butan-2-one, 75-97-8; $PdCl_2$, 7647-10-1; $CuCl_2$, 7447-39-4; $PdCl_2(HNMe_2)_2$, 52217-23-9.

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## A New Synthesis of the Benzothiazole Ring *via* Imidoyl Chlorides and Chloroformamidines


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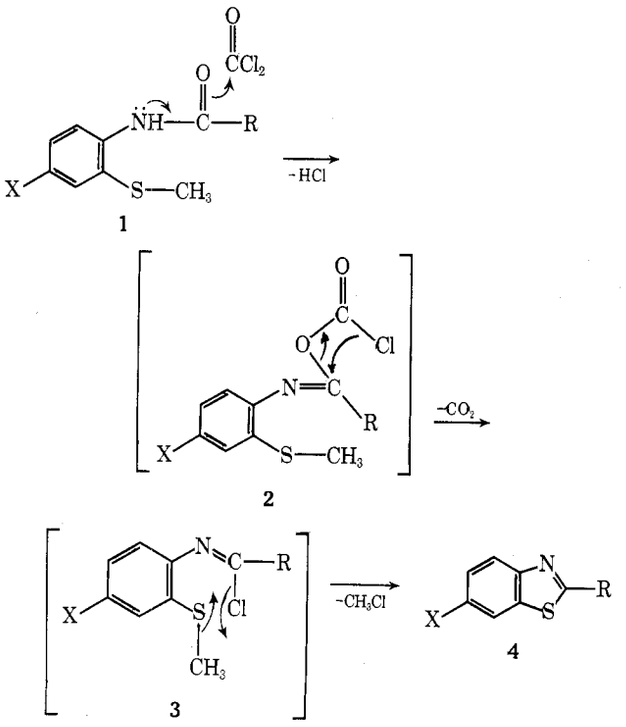
*Received June 14, 1974*

In an attempt to prepare a series of aromatic imidoyl chlorides as intermediates, 2′-(methylthio)acylanilides (**1**) were treated with phosgene in a manner similar to that reported for the preparation of imidoyl chlorides.[1] Although our attempt did not produce the desired imidoyl chlorides, *e.g.*, **3**, we did discover a convenient method of preparing 2-substituted benzothiazoles, **4**.

### Results and Discussion

As a model compound, 2′-(methylthio)acetanilide (**1a**) was converted with phosgene into 2-methylbenzothiazole (**4a**) in 86% yield. In a convenient procedure, the reactants were heated (80°) and stirred in *p*-dioxane. After 0.5 to 1 hr, the hydrochloride of 2-methylbenzothiazole was isolated. Prolonged heating (8 hr at 80–98°) brought about evolution of hydrogen chloride to give **4a** as the only detectable reaction product.



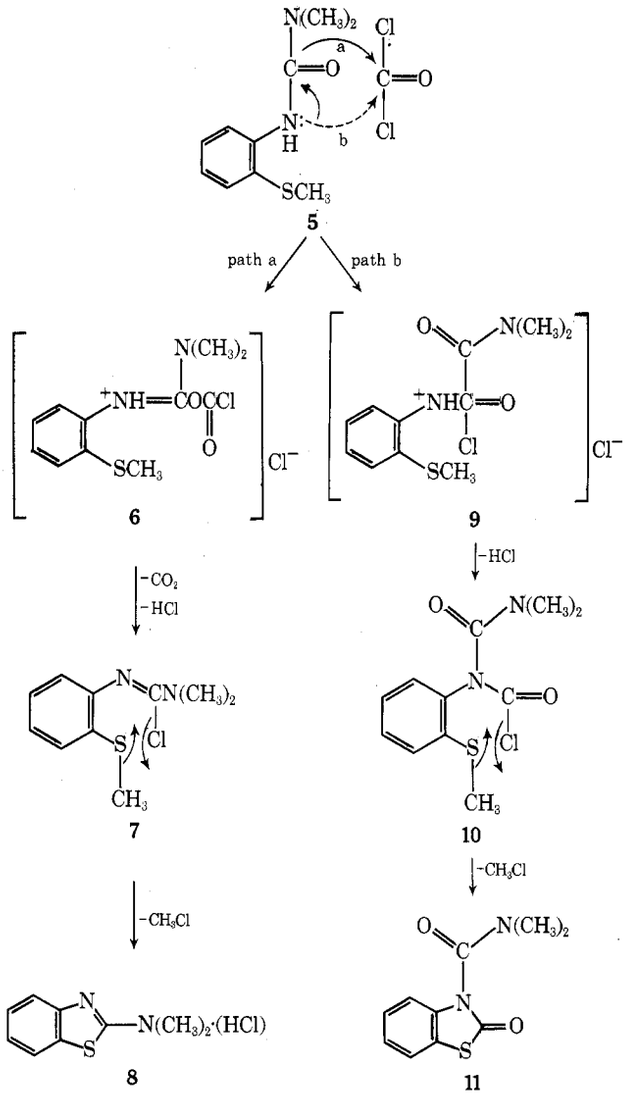
a, R = $CH_3$; X = H
b, R =  ; X = Cl
c, R = $CF_3$; X = H

