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Formation of Tertiary Alcohol via Chelation-Assisted Nickel(II)-Catalyzed Addition of Arylboronic Acids to Unactivated 1-(Quinolin-8-yl)ethan-1-one

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Abstract. The synthesis of tertiary alcohol via chelation-assisted nickel-catalyzed addition of arylboronic acids to unactivated ketones was reported in this study. A series of substituted arylboronic acids was reacted with 1-(quinolin-8-yl)ethan-1-one and its derivatives to provide various substituted 1-aryl-1-(quinolin-8-yl)ethan-1-ols and relevant compounds in medium to good yields. The N-directing group is essential for the addition reaction of arylboronic acids to these unactivated ketones. Nickel(II) acetylacetonate (10.0 mol.%) in combination with sodium iodide (2 equiv.) and potassium carbonate (0.8 equiv.) was identified as the optimal catalytic system for the current transformations.

Keywords: Tertiary alcohol; Chelation-assisted; Arylboronic acids; Unactivated ketones; Addition reaction.

Introduction

Tertiary alcohol moieties exist in a number of therapeutic agents and natural products.[1] Thus, rapid achievement of tertiary alcohol moieties via transformation of readily available feedstocks has been the continuous goal in synthetic organic chemistry. Traditionally, tertiary alcohol moieties can be constructed through addition of carbon nucleophiles, such as Grignard and organozinc reagents to ketones. However, the functional group compatibilities of these reactions are poor owing to high reactivity of these reagents. By contrast, boronic acids are attractive carbon nucleophiles because these reagents are mild air- and moisture-stable species, with reactions tolerating a broad range of functional groups.[2] Boronic acids have been applied in addition to carbonyl compounds over rhodium catalysts.[3, 4] The Rh-catalyzed addition of boronic acids to α, β-unsaturated carbonyl compounds via 1, 4-addition and aldehydes are well characterized. [5] The additions of organoboron compounds to activated ketones, such as ketoesters, [6] trifluoromethyl [7], and difluorinated ketones, [8] to provide tertiary alcohols have been reported recently. However, the additions of organoboron to unactivated ketones are underdeveloped owing to low reactivity of these unactivated ketones. Only a few examples are available for the additions of aryl boronic esters onto the reported unactivated ketones. For example, the intramolecular enantioselective additions of arylboronic acids to unactivated ketones yield ring tertiary alcohols over palladium or rhodium catalysts in the presence of chiral ligands. [9] A number of unactivated ketones were identified to undergo addition with sodium tetraphenylborate by rhodium catalysis.[10] The intermolecular addition of arylboronic acids to unactivated ketones was first achieved in a low yield by a rhodium catalyst containing an electron-poor biphosphane ligand.[11] Then, boroxines can react with unactivated ketones to provide tertiary alcohols over a rhodium(I)/diene catalyst[12] and were further used to efficiently synthesize of escitalopram via rhodium-catalyzed enantioselective addition to aryl ketones (Scheme 1, a). [13] Among the reported intermolecular addition of organoborons to unactivated ketones, and aryl-boroxines, which are generally not commercially available reagents, were used as a stabilized form of the corresponding boronic acids for the transformation. Besides, rhodium or palladium catalysts are the dominant catalysts for these transformations. Only one report used nickel as catalyst to promote the intermolecular addition of arylboronate esters to unactivated ketones (Scheme 1, b).[14] Substitution of arylboronate esters to arylboronic acids in the reaction results in a low yield of the desired product. [14] Overall, the use of precious

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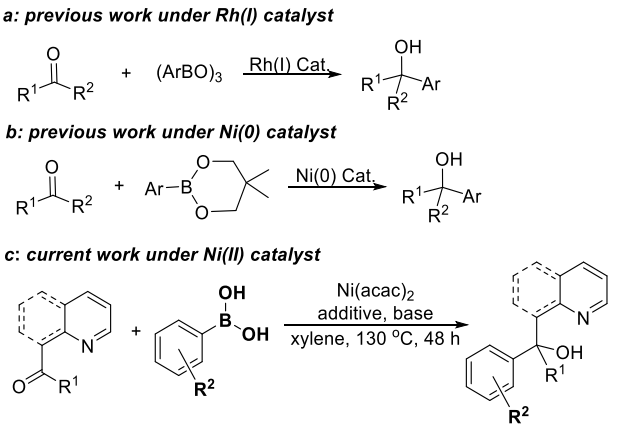


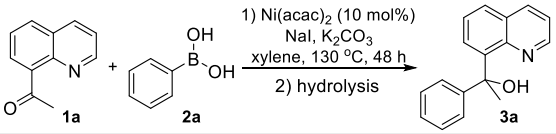
Scheme 1. The reaction of unactivated ketones and arylboronic acids under different catalyst.

metal catalysts and commercially unavailable boroxines seriously hamper the further application of this reaction.

In our laboratory, we are interested in using readily available transition metal complexes for the reactions of arylborons with carbonyl-containing compounds via carbon–carbon bond cleavage.[15] We recently documented a direct exchange of a methyl or aryl group in a quinolinyl ketone to another aryl group via chelation-assisted rhodium-mediated C-C bond activation.[15] In addition, the C-H bond activation reaction [16a-d] and alkyl addition reaction [16e-g] via chelation-assisted catalysis of quinolinyl groups have also been reported continuously. During these studies, we attempted to employ nickel complexes as catalysts for exchange reactions. Unexpectedly, we observed high yield of tertiary alcohol moieties (Scheme 1, c) in our attempts to use nickel complexes as catalysts for such exchange reactions. Here, we report the synthesis of tertiary alcohol via chelation-assisted nickel-catalyzed addition of arylboronic acids to ketones with N-directing group.

Results and Discussion

1-(Quinolin-8-yl)ethan-1-one (**1a**) and phenylboronic acid (**2a**) were selected for optimizing reaction conditions under nickel catalysts. We found that **1a** could smoothly react with **2a** in xylene at 130 °C in the presence of $Ni(acac)_2$ (10 mol.%), K_2CO_3 (0.8 equiv.), and NaI (2.0 equiv.) to provide the tertiary alcohol product **3a** in a high yield (83%) (Table 1). Under these conditions, neither direct exchange of the methyl of **1a** with phenyl group nor homocoupling of **2a** occurred. Several examples of variations from the standard conditions (see the Supporting information for an extensive list of reaction conditions) are listed in Table 1. Other nucleophiles, such as 5, 5-dimethyl-2-phenyl-1,3,2-dioxaborinane($PhBO_2C_5H_{10}$), $PhBF_3K$, $(PhBO)_3$, produced the desired product in low yields (0%–5%). Replacement of the $Ni(acac)_2$ catalyst with other simple nickel compounds, such as NiF_2, $NiCl_2{\cdot}6H_2O$, NiI_2, or $Ni(OAc)_2{\cdot}4H_2O$, resulted in 0%–78% yields of the product. This reaction required both K_2CO_3 and NaI to give high product yield. The use of other bases, namely, K_3PO_4 and Cs_2CO_3, produced 61% and 64% yields, respectively. However, these values were lower than that of K_2CO_3. Other additives, such as CuCl, CuBr, $Cu(OAc)_2$, and I_2, completely terminated the reaction, whereas CuI gave low yields (72%). When the reaction time is shortened to 36 hours, the yield reaches only 63 %. The addition reaction also proceeded slowly at temperature lower than 100 °C to provide the desired **3a** in low yield.



deviation from "standard conditions"		yield (%)[a]
	none	83
Substrate in place of **2a**	$PhBO_2C_5H_{10}$, $PhBF_3K$, $(PhBO)_3$	0-5
Precatalyst in place of $Ni(acac)_2$	$NiCl_2{\cdot}6H_2O$, NiF_2, NiI_2, $Ni(OAc)_2.4H_2O$	0-78
	$PdCl_2$, $Pd(dba)_3$, $[Rh(COD)Cl]_2$	0
Additves in place of NaI	CuCl, CuBr, $Cu(OAc)_2$, I_2	0
	CuI	72
Base in place of K_2CO_3	K_3PO_4, Cs_2CO_3	61-64
Without K_2CO_3		52
Without NaI		55
Change reaction time	24h, 36h	46-63

[a]Rection conditions: **1a** (0.1 mmol), **2a** (2.5 eq), catalyst (10 mol%), additive (2.0 eq), base (0.8 eq) in 0.4 mL xylene, 130 °C , 48h under N_2.

