

Silver-Catalyzed Synthesis of Functionalized 1,7-Naphthyridine Derivatives Using 2-Aminobenzamide Derivatives and *ortho*-Alkynylquinoline Carbaldehydes as Starting Materials [†]

Kapil Chahal *, Ravikumar Badhavath and K. Rajender Reddy *

Catalysis and Fine Chemicals Division, CSIR-Indian Institute of Chemical Technology, Hyderabad-500007, Telangana, India, rajender@iict.res.in

* Correspondence: kapil123chahal@gmail.com (K.C.); rajender@iict.res.in (K.R.R.)

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Abstract

Fused polycyclic 1,7-naphthyridines are important N-heterocyclic scaffolds with potential applications in medicinal chemistry and materials science. Conventional methods for their synthesis often require harsh conditions or multiple steps, limiting functional group compatibility and scalability. Herein, we report a one-pot silver-catalyzed cyclization strategy that proceeds under mild conditions, tolerates diverse functional groups, and is amenable to gram-scale synthesis. The reaction features a simple workup involving celite filtration and standard purification. Preliminary studies indicate that these N-heterocycles exhibit promising photophysical and medicinal properties, highlighting their potential in light-emitting devices and therapeutic development.

Keywords: 1,7-Naphthyridines; silver catalysis; diastereoselective synthesis; fused heterocycles; functional materials; one-pot reaction; polycyclic compounds

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1. Introduction

Fused nitrogen-containing heterocycles, such as naphthyridines, are privileged scaffolds with diverse applications in medicinal chemistry, materials science, and optoelectronics [1–3]. Their unique electronic and structural features allow interactions with biological targets, enabling activities such as antibacterial, antiviral, anti-inflammatory, and anticancer effects (Figure 1) [4]. Naphthyridines also serve as key components in sensors [5], light-emitting devices [6–10], and metal-organic frameworks due to their versatile coordination chemistry and photophysical properties [11,12]. The position of nitrogen atoms within the fused ring system gives rise to various isomers (e.g., 1,5-, 1,6-, 1,7-, 2,7-naphthyridines) [13], with electronic and steric effects that influence chemical reactivity and functionalization potential.

Traditional synthetic methods for naphthyridines, including the Skraup [14], Friedländer [15], and Conrad-Limpach reactions [16], often require multi-step procedures, harsh conditions, or provide limited regioselectivity (Scheme 1a–c). Recent advances employing *ortho*-alkynyl aldehyde scaffolds have enabled regio- and stereoselective formation of naphthyridine derivatives under milder conditions using metal catalysis

[17], including copper- [18] and silver-catalyzed strategies (Scheme 1d). Building on this progress, our group recently developed a one-pot silver-catalyzed approach for the synthesis of fused polycyclic 1,7-naphthyridines [19], 2,7-Naphthyridines [20], and pyrano heterocycles [21]. This method operates under mild conditions, tolerates diverse functional groups, and is scalable to gram quantities, with a simple workup requiring only celite filtration and standard purification.

