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On the Reaction of Chloroalkylbenzothiazoles with Alkoxides

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Abstract: 2-chloroalkylbenzothiazoles **1a-c** react with alkoxides to give substitution and ring-expanded products **3** and **4**. The substitution ring-enlargement competition much depends upon the solvent, the substitution reaction being preferred in alcohols and the ring-enlargement in DMF.
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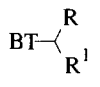
The chemistry of 2-alkylbenzothiazoles has been extensively investigated especially for synthetic purposes.[1] In contrast, the reactivity of 2-halogenoalkylbenzothiazoles has not been studied adequately though they have been found to be useful intermediates for the synthesis of certain benzothiazole derivatives.[2a-f] There are three main reactive sites in the structure of α-halogenoalkylbenzothiazoles: the 2-position of the thiazole system which is available for nucleophilic additions, the acidity of the α-hydrogens (pKa < 20) that can be removed to generate α-halocarbanions and the electrophilic character of the α carbon which allows the nucleophilic displacement of the halogen. We have recently reported that benzothiazolylchloromethyllithium **1d**, promptly available upon deprotonation of 2-chloromethylbenzothiazole **1a**, adds to carbonyl compounds and imines to give oxiranes[2b,c] and aziridines,[2d] while in the absence of an external electrophile it adds to the C-N double bond of its precursor causing a thiazole-thiazine ring-expansion leading to benzothiazolylmethylidene-1,4-benzothiazine **2**.[2e] The bias of **1a** to undergo ring-expansion has been exploited by us to prepare a number of novel heteroarylalkylidene benzothiazines.[2f] In the present paper we report on the competition between nucleophilic displacement of the α halogen and thiazole-thiazine ring-expansion in the reaction of 2-chloroalkylbenzothiazoles with alkoxides.

When 2-chloromethylbenzothiazole **1a** was treated with MeONa in MeOH a mixture of substitution product **3a** (74%) and dihydrobenzothiazine **4a** (26%) was obtained. The rationale for the formation of **4a** is probably that methoxide adds to the C-N double bond of **1a**, thus initiating the thiazole-thiazine ring-enlargement leading to **4a** (Scheme 1). Such an addition is worth noting considering that thiazoles and benzoderivatives are rather reluctant to undergo nucleophilic addition to the C-N double bond. A preliminary activation of the "aza" group of the thiazole system, via alkylation or acylation, that makes the 2-carbon more electrophilic, is usually required.

Scheme 1

Only very strong nucleophiles such as carbanions have been reported to add to the C-N double bond of the unactivated thiazoles.[3] Strong electron-withdrawing substituents in the benzene ring also make the C-2 position sufficiently electrophilic to undergo nucleophilic addition.[4] The conversion of **1a** to **4a** is a new example of unactivated thiazole-thiazine ring-expansion. Indeed, examples of thiazole-thiazine ring-expansion, a synthetically useful reaction,[5] are known, but in all of the reported cases, however, the reaction takes place only if certain carbanions[3] are used or a preliminary activation of the thiazole system by quaternization of the "aza" group is effected.[6-9]



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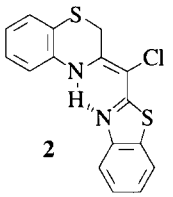

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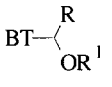

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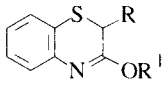

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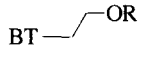
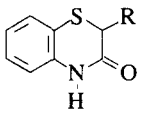
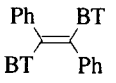
1a: R = H; R^1 = Cl
1b: R = CH_3; R^1 = Cl
1c: R = Ph; R^1 = Cl
1d: R = Li; R^1 = Cl
1e: R = CH_3; R^1 = OH
1f: R = Ph; R^1 = OH



6: R = CH_2CH_3
8: R = $CH(CH_3)_2$



5: R = H
9: R = CH_3



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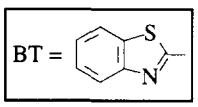
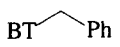




13

a: R = H; R^1 = CH_3
b: R = H; R^1 = CH_2CH_3
c: R = H; R^1 = $CH(CH_3)_2$
d: R = H; R^1 = $C(CH_3)_3$
e: R = R^1 = CH_3
f: R = CH_3; R^1 = CH_2CH_3
g: R = CH_3; R^1 = $CH(CH_3)_2$
h: R = CH_3; R^1 = $C(CH_3)_3$
i: R = Ph; R^1 = CH_3
k: R = Ph; R^1 = CH_2CH_3
l: R = Ph; R^1 = $CH(CH_3)_2$
m: R = Ph; R^1 = $C(CH_3)_3$

