HETEROCYCLES, Vol. 60, No. 8, 2003, pp. 1855 - 1864
Received, 15th May, 2003, Accepted, 8th July, 2003, Published online, 15th July, 2003

SYNTHESIS OF 1,2-BENZISOTHIAZOLIN-3-ONE BY TRANSAMINATION OF SULFENAMIDES

Masao Shimizu,*[a] Ayanobu Takeda,[a] Hidenori Fukazawa,[b] Yoshimoto Abe,[b] and Isao Shibuya[a]

[a]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba Central 5, 1-1-1 Higashi, Tsukuba, Ibaraki 305-8565, Japan and [b]Department of Industrial Chemistry, Faculty of Science and Technology, Tokyo University of Science, Yamazaki, Noda, Chiba 278-8510, Japan

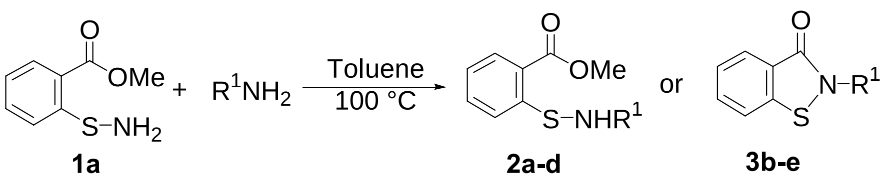
Abstract – *N*-Substituted sulfenamoylbenzoates were synthesized by transamination of *N*-unsubstituted sulfenamoylbenzoates with amines. The reaction did not always proceed by simple amine exchange between the amines and ammonia on the sulfur atom of the sulfenamides. In reactions with aliphatic amines, the sulfenamides cyclized to form *N*-substituted 1,2-benzisothiazolin-3-ones. The synthesis of 1,2-benzisothiazolin-3-ones by intramolecular transamination was also investigated by *S*-amination of 2-mercaptobenzamides.

The synthesis of 1,2-benzisothiazolin-3-ones and their derivatives is of widespread interest owing to their high antibacterial and antifungal activity.[1,2] Typically, in the synthesis of these compounds, thiosalicylic acid derivatives are converted to sulfenyl halides with chlorine or bromine, and subsequent treatment of the products with amines forms the N–S bonds.[1,3,4] However, chlorine gas is toxic and corrosive, and therefore a chlorine-free synthetic method is desirable. Several chlorine-free syntheses of 1,2-benzisothiazolin-3-ones have been reported over the past decade: reaction of ammonia with 3*H*-1,2-benzodithiol-3-one or 3*H*-1,2-benzodithiol-3-one 1-oxide,[5] reaction of thiosalicylic acid with azide compounds,[6] and cyclization of a thiosalicylhydroxamic acid.[7] We developed a convenient method for the synthesis of 1,2-benzisothiazolin-3-ones from 2-sulfenamoylbenzoates prepared by the reaction of thiosalicylates with hydroxylamine-*O*-sulfonic acid (HOSA).[8] In the course of that study, we found that transamination of 2-sulfenamoylbenzoates with 1,2-benzisothiazolin-3-one occurred at the sulfur atom of the sulfenamide in the 2-sulfenamoylbenzoate.[9] Transamination of bivalent sulfur compounds has been reported in a few cases.[10] Although the reactions of 2-sulfenamoylbenzothiazole with amines were intensively investigated to develop vulcanizing agents,[11] reactions of other sulfenamides have scarcely been reported.[10,12] Here we investigate reactions of *N*-unsubstituted 2-sulfenamoylbenzoates with various amines in an effort to develop a chlorine gas–free synthetic method for preparing *N*-substituted 2-sulfenamoylbenzoates, which can be cyclized to 1,2-benzisothiazolin-3-ones.[4,13]

