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The novel reaction of ketones with *o*-oxazoline-substituted anilines

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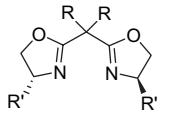
Abstract—A variety of ketones react with *o*-oxazoline-substituted anilines in the presence of catalytic amount of *p*-toluenesulfonic acid in dry *n*-butanol to form 4-amino-substituted quinolines or 4-quinolones in fair to good yields.

1. Introduction

Oxazolines, especially chiral bis(oxazoline) (BOX, **1**), have been successfully used in many catalytic asymmetric reactions as versatile ligands in the past decade.[1] In addition, the oxazoline unit and adjacent hydroxy group may function together to control the catalytic process.[2] On the other hand, Hong and his co-workers have reported the use of Schiff-bases as ligands in the palladium-catalyzed Suzuki cross-coupling reactions.[3] Thus, in the presence of an *N*,*O*-bidentate ligand such as 2-[1-(2,4,6-trimethyl-phenylimino)-ethyl]-phenol **2**, Suzuki cross-coupling reactions could be carried out efficiently at room temperature with a wide variety of arylbromides even with electronically deactivated arenes. As a continuation of our ongoing project on the development of novel chiral ligands on polymer-supported palladium catalyst,[4] we attempted to put the chiral oxazolines on the *N*,*O*-bidentate ligand in order to prepare some chiral Schiff-bases as the ligands for palladium-catalyzed coupling reactions. However, to our surprise, we found that the oxazoline ring underwent ring opening very easily during the preparation of Schiff-bases. As to our knowledge, there is no report so far for this kind of ring opening of oxazoline to form quinoline or quinolone derivatives from *o*-oxazoline-substituted anilines in the presence of acid catalyst. In view of the importance of 4-amino-substituted quinolines in medicinal chemistry[5] such as tacrine, which was used as a drug to cure Alzheimer's disease, and the strong desire for a general synthetic route for their preparations,[6] herein, we report a new entry to 4-amino-substituted quinolines or 4-quinolones by reaction of various ketones with *o*-oxazoline-substituted anilines (Tables 1 and 2).



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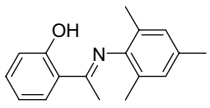

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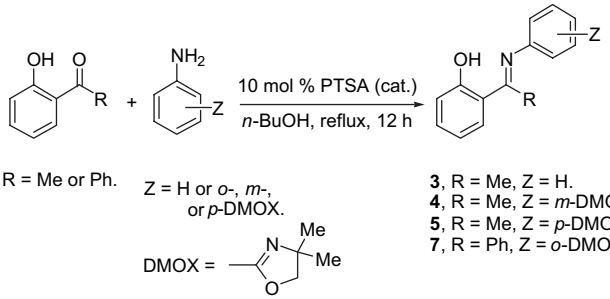
2. Results and discussion

In the synthesis of imine 2-[1-(phenylimino)-ethyl]phenol **3**, by treatment of *o*-hydroxyacetophenone with aniline in distilled *n*-butanol in the presence of 10 mol % of dry PTSA at reflux, the desired product was obtained (Eq. 1). It was found that the use of very dry *n*-butanol[7] is crucial for obtaining good yield (88%). Similar reactions of *m*- or *p*-(oxazolin-2-yl)aniline with *o*-hydroxyacetophenone formed **4** or **5**, respectively, and the reaction of 2-(4,4-dimethyl-1,3-oxazolin-2-yl)phenylamine **6**[8] with 2-hydroxyphenyl phenyl ketone gave 2-{(1*E*)-2-aza-2-[2-(4,4-dimethyl(1,3-oxazolin-2-yl))phenyl]-1-phenylvinyl}phenol **7** (Fig. 1) in 82% yield. To our surprise, under the same conditions, the reaction of **6** with *o*-hydroxyacetophenone gave, unexpectedly, quinoline derivative **8a** as the major product in 79% yield (entry 1, Table 1). The structure of **8a** was established based on the ^{1}H, ^{13}C, and 2D NOESY NMR assignments and was approved by single-crystal X-ray diffraction analysis (Fig. 2).



(1)

Keywords: 4-Amino-substituted quinoline; 4-Quinolone; 4-Hydroxy-quinoline; Oxazoline.
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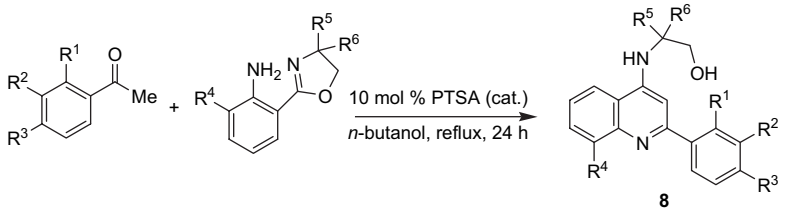
Table 1. Reaction with acetylbenzenes and *o*-oxazoline-substituted aniline for the preparation of *N*-alkyl-substituted 4-aminoquinolines **8**

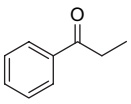
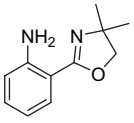
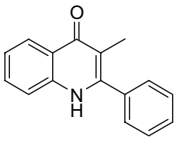
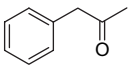
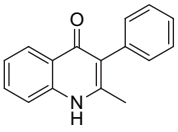
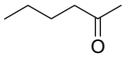
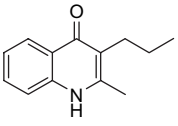
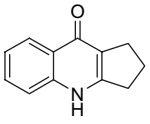
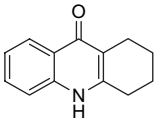


Entry	R^1	R^2	R^3	R^4	R^5	R^6	**8**, Yield (%)[a,b]
1	OH	H	H	H	CH_3	CH_3	**8a** (79)
2	Br	H	H	H	CH_3	CH_3	**8b** (89)
3	CH_3	H	H	H	CH_3	CH_3	**8c** (86)
4	OCH_3	H	H	H	CH_3	CH_3	**8d** (60)
5	H	CH_3	H	H	CH_3	CH_3	**8e** (82)
6	H	H	Br	H	CH_3	CH_3	**8f** (84)
7	H	H	F	H	CH_3	CH_3	**8g** (82)
8	H	H	H	H	CH_3	CH_3	**8h** (88)
9	H	–CH=CH–CH=CH–		H	CH_3	CH_3	**8i** (86)
10	H	H	H	Cl	CH_3	CH_3	**8j** (83)
11	OH	H	H	H	H	Ph	**8k** (75)

[a] All reactions were performed using acetylbenzene (5 mmol), *o*-oxazoline-substituted aniline (5 mmol), and PTSA (10 mol %) in *n*-butanol (5 mL) at reflux temperature for 24 h.
[b] Isolated yields after column chromatography.