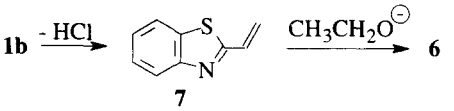
Results comparable to those of the reaction of **1a** with MeO^- were obtained in the reaction of the same **1a** with EtO^- and Pr^iO^- (See Table 1 and Experimental). In contrast, the reaction of **1a** with the sterically hindered base Bu^tO^- gave mainly benzothiazinone **5**,[10] which should be the hydrolysis product of thiazine **4d**.

Table 1. Reaction of Chloroalkylbenzothiazoles **1a-c** with Alkoxides.

Substrate	RO$^{\ominus}$	Solvent	Substitution Product[a] (% yield)	Thiazine[a] (% yield)	Other Products[a]
1a	MeO$^{\ominus}$	MeOH	**3a** (74)	**4a** (26)	
"	EtO$^{\ominus}$	EtOH	**3b** (73)	**4b** (25)	
"	$Pr^{i}O^{\ominus}$	$Pr^{i}OH$	**3c** (73)	**4c** (17)	
"	$Bu^{t}O^{\ominus}$	$Bu^{t}OH$	**3d** (6)		**5** (41)
"	MeO$^{\ominus}$	DMF	**3a** (30)	**4a** (70)	
"	EtO$^{\ominus}$	DMF	**3b** (31)	**4b** (63)	
"	$Pr^{i}O^{\ominus}$	DMF	**3c** (48)	**4c** (35)	
1b	MeO$^{\ominus}$	MeOH	**3e** (73)	**4e** (27)	
"	EtO$^{\ominus}$	EtOH	**3f** (29)	**4f** (29)	**6** (17)
"	$Pr^{i}O^{\ominus}$	$Pr^{i}OH$		**4g** (12)	**8** (18)
"	$Bu^{t}O^{\ominus}$	$Bu^{t}OH$			**9** (64)
1c	MeO$^{\ominus}$	MeOH	**3i** (> 98)	-	
"	EtO$^{\ominus}$	EtOH	**3k** (53)	**4k** (10)	**10** (12)
"	$Pr^{i}O^{\ominus}$	$Pr^{i}OH$	**3l** (20)	-	**10** (58) + **13** (20)
"	$Bu^{t}O^{\ominus}$	$Bu^{t}OH$	-	-	**10** (>95)

[a]Yields calculated on isolated, purified compounds.

The reaction of 2-chloroethylbenzothiazole **1b** with MeO^{-}/MeOH furnished the substitution and the ring-enlarged products **3e** and **4e** respectively, in a 3/1 ratio. A 1/1 ratio of the ether **3f** and the thiazine **4f** was observed in the reaction with EtO^{-}/EtOH. A third product formed in this reaction and it was the ether **6**. The probable explanation for its formation is that **1b** undergoes HCl elimination to give vinylbenzothiazole **7**. Subsequent conjugate addition of EtO^{-} to **7** would give **6** (Scheme 2).



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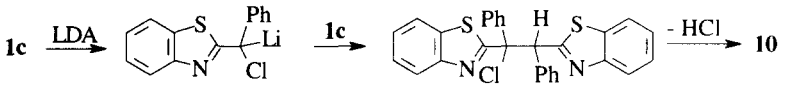
Scheme 2

The products of the reaction of **1b** with $Pr^{i}O^{-}$ were thiazine **4g** and ether **8**, while the reaction with $Bu^{t}O^{-}$ afforded exclusively benzothiazinone **9**, which with all probability derives from the hydrolysis of tert-butyl ether **4h**.

The reaction of **1c** with MeO^-/MeOH was very clean giving substitution product **3i** as the sole product, while the reaction with EtO^-/EtOH provided substitution product **3k**, the ring-enlarged product **4k** in a 5/1 ratio and dibenzothiazolyl diphenyl ethene **10**, which was the main product in the reaction with Pr^iO^- (together with a small percentage of the reduction product **13**) and the sole one in the reaction with Bu^tO^-. We suppose that the use of strong bases such as Pr^iO^- and Bu^tO^- causes deprotonation of **1c** (the pKa of the α hydrogen should be < 20) to give benzothiazolylchlorobenzyllithium **11** which then couples with **1c** to give **12**. HCl elimination would give **10** (Scheme 3).