4′-Chloro-2′-(methylthio)cyclopropanecarboxanilide (**1b**) reacted with phosgene in ethyl acetate at 50–55° (8 hr). Under these conditions, **4b** was obtained in 10% yield. No attempt was made to optimize the yield. The nmr spectrum of **4b** showed the expected proton count, shifts of three aromatic protons at 7–8 ppm, and the five cyclopropyl protons at $\delta$ 1.2 ($CH_2CH_2$) and 2.4 ppm (CH). Consistent with the structure of **4b**, the mass spectrum shows the correct molecular ion at *m/e* 209, 211 ($M^+$, base peak), indicating the presence of one chlorine atom in the molecule.

When 2′-(methylthio)trifluoroacetanilide (**1c**) was treated with phosgene under similar conditions, starting material, **1c**, was recovered unchanged after 96 hr at 80°. Attempted reaction with phosgene in refluxing toluene containing catalytic amounts of dimethylformamide was also unsuccessful. It was not possible to obtain 2-(trifluoromethyl)benzothiazole (**4c**) by either procedure.

The formation of benzothiazoles, **4**, from **1** and phosgene suggests that phosgene is attacked by the oxygen rather than the nitrogen of the anilide. O-Acylation of amides has been demonstrated.[2,3] Thus, the O-acylated intermediate, **2**, initially formed from **1** and phosgene apparently loses carbon dioxide and hydrogen chloride with formation of reactive imidoyl chloride,[1] **3**, which is converted into the benzothiazole, **4**, by loss of methyl chloride.

In a similar manner, the reaction of 1,1-dimethyl-3-(2′-(methylthio)phenyl)urea (**5**) with phosgene in *p*-dioxane was found to give the hydrochloride of the known 2-(di-



methylamino)benzohiazole[4] (8) in 39.7% yield in addition to 3-(dimethylcarbamoyl)benzothiazolin-2-one (11) in 60.2% yield. The structure of 11 is supported by elemental analysis, infrared spectroscopy, nmr and mass spectrum. Evidence for the structural assignment of 11 includes C=O absorption at 1755 $cm^{-1}$ in the infrared spectrum. The nmr spectrum contains two unsplit methyl signals at 3.05 and 3.15 ppm, whereas the aromatic region displays a multiplet at 7.1 ppm. In the mass spectrum of 11, the molecular ion is observed at *m/e* 222 ($M^+$). The initial fragmentation pattern is characterized by the loss from the parent ion of a carbonyl (C=O) and dimethylcarbamoyl group, $(CH_3)_2NCO$ (base peak), to give *m/e* 122.

The reaction of urea 5 with phosgene follows two major pathways. Initial attack by the urea oxygen (path a), similar to that which occurs in the anilide–carbonyl chloride reaction, gives chloroformamidine 7, as an intermediate *via* 6, which cyclocondenses to give 2-(dimethylamino)benzothiazole (8). Alternately, attack of phosgene by the urea nitrogen atom ($N^3$) affords the intermediate allophanoyl chloride 10 by way of 9; loss of methyl chloride from 10 gives 11 directly. The formation of intermediates analogous to 7 and 10 is well documented in the literature.[1,5]

## Experimental Section

**2′-(Methylthio)acetanilide (1a).** This compound was prepared in 90.1% yield from 2-aminothioanisole and acetyl chloride in tetrahydrofuran in the presence of triethylamine as acceptor for hydrogen chloride; colorless crystalline solid, mp 111–113° (lit.[6] mp 114–115°).