Other acetophenones with or without a substituent on the benzene ring may undergo the similar reaction transformations with **6** to form the corresponding quinoline derivatives

Table 2. The formation of 4-quinolone derivative **9**–**13** from the reaction of ketones with *o*-oxazoline-substituted aniline **6**

Entry	Ketones	Anilines	Products, yield (%)[a,b]
1		 **6**	 **9** (90)
2		**6**	 **10** (88)
3		**6**	 **11** (70)
4		**6**	 **12** (76)
5		**6**	 **13** (80)

[a] One equivalent of amine **6** was used unless otherwise stated.
[b] Isolated yields after column chromatography.

8b–**8h** in 60–89% yields (entries 2–8, Table 1). Thus, changing the substituent at R^1, R^2, or R^3 in acetophenones shown in Table 1 seemed to have no effect on the formation of the quinolines. β-Acetonaphthone formed 2-(2-naphthyl)-quinoline derivative **8i** in 86% yield (entry 9, Table 1). The reaction of 6-(4,4-dimethyl(1,3-oxazolin-2-yl))-2-chlorophenylamine with acetophenone could form 8-chloro-2-phenyl-quinoline derivative **8j** in 83% yield (entry 10, Table 1). The use of chiral 2-[(4*R*)-4,5-dihydro-4-phenyl-2-oxazolyl]benzenamine in the reaction with *o*-hydroxyacetophenone gave the chiral product **8k** in 75% yield (entry 11, Table 1). Unfortunately, we did not isolate any other plausible intermediates for the formation of these quinolines. It is

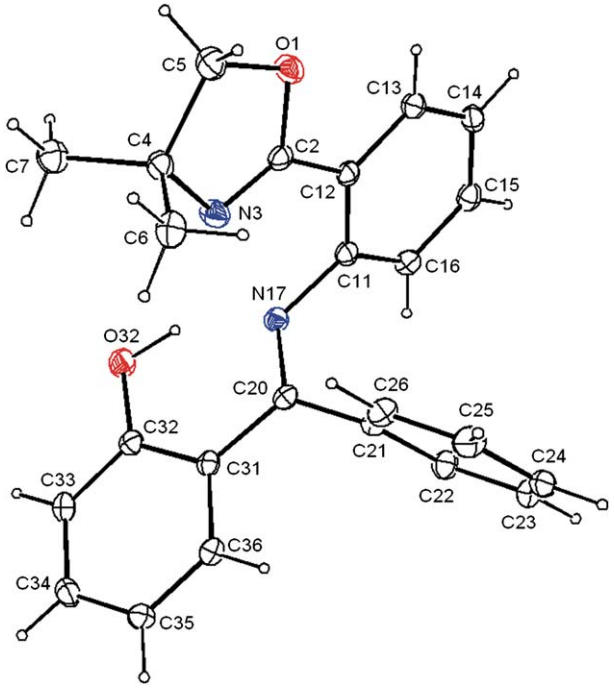


Figure 1. ORTEP diagram of **7**.

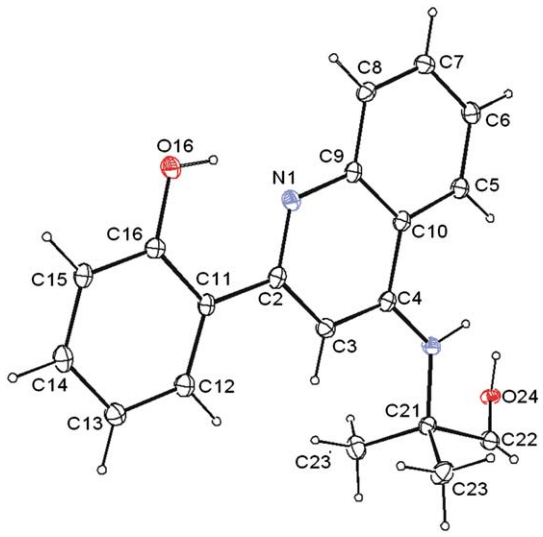
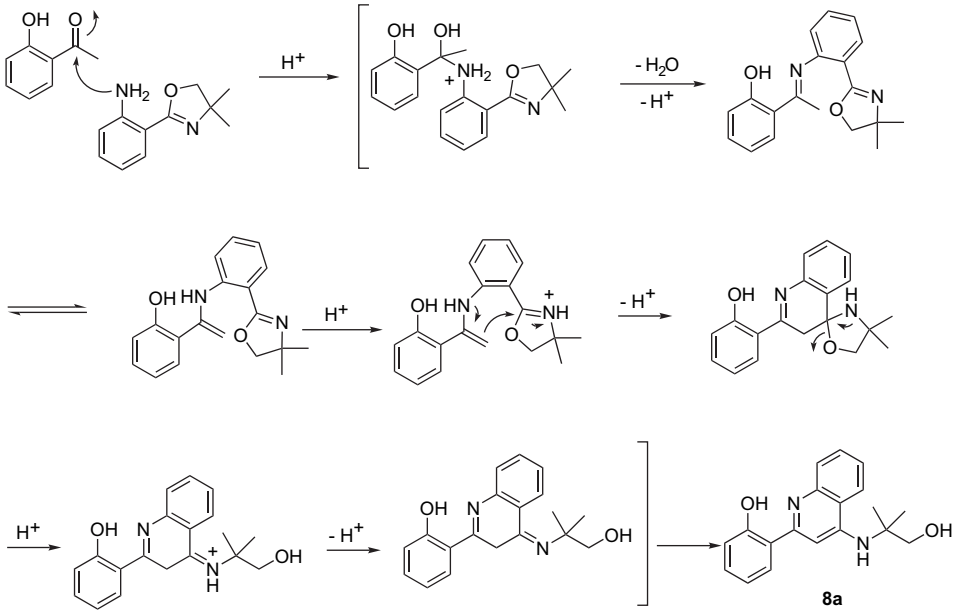


Figure 2. ORTEP diagram of **8a**.