RESULTS AND DISCUSSION

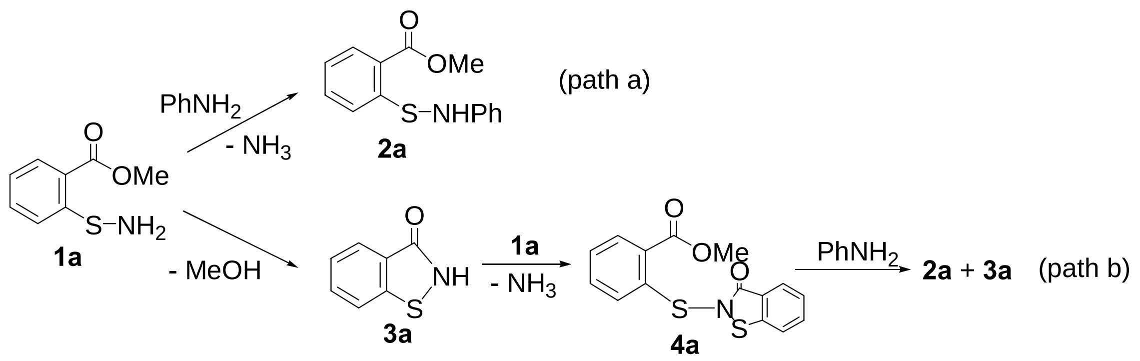
The transamination of sulfenamides sometimes requires heating to high temperature without solvent.[12] In a previous paper, we reported that transamination of 2-sulfenamoylbenzoates (**1**) with 1,2-benzisothiazolin-3-one (**3a**) proceeded in toluene at 100 °C to afford 2-(2-alkoxycarbonylphenylsulfenyl)-1,2-benzisothiazolin-3-ones (**4**).[9] Using these reaction conditions, we carried out the reactions of methyl 2-sulfenamoylbenzoate (**1a**) with various amines (Table 1). When **1a** was treated with aniline in toluene at 100 °C for 8 h, methyl *N*-phenyl-2-sulfenamoylbenzoate (**2a**) was obtained in 48% yield (Entry 1). It seemed that the amine exchange reaction occurred on the sulfur atom of **1a**. However, 1,2-benzisothiazolin-3-one (**3a**) was also a main product of the reaction

Table 1. Reaction of **1a** with amines



Entry	R^1	Product	Yield (%)
1	Ph	**2a**	48
2	*p*-MeC_6H_4	**2b**	51
3	*p*-$MeOC_6H_4$	**2c**	54
4	$PhCH_2$	**3b**	62
5	*p*-$MeOC_6H_4CH_2$	**3c**	61
6	*p*-$ClC_6H_4CH_2$	**3d**	68
7	$HO(CH_2)_3$	**3e**	57
8[a]	*t*-Bu	**2d**	31

[a] In a sealed tube.



Scheme 1.

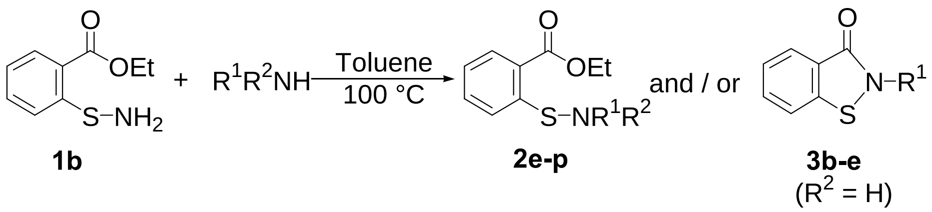
(49% yield). Because **3a** was formed by heating **1a** under these reaction conditions,[8] transamination also occurred on **1a** with **3a**, and 2-(2-methoxycarbonylphenylsulfenyl)-1,2-benzisothiazolin-3-one (**4a**) was formed. The reactivity of **4a** was high toward amines, and **4a** reacted with aniline to afford **2a** and **3a**[13] (Scheme 1). Since almost equivalent amounts of **2a** and **3a** were isolated, it is plausible that **2a** was formed via path b. Once **3a** was formed, the nucleophilicity of aniline decreased because **2a** is an acidic compound. For more basic anilines with higher nucleophilicities, direct transamination (path a) could occur, and the yield of *N*-substituted sulfenamides improved (Entries 2 and 3). In reactions with aliphatic amines, *N*-substituted sulfenamides (**2**) were not isolated, and cyclized *N*-substituted 1,2-benzisothiazolin-3-ones (**3**) were obtained (Entries 4–7). However, *tert*-butylamine provided only *N*-substituted sulfenamide (**2d**) because cyclization was difficult owing to steric hindrance (Entry 8).

To prevent formation of 1,2-benzisothiazolin-3-one (**3a**), ethyl 2-sulfenamoylbenzoate (**1b**) was used as a starting material (Table 2). Benzoate (**1b**) did not give 1,2-benzisothiazolin-3-one (**3a**) on heating at 100 °C in toluene.[9] Thus, *N*-substituted sulfenamides were obtained in better yields with **1b** than with methyl ester (**1a**) (Entries 1–3). However, in reactions with benzylamines, cyclization to *N*-substituted 1,2-benzisothiazolin-3-ones was prohibited, and the products were a mixture of *N*-substituted sulfenamides and 1,2-benzisothiazolin-3-ones (Entries 5–7). Although the *N*-substituted sulfenamides obtained by transamination with aromatic amines such as **2a**, **2b**, **2c**, **2e**, **2f**, and **2g** could be easily converted to *N*-substituted 1,2-benzisothiazolin-3-ones (**3**) in the presence of strong base,[4,13] 2-sulfenamoylbenzoates with bulky substituents on the nitrogen atom such as *tert*-butyl (**2l**) and 2-phenyl-2-propyl (**2m**) did not cyclize to 1,2-benzisothiazolin-3-ones under the same reaction conditions. *N*,*N*-Disubstituted 2-sulfenamoylbenzoates (**2n–p**) were synthesized when secondary amines were used (Entries 11–13).

