8, 128.5, 118.3, 115.2, 105.3, 100.2, 81.5, 42.6, 36.9, 28.2, 26.8. ESI-HR-MS. Calcd for $C_{23}H_{21}ClN_5O_3$ [M-H]$^-$: m/z 450.1332. Found: m/z 450.1324.

***tert*-Butyl 11-(4-bromophenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo[4′,5′:3,4] benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4b)** This compound was obtained in 90% yield (0.446 g) as a pale yellow solid; mp 231–232°C; IR: ν 3420, 3283, 2981, 2934, 2888, 1736, 1636, 1546, 1492, 1467, 1398, 1320, 1248, 1208, 1136, 1073, 1051, 989, 946, 849, 836, 781, 748 cm^{-1}; ^{1}H NMR: δ_H 1.41 (s, 9H, $3CH_3$),

2.63–2.67 (m, 1H, CH), 2.76–2.84 (m, 1H, CH), 3.49–3.53 (m, 1H, CH), 3.98–4.01 (m, 1H, CH), 5.56 (s, 1H, CH), 7.11 (d, *J* = 8.0 Hz, 1H, ArH), 7.31 (d, *J* = 8.4 Hz, 2H, ArH), 7.38 (d, *J* = 8.4 Hz, 2H, ArH), 7.77 (s, 1H, ArH), 9.94 (s, 1H, NH), 15.52 (s, 1H, NH); ^{13}C NMR: δ_C 164.5, 162.0, 152.9, 151.8, 149.1, 148.5, 146.3, 131.4, 130.8, 130.2, 119.8, 118.1, 115.5, 100.0, 81.6, 42.6, 37.0, 28.2, 26.8. ESI-HR-MS. Calcd for $C_{23}H_{21}BrN_5O_3$ [M-H]$^-$: *m/z* 494.0827. Found: *m/z* 494.0836.

***tert*-Butyl 11-(4-cyanophenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo[4′,5′:3,4] benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4c)** This compound was obtained in 93% yield (0.411 g) as a pale yellow solid; mp 235–237°C; IR: *ν* 3412, 3292, 2980, 2932, 2884, 2229, 1724, 1683, 1620, 1546, 1492, 1463, 1396, 1328, 1248, 1215, 1139, 1053, 967, 942, 851, 813, 779, 749 cm^{-1}; ^{1}H NMR: δ_H 1.41 (s, 9H, 3CH$_3$), 2.66–2.70 (m, 1H, CH), 2.77–2.85 (m, 1H, CH), 3.49–3.53 (m, 1H, CH), 3.97–4.01 (m, 1H, CH), 5.65 (s, 1H, CH), 7.13 (s, 1H, ArH), 7.55 (d, *J* = 8.4 Hz, 2H, ArH), 7.68 (d, *J* = 8.4 Hz, 2H, ArH), 7.83 (s, 1H, ArH), 10.02 (s, 1H, NH), 15.54 (s, 1H, NH); ^{13}C NMR: δ_C 164.5, 162.8, 152.8, 152.1, 149.5, 142.1, 134.6, 132.6, 129.0, 124.0, 119.3, 116.2, 109.5, 105.2, 99.4, 81.6, 42.6, 37.8, 28.2, 26.8. ESI-HR-MS. Calcd for $C_{24}H_{21}N_6O_3$ [M-H]$^-$: *m/z* 441.1674. Found: *m/z* 441.1670.

***tert*-Butyl 11-(4-fluorophenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo[4′,5′:3,4] benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4d)** This compound was obtained in 87% yield (0.379 g) as a pale yellow solid; mp 227–229°C; IR: *ν* 3416, 3366, 2978, 2875, 1733, 1652, 1552, 1491, 1428, 1389, 1369, 1278, 1216, 1135, 1022, 1008, 970, 932, 890, 848, 783, 749 cm^{-1}; ^{1}H NMR: δ_H 1.41 (s, 9H, 3CH$_3$), 2.65–2.69 (m, 1H, CH), 2.76–2.85 (m, 1H, CH), 3.46–3.53 (m, 1H, CH), 3.99–4.02 (m, 1H, CH), 5.58 (s, 1H, CH), 6.97–7.03 (m, 2H, ArH), 7.11 (d, *J* = 6.4 Hz, 1H, ArH), 7.37–7.40 (m, 2H, ArH), 7.78 (s, 1H, ArH), 9.93 (s, 1H, NH), 15.54 (s, 1H, NH); ^{13}C NMR: δ_C 164.6, 162.8, 161.1 (d, $J_{(F-C)}$ = 241 Hz), 152.9, 149.0, 143.2, 142.0, 135.2, 132.6, 129.7 (d, $J_{(F-C)}$ = 8 Hz), 118.3, 115.2 (d, $J_{(F-C)}$ = 21 Hz), 106.0, 100.3, 81.5, 42.6, 36.7, 28.2, 26.8. ESI-HR-MS. Calcd for $C_{23}H_{21}FN_5O_3$ [M-H]$^-$: *m/z* 434.1628. Found: *m/z* 434.1644.

