HETEROCYCLES, Vol. 81, No. 9, 2010, pp. 2087 - 2096. © The Japan Institute of Heterocyclic Chemistry
Received, 7th June, 2010, Accepted, 30th July, 2010, Published online, 3rd August, 2010
DOI: 10.3987/COM-10-11987

AN EFFCIENT SYNTHESIS OF 2-AMINOBENZOXAZOLES AND 2-AMINOBENZOTHIAZAZOLES FROM 2-AMINOPHENOLS OR 2-AMINOTHIOPHENOLS AND ISOSELENOCYANATES

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Abstract – An expeditious method to access 2-aminobenzoxazoles and 2-aminobenzothiazoles from various substituted 2-aminophenols and 2-aminothiophenols, respectively, with isoselenocyanates in a one pot procedure is reported. Elemental Se precipitates nearly quantitatively in the reaction without any deselenizing agent and it can be reused. A possible mechanism for the formation of the target products is proposed.

INTRODUCTION

In the past two decades, the chemistry of organoselenium compounds has attracted much attention because of their importance as synthetic tools.[1] Remarkable jobs have been done by Heimgartner's group and other research groups for the utility of isoselenocyanates as building blocks in the synthesis of Se-containing heterocycles.[2]

However, reactions with isoselenocyanates to give corresponding non-Se-containing heterocycles have not been studied profoundly. So far as we know, Fernández-Bolaños and his co-workers discovered the phenomenon that elemental Se precipitated from unprotected glycopyranosyl selenoureas which were synthesized from isoselenocyanates and glycopyranosylamines to give bicyclic isoureas.[3] Very recently, we have reported the preparation of 2-aminobenzimidazoles by the reaction of isoselenocyanates and *o*-phenylenediamines.[4]

2-Aminobenzoxazole and 2-aminobenzothiazole are known as biologically active compounds in many pharmaceuticals and agrochemicals.[5] For example, 2-aminobenzoxazole shows activity against inhibitors or modulators of histamine receptors and is regarded as a drug candidate for the treatment of HIV, neurodegeneration, and inflammatory diseases.[6]

Therefore, there has been an enhanced interest in the synthesis of 2-aminobenzoxazoles and 2-aminobenzothiazoles. The traditional synthetic approach of the formers involves treatment of 2-aminophenol with isothiocyanates to obtain the corresponding thioureas, which later undergo a cyclodesulfurization step with the assistance of diverse desulfurizing agents.[7] Reported routes to 2-aminobenzothiazoles include: i) reacting 2,2'-diaminodiphenyl disulfide with isothiocyanates,[8] ii) copper(I)-catalyzed reaction of 2-iodoaniline with isothiocyanates,[9] and iii) microwave promoted reaction of 2-chlorobenzothiazole with an amine.[10] When an isothiocyanate is invovled as one of the starting material, the methods usually need desulfurizing agents. These desulfurizing agents are mostly converted to acidic gases, compounds with terrible odor, or heavy metals. We also notice that these methods often need longer reaction time, lead to problems with complex workup or suffer from low yields.

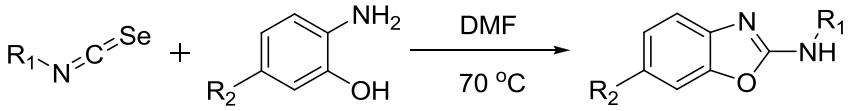
Because of the similarity on structural and chemical properties and especially stronger leaving tendency of selenium, we decided to develop analogous reactions with isoselenocyanates, and herein to report an efficient one-pot procedure for the synthesis of two important classes of compounds, 2-aminobenzoxazoles and 2-aminobenzothiazoles.

RESULTS AND DISCUSSION

Phenyl isoselenocyanates and cyclohexyl isoselenocyanate have been prepared following *Fernández-Bolaños's* procedure.[11] Equimolar amounts of a 2-aminophenol and an isoselenocyanate were then added to DMF. To our great surprise, 2-aminobenzoxazole was obtained in excellent yield and elemental Se was precipitated without any deselenizing agent. The precipitation made the post workup extremely easy: only a filtration was needed to separate Se from the mixture. The filtrate was concentrated and purified chromatographically to give 2-aminobenzoxazole. Futhermore, we optimized the reaction condition of the cyclocondensation of 2-aminophenol **2** and 1-isoselenocyanato-4-methoxybenzene **1c**. The results showed that DMF is the appropriate solvent, and 70 ^{o}C was the optimal reaction temperature to give **3c** in 96% yield, while lower yields were obtained in pyridine at 70 ^{o}C (82%) and in THF under reflux (81%). Other solvents such as CH_2Cl_2, toluene and AcOEt gave no desired product. It might due to DMF provided an alkaline condition that enhanced the attack capability of the amino group of 2-aminophenol.

