Preparation of 1λ⁴,2,4-Benzothiadiazines from *N*-Arylbenzamidines [1]

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N-Arylbenzamidines react with sulphenyl chlorides and *N*-chlorosuccinimide to give the cyclic sulphimides, 1λ⁴,2,4-benzothiadiazines (7), as the major products. Two examples of the analogous 1λ⁴,2,4-benzoselenadiazine system (8) have been prepared by a similar route. When the *ortho*-positions of the *N*-aryl group are blocked, or when an arylsulphenamide is used in place of the sulphenyl chloride in the preparation, the open-chain sulphimides (1) are isolated, but 4,4'-thiobismorpholine gives 1-morpholino-1λ⁴,2,4-benzothiadiazines (2) as the major products.

The reaction of *N*-chloro-amines, -amides, and -amidines with dialkyl sulphides and bases is a well-established method for the preparation of sulphimides.[2] We wished to explore the possibility of extending the reaction to sulphur nucleophiles such as sulphenamides, in which the substituents on sulphur were attached through heteroatoms. Having earlier found that amidines react efficiently with dialkyl sulphides and *N*-chlorosuccinimide to give imidoyl-sulphimides,[3] we chose to investigate analogous reactions between amidines and sulphenamides. The reactions gave not only the expected sulphimides, but also some cyclic ylides, 1λ⁴,2,4-benzothiadiazines. With an appropriate choice of reagents, the latter compounds became the major products of the reactions. In this paper we give details of these preparations and consider the likely mechanisms of the reactions.

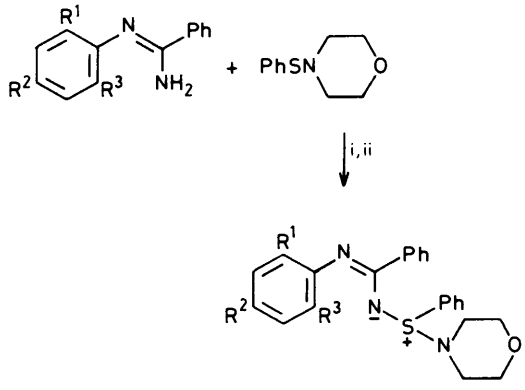
A series of reactions was performed in which *N*-arylbenzamidines were treated with 4-phenylthiomorpholine and *N*-chlorosuccinimide in dichloromethane at −20 °C. The reaction mixtures, after washing with aqueous alkali, gave the sulphimides (1) in moderate yields (Scheme 1); these were isolated as crystalline solids.

In two of these reactions, involving the preparation of compounds (1b) and (1d), minor products were isolated; these were subsequently identified as the benzothiadiazines (7c) and (7f), respectively.

Similar reactions were next attempted using 4,4'-thiobismorpholine in place of 4-phenylthiomorpholine. The products of these reactions proved to be not the acyclic sulphimides analogous to (1), but the cyclic ylides (2) (Scheme 2). The only exception was found with (2,6-dimethylphenyl)benzamidine, in which cyclisation is prevented by the *ortho*-methyl groups: the product isolated from this reaction proved to be the sulphimide (3). An analogous imidoyl-sulphimide (4) was also isolated in low yield from the reaction of *C*,*N*-diphenylacetamidine with 4,4'-thiobismorpholine and *N*-chlorosuccinimide.

The benzothiadiazine derivative (2b) has been reported previously: *N*-(4-chlorophenyl)benzamidine was treated with sulphur dichloride to give the 1-chlorobenzothiadiazine (5), which then gave compound (2b) on reaction with morpholine.[4] Because of a discrepancy between the literature value of the melting point of compound (2b) (167—168 °C) and our value (150—151 °C), we sought additional evidence for its structure. This was obtained by its acid-catalysed hydrolysis to the known [5] benzothiadiazine 1-oxide (6).

From these experiments it was established that the reactions could give either the open-chain imidoylsulphimides, or the cyclic 1λ⁴,2,4-benzothiadiazines, and that the nature of the products seemed to be very dependent on small structural variations in the substrates. On the assumption that a better leaving group on sulphur might favour the formation of cyclic ylides, we next investigated the reactions of the benzamidines with sulphenyl chlorides in place of sulphenamides. This assumption proved to be correct: the products, which were isolated in moderate to good yields, were 1-alkyl- or 1-aryl-1λ⁴,2,4-benzothiadiazines (7) (Scheme 3). Several of these ylides failed to crystallise and they were characterised as picrates. Further possible extensions of such reactions were indicated by the synthesis of the analogous 1λ⁴,2,4-benzoselenadiazines (8) by an analogous route.



(1)

Scheme 1. *Reagents*: i, *N*-chlorosuccinimide, −20 °C; ii, aq. NaOH

a; R^1 = Cl, R^2 = R^3 = H (37%)
b; R^1 = R^3 = H, R^2 = Cl (37%)
c; R^1 = Me, R^2 = R^3 = H (59%)
d; R^1 = R^3 = H, R^2 = Me (40%)
e; R^1 = R^3 = Me, R^2 = H (34%)

The structure of 1,3-diphenylbenzothiadiazine (7a) was established by an independent synthesis from 2-aminophenyl phenyl sulphide (Scheme 4). The product, an oil, was converted into its picrate, which was identical with the picrate of the compound produced from *N*-phenylbenzamidine and benzenesulphenyl chloride. The product was readily hydrolysed to the sulphoxide (9) in methanolic sulphuric acid.