Next, we investigated intramolecular transamination of 2-sulfenamoylbenzamide derivatives. Because cyclization of 2-carbamoylbenzenesulfenyl halides has been reported,[14] we expected that 2-sulfenamoylbenzamide derivatives would undergo intramolecular transamination. When we treated

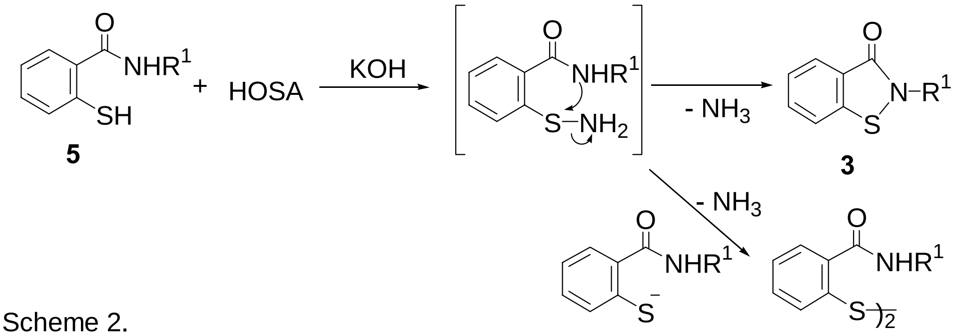
N-(*p*-methylphenyl)thiosalicylamide with HOSA to synthesize sulfenamide, 2-(*p*-methylphenyl)-1,2-benzisothiazolin-3-one (**3g**) was isolated as the main product. This result means that once the sulfur atom was aminated, intramolecular transamination proceeded to form 1,2-benzisothiazolin-3-ones (**3**). Simultaneously, 2,2'-bis[*N*-(*p*-methylphenyl)carbamoylphenyl] disulfide, formed by attack of the sulfur atom of the sulfenamide intermediate by the thiolate anion (Scheme 2), was isolated as a by-product. The same aminations were carried out for various thiosalicylamides (**5**) (Table 3). 1,2-Benzisothiazolin-3-ones (**3**) were obtained and the corresponding sulfenamides were not detected during the reactions. *N*-*tert*-Butyl- (**3j**) and *N*-(2-phenyl-2-propyl)-1,2-benzisothiazolin-3-ones (**3k**), which could not be synthesized by cyclization of the corresponding sulfenamoylbenzoates (**1**), were obtained in these aminations. When the thiosalicylamide (**5**) did not readily dissolve in alkaline solution, a mixture of methanol and water was used as a solvent. *N*-Chloro-4-methylbenzenesulfonamide sodium salt (Chloramine-T) was also used as

Table 2. Reaction of **1b** with amines



Entry	R^1	R^2	Time (h)	Products (% yield)
1	Ph	H	8	**2e** (71)
2	*p*-MeC_6H_4	H	4	**2f** (71)
3	*p*-$MeOC_6H_4$	H	8	**2g** (61)
4	2-Pyridyl	H	8	**2h** (36)
5	$PhCH_2$	H	4	**2i** (33), **3b** (43)
6	*p*-$MeOC_6H_4CH_2$	H	6	**2j** (21), **3c** (53)
7	*p*-$ClC_6H_4CH_2$	H	6	**2k** (45), **3d** (39)
8	$HO(CH_2)_3$	H	4	**3e** (71)
9[a]	*t*-Bu	H	4	**2l** (55)
10	$PhMe_2C$	H	6	**2m** (67)
11[a]	Et	Et	4	**2n** (41)
12[a]	$–(CH_2)_4–$		4	**2o** (51)
13	$–(CH_2)_2–O–(CH_2)_2–$		4	**2p** (76)

[a] In a sealed tube.

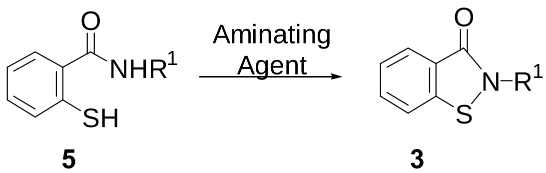


Scheme 2.

an aminating agent, and 1,2-benzisothiazolin-3-ones were prepared (Entries 10–12).