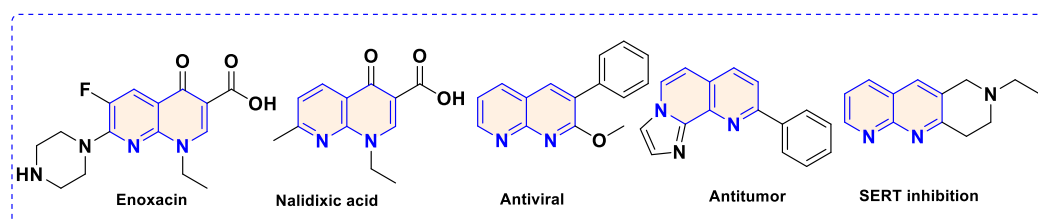
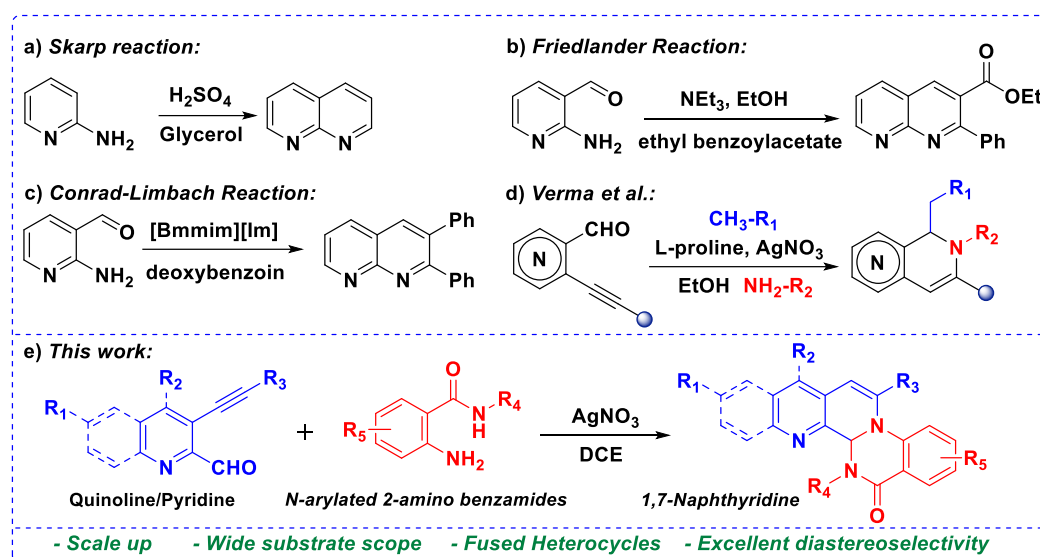


Figure 1. Medicinal properties of Naphthyridines.



Scheme 1. Previous reports and our approach toward Naphthyridines.

Herein, we report a novel application of the aldehyde-alkyne strategy for constructing 1,7-naphthyridines, expanding the synthetic utility of this methodology to a previously unexplored class of fused N-heterocycles. The resulting compounds are being evaluated for their photophysical and medicinal properties, highlighting their potential as multifunctional scaffolds for therapeutic and material applications.

2. Results and Discussion

To optimize the reaction, model substrates 1a and 2a were employed (Table 1). A series of silver catalysts were first screened in DCM at room temperature. Among them, AgNO_3 (10 mol%) afforded 3a in 52% yield (entry 1), while other silver and non-silver catalysts provided only trace or no conversion. Increasing the loading of AgNO_3 to 20 mol% improved the yield (entry 2), whereas further increase to 30 mol% led to a decline (entry 3). Solvent screening identified DCE as the optimal medium, and under these conditions AgNO_3 (20 mol%) delivered 3a in 80% yield within 6 h (entry 4). Prolonging the reaction to 12 h resulted in decreased yield. Thus, the optimized conditions were established as: 1a (0.2 mmol), 2a (0.2 mmol), AgNO_3 (20 mol%), in DCE (2 mL). NMR analysis revealed diastereomeric peaks, attributed to the formation of two stereogenic centers—one at the aldehyde carbon during cyclization and the other at the amide nitrogen. The

latter exhibits hindered inversion, allowing the diastereomers to be observed as distinct signals.

Table 1. Screening conditions for the synthesis of **3a**.

Entry	Catalyst	Solvent	T (°C)	Time (h)	Yield (%) ^[b]
1.	AgNO ₃	DCM	Rt	12	52
2.	AgNO ₃	DCM	Rt	12	35
3.	AgNO ₃	DCM	Rt	12	37
4.	AgNO ₃	DCE	Rt	6/12	80/72

After establishing the optimized conditions (entry 4), the substrate scope of ortho-alkynyl aldehydes and substituted anthranilamides was systematically examined using AgNO₃ in DCE at room temperature for 6 h. Reactions of 3-alkynylquinoline-2-carbaldehydes (**1a–h**) with anthranilamide derivatives (**2a–d**) afforded the desired products **3a–h** in 60–96% yield with good to excellent diastereoselectivity (Table 2). Notably, compounds **3b** and **3g** showed diastereomeric ratios of 11:1 with yields of 90% and 60%, respectively. In contrast, reactions with pyridine-based alkynyl aldehydes (**1i–j**) furnished the corresponding products **4a–c** in good to excellent yields, and compound **4ac** displayed an impressive diastereoselectivity of 20:1.

