A New Synthesis of 2,1-Benzisothiazoles

Gary M. Singerman

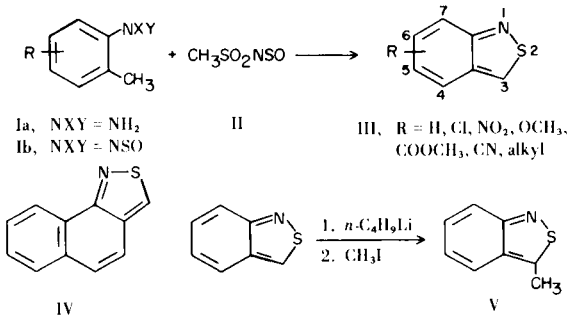
Gulf Research & Development Company, Pittsburgh, Pennsylvania 15230

Received April 18, 1975

A novel synthesis of 2,1-benzisothiazoles is described. When an *o*-toluidine or *N*-sulfinyl-*o*-toluidine is allowed to react with an *N*-sulfinylsulfonamide, a 2,1-benzisothiazole is formed.

2,1-Benzisothiazoles (III) are relatively inaccessible, even though the parent compound was first prepared in low yield 80 years ago (1). With the exception of specific syntheses of 3-amino-2,1-benzisothiazoles (2-4) and 3-hydroxy-2,1-benzisothiazole (5), one of the best general syntheses of 2,1-benzisothiazoles is that reported by Davis and White (6,7), a simple procedure involving cyclization of *o*-toluidines by thionyl chloride. Unfortunately, nuclear-chlorinated by-products, including chlorinated *o*-toluidines and 2,1-benzisothiazoles often are produced in this reaction, sometimes in greater quantity than the desired non-chlorinated product (7-10). For example, in the synthesis of unsubstituted 2,1-benzisothiazole itself from *o*-toluidine and thionyl chloride, Onaka and Oikawa (10) report 3-chloro-2,1-benzisothiazole to be the major reaction product together with smaller amounts of 5-chloro-2,1-benzisothiazole, 3,5-dichloro-2,1-benzisothiazole, 4-chloro-*o*-toluidine, and 2,1-benzisothiazole. Attempts to prepare 3-methyl-2,1-benzisothiazole from 2-ethylaniline and thionyl chloride have been unsuccessful (10,11), although 3-phenyl-2,1-benzisothiazole may be prepared in this fashion from 2-benzylaniline (11).

We now wish to report that *N*-sulfinylmethanesulfonamide (II) is generally superior to thionyl chloride as a reagent for cyclizing *o*-toluidines (Ia and *N*-sulfinyl-*o*-toluidines (Ib) to 2,1-benzisothiazoles (III). This represents an apparently novel utilization of *N*-sulfinylmethanesulfonamide. Yields range from fair to excellent and nuclear-chlorinated by-products are not produced. In addition to 2,1-benzisothiazole itself, a number of benzenoid ring-substituted derivatives have been prepared in this manner, as well as 3-methyl- and 3-phenyl-2,1-benzisothiazole. Attempts to prepare hydroxy- or amino-substituted 2,1-benzisothiazoles from the correspondingly substituted *o*-toluidines have been unsuccessful. The 3-methyl derivative (V) was also prepared by metallation of 2,1-benzisothiazole (III, R = H) with *n*-butyllithium followed by treatment of the resultant lithium derivative with methyl

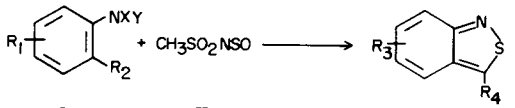


iodide. Naphth[1,2-*c*]isothiazole (IV) was prepared by interaction of 1-amino-2-methylnaphthalene with *N*-sulfinylmethanesulfonamide, and also by interaction of 2-methyl-1-sulfinylaminonaphthalene with *N*-sulfinylmethanesulfonamide.