The i.r. spectra of the solid 1λ⁴,2,4-benzothiadiazines (7) show a characteristic pattern of absorptions with maxima near 1 450, 1 300, 830, and 700 cm^{-1}. The 1-morpholino-1λ⁴,2,4-benzothiadiazines (2) have maxima near 1 460, 1 320, 1 290, 1 100, and 900 cm^{-1}. Both groups of benzothiadiazines

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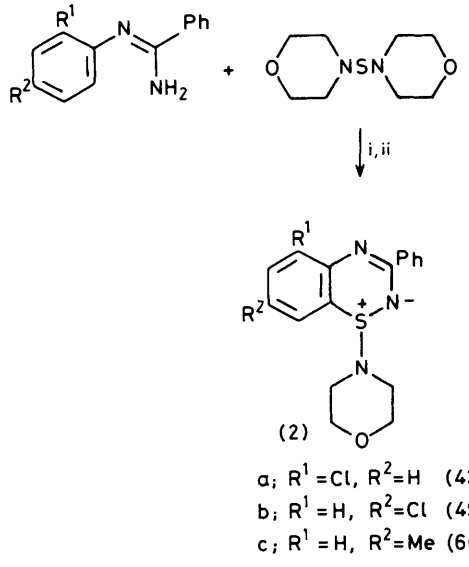
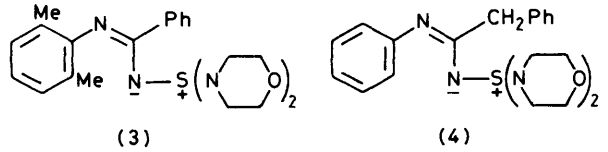
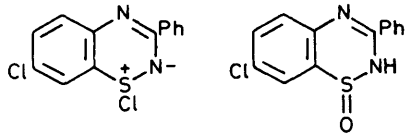
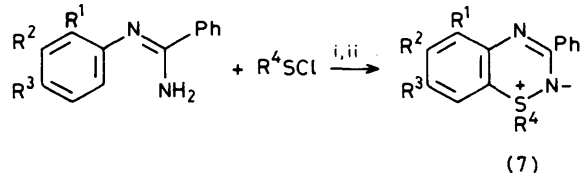


a; R^1 = Cl, R^2 = H (43%)
b; R^1 = H, R^2 = Cl (49%)
c; R^1 = H, R^2 = Me (60%)



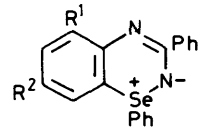
Scheme 2. *Reagents*: i, *N*-chlorosuccinimide, −20 °C; ii aq. NaOH



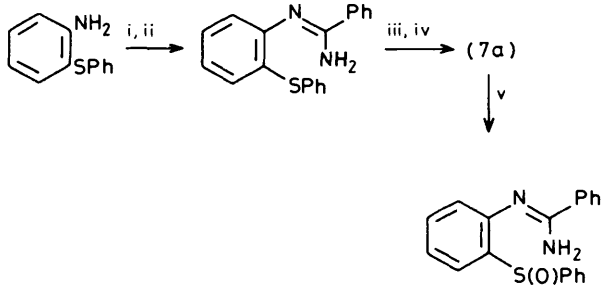


		R^1	R^2	R^3	R^4	Yield (%)
(7)	a;	H	H	H	Ph	56
	b;	Cl	H	H	Ph	60
	c;	H	H	Cl	Ph	62
	d;	Me	H	H	Ph	70
	e;	H	Me	H	Ph	63
	f;	H	H	Me	Ph	82
	g;	Me	H	Cl	Ph	45
	h;	H	H	H	C_6H_4Me-4	86
	i;	Cl	H	H	C_6H_4Me-4	57
	j;	H	H	Cl	C_6H_4Me-4	54
	k;	Me	H	H	C_6H_4Me-4	30
	l;	H	H	Me	C_6H_4Me-4	64
	m;	H	H	H	Me	
	n;	H	H	Me	Me	
	o;	Cl	H	H	Et	
	p;	H	H	Me	Et	

Scheme 3. *Reagents*: i, *N*-chlorosuccinimide; ii, aq. NaOH



(8) a; R^1 = Me, R^2 = H
b; R^1 = H, R^2 = Me

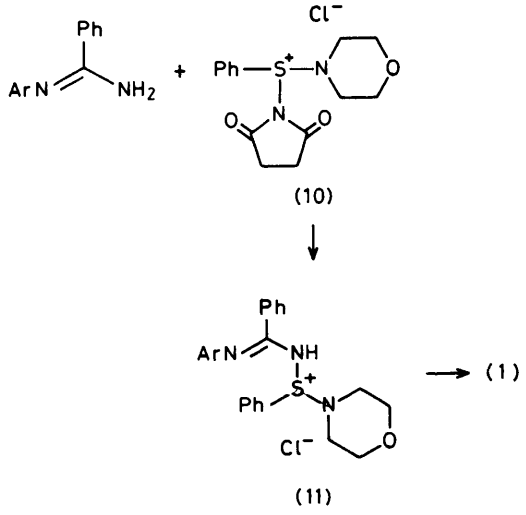


Scheme 4. *Reagents*: i, 4-$MeC_6H_4SO_3H$; ii, PhCN, 200 °C; iii, *N*-chlorosuccinimide; iv, aq. NaOH; v, HCl, MeOH

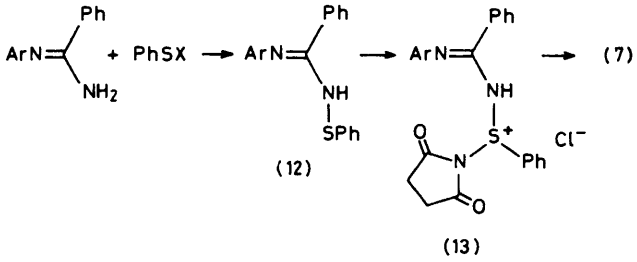
give molecular ions in the mass spectra, but the base peaks are normally derived from the molecular ions by the loss of the 1-substituents. 1-Aryl derivatives (7) show base peaks consistent with the loss of aryl radicals from the molecular ions, whereas those of the 1-alkyl derivatives are derived from the molecular ions by the loss of methylene or ethylene units. The 1-morpholine compounds (2) give base peaks at 86 mass units below the molecular ions, corresponding to the loss of morpholino-radicals.