Under the optimized conditions, a variety of 2-aminobenzoxazoles were prepared. As shown in **Table 1**, phenyl isoselenocyanates containing both electron donating and electron withdrawing groups, respectively, gave 2-aminobenzoxazoles in good to excellent yields. The effect of different substituent on the 2-aminophenol was also considered. With the strong electron withdrawing effect of the nitro group, the nucleophilic tendency of the amino group was largely reduced and the total reaction time was prolonged to 14 h. However, the precipitation of Se promoted the reaction proceeding and gave target products in good yields.

Table 1. Synthesis of 2-aminobenzoxazole from isoselenocyanates



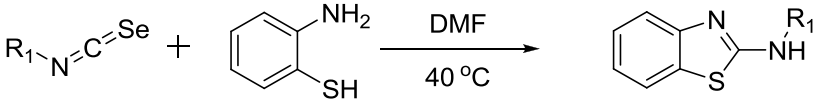
1 **2** **3a-3j**

Entry	$\mathbf{R^1}$	$\mathbf{R^2}$	Product	Reaction time [h][a]	Yield [%][b]
1	Ph	H	**3a**	6.5	85, 83[c]
2	4-MeC_6H_4	H	**3b**	6.5	90
3	4-$MeOC_6H_4$	H	**3c**	6	96
4	4-ClC_6H_4	H	**3d**	5.5	83
5	Ph	NO_2	**3e**	14	77
6	2-MeC_6H_4	NO_2	**3f**	14	83
7	4-$MeOC_6H_4$	NO_2	**3g**	14	84
8	Ph	Cl	**3h**	6	79
9	2-MeC_6H_4	Cl	**3i**	7	91
10	4-$MeOC_6H_4$	Cl	**3j**	8	88

[a]) Monitored by TLC, until 2-aminophenol was fully consumed.
[b]) Yield of isolated product after column chromatography.
[c]) Reproduced isoselenocyanate.

The successful preparation of 2-aminobenzoxazoles encouraged us to apply this methodology for the synthesis of 2-aminobenzothiazoles. As expected, various 2-aminobenzothiazoles were prepared successfully. A lower reaction temperature (40 °C) was needed, which might be the result of the stronger nucleophilicity of the SH group. As can be seen from **Table 2**, different substituents were also well tolerated in this reaction. Electron donating and electron withdrawing groups on phenyl isoselenocyanates as well as cyclohexyl isoselenocyanate performed well in this reaction and gave excellent yields.

Table 2. Synthesis of 2-aminobenzothiazole from isoselenocyanates



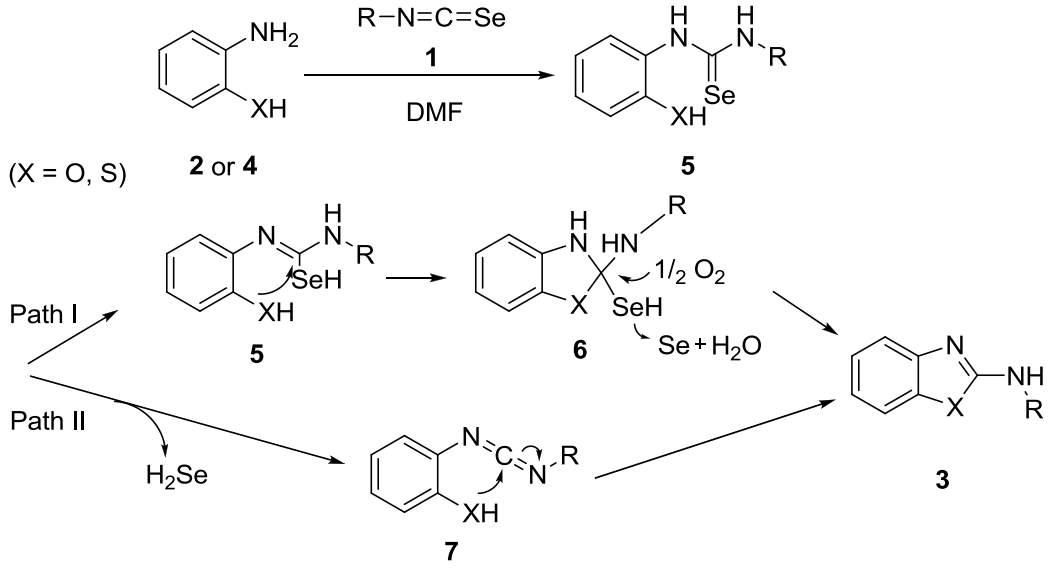
1 **4** **3k-3p**

Entry	$\mathbf{R^1}$	Product	Reaction time [h][a]	Yield [%][b]
1	Ph	**3k**	6	89, 88[c]
2	3-MeC_6H_4	**3l**	6.5	91
3	2-EtC_6H_4	**3m**	5.5	78
4	4-$MeOC_6H_4$	**3n**	5	90
5	4-ClC_6H_4	**3o**	6	82
6	cyclohexyl	**3p**	12	73

[a]) Monitored by TLC, until 2-aminothiophenol was fully consumed.
[b]) Yield of isolated product after column chromatography.
[c]) Reproduced isoselenocyanate.