Initially the cyclization reaction was effected thermally by heating a mixture of *N*-sulfinylmethanesulfonamide and an *o*-toluidine or *N*-sulfinyl-*o*-toluidine neat at 120-180° or in boiling mixed xylenes, but yields of 2,1-benzisothiazoles were poor. At lower temperatures almost no product was formed, and at higher temperatures tar formation predominated. It was subsequently discovered that pyridine markedly catalyzes the reaction, and much better yields of 2,1-benzisothiazoles were obtained by heating *N*-sulfinylmethanesulfonamide and the *o*-toluidine or *N*-sulfinyl-*o*-toluidine in boiling pyridine or in a boiling mixture of pyridine and benzene. The 2,1-benzisothiazoles prepared in this manner are listed in Table I. Little effort was expended to establish optimum reaction times. As seen in Table I, these vary from 1 to 72 hours. Table II lists elemental analyses, melting and boiling points for the 2,1-benzisothiazoles of Table I, while Table III lists the corresponding proton magnetic resonance spectra. The most striking feature in the pmr spectra of the 2,1-benzisothiazoles is the down-field absorption (8.75-10.05 δ) of the proton in the 3-position. This absorption appears as a singlet, finely split due to cross-ring coupling. Its exact

TABLE I

2,1-Benisothiazoles (III) from *N*-Sulfinylmethanesulfonamide (II) and 2-Alkyl-*N*-sulfinylanilines (I, NXY = NSO) or 2-Alkylanilines (I, NXY = NH_2)



I II III

Exp. No.	R_1	R_2	R_3	R_4	II (mol)	I (mol)	I (NXY)	Pyridine (mol)	Benzene (ml)	Reflux (hr)	III (%)
1	H	CH_3	H	H	0.110	0.070	NSO	0.100	80	18	60.4
2	H	CH_3	H	H	0.210	0.100	NH_2	0.100	50	16	27.4
3	4-Cl	CH_3	5-Cl	H	0.160	0.040	NH_2	0.080	70	65	88.9
4	5-Cl	CH_3	6-Cl	H	0.110	0.100	NSO	0.100	80	16	52.6
5	6-Cl	CH_3	7-Cl	H	0.110	0.100	NSO	0.100	80	19	86.5
6	6-Cl	CH_3	7-Cl	H	0.160	0.040	NH_2	0.080	70	64	84.0
7	3-NO_2	CH_3	4-NO_2	H	0.110	0.100	NSO	0.100	80	16	19.4
8	5-NO_2	CH_3	6-NO_2	H	0.160	0.040	NH_2	0.080	70	65	85.3
9	3-OCH_3	CH_3	4-OCH_3	H	0.160	0.132	NSO	0.120	150	60	29.0
10	3-OCH_3	CH_3	4-OCH_3	H	0.568	0.142	NH_2	0.284	210	65	17.9
11	4-OCH_3	CH_3	5-OCH_3	H	0.160	0.110	NSO	0.100	150	60	77.0
12	4-OCH_3	CH_3	5-OCH_3	H	0.160	0.041	NH_2	0.080	70	65	87.5
13	6-OCH_3	CH_3	7-OCH_3	H	0.360	0.330	NSO	0.310	300	72	39.1
14	H	C_2H_5	H	CH_3	0.100	0.100	NSO	100 ml	0	1	55.0
15	H	C_2H_5	H	CH_3	0.160	0.040	NH_2	0.080	70	65	6.0
16	4-CH_3	CH_3	5-CH_3	H	0.110	0.100	NSO	0.090	80	65	69.7
17	6-CH_3	CH_3	7-CH_3	H	0.110	0.100	NSO	0.090	80	65	87.1
18	5-CN	CH_3	6-CN	H	0.055	0.054	NSO	0.051	90	43	84.5
19	3-$COOCH_3$	CH_3	4-$COOCH_3$	H	0.130	0.120	NSO	0.110	250	45	65.1
20	5-$(CH_3)_3C$	CH_3	6-$(CH_3)_3C$	H	0.053	0.050	NSO	0.050	50	44	68.0
21	H	$C_6H_5CH_2$	H	C_6H_5	0.130	0.113	NSO	0.100	100	3.5	10.9

