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SYNTHESIS OF HETEROCYCLIC 1,3-OXAZOLINES FROM ALDEHYDES WITH TRIMETHYLPHENYLAMMONIUM TRIBROMIDE[1]

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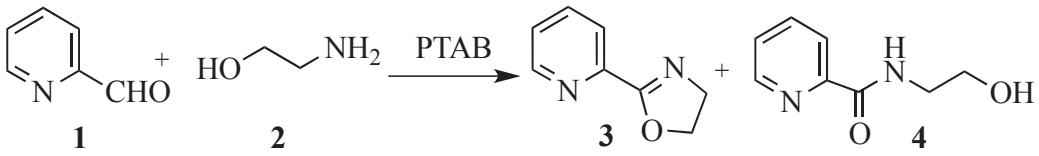
Abstract – Various heterocyclic 1,3-oxazolines were prepared from aldehydes and aminoalcohols with trimethylphenylammonium tribromide at room temperature.

Oxazolines are known to be important compounds for their biological activities.[2] Further, those compounds are also useful for the synthesis of many functional compounds as key intermediates[3,4] and ligands for excellent catalyst.[4] Many useful methods for the synthesis of oxazolines have been reported previously.[5] However, some of these methods involve disadvantages such as acidic conditions and the use of complex reagents in organic solvents. Therefore, there is still considerable interest in investigating other convenient synthetic methods for heterocyclic oxazolines.

On the other hand, ammonium tribromides such as pyridinium hydrobromide perbromide (PHPB) and trimethylphenylammonium tribromide (phenyltrimethylammonium tribromide, PTAB) were reported to be convenient and chemoselective for the oxidation of 1,2-diols, secondary alcohols, and Tishchienko-like esterification of aliphatic alcohols in the previous papers.[6] As ammonium tribromides are much easier to handle and they maintain the desired stoichiometry in comparison with Br_2 and other oxidative reagents,[6,7] the use of commercially available PHPB, PTAB has been more advantageous than that of other complex reagents in organic synthesis. Moreover, the convenient synthesis of aromatic oxazolines from aldehydes was also achieved with PHPB in H_2O in the previous paper.[2a] Therefore, I considered it interesting to find a simple procedure for preparation of heterocyclic oxazolines from aldehydes with PHPB or PTAB. I would like to report the results of studies concerning the conversion of various heterocyclic aldehydes to respective 1,3-oxazolines with PHPB or PTAB.[1]

At first, the reaction of 2-pyridinecarbaldehyde (**1**), chosen as a representative heterocyclic aldehyde for this study, was carried out with PHPB and 2-aminoethanol (**2**) in various solvents at room temperature. The results are summarized in Table 1. At 2.0 molar ratio of PHPB over **1** in the presence of 6.4 molar

Table 1. Reaction of 2-pyridinecarbaldehyde **1** and 2-aminoethanol **2** with PTAB[a]



1 **2** **3** **4**

Run	Molar ratio / **1**		Solvent	Time (h)	**3** Yield (%)
	PTAB	Py			
1	2.0[b]	--	H_2O	22	64[c]
2	2.0[b]	2.0	H_2O	22	67[d]
3	2.0	--	H_2O	22	70
4	2.0	2.0	H_2O	22	73[e]
5	2.0	2.0	C_6H_{14}	23	20[f]
6	2.0	2.0	DMSO	21	29[g]
7	2.0	2.0	CH_2Cl_2	46	69
8	2.0	--	MeOH	23	78
9	2.0	2.0	MeOH	23	84
10	1.0	1.0	MeOH	22	57[h]
11	2.0	2.0	MeCN	21	84

[a] **1**: 0.5 mmol; **2**: 3.2 mmol; Solvent: 6 mL, temp: rt. [b] PHPB was used instead of PTAB. [c] Pyridine-2-*N*-(2-hydroxyethyl)carboxamide **4** was obtained in 32% yield. [d] **4**: 27%. [e] **4**: 18%. [f] Recovered **1**: 68%. [g] Recovered **1**: 61%. [h] **4**: 36%