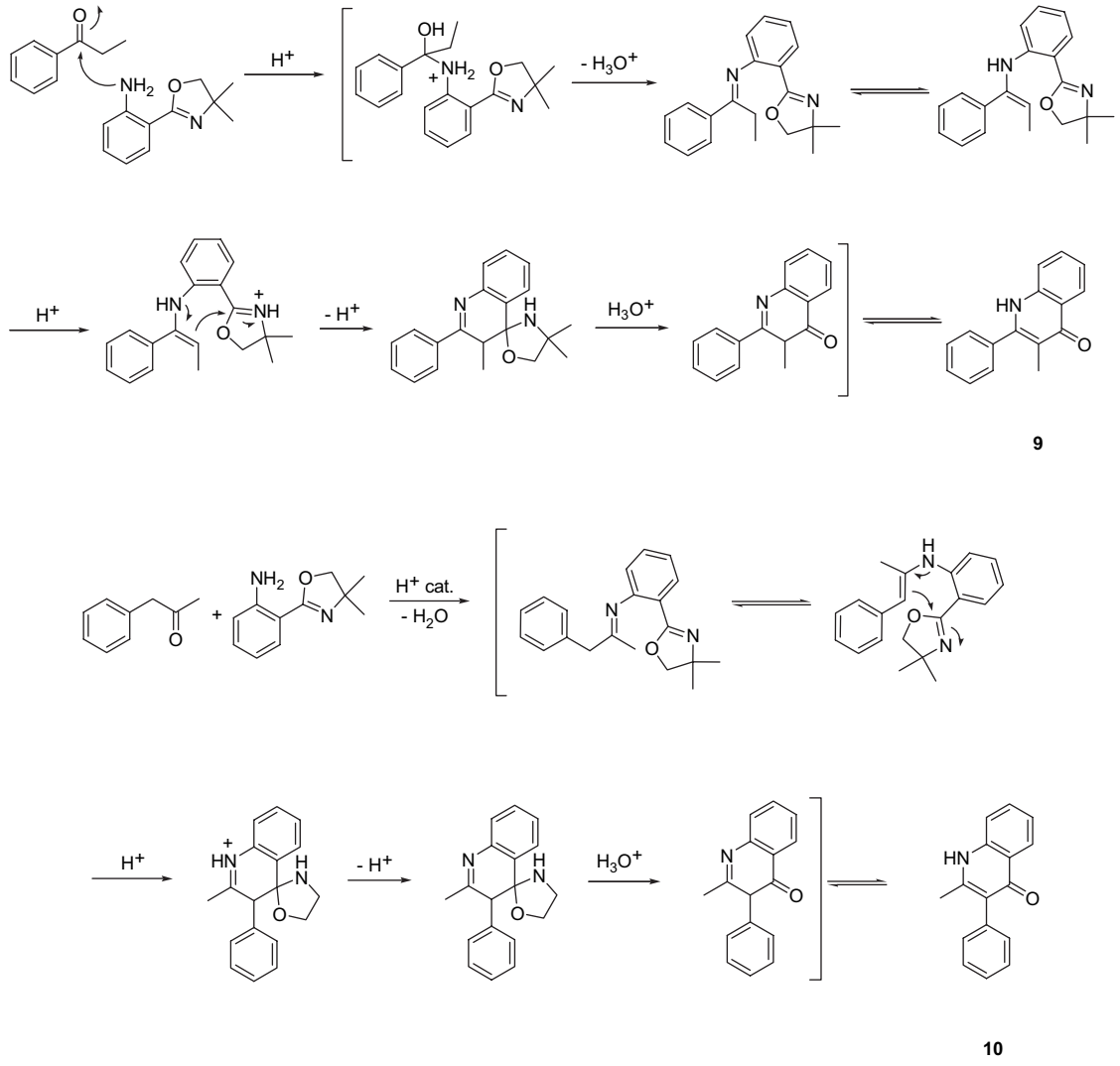
known that the dealkylation of a tertiary alkyl group from alkylaniline derivatives is well documented in the literature.[9] Thus, this procedure was an alternative method for the preparation of 4-amino-substituted quinolines, which may be obtained by the dealkylation of the amino group containing a tertiary alkyl group in **8**.[9,10]

In order to test the generality of the formation of 4-amino-substituted quinolines from acetophenones and **6**, we attempted to use propiophenone instead of acetophenone. However, to our surprise, we found that 3-methyl-2-phenyl-hydroquinolin-4-one **9** was isolated as the major product in 90% yield (entry 1, Table 2). The structure of **9** was confirmed by its IR (ν 1628 cm^{-1} for the conjugated carbonyl group), ^{1}H, and ^{13}C NMR as well as by its 2D NOESY NMR, MS, and high-resolution MS spectral analysis.[11] The reaction of 1-phenyl-2-propanone with **6** gave hydroquinolin-4-one derivative **10** in 88% yield (entry 2, Table 2). The reaction of 2-hexanone with **6** gave hydroquinolin-4-one derivative **11** in 70% yield (entry 3, Table 2). The reaction of cyclic ketones, such as cyclopentanone and cyclohexanone, gave the corresponding hydroquinolin-4-one derivative **12** and **13** in 76 and 80% yields, respectively. Attempts to run the reaction with acetone under the similar reaction conditions failed, only starting material **6** was isolated. The transformation of 4-quinolones to 4-amino-substituted quinolines was also documented in the literature.[9] Again, this procedure was an alternative method for the preparation of 4-amino-substituted quinolines.[9,10]