***tert*-Butyl 11-(4-nitrophenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo[4′,5′:3,4] benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4e)** This compound was obtained in 92% yield (0.425 g) as a yellow solid; mp 239–241°C; IR: *ν* 3420, 3301, 2977, 2932, 2880, 1724, 1620, 1605, 1545, 1514, 1492, 1463, 1394, 1324, 1287, 1213, 1138, 1053, 966, 942, 827, 816, 785, 722 cm^{-1}; ^{1}H NMR: δ_H 1.40 (s, 9H, 3CH$_3$), 2.66–2.70 (m, 1H, CH), 2.78–2.86 (m, 1H, CH), 3.49–3.56 (m, 1H, CH), 3.97–4.01 (m, 1H, CH), 5.70 (s, 1H, CH), 7.11 (d, *J* = 8.8 Hz, 1H, ArH), 7.62 (d, *J* = 8.4 Hz, 2H, ArH), 7.86 (d, *J* = 8.8 Hz, 1H, ArH), 8.08 (d, *J* = 8.4 Hz, 2H, ArH), 10.08 (s, 1H, NH), 15.56 (s, 1H, NH); ^{13}C NMR: δ_C 164.3, 162.8, 152.7, 149.6, 143.9, 134.0, 132.5, 131.5, 128.9, 127.2, 118.3, 114.9, 111.0, 98.8, 81.6, 42.9, 36.5, 28.2, 26.9. ESI-HR MS. Calcd for $C_{23}H_{21}N_6O_5$ [M-H]$^-$: *m/z* 461.1573. Found: *m/z* 461.1564.

***tert*-Butyl 11-(3,5-dimethoxyphenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo [4′,5′:3,4]benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4f)** This compound was obtained in 90% yield (0.429 g) as a gray solid; mp 209–210°C; IR: *ν* 3416, 3296, 2997, 2934, 2885, 2835, 1710, 1622, 1595, 1547, 1489, 1430, 1396, 1371, 1339, 1226, 1205, 1161, 1062, 1047, 992, 802, 780 cm^{-1}; ^{1}H NMR: δ_H 1.42 (s, 9H, 3CH$_3$), 2.67–2.71 (m, 1H, CH), 2.75–2.84 (m, 1H, CH), 3.48–3.54 (m, 1H, CH), 3.64 (s, 6H, 2CH$_3$O), 3.99–4.03 (m, 1H, CH), 5.45 (s, 1H, CH), 6.23 (s, 1H, ArH), 6.54 (s, 2H, ArH), 7.06 (d, *J* = 8.8 Hz, 1H, ArH), 7.80 (d, *J* = 8.8 Hz, 1H, ArH), 9.86 (s, 1H, NH), 15.52 (s, 1H, NH); ^{13}C NMR: δ_C 164.6, 160.5, 152.9, 149.1, 142.2, 135.3, 132.6, 118.1, 115.1, 110.2, 106.4, 105.9, 100.3, 97.8, 81.5, 56.5, 42.7, 37.5, 28.2, 26.7. ESI-HR-MS. Calcd for $C_{25}H_{26}N_5O_5$ [M-H]$^-$: *m/z* 476.1933. Found: *m/z* 476.1932.

***tert*-Butyl 11-(3-chlorophenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo[4′,5′:3,4] benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4g)** This compound was obtained in 87% yield (0.392 g) as a pale yellow solid; mp 220–221°C; IR: *ν* 3416, 3215, 2973, 2887, 1717, 1600, 1545, 1489, 1420, 1397, 1336, 1252, 1211, 1142, 1051, 992, 949, 893, 777 cm^{-1}; ^{1}H NMR: δ_H 1.41 (s, 9H, 3CH$_3$), 2.67–2.71 (m, 1H, CH), 2.76–2.84 (m, 1H, CH), 3.48–3.54 (m, 1H, CH), 3.98–4.01 (m, 1H, CH), 5.54 (s, 1H, CH), 7.08–7.14 (m, 2H, ArH), 7.19–7.23 (m, 2H, ArH), 7.48 (s, 1H, ArH), 7.84 (d, *J* = 6.8 Hz, 1H, ArH), 9.99 (s, 1H, NH), 15.57 (s, 1H, NH); ^{13}C NMR: δ_C 164.6, 162.8, 152.8, 149.3, 142.1, 135.5, 133.1, 132.6, 130.6, 127.7, 126.6, 121.9, 118.4, 115.3, 105.4, 100.1, 81.6, 42.6, 37.3, 28.2, 26.8. ESI-HR-MS. Calcd for $C_{23}H_{21}ClN_5O_3$ [M-H]$^-$: *m/z* 450.1332. Found: *m/z* 450.1326.