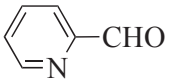
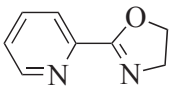
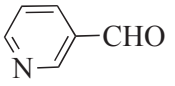
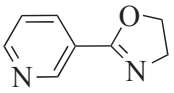
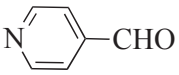
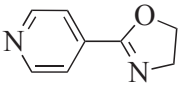
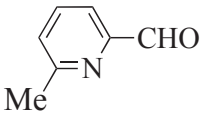
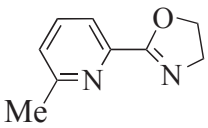
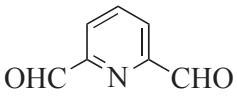
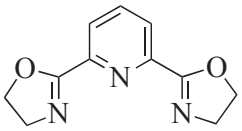
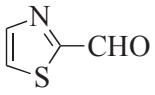
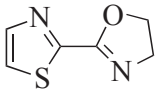
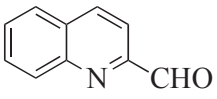
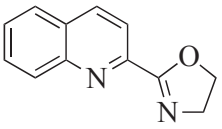
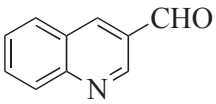
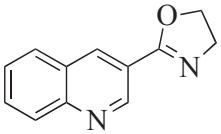
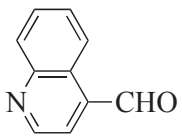
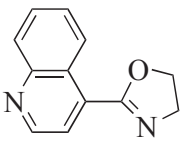
ratio of **2**, 2-(oxazolin-2-yl)pyridine (**3**) in water was mainly obtained, while the yield of **3** was not fully satisfactory accompanied by pyridine-2-*N*-(2-hydroxyethyl)carboxamide (**4**) (run 1). It was seemed that the hydrolysis of oxazoline **3** under the acidic conditions by HBr generated from PHPB afforded carboxamide **4**. The reaction of **1** and **2** with PHPB was carried out in the presence of pyridine (Py) for neutralizing acidity. Even in the presence of 2.0 molar ratio of Py over **1**, the yield of oxazoline **3** (67%) was not fully satisfactory under the same reaction conditions (run 2). Therefore, the reaction of **1** with PTAB instead of PHPB was carried out in H_2O. The reaction of **1** and **2** with PTAB-H_2O took place to give oxazoline **3** (70%) (run 3). In the presence of Py, oxazoline **3** was also afforded in 73% yield accompanied by amide **4** (18%) with PTAB-H_2O (run 4). As PTAB was less soluble in water than other

organic solvents, the yields of **3** with PTAB in H_2O were supposed to be not fully satisfactory. Therefore, the reaction of **1** and **2** with PTAB was carried out in organic solvents such as hexane, DMSO, CH_2Cl_2, MeOH, MeCN. The reaction of **1** and **2** with PTAB-Py afforded a mixture of **3** (20%) and recovered **1** (68%) in hexane (run 5). In DMSO, the yield of **3** was not satisfactory with PTAB-Py (run 6). The reaction of **1** and **2** with PTAB-Py in CH_2Cl_2 afforded **3** (69%) (run 7). Therefore, the reaction of **1** and **2** with PTAB was also carried out in other polar solvents such as MeOH, MeCN. In MeOH without Py, oxazoline **3** was obtained in 78% yield (run 8). Oxazoline **3** (84%) was afforded with 2.0 molar ratio of PTAB-Py in MeOH at room temperature (run 9). At 1.0 molar ratio of PTAB-Py, a mixture of **3** (57%) and amide **4** (36%) was obtained in MeOH (run 10). Accordingly, more than 2.0 molar equivalents of PTAB-Py over **1** was needed to obtain oxazoline **3** in good yields. Similarly, oxazoline **3** was afforded in 84% yield with PTAB-Py in MeCN under the same reaction conditions (run 11). In the present experiments, polar solvents MeOH and MeCN were found to be more useful for the synthesis of oxazoline **3** from pyridinecarbaldehyde **1** with PTAB-Py system than other organic solvents and H_2O.

To clarify the limitations and chemoselectivity for conversion of heterocyclic aldehydes to oxazolines, the reaction of various aldehydes and 2-aminoethanol with PTAB-Py was examined under the same reaction conditions. The results are shown in Table 2. The reaction of pyridinecarbaldehydes (**5**), (**7**) took place to give the corresponding 2-substituted oxazolines (**6**), (**8**) in good yields (runs 2, 3). 6-Methyl-2-pyridine-carbaldehyde (**9**) was converted to oxazoline (**10**) (run 4). 2,6-Pyridinedicarboxaldehyde (**11**) was expectedly converted to 2,6-bis(oxazolin-2-yl)pyridine (**12**) (run 5). The reaction of 2-formylthiazole (**13**) afforded oxazoline (**14**) (run 6). Quinolinecarbaldehydes (**15**), (**17**), (**19**) were also converted to the corresponding (oxazolin-2-yl)quinolines (**16**), (**18**), (**20**) under the same reaction conditions (runs 7-9). 2-Substituted heterocyclic 1,3-oxazoline derivatives **12**, **16** have been well recognized as useful catalyst ligands such as Pybox, Quinox in synthetic organic chemistry.[4] PTAB-Py in MeOH or MeCN was found to be alternative procedure for conversion of various aldehydes to 2-substituted heterocyclic 1,3-oxazolines.