Table 1. Influence of parameters for nickel-catalyzed additions of phenylboronic acid (2a) onto ketone (1a).[a]

With the optimized catalytic system in hand, the effects of various substituted groups on the arylboronic acids to the addition reactions were investigated. The results are shown in Table 2. When **1a** was reacted with phenylboronic acids with a methyl group at *o*-, *m*-, or *p*-position, the desired product **3b**, **3c**, or **3d** was obtained in 37%, 80%, or 74% yields, respectively. The 2,5-Me_2-substituted phenylboronic acid also produced the desired product **3e** in a low yield (42%). These findings showed that increasing steric hindrance of phenylboronic acids decreased the product yield. Phenylboronic acids with an *n*-Bu- or *t*-Bu substitution reacted with **1a** to produce the corresponding tertiary alcohols **3f** and **3g** in 84% and 89% yields, respectively. *m*-MeO- and *p*-MeO- substituted phenylboronic acids can also react with **1a** to produce the corresponding products of **3i** and **3j**, respectively, in 72% and 65% yields. By

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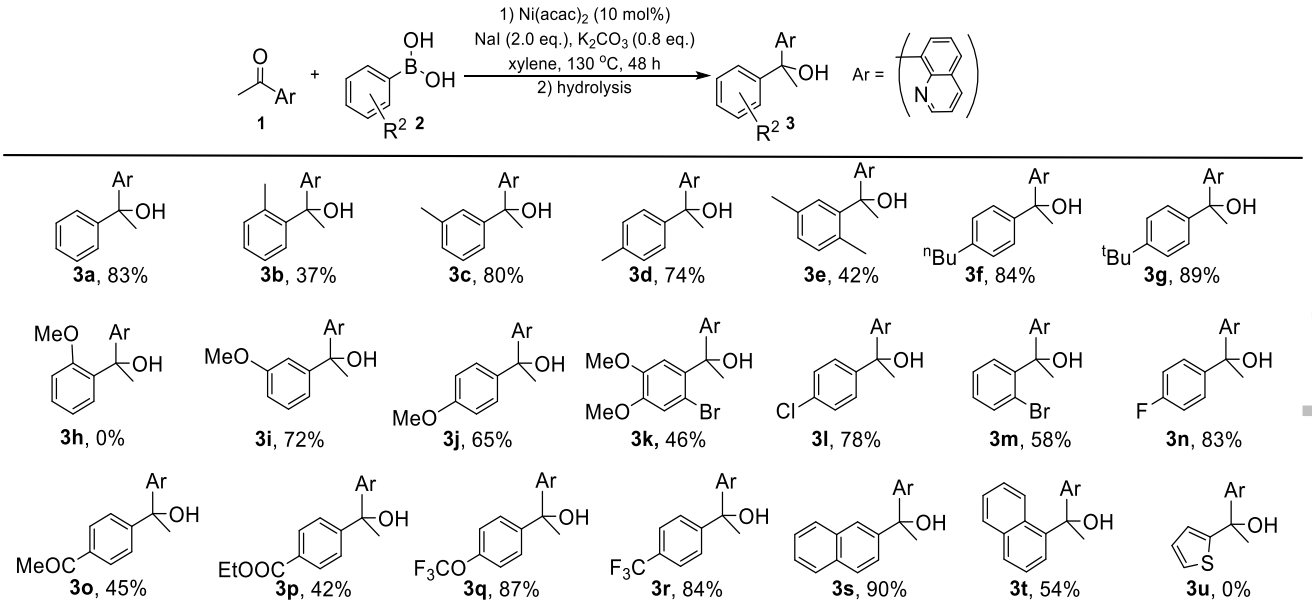
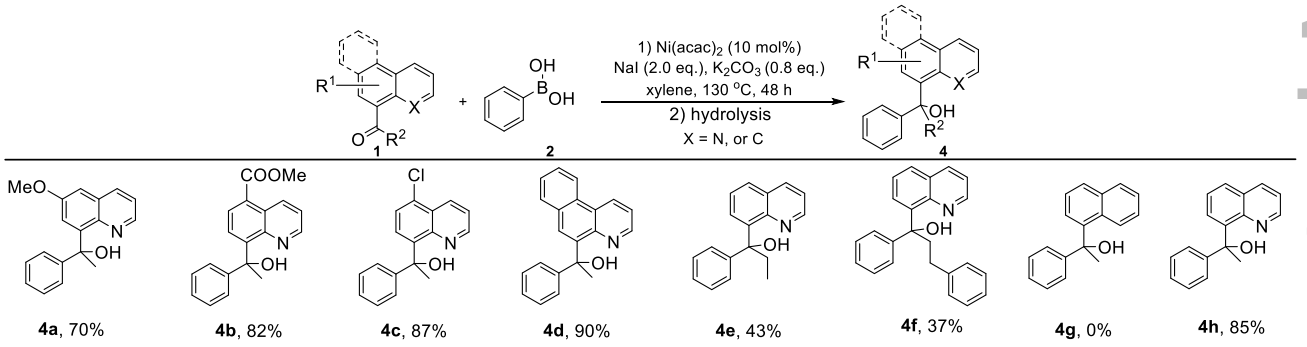
Table 2. Synthesis of tertiary alcohol *via* chelation-assisted nickel(II)-catalyzed addition of arylboronic acids (2) to 1-(quinolin-8-yl)ethan-1-one (1).[a,b]



[a] Reaction conditions: **1** (0.1 mmol), **2** (0.25 mmol), $Ni(acac)_2$ (10.0 mol%), NaI(2.0 eq.), K_2CO_3 (0.8 eq.) in 0.4 mL xylene at 130 °C for 48 h under N_2.
[b] Isolated yields.

Table 3. Chelation-assisted nickel(II)-catalyzed addition of phenylboronic acids (2) to quinoline derivates (1).[a,b]



[a] Reaction conditions: **1** (0.1 mmol), **2** (0.25 mmol), $Ni(acac)_2$ (10.0 mol%), NaI(2.0 eq.), K_2CO_3 (0.8 eq.) in 0.4 mL xylene at 130 °C for 48 h under N_2.
[b] Isolated yields.

contrast, the reaction of phenylboronic acids with the MeO- group at *o*-position with **1a** did not offer any desired product (**3h**). The phenylboronic acids with Cl, Br, and F also reacted with **1a** to produce the desired products **3l**, **3m**, and **3n** in medium to high yields (58%–83%). The electron effect also has a marked impact on the reaction system. For example, the reaction of **1a** with phenylboronic acids with an electron-withdrawing group, such as $–COCH_3$, or –COOEt at *p*-position, produced the corresponding tertiary alcohols **3o**, or **3p** in 45% and 42% yield, respectively, which is significantly lower than those phenylboronic acids having an electron-donating group.