TABLE II

Elemental Analyses, Melting and Boiling Points for 2,1-Benzisothiazoles

Substituent	Molecular Formula	Analyses (Calcd. %/Found %) C	H	N	S	Cl,O	M.p. or B.p., °C. (mm)	Lit. M.p. or B.p. (mm) (h)
None	C_7H_5NS	62.19	3.73	10.36	23.72		60 (0.6)	68 (0.5) (7)
		62.39	3.70	10.56	23.51			
5-Cl (i)	C_7H_4ClNS	49.57	2.38	8.26	18.90	20.90 (a)	70-72 (c)	72 (7)
6-Cl	C_7H_4ClNS	49.57	2.38	8.26	18.90	20.90 (a)	67-69 (c),	71 (7)
		49.35	2.47	8.35	18.87	21.14	77 (0.3)	
7-Cl	C_7H_4ClNS	49.57	2.38	8.26	18.90	20.90 (a)	52-54 (c),	
		49.39	2.39	8.25	18.96	20.98	95 (0.3)	
4-NO_2	$C_7H_4N_2O_2S$	46.66	2.24	15.55	17.79	17.76 (b)	101.5-103.5 (c),	92 (15)
		46.39	2.26	15.70	17.87	17.72	109-110 (0.25)	
6-NO_2	$C_7H_4N_2O_2S$	46.66	2.24	15.55	17.79	17.76 (b)	148.5-150.5 (d)	149 (7)
		46.54	2.35	15.52	17.75	17.76		
4-OCH_3	C_8H_7NOS	58.16	4.27	8.48	19.41	9.68 (b)	91 (0.45)	
		58.07	4.31	8.59	19.06	9.82		
5-OCH_3	C_8H_7NOS	58.16	4.27	8.48	19.41	9.68 (b)	51-55 (e)	55 (9)
		58.37	4.25	8.47	19.35	9.85	94 (0.3)	
7-OCH_3	C_8H_7NOS	58.16	4.27	8.48	19.41		88-93 (0.3)	
		58.05	4.57	8.59	19.31			
3-CH_3	C_8H_7NS	64.40	4.73	9.39	21.49		55-57 (f)	55 (16)
		64.22	4.61	9.42	21.48		60-65 (0.1)	54-54.5 (10)
5-CH_3	C_8H_7NS	64.40	4.73	9.39	21.49		65-67 (0.24)	
		64.39	4.91	9.43	21.30			
7-CH_3	C_8H_7NS	64.40	4.73	9.39	21.49		68-69 (0.5)	106 (1.0) (7)
		64.43	4.81	9.21	21.24			
6-CN	$C_8H_4N_2S$	59.98	2.52	17.49	20.01		109-111 (g)	
		60.03	2.54	17.54	19.97			
4-$COOCH_3$	$C_9H_7NO_2S$	55.95	3.65	7.25	16.59	16.56 (b)	88-89 (e)	
		55.90	3.70	7.24	16.40	16.62		
6-$(CH_3)_3C$	$C_{11}H_{13}NS$	69.07	6.85	7.32			82 (0.35)	
		69.31	7.13	7.27				
3-C_6H_5	$C_{13}H_9NS$	73.90	4.29	6.63	15.17		140-141 (0.35)	56 (11,16),
		74.25	4.26	6.75	15.08			oil (17)

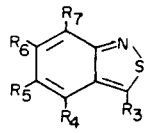
(a) *Anal.* for Cl. (b) *Anal.* for O. (c) From hexane. (d) From benzene-hexane. (e) Not recrystallized. (f) From pentane. (g) From heptane, then sublimed at 100° (0.2 mm). (h) Both mm and lit. reference are given in parentheses, the first being mm. When only one set of parentheses is shown, number enclosed is lit. reference. (i) Not analyzed. Instead, 5-Cl derivative also prepared from 4-chloro-2-methylaniline and thionyl chloride as in reference 7. A mixture m.p. of product from both methods showed no depression, and pmr spectra were identical.

position depends on the nature of the substituent group attached to the benzenoid ring and on solvent polarity.