11 **12**

Scheme 3

A dramatic solvent effect was observed in the reaction of **1a** with alkoxides on going from the corresponding alcohols to dimethylformamide. Indeed, the 3/1 ratio between substitution and ring-expanded products observed in the reaction of **1a** with MeO^-, EtO^- and Pr^iO^- in the corresponding alcohols changed to 1/3 in DMF.

In conclusion, in this work we have disclosed a novel facet of the reactivity of the thiazole system. The bias of 2-chloroalkylbenzotiazoles **1** to undergo ring-expansion has been exploited to prepare novel alkoxybenzothiazines which seem to have some interest in medicinal chemistry.[11] It is worth emphasizing that the ability of alkoxides to cause the above ring-expansion of the thiazole system is peculiar of alkoxides as sulfur and nitrogen nucleophiles have been found to react with **1a** giving just direct displacement of the halogen.[12]

EXPERIMENTAL

^{1}H-NMR spectra were recorded on a Varian EM 390 and a Bruker AM 300 WB spectrometers; chemical shifts are reported in parts per million (δ) from an internal TMS standard. Absolute values of the coupling constants are reported. ^{13}C NMR spectra were recorded on a Varian XL-200 spectrometer and referenced to the center resonance of $CDCl_3$ (77.0 ppm). IR spectra were recorded on a Perkin-Elmer spectrometer model 598. GC analyses were carried out with a Hewlett-Packard MP 5890 series II gaschromatograph (dimethylsilicon capillary column, 30 m, 0.25 mm i.d.). GC-MS analyses were performed on a HP 5890 series II gaschromatograph equipped with a HP 5971 Mass Selective Detector operating at 70 eV (EI). Melting points were uncorrected. TLC was performed on Merck silica gel plates with F-254 indicator; visualization was accomplished by UV light (254 nm). Flash chromatographies were performed with Merck 230-400 mesh silica gel. Microanalyses were performed on Carlo Erba C,H,N analyser.

Materials: 2-(chloromethyl)-1,3-benzothiazole (**1a**) was prepared as reported.[2a,b,13] Petroleum ether refers to the 40-60 °C boiling fraction. All solvents and all other chemicals were of commercial grade and used without further purification or, if necessary, purified by distillation or crystallization prior to use.

2-(1-Hydroxyethyl)-1,3-benzothiazole (1e). A solution of 2-aminothiophenol (9.03 mL, 83.8 mmol) and lactic acid (85% water solution, 7.36 mL, 83.8 mmol) was heated in a claisen at 160-180°C using a Wood and Rose alloy so that all the water formed was removed. After 2h, CH_2Cl_2 (3.0 mL) was added and the organic layer washed with water (5 x 200 mL), dried over Na_2SO_4 and evaporated. The crude product was purified by column chromatography (petroleum ether/Et_2O 1:1) to give 2-(1-hydroxyethyl)-1,3-benzothiazole **1e** (8.96 g, 60% yield) as a white cristalline solid (mp 54-56 °C). ^1H NMR (90 MHz, $CDCl_3$) δ 1.7 (d, 3 H, *J*=7.5 Hz), 4.67 (br s, 1 H, exchanges with D_2O), 5.3 (q, 1 H, *J*=7.5 Hz), 7.15-7.6 (m, 2 H), 7.7-8.1 (m, 2 H); ^{13}C NMR (50.3 MHz) δ 23.86, 68.07, 121.66, 122.43, 124.79, 125.90, 134.43, 152.58, 178.11; MS *m/z* (%) 179 (M^+, 298), 164 (179), 136 (1000), 135 (468), 108 (312), 69 (207); IR (KBr): ν_{O-H} 3500-3200 (br) cm^{-1}. Anal. Calcd for C_9H_9NOS: H, 5.06; C, 60.31; N, 7.81. Found: H, 5.35; C, 60.45; N, 7.48.