Substitution with other electron-withdrawing groups, such as CF_3 or $–OCF_3$ at *p*-position of the phenylboronic acids, gave **3q** and **3r** 87% and 84% yields, respectively. The naphthalen-2-ylboronic acid also reacted with **1a** to generate product **3s** in 90% yield. Furthermore, thiophen-2-ylboronic acid was used to react with **1a**, but no product was isolated. This may be due to the fact that both the thiophene sulfur atom and the nitrogen atom of the directing group can coordinate with the transition metal, and there is a competitive complexation. Subsequently, the effects of different substitution groups on the quinoline ring were investigated. A 6-MeO-substituted quinoline produced the desired product in

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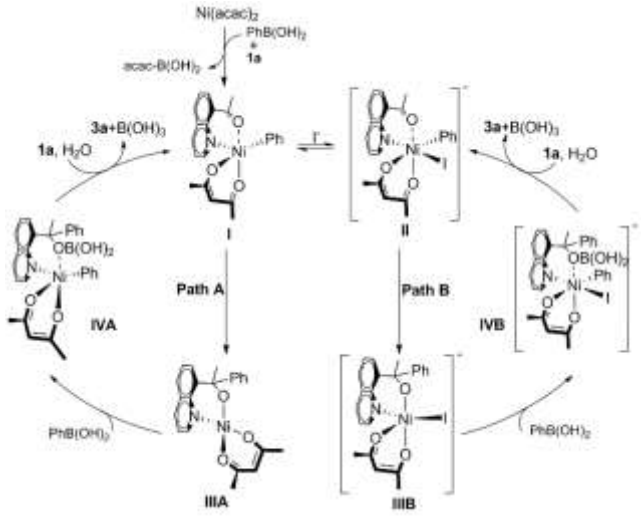
70% yield. This value was slightly lower than that of **1a**. An electron withdrawing group substitution on the quinoline rings, such as 5-MeOOC- and 5-Cl-, gave the corresponding product in 82% and 87% yields, respectively. These yields were comparable or higher than that of **1a**. 1-(Benzo[f]quinolin-5-yl)ethan-1-one was also reacted with phenylboronic acid smoothly to produce the desired product **4d** in 90% yield. However, ethyl and 2-Ph-ethyl ketones generated the desired products **4e** and **4f** in 43% and 37% yields, respectively. By-products through aldol condensation were observed in this reaction system. This finding significantly decreased the product yield. The addition reaction with quinoline-8-carbaldehyde as a substrate also gave a high yield of 85 %. No product was obtained in the reaction with $PhB(OH)_2$ under similar reaction conditions when the quinoline ring was replaced with a naphthalene ring. This result indicated the importance of the N-directing group for the addition of the phenyl group to the ketones. Other ketones containing the N-directing groups, such as 1-(2-methylbenzo [d]oxazol-4-yl)ethan-1-one, also generated no product under similar reaction conditions. This finding implied that the nickel metal center has to be placed in the proximity of the (O)C–C bond to ensure the occurrence of addition reaction.



Scheme 2. A plausible mechanism for addition of arylboronic acid to ketone *via* chelation-assisted nickel-catalysis.

Two possible pathways of the formation of tertiary alcohol **3a** are proposed on the basis of these experiments and previous reports on the catalytic addition of ketones (Scheme 2). One possible mechanism (Scheme 2, Path A) includes the following steps: the precursor of $Ni(acac)_2$ is converted to catalytic intermediate **I** through the transmetallation of phenylboronic acids and the subsequent coordination of **1a**. Then, the intramolecular insertion of the Ph group to the carbonyl group yields intermediate **IIIA**.[14, 17] Phenylboronic acids further undergo transmetallation to the metal center, thereby producing intermediate **IVA**, which contains a Ni‑Ph bond. Finally, the ligand exchange of **IVA** with **1a** releases a borate ester of a tertiary alcohol, thereby generating **3a** after hydrolysis while regenerating **I** that enters another catalytic cycle. During this catalytic process, the intramolecular phenyl migration and insertion reaction (**I→IIIA**), which result in the conversion of the metal center from the five-coordinated pyramid form to the four-coordinated (square planar or tetrahedral structure) mode, is the key transform step. The other possible mechanism (Scheme 2, Path B) includes similar steps except the coordination of iodide: first, **I** is converted to an increasingly active catalyst, namely, intermediate **II**, through the further coordination of iodide. Subsequently, the intramolecular insertion of the carbonyl group, which is moved next to the metal center through the directing group, into the Ni‑Ph bond results in intermediate **IIIB**.[18] The **I→IIIB** process may occur more easily than the corresponding **I→IIIA** process in Path A because the metal center transfers from the six-coordinated octahedral mode, which is a comparatively crowded structure, to the five-coordinated pyramid form. The crowded structure of **II** facilitates the migration and insertion of intramolecular phenyl by tension release. This outcome is consistent with the observation that the addition of iodide to the reaction system can accelerate the reaction and improve product yields. Next, further transmetallation of phenylboronic acids to the metal center forms intermediate **IVB**. Finally, the ligand exchange of **IVB** with **1a** releases a borate ester of a tertiary alcohol, generating tertiary alcohol **3a** after hydrolysis while regenerating intermediate **II** as a catalyst that enters another catalytic cycle. The coordination of iodide can convert the coordination model of the nickel center from pyramidal coordination to octahedral coordination. This condition is essential for the insertion of the carbonyl group to the Ni‑Ph bond.

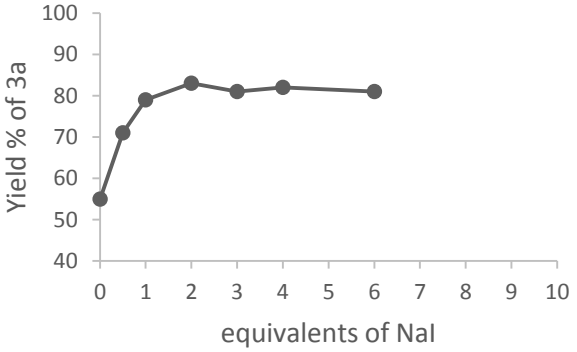


Figure 1. The amount of NaI influences the efficiency of the reaction.

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Although direct observation of the iodide coordinated anionic nickel complex intermediates of **II**, **IIB**, and **IVB** is difficult, there are some experiments to support the proposed mechanism. Firstly, the effect of NaI amounts on reaction efficiency is shown in Figure 1. A significantly lower yield of **3a** was produced using NaI less than 1.0 equivalent. Surprisingly, the addition of up to 3.0 equivalent of NaI does not further improve the reaction yield, and 2.0 equivalent has been the most appropriate. In the absence of NaI, the 1-(quinolin-8-yl)ethan-1-one (**1a**) reacts very slowly with the phenylboronic acid, and the product yield is very low (55%). Secondly, our further study show that the coordination of CuCN and NaSCN to the catalytic metal intermediates also gain high product yields. [19] Thirdly, some reports have demonstrated that the addition of alkali metal halides as an additive could increase the product yields, and the possible mechanism involving anionic nickel complex intermediates has also been studied.[20a-c] For example, Doyle et al [20c] reported a nickel-catalyzed C-C bond forming reaction between simple alkyl aziridines and organozinc reagents. LiCl is an important additive to improve the product yield. The initial reduction of Ni(II) to Ni(0) in the presence of LiCl may generate an anionic $[Ni(0)\text{-}Cl]^-$ complex primed for oxidative addition. In fact, the coordination of halides to form catalytically active anionic metal complexes is very common.[20d-j] The above experiments and studies indicate that NaI may have some interactions with the key transformation intermediates to decrease the activation energy of this reaction.

Conclusion

In conclusion, we developed a new synthetic method for tertiary alcohol *via* chelation-assisted nickel(II)-catalyzed addition of arylboronic acids to unactivated ketones. In the presence of $Ni(acac)_2$ (10.0 mol.%) with NaI (2 equiv.) and K_2CO_3 (0.8 equiv.), a series of substituted phenylboronic acids was reacted with 1-(quinolin-8-yl)ethan-1-one or its derivative to generate various tertiary alcohols in medium to good yields. Various functionalities were tolerated under the standard reaction conditions. The N-directing group is essential for the addition reaction of arylboronic acids to the unactivated ketones. A plausible catalytic mechanism was proposed to explain the production of tertiary alcohol derivatives. Further studies on the applications of this reaction are currently undergoing in this lab.