In summary, the amino groups on the sulfenamides were easily displaced with amines by heating in toluene to afford *N*-substituted 2-sulfenamoylbenzoates, *N*-substituted 1,2-benzisothiazolin-3-ones, or both. Intramolecular transamination proceeded smoothly for 2-sulfenamoylbenzamide derivatives. *N*-Unsubstituted sulfenamides behaved like sulfenyl halides, and new nitrogen–sulfur bonds were formed in good yields.

Table 3. Cyclization of thiosalicylamides (**5**)[a]



Entry	R^1	Aminating Agent	H_2O (mL)	MeOH (mL)	Time (h)	Temp (°C)	Product	Yield (%)
1	Ph	HOSA	10	10	3	0	**3f**	41
2	*p*-MeC_6H_4	HOSA	10	–	0.5	0	**3g**	60
3	$PhCH_2$	HOSA	10	10	1	0	**3b**	44
4	$PhCH_2CH_2$	HOSA	10	10	3	0	**3h**	40
5	$HO(CH_2)_3$	HOSA	10	–	0.5	0	**3e**	79
6	Cyclopropyl	HOSA	10	10	3	0	**3i**	52
7	*t*-Bu	HOSA	10	10	3	0	**3j**	67
8	$PhMe_2C$	HOSA	10	10	3	0	**3k**	88
9	H	HOSA	10	10	3	0	**3a**	52
10	*p*-MeC_6H_4	Chloramine-T	10	10	4	rt	**3g**	87
11	*t*-Bu	Chloramine-T	10	10	5	rt	**3j**	35
12	$PhMe_2C$	Chloramine-T	10	10	4	rt	**3k**	74

[a]1 mmol of thiosalicylamide (**5**) was used.

EXPERIMENTAL

Melting points were determined on a Mettler FP90 microscope plate and are uncorrected. ^{1}H NMR spectra were obtained with a JEOL LA-500 spectrometer (500 MHz), and chemical shifts are reported in ppm relative to internal tetramethylsilane. IR spectra were recorded on a JASCO FTIR-5300 spectrophotometer. Sulfenamides (**1**) were prepared by the method described in a previous paper.[8]

General procedure for the reaction of sulfenamide (1) with amines

A mixture of 2-sulfenamoylbenzoate (**1**, 1 mmol) and amine (1.2 mmol) was dissolved in toluene (10 mL), and the solution was heated at 100 °C. After evaporation of toluene, the residual crude product was chromatographed on silica gel. The structures of the products (**2a**–**d**, **2f**, and **3b**–**e**) were identified with the data of our previous paper.[13]

Ethyl *N*-phenyl-2-sulfenamoylbenzoate (**2e**). Chromatographed with dichloromethane as an eluent; mp 116-117 °C (ethanol); ^{1}H NMR ($CDCl_3$) δ 1.43 (3H, t, *J* = 7.1 Hz), 4.43 (2H, q, *J* = 7.1 Hz), 5.07 (1H, br s), 6.87 (1H, ddd, *J* = 8.1, 7.1, 1.1 Hz), 6.97-7.01 (2H, m), 7.14-7.24 (3H, m), 7.40 (1H, ddd, *J* = 8.0, 7.1, 1.2 Hz), 7.50 (1H, dd, *J* = 8.0, 1.1 Hz), 8.06 (1H, dd, *J* = 8.1, 1.2 Hz); IR (KBr) ν_{max} 3358, 1688, 1599, 1271, 1142, 748, 693 cm^{-1}. Anal. Calcd for $C_{15}H_{15}NO_2S$: C, 65.91; H, 5.53; N, 5.12. Found: C, 65.89; H, 5.48; N, 5.03.

Ethyl *N*-(*p*-methoxyphenyl)-2-sulfenamoylbenzoate (**2g**). Chromatographed with dichloromethane as an eluent; mp 98-99.5 °C (dichloromethane-hexane); ^{1}H NMR ($CDCl_3$) δ 1.42 (3H, t, *J* = 7.1 Hz), 3.74 (3H, s), 4.42 (2H, q, *J* = 7.1 Hz), 4.92 (1H, br s), 6.78 (2H, d, *J* = 9.0 Hz), 6.91 (2H, d, *J* = 9.0 Hz), 7.16 (1H, ddd, *J* = 8.2, 7.7, 1.1 Hz), 7.40 (1H, td, *J* = 7.7, 1.4 Hz), 7.51 (1H, dd, *J* = 8.2, 1.1 Hz), 8.05 (1H, dd, *J* = 7.7, 1.4 Hz); IR (KBr) ν_{max} 3360, 1688, 1510, 1271, 1240, 825, 748 cm^{-1}. Anal. Calcd for $C_{16}H_{17}NO_3S$: C, 63.34; H, 5.65; N, 4.62. Found: C, 63.15; H, 5.63; N, 4.53.