***tert*-Butyl 11-(3-bromophenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo[4′,5′:3,4] benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4h)** This compound was obtained in 89% yield (0.441 g) as a pale yellow solid; mp 214–216°C; IR: *ν* 3443, 3297, 2972, 2923, 2886, 1716, 1624, 1599, 1567, 1545, 1488, 1421, 1398, 1335, 1252, 1224, 1158, 1142, 1050, 992, 891, 776 cm^{-1}; ^{1}H NMR: δ_H 1.42 (s, 9H, 3CH$_3$), 2.66–2.71 (m, 1H, CH), 2.75–2.83 (m, 1H, CH), 3.49–3.54 (m, 1H, CH), 3.97–4.01 (m, 1H, CH), 5.52 (s, 1H, CH), 7.09 (d, *J* = 8.8 Hz, 1H, ArH), 7.13–7.17 (m, 1H, ArH), 7.27 (s, 2H, ArH), 7.63 (s, 1H, ArH), 7.84 (d, *J* = 8.8 Hz, 1H, ArH), 9.99 (s, 1H, NH), 15.57 (s, 1H, NH); ^{13}C NMR: δ_C 164.5, 162.8, 152.8, 149.3, 142.2, 135.5, 132.6, 131.0, 130.6, 129.6, 127.0, 121.9, 118.5, 115.2, 105.2, 100.1, 81.6, 42.6, 37.3, 28.2, 26.8. ESI-HR-MS. Calcd for $C_{23}H_{21}BrN_5O_3$ [M-H]$^-$: *m/z* 494.0827. Found: *m/z* 494.0834.

***tert*-Butyl 11-(2,3-dichlorophenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo [4′,5′:3,4]benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4i)** This compound was obtained in 94% yield (0.456 g) as a brown solid; mp 231–232°C; IR: *ν* 3367, 3173, 2977, 2904, 2831, 1735, 1646, 1605, 1551, 1486, 1423, 1394, 1306, 1280, 1216, 1136, 1050, 964, 943, 842, 773 cm^{-1}; ^{1}H NMR: δ_H 1.40 (s, 9H, 3CH$_3$), 2.60–2.64 (m, 1H, CH), 2.75–2.83 (m, 1H, CH), 3.43–3.47 (m, 1H, CH), 3.97–4.01 (m, 1H, CH), 6.22 (s, 1H, CH), 7.18 (s, 1H, ArH), 7.33 (d, *J* = 6.8 Hz, 1H, ArH), 7.42 (s, 1H, ArH), 7.58 (s, 1H, ArH), 7.84 (s, 1H, ArH), 9.91 (s, 1H, NH), 15.52 (s, 1H, NH); ^{13}C NMR: δ_C 164.4, 162.8, 152.6, 149.5, 147.7, 143.4, 136.5, 132.5, 131.2, 128.5, 127.9, 118.3, 114.9, 110.9, 105.9, 99.1, 81.5, 42.6, 37.6, 28.2, 26.9. ESI-HR-MS. Calcd for $C_{23}H_{20}Cl_2N_5O_3$ [M-H]$^-$: *m/z* 484.0942. Found: *m/z* 484.0940.