Experimental Section

General information: Melting points were determined on a SGWX-4B melting point apparatus. ^{1}H NMR, ^{13}C NMR and ^{19}F NMR were recorded on Bruker AV 400 MHz spectrometer with $CDCl_3$ as solvent and tetramethylsilane as the internal standard. The chemical shifts are reported in ppm relative to $CDCl_3$ (δ = 7.26) for ^{1}H NMR and relative to the central $CDCl_3$ resonance (δ = 77.0) for ^{13}C NMR. In addition, the (trifluoromethyl)benzene was used as an external standard for ^{19}F NMR. NMR data of known compounds is in agreement with literature values. Coupling constants (*J*) are quoted in Hz at 400 MHz for ^{1}H. Multiplicities are reported as follows: singlet (s), doublet (d), doublet of doublets (dd), triplet (t), quartet (q), and multiplet (m). Infrared spectra were recorded on a Perkin-Elmer Model 1600 FT-IR spectrophotometer and Nicolet Magna 550 FT-IR spectrophotometer. High resolution mass spectra (HRMS) were obtained on a JEOL JMS-DX303 instrument. Elemental analyses were performed by the Elemental Analysis Section of Tianjin University.

Materials and Methods: Unless otherwise noted, the reaction was monitored by analytical thin layer chromatography on a 0.20 mm silica gel plate and spot detected by UV absorbance. Flash chromatography was performed using silica gel (200-300 mesh) (from Yantai Huagong Chemical Co., Ltd.). The starting materials for the various substitutions **1** were synthesized and purified according to literature procedures. Various substituted phenylboronic acids and other chemicals or reagents are obtained from commercial sources.

General Experimental Procedure for the Ni-Catalyzed Synthesis of Tertiary Alcohol: To an oven-dried screwed vial were added substituted 1-(quinolin-8-yl)ethan-1-one (or quinoline-8-carbaldehyde) (0.1 mmol), substituted phenylboronic acid (0.25 mmol), $Ni(acac)_2$ (2.57 mg, 0.01 mmol), NaI (2.0 eq.), K_2CO_3 (0.8 eq.), and dry xylene (0.4 mL). The mixture was vigorously stirred at 130 °C under N_2 atmosphere for 48 hours to the end of the reaction. Organic solvents were removed, and then the residue was purified by a silica gel column chromatography to give the desired product.

Characterization data of all products:

1-phenyl-1-(quinolin-8-yl)ethan-1-ol (3a): Purified by column chromatography to provide a white solid (20.6 mg, yield: 83%). mp 112-114 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.59 (dd, *J* = 4.2, 1.7 Hz, 1H), 8.42 (s, 1H), 8.04 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.67 (t, *J* = 7.3 Hz, 2H), 7.45 (t, *J* = 7.7 Hz, 1H), 7.36 (d, *J* = 7.7 Hz, 2H), 7.22 (dd, *J* = 8.3, 4.3 Hz, 1H), 7.15 (t, *J* = 7.6 Hz, 2H), 7.06 (t, *J* = 7.3 Hz, 1H), 1.96 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 149.81, 147.73, 146.25, 143.14, 137.23, 129.02, 127.65, 127.60, 127.33, 126.15, 126.04, 125.27, 120.64, 77.68, 31.11; IR (KBr): *v* 3228, 2988, 2930, 1596, 1493, 1437, 1368,1311, 1201, 1108, 1058, 799, 696 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{17}H_{15}NO$: 249.1154, found: 272.1047; Analytical Data. Found (calcd) for: $C_{17}H_{15}NO$ C, 81.88 (81.90); H, 6.05 (6.06); N, 5.63 (5.62).

1-(quinolin-8-yl)-1-(o-tolyl)ethan-1-ol (3b): Purified by column chromatography to provide a white solid (9.7 mg, yield: 37%). mp 138-141 °C. ^{1}H NMR (400 MHz, $CDCl_3$):

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δ 9.06 (s, 1H), 8.84 (dd, *J* = 3.8, 2.1 Hz, 1H), 8.27 - 8.19 (m, 1H), 7.72 (d, *J* = 8.1 Hz, 1H), 7.60 - 7.53 (m, 1H), 7.44 (dd, *J* = 8.3, 4.3 Hz, 1H), 7.36 (t, *J* = 7.7 Hz, 1H), 7.25 - 7.19 (m, 2H), 7.19 - 7.12 (m, 2H), 2.15 (d, *J* = 8.1 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 147.41, 146.48, 144.73, 144.18, 138.00, 137.48, 132.39, 128.97, 127.44, 127.26, 126.92, 126.45, 126.31, 125.00, 120.59, 79.48, 32.11, 21.99; IR (KBr): *v* 3323, 2924, 2854, 1596, 1495, 1461, 1348, 1177, 1097, 823, 792, 749, 673, 479 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{18}H_{17}NO$: 263.1310, found: 286.1211; Analytical Data. Found (calcd) for: $C_{18}H_{17}NO$ C, 82.16 (82.10); H, 6.52 (6.51); N, 5.31 (5.32).

1-(quinolin-8-yl)-1-(m-tolyl)ethan-1-ol (3c): Purified by column chromatography to provide a white solid (21 mg, yield: 80%). mp 86-88 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.71 (dd, *J* = 4.3, 1.7 Hz, 1H), 8.55 (s, 1H), 8.16 (dd, *J* = 8.3, 1.7 Hz, 1H), 7.76 (d, *J* = 7.6 Hz, 2H), 7.56 (t, *J* = 7.7 Hz, 1H), 7.37 - 7.30 (m, 2H), 7.19 (d, *J* = 7.9 Hz, 1H), 7.12 (t, *J* = 7.6 Hz, 1H), 6.98 (d, *J* = 7.4 Hz, 1H), 2.29 (s, 3H), 2.04 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 149.68, 147.73, 146.29, 143.22, 137.25, 137.18, 129.03, 127.54, 127.49, 127.40, 126.98, 126.08, 126.06, 122.38, 120.63, 77.71, 31.23, 21.61; IR (KBr): *v* 3299, 3043, 2978, 2927, 1600, 1594, 1409, 1366, 1162, 1059, 793, 706, 686 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{18}H_{17}NO$: 263.1310, found: 286.1208; Analytical Data. Found (calcd) for: $C_{18}H_{17}NO$ C, 82.15 (82.10); H, 6.50 (6.51); N, 5.32 (5.32).

1-(quinolin-8-yl)-1-(p-tolyl)ethan-1-ol (3d): Purified by column chromatography to provide a white solid (19.4 mg, yield: 74%).mp 118-120 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.62 (dd, *J* = 4.2, 1.8 Hz, 1H), 8.54 (d, *J* = 3.8 Hz, 1H), 8.06 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.76 - 7.64 (m, 2H), 7.49 (t, *J* = 7.7 Hz, 1H), 7.33 (dt, *J* = 8.3, 2.0 Hz, 2H), 7.23 (dd, *J* = 8.3, 4.3 Hz, 1H), 7.03 (d, *J* = 7.8 Hz, 2H), 2.24 (s, 3H), 2.03 (d, *J* = 1.6 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 147.58, 146.84, 146.20, 143.24, 137.13, 135.52, 128.93, 128.31, 127.44, 127.21, 125.97, 125.17, 120.50, 77.56, 31.15, 20.85; IR (KBr): *v* 3235, 2980, 2931, 1598, 1500, 1441, 1369, 1102, 1059, 930, 817, 798, 706, 517cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{18}H_{17}NO$: 263.1310, found: 286.1206; Analytical Data. Found (calcd) for: $C_{18}H_{17}NO$ C, 82.17 (82.10); H, 6.52 (6.51); N, 5.32 (5.32).

