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An effective synthesis of *N*-substituted 2-sulfenamoylbenzoates and 1,2-benzisothiazolin-3-ones that uses 1,2-benzisothiazolin-3-one as a leaving group

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Abstract—*N*-Substituted 2-sulfenamoylbenzoates and 1,2-benzisothiazolin-3-ones were effectively synthesized by the substitution reaction between *S*-[2-(3-oxo-1,2-benzisothiazolinyl)]-2-mercaptobenzoates (**2**) and primary amines. The substitution reaction occurred on the sulfur atom of the 2-sulfenamoyl group of **2**, and 1,2-benzisothiazolin-3-one behaved as a leaving group. The eliminated 1,2-benzisothiazolin-3-one could be reused as a starting material for the synthesis of **2**. *N*,*N*-Disubstituted 2-sulfenamoylbenzoates were prepared by the reaction of **2** with secondary amines.

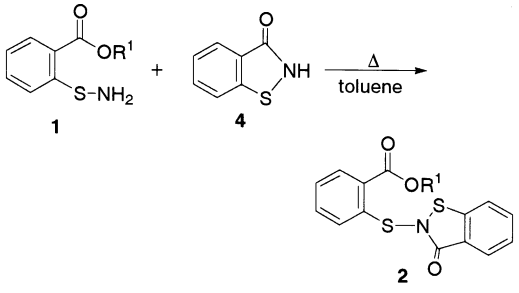
1. Introduction

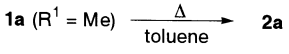
It has been reported that sulfenamide derivatives are important in the rubber industry, agriculture, and medicinal applications.[1] 1,2-Benzisothiazolin-3-ones, which can be regarded as cyclic sulfenamide compounds, have also shown various fungistatic, antimicrobial, and antipsychotic bioactivities.[2] The most common method employed for the formation of the N–S bonds in sulfenamides and 1,2-benzisothiazolin-3-ones is the reaction of amines with sulfenyl chlorides.[1,2a,3,4a] Although sulfenyl chlorides are usually prepared by chlorination of disulfides or thiols with chlorine,[4b] the use of chlorine in the laboratory is sometimes restricted because it is difficult to handle. *N*-Sulfenyl heterocycles could replace sulfenyl chloride as starting materials for the preparation of the sulfenamides because these heterocycles are good leaving groups;[5] however, *N*-sulfenyl heterocycles are also prepared from sulfenyl halides.

In a previous paper, we reported a convenient synthesis of 1,2-benzisothiazolin-3-ones by the cyclization of 2-sulfenamoylbenzoates.[6] During this investigation, we found that heating methyl 2-sulfenamoylbenzoate (**1a**) in toluene at 100°C gave methyl *S*-[2-(3-oxo-1,2-benzisothiazolinyl)]-2-mercaptobenzoate (**2a**) in a good yield. In a subsequent paper,[7] we showed that transamination occurred on the sulfur atom of **1** and that *S*-[2-(3-oxo-1,2-benzisothiazolinyl)]-2-mercaptobenzoates (**2**) could also be prepared by the reaction of 2-sulfenamoylbenzoates (**1**) with 1,2-benzisothiazolin-3-one (**4**) (Scheme 1). Because the reaction of **2a** with sodium methoxide afforded a methyl sulfenate derivative and 1,2-benzisothiazolin-3-one (**4**),[6] we expected that the substitution reaction on the sulfur atom of the 2-mercapto group of **2** would also occur with various other nucleophiles. Therefore, we herein investigated the reaction of **2** with amines for the synthesis of *N*-substituted 2-sulfenamoylbenzoates that could serve as starting materials for the preparation of *N*-substituted 1,2-benzisothiazolin-3-ones, and we report the results herein.

2. Results and discussion

First we examined the reaction of **2** with substituted anilines, and the results are shown in Table 1. When **2a** was treated with *p*-methylaniline in methanol for 7.5 h at





Scheme 1.

Keywords: amines; benzisothiazoles; substitution; sulfenic acids and derivatives.