***tert*-Butyl 11-(3-methoxyphenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo[4′,5′:3,4] benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4j)** This compound was obtained in 86% yield (0.384 g) as a pale yellow solid; mp 207–208°C; IR: *ν* 3416, 3366, 2977, 2874, 2839, 1740, 1645, 1585, 1494, 1459, 1388, 1304, 1265, 1212, 1154, 1079, 1021, 962, 880, 838, 769 cm^{-1}; ^{1}H NMR: δ_H 1.42 (s, 9H, 3CH$_3$), 2.66–2.70 (m, 1H, CH), 2.76–2.84 (m, 1H, CH), 3.47–3.53 (m, 1H, CH), 3.67 (s, 3H, CH$_3$O), 3.99–4.03 (m, 1H, CH), 5.50 (s, 1H, CH), 6.64–6.66 (m, 1H, ArH), 6.89 (d, *J* = 7.6 Hz, 1H, ArH), 7.01 (s, 1H, ArH), 7.06–7.11 (m, 2H, ArH), 7.80 (d, *J* = 8.8 Hz, 1H, ArH), 9.92 (s, 1H, NH), 15.54 (s, 1H, NH); ^{13}C NMR: δ_C 164.6, 159.5, 152.3, 148.9, 148.3, 142.2, 135.3, 132.6, 129.7, 120.0, 118.1, 115.1, 114.2, 111.5, 105.9, 100.45, 81.5, 56.5, 42.6, 37.4, 28.2, 26.8. ESI-HR-MS. Calcd for $C_{24}H_{24}N_5O_4$ [M-H]$^-$: *m/z* 446.1828. Found: *m/z* 446.1839.

***tert*-Butyl 11-(3,4-dichlorophenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo [4′,5′:3,4]benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4k)** This compound was obtained in 92% yield

(0.455 g) as a brown solid; mp 222–224°C; IR: ν 3420, 3367, 2987, 2906, 2870, 2833, 1737, 1651, 1551, 1487, 1426, 1394, 1305, 1279, 1139, 1076, 1031, 944, 901, 847, 830, 781 cm^{-1}; ^{1}H NMR: δ_H 1.41 (s, 9H, 3CH$_3$), 2.64–2.70 (m, 1H, CH), 2.75–2.83 (m, 1H, CH), 3.50–3.55 (m, 1H, CH), 3.96–4.99 (m, 1H, CH), 5.53 (s, 1H, CH), 7.09 (d, J = 8.8 Hz, 1H, ArH), 7.21–7.23 (m, 1H, ArH), 7.45 (d, J = 8.4 Hz, 1H, ArH), 7.67 (s, 1H, ArH), 7.86 (d, J = 8.8 Hz, 1H, ArH), 10.03 (s, 1H, NH), 15.57 (s, 1H, NH); ^{13}C NMR: δ_C 164.5, 162.8, 152.8, 149.2, 147.5, 142.2, 135.4, 132.5, 131.0, 129.8, 129.4, 128.3, 118.7, 115.2, 104.6, 99.9, 81.6, 42.6, 37.0, 28.2, 26.7. ESI-HR-MS. Calcd for $C_{23}H_{20}Cl_2N_5O_3$ [M-H]$^-$: m/z 484.0942. Found: m/z 484.0939.

***tert*-Butyl 11-(2,4-dichlorophenyl)-10-oxo-7,8,10,11-tetrahydro-1*H*-[1,2,3]triazolo [4′,5′:3,4]benzo[1,2-*b*][1,6]naphthyridine-9(6*H*)-carboxylate (4l)** This compound was obtained in 91% yield (0.441 g) as a pale yellow solid; mp 227–228°C; IR: ν 3420, 3377, 2979, 2883, 2834, 1728, 1650, 1604, 1586, 1555, 1489, 1425, 1393, 1323, 1281, 1216, 1134, 1051, 1006, 998, 943, 892, 844, 770 cm^{-1}; ^{1}H NMR: δ_H 1.40 (s, 9H, 3CH$_3$), 2.58–2.63 (m, 1H, CH), 2.74–2.82 (m, 1H, CH), 3.45–3.51 (m, 1H, CH), 3.97–4.00 (m, 1H, CH), 6.12 (s, 1H, CH), 7.15 (d, J = 6.8 Hz, 1H, ArH), 7.26–7.35 (m, 2H, ArH), 7.46 (s, 1H, ArH), 7.82 (s, 1H, ArH), 9.89 (s, 1H, NH), 15.52 (s, 1H, NH); ^{13}C NMR: δ_C 164.5, 162.8, 154.7, 152.8, 149.4, 146.5, 142.2, 135.5, 132.6, 129.1, 123.9, 118.8, 115.2, 110.9, 104.4, 99.6, 81.6, 42.6, 37.7, 28.2, 26.8. ESI-HR-MS. Calcd for $C_{23}H_{20}Cl_2N_5O_3$ [M-H]$^-$: m/z 484.0942. Found: m/z 484.0942.

Acknowledgments: We are grateful to the Major Natural Science Foundation of Jiangsu Province (14KJA150004), a project funded by the Priority Academic Program Development of Jiangsu Higher Education Institutions for financial support.