1-(2,5-dimethylphenyl)-1-(quinolin-8-yl)ethan-1-ol (3e): Purified by column chromatography to provide a white solid (11.6 mg, yield: 42%). mp 151-153 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.06 (s, 1H), 8.84 (dd, *J* = 4.3, 1.8 Hz, 1H), 8.22 (dd, *J* = 8.4, 1.8 Hz, 1H), 7.74 - 7.67 (m, 1H), 7.47 - 7.40 (m, 2H), 7.36 (t, *J* = 7.7 Hz, 1H), 7.18 (dd, *J* = 7.3, 1.4 Hz, 1H), 7.05 (s, 2H), 2.38 (s, 3H), 2.14 (s, 3H), 2.09 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 147.36, 146.46, 144.43, 144.23, 137.45, 134.70, 134.14, 132.25, 128.92, 127.77, 127.49, 127.30, 126.84, 126.29, 120.53, 79.40,32.21, 21.50, 21.26; IR (KBr): *v* 3200, 2975, 2922, 1601, 1488, 1456, 1368, 1310, 1166, 1103, 1050, 1000, 792, 686, 626 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{19}H_{19}NO$: 277.1467, found: 300.1361; Analytical Data. Found (calcd) for: $C_{19}H_{19}NO$ C, 82.25 (82.28); H, 6.91 (6.90); N, 5.05 (5.05).

1-(4-butylphenyl)-1-(quinolin-8-yl)ethan-1-ol (3f): Purified by column chromatography to provide a white solid (25.6 mg, yield: 84%). mp 53-55 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.68 (dd, *J* = 4.2, 1.6 Hz, 1H), 8.64 (s, 1H), 8.12 (dd, *J* = 8.3, 1.7 Hz, 1H), 7.74 (t, *J* = 7.4 Hz, 2H), 7.54 (t, *J* = 7.7 Hz, 1H), 7.39 (d, *J* = 7.8 Hz, 2H), 7.29 (dd, *J* = 8.3, 4.3 Hz, 1H), 7.09 (d, *J* = 7.8 Hz, 2H), 2.56 (t, *J* = 7.8 Hz, 2H), 2.08 (s, 3H), 1.62 - 1.51 (m, 2H), 1.40 - 1.29 (m, 2H), 0.91 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 147.58, 146.91, 146.28, 143.36, 140.60, 137.17, 128.97, 127.65, 127.44, 127.33, 126.01, 125.21, 120.53, 77.69, 35.10, 33.46, 31.19, 22.36, 13.90; IR (KBr): *v* 3303, 2927, 2862, 1602, 1498, 1371, 1102, 1053, 919, 828, 796, 683, 580 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{21}H_{23}NO$: 305.1780, found: 328.1669; Analytical Data. Found (calcd) for: $C_{21}H_{23}NO$ C, 82.56 (82.58); H, 7.61 (7.59); N, 4.58 (4.59).

1-(4-(tert-butyl)phenyl)-1-(quinolin-8-yl)ethan-1-ol (3g): Purified by column chromatography to provide a white solid (27.1 mg, yield: 89%). mp 141-142 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.72 (dd, *J* = 4.3, 1.7 Hz, 1H), 8.64 (s, 1H), 8.16 (dd, *J* = 8.4, 1.8 Hz, 1H), 7.74 (t, *J* = 7.8 Hz, 2H), 7.54 (t, *J* = 7.7 Hz, 1H), 7.35 (dd, *J* = 8.3, 3.4 Hz, 3H), 7.25 (d, *J* = 8.5 Hz, 2H), 2.04 (s, 3H), 1.26 (s, 9H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 148.77, 147.56, 146.55, 146.37, 143.42, 137.19, 129.00, 127.42, 126.05, 125.05, 124.54, 120.53, 77.73, 34.22, 31.31, 31.20; IR (KBr): *v* 3244, 2957, 2865, 1595, 1576, 1494, 1450, 1365, 1266, 1105, 1017, 933, 832, 798, 712, 548 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{21}H_{23}NO$: 305.1780, found: 328.1673; Analytical Data. Found (calcd) for: $C_{21}H_{23}NO$ C, 82.57 (82.58); H, 7.60 (7.59); N, 4.58 (4.59).

1-(3-methoxyphenyl)-1-(quinolin-8-yl)ethan-1-ol (3i): Purified by column chromatography to provide a white solid (20.1 mg, yield: 72%). mp 97-99 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.50 (dq, *J* = 4.1, 1.9 Hz, 1H), 8.44 (d, *J* = 2.8 Hz, 1H), 7.94 (dt, *J* = 8.2, 1.6 Hz, 1H), 7.67 - 7.54 (m, 2H), 7.43 - 7.35 (m, 1H), 7.11 (ddq, *J* = 8.3, 4.3, 2.7, 1.5 Hz, 1H), 7.02 - 6.96 (m, 2H), 6.87 - 6.80 (m, 1H), 6.56 (dd, *J* = 8.2, 2.5 Hz, 1H), 3.60 (s, 3H), 1.92 (d, *J* = 1.6 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 159.04, 151.65, 147.60, 146.11, 142.83, 137.12, 128.88, 128.48, 127.53, 127.22, 125.94, 120.51, 117.77, 111.36, 111.12, 77.58, 54.94, 30.98; IR (KBr): *v* 3273, 2961, 2938, 2835, 1606, 1578, 1496, 1480, 1430, 1371, 1313, 1049, 932, 882, 780, 707,550 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{18}H_{17}NO_2$: 279.1259, found: 302.1154; Analytical Data. Found (calcd) for: $C_{18}H_{17}NO_2$ C, 77.42 (77.40); H, 6.14 (6.13); N, 5.02 (5.01).

1-(4-methoxyphenyl)-1-(quinolin-8-yl)ethan-1-ol (3j): Purified by column chromatography to provide a white solid (18.1 mg, yield: 65%). mp 104-106 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (dd, *J* = 4.3, 1.8 Hz, 1H), 8.54 (s, 1H), 8.17 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.73 (ddd, J = 18.8, 7.7, 1.4 Hz, 2H), 7.53 (dd, *J* = 8.2, 7.3 Hz, 1H), 7.35 (dd, *J* = 8.6,

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4.6 Hz, 3H), 6.81 – 6.75 (m, 2H), 3.75 (s, 3H), 2.04 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 157.96, 147.68, 146.41, 143.56, 142.05, 137.29, 129.11, 127.51, 127.40, 126.59, 126.09, 120.63, 113.03, 77.57, 55.13, 31.26; IR (KBr): *v* 3289, 2929, 2837, 1605, 1504, 1459, 1368, 1248, 1176, 1100, 1031, 832, 797, 586 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{18}H_{17}NO_2$: 279.1259, found: 302.1157; Analytical Data. Found (calcd) for: $C_{18}H_{17}NO_2$ C, 77.43 (77.40); H, 6.14 (6.13); N, 5.00 (5.01).

1-(3,4-dimethoxyphenyl)-1-(quinolin-8-yl)ethan-1-ol (3k): Purified by column chromatography to provide a white solid (14.2 mg, yield: 46%). mp 88-90 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.75 – 8.68 (m, 2H), 8.17 (dd, *J* = 8.3, 1.7 Hz, 1H), 7.79 – 7.73 (m, 1H), 7.71 – 7.63 (m, 1H), 7.52 (t, *J* = 7.7 Hz, 1H), 7.36 (dd, *J* = 8.3, 4.3 Hz, 1H), 7.22 (d, *J* = 2.0 Hz, 1H), 6.78 – 6.63 (m, 2H), 3.82 (d, *J* = 13.9 Hz, 6H), 2.05 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 148.33, 147.66, 147.30, 146.31, 143.21, 142.39, 137.30, 129.02, 127.54, 127.43, 126.03, 120.62, 117.49, 110.04, 109.25, 77.76, 55.73, 55.68, 31.15; IR (KBr): *v* 3372, 2927, 2857, 1595, 1508, 1445, 1407, 1367, 1257, 1229, 1133, 1026 , 801, 765, 652 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{19}H_{19}NO_3$: 309.1365, found: 332.1258; Analytical Data. Found (calcd) for: $C_{19}H_{19}NO_3$ C, 73.75 (73.77); H, 6.18 (6.19); N, 4.54 (4.53).