Since a variety of 2-aminobenzoxazoles and 2-aminobenzothiazoles were prepared by this method, we were eager to know the recovery rate of Se precipitated in the reaction. With great success, the recovery rate was 95-97%, which means that Se was nearly quantitatively recovered. Isoselenocyanates could be reproduced from these selenium, thus to cut the waste to the minimum (**Table 1,** Entry **1; Table 2,** Entry 1).

In the light of all these results, two possible reaction mechanisms are proposed in **Scheme 1**. In both cases, a selenourea **5** was generated by the reaction of 2-aminophenol or 2-aminothiophenol with isoselenocyanate. In path I, **5** was then converted to product **3** through an intramolecular cyclization with the assistant of O_2. Another popular mechanism[12] for this type of reaction shown as path II involved the formation of a carbodiimide intermediate **7**, which cyclized spontaneously to give the desired product **3**. An experiment under N_2 atmosphere had been carried out to determine the necessity of the O_2. According to our results, only selenourea **5** was formed after 36 h, which means that the reaction does not lead to **3** without the help of O_2, thus supporting path I.



Scheme 1. Possible mechanism for the synthesis of 2-aminobenzoxazole and 2-aminobenzothiazole

In summary, we have developed a novel one-pot procedure for the synthesis of 2-aminobenzoxazoles and 2-aminobenzothiazoles by reacting isoselenocyanates with 2-aminophenol or 2-aminothiophenol without using a deselenizing agent. Compared with traditional routes, this method provides a high yield of the target products with both electron-donating and electron-withdrawing groups. The reaction was performed under mild conditions, and the key material, i.e. the isoselenocyanates, could be reproduced from the precipitated elemental Se, which largely simplifies the purification procedures and minimizes the harm to the environment. The method also widens the application of isoselenocyanates as important

reagents. An experiment was carried out to determine the reaction mechanism and the oxygen-involved intramolecular cyclization pathway was confirmed.

EXPERIMENTAL

General. Mp: *Büchi B-540* apparatus; uncorrected. IR Spectra: *Nicolet Avatar-370* spectrometer, in KBr; in cm^{-1}. ^1H- and ^{13}C-NMR Spectra: *Varian Mercury Plus-400* instrument, in (d_6) DMSO at 400 and 100 MHz, resp.; δ in ppm, *J* in Hz. ESI-MS: *Thermo Finnigan LCQ Advantage* instrument; in *m/z*. HRMS: *Agilent 6210 TOF* instrument.

*General Procedure for the Synthesis of 2-Aminobenzoxazoles. (Take **3a** for example).* Phenyl isoselenocyanate (0.182g, 1 mmol) and 2-aminophenol (0.109g, 1 mmol) were added to DMF (20 mL) with magnetic stirring. The mixture was heated to 70 °C for 6.5 h. When the reaction was completed as monitored by TLC, the mixture was cooled to rt. The solid Se was filtered off and washed with AcOEt (10 mL). The recovery rate of Se is 95% - 97%. The combined filtrate was concentrated *in vacuo* and the residue was chromatographed on silica gel (hexane:AcOEt = 1:1) to give white solid *N*-Phenylbenzo[*d*]oxazol-2-amine **3a** (0.179 g, 85%).

*General Procedure for the Synthesis of 2-Aminobenzothiazoles. (Take **3k** for example).* Phenyl isoselenocyanate (0.182 g, 1 mmol) and 2-aminothiophenol (0.125 g, 1 mmol) were added to DMF (20 mL) with magnetic stirring. The mixture was heated to 40 °C for 6 h. When the reaction was completed as monitored by TLC, the mixture was cooled to rt. The solid Se was filtered off and washed with AcOEt (10 mL). The combined filtrate was concentrated *in vacuo* and the residue was chromatographed on silica gel (hexane : AcOEt = 1 : 1) to give white solid *N*-phenylbenzo[*d*]thiazol-2-amine **3k** (0.201 g, 89%).

Procedure for Control Experiment. Phenyl isoselenocyanate (0.182 g, 1 mmol) and 2-aminophenol (0.109 g, 1 mmol) were added successively to DMF (20 mL) with magnetic stirring under an N_2 atmosphere. The mixture was heated to 70 °C and monitored by TLC. The reaction time was prolonged to 36 h, no product **3a** was detected.

N-Phenylbenzo[*d*]oxazol-2-amine (3a; *Table 2*).