2-(1-Chloroethyl)-1,3-benzothiazole (1b). A mixture of 2-(1-hydroxyethyl)-1,3-benzothiazole (**1e**) (8.96 g, 50.03 mmol) and triethylamine (17.69 g, 175.13 mmol) was cooled at 0 °C. To this stirred mixture, CH_3SO_2Cl (20.05 g, 175.03 mmol) was added dropwise. The reaction was allowed to warm to rt over a 30-min period, and then refluxed for 2 h. The mixture was diluted with CH_2Cl_2 (150 mL), the organic phase washed with 5% $NaHCO_3$ (3 x 200 mL) and brine until neutral pH, dried over Na_2SO_4 and evaporated. The residue (12.1 g) was column chromatographed on silica gel (petroleum ether/Et_2O 9:1) to give 2-(1-chloroethyl)-1,3-benzothiazole **1b** (6 g, 61% yield) as a light yellow oil. ^1H NMR (300 MHz, $CDCl_3$) δ 2.02 (d, 3 H, *J*= 6.8 Hz), 5.40 (q, 1 H, *J*= 6.8 Hz), 7.36-7.41 (m, 1 H), 7.45-7.51 (m, 1 H), 7.86-7.89 (m,1 H), 7.98-8.01 (m, 1 H); ^{13}C NMR (50.3 MHz) δ 25.36, 54.65, 121.68, 123.35, 125.56, 126.29, 135.29, 152.53, 172.15; MS *m/z* (%) 199 (M^++2, 72), 197 (M^+, 209), 162 (1000), 109 (292), 69 (185); IR (film) 1505, 1430, 1240, 1065, 859 cm^{-1}.

2-(α-Hydroxybenzyl)-1,3-benzothiazole (1f). The reaction was performed as in the case of 2-(1-hydroxyethyl)-1,3-benzothiazole (**1e**) with the exception that mandelic acid was used instead of lactic acid. The crude product was purified by column chromatography (9:1 petroleum ether/Et_2O) to give 2-(α-hydroxybenzyl)-1,3-benzothiazole **1f** (43% yield) as a light yellow solid (mp 79-80 °C). ^1H NMR (90 MHz, $CDCl_3$) δ 4.23-4.37 (br s, 1 H, exchanges with D_2O), 6.17 (s, 1 H), 7.27-7.62 (m, 2 H), 7.80-8.05 (m, 2 H); ^{13}C NMR (50.3 MHz) δ 74.26, 121.72, 122.98, 125.09, 126.07, 126.70, 128.59, 128.76, 135.15, 140.90, 152.52, 175.19; MS *m/z* (%) 241 (M^+, 907), 240 (154), 212 (218), 164 (113), 136 (909), 135 (1000), 108 (306), 107 (162), 105 (229), 91 (110), 79 (439), 77 (754), 51 (343); IR (KBr) ν_{O-H} 3500-3200 (br) cm^{-1}; Anal. Calcd for $C_{14}H_{11}NOS$: H, 4.59; C, 69.68; N, 5.80. Found: H, 4.58; C, 69.72; N, 5.84.

2-(α-Chlorobenzyl)-1,3-benzothiazole (1c). This preparation was performed in the same manner as in the case of 2-(1-chloroethyl)-1,3-benzothiazole (**1b**) with the exception that the refluxing time was 2 days. Identical work-up and column chromatography (petroleum ether/Et_2O 9:1) provided 2-(α-chlorobenzyl)-1,3-benzothiazole **1c** (46% yield) as an oil. ^1H NMR (90 MHz, $CDCl_3$) δ 6.45 (s, 1 H), 7.20-8.10 (4 m, 9H); ^{13}C NMR (50.3 MHz) δ 60.58, 121.65, 123.64, 125.64, 126.37, 127.77, 128.92, 129.15, 135.79, 138.54, 152.86, 171.01; MS *m/z* (%) 261 (M^++2, 37), 259 (M^+, 95), 224 (1000), 223 (401), 111 (111); IR (film) 1646, 1483, 1289, 1274 cm^{-1}. Anal. Calcd for $C_{14}H_{10}ClNS$: H, 3.88; C, 64.74; N, 5.39. Found: H, 3.93; C, 64.85; N, 5.38.

Reactions of 2-chloroalkylbenzothiazoles 1a-c with alkoxides. Representative Experimental Procedure.