The mechanism of the reaction is unclear. If one uses an *o*-toluidine as reactant instead of an *N*-sulfinyl-*o*-toluidine, the first step would almost certainly be rapid conversion of the *o*-toluidine by *N*-sulfinylmethanesulfonamide to an *N*-sulfinyl-*o*-toluidine (12,13). Thus whether one uses an *o*-toluidine or an *N*-sulfinyl-*o*-toluidine as reactant appears to be arbitrary, although in some cases the product mixture seemed cleaner and purification less tedious if one used an *N*-sulfinyl-*o*-toluidine as initial reactant. It was demonstrated experimentally that the *N*-sulfinyl-*o*-toluidine does not by itself cyclize to a 2,1-benzisothiazole in a boiling mixture of pyridine and benzene, nor does it cyclize when heated neat at 120-180°. Under identical conditions, but in the presence of *N*-sulfinylmethanesulfonamide, a 2,1-benzisothiazole is produced. The reaction is not specific to *N*-sulfinylmethanesulfonamide. *N*-Sulfinylbenzenesulfonamide and *N*-sulfinyl-*p*-toluenesulfonamide also cause cyclization of the *N*-sulfinyl-*o*-toluidine to a 2,1-benzisothiazole, but in limited experiments *N*-sulfinylmethanesulfonamide seemed to provide the cleanest, most easily purified products. This reagent was therefore used exclusively. A possible sequence for the cyclization step is one in which the *N*-sulfinyl-*o*-toluidine (Ib) and *N*-sulfinylmethanesulfonamide (II) interact to produce

TABLE III

Proton Magnetic Resonance Spectra of 2,1-Benzisothiazoles (a)

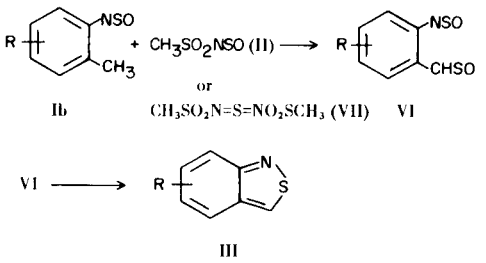


R_3	R_4	R_5	R_6	R_7
H	H	H	H	H
9.07 (S)	← 7.97-6.95 (M) →			
H	H	Cl	H	H
9.07 (S)	7.68 (S)	–	7.33 (D) (b)	7.79 (D)
H	H	H	Cl	H
9.10 (S)	7.58 (D)	7.07 (D) (b)	–	7.77 (S) (b)
H	H	H	H	Cl
9.17 (S)	←	7.53-6.73 (M)	→	–
H	NO_2	H	H	H
10.05 (S)	–	← 8.43-8.03 (M) + 7.73-7.20 (M) →		
H	H	H	NO_2	H
9.50 (S)	8.00 (S) (c)	8.00 (S) (c)	–	8.80 (S)
H	OCH_3	H	H	H
9.32 (S)	3.90 (S)	6.33 (D) (b)	← 7.55-7.15 (M) →	
H	H	OCH_3	H	H
8.75 (S)	6.76 (S) (b)	3.70 (S)	7.07 (D) (b)	7.65 (D)
H	H	H	H	OCH_3
9.06 (S)	←	7.37-6.47 (M)	→	3.97 (S)
CH_3	H	H	H	H
2.75 (S)	← 7.87-6.93 (M) →			
H	H	CH_3	H	H
8.87 (S)	7.33 (S) (b)	2.33 (S)	7.13 (D) (b)	7.69 (D)
H	H	H	H	CH_3
8.98 (S)	←	7.63-6.87 (M)	→	2.67 (S)
H	H	H	CN	H
9.40 (S)	7.92 (D)	7.35 (D) (b)	–	8.27 (S) (b)
H	$COOCH_3$	H	H	H
9.97 (S)	3.97 (S)	8.03 (D) (d)	7.48 (D) + 7.38 (D)	8.03 (D) (d)
H	H	H	$(CH_3)_3C$	H
9.10 (S)	7.73 (D)	7.36 (D) (b)	1.37 (S)	7.80 (S)
C_6H_5	H	H	H	H
← 8.00-7.08 (M) →				