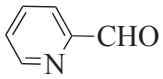
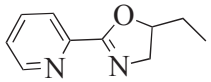
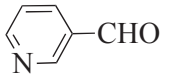
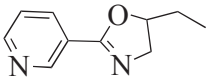
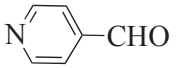
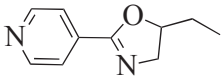
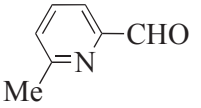
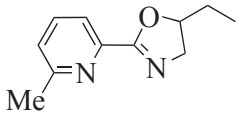
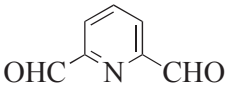
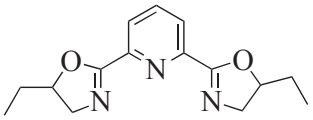
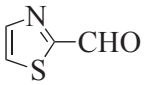
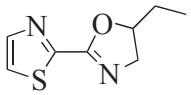
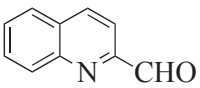
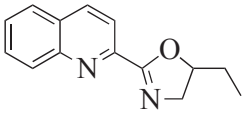
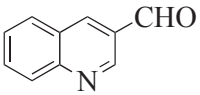
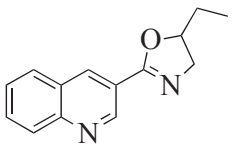
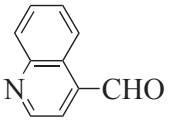
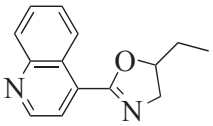
The following reaction of heterocyclic aldehydes and 1-amino-2-butanol instead of 2-aminoethanol with PTAB-Py was also carried out to clarify the chemoselectivity and limitations of this method. The results are summarized in Table 3. Pyridinecarbaldehydes **1**, **5**, **7** were converted to respective 5-ethyl-1,3-oxazolines (**21**)-(**23**) in good yields (runs 1-3). 6-Methyl-2-pyridinecarbaldehyde **9** was also converted to 5-ethyl-1,3-oxazoline (**24**) (run 4). The reaction of 2,6-pyridinedicarboxaldehyde **11** took place to give dioxazoline derivative (**25**) (run 5). The reaction of 2-formylthiazole **13** similarly afforded 5-ethyl-1,3-oxazoline (**26**) (run 6). Quinolinecarbaldehydes **15**, **17**, **19** were also converted to the corresponding 5-ethyl-1,3-oxazolines (**27**), (**28**), (**29**) under the same reaction conditions (runs 7-9).

Table 2. Reaction of various heterocyclic aldehydes and 2-aminoethanol with PTAB-Py[a]

Run	Substrate (**S**)		Time (h)	Products	Yield (%)	
1		**1**	23[b]		**3**	84
2		**5**	23		**6**	81
3		**7**	23		**8**	84
4		**9**	24		**10**	70
5		**11**	22[b,c]		**12**	69
6		**13**	22		**14**	72
7		**15**	21		**16**	81
8		**17**	22		**18**	86
9		**19**	23		**20**	78

[a] **S**: 0.5 mmol; PTAB: 1.0 mmol; Py: 1.0 mmol; 2-aminoethanol: 3.3 mmol; MeOH: 6.0 mL. [b] MeCN was used instead of MeOH. [c] **11**: 0.25 mmol.

Table 3. Reaction of various aldehydes and 1-amino-2-butanol with PTAB-Py[a]

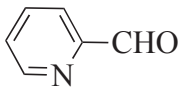
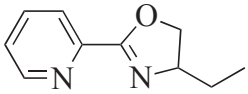
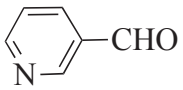
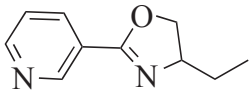
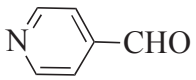
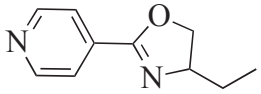
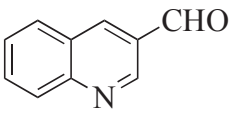
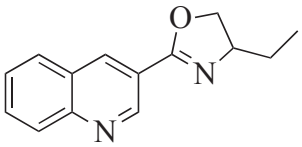
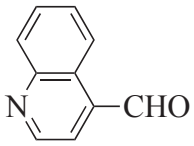
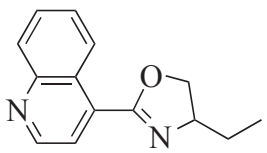
Run	Substrate (**S**)		Time (h)	Products	Yield (%)	
1		**1**	22		**21**	84
2		**5**	23		**22**	86
3		**7**	21		**23**	86
4		**9**	22[b]		**24**	75
5		**11**	18[b,c]		**25**	63
6		**13**	22[b]		**26**	70
7		**15**	22		**27**	83
8		**17**	23		**28**	81
9		**19**	22		**29**	92

[a] **S**: 0.5 mmol; PTAB: 1.0 mmol; Py: 1.0 mmol; 1-amino-2-butanol: 1.3-2.0 mmol; MeOH: 6.0 mL. [b] MeCN was used instead of MeOH. [c] **11**: 0.25 mmol.

To exhibit the utility of aminoalcohols in this method, the reaction of heterocyclic aldehydes and 2-amino-1-butanol with PTAB-Py was also carried out in MeOH under the same reaction conditions. The results are summarized in Table 4. Pyridinecarbaldehydes **1**, **5**, **7** were converted to corresponding

4-ethyl-1,3-oxazoline derivatives (**30**), (**31**), (**32**) (runs 1-3). The reaction of quinolinecarbaldehydes **17**, **19** was also carried out to clarify the limitations of this method. Quinolinecarbaldehydes **17**, **19** were converted to respective 4-ethyl-1,3-oxazolines (**33**), (**34**) (runs 4, 5). The yields of 4-ethyl-1,3-oxazolines were less than those of 5-ethyl-1,3-oxazolines. Amino group of 2-amino-1-butanol hindered by ethyl and hydroxymethyl moieties was supposed to be less reactive than that of 2-aminoethanol and 1-amino-2-butanol.