The reaction of 2-(chloromethyl)-1,3-benzothiazole **1a** with MeONa/MeOH is described as an example. 4.67 ml of 0.935 N MeONa (in MeOH) was added to a MeOH (10 mL) solution of **1a** (200 mg) under stirring. The reaction mixture was refluxed for 3 h and then quenched with aq. NH_4Cl, extracted with Et_2O (3 x 15 mL) and dried over Na_2SO_4. Evaporation of the solvent under reduced pressure gave 200 mg of a residue that was flash chromatographed (petroleum ether/diethyl ether: 8/2 as the eluent) to give 2-methoxymethyl-1,3-benzothiazole **3a** (148 mg) and 2*H*-3-methoxy-1,4-benzothiazine **4a** (52 mg). In DMF the reaction was much faster and we obtained **3a** (60 mg) and **4a** (140 mg) starting from the same amount of **1a**.

2-Methoxymethyl-1,3-benzothiazole (**3a**).[14] Oil, see Table 1 for yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 3.52 (s, 3 H) 4.83 (s, 2 H), 7.23-7.50 (m, 2 H), 7.80-8.07 (m, 2 H); MS *m/z* (%) 179 (M^+, 99), 149 (1000), 148 (145), 108 (112) 45 (505); IR (film) 3050, 1185, 1100, 755, 725 cm^{-1}.

2*H*-3-Methoxy-1,4-benzothiazine (**4a**).[2f] Oil, see Table 1 for yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 3.17 (s, 2 H), 3.89 (s, 3 H), 6.83-7.27 (m, 4 H); MS *m/z* (%) 179 (M^+, 1000), 164 (256), 150 (375), 149 (274), 136 (680), 109 (380), 45 (402); IR (film) $\nu_{C=N}$ 1630 cm^{-1}.

2-Ethoxymethyl-1,3-benzothiazole (**3b**).[15] Oil, see Table 1 for yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 1.30 (t, *J*= 7.5 Hz, 3 H), 3.67 (q, *J*= 7.5 Hz, 2 H), 4.90 (s, 2 H), 7.16-7.53 (m, 2 H), 7.80-8.13 (m, 2 H); MS *m/z* (%) 193 (M^+,16), 149 (1000), 148 (200), 109 (76), 108 (131), 69 (151), 45 (190); IR (film) 3050, 1515, 1430, 1338, 755, 725 cm^{-1}.

2*H*-3-Ethoxy-1,4-benzothiazine (**4b**).[16] Oil, see Table 1 for yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 1.40 (t, *J*= 7.5 Hz, 3 H), 3.25 (s, 2 H), 4.42 (q, *J*= 7.5 Hz, 2 H), 6.90-7.35 (m, 4 H); MS *m/z* (%) 193 (M^+, 511), 165 (504), 149 (345), 136 (1000), 120 (291), 109 (250), 45 (318). IR (film) $\nu_{C=N}$ 1630 cm^{-1}.

2-(Isopropoxymethyl)-1,3-benzothiazole (**3c**).[15] Waxy solid, see Table 1 for yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 1.30 (d, *J*= 6 Hz, 6 H), 3.83 (septet, *J*= 6 Hz, 1 H), 4.93 (s, 2 H), 7.26-7.57 (m, 2 H), 7.83-8.10 (m, 2 H); MS *m/z* (%) 207 (M^+, 12), 149 (1000), 148 (326), 136 (132), 135 (89), 109 (66), 108 (137), 45 (157), 43 (229); IR (KBr) 1705, 1513, 1430, 1170, 1090 cm^{-1}.

2*H*-3-Isopropoxy-1,4-benzothiazine (**4c**). Oil, see Table 1 for yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 1.37 (d, *J*= 6 Hz, 6 H), 3.18 (s, 2 H), 5.42 (septet, *J*= 6 Hz, 1 H), 6.88-7.33 (m, 4 H); MS *m/z* (%) 207 (M^+, 337), 165 (816), 136 (1000), 120 (440), 109 (188), 69 (120), 45 (229), 43 (292), 41 (294); IR (film)$\nu_{C=N}$ 1630 cm^{-1}.

2-*ter*-Butoxymethyl-1,3-benzothiazole (**3d**). Waxy solid, 6% yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 1.35 (s, 9 H), 4.87 (s, 2 H), 7.26-7.61 (m, 2 H), 7.83-8.10 (m, 2 H); MS *m/z* (%) 221 (M^+, 214), 206 (41), 191 (121), 176 (117), 165 (106), 164 (122), 148 (1000), 136 (459), 135 (208), 108 (145), 57 (332), 45 (249); IR (KBr) 1525, 1430, 1260, 1090, 1020 cm^{-1}.