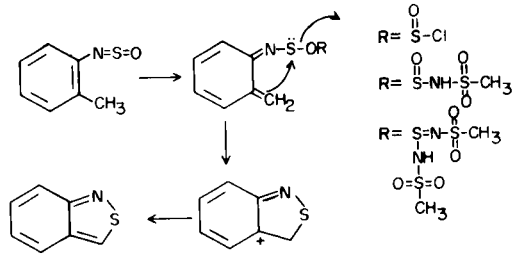
(a) Spectra were recorded on a Varian T60 spectrometer using deuteriochloroform as solvent and tetramethylsilane as internal reference standard. Chemical shift values (ppm in δ units) are given immediately below the proton(s) to which they refer. The multiplicity of each absorption is given in parenthese following the δ values as S = singlet, D = doublet, M = multiplet. Generally, the coupling constant between doublets is 8-9 cps. (b) Shows *meta* splitting. (c) The 4-H and 5-H protons are magnetically equivalent in deuteriochloroform and appear as one singlet. However, in a mixture of acetone-d_6 and DMSO-d_6, the pmr spectrum of 6-nitro-2,1-benzisothiazole shows absorption at 9.92 (S), 8.60 (S), 8.15 (D), and 7.90 (D). (d) The doublets for 5-H and 7-H are exactly superimposed.

intermediate VI (Scheme I). Intermediate VI then cyclizes with loss of sulfur dioxide to give the 2,1-benzisothiazole (III). This sequence is similar to that proposed by Davis and White (7) for cyclization of *o*-toluidine by thionyl chloride. However, it is known (14) that *N*-sulfinylmethanesulfonamide in presence of pyridine at room temperature converts to benzene-insoluble, crystalline bis-*N*-methanesulfonylsulfodiimide (VII). In most of the reactions reported herein, admixture of the *N*-sulfinyl-*o*-toluidine, *N*-sulfinylmethanesulfonamide, pyridine, and benzene initially gave a clear, homogeneous solution which precipitated a crystalline material, possible VII, within a few minutes. This material slowly dissolved when the reaction mixture was stirred and heated at reflux temperature. To investigate the possibility that VII is involved in cyclization of Ib to III, VII was prepared from equimolar amounts of II and pyridine in dry benzene in a manner similar to that described by Wucherpfennig and Kresze (14). It was isolated by suction filtration in a dry box under nitrogen, washed with benzene, and allowed to interact with *N*-sulfinyl-*o*-toluidine in boiling benzene. 2,1-Benzisothiazole was produced.

Scheme I



Scheme II



Another possible sequence (Scheme II) for the cyclization step accounts for the role of pyridine through its ability to abstract a proton from the methyl group adjacent to the NSO function. This sequence also accounts for the nuclear-chlorinated products obtained when thionyl chloride is used as the cyclizing reagent, since one would expect the intermediate aromatic carbonium ion to be susceptible to chloride ion attack. In the absence of a good nucleophile (by using *N*-sulfinylmethanesulfonamide), no such attack occurs (14a).

EXPERIMENTAL

Melting and boiling points (°C) are not corrected. Microanalyses were performed by Micro-Analysis, Inc., Wilmington, Delaware.

General Procedure for Synthesis of 2,1-Benzisothiazoles.

The following preparation of 2,1-benzisothiazole (Table I, Experiment No. 1) will serve as an example of the procedure used to prepare the 2,1-benzisothiazoles listed in Table I. In this case, a benzene solution of *N*-sulfinylmethanesulfonamide is added to a benzene solution of *N*-sulfinyl-*o*-toluidine at room temperature. When an *o*-toluidine instead of an *N*-sulfinyl-*o*-toluidine is used, as in Experiment No. 2, Table I, the only essential difference is that the benzene solution of the *o*-toluidine is thoroughly chilled in an ice bath before the benzene solution of *N*-sulfinylmethanesulfonamide is added because of the exothermic nature of the *trans*-sulfinylation reaction between the toluidine and the sulfinylsulfonamide.