White solid. Mp 176.6–177.1 °C. Lit.,[12] mp 176–178 °C. IR (KBr): 3379, 3154, 3105, 3039, 1928, 1662, 1572, 1490, 1282, 1217, 971, 738, 681 cm^{-1}. ^1H-NMR (400 MHz, DMSO-d_6): 10.62 (s, 1H); 7.77(d, *J* = 8.4, 2H); 7.45-7.50 (m, 2H); 7.38 (t, *J* = 8.4, 2H); 7.23 (t, *J* =8.4, 1H); 7.14 (t, *J* = 7.2, 1H); 7.04 (t, *J* = 7.2, 1H). ^{13}C-NMR (400 MHz, DMSO-d_6): 157.9 (s); 147.0 (s); 142.4 (s); 138.74 (s); 128.9 (2×CH); 123.9 (d); 122.1 (d); 121.6 (d); 117.5 (2×CH); 116.6 (d); 108.9 (d). ESI-MS: 211 $(M-H)^-$.

N-(4-Methylphenyl)benzo[*d*]oxazol-2-amine (3b; *Table 2*).

White solid. Mp 172.3–172.8 °C. Lit.,[13] mp 169–171 °C. IR (KBr): 3382, 3161, 1664, 1574, 1460, 1401, 1227, 820, 737 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.50 (s, 1H); 7.64 (d, J = 8.4, 2H); 7.43-7.48(m, 2H); 7.17-7.23 (m, 3H); 7.12 (t, J = 7.2, 1H); 2.28 (s, 3H). ^{13}C-NMR (400 MHz, DMSO-d_6): 158.1 (s); 147.0 (s); 142.5 (s); 136.2 (s); 131.0 (s); 129.3 (2×CH); 123.9 (d); 121.5 (d); 117.6 (2×CH); 116.4 (d); 108.8 (d); 20.3(q). ESI-MS: 225 $(M-H)^-$.

***N*-(4-Methoxyphenyl)benzo[*d*]oxazol-2-amine (3c; *Table 2*).**

White solid. Mp 135.4–136.5 °C. Lit.,[12] mp 136–138 °C. IR (KBr): 3383, 2994, 2839, 1675, 1581, 1512, 1460, 1232, 1033, 822, 742 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.41 (s, 1H); 7.68 (d, J = 8.0, 2H); 7.42-7.47 (m, 2H); 7.21 (t, J = 7.2, 1H); 7.10 (t, J = 7.2, 1H); 6.97 (d, J = 9.2, 2H); 3.75 (s, 3H). ^{13}C-NMR (400 MHz, DMSO-d_6): 159.4 (s); 156.1 (s); 147.9 (s); 142.1 (s); 131.0 (s); 124.2 (d); 121.4 (d), 121.1 (2×CH); 116.5 (d); 114.5 (2×CH); 109.1 (d); 55.5 (q). ESI-MS: 241 $(M-H)^-$.

***N*-(4-Chlorophenyl)benzo[*d*]oxazol-2-amine (3d; *Table 2*).**

White solid. Mp 153.1–154.5 °C. IR (KBr): 3428, 3157, 1663, 1575, 1491, 1400, 1230, 738 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.79 (s, 1H); 7.79 (d, J = 8.4, 2H); 7.46-7.52 (m, 2H); 7.44 (d, J = 8.4, 2H); 7.24 (t, J = 7.2, 1H); 7.15 (t, J = 7.2, 1H). ^{13}C-NMR (400 MHz, DMSO-d_6): 157.7 (s); 147.0 (s); 142.2 (s); 137.7 (s); 128.9 (2×CH); 125.7 (s); 124.1 (d); 121.9 (d); 119.1 (2×CH); 116.7 (d); 109.1 (d). ESI-MS: 245$(M-H)^-$; 247 $(M+2-H)^-$.

5-Nitro-*N*-phenylbenzo[*d*]oxazol-2-amine (3e; *Table 2*).

Yellow solid. Mp 238.5–239.4 °C. Lit.,[13] mp 236 °C. IR (KBr): 3109, 3041, 2882, 1720, 1601, 1530, 1336, 1266, 978, 875, 813, 734 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 11.04 (s, 1H), 8.24 (d, J = 2.4, 1H); 8.08 (dd, J = 2.4, 8.8, 1H); 7.72-7.77 (m, 3H); 7.42 (t, J = 7.6, 2H); 7.10 (t, J = 7.6, 1 H). ^{13}C-NMR (400 MHz, DMSO-d_6): 160.0 (s); 151.3 (s); 144.5 (s); 143.3 (s); 137.9 (s); 128.9 (2×CH); 122.8 (d); 118.1 (3×CH); 111.4 (d); 109.1 (d). ESI-MS: 256 $(M+H)^+$.

5-Nitro-*N*-(2-methylphenyl)benzo[*d*]oxazol-2-amine (3f; *Table 2*).