Table 4. Reaction of various aldehydes and 2-amino-1-butanol with PTAB-Py[a]

Run	Substrate (**S**)	Time (h)	Products	Yield (%)
1		**1** 22		**30** 58
2		**5** 21		**31** 73
3		**7** 22		**32** 73
4		**17** 22		**33** 75
5		**19** 23		**34** 55

[a] **S**: 0.5 mmol; PTAB: 1.0 mmol; Py: 1.0 mmol; 2-amino-1-butanol: 2.2 mmol; MeOH: 6.0 mL.

In conclusion, PTAB-Py in the presence of the 2-aminoethanol or 1-amino-2-butanol was confirmed to be an alternative simple method for the transformation of various heterocyclic aldehydes into 2-substituted 1,3-oxazolines in MeOH or MeCN without overoxidation to carboxylic acid.

EXPERIMENTAL

Melting points were measured on a Buchi Melting Point B-540 apparatus. IR spectra were recorded on a Perkin Elmer Spectrum One FT-IR spectrometer. ^{1}H and ^{13}C NMR spectra were recorded with a JEOL

JNM-EX270 spectrometer at room temperature and the chemical shifts (δ) were given relative to internal standard $SiMe_4$ in $CDCl_3$. Anal were run on a Yanagimoto MT-6.

Typical procedure

To a solution of 3-quinolinecarbaldehyde **17** (79 mg, 0.5 mmol), 2-aminoethanol (200 μL, 3.2 mmol), and pyridine (80 μL, 1.0 mmol) in MeOH (6 mL), was added PTAB (trimethylphenylammonium tribromide or phenyltrimethylammonium tribromide, 376 mg, 1.0 mmol) at room temperature. After stirring for 22 h at rt, the reaction mixture was treated with 0.5 M aq $Na_2S_2O_3$ (10 mL), 1.0 M aq $NaHCO_3$ (15 mL) and extracted with EtOAc (60 mL). The organic layer was washed with 0.5 M aq $Na_2S_2O_3$ and successively washed with saturated aq NaCl, and dried over $MgSO_4$. After removal of solvent in vacuo, the residue was purified by column chromatography on silica gel (Wako C-200) with CCl_4, CCl_4-$CHCl_3$ (2:1 v/v). 3-(Oxazolin-2-yl)quinoline (**18**, 85 mg) was obtained in 86% yield.

2-(Oxazolin-2-yl)pyridine (3): Pale yellow solid; mp 44.5-45.5 ºC. IR (neat, cm^{-1}) 3063, 2979, 2909, 2881, 1654, 1585, 1570, 1472, 1441, 1367, 1293, 1269, 1248, 1195, 1151, 1122, 1098, 1044, 1000, 977, 944, 905, 802, 747, 674. ^{1}H NMR ($CDCl_3$) δ 4.14 (2H, t, *J* = 8.1 Hz), 4.53 (2H, t, *J* = 8.1 Hz), 7.40 (1H, dd, *J* = 8.1, 5.4 Hz), 7.79 (1H, t, *J* = 8.1 Hz), 8.05 (1H, d, *J* = 8.1 Hz), 8.71 (1H, d, *J* = 5.4 Hz). ^{13}C NMR ($CDCl_3$) δ 55.04, 68.13, 123.73, 125.47, 136.57, 146.66, 149.62, 163.80. *Anal*. Calcd for $C_8H_8ON_2$: C, 64.84; H, 5.44; N, 18.91. Found: C, 65.01; H, 5.47; N, 18.86.

Pyridine-2-*N*-(2-hydroxyethyl)carboxamide (4): Brown oil. IR (neat, cm^{-1}) 3378, 3059, 2935, 2878, 1661, 1590, 1569, 1537, 1465, 1435, 1361, 1290, 1246, 1220, 1170, 1147, 1065, 997, 913, 820, 750, 693, 621. ^{1}H ($CDCl_3$) δ 3.66 (2H, t, *J* = 5.4 Hz), 3.86 (2H, t, *J* = 5.4 Hz), 7.44 (1H, m), 7.86 (1H, t, *J* = 8.1 Hz), 8.20 (1H, d, *J* = 8.1 Hz), 8.55 (1H, d, *J* = 5.4 Hz). ^{13}C NMR ($CDCl_3$) δ 42.53, 62.48, 122.29, 126.33, 137.44, 148.14, 149.71, 165.55. *Anal*. Calcd for $C_8H_{10}O_2N_2$: C, 57.82; H, 6.07; N, 16.86. Found: C, 57.95; H, 6.04; N, 16.97.