1-(4-chlorophenyl)-1-(quinolin-8-yl)ethan-1-ol (3l): Purified by column chromatography to provide a white solid (22.0 mg, yield: 78%). mp 110-112 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.57 (dd, *J* = 4.2, 1.8 Hz, 1H), 8.37 (s, 1H), 8.05 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.66 (dd, *J* = 7.8, 4.5 Hz, 2H), 7.45 (t, *J* = 7.7 Hz, 1H), 7.29 – 7.20 (m, 3H), 7.12 – 7.05 (m, 2H), 1.92 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 148.52, 147.70, 146.07, 142.62, 137.21, 131.80, 128.99, 127.73, 127.69, 127.16, 126.76, 126.00, 120.65, 77.31, 30.90; IR (KBr): *v* 3212, 2926, 2854, 1600, 1487, 1437, 1369, 1204, 1092, 1051, 818,797, 674 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{17}H_{14}ClNO$: 283.0764, found: 306.0665; Analytical Data. Found (calcd) for: $C_{17}H_{14}ClNO$ C, 71.98 (71.96); H, 4.96 (4.97); N, 4.95 (4.94).

1-(2-bromophenyl)-1-(quinolin-8-yl)ethan-1-ol (3m): Purified by column chromatography to provide a white solid (18.9 mg, yield: 58%). mp 95-97 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.84 (s, 1H), 8.74 (dd, *J* = 4.3, 1.7 Hz, 1H), 8.19 (dd, *J* = 8.4, 1.7 Hz, 1H), 7.90 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.74 (dd, *J* = 7.9, 1.7 Hz, 1H), 7.52 - 7.43 (m, 3H), 7.40 -7.32 (m, 2H), 7.09 (td, *J* = 7.6, 1.6 Hz, 1H), 2.17 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 147.44, 146.44, 146.15, 142.23, 137.37, 135.16, 128.78, 128.52, 128.44, 128.41, 127.19, 126.67, 126.03, 122.77, 120.53, 78.88, 30.31; IR (KBr): *v* 3227, 2924, 2854, 1596, 1461, 1430, 1366, 1265, 1068, 1023, 926, 830, 794, 756, 648, 508 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{17}H_{14}BrNO$: 327.0259, found: 350.0149; Analytical Data. Found (calcd) for: $C_{17}H_{14}BrNO$ C, 62.23 (62.21); H, 4.29 (4.30); N, 4.27 (4.27).

1-(4-fluorophenyl)-1-(quinolin-8-yl)ethan-1-ol (3n): Purified by column chromatography to provide a bronzing solid (22.2 mg, yield: 83%). mp 105-107 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.58 – 8.53 (m, 1H), 8.42 (s, 1H), 8.02 (dd, *J* = 8.4, 1.7 Hz, 1H), 7.66 – 7.58 (m, 2H), 7.42 (t, *J* = 7.7 Hz, 1H), 7.29 (dd, *J* = 8.5, 5.5 Hz, 2H), 7.20 (dd, *J* = 8.3, 4.3 Hz, 1H), 6.79 (t, *J* = 8.6 Hz, 2H), 1.92 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 161.27(d, *J*=242 Hz), 147.71, 146.14, 145.58 (d, *J*=3Hz), 142.89, 137.27, 129.02, 127.70, 127.24, 126.98, 126.90, 126.02, 120.67, 114.30 (d, *J*=21Hz), 77.38, 31.14; ^{19}F NMR (376 MHz, $CDCl_3$): δ -117.37 (s,1F); IR (KBr): *v* 3214, 2976, 2928, 1597, 1502, 1444, 1367, 1211, 1074, 1010, 931, 836, 796, 765, 720, 522 cm^{-1};ESI-MS $[M+Na]^+$ calcd for $C_{17}H_{14}FNO$: 267.1059, found: 290.0958; Analytical Data. Found (calcd) for: $C_{17}H_{14}FNO$ C, 76.41 (76.39); H, 5.29 (5.28); N, 5.25 (5.24).

1-(4-(1-hydroxy-1-(quinolin-8-yl) ethyl)phenyl)ethan-1-one (3o): Purified by column chromatography to provide a white solid (13.1 mg, yield: 45%). mp 175-177 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.68 (dd, *J* = 4.3, 1.8 Hz, 1H), 8.40 (s, 1H), 8.18 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.86 – 7.77 (m, 4H), 7.59 (t, *J* = 7.7 Hz, 1H), 7.55 – 7.48 (m, 2H), 7.36 (dd, *J* = 8.3, 4.3 Hz, 1H), 2.53 (s, 3H), 2.03 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 197.83, 155.57, 147.93, 146.14, 142.43, 137.35, 135.23, 129.12, 127.97, 127.25, 126.16, 125.46, 120.85, 77.58, 30.67, 26.55; IR (KBr): *v* 3221, 2971, 2920, 1674, 1600, 1495, 1403, 1369, 1270, 1208, 1098, 836, 798, 653, 601 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{19}H_{17}NO_2$: 291.1259, found: 314.1152; Analytical Data. Found (calcd) for: $C_{19}H_{17}NO_2$ C, 78.30 (78.33); H, 5.88 (5.88); N, 4.80 (4.81).

Ethyl 4-(1-hydroxy-1-(quinolin-8-yl)ethyl)benzoate (3p): Purified by column chromatography to provide a yellow solid (13.5 mg, yield: 42%). mp 86-88 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.59 (dd, *J* = 4.3, 1.9 Hz, 1H), 8.32 (s, 1H), 8.08 (dd, *J* = 8.4, 1.8 Hz, 1H), 7.85 – 7.78 (m, 2H), 7.72 (t, *J* = 8.1 Hz, 2H), 7.50 (t, *J* = 7.8 Hz, 1H), 7.41 (d, *J* = 8.4 Hz, 2H), 7.26 (dd, *J* = 8.4, 4.2 Hz, 1H), 4.24 (q, *J* = 7.1 Hz, 2H), 1.95 (s, 3H), 1.26 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 166.54, 155.18, 147.87, 146.13, 142.52, 137.30, 129.06, 128.40, 127.90, 127.22, 126.12, 125.24, 120.80, 77.59, 60.68, 30.68, 14.29; IR (KBr): *v* 3298, 2985, 2935, 1715, 1603, 1496, 1371, 1278, 1117, 798, 772, 710, 577 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{20}H_{19}NO_3$: 321.1365, found: 344.1257; Analytical Data. Found (calcd) for: $C_{20}H_{19}NO_3$ C, 74.76 (74.75); H, 5.95 (5.96); N, 4.37 (4.36).

1-(quinolin-8-yl)-1-(4-(trifluoromethoxy)phenyl)ethan-1-ol (3q): Purified by column chromatography to provide a bronzing solid (28.9 mg, yield: 87%). mp 57-59 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.70 (dd, *J* = 4.3, 1.9 Hz, 1H), 8.53 (s, 1H), 8.18 (dd, *J* = 8.3, 1.9 Hz, 1H), 7.76 (ddd, *J* = 12.6, 7.7, 1.5 Hz, 2H), 7.59 – 7.52 (m, 1H), 7.47 – 7.41 (m, 2H), 7.36 (dd, *J* = 8.3, 4.3 Hz, 1H), 7.09 – 7.03 (m, 2H), 2.03 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 148.63, 147.86, 147.61, 147.59, 146.24, 142.71, 137.38, 129.16, 127.88, 127.34, 126.80, 126.13, 120.82,120.48 (d, *J*=255 Hz), 120.06, 77.47, 31.08; ^{19}F NMR (376 MHz, $CDCl_3$): δ -57.80 (s, 3F); IR (KBr): *v* 3246, 2985, 2932, 1597, 1500, 1259, 1174, 1098, 1053, 796, 713, 586 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{18}H_{14}F_3NO_2$: 333.0977, found:

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356.0870; Analytical Data. Found (calcd) for: $C_{18}H_{14}F_3NO_2$ C, 64.88 (64.86); H, 4.23 (4.23); N, 4.21 (4.20).