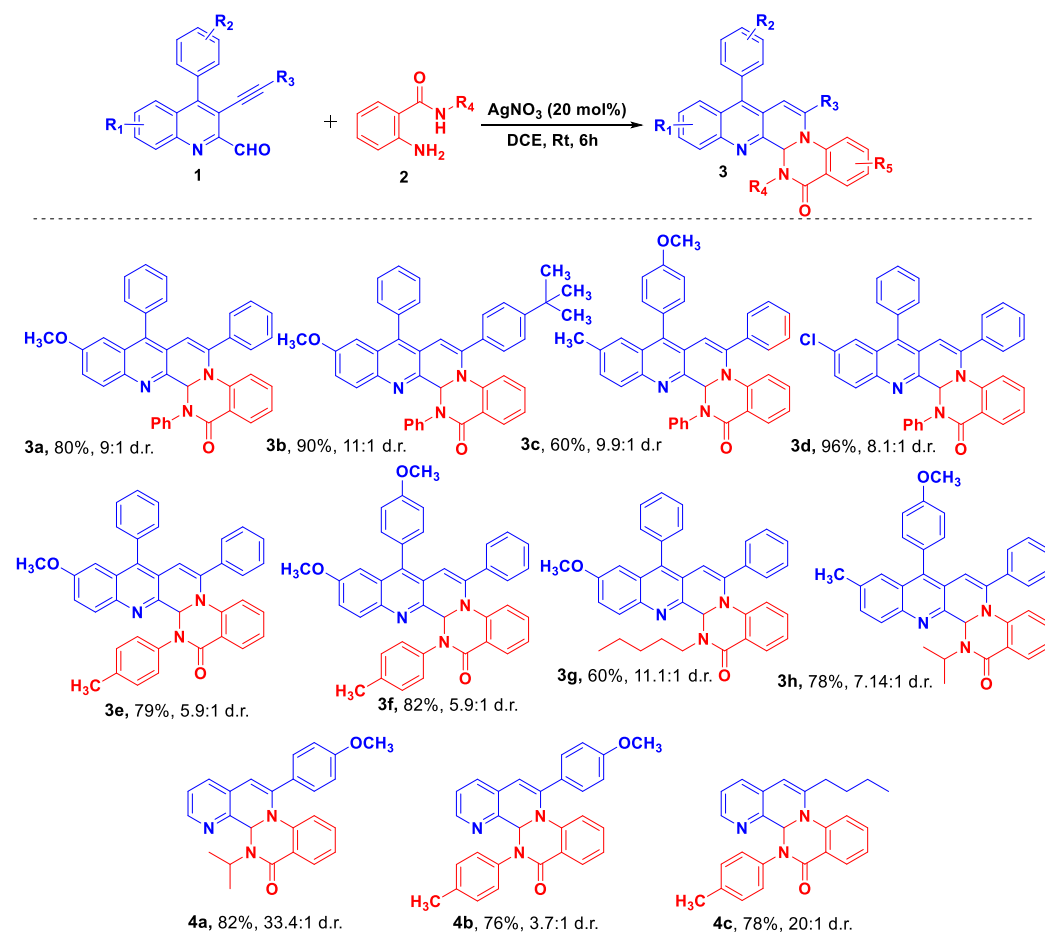


Figure 2. Substrate scope of Naphthyridines.

3. Experimental Section

3.1. General Information, Instrumentation and Chemicals

All chemicals were purchased from Sigma-Aldrich, Alfa Aesar and S. D. Fine Chemicals, Pvt. Ltd. India and used without further purification. ACME silica gel (100–200 mesh) was used for column chromatography and thin-layer chromatography was performed on Merck-pre-coated silica gel 60-F254 plates. TLC plates are visualized by UV-light and developed by Iodine. All the solvents were obtained from commercial sources and purified using standard methods. All ^1H , ^{13}C NMR spectra were recorded on Avance-300, Avance-400 and Avance-500 MHz Spectrometer. Chemical shifts (δ) are referenced to signals at 7.26 and 77.0 ppm, respectively, using TMS ($\delta = 0$) as an internal standard in CDCl_3 . The peak patterns are indicated as follows: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; dd, doublet of doublet; dt, doublet of triplet; tt, triplet of triplet. The coupling constants (J) are reported in Hertz (Hz). Mass spectral data were compiled using MS (ESI) and (HRMS) high-resolution mass spectrometer. Melting points were investigated using melting point instrument and are uncorrected. Bruker Infrared spectrometer was used to record IR spectra and shown as cm^{-1} .