The plausible reaction mechanism for the formation of **8a** was shown in Scheme 1. Thus, the carbonyl group of acetophenone can react with the amino group of 2-oxazoline-substituted aniline to form the imine intermediate in the presence of acid catalyst. Then, the imine intermediate will be tautomerized into enamine intermediate.[12] The following intramolecular ring formation will be promoted by the protonation of the nitrogen atom in oxazoline ring, and followed by acid-catalyzed ring opening and tautomerization to give 4-amino-substituted quinolines **8**. In the case of these cyclic or acyclic ketone substrates shown in Table 2, the formation of the carbonyl group at 4-position of quinolones may be rationalized as shown in Scheme 2. Thus, the intermediate 1,3-oxazolidine with a neighboring methyl of phenyl group will be hydrolyzed more easily due to steric reason to form the carbonyl group.[13] Alternatively, the formation of stable tetra-substituted carbon–carbon double bond may also further accelerate the hydrolysis of 1,3-oxazolidine ring to form the carbonyl group. While in the case of ketone substrates shown in Table 1, the intermediate with 1,3-oxazolidine at benzylic position will be hydrolyzed slowly when hydrogens were substituted at the homobenzylic position adjacent to the 1,3-oxazolidine ring. Thus, the acid-catalyzed ring opening will overwhelm the hydrolysis and the following tautomerization could form the 4-amino-substituted quinolines **8a**.



Scheme 1. Plausible reaction mechanism for the formation of **8a** from acetophenones and *o*-oxazoline-substituted aniline.



Scheme 2. Plausible reaction mechanisms for the formation of **9** and **10**.

3. Conclusion

In summary, we have demonstrated a novel reaction of various ketones with *o*-oxazoline-substituted anilines in the presence of catalytic amount of PTSA in dry *n*-butanol to provide a new route for the preparation of 4-amino-substituted quinolines or 4-quinolones. Typically, acetophenones formed 4-amino-substituted quinolines, while either cyclic or acyclic ketones with more than three carbons in a chain involving the keto group formed 4-quinolones.

4. Experimental

4.1. General experimental methods

All reactions were carried out in oven-dried glassware under argon or nitrogen atmosphere. *n*-Butanol was dried over $MgSO_4$ and followed by refluxing and distilling from magnesium activated by iodine. Other solvents were purified and dried by appropriate methods wherever needed. TLC was done on aluminum sheets with precoated silica gel 60 F_{254} (40×80 mm). Purification by column chromatography was carried out with neutral silica gel 60 (70–230 mesh ASTM). The purity of each compound was judged to be >95% by ^1H or ^{13}C NMR spectral analyses. Melting points were taken on a capillary tube apparatus and are uncorrected. IR spectra were recorded as either Nujol mulls or in the solution form as denoted. ^1H and ^{13}C NMR spectra were recorded in $CDCl_3$ or DMSO-d_6 or their mixture solution on either a 400 or a 500 MHz instrument using TMS (0 ppm) and $CDCl_3$ (77.0 ppm) as internal standards. HRMS spectra were collected on an orthogonal acceleration-time-of-flight mass spectrometer with a resolution of 6000 (5% valley definition) and fitted with a magnet bypass flight tube. MS spectra were determined on a quadrupole spectrometer or on a GC–MS spectrometer.

4.2. Representative procedure for the synthesis of quinoline 8a or other quinolines and quinolones from ketones and *o*-oxazoline-substituted anilines

A solution of **6** (1.9 g, 10 mmol), *o*-hydroxyacetophenone (1.2 mL, 10 mmol), and PTSA (60 mg, 10 mol %) in dry *n*-butanol (10 mL) was stirred at reflux temperature for 24 h. The reaction mixture was then cooled to room temperature, *n*-butanol was removed under low pressure, and to the residue was added water (20 mL) and the solution

was extracted with ethyl acetate (20 mL×3). The combined organic layers were dried over $MgSO_4$. Filtration and concentration followed by column chromatography (silica gel, hexane/EtOAc=1:1) gave 2.44 g of **8a** in 79% yield as a yellow solid,[14] mp 172–174 °C. ^{1}H NMR ($CDCl_3$, TMS) δ 1.61 (s, 6H), 3.82 (s, 2H), 6.91 (t, J=7.7 Hz, 1H), 7.05 (d, J=7.7 Hz, 1H), 7.25 (s, 1H), 7.32 (t, J=7.7 Hz, 1H), 7.44 (t, J=7.6 Hz, 1H), 7.64 (t, J=7.6 Hz, 1H), 7.74 (d, J=7.7 Hz, 1H), 7.80 (d, J=7.6 Hz, 1H), 7.89 (d, J=7.6 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 23.65, 54.93, 69.95, 95.70, 118.06, 118.27, 118.71, 119.01, 119.32, 124.88, 126.28, 127.67, 129.85, 131.48, 144.65, 149.12, 157.68, 161.80 ppm. IR (KBr) ν 3395 (br), 1587, 1535 cm^{-1}. MS m/z 309 (M^++H), 308, 277, 237. HRMS calcd for $C_{19}H_{21}N_2O_2$: 309.1603; found: 309.1600. Anal. Calcd for $C_{19}H_{20}N_2O_2$: C, 74.00; H, 6.54; N, 9.08. Found: C, 73.53; H, 6.10; N, 8.88.

4.2.1. Preparation of 2-((1*E*)-2-aza-1-methyl-2-phenylvinyl)phenol (3). A solution of aniline (0.9 mL, 10 mmol), *o*-hydroxyacetophenone (1.2 mL, 10 mmol), and *p*-toluenesulfonic acid (0.17 g, 10 mol %) in dry *n*-butanol (10 mL) was stirred at reflux temperature for 24 h. The reaction mixture was then cooled to room temperature, the *n*-butanol was removed, and the residue was purified by recrystallization (hexane) to afford 1.86 g (88% yield) of the title compound as yellow solid. Mp 80–81 °C (lit.[15] 81–82 °C).