2-(1-Methoxyethyl)-1,3-benzothiazole (**3e**). Oil, 73% yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 1.64 (d, *J*= 7 Hz, 3 H), 4.80 (q, *J*= 7 Hz, 1 H), 3.44 (s, 3 H), 7.25-7.61 (m, 2 H), 7.80-8.13 (m, 2 H); MS *m/z* (%) 193 (M^+, 56), 178 (103), 163 (1000), 162 (433), 136 (180), 135 (118), 109 (218), 108 (134), 59 (899); IR (film) 1510, 1435, 1305, 1110, 1090 cm^{-1}.

2*H*-3-Methoxy-2-methyl-1,4-benzothiazine (**4e**). Oil, 27% yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 1.32 (d, *J*=7.0 Hz, 3 H), 3.50 (q , *J*=7.0 Hz, 1 H), 3.95 (s, 3 H), 6.93-7.37 (m, 4 H); MS *m/z* (%) 193 (M^+, 598), 178 (1000), 162 (144) 150 (289), 136 (166), 109 (266). IR (film) $\nu_{C=N}$ 1630 cm^{-1}.

2-(1-Ethoxyethyl)-1,3-benzothiazole (**3f**). Oil, 29% yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 1.30 (t, *J*= 7.5 Hz, 3 H), 1.65 (d, *J*= 6 Hz, 3 H), 3.63 (q, *J*= 7.5 Hz, 2 H), 4.88 (q, *J*= 6 Hz, 1 H), 7.26-7.65 (m, 2 H), 7.83-

8.10 (m, 2 H); MS *m/z* (%) 207 (M^+, 8), 163 (999), 162 (569), 136 (197), 135 (97), 109 (221), 108 (133), 45 (909); IR (film) 1515, 1435, 1310, 1100 cm^{-1}.

2*H*-3-Ethoxy-2-methyl-1,4-benzothiazine (4f). Oil, 29% yield; ^1H NMR (90 MHz, $CDCl_3$) δ 1.34 (t overlap, *J* =7.5 Hz, 3 H), 1.37 (t overlap, *J* = 7.5 Hz, 3 H), 3.42 (q, *J*= 7.5 Hz, 1 H), 4.37 (q, *J*= 7.5 Hz, 2 H), 6.92-7.35 (m, 4 H); MS *m/z* (%) 207 (M^+, 667), 192 (254), 179 (519), 178 (159), 164 (472), 162 (480), 150 (274), 136 (1000), 120 (288), 109 (342), 45 (258); IR (film) $\nu_{C=N}$ 1630 cm^{-1}.

2*H*-3-Isopropoxy-2-methyl-1,4-benzothiazine (4g). Oil, 12% yield; ^1H NMR (90 MHz, $CDCl_3$) δ 1.20-1.43 (m, 6 H + 3 H), 3.38 (q, *J*= 7.5 Hz, 1 H), 5.40 (septet, *J*= 6 Hz, 1 H), 6.91-7.35 (m, 4 H); MS *m/z* (%) 221 (M^+, 463), 179 (899), 164 (668), 150 (253), 136 (1000), 120 (653), 109 (309), 43 (505), 41(501); IR (film) 1630, 1180, 1105 cm^{-1}.

2-(α-Methoxybenzyl)-1,3-benzothiazole (3i). Oil, > 98% yield; ^1H NMR (90 MHz, $CDCl_3$) δ 3.47 (s, 3 H), 5.62 (s, 1 H), 7.20-7.60 (m, 7 H), 7.70-8.03 (m, 2 H); MS *m/z* (%) 255 (M^+, 41), 240 (81), 225 (1000), 224 (229), 121 (942), 105 (217), 91 (240), 77 (511), 69 (134); IR (film) $\nu_{C=N}$ 1630 cm^{-1}.

2-(α-Ethoxybenzyl)-1,3-benzothiazole (3k). Oil, 53% yield; ^1H NMR (90 MHz, $CDCl_3$) δ 1.30 (t, *J*= 7.5 Hz, 3 H), 3.68 (q, *J*= 7.5 Hz, 2 H), 5.80 (s, 1 H), 7.18-7.60 (m, 7 H), 7.73-8.07 (m, 2 H); MS *m/z* (%) 269 (M^+, 6), 240 (37), 225 (1000), 224 (274), 135 (207), 107 (388), 79 (393), 77 (320), 69 (114), 51 (148); IR (film) 1510, 1450, 1310, 1150, 1095 cm^{-1}.