Ethyl *N*-(2-pyridyl)-2-sulfenamoylbenzoate (**2h**). Chromatographed with dichloromethane-acetone-methanol (100 : 5 : 1) mixture as an eluent; mp 121.5-122.5 °C (dichloromethane-hexane); ^{1}H NMR ($CDCl_3$) δ 1.43 (3H, t, *J* = 7.1 Hz), 4.44 (2H, q, *J* = 7.1 Hz), 6.77 (1H, ddd, *J* = 7.1, 5.1, 0.8 Hz), 7.01 (1H, dt, *J* = 8.4, 0.8 Hz), 7.18 (1H, ddd, *J* = 8.5, 7.5, 1.4 Hz), 7.39-7.52 (3H, m), 8.07 (1H, dd, *J* = 7.8, 1.4 Hz), 8.17 (1H, ddd, *J* = 5.0, 1.7, 0.8 Hz); IR (KBr) ν_{max} 3133, 2976, 2890, 1699, 1601, 1439, 1271, 1144, 920, 748 cm^{-1}. Anal. Calcd for $C_{14}H_{14}N_2O_2S$: C, 61.29; H, 5.14; N, 10.21. Found: C, 61.41; H, 5.07; N, 10.11.

Ethyl *N*-benzyl-2-sulfenamoylbenzoate (**2i**). Chromatographed with dichloromethane as an eluent; Oil; ^{1}H NMR ($CDCl_3$). δ 1.39 (3H, t, J = 7.1 Hz), 2.87 (1H, br t, *J* = 5.8 Hz), 4.12 (2H, d, *J* = 5.8 Hz), 4.37 (2H, q, *J* = 7.1 Hz), 7.16 (1H, ddd, *J* = 8.2, 7.2, 1.1 Hz), 7.29-7.42 (5H, m), 7.54 (1H, ddd, *J* = 8.2, 7.2, 1.5 Hz), 7.89 (1H, dd, *J* = 8.2, 1.1 Hz), 8.03 (1H, dd, *J* = 7.8, 1.5 Hz); IR (KBr) ν_{max} 3339, 1701, 1456, 1271, 1269, 1101, 1055, 745 cm^{-1}; HRMS Calcd for $C_{16}H_{17}NO_2S$: 287.0980. Found: 287.0994.

Ethyl *N*-(4-methoxybenzyl)-2-sulfenamoylbenzoate (**2j**). Chromatographed with dichloromethane as an eluent; mp 91.5-93.5 °C (ethanol-hexane); ^{1}H NMR ($CDCl_3$) δ 1.39 (3H, t, *J* = 7.1 Hz), 2.80 (1H, br t, *J* = 5.8 Hz), 3.81 (3H, s), 4.05 (2H, d, *J* = 5.8 Hz), 4.38 (2H, q, *J* = 7.1 Hz), 6.89 (2H, dt, *J* = 8.8, 2.2 Hz), 7.16 (1H, ddd, *J* = 7.8, 7.6, 1.1 Hz), 7.32 (2H, dt, *J* = 8.8, 2.2 Hz), 7.54 (1H, ddd, *J* = 8.0, 7.4, 1.6 Hz), 7.88 (1H, dd, *J* = 8.2, 1.1 Hz), 8.04 (1H, dd, *J* = 7.8, 1.6 Hz); IR (KBr) ν_{max} 3308, 1686, 1510, 1269, 1248, 1030, 747 cm^{-1}. Anal. Calcd for $C_{17}H_{19}NO_3S$: C, 64.33; H, 6.03; N, 4.41. Found: C, 64.30; H, 5.98; N, 4.20.