3.2. General Procedure (GP)

A mixture containing 0.2 mmol of compound (**1a–j**) and 0.2 mmol of compound (**2a–d**) was stirred in 2 mL of DCE. To this stirring mixture, 20 mol% silver nitrate (AgNO_3) was added at room temperature. The reaction was allowed to proceed for 6 h under stirring. After completion, the reaction mixture was filtered through a celite pad to remove any solid particles. The filtrate, containing the desired product(s), was concentrated by evaporating the solvent under reduced pressure, leaving behind a residue. This residue was further purified using column chromatography. This purification process yielded the corresponding products (**3a–h** and **4a–c**).

3.3. Spectral Data

3.3.1. Characterization of the

10-methoxy-6,8,14-triphenyl-13b,14-dihydro-15H-benzo [2,3][1,7]naphthyridino[7,8-a]quinazolin-15-one (**3a**)

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3a** yellow semi-solid (89 mg, 80% yield) (d.r. 9:1). ^1H NMR (400 MHz, CDCl_3) δ 8.12 – 8.05 (m, 2H), 7.92 (dt, $J = 8.8, 1.8$ Hz, 2H), 7.74 (dt, $J = 4.3, 2.4$ Hz, 2H), 7.66 – 7.57 (m, 3H), 7.48 – 7.38 (m, 6H), 7.33 – 7.28 (m, 3H), 7.05 (ddd, $J = 8.4, 7.3, 1.6$ Hz, 1H), 6.92 (s, 1H), 6.83 (ddd, $J = 8.8, 7.8, 1.8$ Hz, 2H), 6.30 (d, $J = 7.9$ Hz, 1H), 6.09 (s, 1H), 3.70 (s, 3H). ^{13}C NMR (101 MHz, CDCl_3) δ 162.2, 158.1, 149.9, 144.7, 144.2, 143.2, 141.8, 141.7, 135.3, 134.9, 133.1, 131.5, 130.3, 129.6, 129.6, 129.2, 129.1, 128.9, 128.8, 128.6, 128.5, 128.3, 128.0, 127.6, 126.9, 126.0, 123.4, 120.9, 120.5, 118.8, 116.1, 114.2, 104.7, 55.4. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{38}\text{H}_{28}\text{N}_3\text{O}_2$ 558.2176; Found 558.2180.

6-(4-(tert-butyl)phenyl)-10-methoxy-8,14-diphenyl-13b,14-dihydro-15H-benzo[2,3][1,7]naphthyridino[7,8-a]quinazolin-15-one (**3b**)

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3b** yellow semi-solid (110 mg, 90% yield) (d.r. 11:1). ^1H NMR (400 MHz, CDCl_3) δ 8.11 – 8.05 (m, 2H), 7.94 – 7.90 (m, 2H), 7.69 – 7.65 (m, 2H), 7.62 – 7.56 (m, 3H), 7.48 – 7.43 (m, 3H), 7.43 – 7.38 (m, 2H), 7.30 (dddd, $J = 9.1, 7.5, 3.2, 2.0$ Hz, 3H), 7.07 (ddd, $J = 8.4, 7.3, 1.6$ Hz, 1H), 6.88 (s, 1H), 6.84 (td, $J = 7.7, 0.9$ Hz, 1H), 6.80 (d, $J = 2.8$ Hz, 1H), 6.34 (d, $J = 7.8$ Hz, 1H), 6.06 (s, 1H), 3.69 (s, 3H), 1.34 (s, 9H). ^{13}C NMR (101 MHz, CDCl_3) δ 162.3, 158.1, 153.1,

150.1, 145.0, 144.2, 143.2, 141.9, 141.5, 135.5, 133.2, 132.0, 131.6, 130.4, 129.6, 129.1, 128.9, 128.8, 128.7, 128.5, 128.4, 127.8, 127.0, 126.1, 125.8, 123.6, 120.8, 120.5, 118.8, 116.3, 113.5, 104.7, 55.4, 34.8, 31.3. **HRMS** (ESI) m/z : $[M + H]^+$ Calcd for $C_{42}H_{36}N_3O_2$ 614.2802; Found 614.2807.