**4′-Chloro-2′-(methylthio)cyclopropanecarboxanilide (1b).** This compound was prepared in 95% yield from 2-amino-5-chlorothioanisole[7] and cyclopropanecarbonyl chloride as outlined above for 1a: mp 117–119°; ir (KBr) 3260 (NH) and 1655 $cm^{-1}$ (C=O); nmr ($CDCl_3$) δ 0.7–1.8 (5, m, cyclopropyl), 2.4 (3, s, $CH_3$), and 7–9 ppm (3, m, $C_6H_3$); mass spectrum (70 eV) *m/e* 243 ($M^+$), 196, 194 ($M^+ - CH_3S$), 175, 173 ($M^+ - C_3H_5CO$), 69 ($C_3H_5CO$), 41 ($C_3H_5$).

*Anal.* Calcd for $C_{11}H_{12}ClNOS$: C, 54.7; H, 5.0; N, 5.8. Found: C, 54.5; H, 5.4; N, 5.6.

**2′-(Methylthio)-2,2,2-trifluoroacetanilide (1c).** This compound was prepared analogously in 89.4% yield from 2-aminothioanisole and trifluoroacetyl chloride in the presence of 1 molar equiv of triethylamine: mp 45–47°; ir (KBr) 3220 (NH) and 1740 $cm^{-1}$ (C=O); nmr (DMSO-$d_6$) δ 2.4 (3, s, $CH_3$), 7.3 (4, q, $C_6H_4$), and 11.0 ppm (1, s, NH).

*Anal.* Calcd for $C_9H_8F_3NOS$: C, 46.0; H, 3.4; N, 6.0. Found: C, 45.7; H, 3.3; N, 5.7.

**2-Methylbenzothiazole Hydrochloride and 2-Methylbenzothiazole (4a).** To a stirred solution of 13.5 g (0.075 mol) of 1a in 200 ml of *p*-dioxane was added dropwise a solution of 30.0 g (0.30 mol) of phosgene (*caution: highly toxic*) in 50 ml of *p*-dioxane. The resulting yellow solution was heated to reflux (80–85°). After 3.5 hr, a sample was withdrawn, cooled, filtered, and dried to give a crystalline solid: mp 180–183°; ir (KBr) 2600 $cm^{-1}$ (HX-salt); nmr (DMSO-$d_6$) δ 2.9 (3, m, $CH_3$), 7–8.2 (4, m, aromatic H), and 12.2 ppm (1, m, HCl); mass spectrum (70 eV) *m/e* 149 ($M^+$ – HCl, base peak), 121, 117 ($M^+ - S$), 108 ($C_6H_4S^+$), 82, 75, 69, 63, 50, 45, 39.

*Anal.* Calcd for $C_8H_8ClNS$: C, 51.8; H, 4.3; N, 7.5; Cl, 19.1. Found: C, 51.4; H, 4.2; N, 7.3; Cl, 19.1.

After a heating period of 8 hr at 80–98°, thin layer chromatography indicated the complete disappearance of starting material, and hydrogen chloride evolution had ceased. The reaction mixture was concentrated under reduced pressure, washed with water, dissolved in ether, dried ($MgSO_4$), concentrated, and distilled to give 9.5 g (86%) of a colorless liquid: bp 128–130° (35 mm); bp 236° (760 mm) (lit.[8] bp 238°); nmr ($CDCl_3$) δ 2.8 (3, s, $CH_3$), and 7–8 ppm (4, m, aromatic H).

*Anal.* Calcd for $C_8H_7NS$: C, 64.4; H, 4.7; N, 9.4. Found: C, 64.4; H, 4.7; N, 9.4.

**6-Chloro-2-cyclopropylbenzothiazole (4b).** A solution of 19.0 g (0.079 mol) of 1b in 200 ml of ethyl acetate containing 30.0 g (0.30 mol) of phosgene was refluxed at 50–55° for 8 hr. In order to contain the low-boiling phosgene in the reaction flask, the reflux condenser was topped with a Dry Ice–acetone condenser. The solvent and excess phosgene were removed by distillation leaving a residue which crystallized from ethyl acetate to give 2.0 g (10%) of 4b, a colorless crystalline solid: mp 65–67°; nmr ($CDCl_3$) δ 1.2 [4, s, $(CH_2)_2$ cyclopropyl], 2.4 (1, m, CH cyclopropyl), and 7–8 ppm (3, m, CH aromatic); mass spectrum (70 eV) *m/e* 211, 209 ($M^+$, base peak), 210, 208 ($M^+$ – H), 196, 194, 185, 183 ($M^+$ – HCl), 142 ($ClC_6H_4S^+$), 107, 92, 75, 69, 63, 45, 41, 39; ir (KBr) no carbonyl bands, mostly phenyl bands.