Ethyl *N*-(4-chlorobenzyl)-2-sulfenamoylbenzoate (**2k**). Chromatographed with dichloromethane as an eluent; mp 59.0-61.5 °C (EtOH); ^{1}H NMR ($CDCl_3$) δ 1.39 (3H, t, *J* = 7.1 Hz), 2.91 (1H, br t, *J* = 5.8 Hz), 4.10 (2H, d, *J* = 5.8 Hz), 4.38 (2H, q, *J* = 7.1 Hz), 7.17 (1H, ddd, *J* = 7.8, 6.9, 1.0 Hz), 7.32 (4H, s), 7.54 (1H, ddd, *J* = 8.2, 6.9, 1.4 Hz), 7.84 (1H, dd, *J* = 8.2, 1.0 Hz), 8.04 (1H, dd, *J* = 7.8, 1.4 Hz); IR (KBr) ν_{max} 3326, 1701, 1271, 1254, 1101, 1059, 745 cm^{-1}. Anal. Calcd for $C_{16}H_{16}NO_2S$: C, 59.71; H, 5.01; N, 4.35. Found: C, 59.72; H, 4.96; N, 4.21.

Ethyl *N*-(*t*-butyl)-2-sulfenamoylbenzoate (**2l**). Chromatographed with dichloromethane-hexane (2 : 1) mixture as an eluent; mp 71.5-72.5 °C (dichloromethane-hexane); ^{1}H NMR ($CDCl_3$) δ 1.22 (9H, s), 1.40 (3H, t, *J* = 7.1 Hz), 2.54 (1H, br s), 4.38 (2H, q, *J* = 7.1 Hz), 7.10 (1H, ddd, *J* = 7.8, 7.2, 1.2 Hz), 7.49 (1H, ddd, *J* = 8.4, 7.7, 1.5 Hz), 7.99 (1H, dd, *J* = 7.8, 1.5 Hz), 8.16 (1H, dd, *J* = 8.4, 1.2 Hz); IR (KBr) ν_{max} 3297, 2961, 1694, 1456, 1308, 1265, 1148, 748 cm^{-1}. Anal. Calcd for $C_{13}H_{19}NO_2S$: C, 61.63; H, 7.56; N, 5.53. Found: C, 61.92; H, 7.59; N, 5.44.

Ethyl *N*-(2-phenyl-2-propyl)-2-sulfenamoylbenzoate (**2m**). Chromatographed with dichloromethane-hexane (2 : 1) mixture as an eluent; mp 87.5-88 °C (ethanol-hexane); ^{1}H NMR ($CDCl_3$) δ 1.37 (3H, t, *J* = 7.1 Hz), 1.57 (6H, s), 3.06 (1H, br s), 4.36 (2H, q, *J* = 7.1Hz), 7.17 (1H, ddd, *J* = 8.2, 7.7, 1.1 Hz), 7.23-7.39 (3H, m), 7.50-7.57 (3H, m), 7.99 (1H, dd, *J* = 8.0, 1.1 Hz), 8.26 (1H, dd, *J* = 8.2, 1.1 Hz); IR (KBr) ν_{max} 3299, 2976, 1686, 1456, 1267, 1100, 747 cm^{-1}. Anal. Calcd for $C_{18}H_{21}NO_2S$: C, 68.54; H, 6.71; N, 4.44. Found: C, 68.68; H, 6.71; N, 4.35.

Ethyl *N*,*N*-diethyl-2-sulfenamoylbenzoate (**2n**). Chromatographed with dichloromethane-hexane (1 : 1) mixture as an eluent; bp 163 °C (0.01 kPa); ^{1}H NMR ($CDCl_3$) δ 1.16 (6H, t, *J* = 7.1 Hz), 1.39 (3H, t, *J* = 7.1 Hz), 3.07 (4H, q, *J* = 7.1 Hz), 4.38 (2H, q, *J* = 7.1 Hz), 7.11 (1H, ddd, *J* = 8.0, 7.1, 1.1 Hz), 7.48 (1H, ddd, *J* = 8.2, 7.1 1.4 Hz), 7.93 (1H, dd, *J* = 8.2, 1.1 Hz), 8.01 (1H, dd, *J* = 8.0, 1.4 Hz); IR (KBr) ν_{max} 1705, 1456, 1267, 1100, 1053, 745 cm^{-1}. Anal. Calcd for $C_{13}H_{19}NO_2S$: C, 61.63; H, 7.56; N, 5.53. Found: C, 61.69; H, 7.77; N, 5.44.

Ethyl *S*-pyrrolidino-2-thiobenzoate (**2o**). Chromatographed with dichloromethane-hexane (2 : 1) mixture as an eluent; mp 57.5-59 °C (pentane); ^{1}H NMR ($CDCl_3$) δ 1.40 (3H, t, *J* = 7.0 Hz), 1.93-1.96 (4H, m), 3.20 (4H, br s), 4.37 (2H, q, *J* = 7.0 Hz), 7.12 (1H, td, *J* = 7.9, 0.9 Hz), 7.49 (1H, ddd, *J* = 8.2, 7.4, 1.2 Hz), 7.71 (1H, dd, *J* = 8.2, 0.9 Hz), 8.02 (1H, dd, *J* = 7.9, 1.2 Hz); IR (KBr) ν_{max} 1692, 1271, 1103, 1053, 748 cm^{-1}. Anal. Calcd for $C_{13}H_{17}NO_2S$: C, 62.12; H, 6.82; N, 5.57. Found: C, 62.42; H, 6.84; N, 5.50.