By analogy with earlier work,[2,3] a likely route for the formation of the open sulphimides (1) is nucleophilic attack of the amidines on the sulphonium salt (10) (Scheme 5). We considered the possibility that the benzothiadiazines (7) which were isolated as by-products in some of these reactions were derived from the sulphimides (1) or their conjugate acids (11). The conversion of the sulphimide (1b) into (7c) could not, however, be effected either by heating it in solution or by stirring it with an excess of toluene-4-sulphonic acid at 0 °C. The cyclisation could be achieved under more forcing conditions (heating with toluene-4-sulphonic acid in toluene under reflux for 18 h) but these conditions were much more severe than those in which the benzothiadiazine (7c) was originally formed. It therefore seems likely that the by-products (7) are formed by an independent route. Possible alternative intermediates are the sulphenamides (12), which could be formed by reaction between 4-phenylthiomorpholine and the amidines. These sulphenamides would presumably be formed much more readily by the reaction of benzenesulphenyl chloride with the amidines. Oxidation at sulphur with *N*-chlorosuccinimide would then give intermediate sulphonium salts (13) which could, presumably, cyclise readily (Scheme 6). We attempted to test this possibility by carrying out an independent synthesis of an intermediate of type (12) by the reaction of *N*-(4-methylphenyl)benzamidine with benzenesulphenyl chloride. This gave an unstable oil which was not fully characterised, but which, on treatment with *N*-chlorosuccinimide, gave the benzothiadiazine (7f).

In the reactions involving 4,4′-thiobismorpholine the cyclic



Scheme 5



Scheme 6

ylides (2) are normally the major products; a route analogous to that shown in Scheme 6 can be envisaged for their formation. These reactions considerably extend the few known routes [4,5] to cyclic ylides of this type, and they are clearly capable of further extension.

Experimental

I.r. spectra were recorded for liquids as thin films on a Pye Unicam SP 100 instrument, and for solids as KBr discs on a Perkin-Elmer 125 spectrometer. ^{1}H N.m.r. spectra were obtained for solutions in $CDCl_3$ on a Perkin-Elmer R34B instrument (operating at 220 MHz). Mass spectra were measured using an A.E.I. MS12 spectrometer with a direct-insertion probe, at 70 eV. Kieselgel GF254 (Merck) was used for preparative t.l.c. M.p.s are uncorrected. Ether refers to diethyl ether.

N-Arylamidines were prepared by the general procedure of Oxley, Partridge, and Short,[6] from the appropriate aniline, benzonitrile, and aluminium chloride. Sulphenamides were prepared by dropwise addition of the sulphenyl chlorides in dry ether to solutions of the freshly distilled secondary amines in dry ether at 0 °C; the products were purified by distillation under reduced pressure. 4,4′-Thiobismorpholine [7] was prepared in a similar manner from freshly distilled sulphur dichloride and morpholine.

1-*Aryl*-1λ⁴,2,4-*benzothiadiazines* (7a—l). *General Procedure.*—A solution of the freshly distilled sulphenyl chloride (2 mmol) in dichloromethane (10 cm³) was added to a solution of the amidine (2 mmol) in dichloromethane (10 cm³) at −20 °C. The mixture was stirred at −20 °C for 45 min and *N*-chlorosuccinimide (2 mmol) in dichloromethane (10 cm³) was then added. The reaction mixture was stirred at −20 °C for 1 h and at room temperature for 18 h. The solution was washed with aqueous sodium hydroxide (10%; 50 cm³) and water, and was then dried and evaporated. The residual oil was subjected to layer chromatography (silica; hexane–ether, 3 : 7) and the yellow products were isolated. Those which failed to crystallise were characterised as picrates. The following compounds were prepared in this way.

(*a*) 1,3-*Diphenyl*-1λ⁴,2,4-*benzothiadiazine* (7a). This *compound* (56%) was obtained from benzenesulphenyl chloride and *N*-phenylbenzamidine as an oil; *m/e* 302 (M^+) and 225 (M^+ − Ph, base). It was characterised as its *picrate*, m.p. 173—175 °C (from acetone) (Found: C, 56.7; H, 3.4; N, 13.0. $C_{25}H_{17}N_5O_7S$ requires C, 56.5; H, 3.2; N, 13.2%); δ 7.35—7.85 (11 H, m), 8.09 (2 H, d, *ortho*-H on 3-Ph), 8.19 (1 H, d, *J* 8 Hz, 5-H), and 8.80 (2 H).

(*b*) 5-*Chloro*-1,3-*diphenyl*-1λ⁴,2,4-*benzothiadiazine* (7b). This *compound* (60%) was obtained from benzenesulphenyl chloride and *N*-(2-chlorophenyl)benzamidine as an oil; *m/e* 336 and 338 (M^+), and 259 and 261 (M^+ − Ph, base). It was characterised as its *picrate*, m.p. 152—153 °C (from acetone) (Found: C, 53.0; H, 3.1; N, 12.3. $C_{25}H_{16}ClN_5O_7S$ requires C, 53.0; H, 2.8; N, 12.4%); δ 7.45—7.75 (8 H, m), 7.80—7.87 (3 H, m), 8.05—8.10 (2 H, m), and 8.70 (2 H).