Yellow solid. Mp 171.2–172.1 °C. IR (KBr): 3419, 1663, 1598, 1525, 1463, 1346, 1274, 1241, 877, 737 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.17 (s, 1H); 8.13 (s, 1H); 8.03-8.06 (m, 1H); 7.68-7.72 (m, 2H); 7.28 (t, J = 8.0, 2H); 7.16 (t, J = 7.2, 1H); 2.31 (s, 3H). ^{13}C-NMR (400 MHz, DMSO-d_6): 161.8 (s); 151.9 (s); 144.5 (s); 143.6 (s); 135.7 (d); 131.3 (s); 130.6 (s); 126.5 (d); 125.4 (d); 123.8 (d); 117.6 (d); 111.1 (d); 109.1 (d); 17.7 (q). HRMS: calcd for $C_{14}H_{10}N_3O_3$: 268.0722; found: 268.0730.

***N*-(4-Methoxyphenyl)-5-nitrobenzo[*d*]oxazol-2-amine (3g; *Table 2*).**

Yellow solid. Mp 203.2–204.7 °C. IR (KBr): 3400, 3114, 1672, 1584, 1524, 1511, 1345, 1248, 878, 818, 739 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.83 (s, 1H); 8.20 (d, J = 2.4, 1H); 8.06 (dd, J = 2.4, 8.8, 1H); 7.70 (d, J = 8.8, 1H); 7.65 (d, J = 9.2, 2H); 6.99 (d, J = 9.2, 2H); 3.76 (s, 3H). ^{13}C-NMR (400 MHz, DMSO-d_6): 160.4 (s); 155.2 (s); 151.5 (s); 144.5 (s); 143.6 (s); 131.0 (s); 119.8 (2×CH); 117.8 (d); 114.3 (2×CH); 111.1 (d); 109.0 (d); 55.2 (q). HRMS: calcd for $C_{14}H_{10}N_3O_4$: 284.0671; found: 284.0684.

5-Chloro-*N*-phenylbenzo[*d*]oxazol-2-amine (3h; *Table 2*).

Grey solid. Mp 203.4–204.9 °C. Lit.,[14] mp 212–213 °C. IR (KBr): 3481, 3414, 3124, 1679, 1618, 1577, 1446, 1401, 1230, 980, 788 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.79 (s, 1H); 7.73-7.75 (m, 2 H); 7.51-7.53 (m, 2H); 7.37-7.41 (m, 2H); 7.16 (dd, J = 2.0, 8.4, 1H); 7.06 (t, J = 7.6, 1 H). ^{13}C-NMR (400 MHz, DMSO-d_6): 159.1 (s); 145.8 (s); 144.0 (s); 138.3 (s); 128.9 (2×CH); 128.1 (s); 122.4 (d); 121.2 (d); 117.8 (2×CH); 116.2 (d); 110.0 (d). ESI-MS: 243 $(M-H)^-$; 245 $(M+2-H)^-$.

5-Chloro-*N*-(2-methylphenyl)benzo[*d*]oxazol-2-amine (3i; *Table 2*).

White solid. Mp 195.3–196.4 °C. IR (KBr): 3128, 3028, 2893, 1660, 1577, 1459, 1358, 1236, 1191, 972, 846, 763 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 9.88 (s, 1H); 7.73-7.75 (m, 1H); 7.47 (d, J = 8.4, 1H); 7.41 (d, J = 2.4, 1H); 7.26 (t, J = 7.2, 2H); 7.10-7.14 (m, 2H); 2.30 (s, 3H). ^{13}C-NMR (400 MHz, DMSO-d_6): 160.8 (s); 146.4 (s); 144.2 (s); 136.1 (s); 130.8 (s); 130.5 (d); 128.0 (s); 126.4 (d); 124.9 (d); 123.3 (d); 120.7 (d); 115.9 (d); 109.9 (d); 17.7 (q). HRMS: calcd for $C_{14}H_{10}ClN_2O$: 257.0482; found: 257.0489.

5-Chloro-*N*-(4-methoxyphenyl)benzo[*d*]oxazol-2-amine (3j; *Table 2*).

White solid. Mp 182.3–182.9 °C. IR (KBr): 3148, 3006, 2936, 1689, 1578, 1513, 1492, 1462, 1259, 1035, 972, 829, 794 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.56 (s, 1H); 7.63 (d, J = 8.8, 2H); 7.46-7.49 (m, 2H), 7.12 (dd, J = 2.4, 8.4, 1H); 6.97 (d, J = 7.2, 2H); 3.75 (s, 3H). ^{13}C-NMR (400 MHz, DMSO-d_6): 159.5 (s); 154.9 (s); 145.9 (s); 144.2 (s), 131.4 (s); 128.0 (s); 120.9 (d); 119.5 (2×CH); 116.0 (d); 114.2 (2×CH); 109.8 (d); 55.2 (q). ESI-MS: 273 $(M-H)^-$; 275 $(M+2-H)^-$.