8-(4-methoxyphenyl)-10-methyl-6,14-diphenyl-13b,14-dihydro-15H-benzo[2,3][1,7]naphthyridino[7,8-a]quinazolin-15-one (3c)

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3c** yellow semi-solid (62 mg, 60% yield) (d.r. 9.9:1). **¹H NMR** (500 MHz, $CDCl_3$) δ 8.06 (dd, J = 11.9, 5.0 Hz, 2H), 7.94 – 7.90 (m, 2H), 7.79 – 7.74 (m, 2H), 7.48 – 7.38 (m, 6H), 7.34 – 7.31 (m, 2H), 7.29 (d, J = 7.4 Hz, 1H), 7.23 (dd, J = 8.3, 2.0 Hz, 1H), 7.15 (ddd, J = 14.7, 8.4, 2.5 Hz, 2H), 7.07 – 7.03 (m, 1H), 6.98 (s, 1H), 6.85 – 6.81 (m, 1H), 6.30 (d, J = 8.2 Hz, 1H), 6.08 (s, 1H), 3.98 (s, 3H), 2.39 (s, 3H). **¹³C NMR** (101 MHz, $CDCl_3$) δ 162.2, 159.6, 151.5, 145.8, 144.8, 143.8, 142.2, 141.8, 136.8, 134.9, 133.1, 131.7, 131.1, 131.0, 129.9, 129.5, 129.1, 129.0, 128.9, 128.1, 127.6, 127.5, 127.2, 126.9, 126.0, 125.1, 123.4, 120.5, 118.8, 116.1, 114.4, 114.2, 113.9, 55.4, 21.7. **HRMS** (ESI) m/z : $[M + H]^+$ Calcd for $C_{39}H_{30}N_3O_2$ 572.2333; Found 572.2336.

10-chloro-6,8,14-triphenyl-13b,14-dihydro-15H-benzo[2,3][1,7]naphthyridino[7,8-a]quinazolin-15-one (3d)

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3d** yellow semi-solid (107 mg, 96% yield) (d.r. 8.1:1). **¹H NMR** (400 MHz, $CDCl_3$) δ 8.12 (d, J = 8.9 Hz, 1H), 8.07 (dd, J = 7.8, 1.5 Hz, 1H), 7.90 (dt, J = 8.8, 1.8 Hz, 2H), 7.77 – 7.72 (m, 2H), 7.67 – 7.63 (m, 1H), 7.63 – 7.59 (m, 2H), 7.57 (dd, J = 8.9, 2.3 Hz, 1H), 7.50 – 7.40 (m, 6H), 7.39 – 7.35 (m, 1H), 7.34 – 7.29 (m, 2H), 7.06 (ddd, J = 8.4, 7.4, 1.6 Hz, 1H), 6.91 (s, 1H), 6.89 – 6.83 (m, 1H), 6.29 (d, J = 8.2 Hz, 1H), 6.09 (s, 1H). **¹³C NMR** (101 MHz, $CDCl_3$) δ 162.1, 152.6, 145.5, 144.9, 144.5, 142.0, 141.6, 134.6, 134.4, 133.2, 132.9, 131.7, 130.3, 129.9, 129.8, 129.6, 129.2, 129.1, 128.9, 128.9, 128.8, 128.2, 127.6, 127.1, 126.1, 125.0, 124.0, 120.7, 118.7, 116.2, 113.6. **HRMS** (ESI) m/z : $[M + H]^+$ Calcd for $C_{37}H_{25}ClN_3O$ 562.1681; Found 562.1683.