(*c*) 7-*Chloro*-1,3-*diphenyl*-1λ⁴,2,4-*benzothiadiazine* (7c). This *compound* (62%) was obtained from benzenesulphenyl chloride and *N*-(4-chlorophenyl)benzamidine; m.p. 122—123 °C (from ethanol) (Found: C, 67.7; H, 4.0; N, 8.2. $C_{19}H_{13}ClN_2S$ requires C, 67.7; H, 3.9; N, 8.3%); $\nu_{max.}$ 1 447, 1 430, 1 315, 1 266, 827, and 695 cm^{-1}; δ 7.35—7.55 (11 H, m) and 8.30—8.36 (2 H, m); *m/e* 336 and 338 (M^+), and 259 and 261 (M^+ − Ph), base.

(*d*) 5-*Methyl*-1,3-*diphenyl*-1λ⁴,2,4-*benzothiadiazine* (7d). This *compound* (70%) was obtained from benzenesulphenyl chloride and *N*-(2-tolyl)benzamidine as an oil; *m/e* 316 (M^+) and 239 (M^+ − Ph, base). It was characterised as its *picrate*, m.p. 156—157 °C (from acetone) (Found: C, 57.1; H, 3.5; N, 12.8. $C_{26}H_{19}N_5O_7S$ requires C, 57.2; H, 3.5; N, 12.8%); δ 2.85 (3 H), 7.25—7.93 (13 H, m), and 8.65 (2 H).

(*e*) 6-*Methyl*-1,3-*diphenyl*-1λ⁴,2,4-*benzothiadiazine* (7e). This *compound* (63%) was obtained from benzenesulphenyl chloride and *N*-(3-tolyl)benzamidine as an oil; *m/e* 316 (M^+) and 239 (M^+ − Ph, base). It was characterised as its *picrate*, m.p. 197—199 °C (from acetone) (Found: C, 57.2; H, 3.5; N, 12.8. $C_{26}H_{19}N_5O_7S$ requires C, 57.2; H, 3.5; N, 12.8%); δ 2.50 (3 H), 7.30—7.80 (10 H, m), 8.05—8.10 (3 H, m), and 8.80 (2 H).

(*f*) 7-*Methyl*-1,3-*diphenyl*-1λ⁴,2,4-*benzothiadiazine* (7f). This *compound* was obtained from benzenesulphenyl chloride and *N*-(4-tolyl)benzamidine; m.p. 137—138 °C (from ethanol) (Found: C, 75.7; H, 5.2; N, 8.7. $C_{20}H_{16}N_2S$ requires C, 75.9; H, 5.1; N, 8.9%); $\nu_{max.}$ 1 455, 1 312, 1 265, 831, and 698 cm^{-1}; δ 2.38 (3 H), 7.18 (1 H), 7.25—7.45 (10 H, m), and 8.30—8.37 (2 H, m); *m/e* 316 (M^+) and 239 (M^+ − Ph, base).

(*g*) 7-*Chloro*-5-*methyl*-1,3-*diphenyl*-1λ⁴,2,4-*benzothiadiazine* (7g). This *compound* (45%) was obtained from benzenesulphenyl chloride and *N*-(4-chloro-2-methylphenyl)benzamidine, m.p. 95—96 °C (from ethanol) (Found: C, 68.5; H, 4.5; N, 7.9. $C_{20}H_{15}ClN_2S$ requires C, 68.5; H, 4.3; N, 8.0%); $\nu_{max.}$ 1 478, 1 439, 1 280, 742, and 695 cm^{-1}; δ 2.55 (3 H), 7.28—7.50 (10 H, m), and 8.39—8.45 (2 H, m); *m/e* 350 and 352 (M^+), and 273 and 275 (M^+ − Ph, base).

(*h*) 1-(4-*Methylphenyl*)-3-*phenyl*-1λ⁴,2,4-*benzothiazine* (7h). This *compound* (86%) was obtained from 4-methylbenzenesulphenyl chloride and *N*-phenylbenzamidine as an oil; *m/e* 316 (M^+) and 225 (M^+ − C_7H_7, base). It was characterised

as its *picrate*, m.p. 172—173 °C (from acetone) (Found: C, 57.5; H, 3.5; N, 12.8. $C_{26}H_{19}N_5O_7S$ requires C, 57.2; H, 3.5; N, 12.8%); δ 2.45 (3 H), 7.38—7.84 (11 H, m), 8.05—8.10 (2 H, m), and 8.81 (2 H).

(*i*) 5-*Chloro*-1-(4-*methylphenyl*)-2-*phenyl*-1λ⁴,2,4-*benzothiadiazine* (7i). This *compound* (57%) was obtained from 4-methylbenzenesulphenyl chloride and *N*-(2-chlorophenyl)-benzamidine; m.p. 119—120 °C (from ethanol) (Found: C, 68.4; H, 4.4; N, 7.8. $C_{20}H_{15}ClN_2S$ requires C, 68.5; H, 4.3; N, 8.0%); $\nu_{max.}$ 1 465, 1 416, 1 325, 747, and 692 cm^{-1}; δ 2.28 (3 H), 7.10—7.70 (10 H, m), and 8.40—8.46 (2 H, m); *m/e* 350 and 352 (M^+) and 259 and 261 ($M^+ - C_7H_7$, base).

(*j*) 7-*Chloro*-1-(4-*methylphenyl*)-3-*phenyl*-1λ⁴,2,4-*benzothiadiazine* (7j). This *compound* (54%) was obtained from 4-methylbenzenesulphenyl chloride and *N*-(4-chlorophenyl)-benzamidine; m.p. 122—123 °C (from ethanol) (Found: C, 67.9; H, 4.4; N, 7.8. $C_{20}H_{15}ClN_2S$ requires C, 68.5; H, 4.3; N, 8.0%); $\nu_{max.}$ 1 472, 1 448, 1 315, 1 280, 1 265, 822, and 695 cm^{-1}; δ 2.30 (3 H), 7.15—7.50 (10 H, m), and 8.30—8.35 (2 H, m); *m/e* 350 and 352 (M^+) and 259 and 261 ($M^+ - C_7H_7$, base).