Ethyl *S*-morpholino-2-thiobenzoate (**2p**). Chromatographed with dichloromethane as an eluent; mp 105.5-107 °C (benzene-hexane); ^{1}H NMR ($CDCl_3$) δ 1.41 (3H, t, *J* = 7.0 Hz), 3.07 (4H, t, *J* = 4.8 Hz), 3.82 (4H, t, *J* = 4.8 Hz), 4.37 (2H, q, *J* = 7.0 Hz), 7.16 (1H, td, *J* = 7.3, 1.2 Hz), 7.54 (1H, ddd, *J* = 8.5, 7.3, 1.5 Hz), 8.02-8.05 (2H, m); IR (KBr) ν_{max} 1690, 1454, 1368, 1302, 1269, 1119, 922, 752 cm^{-1}. Anal. Calcd for $C_{13}H_{17}NO_3S$: C, 58.40; H, 6.41; N, 5.24. Found: C, 58.68; H, 6.43; N, 5.11.

General procedure for the reaction of thiosalicylamide (5) with hydroxylamine-*O*-sulfonic acid (HOSA)

The thiosalicylamide (**5**, 1 mmol) was dissolved in a solution of potassium hydroxide (67 mg, 1.2 mmol) in water (10 mL) or, when the thiosalicylamide did not readily dissolve in alkaline solution, in a methanol (10 mL)–water (10 mL) mixture. HOSA (170 mg, 1.5 mmol) in a solution of potassium hydroxide (112 mg, 2 mmol) in water (10 mL) was added dropwise to the thiosalicylamide solution at 0 °C (ice bath) under a nitrogen atmosphere. The product was extracted three times with dichloromethane (20 mL each time), and the organic layer was dried over magnesium sulfate. After the solvent was evaporated, the crude product was chromatographed on silica gel. The structures of the products (**3a**, **3b**, **3e**, **3f**, **3g**, and **3i**) were identified with the data of our previous papers.[8,13]

2-(2-Phenylethyl)-1,2-benzisothiazolin-3-one (**3h**). Chromatographed with ethyl acetate-hexane (1 : 1) mixture as an eluent; mp 92.5-93.5 °C (hexane) (lit.,[5] 95-96 °C); ^{1}H NMR ($CDCl_3$) δ 3.07 (2H, t, *J* = 7.5 Hz), 4.13 (2H, t, J = 7.5 Hz), 7.22-7.26 (3H, m), 7.29-7.32 (2H, m), 7.39 (1H, ddd, *J* = 7.9, 7.6, 0.9 Hz), 7.51 (1H, d, *J* = 8.2 Hz), 7.59 (1H, ddd, *J* = 8.2, 7.6, 1.2 Hz), 8.03 (1H, d, *J* = 7.9 Hz); IR (KBr) ν_{max} 1645, 1449, 1341, 1252, 1184, 735 cm^{-1}.

2-*t*-Butyl-1,2-benzisothiazolin-3-one (**3j**). Chromatographed with dichloromethane-acetone-methanol (100 : 5 : 1) mixture as an eluent; oil (lit.,[15] mp 57-58 °C); ^{1}H NMR ($CDCl_3$) δ 1.71 (9H, s), 7.37(1H, ddd, *J* = 8.0, 6.9, 1.1 Hz), 7.50 (1H, ddd, *J* = 8.0, 1.1, 0.8 Hz), 7.57 (1H, ddd, *J* = 8.0, 6.9, 1.3 Hz), 7.97 (1H, ddd, *J* = 8.0, 1.3, 0.8 Hz); IR (KBr) ν_{max} 1651, 1451, 1302, 1206, 741, 675 cm^{-1}.

2-(2-Phenyl-2-propyl)-1,2-benzisothiazolin-3-one (**3k**). Chromatographed with dichloromethane as an eluent; mp 131-132 °C (ethyl acetate-hexane); ^{1}H NMR ($CDCl_3$). δ 2.06 (6H, s), 7.29-7.43 (6H, m), 7.48

(1H, ddd, *J* = 8.0, 1.1, 0.8 Hz), 7.58 (1H, ddd, *J* = 8.0, 7.1, 1.1 Hz), 7.92 (1H, ddd, *J* = 8.0, 1.3, 0.8 Hz); IR (KBr) ν_{max} 1638, 1445, 1327, 1179, 745, 698 cm^{-1}. Anal. Calcd for $C_{16}H_{15}NOS$: C, 71.34; H, 5.61; N, 5.20. Found: C, 71.38; H, 5.59; N, 5.12.