2*H*-3-Ethoxy-2-phenyl-1,4-benzothiazine (4k). Waxy solid, 10% yield; ^1H NMR (90 MHz, $(CD_3)_2CO$) δ 1.33 (t, *J*= 6.0 Hz, 3 H), 4.47 (q, *J*= 6.0 Hz, 2 H), 4.80 (s, 1 H), 7.03-7.33 (m, 9 H); MS *m/z* 269 (M^+, 1000), 241 (365), 240 (425), 212 (710), 165 (536), 136 (336), 121 (273), 109 (490), 105 (472), 91 (740), 77 (256), 63 (271), 45 (224); IR (KBr) 1628, 1310, 1175, 1025 cm^{-1}.

2-(α-Isopropoxybenzyl)-1,3-benzothiazole (3l). Waxy solid, 20% yield; ^1H NMR (90 MHz, $CDCl_3$) δ 1.31 (d, *J*= 6.0 Hz, 6 H), 3.88 (septet, *J*= 6.0 Hz, 1 H), 5.93 (s, 1 H), 7.20-7.70 (m, 7 H), 7.82-8.07 (m, 2 H); MS *m/z* (%) 283 (M^+, 3), 225 (1000), 224 (309), 212 (74), 107 (525), 79 (187), 77 (184), 43 (202); IR (KBr) 1510, 1450, 1160, 1095 cm^{-1}.

2-(2-Ethoxyethyl)-1,3-benzothiazole (6). Oil, 17% yield; ^1H NMR (90 MHz, $CDCl_3$) δ 1.24 (t, *J*= 6 Hz, 3 H), 3.30-3.67 (m, 4 H), 3.90 (t, *J*= 6 Hz, 2 H), 7.26-7.66 (m, 2 H), 7.83-8.13 (m, 2 H); MS *m/z* (%) 207 (M^+, 79), 178 (495), 163 (1000), 162 (442), 150 (198), 149 (258), 148 (274), 109 (234), 108 (202), 59 (567), 45 (333); IR (film) 1510, 1435, 1120 cm^{-1}.

2-(2-Isopropoxyethyl)-1,3-benzothiazole (8). Oil, 18% yield; ^1H NMR (90 MHz, $CDCl_3$) δ 1.20 (d, *J*= 6.0 Hz, 6 H), 3.38 (t, *J*= 6 Hz, 2 H), 3.67 (septet overlap, *J*= 6.0 Hz, 1 H), 3.90 (t, *J*= 6.0 Hz, 2 H), 7.26-7.57 (m, 2 H), 7.82-8.0 (m, 2 H); MS *m/z* (%) 221 (M^+, 6), 178 (339), 163 (784), 162 (349), 149 (873), 148 (206), 109 (246), 108 (162), 43 (1000); IR (film) 1510, 1435, 1120, 1080 cm^{-1}.

2*H*-2-methyl-1,4-benzothiazin-3(4*H*)-one (9).[17] Yellow solid, 64% yield, mp 119-122 °C; ^1H NMR (90 MHz, $CDCl_3$) δ 1.54 (d, *J*= 7.0 Hz, 3 H), 3.60 (q, *J*= 7.0 Hz, 1 H), 6.90-7.43 (m, 4 H), 10.08 (br s, exchanges with D_2O); MS *m/z* (%) 179 (M^+, 1000), 164 (342), 150 (154), 136 (949), 120 (459), 109 (210), 96 (184), 45 (198); IR (KBr) 1660, 1580, 1475, 1380 cm^{-1}.

1,2-Diphenyl-1,2-dibenzothiazolyl-ethene[18] (10). Waxy solid, see Table 1 for yield; ^1H NMR (90 MHz, $CDCl_3$) δ 7.16-7.53 (m, 14 H), 7.63-8.00 (m, 4 H); MS *m/z* (%) 448 (M^++2, 107), 446 (M^+, 904), 369 (415), 312 (370), 310 (176), 223 (99); IR (film) 1590, 1425, 1310, 1260 cm^{-1}.

2-Benzyl-1,3-benzothiazole (13).[19] Oil, 20% yield; ^{1}H NMR (90 MHz, $CDCl_3$) δ 4.45 (s, 2 H), 7.23-7.60 (m, 7 H), 7.73-8.10 (m, 2 H); MS *m/z* (%) 225 (M^+, 807), 224 (1000), 223 (181), 91 (246), 65 (173), 63 (105); IR (film) 1720, 1510, 1450, 1430 cm^{-1}.

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