3-(Oxazolin-2-yl)pyridine (6):[2d] Pale yellow solid; mp 69.0-69.5 ºC. IR (KBr, cm^{-1}) 3090, 3045, 2985, 2952, 2935, 2909, 2881, 1652, 1591, 1573, 1484, 1422, 1359, 1263, 1240, 1189, 1116, 1080, 1034, 1022, 979, 933, 896, 819, 745, 703, 686, 622. ^{1}H NMR ($CDCl_3$) δ 4.09 (2H, t, *J* = 8.1 Hz), 4.47 (2H, t, *J* = 8.1 Hz), 7.36 (1H, dd, *J* = 5.4, 2.7), 8.22 (1H, d, *J* = 5.4 Hz), 7.71 (1H, dd, *J* = 5.4, 2.7 Hz), 9.16 (1H, brs). ^{13}C NMR ($CDCl_3$) δ 54.92, 67.73, 123.16, 123.81, 135.46, 149.38, 151.95, 162.65. *Anal*. Calcd for $C_8H_8ON_2$: C, 64.84; H, 5.44; N, 18.91. Found: C, 64.86; H, 5.37; N, 18.84.

4-(Oxazolin-2-yl)pyridine (8):[2d] Pale yellow solid; mp 113.5-114.2 ºC. IR (neat, cm^{-1}) 3032, 2974, 1650, 1599, 1552, 1497, 1474, 1409, 1365, 1335, 1260, 1215, 1092, 1074, 992, 972, 943, 898, 841, 743, 672. ^{1}H NMR ($CDCl_3$) δ 4.11 (2H, t, *J* = 8.1 Hz), 4.48 (2H, t, *J* = 8.1 Hz), 7.78 (2H, d, *J* = 5.4 Hz), 8.71 (2H, d,

J = 5.4 Hz). ^{13}C NMR ($CDCl_3$) δ 55.06, 67.91, 121.84, 134.99, 150.22, 162.92. *Anal*. Calcd for $C_8H_8ON_2$: C, 64.84; H, 5.44; N, 18.91. Found: C, 64.46; H, 5.29; N, 18.45.

2-(Oxazolin-2-yl)-6-methylpyridine (10): Colorless solid; mp 47.0-48.0 ºC. IR (KBr, cm^{-1}) 3054, 2998, 2975, 2926, 2901, 2875, 1656, 1642, 1591, 1572, 1459, 1364, 1329, 1279, 1254, 1230, 1163, 1129, 1109, 1079, 1008, 996, 989, 974, 948, 911, 834, 814, 746, 690, 669. ^{1}H NMR ($CDCl_3$) δ 2.64 (3H, s), 4.12 (2H, t, *J* = 8.1 Hz), 4.53 (2H, t, *J* = 8.1 Hz), 7.27 (1H, d, *J* = 8.1 Hz), 7.67 (1H, t, *J* = 8.1 Hz), 7.85 (1H, d, *J* = 8.1 Hz). ^{13}C NMR ($CDCl_3$) δ 24.61, 54.99, 68.19, 120.90, 125.32, 136.76, 146.06, 158.79, 163.93. *Anal*. Calcd for $C_9H_{10}ON_2$: C, 66.64; H, 6.21; N, 17.27. Found: C, 66.47; H, 6.09; N, 17.07.

2,6-Bis(oxazolin-2-yl)pyridine (12): Colorless solid; mp 140-160 ºC (decomp). IR (neat, cm^{-1}) 3049, 2974, 2932, 2874, 1644, 1569, 1476, 1453, 1427, 1357, 1323, 1274, 1239, 1151, 1125, 1096, 1065, 992, 975, 955, 937, 910, 894, 843, 743, 660, 648. ^{1}H NMR ($CDCl_3$) δ 4.13 (4H, t, *J* = 8.1 Hz), 4.54 (4H, t, *J* = 8.1 Hz), 7.88 (1H, t, *J* = 8.1 Hz), 8.16 (2H, d, *J* = 8.1 Hz). ^{13}C NMR ($CDCl_3$) δ 55.05, 68.32, 125.49, 137.35, 146.73, 163.44. *Anal*. Calcd for $C_{11}H_{11}N_3O_2$: C, 60.82; H, 5.10; N, 19.34. Found: C, 61.15; H, 5.28; N, 18.88.

2-(Oxazolin-2-yl)thiazole (14): Pale yellow solid; mp 80.1-81.1 ºC. IR (neat, cm^{-1}) 3107, 3075, 2984, 2875, 1645, 1493, 1426, 1360, 1314, 1260, 1243, 1198, 1149, 1070, 1040, 992, 972, 925, 875, 765, 695 607. ^{1}H NMR ($CDCl_3$) δ 4.13 (2H, t, *J* = 8.1 Hz), 4.55 (2H, t, *J* = 8.1 Hz), 7.51 (1H, d, *J* = 5.4 Hz), 7.96 (1H, d, *J* = 5.4 Hz). ^{13}C NMR ($CDCl_3$) δ 55.04, 68.71, 122.89, 144.34, 155.62, 159.38. *Anal*. Calcd for $C_6H_6N_2OS$: C, 46.74; H, 3.92; N, 18.17. Found: C, 46.58; H, 4.01; N, 17.75.