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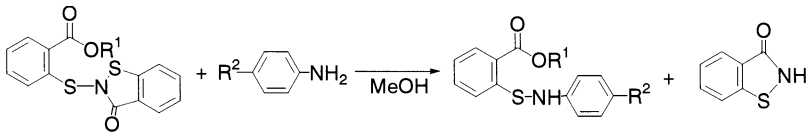
Table 1. Reactions of **2** with anilines



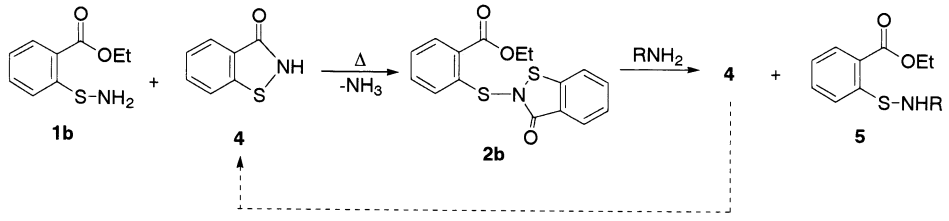
2a: R^1 = Me
2b: R^1 = Et

3: R^1 = Me
5: R^1 = Et

4

Entry	2	R^2	Temperature	Time (h)	Product	Yield[a] (%)	Yield[a] (%) of **4**
1	**2a**	MeO	Reflux	1.5	**3a**	97	71
2	**2a**	Me	rt	7.5	**3b**	83	66
3	**2a**	Me	Reflux	3	**3b**	90	47
4	**2a**	H	Reflux	3	**3c**	94	65
5	**2a**	Cl	Reflux	3	**3d**	31	44
6	**2a**	Cl	Reflux	10	**3d**	63	61
7	**2b**	Me	Reflux	3	**5**	99	60

2, 0.4 mmol; aniline, 0.5 mmol; MeOH, 10 mL.
[a] Isolated yield.

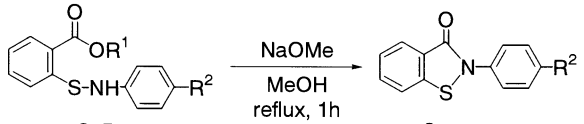


Scheme 2.

room temperature, methyl 2-[*N*-(*p*-methylphenyl)sulfenamoyl]benzoate (**3b**) and 1,2-benzisothiazolin-3-one (**4**) were obtained in good yields (entry 2). This result showed that transamination occurred between the aniline and **4** on the sulfur atom of the 2-mercapto group of **2**. When this reaction was carried out in refluxing methanol for 3 h, the yield of **3b** increased (entry 3). With various other anilines, substitution reactions gave *N*-substituted 2-sulfenamoylbenzoates (**3** and **5**) and the eliminated 1,2-benzisothiazolin-3-one (**4**). Because **2b** was prepared by means of the reaction of **1b** with **4**, the isolated **4** could be used as the starting material for **2b** (Scheme 2).

When **2a** was treated with *p*-chloroaniline, which have weak nucleophilicity, the yields of **3d** and **4** were low and the amount of unreacted starting material **2a** increased (entry 5). Therefore, long reaction time was required to synthesize **3d** in satisfactory yield (entry 6). In the case of *p*-cyanoaniline, the reaction had not proceeded at all after 3 h, and **2a** was recovered. In all cases, the products were *N*-substituted 2-sulfenamoylbenzoates (**3** and **5**), and *N*-substituted 1,2-benzisothiazolin-3-ones (**6**) were not formed even when the reaction time was increased. To obtain *N*-substituted 1,2-benzisothiazolin-3-ones (**6**), we had to treat the sulfenamides with base, as has been reported in the literature.[8] Treatment of **3** or **5** with sodium methoxide in methanol resulted in the cyclization of the *N*-substituted sulfenamides, and *N*-substituted 1,2-benzisothiazolin-3-ones (**6**) were obtained in good yields. The results are shown in Table 2. When we attempted the direct cyclization of **2a** to **6b** by treating **2a** with *p*-methylaniline in the presence of sodium methoxide, we obtained a complicated mixture of reaction products and no **6b** was isolated. However, we did achieve a one-pot synthesis of **6b** from **2a** by first heating **2a** and *p*-methylaniline in refluxing methanol for 4.5 h, and then adding sodium methoxide; heating the reaction mixture at reflux for an additional 1 h gave **6b** in 60% yield.