To a solution of 10.7 g. (0.0699 mole) of *N*-sulfinyl-*o*-toluidine and 30 ml. of dry benzene in a 250 ml. single-neck round-bottom flask was added at room temperature a solution of 15.5 g. (0.11 mole) of *N*-sulfinylmethanesulfonamide and 30 ml. of dry benzene. The mixture was chilled in an ice bath and to it was added a solution of 7.9 g. (0.10 mole) of dry pyridine and 20 ml. of dry benzene. A white solid precipitated from the reaction mixture. After the reaction exotherm was dissipated in the ice bath, the mixture was stirred magnetically and heated at reflux temperature for 18 hours under a condenser fitted with a calcium sulfate drying tube. The white solid dissolved approximately 20 minutes after reflux temperature was reached. After completion of the reflux period, benzene and pyridine were removed from the reaction mixture by evaporation on a rotatory evaporator at 15-20 mm. The residue was chilled in an ice bath and to it was added 35 ml. of water. The mixture was allowed to stand at room temperature for 30 minutes with occasional swirling and was extracted with chloroform. The chloroform extract was dried over calcium sulfate. Calcium sulfate was removed by filtration and chloroform was removed from the filtrate by evaporation on a rotatory evaporator. The dark, oily residue was distilled to give 6.0 g. of a yellow oil, boiling range 50-60° (0.4 mm). The pmr spectrum of the distillate showed it to be principally 2,1-benzisothiazole containing small amounts of *N*-sulfinyl-*o*-toluidine and *o*-toluidine. Water (20 ml.) was added to the distillate and the mixture was acidified to approximately *p*H 4 with 50% aqueous hydrochloric acid. The acidic mixture was extracted with chloroform. The chloroform extract was dried, filtered, stripped of chloroform as before, and the residue was distilled to give 5.7 g. (60.4%) of pure 2,1-benzisothiazole as a light yellow oil, b.p. 60° (0.6 mm).

Preparation of 2,1-Benzisothiazole From Bis-*N*-methanesulfonylsulfodiimide (VII).

In a manner similar to that described by Wucherpfennig and Kresze (14) for the preparation of bis-*N*-sulfonylsulfodiimides, a solution of 14.1 g. (0.1 mole) *N*-sulfinylmethanesulfonamide and 50 ml. of dry benzene was thoroughly chilled in an ice bath. To it was added portionwise with swirling, a solution of 7.9 g. (0.1 mole) of dry pyridine and 20 ml. of dry benzene. Bis-*N*-methanesulfonylsulfodiimide precipitated. The mixture was removed from the ice bath, stoppered, and allowed to stand at room temperature overnight. The crystalline product (VII) was isolated by suction filtration under nitrogen in a dry box and washed with benzene. While still in the dry box and under nitrogen, 15 g. (0.068 mole) of VII was added to 80 ml. of dry benzene. To this was added 6.12 g. (0.04 mole) of *N*-sulfinyl-*o*-toluidine. The mixture was removed from the dry box, then stirred magnetically and heated at reflux temperature for 69 hours under a condenser fitted with a calcium sulfate drying tube. Benzene was then removed from the mixture by evaporation on a rotatory evaporator. Water (100 ml.) was added to the residue and the mixture was allowed to stand at room temperature 30 minutes with occasional swirling, then heated on a steam bath 10 minutes with swirling. After cooling, the mixture was extracted with chloroform. The chloroform extract was washed once with water and dried over calcium sulfate. Calcium sulfate was removed by filtration and chloroform was removed from the filtrate by evaporation on a rotatory evaporator. The pmr spectrum of the dark, oily residue showed it to be essentially pure 2,1-benzisothiazole. This was distilled to give 3.4 g. (63%) of pure 2,1-benzisothiazole as a light yellow oil, b.p. 55° (0.4 mm).

Preparation of 3-Methyl-2,1-Benzisothiazole from 2,1-Benzisothiazole.