(*k*) 5-*Methyl*-1-(4-*methylphenyl*)-3-*phenyl*-1λ⁴,2,4-*benzothiadiazine* (7k). This *compound* (30%) was obtained from 4-methylbenzenesulphenyl chloride and *N*-(2-methylphenyl)-benzamidine as an oil; *m/e* 330 (M^+) and 239 ($M^+ - C_7H_7$, base). It was characterised as its *picrate*, m.p. 155 °C (from acetone) (Found: C, 58.2; H, 3.8; N, 12.6. $C_{27}H_{21}N_5O_7S$ requires C, 58.0; H, 3.8; N, 12.5%); δ 2.45 (3 H, 1-Me), 2.87 (3 H, 5-Me), 7.33—7.55 (7 H, m), 7.65—7.73 (3 H, m), 7.89 (2 H, d), and 8.68 (2 H).

(*l*) 7-*Methyl*-1-(4-*methylphenyl*)-3-*phenyl*-1λ⁴,2,4-*benzothiazine* (7l). This *compound* (64%) was obtained from 4-methylbenzenesulphenyl chloride and *N*-(4-methylphenyl)-benzamidine as an oil; *m/e* 330 (M^+) and 239 ($M^+ - C_7H_7$, base). It was characterised as its *picrate*, m.p. 180—182 °C (from acetone) (Found: C, 58.5; H, 3.8; N, 12.2. $C_{27}H_{21}N_5O_7S$ requires C, 58.0; H, 3.8; N, 12.5%); δ 2.51 (6 H), 7.37 (1 H, H-8), 7.50—7.80 (8 H, m), 8.15—8.23 (3 H, m), and 8.96 (2 H).

1-*Alkyl*-1λ⁴,2,4-*benzothiadiazines* (7m—p). *General Procedure*.—The appropriate amidine (1 mmol), *N*-chlorosuccinimide (2 mmol) and the dialkyl disulphide (0.5 mmol) were dissolved in dry dichloromethane (20 cm^3) and the solution was kept at room temperature for 18 h. It was then washed with aqueous sodium hydroxide (5%), dried, and evaporated to leave an unstable oil, which was used immediately in the other experiments. The following benzothiadiazines were also characterised as picrates.

(*a*) 1-*Methyl*-3-*phenyl*-1λ⁴,2,4-*benzothiadiazine* (7m). This *compound* had *m/e* 240 (M^+) and 226 ($M^+ - CH_2$, base); *picrate*, m.p. 142—146 °C (from acetone) (Found: C, 50.9; H, 3.45; N, 14.8. $C_{20}H_{15}N_5O_7S$ requires C, 51.2; H, 3.2; N, 14.9%); δ 3.00 (3 H), 7.25—7.60 (6 H, m), 7.75—7.85 (1 H, m), 8.05—8.15 (2 H, m), and 8.79 (2 H).

(*b*) 1,7-*Dimethyl*-3-*phenyl*-1λ⁴,2,4-*benzothiazine* (7n). This *compound* had *m/e* 254 (M^+) and 240 ($M^+ - CH_2$, base); *picrate* m.p. 171—172 °C (from acetone) (Found: C, 52.2; H, 3.7; N, 14.5. $C_{21}H_{17}N_5O_7S$ requires C, 52.2; H, 3.5; N, 14.5%); δ 2.49 (3H, 7-Me), H, 3.00 (3 H, 1-Me), 7.29 (1 H, 8-H), 7.40—7.65 (4 H, m), 8.00—8.15 (3 H, m), and 8.80 (2 H).

(*c*) 5-*Chloro*-1-*ethyl*-3-*phenyl*-1λ⁴,2,4-*benzothiadiazine* (7o). This *compound* had *m/e* 288 and 290 (M^+) and 260 and 262 ($M^+ - C_2H_4$, base); *picrate*, m.p. 92—95 °C (from acetone) (Found: C, 48.3; H, 3.4; N, 13.4. $C_{21}H_{16}ClN_5O_7S$ requires C, 48.7; H, 3.1; N, 13.5%); δ 1.45 (3 H, t), 3.60—3.83 (2 H, m), 7.45—7.70 (5 H, m), 7.87 (1 H, d), 8.05 (2 H, d), and 8.70 (2 H).

(*d*) 1-*Ethyl*-7-*methyl*-3-*phenyl*-1λ⁴,2,4-*benzothiadiazine* (7p). This *compound* had *m/e* 268 (M^+), 240 ($M^+ - C_2H_4$), and 137 (base); *picrate*, m.p. 179—181 °C (from acetone) (Found: C, 53.2; H, 4.0; N, 14.3. $C_{22}H_{19}N_5O_7S$ requires C, 53.1; H, 3.8; N, 14.1%); δ 1.41 (3 H, t), 2.45 (3 H), 3.35 (2 H, q), 7.23 (1 H), 7.39—7.60 (4 H, m), 7.98 (1 H, d), 8.08 (2 H, d), and 8.80 (2 H).

5-*Methyl*-1,3-*diphenyl*-1λ⁴,2,4-*benzoselenadiazine* (8a).—*N*-(2-Methylphenyl)benzamidine (0.420 g, 2.0 mmol) and diphenyl diselenide (0.312 g, 1.0 mmol) were dissolved in dry dichloromethane at room temperature, and to the solution was added *N*-chlorosuccinimide (0.532 g, 4.0 mmol). The resulting orange solution was stirred overnight, then washed with aqueous sodium hydroxide (5%) and water and dried. Evaporation gave the *benzoselenadiazine* (0.543 g, 75%) as an oil; *m/e* 362, 364, and 366 (M^+), and 104 (base); *picrate*, m.p. 147—149 °C (from acetone) (Found: C, 52.9; H, 3.1; N, 11.8. $C_{26}H_{19}N_5O_7Se$ requires C, 52.7; H, 3.2; N, 11.8%); δ 2.80 (3 H), 7.30—7.75 (11 H, m), 7.80—7.85 (2 H, m), and 8.65 (2 H).