Table 2. Synthesis of *N*-substituted 1,2-benzisothiazolin-3-ones (**6**) from *N*-substituted sulfenamides (**3** and **5**)



3, **5**

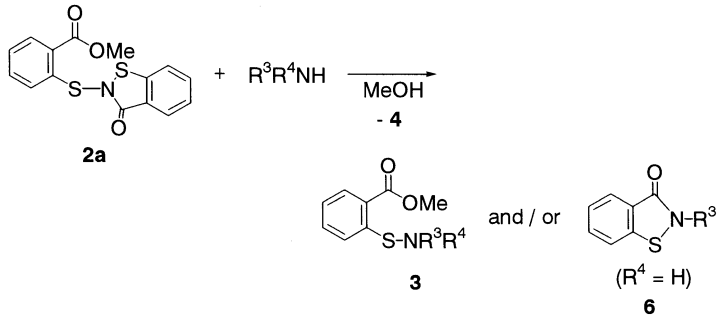
6

Entry	Sulfenamide	R^2	Product	Yield[a] (%)
8	**3a**	MeO	**6a**	69
9	**3b**	Me	**6b**	88
10	**3c**	H	**6c**	76
11	**5**	Me	**6b**	69

Sulfenamide (**3** or **5**), 0.8 mmol; NaOMe, 0.1 mmol; MeOH, 5 mL.
[a] Isolated yield.

We next investigated the reaction of **2a** with aliphatic amines, and the results are summarized in Table 3. The treatment of **2a** with benzylamine in methanol at reflux afforded a mixture of methyl 2-(*N*-benzylsulfenamoyl)-benzoate (**3e**) and 2-benzyl-1,2-benzisothiazolin-3-one (**6e**), along with eliminated 1,2-benzisothiazolin-3-one (**4**) (entry 13). When the reaction was carried out in toluene at 100°C, the corresponding benzisothiazolin-3-one (**6e**) was obtained in quantitative yield (entry 15). Reactions of **2a** with various aliphatic amines were also carried out. Sterically hindered amines gave only *N*-substituted sulfenamides, and cyclization to 1,2-benzisothiazolin-3-ones did

Table 3. Reactions of **2a** with aliphatic amines



Entry	R^3	R^4	Temperature	Time (h)	**3**	Yield[a] (%) of **3**	**6**	Yield[a] (%) of **6**
12	$PhCH_2$	H	rt	5	**3e**	70		
13	$PhCH_2$	H	Reflux	3	**3e**	52	**6e**	44
14	$PhCH_2$	H	Reflux	5.5	**3e**	23	**6e**	60
15	$PhCH_2$	H	100°C[b]	3			**6e**	100
16	*p*-$ClC_6H_4CH_2$	H	Reflux	3	**3f**	58	**6f**	38
17	*p*-$ClC_6H_4CH_2$	H	100°C[b]	3			**6f**	99
18	*p*-$MeOC_6H_4CH_2$	H	100°C[b]	3			**6g**	99
19	Pr	H	80°C[c]	3			**6h**	98
20	$HO(CH_2)_2$	H	Reflux	3			**6i**	90
21	$HO(CH_2)_3$	H	Reflux	3			**6j**	69
22	*cyclo*-Pr	H	80°C[c]	3			**6k**	82
23	*t*-Bu	H	80°C[c]	3	**3l**	82		
24	$PhMe_2C$	H	Reflux	3	**3m**	85		
25	Et	Et	80°C[c]	3	**3n**	66		
26	$-(CH_2)_4-$		Reflux	3	**3o**	79		
27	$-(CH_2)_2-O-(CH_2)_2-$		Reflux	3	**3p**	67		

2a, 0.4 mmol; amine, 0.5 mmol; MeOH, 10 mL.
[a] Isolated yield.
[b] Reaction carried out in toluene.
[c] Reaction carried out in a sealed tube.

not occur (entries 23 and 24). The eliminated **4** was more difficult to isolate in pure form from the reactions shown in Table 3 than from the reactions with anilines. The aliphatic amines, which are more basic than anilines, formed salts with **4**. This was especially true for the reaction with 2-hydroxyethylamine (entry 20): a salt with a formula of $C_9H_{12}N_2O_2S$ precipitated after the reaction. Secondary amines were also utilized for the same substitution reactions with **2**, and *N*,*N*-disubstituted sulfenamides (**3**) were obtained in good yields (entries 25–27).