4.2.2. Preparation of 2-(4,4-dimethyl-1,3-oxazolin-2-yl)-phenylamine (6). Zinc chloride (0.34 g, 2.5 mmol) was put in a 50 mL two-necked flask and melted under high vacuum. After cooling down to room temperature under argon, a solution of 2-aminobenzonitrile (5.90 g, 50 mmol) and 2-amino-2-methylpropanol (6.70 g, 75 mmol) in 150 mL of chlorobenzene was added. The mixture was heated under reflux for 24 h. The solvent was removed under reduced pressure to give an oily residue, which was dissolved in 150 mL of dichloromethane. The solution was washed three times with 100 mL of water and the aqueous phase was extracted with 150 mL of dichloromethane. The combined organic layers were dried over magnesium sulfate, and the solvent was removed in vacuo. The resulting solid was purified by recrystallization (ethyl acetate/hexane) to afford 6.95 g (73% yield) of the title compound. Mp 106–108 °C (lit.[16] 103–106 °C).

4.2.3. Preparation of 2-[(4*R*)-4,5-dihydro-4-phenyl-2-oxazolyl]benzenamine. The procedure for preparing the title compound is similar to that for the preparation of **6** by using zinc chloride (0.34 g, 2.5 mmol), 2-aminobenzonitrile (5.90 g, 50 mmol), and (*R*)-(−)-phenylglycinol (10.3 g, 75 mmol) in 200 mL of chlorobenzene. The compound was purified by chromatography (silica gel, ethyl acetate/hexane=1:4) to afford 6.90 g (58% yield) of the title compound. Mp 77–79 °C (lit.[17] 71 °C).

4.2.4. Preparation of 2-chloro-6-cyanoaniline. CuCN (3.45 g, 38.5 mmol) was added in small portions with vigorous stirring to a warm (~80 °C) solution of 2,6-dichloroaniline (2.5 g, 15.4 mmol) in *N*-methyl-pyrrolidinone (20 mL). The mixture was then heated to 150–170 °C. After 0.5 h, the reaction mixture was cooled to about 80 °C. Another CuCN (3.45 g, 38.5 mmol) was added in small portions and the reaction mixture was again heated to 150–170 °C for an additional 2 h. It was then cooled to 60 °C and poured into a 50:50 (v/v) mixture of ammonia and ice water (60 mL), stirred well for 1 h, and filtered. The residue was washed with CH_2Cl_2 (20 mL) and all the filtrates were combined, and extracted with CH_2Cl_2 (60 mL×3). The CH_2Cl_2 extracts were combined and washed well with water (50 mL×3), and dried over magnesium sulfate. The solvent was removed in vacuo. The residue was purified by column chromatography (silica gel, ethyl acetate/hexane=2:3) to afford 0.73 g (31% yield) of the title compound. Mp 94–96 °C (lit.[18] 94–96 °C).

4.2.5. Preparation of 6-(4,4-dimethyl(1,3-oxazoline-2-yl))-2-chlorophenylamine. The procedure for preparing the title compound is similar to that for the preparation of **6** by using zinc chloride (22 mg, 0.16 mmol), 2-chloro-6-cyanoaniline (0.50 g, 3.26 mmol), and 2-amino-2-methylpropanol (0.46 mL, 4.90 mmol) in 10 mL of chlorobenzene. The compound was purified by chromatography (silica gel, ethyl acetate/hexane=1:4) to afford 0.45 g (62% yield) of the title compound. ^{1}H NMR ($CDCl_3$, TMS) δ 1.37 (s, 6H), 4.00 (s, 2H), 6.58 (t, J=7.9 Hz, 1H), 7.31 (d, J=7.9 Hz, 1H), 7.62 (d, J=7.9 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 28.60, 67.83, 77.59, 110.23, 115.53, 119.29, 128.08, 131.63, 144.74, 161.66 ppm. IR (KBr) ν 3466, 3266, 1632, 742 cm^{-1}. MS m/z 225 (M^++H), 224, 209, 153. HRMS calcd for $C_{11}H_{14}N_2OCl$: 225.0795; found: 225.0798.

4.2.6. 2-{[2-(2-Bromophenyl)(4-quinolyl)]amino}-2-methylpropan-1-ol (8b). Yield: 89%. Mp 184–186 °C. ^{1}H NMR ($CDCl_3$+DMSO-d_6 (10:1, v/v), TMS) δ 1.47 (s, 6H), 3.61 (s, 2H), 6.88 (s, 1H), 7.26 (t, J=7.7 Hz, 1H), 7.39–7.44 (m, 2H), 7.59–7.68 (m, 3H), 7.89 (d, J=8.4 Hz, 1H), 7.99 (d, J=8.4 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$+DMSO-d_6 (10:1, v/v), TMS) δ 22.94, 54.40, 70.15, 102.37, 118.69, 119.66, 121.45, 124.23, 127.21, 128.66, 129.21, 129.72, 131.18, 132.75, 142.59, 147.76, 148.16, 158.40 ppm. IR (KBr) ν 3395, 1587 cm^{-1}. MS m/z 371 (M^++H), 373, 339. HRMS calcd for $C_{19}H_{20}N_2OBr$: 371.0759; found: 371.0753.