7-*Methyl*-1,3-*diphenyl*-1λ⁴,2,4-*benzoselenadiazine* (8b).—The compound was prepared as in the preceding description from *N*-(4-methylphenyl)benzamidine (0.420 g, 2.0 mmol). It was isolated (75%) as a solid by trituration of the product mixture with ethanol. Crystallisation gave the *benzoselenadiazine*, m.p. 165—166 °C (from ethanol) (Found: C, 66.3; H, 4.6; N, 7.8. $C_{20}H_{16}N_2Se$ requires C, 66.1; H, 4.4; N, 7.7%); $\nu_{max.}$ 1 455, 1 425, 1 310, 1 275, 830, and 695 cm^{-1}; δ 2.40 (3 H), 7.25 (1 H), 7.35—7.45 (10 H, m), and 8.25—8.32 (2 H, m); *m/e* 362, 364 and 366 (M^+) and 104 (base).

Reactions of Amidines with N-*Chlorosuccinimide and* 4,4'-*Thiobismorpholine. General Procedure*.—A solution of thiobismorpholine (5 mmol) in dry dichloromethane (20 cm^3) was added dropwise to a solution of *N*-chlorosuccinimide (5 mmol) in dichloromethane (10 cm^3) at −20 °C. After 10 min a solution of the amidine (5 mmol) in dichloromethane (30 cm^3) was added dropwise. The reaction mixture was stirred at −20 °C for 1 h then allowed to warm to room temperature. It was washed with aqueous sodium hydroxide (10%) and water; the organic phase was then dried and evaporated. The components of the residue were isolated as follows. (*a*) *N*-(2-Chlorophenyl)benzamidine gave, by crystallisation of the crude reaction product, 5-*chloro*-1-*morpholino*-3-*phenyl*-1λ⁴,2,4-*benzothiadiazine* (2a) (43%), m.p. 129—130 °C (from ethanol) (Found: C, 58.75; H, 4.5; N, 11.9. $C_{17}H_{16}ClN_3OS$ requires C, 59.0; H, 4.6; N, 12.2%); $\nu_{max.}$ 1 470, 1 425, 1 325, 1 290, 1 105, and 925 cm^{-1}; δ 2.85—2.95 (4 H, m), 3.55—3.65 (4 H, m), 7.25—7.40 (2 H, m), 7.47—7.55 (3 H, m), 7.67 (1 H, dd, *J* 2.5 and 7 Hz), and 8.43—8.50 (2 H, m); *m/e* 345 and 347 (M^+), and 259 and 261 ($M^+ - C_4H_8NO$, base). (*b*) *N*-(4-Chlorophenyl)benzamidine gave, by trituration of the crude reaction product with light petroleum followed by crystallisation of the residue, 7-*chloro*-1-*morpholino*-3-*phenyl*-1λ⁴,2,4-*benzothiadiazine* (2b) (49%), m.p. 150—151 °C (from ethanol) (Found: C, 59.3; H, 4.5; N, 12.3. $C_{17}H_{16}ClN_3OS$ requires C, 59.0; H, 4.6; N, 12.2%); $\nu_{max.}$ 1 467, 1 435, 1 320, 1 287, 1 100, and 896 cm^{-1}; δ 2.85—2.95 (4 H, m), 3.55—3.65 (4 H, m), 7.38—7.63 (6 H, m), and 8.30—8.40 (2 H, m); *m/e* 345 and 347 (M^+), and 259 and 261 ($M^+ - C_4H_8NO$, base). (*c*) *N*-(4-Methylphenyl)benzamidine gave, by crystallisation of the crude reaction product 7-*methyl*-1-*morpholino*-3-*phenyl*-1λ⁴,2,4-*benzothiadiazine* (2c) (60%), m.p. 156—157 °C (from ethanol) (Found: C, 66.1; H, 5.9; N, 12.8. $C_{18}H_{19}N_3OS$ requires C, 66.45; H, 5.9; N, 12.9%); $\nu_{max.}$ 1 462, 1 320, 1 287, 1 252, 1 103, and 897 cm^{-1}; δ 2.44

(3 H), 2.83—2.93 (4 H, m), 3.55—3.65 (4 H, m), 7.40—7.50 (6 H, m), and 8.30—8.40 (2 H, m); *m/e* 325 (M^+) and 239 ($M^+ - C_4H_8NO$, base). (*d*) *N*-(2,6-Dimethylphenyl)benzamidine gave, by layer chromatography (silica; methanol), N-[N-(2,6-*dimethylphenyl*)*benzimidoyl*]-S,S-*bismorpholinosulphimide* (3) (25%), m.p. 155 °C (from ethanol) (Found: C, 64.5; H, 6.9; N, 12.9. $C_{23}H_{30}N_4O_2S$ requires C, 64.8; H, 7.1; N, 13.1%); $\nu_{max.}$ 1 540, 1 305, 1 105, and 910 cm^{-1}; δ 2.09 (6 H), 3.20—3.40 (8 H, m, br), 3.70—3.90 (8 H, m, br), 6.77 (1 H, t, *J* 8 Hz), 6.92 (2 H, d, *J* 8 Hz), 7.10—7.30 (3 H, m), and 7.35—7.50 (2 H, m); *m/e* 426 (M^+), 341 ($M^+ - C_4H_7NO$), and 208 (base). (*e*) *N*,2-Diphenylacetamidine gave, by trituration of the crude reaction product with ethanol followed by crystallisation, N-(N,2-*diphenylacetimidoyl*)-S,S-*dimorpholinosulphimide* (4) (23%), m.p. 136—137.5 °C (from ethanol) (Found: C, 64.1; H, 6.6; N, 13.5. $C_{22}H_{28}N_4O_2S$ requires C, 64.1; H, 6.8; N, 13.6%); $\nu_{max.}$ 1 560, 1 325, 1 100, and 920 cm^{-1}; δ 2.95—3.10 (4 H, m), 3.10—3.25 (4 H, m), 3.61 (2 H), 3.65—3.75 (8 H, m), 6.80 (2 H, d, *J* 8 Hz), 6.98 (1 H, t, *J* 8 Hz), 7.15—7.20 (5 H, m), and 7.26 (2 H, t, *J* 8 Hz); *m/e* 412 (M^+), 327 ($M^+ - C_4H_7NO$), and 194 (base).