2-(Oxazolin-2-yl)quinoline (16):[4d] Colorless solid; mp 107.9-108.3 ºC. IR (KBr, cm^{-1}) 3055, 3009, 2974, 2932, 2903, 2876, 1641, 1591, 1558, 1503, 1481, 1465, 1460, 1429, 1366, 1341, 1299, 1268, 1242, 1207, 1133, 1120, 1095, 1078, 1004, 975, 956, 936, 911, 882, 844, 793, 760, 625. ^{1}H NMR ($CDCl_3$) δ 4.19 (2H, t, *J* = 8.1 Hz), 4.60 (2H, t, *J* = 8.1 Hz), 7.60 (1H, t, *J* = 8.1 Hz), 7.76 (1H, t, *J* = 8.1 Hz), 7.78 (1H, d, *J* = 5.4 Hz), 8.15-8.29 (3H, m). ^{13}C NMR ($CDCl_3$) δ 55.12, 68.41, 120.57, 127.46, 127.87, 128.85, 130.01, 130.30, 136.72, 146.66, 147.49, 164.09. *Anal*. Calcd for $C_{12}H_{10}ON_2$: C, 72.70; H, 5.08; N, 14.13. Found: C, 72.85; H, 5.07; N, 13.96.

3-(Oxazolin-2-yl)quinoline (18): Colorless solid; mp 128.3-128.8 ºC. IR (KBr, cm^{-1}) 2979, 2941, 2908, 2882, 1651, 1618, 1572, 1497, 1460, 1426, 1380, 1352, 1314, 1277, 1237, 1221, 1193, 1147, 1129, 1082, 1065, 1019, 978, 968, 933, 918, 906, 867, 785, 705, 631. ^{1}H NMR ($CDCl_3$) δ 4.15 (2H, t, *J* = 8.1 Hz), 4.51 (2H, t, *J* = 8.1 Hz), 7.59 (1H, t, *J* = 8.1 Hz), 7.78 (1H, t, *J* = 8.1 Hz), 7.88 (1H, d, *J* = 8.1 Hz), 8.14 (1H, d, *J* = 8.1 Hz), 8.67 (1H, brs), 9.45 (1H, brs). ^{13}C NMR ($CDCl_3$) δ 55.09, 67.68, 120.84, 126.94, 127.25, 128.62, 129.42, 130.95, 136.01, 149.02, 149.47, 162.78. *Anal*. Calcd for $C_{12}H_{10}ON_2$: C, 72.70; H, 5.08; N, 14.13. Found: C, 72.86; H, 5.09; N, 13.98.

4-(Oxazolin-2-yl)quinoline (20): Pale yellow solid**;** mp 64.5-65.6 ºC. IR (KBr, cm^{-1}) 3079, 2978, 2931, 2908, 2875, 1641, 1577, 1509, 1463, 1353, 1326, 1300, 1266, 1249, 1206, 1188, 1145, 1128, 1073, 999, 973, 943, 902, 879, 866, 813, 798, 768, 659. ^{1}H NMR ($CDCl_3$) δ 4.25 (2H, t, *J* = 8.1 Hz), 4.49 (2H, t, *J* = 8.1 Hz), 7.63 (1H, t, *J* = 8.1 Hz), 7.76 (1H, t, *J* = 8.1 Hz), 7.88 (1H, d, *J* = 5.4 Hz), 8.15 (1H, d, *J* = 8.1 Hz), 8.98 (1H, d, *J* = 2.7 Hz), 9.09 (1H, d, *J* = 8.1 Hz). ^{13}C NMR ($CDCl_3$) δ 55.86, 66.89, 121.71, 125.26, 126.37, 127.73, 129.54, 129.90, 132.19, 148.83, 149.72, 162.81. *Anal*. Calcd for $C_{12}H_{10}ON_2$: C, 72.70; H, 5.08; N, 14.13. Found: C, 72.79; H, 4.97; N, 13.94.

2-(5-Ethyloxazolin-2-yl)pyridine (21): Pale yellow oil. IR (neat, cm^{-1}) 3063, 2968, 2938, 2878, 1651, 1644, 1585, 1569, 1530, 1471, 1441, 1382, 1359, 1291, 1269, 1247, 1201, 1102, 1045, 992, 964, 929, 909, 802, 747, 678. ^{1}H NMR ($CDCl_3$) δ 1.03 (3H, t, *J* = 8.1 Hz), 1.73 (2H, m), 3.74 (1H, dd, *J* = 13.5, 8.1 Hz), 4.17 (1H, dd, *J* = 13.5, 8.1 Hz), 4.78 (1H, m), 7.38 (1H, m), 7.77 (1H, t, *J* = 8.1 Hz), 8.03 (1H, d, *J* = 8.1 Hz), 8.71 (1H, d, *J* = 5.4 Hz). ^{13}C NMR ($CDCl_3$) δ 8.87, 27.97, 59.44, 81.84, 123.65, 125.32, 136.49, 146.84, 149.58, 163.24. *Anal*. Calcd for $C_{10}H_{12}N_2O$: C, 68.16; H, 6.86; N, 15.90. Found: C, 68.01; H, 6.80; N, 15.73.