4.2.7. 2-Methyl-2{[2-(2-methylphenyl)(4-quinolyl)]-amino}propan-1-ol (8c). Yield: 85%. Mp 169–171 °C. ^{1}H NMR ($CDCl_3$, TMS) δ 1.42 (s, 6H), 2.37 (s, 3H), 3.60 (s, 2H), 6.70 (s, 1H), 7.23–7.30 (m, 3H), 7.34–7.44 (m, 2H), 7.60 (t, J=7.5 Hz, 1H), 7.85 (d, J=8.4 Hz, 1H), 8.05 (d, J=8.4 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 20.21, 23.31, 54.91, 69.97, 102.10, 118.36, 119.82, 124.81, 125.83, 128.42, 128.80, 129.35, 129.57, 130.62, 135.80, 140.95, 147.13, 148.84, 159.47 ppm. IR (KBr) ν 3387, 1587, 1528 cm^{-1}. MS m/z 307 (M^++H), 176. HRMS calcd for $C_{20}H_{23}N_2O$: 307.1810; found: 307.1807.

4.2.8. 2-{[2-(2-Methoxyphenyl)(4-quinolyl)]amino}-2-methylpropan-1-ol (8d). Yield: 60%. Mp 187–189 °C. ^{1}H NMR ($CDCl_3$, TMS) δ 1.47 (s, 6H), 3.70 (s, 2H), 3.83 (s, 3H), 6.99 (d, J=8.2 Hz, 1H), 7.09 (t, J=7.3 Hz, 1H), 7.15 (s, 1H), 7.34–7.38 (m, 2H), 7.56 (t, J=7.3 Hz, 1H), 7.78–7.82 (m, 2H), 8.05 (d, J=8.2 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 23.49, 54.93, 55.77, 69.71, 103.46, 111.52, 118.56, 119.65, 121.17, 124.58, 129.02, 129.12, 129.71, 130.17, 131.21, 147.57, 147.97, 156, 157.03 ppm. IR (KBr) ν 3395, 1587, 1528 cm^{-1}. MS m/z 323 (M^++H),

251. HRMS calcd for $C_{20}H_{23}N_2O_2$: 323.1760; found: 323.1755.

4.2.9. 2-Methyl-2-{[2-(3-methylphenyl)(4-quinolyl)]-amino}propan-1-ol (8e). Yield: 82%. Mp 132–134 °C. ^{1}H NMR ($CDCl_3$, TMS) δ 1.47 (s, 6H), 2.44 (s, 3H), 3.70 (s, 2H), 6.90 (s, 1H), 7.23 (d, J=7.6 Hz, 1H), 7.30 (t, J=7.6 Hz, 1H), 7.35 (t, J=7.6 Hz, 1H), 7.55–7.61 (m, 2H), 7.67 (d, J=7.9 Hz, 1H), 8.06 (d, J=7.9 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 21.56, 23.90, 55.02, 69.14, 99.19, 118.70, 119.44, 124.52, 124.70, 128.26, 128.48, 129.23, 129.39, 129.82, 138.25, 140.28, 148.04, 148.82, 157.71 ppm. IR (KBr) ν 3395, 1587, 1528 cm^{-1}. MS m/z 307 (M^++H), 275, 235. HRMS calcd for $C_{20}H_{23}N_2O$: 307.1810; found: 307.1808.

4.2.10. 2-{[2-(4-Bromophenyl)(4-quinolyl)]amino}-2-methylpropan-1-ol (8f). Yield: 84%. Mp 171–174 °C. ^{1}H NMR ($CDCl_3$, TMS) δ 1.50 (s, 6H), 3.75 (s, 2H), 6.90 (s, 1H), 7.36 (t, J=7.6 Hz, 1H), 7.58–7.64 (m, 4H), 7.81–7.83 (m, 2H), 8.03 (d, J=8.4 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 24.11, 55.06, 68.52, 98.37, 118.69, 119.29, 123.36, 124.70, 129.04, 129.28, 129.68, 131.65, 139.30, 148.39, 148.66, 156.29 ppm. IR (KBr) ν 3395, 1587, 1532 cm^{-1}. MS m/z 373, 371 (M^++H), 339, 299. HRMS calcd for $C_{19}H_{20}N_2OBr$: 371.0759; found: 371.0753.

4.2.11. 2-{[2-(4-Fluorophenyl)(4-quinolyl)]amino}-2-methylpropan-1-ol (8g). Yield: 82%. Mp 176–178 °C. ^{1}H NMR ($CDCl_3$, TMS) δ 1.49 (s, 6H), 3.73 (s, 2H), 6.85 (s, 1H), 7.14 (t, J=8.6 Hz, 2H), 7.34 (t, J=7.6 Hz, 1H), 7.55 (d, J=8.4 Hz, 1H), 7.61 (t, J=7.6 Hz, 1H), 7.88–7.91 (m, 2H), 8.02 (d, J=8.4 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 24.03, 55.16, 68.63, 98.45, 115.37, 115.59, 118.48, 119.45, 124.64, 129.15, 129.31, 129.39, 136.11, 147.83, 148.91, 156.19, 162.31, 164.79 ppm. IR (KBr) ν 3395, 1587, 1532, 1510, 1226, 828 cm^{-1}. MS m/z 311 (M^++H), 279, 239. HRMS calcd for $C_{19}H_{20}N_2OF$: 311.1560; found: 311.1564.

4.2.12. 2-Methyl-2-[(2-phenyl(4-quinolyl))amino]propan-1-ol (8h). Yield: 88%. Mp 168–170 °C. ^{1}H NMR ($CDCl_3$, TMS) δ 1.52 (s, 6H), 3.75 (s, 2H), 7.01 (s, 1H), 7.37 (t, J=7.6 Hz, 1H), 7.41–7.51 (m, 3H), 7.60–7.65 (m, 2H), 7.97–7.99 (m, 2H), 8.05 (d, J=7.9 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 24.03, 54.96, 68.64, 98.97, 118.72, 119.29, 124.49, 127.56, 128.55, 128.89, 129.09, 129.71, 140.56, 148.45, 148.54, 157.68 ppm. IR (KBr) ν 3395, 1587 cm^{-1}. MS m/z 293 (M^++H), 261, 221. HRMS calcd for $C_{19}H_{21}N_2O$: 293.1655; found: 293.1654.