***N*-Phenylbenzo[*d*]thiazol-2-amine (3k; *Table 3*).**

White solid. Mp 160.4–161.5 °C. Lit.,[15] mp 160–162 °C. IR (KBr): 3422, 3189, 3129, 3053, 2936, 1626, 1573, 1467, 1447, 1249, 922, 745, 721 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.48 (s, 1H); 7.79-7.82 (m, 3H); 7.61 (d, J = 8.4, 1H); 7.31-7.39 (m, 3H); 7.16 (t, J = 7.2, 1H), 7.03 (t, J = 7.2, 1H). ^{13}C-NMR (400 MHz, DMSO-d_6): 161.6 (s); 152.1 (s); 140.6 (s); 130.0 (s); 129.0 (2×CH), 125.9 (d); 122.3 (d); 122.0 (d); 121.1 (d); 119.2 (d); 117.7 (2×CH). ESI-MS: 227 $(M+H)^+$.

***N*-(3-Methylphenyl)benzo[*d*]thiazol-2-amine (3l; *Table 3*).**

White solid. Mp 120.3–121.1 °C. Lit.,[16] mp 124 °C. IR (KBr): 3447, 2922, 1626, 1575, 1448, 1276, 1250, 746, 721 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.40 (s, 1H); 7.80 (d, J = 8.0, 1H); 7.56-7.65 (m, 3H); 7.33 (t, J = 7.2, 1H); 7.25 (t, J = 7.6, 1H); 7.16 (t, J = 8.0, 1H); 6.85 (d, J = 7.6, 1H); 2.33 (s, 3H). ^{13}C-NMR (400 MHz, DMSO-d_6): 161.6 (s); 152.1 (s); 140.6 (s); 138.2 (d); 130.0 (s); 128.9 (d); 125.9 (d); 122.9 (d); 122.2 (d); 121.0 (d); 119.2 (s); 118.3 (d); 115.1 (d); 21.3 (q). ESI-MS: 241 $(M+H)^+$.

***N*-(2-Ethylphenyl)benzo[*d*]thiazol-2-amine (3m; *Table 3*).**

White solid. Mp 152.5–153.9 °C. IR (KBr): 3446, 3176, 2964, 2868, 1612, 1595, 1562, 1446, 1265, 1018, 752, 725 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 9.69 (s, 1H); 7.72-7.76 (m, 2H); 7.46 (d, J = 7.6, 1H); 7.24-7.30 (m, 3H); 7.15-7.19 (m, 1H); 7.07-7.11 (m, 1 H); 2.69 (q, J = 7.6, 2H); 1.14 (t, J = 7.6, 3H). ^{13}C-NMR (400 MHz, DMSO-d_6): 164.9 (s); 152.0 (s); 138.1 (s); 137.2 (d); 130.2 (s); 129.0 (d); 126.6 (d); 125.7 (d); 125.4 (d); 124.5 (d); 121.6 (d); 121.0 (d); 118.5 (s); 23.9 (t); 14.4 (q). ESI-MS: 255 $(M+H)^+$.

***N*-(4-Methoxyphenyl)benzo[*d*]thiazol-2-amine (3n; *Table 3*).**

White solid. Mp 161.4–162.5 °C. Lit.,[17] mp 158–160 °C. IR (KBr): 3445, 2836, 1620, 1572, 1511, 1453, 1232, 1037, 826, 745 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.29 (s, 1H); 7.77 (d, J = 7.6, 1H); 7.69 (d, J = 8.8, 2H); 7.55 (d, J = 7.6, 1H); 7.31(t, J = 7.6, 1H); 7.12 (t, J = 7.6, 1H), 6.96 (d, J = 8.8, 2H); 3.75 (s, 3H). ^{13}C-NMR (400 MHz, DMSO-d_6): 162.0 (s); 154.6 (s); 152.3 (s); 134.0 (s); 129.9 (s); 125.8 (d); 121.9 (d); 121.0 (d); 119.6 (2×CH); 118.9 (d); 114.2 (2×CH); 55.2 (q). ESI-MS: 257 $(M+H)^+$.

***N*-(4-Chlorophenyl)benzo[*d*]thiazol-2-amine (3o; *Table 3*).**

White solid. Mp 194.5–195.2 °C. Lit.,[18] mp 195–196 °C. IR (KBr): 3445, 3170, 3065, 2845, 1609, 1561, 1448, 1269, 1216, 1056, 918, 841, 751 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 10.08 (s, 1H); 8.33 (d, J = 8.0, 1H); 7.82 (d, J = 7.6, 1H); 7.58 (d, J = 8.4, 1H); 7.53 (dd, J= 1.2, 8.0, 1H); 7.41 (td, J= 1.2, 8.0, 1H); 7.33 (td, J= 1.2, 8.0, 1H); 7.13-7.19 (m, 2H). ^{13}C-NMR (400 MHz, DMSO-d_6): 162.8 (s); 151.1 (s); 137.4 (s); 129.7 (s); 127.8 (2×CH); 125.8 (d); 124.8 (d); 124.3 (s); 123.4 (2×CH); 122.3 (d); 121.1 (d). ESI-MS: 259 $(M-H)^-$; 261 $(M+2-H)^-$.