3. Conclusion

The 2-(3-oxo-1,2-benzisothiazolinyl) group in *S*-[2-(3-oxo-1,2-benzisothiazolinyl)]-2-mercaptobenzoates (**2**) was easily replaced with various amines to yield *N*-substituted 2-sulfenamoylbenzoates or *N*-substituted 1,2-benzisothiazolin-3-ones, which indicates that **2** is a useful intermediate for the synthesis of *N*-substituted 2-sulfenamoylbenzoates and *N*-substituted 1,2-benzisothiazolin-3-ones. The eliminated 1,2-benzisothiazolin-3-one (**4**) could be reused for the synthesis of **2**.

4. Experimental

4.1. General

Mps were determined on a Mettler FP90 microscope plate, and are uncorrected. ^{1}H NMR spectra were obtained with a Varian Gemini 300 BB (300 MHz) spectrometer with tetramethylsilane as an internal standard. IR spectra were recorded on a JASCO FTIR-5300 spectrophotometer.

4.2. Materials

Methyl *S*-[2-(3-oxo-1,2-benzisothiazolinyl)]-2-mercaptobenzoate (**2a**) was synthesized by heating methyl 2-sulfenamoylbenzoate (**1a**) in toluene, and ethyl *S*-[2-(3-oxo-1,2-benzisothiazolinyl)]-2-mercaptobenzoate was synthesized by heating ethyl 2-sulfenamoylbenzoate (**1b**) with 1,2-benzisothiazolin-3-one (**4**) in toluene as reported in our previous papers.[6,7]

4.3. General procedure for reaction of 2 with anilines

To a solution of **2** (0.4 mmol) in methanol (10 mL) was added an aniline (0.5 mmol), and reaction was carried out under the conditions as described in Table 1. After the reaction, the solvent was evaporated and a crude reaction mixture was chromatographed on silica gel with CH_2Cl_2 as eluent to isolate **3** or **5**, then with CH_2Cl_2–acetone–methanol (100:40:8) mixture as eluent to isolate **4**. The product was recrystallized from appropriate solvent.

4.3.1. Methyl 2-[*N*-(*p*-methoxyphenyl)sulfenamoyl]-benzoate (3a). Mp 106.5–108°C (CH_2Cl_2–MeOH) (lit.[8] 106–107°C); ^{1}H NMR ($CDCl_3$) δ 3.75 (3H, s), 3.95 (3H, s), 4.90 (1H, br s), 6.79 (2H, d, J=9.1 Hz), 6.92 (2H, d, J=9.1 Hz), 7.16 (1H, ddd, J=8.2, 6.7, 1.1 Hz), 7.42 (1H,

td, J=7.3, 1.4 Hz), 7.52 (1H, dd, J=8.2, 1.4 Hz), 8.04 (1H, dd, J=8.1, 1.1 Hz); IR (KBr) ν_{max} 3347, 1692, 1508, 1273, 1242, 820, 741 cm^{-1}.

4.3.2. Methyl 2-[*N*-(*p*-methylphenyl)sulfenamoyl]benzoate (3b). Mp 131.5–132°C (CH_2Cl_2–hexane); ^1H NMR ($CDCl_3$) δ 2.25 (3H, s), 3.95 (3H, s), 4.99 (1H, br s), 6.88 (2H, d, J=8.5 Hz), 7.02 (2H, d, J=8.5 Hz), 7.15 (1H, td, J=7.5, 0.8 Hz), 7.40 (1H, ddd, J=8.2, 7.5, 1.5 Hz), 7.50 (1H, dd, J=8.2, 0.8 Hz), 8.03 (1H, dd, J=7.8, 1.5 Hz); IR (KBr) ν_{max} 3343, 1692, 1510, 1435, 1275, 1238, 905, 812, 745 cm^{-1}; Anal. calcd for $C_{15}H_{15}NO_2S$: C, 65.91; H, 5.53; N, 5.12. Found: C, 65.87; H, 5.46; N, 5.01.

4.3.3. Methyl 2-(*N*-phenylsulfenamoyl)benzoate (3c). Mp 152.5–154°C (MeOH) (lit.[8] 154–155.5°C); ^1H NMR ($CDCl_3$) δ 3.96 (3H, s), 5.08 (1H, br s), 6.87 (1H, t, J=7.3 Hz), 6.97–7.00 (2H, m), 7.14–7.25 (3H, m), 7.41 (1H, td, J=7.7, 1.4 Hz), 7.50 (1H, dd, J=8.2, 1.1 Hz), 8.05 (1H, dd, J=8.1, 1.4 Hz); IR (KBr) ν_{max} 3333, 1696, 1437, 1277, 1233, 855, 748 cm^{-1}.