Reactions of Amidines with N-*Chlorosuccinimide and* 4-*Phenylthiomorpholine. General Procedure.*—A solution of 4-phenylthiomorpholine (5 mmol) in dry dichloromethane (20 cm^3) was added dropwise to a solution of *N*-chlorosuccinimide (5 mmol) in dichloromethane (10 cm^3) at −20 °C. After 0.5 h a solution of the amidine (5 mmol) in dichloromethane (30 cm^3) was added dropwise. The reaction mixture was stirred at −20 °C for 1 h and then at room temperature for 18 h. It was washed with aqueous sodium hydroxide (10%) and water, and the organic phase was separated, dried, and evaporated. The components of the residue were separated by layer chromatography [silica; ether–hexane (7 : 3)]. (*a*) *N*-(2-Chlorophenyl)benzamidine gave N-[N-(2-*chlorophenyl*)-*benzimidoyl*]-S-*morpholino*-S-*phenylsulphimide* (1a) (37%), m.p. 155—156 °C (from ethanol) (Found: C, 65.0; H, 5.2; N, 9.5. $C_{23}H_{22}ClN_3OS$ requires C, 65.2; H, 5.2; N, 9.9%); $\nu_{max.}$ 1 540, 1 325, 1 105, and 915 cm^{-1}; δ 3.22—3.45 (4 H, m), 3.69—3.85 (4 H, m), 6.57 (1 H, d, *J* 8 Hz), 6.79 (1 H, t, *J* 8 Hz), 6.93 (1 H, t, *J* 8 Hz), 7.18—7.33 (4 H, m), 7.43—7.60 (5 H, m), and 8.00—8.10 (2 H, m); *m/e* 423 and 425 (M^+), 338 and 340 ($M^+ - C_4H_7NO$), and 109 (base). (*b*) *N*-(4-Chlorophenyl)benzamidine gave N-[N-(4-*chlorophenyl*)*benzimidoyl*]-S-*morpholino*-S-*phenylsulphimide* (1b) (37%), m.p. 162—164 °C (from ethanol) (Found: C, 65.5; H, 5.3; N, 10.0. $C_{23}H_{22}ClN_3OS$ requires C, 65.2; H, 5.2; N, 9.9%); $\nu_{max.}$ 1 525, 1 327, 1 105, and 920 cm^{-1}; δ 3.25—3.39 (4 H, m), 3.73—3.82 (4 H, m), 6.66 (2 H, d, br), 7.06 (2 H, d, *J* 8.2 Hz), 7.23—7.30 (3 H, m), 7.40—7 50 (2 H, m), 7.50—7.65 (3 H, m), and 7.97—8.10 (2 H, m); *m/e* 423 and 425 (M^+), 338 and 340 ($M^+ - C_4H_7NO$), and 109 (base). A second product was identified as 7-chloro-1,3-diphenyl-1λ⁴,2,4-benzothiadiazine (7c) (4%). (*c*) *N*-(2-Methylphenyl)benzamidine gave N-[N-(2-*methylphenyl*)-*benzimidoyl*]-S-*morpholino*-S-*phenylsulphimide* (1c) (59%), m.p. 143—146 °C (from ethanol) (Found: C, 71.7; H, 6.3; N, 10.2. $C_{24}H_{25}N_3OS$ requires C, 71.4; H, 6.25; N, 10.4%); $\nu_{max.}$ 1 541, 1 325, 1 100, and 917 cm^{-1}; δ 2.17 (3 H), 3.20—3.30 (4-H, m), 3.68—3.78 (4 H, m), 6.48 (1 H, d, *J* 8 Hz), 6.76 (1 H, t, *J* 8 Hz), 6.89 (1 H, t, *J* 8 Hz), 7.03 (1 H, d, *J* 8 Hz), 7.14—7.25 (3 H, m), 7.35—7.50 (2 H, m), 7.50—7.56 (3 H, m), and 8.00—8.05 (2 H, m); *m/e* 403 (M^+), 318 ($M^+ - C_4H_7NO$), and 109 (base). (*d*) *N*-(4-Methylphenyl)benzamidine gave N-[N-(4-*methylphenyl*)*benzimidoyl*]-S-*morpholino*-S-*phenylsulphimide* (1d) (40%), m.p. 149—157 °C (from ethanol) (Found: C, 71.2; H, 6.4; N, 10.2. $C_{24}H_{25}N_3OS$ requires C, 71.4; H, 6.25; N, 10.4%); $\nu_{max.}$ 1 545, 1 322, 1 105, and 911 cm^{-1}; δ 2.24 (3 H), 3.25—3.40 (4 H, m), 3.73—3.83 (4 H, m), 6.60—6.70 (2 H, m), 6.93 (2 H, d, *J* 8.2 Hz), 7.20—7.30 (3 H, m), 7.42—7.50 (2 H, m), 7.50—7.59 (3 H, m), and 8.00—8.10 (2 H, m); *m/e* 403 (M^+), 318 ($M^+ - C_4H_7NO$) and 109 (base). A second product from the reaction mixture was identified as 7-methyl-1,3-diphenyl-1λ⁴,2,4-benzothiadiazine (7f) (28%). (*e*) *N*-(2,6-Dimethylphenyl)benzamidine gave N-[N-(2,6-*dimethylphenyl*)*benzimidoyl*]-S-*morpholino*-S-*phenylsulphimide* (1e) (34%), m.p. 113.5—114 °C (from ethanol) (Found: C, 71.8; H, 6.7; N, 9.9. $C_{25}H_{27}N_3OS$ requires C, 71.9; H, 6.5; N, 10.1%); $\nu_{max.}$ 1 540, 1 315, 1 105, and 910 cm^{-1}; δ 1.95 (3 H), 2.25 (3 H), 3.15—3.35 (4 H, m), 3.65—3.85 (4 H, m), 6.76 (1 H, t, *J* 8 Hz), 6.87 (1 H, d, *J* 8 Hz), 6.97 (1 H, d, *J* 8 Hz), 7.15—7.30 (3 H, m), 7.44—7.60 (5 H, m), and 8.05—8.15 (2 H, m); *m/e* 417 (M^+), 332 ($M^+ - C_4H_7NO$), and 208 (base).