General procedure for the reaction of thiosalicylamide (5) with *N*-chloro-4-methylbenzenesulfonamide sodium salt (Chloramine-T).

The thiosalicylamide (**5**, 1 mmol) was dissolved in a solution of potassium hydroxide (67 mg, 1.2 mmol) in a methanol (10 mL)–water (10 mL) mixture. Chloramine-T trihydrate (423 mg, 1.5 mmol) in water (10 mL) was added dropwise to the thiosalicylamide solution at rt under a nitrogen atmosphere. The product was extracted three times with dichloromethane (20 mL each time), and the organic layer was dried over magnesium sulfate. After the solvent was evaporated, the crude product was chromatographed on silica gel.

REFERENCES

1. M. Davis, *Adv. Heterocycl. Chem.,* 1972, **14**, 58.
2. D. L. Pain, B. J. Peart, and K. R. H. Wooldridge, In ‘Comprehensive Heterocyclic Chemistry,’ Vol. 6, ed. by K. T. Potts, Pergamon, Oxford, 1984, p. 175; R. F. Chapman and B. J. Peart, In ‘Comprehensive Heterocyclic Chemistry II,’ Vol. 3, ed. by I. Shinkai, Pergamon, Oxford, 1996, pp. 371–372.
3. R. Schubart, In ‘Methoden der Organischen Chemie (Houben-Weyl),’ Vol. 11E, 5th ed., ed. by C. Klamann, Thieme, Stuttgart, 1985, pp. 107–122; J. Drabowicz, P. Kielbasin’ski, and M. Mitolajczyk, In ‘The Chemistry of Sulphenic Acids and Their Derivatives,’ ed. by S. Patai, Wiley, Chichester, 1990, pp. 221–292.
4. J. C. Grivas, *J. Org. Chem*., 1975, **40**, 2029.
5. W. Kim, J. Dannaldson, and K. S. Gates, *Tetrahedron Lett*., 1996, **30**, 5337.
6. T. Chiyoda, K. Iida, K. Takatori, and M. Kajiwara, *Synlett*, 2000, 1427.
7. T. Etsuzan, S. Kitagawa, C. Kamioka, and S. Miki, *JP*, 2000-007667 (2000) (*Chem. Abstr*., 2000, **132**, 78550).
8. M. Shimizu, H. Kikumoto, T. Konakahara, Y. Gama, and I. Shibuya, *Heterocycles*, 1999, **51**, 3005.
9. M. Shimizu, T. Takagi, M. Shibakami, Y. Gama, and I. Shibuya, *Heterocycles*, 2000, **53**, 2803.
10. D. A. Armitage, M. J. Clark, and A. M. White, *J. Chem. Soc*., 1971, 3141.
11. L. H. Howland, *US Patent*, 2382793 (1945) (*Chem. Abstr*., 1948, **40**, 368); L. B. Tewksbury, *US Patent*, 2476688 (1949) (*Chem. Abstr*., 1949, **43**, 8195); Goodyear Tire & Rubber Co., *US Patent*, 2866777 (1955) (*Chem. Abstr*., 1959, **53**, 5728); M. J. Gattuso, *Ger. Offen*., 2161327 (1970) (*Chem. Abstr*., 1972, **77**, 114393); E. L. Carr, G. E. P. Smith, Jr., and G. Alliger, *J. Org. Chem*., 1949, **14**, 921;

V. A. Ignatov, R. A. Akchurina, P. A. Pirogov, and R. S. Bairakova, *Zh. Obshch. Khim.*, 1981, **51**, 609 (*J. Gen. Chem. USSR*, 1981, **51**, 483).

12. F. Kurzer, *J. Chem. Soc.*, 1953, 2230.
13. M. Shimizu, Y. Sugano, T. Konakahara, Y. Gama, and I. Shibuya, *Tetrahedron*, 2002, **58**, 3779.
14. R. Okachi, H. Niino, K. Kitaura, K. Mineura, Y. Makamizo, Y. Murayama, T. Ono, and A. Nakamizu, *J. Med. Chem.*, 1985, **28**, 1772.
15. Y. Uchida and S. Kozuka, *Bull. Chem. Soc. Jpn.*, 1982, **55**, 1183.