***N*-Cyclohexylbenzo[*d*]thiazol-2-amine (3p; *Table 3*).**

White solid. Mp 103.1 - 104.5 °C. Lit.,[19] mp 103–104 °C. IR (KBr): 3456, 2929, 2852, 1608, 1567, 1445, 1365, 1275, 885, 752 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 7.94 (d, J = 7.6, 1H); 7.63 (d, J = 8.0, 1H); 7.37 (d, J = 8.0, 1H); 7.19 (t, J = 7.6, 1H); 6.99 (t, J = 7.6, 1H); 3.68 v 3.72 (m, 1H), 1.97–2.00 (m, 2H), 1.70-1.75 (m, 2H); 1.56-1.60 (m, 1H); 1.17-1.38 (m, 5H). ^{13}C-NMR (400 MHz, DMSO-d_6): 165.1 (s); 152.8 (s); 130.1 (s); 125.4 (d); 120.7 (d); 120.6 (d); 117.8 (d); 52.7 (d); 32.3 (2×CH_2); 25.3 (t); 24.4

(2×CH_2). ESI-MS: 233 $(M+H)^+$.

1-(2-hydroxyphenyl)-3-phenylselenourea (5a).

Pink solid. Mp 153–155 °C. IR (KBr): 3302, 3186, 3114, 2932, 1600, 1546, 1492 cm^{-1}. ^{1}H-NMR (400 MHz, DMSO-d_6): 9.99 (s, 1H); 9.77 (s, 1H); 9.42 (s, 1H); 7.59 (d, J = 7.6 Hz, 1H); 7.43 (d, J = 7.6 Hz, 2H); 7.32 (t, J = 7.6 Hz, 2H); 7.16 (t, J = 7.6 Hz, 1H); 7.03 (t, J = 8.0 Hz, 1H); 6.86 (d, J = 8.0 Hz, 1H); 6.76 (t, J = 7.6 Hz, 1H). ^{13}C-NMR (400 MHz, DMSO-d_6): 177.7 (s); 150.7 (s); 139.4 (s); 128.4 (2×CH); 126.9 (d); 126.7 (d); 126.5 (s); 125.2 (d); 124.8 (2×CH); 118.5 (d); 115.8 (d). ESI-MS: 291 $(M-H)^-$. HRMS: calcd for $C_{13}H_{11}N_2OSe$: 291.0037; found: .291.0041

ACKNOWLEDGEMENTS

We are grateful to the National Natural Science Foundation of China (No 20906083 and No 20806073) and Natural Science Foundation of Zhejiang Province (No Y40900488) for financial support.

REFERENCES

1. (a) C. Paulmier, *Selenium Reagents and Intermediates in Organic Synthesis* Pergamon Press, Oxford, 1986; (b) M. Renson, In *The Chemistry of Organic Selenium and Tellurium Compounds*, ed. by S. Patai and Z. Rappoport, John Wiley & Sons, New York, 1986, p. 1; (c) A. Krief and L. Hevesi, 'Organoselenium Chemistry I,' Springer Verlag, Berlin, Heidelberg, 1988; (d) V. P. Litvinov and V. D. Dyachenko, *Russ. Chem. Rev.*, 1997, **66**, 923; (e) T. Wirth, *Tetrahedron*, 1999, **55**, 1; (f) 'Topics in Current Chemistry: Organoselenium Chemistry, ed. by T. Wirth, Modern Development in Organic Synthesis,' Springer Verlag, Berlin, 2000, p. 208; (g) 'Organoselenium Chemistry A Practical Approach,' ed. by. T. G. Back Oxford University Press, Oxford, 1999.
2. (a) H. Heimgartner, Y. Zhou, P. K. Atanassov, and G. L. Sommen, *Phosphorus, Sulfur, and Silicon*, 2008, **183**, 840. (b) H. Maeda, N. Kambe, N. Sonoda, S.-I. Fujiwara, and T. Shin-ike, *Tetrahedron*, 1997, **53**, 13667; (c) M. L. Petrov and N. I. Zmitrovich. *Russ. J. Gen.Chem.*, 1999, **69**, 245; (d) D. R. Garud, M. Koketsu, and H. Ishihara, Isoselenocyanates: *Molecules*, 2007, **17**, 504.
3. J. G. Fernández-Bolaños, Ó. López, V. Ulgar, I. Maya, and J. Fuentes, *Tetrahedron Lett.*, 2004, **45**, 4081.
4. Y.Y. Xie, F. Zhang, J. L. Li, and X. J. Shi, *Synlett*, 2010, 901.
5. (a) C. J. Paget, K. Kisner, R. L. Stone, and D. C. DeLong, *J. Med. Chem.*, 1969, **12**, 1016; (b) M. Yoshida, I. Hayakawa, N. Hayashi, T. Agatsuma, Y. Oda, F. Tanzawa, S. Iwasaki, K. Koyama, H. Furukawa, S. Kurakatad, and Y. Suganob, *Bioorg. Med. Chem. Lett.*, 2005, **15**, 3328.
6. (a) G. Fenton and N. V. Harris, WO 2002098426, 2002; (b) D. L. N. G. Surleraux, S. M. H.