1-(quinolin-8-yl)-1-(4-(trifluoromethyl) phenyl) ethan-1-ol (3r): Purified by column chromatography to provide a white solid (26.6 mg, yield: 84%). mp 117-119 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.55 (dd, *J* = 4.4, 1.7 Hz, 1H), 8.36 (s, 1H), 8.04 (dd, *J* = 8.4, 1.7 Hz, 1H), 7.69 (dd, *J* = 12.2, 7.7 Hz, 2H), 7.46 (dd, *J* = 12.8, 8.0 Hz, 3H), 7.36 (d, *J* = 8.2 Hz, 2H), 7.21 (dd, *J* = 8.3, 4.3 Hz, 1H), 1.93 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 154.08, 147.90, 146.04, 142.27, 137.32, 129.06, 128.27 (d, *J*=32 Hz)127.98, 127.23, 126.10, 125.55, 124.65 (d, *J*=4 Hz), 124.26 (d, J=270Hz), 120.82, 77.43, 30.80; ^{19}F NMR (376 MHz, $CDCl_3$): δ -62.21 (s, 3F); IR (KBr): *v* 3279, 2926, 1592, 1496, 1406, 1372, 1323, 1174, 1132, 1103, 1077, 1065, 1052, 842, 833, 612 cm^{-1}; ESI-MS [M+Na]$^+$ calcd for $C_{18}H_{14}F_3NO$: 317.1027, found: 340.0923; Analytical Data. Found (calcd) for: $C_{18}H_{14}F_3NO$ C, 68.16 (68.13); H, 4.45 (4.45); N, 4.40 (4.41).

1-(naphthalen-2-yl)-1-(quinolin-8-yl)ethan-1-ol (3s): Purified by column chromatography to provide a white solid (26.9 mg, yield: 90%). mp 58-60 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.59 (s, 1H), 8.43 (d, *J* = 4.0 Hz, 1H), 7.86 (d, *J* = 8.3 Hz, 1H), 7.81 (s, 1H), 7.66 – 7.50 (m, 5H), 7.45 (d, *J* = 8.6 Hz, 1H), 7.36 (t, *J* = 7.7 Hz, 1H), 7.28 – 7.17 (m, 2H), 7.01 (dd, *J* = 8.3, 4.3 Hz, 1H), 2.00 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 147.59, 147.17, 146.19, 142.90, 137.12, 132.90, 132.04, 128.91, 128.04, 127.59, 127.38, 127.30, 127.24, 125.97, 125.64, 125.31, 124.43, 123.42, 120.50, 77.83, 30.99; IR (KBr): *v* 3320, 2924, 2855, 1598, 1495, 1437, 1370, 1124, 1096, 905, 820, 792, 747, 673, 479 cm^{-1}; ESI-MS [M+Na]$^+$ calcd for $C_{21}H_{17}NO$: 299.1310, found: 322.1203; Analytical Data. Found (calcd) for: $C_{21}H_{17}NO$ C, 84.27 (84.25); H, 5.72 (5.72); N, 4.67 (4.68).

1-(naphthalen-1-yl)-1-(quinolin-8-yl)ethan-1-ol (3t): Purified by column chromatography to provide a white solid (16.1 mg, yield: 54%). mp 170-172 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.31 (s, 1H), 8.89 (dd, *J* = 4.3, 1.9 Hz, 1H), 8.38 (d, *J* = 8.8 Hz, 1H), 8.26 (dd, *J* = 8.4, 1.9 Hz, 1H), 7.86 – 7.80 (m, 2H), 7.67 (ddd, *J* = 23.9, 7.7, 1.4 Hz, 2H), 7.50 – 7.42 (m, 2H), 7.35 (ddd, *J* = 8.1, 6.6, 1.2 Hz, 1H), 7.28 – 7.23 (m, 1H), 7.18 (ddd, *J* = 8.5, 6.7, 1.5 Hz, 1H), 7.07 (dd, *J* = 7.4, 1.5 Hz, 1H), 2.31 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 147.48, 146.30, 144.34, 142.08, 137.55, 135.03, 131.49, 129.08, 128.85, 128.81, 128.38, 127.97, 126.99, 126.32, 124.86, 124.74, 124.50, 124.39, 120.60, 79.83,32.47; IR (KBr): *v* 3194, 2924, 2854, 1597, 1497, 1462, 1312, 1093, 1058, 831, 788, 690 cm^{-1}; ESI-MS [M+Na]$^+$ calcd for $C_{21}H_{17}NO$: 299.1310, found: 322.1209; Analytical Data. Found (calcd) for: $C_{21}H_{17}NO$ C, 84.28 (84.25); H, 5.71 (5.72); N, 4.68 (4.68).

1-(6-methoxyquinolin-8-yl)-1-phenylethan-1-ol (4a): Purified by column chromatography to provide a white solid (19.5 mg, yield: 70%). mp 112-114 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.47 – 8.41 (m, 2H), 7.93 (dd, *J* = 8.5, 1.7 Hz, 1H), 7.40 – 7.31 (m, 3H), 7.20 – 7.12 (m, 3H), 7.06 (t, *J* = 7.3 Hz, 1H), 6.88 (d, *J* = 2.6 Hz, 1H), 3.84 (s, 3H), 1.92 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 156.97, 149.41, 145.20, 144.86, 142.62, 135.89, 130.29, 127.68, 126.21, 125.24, 120.99, 120.86, 104.09, 77.55, 55.47, 30.98; IR (KBr): *v* 3195, 2961, 2931, 1617, 1600, 1416, 1371, 1256, 1047, 1029, 843, 801, 700 cm^{-1}; ESI-MS [M+Na]$^+$ calcd for $C_{18}H_{17}NO_2$: 279.1259, found: 302.1156; Analytical Data. Found (calcd) for: $C_{18}H_{17}NO_2$ C, 77.43 (77.40); H, 6.14 (6.13); N, 5.02 (5.01).

Methyl 8-(1-hydroxy-1-phenylethyl)quinoline-5-carboxylate (4b): Purified by column chromatography to provide a white liquide (25.1 mg, yield: 82%). mp 35-37 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.40 (dd, *J* = 8.8, 1.8 Hz, 1H), 8.73 (dd, *J* = 4.1, 1.9 Hz, 1H), 8.44 (s, 1H), 8.29 (d, *J* = 7.8 Hz, 1H), 7.80 (d, *J* = 7.8 Hz, 1H), 7.46 (dd, *J* = 8.8, 4.2 Hz, 1H), 7.41 – 7.37 (m, 2H), 7.23 (t, *J* = 7.7 Hz, 2H), 7.16 (d, *J* = 7.0 Hz, 1H), 4.01 (s, 3H), 2.05 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 166.65, 149.30, 148.53, 147.81, 146.33, 135.63, 130.35, 127.81, 127.78, 126.36, 126.14, 125.21, 121.96, 77.74, 52.36, 31.02; IR (KBr): *v* 3383,2927, 2853, 1718, 1504, 1435, 1367, 1277,1201, 1132, 1055, 1023, 762, 738, 701 cm^{-1}; ESI-MS [M+Na]$^+$ calcd for $C_{19}H_{17}NO_3$: 307.1208, found: 330.1107; Analytical Data. Found (calcd) for: $C_{19}H_{17}NO_3$ C, 74.27 (74.25); H, 5.57 (5.58); N, 4.55 (4.56).