10-methoxy-6,8-diphenyl-14-(p-tolyl)-13b,14-dihydro-15H-benzo[2,3][1,7]naphthyridino[7,8-a]quinazolin-15-one (3e)

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3e** yellow semi-solid (90 mg, 79% yield) (d.r. 5.9:1). **¹H NMR** (400 MHz, $CDCl_3$) δ 8.03 – 7.95 (m, 2H), 7.76 – 7.72 (m, 2H), 7.68 – 7.63 (m, 2H), 7.55 – 7.48 (m, 3H), 7.33 – 7.29 (m, 3H), 7.25 – 7.15 (m, 5H), 6.96 (ddd, J = 8.4, 7.3, 1.6 Hz, 1H), 6.82 (s, 1H), 6.75 (td, J = 7.6, 0.9 Hz, 1H), 6.71 (d, J = 2.7 Hz, 1H), 6.20 (d, J = 7.8 Hz, 1H), 5.98 (s, 1H), 3.61 (s, 3H), 2.28 (s, 3H). **¹³C NMR** (126 MHz, $CDCl_3$) δ 162.3, 158.0, 149.9, 144.6, 144.1, 143.2, 141.7, 139.1, 136.8, 135.3, 134.8, 133.0, 131.5, 130.3, 129.5, 129.5, 129.5, 129.1, 129.0, 128.8, 128.6, 128.5, 128.3, 127.6, 126.0, 123.3, 120.8, 120.5, 118.8, 116.1, 114.1, 104.7, 55.3, 21.1. **HRMS** (ESI) m/z : $[M + H]^+$ Calcd for $C_{39}H_{30}N_3O_2$ 572.2333; Found 572.2340.

10-methoxy-8-(4-methoxyphenyl)-6-phenyl-14-(p-tolyl)-13b,14-dihydro-15H-benzo[2,3][1,7]naphthyridino[7,8-a]quinazolin-15-one (3f)

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3f** yellow semi-solid (99 mg, 82% yield) (d.r. 5.9:1). **¹H NMR** (400 MHz, $CDCl_3$) δ 8.06 (dd, J = 12.7, 5.3 Hz, 2H), 7.83 – 7.79 (m, 2H), 7.78 – 7.74 (m, 2H), 7.42 – 7.40 (m, 2H), 7.34 – 7.29 (m, 2H), 7.27 (d, J = 2.8 Hz, 1H), 7.25 – 7.22 (m, 2H), 7.14 (ddd, J = 15.5, 8.4, 2.6 Hz, 3H), 7.06 – 7.01 (m, 1H), 6.95 (s, 1H), 6.86 – 6.80 (m, 2H), 6.28 (d, J = 7.8 Hz, 1H), 6.05 (s, 1H), 3.97 (s, 3H), 3.71 (s, 3H), 2.36 (s, 3H). **¹³C NMR** (126 MHz, $CDCl_3$) δ 162.3, 159.6, 158.0, 150.0, 144.7, 143.9, 143.3, 141.6, 139.2, 136.8, 135.0, 133.0, 131.7, 131.5, 130.9, 129.5, 129.5, 129.2, 129.0, 128.6, 127.6, 127.4, 126.0, 123.6, 120.8, 120.4, 118.8, 116.1, 114.4, 114.3, 114.0, 104.7, 55.4, 55.4, 21.1. **HRMS** (ESI) m/z : $[M + H]^+$ Calcd for $C_{40}H_{32}N_3O_3$ 594.1743; Found 594.1752.

10-methoxy-14-pentyl-6,8-diphenyl-13b,14-dihydro-15H-benzo[2,3][1,7]naphthyridino[7,8-a]quinazolin-15-one (3g)