4.2.13. 2-Methyl-2-[(2-naphthyl(4-quinolyl))amino]propan-1-ol (8i). Yield: 86%. Mp 162–164 °C. ^{1}H NMR ($CDCl_3$, TMS) δ 1.57 (s, 6H), 3.82 (s, 2H), 7.18 (s, 1H), 7.39 (t, J=7.1 Hz, 1H), 7.50–7.52 (m, 2H), 7.63–7.69 (m, 2H), 7.89–7.90 (m, 1H), 7.96–7.98 (m, 2H), 8.11 (d, J=7.1 Hz, 1H), 8.18 (d, J=8.4 Hz, 1H), 8.45 (s, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 24.16, 55.09, 68.44, 99.03, 118.74, 119.31, 124.56, 125.28, 126.12, 126.46, 126.80, 127.62, 128.21, 128.85, 129.14, 129.59, 133.32, 133.66, 137.71, 148.57, 157.33 ppm. IR (KBr) ν 3395, 1583, 1528 cm^{-1}. MS m/z 343 (M^++H), 271. HRMS calcd for $C_{23}H_{23}N_2O$: 343.1810; found: 343.1804.

4.2.14. 2-[(8-Chloro-2-phenyl(4-quinolyl))amino]-2-methylpropan-1-ol (8j). Yield: 83%. ^{1}H NMR ($CDCl_3$, TMS) δ 1.53 (s, 6H), 3.76 (s, 2H), 7.16 (s, 1H), 7.29 (t, J=8.0 Hz, 1H), 7.44–7.54 (m, 3H), 7.73–7.78 (m, 2H), 8.13 (d, J=7.6 Hz, 2H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 23.41, 55.68, 70.05, 99.39, 119.74, 120.06, 124.44, 127.48, 128.95, 129.86, 130.06, 132.57, 139.09, 143.23, 150.28, 156.54 ppm. IR (KBr) ν 3387, 1583, 1528, 694 cm^{-1}. MS m/z 326 (M^+), 295, 245. HRMS calcd for $C_{19}H_{19}N_2OCl$: 326.1186; found: 326.1190.

4.2.15. (2*R*)-2-{[2-(2-Hydroxyphenyl)(4-quinolyl)]-amino}-2-phenylethan-1-ol (8k). Yield: 75%. ^{1}H NMR ($CDCl_3$, TMS) δ 3.88 (dd, J=7.4, 11.4 Hz, 1H), 4.11 (dd, J=3.8, 11.4 Hz, 1H), 4.52 (t, J=3.8 Hz, 1H), 6.47 (s, 1H), 6.81 (t, J=7.9 Hz, 1H), 7.01 (d, J=7.9 Hz, 1H), 7.26–7.36 (m, 7H), 7.52 (t, J=8.0 Hz, 2H), 7.70 (d, J=8.0 Hz, 1H), 7.80 (d, J=8.0 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 59.42, 66.91, 95.39, 117.34, 117.91, 118.70, 118.94, 119.43, 124.97, 126.33, 126.46, 126.92, 128.20, 129.16, 130.04, 131.72, 138.29, 143.48, 149.89, 157.45, 162.30 ppm. IR (KBr) ν 3365, 1594 cm^{-1}. MS m/z 357 (M^++H), 356, 237. HRMS calcd for $C_{23}H_{21}N_2O_2$: 357.1603; found: 357.1610.

4.2.16. 2-{(1*E*)-2-Aza-2-[3-(4,4-dimethyl(1,3-oxazolin-2-yl))phenyl]-1-methylvinyl}phenol (4). Yield: 86%. Yellow oil. ^{1}H NMR ($CDCl_3$, TMS) δ 1.39 (s, 6H), 2.34 (s, 3H), 4.13 (s, 2H), 6.89 (t, J=7.6 Hz, 1H), 7.00–7.02 (m, 2H), 7.37 (t, J=7.9 Hz, 1H), 7.43 (t, J=7.9 Hz, 1H), 7.52 (s, 1H), 7.62 (d, J=7.9 Hz, 1H), 7.77 (d, J=7.9 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 17.27, 28.38, 67.65, 79.25, 118.19, 118.26, 119.62, 120.97, 124.03, 124.60, 128.95, 129.02, 129.12, 133.18, 147.23, 161.74, 161.87, 171.70 ppm. IR (KBr) ν 1644, 1610 cm^{-1}. MS m/z 308 (M^+), 307, 293. HRMS calcd for $C_{19}H_{20}N_2O_2$: 308.1525; found: 308.1523.

4.2.17. 2-{(1*E*)-2-Aza-2-[4-(4,4-dimethyl(1,3-oxazolin-2-yl))phenyl]-1-methylvinyl}phenol (5). Yield: 74%. Yellow oil. ^{1}H NMR ($CDCl_3$, TMS) δ 1.36 (s, 6H), 2.28 (s, 3H), 4.09 (s, 2H), 6.84–6.91 (m, 3H), 6.98 (d, J=7.8 Hz, 1H), 7.34 (t, J=7.8 Hz, 1H), 7.58 (d, J=7.8 Hz, 1H), 7.93–7.95 (m, 2H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 17.20, 28.37, 67.53, 76.68, 79.11, 118.23, 119.54, 121.08, 124.59, 128.92, 129.21, 133.25, 149.71, 161.72, 161.73, 171.33 ppm. IR (KBr) ν 1645, 1608, 1574 cm^{-1}. MS m/z 308 (M^+), 307, 293, 221. HRMS calcd for $C_{19}H_{20}N_2O_2$: 308.1525; found: 308.1523.