Vendeville, W. G. Verschueren, M.-P. T. M. M. G. De Bethune, H. A. De Kock, and A. Tahre, WO 2002092595, 2002; (c) G. Fenton, C. McCarthy, R. E. Mackenzie, and A. D. Morley, WO 2001064659, 2001; (d) D. R. Brittain, C. Johnstone, G. M. Davies, and M. S. Large, WO 200005223, 2000.

7. (a) H. Ogura, S. Mineo, and K. Nakagawa, *Chem. Pharm. Bull.*, 1981, **29**, 1518; (b) F. E. Janssens, T. T. van Offenwert, R. A. Stokbroekx, and B. R. Boar, EP 199400, 1986; (c) R. A. Stokbroekx, M. G. M. Luyckx, and F. E. Janssens, EP 184257, 1986; (d) X. H. Qian, G.-H. Song, and Z.-B. Li, *Gangkai Shuomingshu*, 1294126, 2001; (e) X. Qian, Z. Li, G. Song, and Z. Li, *J. Chem. Res.* 2001, 138; (f) D. Simov and K. Davidkov, *Chem. Heterocycl. Compd.*, 1976, **12**, 151; (g) D. Simov and K. Davidkov, *Chem. Heterocycl. Compd.*, 1981, **17**, 437; (h) H. S. Chang, G. H. Yon, and Y. H. Kim, *Chem. Lett.*, 1986, 1291; (i) D. P. Mellor, *Chem. Ind. (London)*, 1965, 723; (j) N. Wishart, A. Rudolph, and K. Ritter, US 20030109714, 2003; (k) S. W. You and K. J. Lee, *Bull. Korean Chem. Soc.*, 2001, **22**, 1270; (l) X. Qian, X. Xu, Z. Li, Z. Li, and G. Song, *J. Fluorine.Chem.*, 2004, **125**, 1609; (m) F. Muro, S. Limura, Y. Yoneda, J. Chiba, T. Watanabe, M. Setoguchi, G. Takayama, M. Yokoyama, T. Takashi, A. Nakayama, and N. Machinaga, *Bioorg. Med. Chem.*, 2009, **17**, 1232; (n) F. Muro, S. Iimura, Y. Sugimoto, Y. Yoneda, J. Chiba, T. Watanabe, M. Setoguchi, Y. Iigou, K. Matsumoto, A. Satoh, G. Yakayama, T. Taira, M. Yokoyama, T. Takashi, A. Nakayama, and N. Machinaga, *J. Med. Chem.*, 2009, **52**, 7974.
8. D. Fajkusova and P. Pazdera, *Synthesis*, 2008, **8**, 1297.
9. Q. Ding, X. He, and J. Wu, *J. Comb. Chem.*, 2009, **11**, 587.
10. H. F. Moliwala, R. Kumar, and A. K. Chakraborti, *Aust. J. Chem.*, 2007, **60**, 369.
11. Ó. López, S. Maza, V. Ulgar, I. Maya, and J. G. Fernández-Bolaños, *Tetrahedron*, 2009, **65**, 2556.
12. H. Ghosh, R. Yella, J. Nath, and B. K. Patel, *Eur. J. Org. Chem.*, 2008, 6189.
13. D. Simov and K. Davidkov, *Khim. Geterotsikl. Soedin.*, 1981, 604.
14. M. Yamato, Y. Takeuchi, K. Hattori, and K. Hashigaki, *Chem. Pharm. Bull.*, 1984, **32**, 3053.
15. J. D. Spivack and M. Dexter, US 3228888, 1966.
16. A. Cerniani and R. Passerini, *J. Chem. Soc.* 1954, 2261.
17. G. D. Shen, X. Lv, and W. L. Bao, *Eur. J. Org. Chem.*, 2009, 5897.
18. H. F. Motiwala, R. Kumar, and A. K. Chakraborti, *Aust. J. Chem.*, 2007, **60**, 369.
19. R. F. Hunter, E. R. Parken, and E. M. Short, *J. Chem. Soc.*, 1958, 1561.