3-(5-Ethyloxazolin-2-yl)pyridine (22): Pale yellow oil. IR (neat, cm^{-1}) 3046, 2968, 2938, 2878, 1651, 1594, 1571, 1484, 1475, 1463, 1430, 1416, 1351, 1297, 1263, 1193, 1085, 1036, 1024, 963, 929, 902, 819, 708. ^{1}H NMR ($CDCl_3$) δ 1.03 (3H, t, *J* = 8.1 Hz), 1.73 (2H, m), 3.69 (1H, dd, *J* = 13.5, 8.1 Hz), 4.13 (1H, dd, *J* = 13.5, 8.1 Hz), 4.71 (1H, m), 7.34 (1H, m), 8.22 (1H, d, *J* = 8.1 Hz), 8.70 (1H, d, *J* = 5.4 Hz), 9.15 (1H, brs). ^{13}C NMR ($CDCl_3$) δ 9.12, 28.24, 59.54, 81.50, 123.17, 124.15, 135.47, 149.35, 151.85, 162.11. *Anal*. Calcd for $C_{10}H_{12}N_2O$: C, 68.16; H, 6.86; N, 15.90. Found: C, 68.20; H, 7.05; N, 15.75.

4-(5-Ethyloxazolin-2-yl)pyridine (23): Colorless oil. IR (neat, cm^{-1}) 2969, 2939, 2878, 1651, 1600, 1556, 1497, 1463, 1412, 1383, 1357, 1321, 1296, 1263, 1228, 1094, 1063, 994, 963, 928, 905, 838, 745, 680. ^{1}H NMR ($CDCl_3$) δ 1.04 (3H, t, *J* = 8.1 Hz), 1.77 (2H, m), 3.70 (1H, dd, *J* = 13.5, 8.1 Hz), 4.15 (1H, dd, *J* = 13.5, 8.1 Hz), 4.71 (1H, m), 7.79 (2H, d, *J* = 5.4 Hz), 8.70 (2H, d, *J* = 5.4 Hz). ^{13}C NMR ($CDCl_3$) δ 8.89, 28.02, 59.45, 81.51, 121.70, 135.19, 149.92, 162.11. *Anal*. Calcd for $C_{10}H_{12}N_2O$: C, 68.16; H, 6.86; N, 15.90. Found: C, 68.32; H, 6.99; N, 15.48.

2-(5-Ethyloxazolin-2-yl)-6-methylpyridine (24): Pale yellow oil. IR (neat, cm^{-1}) 3065, 2966, 2938, 2877, 1639, 1590, 1575, 1463, 1380, 1351, 1275, 1256, 1236, 1166, 1119, 1084, 1016, 966, 929, 837, 810, 747, 695, 670. ^{1}H NMR ($CDCl_3$) δ 1.02 (3H, t, *J* = 8.1 Hz), 1.77 (2H, m), 2.64 (3H, s), 3.72 (1H, dd, *J* = 13.5, 8.1 Hz), 4.16 (1H, dd, *J* = 13.5, 8.1 Hz), 4.76 (1H, m), 7.24 (1H, d, *J* = 8.1 Hz), 7.68 (1H, t, *J* = 8.1 Hz), 7.80 (1H, d, *J* = 8.1 Hz). ^{13}C NMR ($CDCl_3$) δ 8.96, 24.56, 28.08, 59.51, 81.81, 120.77, 125.19, 136.65, 146.22, 158.84, 163.34. *Anal*. Calcd for $C_{11}H_{14}N_2O$: C, 69.45; H, 7.42; N, 14.73. Found: C, 69.69; H, 7.41; N, 14.81.

2,6-Bis(5-ethyloxazolin-2-yl)pyridine (25): Pale yellow oil. IR (neat, cm^{-1}) 2968, 2938, 2878, 1660, 1575, 1536, 1461, 1434, 1382, 1344, 1273, 1244, 1172, 1138, 1111, 1079, 996, 966, 930, 831, 748, 667, 649. ^1H NMR ($CDCl_3$) δ 1.03 (6H, t, *J* = 8.1 Hz), 1.76 (4H, m), 3.73 (2H, dd, *J* = 16.2, 8.1 Hz), 4.17 (2H, dd, *J* = 16.2, 8.1 Hz), 4.77 (2H, m), 7.86 (1H, t, *J* = 8.1 Hz), 8.08 (2H, m). ^{13}C NMR ($CDCl_3$) δ 9.14, 9.17, 28.12, 28.16, 59.55, 59.58, 82.26, 82.30, 125.32, 137.34, 146.92, 162.90. *Anal*. Calcd for $C_{15}H_{19}N_3O_2$: C, 65.91; H, 7.01; N, 15.37. Found: C, 65.79: H, 6.69; N, 15.32.