*Anal.* Calcd for $C_{10}H_8ClNS$: C, 57.3; H, 3.8; N, 6.7. Found: C, 57.4; H, 3.9; N, 6.6.

**1,1-Dimethyl-3-(2′-(methylthio)phenyl)urea (5).** Reaction of 2-(methylthio)phenyl isocyanate with dimethylamine in benzene afforded 5 in 97% yield, mp 98–100°.

*Anal.* Calcd for $C_{10}H_{14}N_2OS$: N, 13.3; S, 15.3. Found: N, 13.5; S, 15.5.

**2-(Dimethylamino)benzothiazole (8) and 3-(Dimethylcarbamoyl)benzothiazolin-2(3*H*)-one (11).** A solution of 15.7 g (0.075 mol) of 5 in 200 ml of *p*-dioxane containing 30.0 g (0.30 mol) of phosgene was refluxed at 70° with stirring. After approximately 15 min, a colorless solid began to precipitate. After 12 hr, the mixture was cooled to 20° and filtered to give 6.4 g (39.7%) of the hydrochloride of 8: mp 234–235°; ir (KBr) 3500, 3420 (NH or OH), 2800 $cm^{-1}$ (bonded OH, NH, HX); nmr (DMSO-$d_6$, TFA-$d$) δ 3.6 [6, s, $(CH_3)_2$], and 7.5 ppm (4, m, aromatic H).

*Anal.* Calcd for $C_9H_{11}ClN_2S$: C, 50.3; H, 5.2; Cl, 16.5; N, 13.1. Found: C, 47.9; H, 5.4; Cl, 16.0; N, 12.5.

The above salt was dissolved in 50 ml of water and the solution was made basic by addition of aqueous sodium hydroxide to give 6.0 g (37.5%) of 8, a colorless crystalline solid: mp 82–83° and 88–90° (lit.[4] mp 87°); ir (KBr) bands at 1560, 1570, and 1605 $cm^{-1}$ (aromatic H); nmr ($CDCl_3$) δ 3.2 [6, s, $(CH_3)_2$], and 6.8–7.7 ppm (4, m, aromatic H).

*Anal.* Calcd for $C_9H_{10}N_2S$: C, 60.7; H, 5.6; N, 15.7. Found: C, 60.6; H, 5.7; N, 15.8.

The original filtrate was concentrated to dryness and triturated with hexane to give 10.0 g (60.2%) of 11, as a colorless crystalline solid: mp 80–82°; ir (KBr) 1600 (C=) and 1755 $cm^{-1}$ (C=O); nmr ($CDCl_3$) δ 3.05 and 3.15 [6, s, $(CH_3)_2$], and 7.1 ppm (4, m, aromatic H); mass spectrum (70 eV) *m/e* 222 ($M^+$), 150 [$M^+ - (CH_3)_2NCO$], 122 ($C_6H_4NS$), 106, 95, 78, 72 [$(CH_3)_2NCO$, base peak], 69, 56, 51, 45, 44, 42, 38, 15.

*Anal.* Calcd for $C_{10}H_{10}N_2SO_2$: C, 54.1; H, 4.5; N, 12.6. Found: C, 53.8; H, 4.5; N, 12.3.

**Registry No.**—1a, 6310-41-4; 1b, 52260-23-8; 1c, 52260-24-9; 4a, 120-75-2; 4a HCl, 52260-25-0; 4b, 52260-26-1; 5, 52260-27-2; 8, 4074-74-2; 8 HCl, 52260-28-3; 11, 52260-29-4; 2-aminothioanisole, 2987-53-3; acetyl chloride, 75-36-5; cyclopropanecarbonyl chloride, 4023-34-1; trifluoroacetyl chloride, 354-32-5; 2-(methythio)phenyl isocyanate, 52260-30-7; dimethylamine, 124-40-3.

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# Syntheses of Some Derivatives of Pyrrolo- and Thieno[2,3-*c*]quinoxaline and -quinoline

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*Received March 19, 1974*

The recent isolation of the elusive isobenzofuran (1a) and isoindole (1b) rounds out the identification of all the parent benzo[*c*] heterocycles 1.[1-3] In contrast, none of the parent naphtho[2,3-*c*] heterocycles 2 has been reported, although transient formation of 2b (R = H) and 2c (R = H) was demonstrated by trapping them with *N*-phenylmaleimide.[4,5] 1,3-Diphenylnaphtho[2,3-*c*]furan (2a, R = Ph)