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3g** yellow semi-solid (66 mg, 60% yield) (d.r. 11.1:1). ¹H NMR (500 MHz, CDCl₃) δ 8.01 (d, *J* = 9.2 Hz, 1H), 7.98 (dd, *J* = 7.7, 1.5 Hz, 1H), 7.68 (dd, *J* = 7.8, 1.6 Hz, 2H), 7.65 – 7.56 (m, 3H), 7.43 (d, *J* = 7.2 Hz, 1H), 7.39 (d, *J* = 7.5 Hz, 2H), 7.31 (d, *J* = 7.2 Hz, 1H), 7.27 (dd, *J* = 8.8, 2.3 Hz, 1H), 7.01 – 6.95 (m, 1H), 6.87 (s, 1H), 6.81 – 6.77 (m, 2H), 6.20 (d, *J* = 8.2 Hz, 1H), 5.76 (s, 1H), 4.76 – 4.67 (m, 1H), 3.69 (s, 3H), 3.31 (ddd, *J* = 14.3, 8.3, 6.1 Hz, 1H), 1.93 – 1.80 (m, 2H), 1.53 – 1.38 (m, 4H), 0.93 (t, *J* = 7.2 Hz, 3H). ¹³C NMR (126 MHz, CDCl₃) δ 162.3, 158.0, 149.8, 144.0, 143.7, 143.2, 141.5, 135.4, 135.0, 132.5, 131.5, 130.4, 129.5, 129.5, 129.2, 129.0, 128.8, 128.6, 128.5, 128.4, 128.2, 126.0, 123.3, 120.8, 120.3, 118.4, 116.0, 114.0, 104.7, 73.5, 55.3, 46.9, 29.2, 22.6, 14.1. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₃₇H₃₄N₃O₂ 552.2646; Found 552.2657.

14-isopropyl-8-(4-methoxyphenyl)-10-methyl-6-phenyl-13b,14-dihydro-15H-benzo[2,3][1,7] naphthyridino[7,8-a]quinazolin-15-one (3h)

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3h** yellow semi-solid (84 mg, 78% yield) (d.r. 7.14:1). ¹H NMR (400 MHz, CDCl₃) δ 8.15 (t, *J* = 8.2 Hz, 1H), 7.95 (dd, *J* = 7.7, 1.4 Hz, 1H), 7.72 – 7.68 (m, 2H), 7.47 – 7.44 (m, 1H), 7.39 (dd, *J* = 7.1, 4.3 Hz, 3H), 7.32 (s, 1H), 7.23 – 7.20 (m, 1H), 7.16 (ddd, *J* = 6.6, 4.0, 2.2 Hz, 2H), 6.99 – 6.94 (m, 2H), 6.80 – 6.76 (m, 1H), 6.18 (d, *J* = 8.1 Hz, 1H), 5.70 (s, 1H), 5.20 (dt, *J* = 13.2, 6.6 Hz, 1H), 3.99 (s, 3H), 2.39 (s, 3H), 1.51 (d, *J* = 6.6 Hz, 3H), 1.43 (d, *J* = 7.0 Hz, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 162.3, 159.7, 151.8, 145.4, 144.2, 142.2, 136.7, 135.0, 132.4, 131.8, 131.1, 131.0, 129.6, 129.5, 129.2, 128.6, 127.4, 127.3, 125.9, 125.1, 123.6, 120.4, 119.6, 115.8, 114.3, 114.2, 113.9, 70.2, 55.4, 46.6, 21.7, 21.3, 20.3. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₃₆H₃₁N₃O₂ 538.2489; Found 538.2497.

5-isopropyl-12-(4-methoxyphenyl)-4b,5-dihydro-6H-[1,7]naphthyridino[7,8-a]quinazolin-6-one (4a)

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **4a** yellow semi-solid (65 mg, 82% yield) (d.r. 33.4:1). ¹H NMR (400 MHz, CDCl₃) δ 8.38 (dd, *J* = 4.9, 1.5 Hz, 1H), 7.92 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.83 – 7.69 (m, 2H), 7.46 (dd, *J* = 7.7, 1.5 Hz, 1H), 7.14 (dd, *J* = 7.6, 4.9 Hz, 1H), 7.00 – 6.95 (m, 3H), 6.95 – 6.92 (m, 1H), 6.77 (td, *J* = 7.5, 1.0 Hz, 1H), 6.17 – 6.14 (m, 1H), 5.51 (s, 1H), 5.16 (hept, *J* = 6.8 Hz, 1H), 3.86 (s, 3H), 1.43 (d, *J* = 6.6 Hz, 3H), 1.29 (d, *J* = 7.0 Hz, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 162.0, 161.0, 151.0, 147.8, 144.6, 143.5, 132.3, 131.8, 128.4, 128.1, 127.7, 127.1, 123.1, 120.5, 119.8, 116.1, 114.7, 112.4, 69.0, 55.4, 45.9, 21.3, 19.9. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₂₅H₂₄O₂ N₃ 398.1863; Found 398.1871.