1-(5-chloroquinolin-8-yl)-1-phenylethan-1-ol (4c): Purified by column chromatography to provide a white solid (24.6 mg, yield: 87%). mp 113-115 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.64 (dd, *J* = 4.4, 1.8 Hz, 1H), 8.50 (dd, *J* = 8.6, 1.8 Hz, 1H), 8.07 (s, 1H), 7.61 – 7.51 (m, 2H), 7.36 – 7.30 (m, 3H), 7.17 – 7.12 (m, 2H), 7.09 – 7.04 (m, 1H), 1.93 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 149.44, 148.32, 146.83, 142.67, 134.06, 130.82, 127.74, 127.17, 126.94, 126.30, 126.03, 125.20, 121.39, 77.43, 31.03; IR (KBr): *v* 3317, 3063, 2985, 2932, 1570, 1492, 1448, 1355, 1290, 1160, 1067, 1035, 997, 940, 854, 797, 690, 612, 535 cm^{-1}; ESI-MS [M+Na]$^+$ calcd for $C_{17}H_{14}ClNO$: 283.0764, found: 306.0660; Analytical Data. Found (calcd) for: $C_{17}H_{14}ClNO$ C, 71.98 (71.96); H, 4.96 (4.97); N, 4.94 (4.94).

1-(benzo[f]quinolin-5-yl)-1-phenylethan-1-ol (4d): Purified by column chromatography to provide a white solid (26.9 mg, yield: 90%). mp 162-164 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.91 (dd, *J* = 8.5, 1.6 Hz, 1H), 8.68 (dd, *J* = 4.4, 1.7 Hz, 1H), 8.56 – 8.50 (m, 1H), 8.37 (s, 1H), 8.06 (s, 1H), 7.97 (dd, *J* = 6.3, 3.1 Hz, 1H), 7.70 – 7.65 (m, 2H), 7.51 – 7.40 (m, 3H), 7.21 (t, *J* = 7.5 Hz, 2H), 7.13 (t, *J* = 7.2 Hz, 1H), 2.10 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 149.82, 147.10, 146.94, 140.64, 131.65, 130.90, 129.23, 128.44, 127.73, 127.67, 127.27, 126.42, 126.13, 125.19, 122.21, 120.89, 77.52, 31.07; IR (KBr): *v* 3286, 2977, 2932, 1596, 1486, 1403, 1368, 1174, 1107, 1002, 903, 760, 699, 512 cm^{-1}; ESI-MS [M+Na]$^+$ calcd for $C_{21}H_{17}NO$: 299.1310, found: 322.1208; Analytical Data. Found (calcd) for: $C_{21}H_{17}NO$ C, 84.28 (84.25); H, 5.72 (5.72); N, 4.69 (4.68).

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1-phenyl-1-(quinolin-8-yl)propan-1-ol (4e): Purified by column chromatography to provide a white solid (11.3 mg, yield: 43%). mp 99-101 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.90 (s, 1H), 8.70 (dd, *J* = 4.3, 1.7 Hz, 1H), 8.14 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.75 (dd, *J* = 10.8, 7.7 Hz, 2H), 7.56 (t, *J* = 7.7 Hz, 1H), 7.47 (d, *J* = 7.5 Hz, 2H), 7.33 (dd, *J* = 8.3, 4.3 Hz, 1H), 7.28 - 7.19 (m, 2H), 7.13 (t, *J* = 7.2 Hz, 1H), 2.50 (dq, *J* = 14.3, 7.2 Hz, 1H), 2.27 (dq, *J* = 14.4, 7.3 Hz, 1H), 1.05 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 148.51, 147.45, 146.76, 142.12, 137.33, 129.16, 127.64, 127.51, 127.34, 126.04, 125.99, 125.82, 120.56, 80.14, 35.29, 8.47; IR (KBr): *v* 3379, 2926, 1612, 1496, 1406, 1372, 1323, 1174, 1132, 1102, 1076, 1065, 915,842, 832, 612 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{18}H_{17}NO$: 263.1310, found: 286.1201; Analytical Data. Found (calcd) for: $C_{18}H_{17}NO$ C, 82.14 (82.10); H, 6.50 (6.51); N, 5.33 (5.32).

1,3-diphenyl-1-(quinolin-8-yl)propan-1-ol (4f): Purified by column chromatography to provide a colorless liquid (12.5 mg, yield: 37%). ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.02 (s, 1H), 8.59 (dd, *J* = 4.3, 1.7 Hz, 1H), 8.00 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.69 (d, *J* = 7.3 Hz, 1H), 7.61 (d, *J* = 8.1 Hz, 1H), 7.45 (dd, *J* = 7.8, 6.0 Hz, 3H), 7.21 - 7.11 (m, 7H), 7.06 (dt, *J* = 9.6, 4.5 Hz, 2H), 2.95 - 2.86 (m, 1H), 2.74 - 2.59 (m, 2H), 2.52 - 2.43 (m, 1H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 148.10, 147.48, 146.60, 143.01, 142.01, 137.38, 129.15, 128.42, 128.31, 128.27, 127.66, 127.47, 126.17, 126.08, 125.77, 125.54, 120.63, 79.89, 44.71, 30.34; IR (KBr): *v* 3289, 3058, 3026, 2930, 1602, 1494, 1447, 1370, 1056, 829, 795, 700 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{24}H_{21}NO$: 339.1623, found: 362.1513; Analytical Data. Found (calcd) for: $C_{24}H_{21}NO$ C, 84.90 (84.92); H, 6.23 (6.24); N, 4.13 (4.13).

phenyl(quinolin-8-yl)methanol (4h): Purified by column chromatography to provide a white solid (19.9 mg, yield: 85%). mp 102-105 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.87 - 8.80 (m, 1H), 8.22 - 8.14 (m, 1H), 7.73 (d, *J* = 8.0 Hz, 1H), 7.50 (d, *J* = 7.7 Hz, 2H), 7.47 - 7.38 (m, 3H), 7.33 (t, *J* = 7.5 Hz, 2H), 7.25 - 7.21 (m, 1H), 6.95 (s, 1H), 6.41 (s, 1H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 148.54, 146.51, 143.85, 140.17, 137.03, 128.80, 128.50, 128.13, 127.38, 127.05, 126.77, 126.32, 121.00, 76.42; IR (KBr): *v* 3228, 1596, 1497, 1448, 1369, 1260, 1242, 1016, 890, 794, 729, 605 cm^{-1}; ESI-MS $[M+Na]^+$ calcd for $C_{16}H_{13}NO$: 235.0997, found: 258.0892; Analytical Data. Found (calcd) for: $C_{16}H_{13}NO$ C, 81.70 (81.68); H, 5.56 (5.57); N, 5.96 (5.95).

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[19]Unpublished experiments: reaction of 1-(quinolin-8-yl)ethan-1-one(0.1mmol) and arylboronic acids (2.5 eq.) in the presence of $[Rh(COD)Cl]_2$ (5 mol%), K_2CO_3 (0.8 eq.), CuCN (1.5 eq.) under similar reaction conditions gave **3a** in 87% yield; Substitution of CuCN with NaSCN gave **3a** in 61% yield.

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FULL PAPER

Formation of Tertiary Alcohol via Chelation-Assisted Nickel(II)-Catalyzed Addition of Arylboronic Acids to Unactivated 1-(Quinolin-8-yl)ethan-1-one

Adv. Synth. Catal. **Year**, *Volume*, Page – Page

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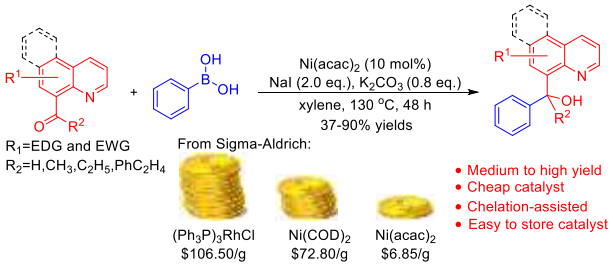

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