Independent Synthesis of 1,3-*Diphenyl*-1λ⁴,2,4-*benzothiadiazine* (7a).—2-Aminophenyl phenyl sulphide [8] was converted into its toluene-4-sulphonate salt by adding it to toluene-4-sulphonic acid in hot ethanol. The toluene-4-sulphonate (1.0 g) and benzonitrile (0.5 g) were heated together for 2 h at 200 °C. The reaction mixture was cooled and taken up in hot water (200 cm^3). The solution was basified and extracted with dichloromethane (3 × 50 cm^3) to give *N*-(2-phenylthiophenyl)-benzamidine (0.50 g, 60%), m.p. 104 °C (lit.,[9] 103—104.5 °C) (Found: C, 74.7; H, 5.1; N, 8.9. Calc. for $C_{19}H_{16}N_2S$: C, 75.0; H, 5.3; N, 9.2%); $\nu_{max.}$ 3 460, 3 300, 1 620, and 1 560 cm^{-1}; δ 4.60—5.20 (2 H), 6.95—7.50 (12 H, m), and 7.75—7.85 (2 H, m).

The amidine (100 mg) and *N*-chlorosuccinimide (44 mg) were stirred together in dichloromethane (10 cm^3) for 18 h at 20 °C. The reaction mixture was washed with aqueous sodium hydroxide and water, then dried and evaporated to leave an oil. Layer chromatography (silica; ether) gave the benzothiadiazine (90 mg, 91%); picrate, m.p. and mixed m.p. 173—175 °C.

Hydrolysis of Cyclic Sulphimides.—(*a*) 1,3-*Diphenyl*-1λ⁴,2,4-*benzothiadiazine* (7a). The sulphimide (188 mg) was heated in methanol (100 cm^3) containing sulphuric acid (6 drops) for 1 h. The solution was cooled, neutralised, and evaporated and the residue was extracted with dichloromethane to give N-(2-*phenylsulphinylphenyl*)*benzamidine* (9) (155 mg, 78%), m.p. 65—67 °C (from toluene–hexane) (Found: C, 71.3; H, 5.1; N, 8.5. $C_{19}H_{16}N_2OS$ requires C, 71.2; H, 5,0; N, 8.7%); $\nu_{max.}$ 3 410 and 3 220 (NH), 1 635, 1 570, and 1 010 cm^{-1}; δ 4.65—4.90 (2 H), and 6.90—8.10 (14 H, m); *m/e* 320 (M^+) and 304.

(*b*) 7-*Chloro*-1-*morpholino*-3-*phenyl*-1λ⁴,2,4-*benzothiadiazine* (2b). The sulphimide (120 mg) was hydrolysed by the method described in (*a*) and gave 7-chloro-3-phenyl-2*H*-1,2,4-benzothiadiazine 1-oxide (6) (45 mg, 47%), m.p. 239—240 °C (from ethanol) (lit.,[5] 240 °C).

7-*Methyl*-1,3-*diphenyl*-1λ⁴,2,4-*benzothiadiazine* (7f) *from* N-[N-(4-*Methylphenyl*)*benzimidoyl*]*benzenesulphenamide* (12; Ar = 4-MeC_6H_4).—Freshly distilled benzenesulphenyl chloride (1.30 g, 9.0 mmol) in ether (20 cm^3) was added dropwise to a solution of *N*-(4-methylphenyl)benzamidine (3.80 g, 18.0 mmol) in ether (200 cm^3) at 0 °C. After a further 0.5 h the solid precipitate was filtered off and the filtrate was evaporated to leave an oil (2.7 g). The oil gave spectra which were consistent with its formulation as the sulphenamide (12; Ar = 4-MeC_6H_4); δ 2.31 (3 H), 4.55 (1 H, br), 6.89 (2 H, d, *J* 8 Hz), 7.15 (2 H, d, *J* 8 Hz), 7.20—7.55 (8 H, m), and 7.80—7.90 (2 H, m); *m/e* 318 (M^+, base) and 285. It decomposed on attempted purification by distillation or by layer chromatography. The compound (43 mg) and *N*-chloro-

succinimide (18 mg) were stirred at room temperature for 1 h in dichloromethane (10 cm^3); after washing with base and layer chromatography, 7-methyl-1,3-diphenyl-1λ^4,2,4-benzothiadiazine (7f) (30 mg, 70%) was isolated, m.p. 137—138 °C (from ethanol).

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