*12-(4-methoxyphenyl)-5-(*p*-tolyl)-4b,5-dihydro-6H-[1,7]naphthyridino[7,8-a]quinazolin-6-one (4b)*

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **4b** yellow semi-solid (68 mg, 76% yield) (d.r. 3.7:1). ¹H NMR (400 MHz, CDCl₃) δ 8.44 (dd, *J* = 4.9, 1.5 Hz, 1H), 8.02 (dd, *J* = 7.8, 1.6 Hz, 1H), 7.86 – 7.80 (m, 2H), 7.67 – 7.58 (m, 2H), 7.47 (dd, *J* = 7.7, 1.5 Hz, 1H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.19 – 7.15 (m, 1H), 7.01 – 6.97 (m, 3H), 6.95 (s, 1H), 6.92 (s, 1H), 6.82 (td, *J* = 7.6, 1.0 Hz, 1H), 6.26 – 6.23 (m, 1H), 5.88 (s, 1H), 3.87 (s, 3H), 2.35 (s, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 163.1, 162.5, 160.9, 159.6, 150.0, 147.6, 145.7, 144.0, 143.9, 142.3, 141.9, 140.9, 138.5, 137.1, 136.8, 133.1, 132.5, 132.1, 131.4, 131.2, 130.2, 129.6, 129.3, 128.9, 128.5, 128.4, 127.9, 127.6, 127.1, 126.7, 126.5, 125.1, 124.2, 123.8, 123.4, 120.5, 118.4, 116.3, 114.5, 113.3, 112.3, 101.1, 75.9, 73.8, 55.1, 55.0, 49.3, 49.1, 48.9, 48.7, 48.4, 48.2, 48.0, 20.7. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₂₉H₂₄N₃O₂ 446.1863; Found 446.1568.

*12-butyl-5-(*p*-tolyl)-4b,5-dihydro-6H-[1,7]naphthyridino[7,8-a]quinazolin-6-one (4c)*

The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **4c** yellow semi-solid (62 mg, 78% yield) (d.r. 20:1). ¹H NMR (500 MHz, CDCl₃) δ 8.16 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.92 (dd, *J* = 4.7, 1.5 Hz, 1H), 7.49 (td, *J* = 7.7, 1.6 Hz, 1H), 7.35 (td, *J* = 7.6, 0.9 Hz, 1H), 7.23 (d, *J* = 8.0 Hz, 1H), 7.21 (dd, *J* = 7.9, 1.3 Hz, 1H), 6.93 (dd, *J* = 7.8, 4.8 Hz,

1H), 6.83 (d, $J = 7.2$ Hz, 2H), 6.75 (s, 2H), 6.51 (s, 1H), 5.63 (s, 1H), 2.31 – 2.26 (m, 2H), 2.13 (s, 3H), 1.18 (ddd, $J = 17.7, 11.2, 3.6$ Hz, 4H), 0.72 (t, $J = 7.1$ Hz, 3H). ^{13}C NMR (126 MHz, CDCl_3) δ 165.0, 163.6, 162.8, 149.4, 145.7, 145.6, 143.9, 142.4, 141.5, 140.0, 137.0, 135.2, 134.3, 133.8, 133.2, 131.9, 131.3, 130.3, 129.8, 129.6, 129.3, 129.3, 129.1, 129.0, 128.1, 127.3, 126.4, 124.1, 123.9, 119.9, 103.6, 98.9, 74.5, 31.9, 29.6, 22.2, 21.1, 13.7. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{26}\text{H}_{26}\text{ON}_3$ 396.2070; Found 396.2075.

4. Conclusions

This study expands the synthetic utility of silver catalysis in complex heterocycle construction. The resulting 1,7-naphthyridine derivatives are being further investigated for their photophysical properties with potential applications in light-emitting devices and solar energy materials. Simultaneously, their biological activity is being evaluated to identify leads of therapeutic relevance. Overall, this method provides a versatile platform for accessing functional heterocyclic frameworks relevant to materials science and medicinal chemistry.

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