References

[1] Mogilaiah, K.; Reddy, C. T.; Reddy, N. Efficient of synthesis and antibacterial activity of 2-(4-cinnamoylphenylamino)-3-(3-trifluoromethylphenyl)-1,8- naphthyridines. *Indian J. Heterocycl. Chem*. **2014**, *23*, 267–270.

[2] Surivet, J. P.; Zumbrunn, C.; Rueedi, G.; Hubschwerlen, C.; Bur, D.; Bruyere, T.; Locher, H.; Ritz, D.; Keck, W.; Seiler, P. Design, synthesis, and characterization of novel tetrahydropyran-based bacterial topoisomerase inhibitors with potent anti-Gram-positive activity. *J. Med. Chem*. **2013**, *56*, 7396–7415.

[3] Surivet, J. P.; Lange, R.; Hubschwerlen, C.; Keck, W.; Specklin, J. L.; Ritz, D.; Bur, D.; Locher, H.; Seiler, P.; Strasser, D. S. Structure-guided design, synthesis and biological evaluation of novel DNA ligase inhibitors with *in vitro* and *in vivo* anti-staphylococcal activity. *Bioorg. Med. Chem. Lett*. **2012**, *22*, 6705–6711.

[4] Varadi, L.; Gray, M.; Groundwater, P. W.; Hall, A. J.; James, A. L.; Orenga, S.; Perry, J. D.; Anderson, R. J. Synthesis and evaluation of fluorogenic 2-amino-1,8-naphthyridine derivatives for the detection of bacteria. *Org. Biomol. Chem*. **2012**, *10*, 2578–2589.

[5] Gootz, T. D.; Zaniewski, R.; Haskell, S.; Schmieder, B.; Tankovic, J.; Girard, D.; Courvalin, P.; Polzer, R. J. Activity of the new fluoroquinolone trovafloxacin (CP-99,219) against DNA gyrase and topoisomerase IV mutants of Streptococcus pneumoniae selected in vitro. *Antimicrob. Agents Chemother*. **1996**, *40*, 2691–2697.

[6] Flori, N.; Funakoshi, N.; Duny, Y.; Valats, J. C.; Bismuth, M.; Christophorou, D.; Daurès, J. P.; Blanc, P. Pegylated interferon-α2a and ribavirin versus pegylated interferon-α2b and ribavirin in chronic hepatitis C: a meta-analysis. *Drugs* **2013**, *73*, 263–277.

[7] Bishnoi, A.; Tiwari, A. K.; Singh, S.; Sethi, A.; Tripathi, C. M.; Banerjee, B. Synthesis, characterization, and biological evaluation of novel thiazole and pyrazole derivatives of quinoline-4-carboxylic acid as potential antimicrobial agents. *Med. Chem. Res*. **2013**, *22*, 3527–3535.

[8] Li, C.; Zhang, W. T.; Wang, X. S. Domino synthesis of fused hexacyclic imidazoquinolinoacridinones catalyzed by CuI/L-proline. *Tetrahedron* **2014**, *70*, 8919–8924.

[9] Wang, W.; Jiang, H.; Zhang, M. M.; Wang, X. S. Iodine-catalyzed synthesis of cyclopenta[*c*]quinoline derivatives via imino Diels-Alder reaction. *J. Heterocycl. Chem*. **2014**, *51*, 830–834.

[10] Chen, D. S.; Li, Y. L.; Liu, Yun; Wang, X. S. Synthesis of bis-benzoquinoline derivatives catalyzed by iodine via ring-opening of furan. *Tetrahedron* **2013**, *69*, 7045–7050.

[11] Du, B. X.; Zhao, B.; Cai, G.; Li, Y. L.; Wang, X. S. Mild and efficient one-pot three-component synthesis of benzopyrimidoquinoline-tetralone derivatives in ionic liquids. *J. Chem. Res*. **2012**, *36*, 453–456.

[12] Wang, W.; Yin, M. Y.; Zhang, M. M.; Wang, X. S. Iodine-catalysed synthesis of thiopyrano[3,4-*c*]quinoline derivatives via imino-Diels-Alder reaction. *J. Chem. Res*. **2012**, *36*, 318–321.

[13] Wasik, R.; Lebska, M.; Felczak, K.; Poznanski, J.; Shugar, D. relative role of halogen bonds and hydrophobic interactions in inhibition of human protein kinase CK2α by tetrabromobenzotriazole and some C(5)-substituted analogues. *J. Phys. Chem. B*. **2010**, *114*, 10601–10611.