4.3.4. Methyl 2-[*N*-(*p*-chlorophenyl)sulfenamoyl]benzoate (3d). Mp 154–155°C (CH_2Cl_2–hexane) (lit.[8] 152–153°C); ^1H NMR ($CDCl_3$) δ 3.96 (3H, s), 5.09 (1H, br s), 6.90–6.93 (2H, m), 7.15–7.22 (3H, m), 7.42–7.44 (2H, m), 8.05 (1H, dt, J=7.4, 1.0 Hz); IR (KBr) ν_{max} 3352, 3329, 1690, 1491, 1275, 905, 826, 743 cm^{-1}.

4.3.5. Ethyl 2-[*N*-(*p*-methylphenyl)sulfenamoyl]benzoate (5). Mp 101–102.5°C (CH_2Cl_2–hexane); ^1H NMR ($CDCl_3$) δ 1.43 (3H, t, J=7.1 Hz), 2.26 (3H, s), 4.42 (2H, q, J=7.1 Hz), 4.98 (1H, br s), 6.89 (2H, d, J=8.5 Hz), 7.02 (2H, d, J=8.5 Hz), 7.16 (1H, ddd, J=8.0, 7.7, 1.1 Hz), 7.40 (1H, td, J=7.7, 1.4 Hz), 7.50 (1H, dd, J=8.2, 1.1 Hz), 8.06 (1H, dd, J=7.7, 1.4 Hz); IR (KBr) ν_{max} 3356, 1690, 1512, 1269, 1248, 1098, 810, 745 cm^{-1}; Anal. calcd for $C_{16}H_{17}NO_2S$: C, 66.87; H, 5.96; N, 4.87. Found: C, 66.73; H, 5.86; N, 4.71.

4.4. General procedure for synthesis of *N*-substituted 1,2-benzisothiazolin-3-one (6) from 3 or 5

To a solution of sodium methoxide (0.03 mmol) in methanol (5 mL) was added *N*-substituted sulfenamide (**3** or **5**) (0.8 mmol) at reflux and the mixture was stirred for 1 h. The solvent was evaporated and a crude reaction mixture was chromatographed on silica gel with CH_2Cl_2–ethyl acetate (10:1) mixture as eluent. The product was recrystallized from appropriate solvent.

4.4.1. 2-(*p*-Methoxyphenyl)-1,2-benzisothiazolin-3-one (6a). Mp 147–148°C (EtOH) (lit.[8] 147–149°C); ^1H NMR ($CDCl_3$) δ 3.84 (3H, s), 6.98 (2H, d, J=9.2 Hz), 7.44 (1H, td, J=7.6, 1.2 Hz), 7.54 (2H, d, J=9.2 Hz), 7.57 (1H, d, J=8.3 Hz), 7.65 (1H, ddd, J=8.3, 7.6, 1.1 Hz), 8.09 (1H, dd, J=7.6, 1.1 Hz); IR (KBr) ν_{max} 1659, 1507, 1443, 1242, 1019, 839, 749 cm^{-1}.

4.4.2. 2-(*p*-Methylphenyl)-1,2-benzisothiazolin-3-one (6b). Mp 136.7–137.1°C (benzene–hexane) (lit.[9] 136–137°C); ^1H NMR ($CDCl_3$) δ 2.39 (3H, s), 7.28 (2H, d, J=8.2 Hz), 7.45 (1H, ddd, J=8.0, 6.9, 1.1 Hz), 7.55–7.60 (3H, m), 7.66 (1H, ddd, J=8.0, 6.9, 1.1 Hz), 8.11 (1H, dt, J=8.0, 1.1 Hz); IR (KBr) ν_{max} 1642, 1505, 1447, 1331, 1127, 750 cm^{-1}.

4.4.3. 2-Phenyl-1,2-benzisothiazolin-3-one (6c). Mp 138–140°C (EtOH) (lit.[8] 142–143.5°C); ^1H NMR ($CDCl_3$) δ 7.33 (1H, t, J=7.7 Hz), 7.43–7.51 (3H, m), 7.59 (1H, d, J=8.2 Hz), 7.65–7.73 (3H, m), 8.11 (1H, dd, J=8.0, 1.1 Hz); IR (KBr) ν_{max} 1663, 1591, 1491, 1445, 1325, 1304, 764, 733 cm^{-1}.