4.2.18. 2-{(1*E*)-2-Aza-2-[2-(4,4-dimethyl(1,3-oxazolin-2-yl))phenyl]-1-phenylvinyl}phenol (7). Yield: 82%. Yellow solid.[19] Mp 107–109 °C (recrystallization from ethanol). ^{1}H NMR ($CDCl_3$, TMS) δ 1.36 (s, 6H), 4.08 (s, 2H), 6.55 (d, J=7.5 Hz, 1H), 6.74 (t, J=7.5 Hz, 1H), 7.01 (t, J=7.5 Hz, 1H), 7.04–7.09 (m, 2H), 7.12 (t, J=7.7 Hz, 1H), 7.19–7.22 (m, 2H), 7.26–7.28 (m, 3H), 7.36 (t, J=7.7 Hz, 1H), 7.77 (d, J=7.7 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$, TMS) δ 28.21, 67.19, 79.45, 117.86, 117.92, 120.13, 122.43, 124.09, 127.98, 128.32, 128.39, 128.82, 129.13, 130.01, 131.04, 132.29, 133.12, 134.45, 147.15, 162.10, 172.51 ppm. IR (KBr) ν 1645, 1607, 1569 cm^{-1}. MS m/z 371 (M^++H), 299, 191, 190, 119. HRMS calcd for $C_{24}H_{23}N_2O_2$: 371.1760; found: 371.1758.

4.2.19. 3-Methyl-2-phenylhydroquinolin-4-one (9).[20] Yield: 90%. Mp 287–290 °C. ^{1}H NMR ($CDCl_3$, TMS) δ 2.03 (s, 3H), 7.29 (t, J=7.6 Hz, 1H), 7.50 (s, 5H), 7.55 (t, J=7.6 Hz, 1H), 7.62 (d, J=7.6 Hz, 1H), 8.33 (d, J=7.6 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$+DMSO-d_6 (10:1, v/v), TMS) δ 11.94, 115.26, 117.75, 122.51, 123.15, 125.18, 128.10, 128.65, 128.87, 130.81, 135.32, 139.30, 147.65, 177.73 ppm. IR (KBr) ν 3255, 1628 cm^{-1}. MS m/z 236 (M^++H). HRMS calcd for $C_{16}H_{14}NO$: 236.1075; found: 236.1078.

4.2.20. 2-Methyl-3-phenylhydroquinolin-4-one (10). Yield: 88%. Mp 304–306 °C (lit.[21] 302–304 °C). ^{1}H NMR ($CDCl_3$+DMSO-d_6 (10:1, v/v), TMS) δ 2.74 (s, 3H), 7.30–7.32 (m, 2H), 7.51–7.59 (m, 3H), 7.68 (t, J=7.7 Hz, 1H), 7.90 (t, J=7.7 Hz, 1H), 8.45 (d, J=7.7 Hz, 1H), 8.79 (d, J=7.7 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$+DMSO-d_6 (10:1, v/v), TMS) δ 19.48, 119.27, 119.92, 120.63, 123.36, 127.24, 128.99, 129.24, 130.32, 131.13, 133.39, 138.95, 156.01, 164.81 ppm. IR (KBr) ν 3261, 1628 cm^{-1}. MS m/z 236 (M^++H), 235 (M^+). HRMS calcd for $C_{16}H_{14}NO$: 236.1075; found: 236.1074.

4.2.21. 2-Methyl-3-propylhydroquinolin-4-one (11). Yield: 70%. Mp>360 °C (decomp.). ^{1}H NMR ($CDCl_3$+DMSO-d_6 (10:1, v/v), TMS) δ 0.99 (t, J=7.5 Hz, 3H), 1.55 (sextet, J=7.5 Hz, 2H), 2.59 (s, 3H), 2.67 (t, J=7.5 Hz, 2H), 7.33 (t, J=7.9 Hz, 1H), 7.58 (t, J=7.9 Hz, 1H), 7.75 (d, J=7.9 Hz, 1H), 8.37 (d, J=7.9 Hz, 1H) ppm. ^{13}C NMR ($CDCl_3$+DMSO-d_6 (10:1, v/v), TMS) δ 13.76, 17.72, 21.67, 26.91, 117.71, 119.62, 122.39, 123.18, 124.69, 130.80, 138.72 (2C's), 148.04 ppm. IR (KBr) ν 3262, 1635 cm^{-1}. MS m/z 201 (M^+), 186, 172. HRMS calcd for $C_{13}H_{15}NO$: 201.1154; found: 201.1155.

4.2.22. 1,2,3,4-Tetrahydrocyclopenta[2,1-*b*]quinolin-9-one (12).[22] Yield: 76%. Mp 312–314 °C. ^{1}H NMR ($CDCl_3$+DMSO-d_6 (10:1, v/v), TMS) δ 2.27 (q, J=7.6 Hz, 2H), 3.18 (t, J=7.6 Hz, 2H), 3.47 (t, J=7.6 Hz, 2H), 7.58 (t, J=7.6 Hz, 1H), 7.78 (t, J=7.6 Hz, 1H), 8.37–8.40 (m, 2H) ppm. ^{13}C NMR ($CDCl_3$+DMSO-d_6 (10:1, v/v), TMS) δ 21.86, 27.56, 32.08, 118.18, 120.02, 123.34, 123.82, 124.71, 130.77, 139.86, 156.53, 172.94 ppm. IR (KBr) ν 3225, 1628 cm^{-1}. MS m/z 185 (M^+), 184, 156. HRMS calcd for $C_{12}H_{11}NO$: 185.0841; found: 185.0841.

4.2.23. 5,6,7,8,10-Pentahydroacridin-9-one (13). Yield: 80%. Mp 354–356 °C (lit.[23] 357–358 °C). ^{1}H NMR (DMSO-d_6) δ 1.68–1.78 (m, 4H), 2.43 (t, J=6.1 Hz, 2H), 2.69 (t, J=6.1 Hz, 2H), 7.22 (t, J=7.9 Hz, 1H), 7.45 (d, J=7.9 Hz, 1H), 7.56 (t, J=7.9 Hz, 1H), 8.04 (d, J=7.9 Hz, 1H) ppm. ^{13}C NMR (DMSO-d_6) δ 21.56, 21.75, 21.95, 27.21, 115.66, 117.44, 122.16, 123.24, 124.92, 131.11, 139.30, 147.05, 176.12 ppm. IR (KBr) ν 3402, 1635 cm^{-1}. MS m/z 200 (M^++H), 176. HRMS calcd for $C_{13}H_{14}NO$: 200.1075; found: 200.1073.

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