2-(5-Ethyloxazolin-2-yl)thiazole (26): Pale yellow oil. IR (neat, cm^{-1}) 3082, 2967, 2937, 2877, 1645, 1533, 1494, 1462, 1428, 1349, 1314, 1244, 1148, 1043, 957, 924, 875, 761, 610. ^1H NMR ($CDCl_3$) δ 1.04 (3H, t, *J* = 8.1 Hz), 1.80 (2H, m), 3.72 (1H, dd, *J* = 13.5, 8.1 Hz), 4.16 (1H, dd, *J* = 13.5, 8.1 Hz), 4.81 (1H, m), 7.51 (1H, d, *J* = 2.7 Hz), 7.95 (1H, d, *J* = 2.7 Hz). ^{13}C NMR ($CDCl_3$) δ 8.94, 27.95, 59.48, 82.73, 122.77, 144.25, 156.00, 158.86. *Anal*. Calcd for $C_8H_{10}OSN_2$: C, 52.72; H, 5.53; N, 15.37. Found: C, 52.25; H, 5.47; N, 14.92.

2-(5-Ethyloxazolin-2-yl)quinoline (27): Pale yellow solid; mp 81.4-83.0 ºC. IR (neat, cm^{-1}) 3061, 2966, 2937, 2876, 1637, 1595, 1561, 1505, 1464, 1429, 1377, 1364, 1354, 1302, 1268, 1243, 1209, 1125, 1085, 949, 929, 840, 766. ^1H NMR ($CDCl_3$) δ 1.05 (3H, t, *J* = 8.1 Hz), 1.84 (2H, m), 3.80 (1H, dd, *J* = 16.2, 8.1 Hz), 4.23 (1H, dd, *J* = 16.2, 8.1 Hz), 4.84 (1H, m), 7.59 (1H, t, *J* = 8.1 Hz), 7.75 (1H, t, *J* = 8.1 Hz), 7.83 (1H, d, *J* = 8.1 Hz), 8.16-8.30 (3H, m). ^{13}C NMR ($CDCl_3$) δ 8.89, 28.03, 59.57, 82.08, 120.51, 127.37, 127.73, 128.59, 129.85, 130.35, 136.60, 146.88, 147.54, 163.56. *Anal*. Calcd for $C_{14}H_{14}N_2O$: C, 74.31; H, 6.24; N, 12.38. Found: C, 74.32; H, 6.40; N, 12.33.

3-(5-Ethyloxazolin-2-yl)quinoline (28): Pale yellow oil. IR (neat, cm^{-1}) 2967, 2938, 2876, 1651, 1620, 1571, 1497, 1462, 1428, 1382, 1315, 1275, 1236, 1196, 1128, 1070, 1007, 968, 927, 865, 844, 787, 756. ^1H NMR ($CDCl_3$) δ 1.07 (3H, t, *J* = 8.1 Hz), 1.84 (2H, m), 3.75 (1H, dd, *J* = 16.2, 8.1 Hz), 4.19 (1H, dd, *J* = 16.2, 8.1 Hz), 4.76 (1H, m), 7.60 (1H, t, *J* = 8.1 Hz), 7.79 (1H, t, *J* = 8.1 Hz), 7.89 (1H, d, *J* = 8.1 Hz), 8.15 (1H, d, *J* = 8.1 Hz), 8.68 (1H, brs), 9.44 (1H, brs). ^{13}C NMR ($CDCl_3$) δ 9.13, 28.23, 59.64, 81.46, 121.10, 126.98, 127.24, 128.60, 129.33, 130.92, 135.98, 148.93, 149.43, 162.24. *Anal*. Calcd for $C_{14}H_{14}N_2O$: C, 74.31; H, 6.24; N, 12.38. Found: C, 74.44; H, 6.39; N, 12.31.

4-(5-Ethyloxazolin-2-yl)quinoline (29): Pale yellow oil. IR (neat, cm^{-1}) 3066, 2966, 2937, 2876, 1644, 1576, 1509, 1463, 1434, 1380, 1337, 1322, 1296, 1268, 1247, 1180, 1144, 1130, 1093, 1073, 1026, 1001, 959, 931, 904, 878, 858, 816, 770, 657, 627. ^1H NMR ($CDCl_3$) δ 1.05 (3H, t, *J* = 8.1 Hz), 1.79 (2H, m), 3.85 (1H, dd, *J* = 16.2, 8.1 Hz), 4.28 (1H, dd, *J* = 16.2, 8.1 Hz), 4.73 (1H, m), 7.63 (1H, t, *J* = 8.1 Hz), 7.75 (1H, t, *J* = 8.1 Hz), 7.89 (1H, d, *J* = 5.4 Hz), 8.15 (1H, d, *J* = 8.1 Hz), 8.98 (1H, d, *J* = 5.4 Hz), 9.08 (1H, d, *J* = 8.1 Hz). ^{13}C NMR ($CDCl_3$) δ 9.14, 28.23, 60.35, 80.61, 121.66, 125.31, 126.34, 127.67, 129.51, 129.81, 132.59, 148.78, 149.67, 162.31. *Anal*. Calcd for $C_{14}H_{14}N_2O$: C, 74.31; H, 6.24; N, 12.38.

Found: C, 74.28; H, 6.03; N, 12.14.

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