4.5. General procedure for reaction of 2a with aliphatic amines

To a solution of **2a** (127 mg, 0.4 mmol) in methanol (10 mL) was added an aliphatic amine (0.5 mmol), and reaction was carried out under the conditions as described in Table 3. After the reaction, the solvent was evaporated and a crude reaction mixture was chromatographed on silica gel with CH_2Cl_2 as eluent to isolate **3**, then with CH_2Cl_2–acetone–methanol (100:5:1) mixture as eluent to isolate **6**, and then with CH_2Cl_2–acetone–methanol (100:40:8) mixture as eluent to isolate **4**. The product was recrystallized from appropriate solvent.

4.5.1. Methyl 2-(*N*-benzylsulfenamoyl)benzoate (3e). Oil (lit.[8] mp 61–62.5°C); ^1H NMR ($CDCl_3$) δ 2.88 (1H, br t), 3.91 (3H, s), 4.13 (2H, d, J=5.2 Hz), 7.17 (1H, td, J=1.0, 8.0 Hz), 7.26–7.42 (5H, m), 7.56 (1H, ddd, J=8.2, 7.1, 1.4 Hz), 7.90 (1H, dd, J=8.2, 1.1 Hz), 8.02 (1H, dd, J=8.0, 1.4 Hz); IR (neat) ν_{max} 3337, 1707, 1271, 1055, 745 cm^{-1}.

4.5.2. 2-Benzyl-1,2-benzisothiazolin-3-one (6e). Mp 85.5–87°C (isopropanol) (lit.[8] 86–89°C); ^1H NMR ($CDCl_3$) δ 5.06 (2H, s), 7.34–7.43 (6H, m), 7.49 (1H, dd, J=8.2, 0.8 Hz), 7.59 (1H, ddd, J=8.2, 7.1, 1.1 Hz), 8.07 (1H, dd, J=8.0, 1.1 Hz); IR (KBr) ν_{max} 1667, 1447, 1337, 1244, 750 cm^{-1}.

4.5.3. Methyl 2-[*N*-(*p*-chlorobenzyl)sulfenamoyl]benzoate (3f). Oil; ^1H NMR ($CDCl_3$) δ 2.93 (1H, br t), 3.90 (3H, s), 4.09 (2H, d, J=5.8 Hz), 7.17 (1H, ddd, J=7.7, 7.1, 1.1 Hz), 7.31 (4H, s), 7.55 (1H, ddd, J=8.2, 7.1, 1.4 Hz), 7.84 (1H, dd, J=8.2, 1.1 Hz), 8.02 (1H, dd, J=7.7, 1.4 Hz); IR (neat) ν_{max} 3329, 1705, 1271, 1100, 745 cm^{-1}; HRMS calcd for $C_{15}H_{14}ClNO_2S$: 307.0434. Found: 307.0447.

4.5.4. 2-(*p*-Chlorobenzyl)-1,2-benzisothiazolin-3-one (6f). Mp 83.4–84.4°C (EtOH) (lit.[10] 86–89°C); ^1H NMR ($CDCl_3$) δ 5.02 (2H, s), 7.28–7.35 (4H, m), 7.42 (1H, ddd, J=8.0, 7.2, 1.0 Hz), 7.51 (1H, dt, J=8.0, 0.8 Hz), 7.61 (1H, ddd, J=8.0, 7.2, 1.0 Hz), 8.07 (1H, ddd, J=8.0, 1.0, 0.8 Hz); IR (KBr) ν_{max} 1651, 1597, 1487, 1331, 1090, 731, 584 cm^{-1}.

4.5.5. 2-(*p*-Methoxybenzyl)-1,2-benzisothiazolin-3-one (6g). Mp 75.2–76.3°C (EtOH); ^1H NMR ($CDCl_3$) δ 3.80 (3H, s), 5.00 (2H, s), 6.89 (2H, d, J=8.7 Hz), 7.31 (2H, d, J=8.7 Hz), 7.40 (1H, ddd, J=8.0, 6.9, 0.8 Hz), 7.48 (1H, dd, J=8.0, 0.8 Hz), 7.58 (1H, ddd, J=8.0, 6.9, 1.2 Hz), 8.06 (1H, dd, J=8.0, 1.2 Hz); IR (KBr) ν_{max} 1672, 1514, 1445, 1335, 1254, 1020, 737 cm^{-1}; Anal. calcd for $C_{15}H_{13}NO_2S$:

C, 66.40; H, 4.83; N, 5.16. Found: C, 66.30; H, 4.76; N, 5.07.