A solution of 6.4 g. (0.0474 mole) of 2,1-benzisothiazole and 100 ml. of dry tetrahydrofuran was chilled thoroughly in a dry ice-acetone bath, while to it was added from a syringe 37.5 ml. of a 1.6 molar solution of *n*-butyllithium in hexane (0.06 mole *n*-butyllithium). After completion of addition, the reaction mixture was removed from the cooling bath and was stirred magnetically 30 minutes while being protected from atmospheric moisture with

a drying tube. The mixture was then placed in an ice-water bath and to it was added 8.5 g. (0.06 mole) of methyl iodide. After completion of addition, the mixture was stirred magnetically 1 hour at room temperature, then allowed to stand, stoppered, overnight at room temperature. Tetrahydrofuran was stripped from the mixture on a rotatory evaporator, and 100 ml. water was added to the residue. The mixture was extracted with ether, and the ethereal extract was dried over magnesium sulfate. Magnesium sulfate was removed by filtration and ether was stripped from the filtrate on a rotatory evaporator to give a black, viscous, oily residue. Its pmr spectrum showed it to be mainly 3-methyl-2,1-benzisothiazole containing a small amount of 2,1-benzisothiazole. This was distilled to give 3.1 g. of light yellow oil, boiling range 57-68° (0.2 mm). The distillate solidified in cold pentane (dry ice-acetone bath), and was then recrystallized from pentane to give 3-methyl-2,1-benzisothiazole as a white solid, m.p. 51-54°, undepressed when mixed with a sample of 3-methyl-2,1-benzisothiazole prepared as indicated in Table I (Experiment No. 14). The pmr spectrum of the product was identical to that of 3-methyl-2,1-benzisothiazole prepared according to the procedure of Table I.

Preparation of Naphth[1,2-*c*]isothiazole (IV).

A mixture of 8.88 g. (0.046 mole) of 2-methyl-1-sulfinylaminonaphthalene, 12.97 g. (0.092 mole) of *N*-sulfinylmethanesulfonamide, 3.6 g. (0.046 mole) of dry pyridine, and 50 ml. of dry benzene was prepared according to the general procedure, then stirred and heated at reflux temperature 48 hours under a condenser fitted with a calcium sulfate drying tube. Benzene and pyridine were removed from the reaction mixture by evaporation on a rotatory evaporator and 50 ml. of water was added to the residue. After standing 45 minutes at room temperature with occasional swirling, the mixture was acidified with 50% aqueous hydrochloric acid to *p*H 4 and extracted with chloroform. The chloroform extract was washed once with water and dried over calcium sulfate. After removing calcium sulfate by filtration and evaporating chloroform from the filtrate, there was obtained 7.7 g. of crude product which was shown by pmr to be contaminated with 2-methyl-1-sulfinylaminonaphthalene. The crude product was purified by eluting it through a column of basic alumina, first with hexane, then 50% benzene-hexane, finally with benzene. 2-Methyl-1-sulfinylaminonaphthalene was eluted first from the column, then mixtures of this with product, and finally pure product (IV). Impure fractions were rechromatographed so that a total of 5.3 g. (62.3%) pure IV was obtained as white needles, m.p. 69-71° after recrystallization from hexane, lit. (8) m.p. 66-66.5°. The pmr spectrum of IV in deuteriochloroform showed a singlet absorption at 8.90 ppm (δ) for the proton attached to the 3-position of the ring, and a complex multiplet absorption spread between 7.83 and 7.20 ppm for the remaining protons.

Anal. Calcd. for $C_{11}H_7NS$: C, 71.32; H, 3.81; N, 7.56; S, 17.31. Found: C, 71.27; H, 3.84; N, 7.50; S, 17.25.

In similar fashion, a mixture of 6.3 g. (0.04 mole) of 1-amino-2-methylnapthalene, 22.6 g. (0.16 mole) of *N*-sulfinylmethanesulfonamide, 6.3 g. (0.08 mole) of dry pyridine, and 70 ml. of dry benzene was prepared, stirred and heated at reflux temperature 46 hours, and processed as above to give 4.05 g. (54.7%) of IV.