4.5.6. 2-Propyl-1,2-benzisothiazolin-3-one (6h). Oil (lit.[8] bp 126–128°C/0.2 mmHg); ^{1}H NMR ($CDCl_3$) δ 0.99 (3H, t, J=7.3 Hz), 1.80 (2H, hex, J=7.3 Hz), 3.87 (2H, t, J=7.3 Hz), 7.40 (1H, ddd, J=7.9, 7.0, 0.9 Hz), 7.55 (1H, d, J=7.9 Hz), 7.60 (1H, ddd, J=7.9, 7.0, 1.2 Hz), 8.04 (1H, dt, J=7.9, 0.9 Hz); IR (neat) ν_{max} 1657, 1447, 1333, 741 cm^{-1}.

4.5.7. 2-(2-Hydroxyethyl)-1,2-benzisothiazolin-3-one (6i). This compound was purified with chromatography on silica gel with CH_2Cl_2–acetone–methanol (100:20:4) mixture as eluent. Mp 112–112.5°C (ethyl acetate) (lit.[8] 112–114°C); ^{1}H NMR ($CDCl_3$) δ 3.97 (2H, td, J=4.9, 1.1 Hz), 4.05 (2H, td, J=4.9, 1.1 Hz), 7.40 (1H, ddd, J=8.0, 6.9, 1.1 Hz), 7.54 (1H, dt, J=8.0, 1.4 Hz), 7.62 (1H, ddd, J=8.0, 6.9, 1.4 Hz), 8.03 (1H, dt, J=8.0, 1.1 Hz); IR (KBr) ν_{max} 3331, 1632, 1454, 1345, 1080, 748 cm^{-1}. A 2-hydroxyethylammonium salt of **4** precipitated after the reaction. The salt, mp 143–144.5°C (EtOH); ^{1}H NMR (CD_3OD) δ 2.94 (2H, t, J=5.5 Hz), 3.70 (2H, t, J=5.5 Hz), 7.32 (1H, ddd, J=8.0, 7.1, 0.8 Hz), 7.48 (1H, ddd, J=8.2, 7.1, 1.4 Hz), 7.69 (1H, dt, J=8.2, 0.8 Hz), 7.92 (1H, ddd, J=8.0, 1.4, 0.8 Hz); IR (KBr) ν_{max} 2861, 1470, 1431, 1076, 743 cm^{-1}; Anal. calcd for $C_9H_{12}N_2O_2S$: C, 50.93; H, 5.69; N, 13.20. Found: C, 51.04; H, 5.73; N, 13.07.

4.5.8. 2-(3-Hydroxypropyl)-1,2-benzisothiazolin-3-one (6j). This compound was purified with chromatography on silica gel with CH_2Cl_2–acetone–methanol (100:20:4) mixture as eluent. Mp 76.6–77.4°C (ethyl acetate) (lit.[10] 74–75°C); ^{1}H NMR ($CDCl_3$) δ 1.92 (2H, tt, J=6.2, 5.6 Hz), 3.58 (2H, t, J=5.6 Hz), 3.65 (1H, br s), 4.08 (2H, t, J=6.2 Hz), 7.44 (1H, ddd, J=8.0, 7.0, 1.1 Hz), 7.58 (1H, dt, J=8.0, 1.1 Hz), 7.65 (1H, td, J=7.8, 1.1 Hz), 8.05 (1H, dt, J=7.8, 1.1 Hz); IR (KBr) ν_{max} 3364, 2944, 1632, 1445, 1350, 1192, 1065, 937, 743 cm^{-1}.

4.5.9. 2-Cyclopropyl-1,2-benzisothiazolin-3-one (6k). Oil; ^{1}H NMR ($CDCl_3$) δ 1.05–1.12 (4H, m), 3.10–3.17 (1H, m), 7.38 (1H, ddd, J=8.0, 6.9, 1.1 Hz), 7.50 (1H, dt, J=8.0, 0.8 Hz), 7.60 (1H, ddd, J=8.0, 6.9, 1.4 Hz), 8.01 (1H, ddd, J=8.0, 1.4, 0.8 Hz); IR (neat) ν_{max} 1657, 1449, 1333, 741, 673 cm^{-1}; HRMS calcd for $C_{10}H_9NOS$: 191.0405. Found: 191.0363.

4.5.10. Methyl 2-[*N*-(*tert*-butyl)sulfenamoyl]benzoate (3l). Mp 89–89.7°C (CH_2Cl_2–hexane); ^{1}H NMR ($CDCl_3$) δ 1.22 (9H, s), 2.55 (1H, br s), 3.92 (3H, s), 7.10 (1H, td, J=7.8, 1.1 Hz), 7.50 (1H, ddd, J=8.4, 7.1, 1.4 Hz), 7.98 (1H, dd, J=7.8, 1.4 Hz), 8.16 (1H, dd, J=8.4, 1.1 Hz); IR (KBr) ν_{max} 3291, 2961, 1701, 1433, 1269, 748 cm^{-1}; Anal. calcd for $C_{12}H_{17}NO_2S$: C, 60.22; H, 7.16; N, 5.85. Found: C, 60.33; H, 7.18; N, 5.76.

4.5.11. Methyl 2-[*N*-(1-methyl-1-phenylethyl)sulfenamoyl]benzoate (3m). Mp 138.5–140°C (benzene–hexane); ^{1}H NMR ($CDCl_3$) δ 1.58 (6H, s), 3.07 (1H, br s), 3.89 (3H, s), 7.12 (1H, td, J=7.1, 1.1 Hz), 7.23–7.28 (1H, m), 7.34–7.39 (2H, m), 7.51–7.57 (3H, m), 7.98 (1H, dd, J=7.7, 1.4 Hz), 8.26 (1H, dd, J=8.2, 0.8 Hz); IR (KBr) ν_{max} 3304, 1692, 1435, 1273, 1101, 750, 698 cm^{-1}; Anal. calcd for $C_{17}H_{19}NO_2S$: C, 67.74; H, 6.35; N, 4.65. Found: C, 67.57; H, 6.31; N, 4.57.

4.5.12. Methyl 2-(*N*,*N*-diethylsulfenamoyl)benzoate (3n). Oil; ^{1}H NMR ($CDCl_3$) δ 1.16 (6H, t, J=7.1 Hz), 3.07 (4H, q, J=7.1 Hz), 3.91 (3H, s), 7.11 (1H, ddd, J=7.7, 7.1, 1.1 Hz), 7.49 (1H, ddd, J=8.2, 7.1, 1.4 Hz), 7.94 (1H, dd, J=8.2, 1.1 Hz), 8.00 (1H, dd, J=7.7, 1.1 Hz); IR (neat) ν_{max} 1711, 1458, 1435, 1269, 745 cm^{-1}; HRMS calcd for $C_{12}H_{17}NO_2S$: 239.0980; Found: 239.1005.

4.5.13. Methyl *S*-pyrrolidino-2-mercaptobenzoate (3o). Mp 43.5–44.4°C (hexane); ^{1}H NMR ($CDCl_3$) δ 1.93–1.97 (4H, m), 3.18–3.22 (4H, m), 3.91 (3H, s), 7.12 (1H, ddd, J=7.4, 7.1, 1.4 Hz), 7.50 (1H, ddd, J=8.2, 7.1, 1.6 Hz), 7.71 (1H, dd, J=8.2, 1.1 Hz), 8.01 (1H, dd, J=7.4, 1.6 Hz); IR (KBr) ν_{max} 1709, 1458, 1439, 1269, 745 cm^{-1}; HRMS calcd for $C_{12}H_{15}NO_2S$: 237.0823. Found: 237.0817.

4.5.14. Methyl *S*-morpholino-2-mercaptobenzoate (3p). Mp 104–105°C (hexane); ^{1}H NMR ($CDCl_3$) δ 3.08 (4H, t, J=4.7 Hz), 3.82 (4H, t, J=4.7 Hz), 3.91 (3H, s), 7.17 (1H, td, J=6.6, 1.1 Hz), 7.55 (1H, td, J=7.1, 1.4 Hz), 8.01–8.05 (2H, m); IR (KBr) ν_{max} 1709, 1458, 1433, 1269, 745 cm^{-1}; Anal. calcd for $C_{12}H_{15}NO_3S$: C, 56.90; H, 5.97; N, 5.53. Found: C, 57.04; H, 5.94; N, 5.48.

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