Preparation of *N*-Sulfinylmethanesulfonamide (II).

A mixture of 53.4 g. of methanesulfonamide, 60 ml. of thionyl chloride, and 90 ml. of dry benzene was stirred magnetically and heated at reflux temperature 17 hours under a condenser fitted with a calcium sulfate drying tube. After cooling, benzene was removed from the mixture by evaporation on a rotatory evaporator and the residue was distilled to give 64.6 g. of *N*-sulfinylmethanesulfonamide as a yellow liquid, b.p. 86-88° (0.75 mm), lit. (13) b.p. 80-81° (10^{-4} mm). This material reacts violently with water, and care should be taken to protect it from atmospheric moisture which will rapidly hydrolyze it to methanesulfonamide. It may be safely stored under nitrogen at room temperature for several months in a closed glass container.

Preparation of *N*-Sulfinyl-*o*-toluidines.

These compounds were prepared according to the procedure of Kresze, *et al.* (12), by refluxing a mixture of a 2-alkylaniline, a slight excess of thionyl chloride, and dry benzene for a period of time ranging from 30 minutes to 24 hours, then removing benzene from the mixture by evaporation, usually on a rotatory evaporator. Liquid products were distilled (0.2-5.0 mm). Solid products were recrystallized from benzene or hexane.

REFERENCES

(1) S. Gabriel and T. Posner, *Ber.*, **28**, 1025 (1895); S. Gabriel and R. Stelzner, *ibid.*, **29**, 160 (1896).

(2) R. F. Meyer, B. L. Cummings, P. Bass, and H. O. J. Collier, *J. Med. Chem.*, **8**, 515 (1965).

(3) Badische Anilin- & Soda-Fabrik A. G. (by M. Seefelder and H. Armbrust), Belgium Patent 670, 652, April 7, 1966; through *Chem. Abstr.*, **66**, 65467q (1967).

(4) Parke, Davis & Company, Netherlands Patent Application 6,408,290, January 25, 1965; through *Chem. Abstr.*, **63**, 1768b (1965).

(5) A. H. Albert, R. K. Robins, and D. E. O'Brien, *J. Heterocyclic Chem.*, **10**, 413 (1973).

(6) M. Davis and A. W. White, *Chem. Commun.*, 1547 (1968).

(7) M. Davis and A. W. White, *J. Org. Chem.*, **34**, 2985 (1969).

(8) M. Davis, G. C. Ramsay, and L. J. Stephens, Aust. *J. Chem.*, **25**, 1355 (1972).

(9) M. Davis and K. S. L. Srivastava, *J. Chem. Soc. Perkin I*, 935 (1972).

(10) T. Onaka and T. Oikawa, Itsuu Kenkyusho Nempo, **16**, 53 (1971); *Chem. Abstr.*, 77, 48320w (1972).

(11) M. Davis, T. G. Paproth, and L. J. Stephens, *J. Chem. Soc. Perkin I*, 2057 (1973).

(12) G. Kresze, A. Maschke, R. Albrecht, K. Bederke, H. P. Patzschke, H. Smalla, and A. Trede, *Angew. Chem. Intern. Edit.*, **1**, 89 (1962).

(13) G. Kresze and W. Wucherpfennig, *ibid.*, **6**, 149 (1967).

(14) W. Wucherpfennig and G. Kresze, *Tetrahedron Letters*, 1671 (1966).

(14a) The author is indebted to Dr. Robert Volkmann of Central Research, Pfizer, Inc., Groton, Ct., for suggesting the mechanism outlined in Scheme II.

(15) M. Davis and A. W. White, *J. Chem. Soc. (C)*, 2189 (1969).

(16) J. Ashby and H. Suschitzky, *Tetrahedron Letters*, 1315 (1971).

(17) O. Aki, Y. Nakagawa, and K. Sirakawa, *Chem. Pharm. Bull. (Tokyo)*, **20**, 2372 (1972).