Synthesis of 5-(Substituted Phenyl) 4-Acetyl-2-methylthio-Δ²-1,3,4-thiadiazolines and their Oxidation with Potassium Permanganate

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The reaction of aldehyde methylthio(thiocarbonyl)hydrazones (2) with acetic anhydride or acetyl chloride gave 5-(substituted phenyl) 4-acetyl-2-methylthio-Δ²-1,3,4-thiadiazolines (3). Oxidation of compounds (3) with potassium permanganate in acetic acid furnished 5-aryl-2-methylsulphonyl-1,3,4-thiadiazoles (4), 4-acetyl-5-aryl-2-methylsulphonyl-Δ²-1,3,4-thiadiazolines (5), and 4-acetyl-5-aryl-2-methylsulphonyl-Δ²-1,3,4-thiadiazoline 1,1-dioxides (6).

Recently, we have reported that the reaction of benzaldehyde thiosemicarbazone with acetic anhydride or acetyl chloride gave 2-acetamido-4-acetyl-5-phenyl-Δ²-1,3,4-thiadiazoline (1) which was oxidized with potassium permanganate in acetic acid to 2-acetamido-5-phenyl-1,3,4-thiadiazole.[1] We now report the application of this new route to 1,3,4-thiadiazole derivatives to the synthesis of 5-(substituted phenyl) 2-methylsulphonyl-1,3,4-thiadiazole derivatives (4) which are important key intermediates in the preparation of 2,5-disubstituted 1,3,4-thiadiazole derivatives since the methylsulphonyl group can be substituted by various nucleophilic groups.[2,3] Generally, these 2-methylsulphonyl-1,3,4-thiadiazole derivatives were prepared by the oxidation of 2-methylthio-1,3,4-thiadiazole derivatives.[2,4-6]

This paper describes the novel synthesis of 5-(substituted phenyl) 2-methylsulphonyl-1,3,4-thiadiazoles (4), 5-(substituted phenyl) 4-acetyl-2-methylsulphonyl-Δ²-1,3,4-thiadiazolines (5), and 5-(substituted phenyl) 4-acetyl-2-methylsulphonyl-Δ²-1,3,4-thiadiazoline 1,1-dioxides (6) by the oxidation of 5-(substituted phenyl) 4-acetyl-2-methylthio-Δ²-1,3,4-thiadiazolines (3) which were obtained by the reaction of aldehyde methylthio(thiocarbonyl)hydrazones (2) with acetic anhydride or acetyl chloride [for (3a)].

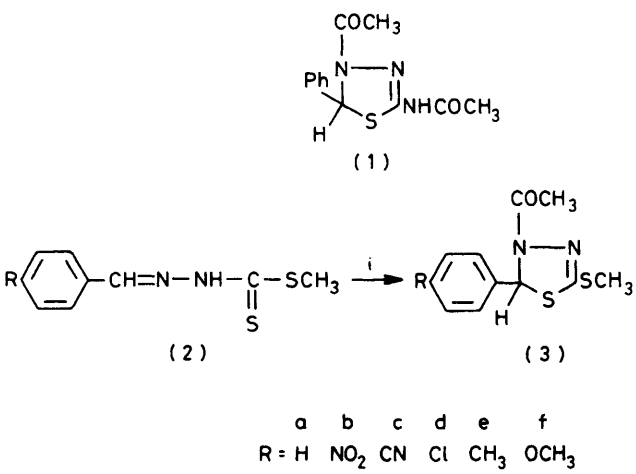
Acetylation of benzaldehyde methylthio(thiocarbonyl)-hydrazone (2a) with acetic anhydride at 100 °C, or with acetyl chloride in pyridine at room temperature, gave 4-acetyl-2-methylthio-5-phenyl-Δ²-1,3,4-thiadiazoline (3a). The ^{1}H n.m.r. spectrum of compound (3a) showed a 5-H absorption at δ_H 7.22 with an upfield shift of 1.10 p.p.m. from that of the methine proton of the starting material (2a), in good agreement with other 5-H shifts reported for 1,3,4-thiadiazoline derivatives.[1,7,8] The ^{13}C n.m.r. chemical shifts at δ_C 69.14 (C-5) and 150.35 p.p.m. (C-2) also support the 1,3,4-thiadiazoline structure.

Similarly, the 4-acetyl-5-aryl-2-methylthio-Δ²-1,3,4-thiadiazolines (3b—f) have been prepared from the corresponding aldehyde methylthio(thiocarbonyl)hydrazones (2b—f) by reaction with acetic anhydride.

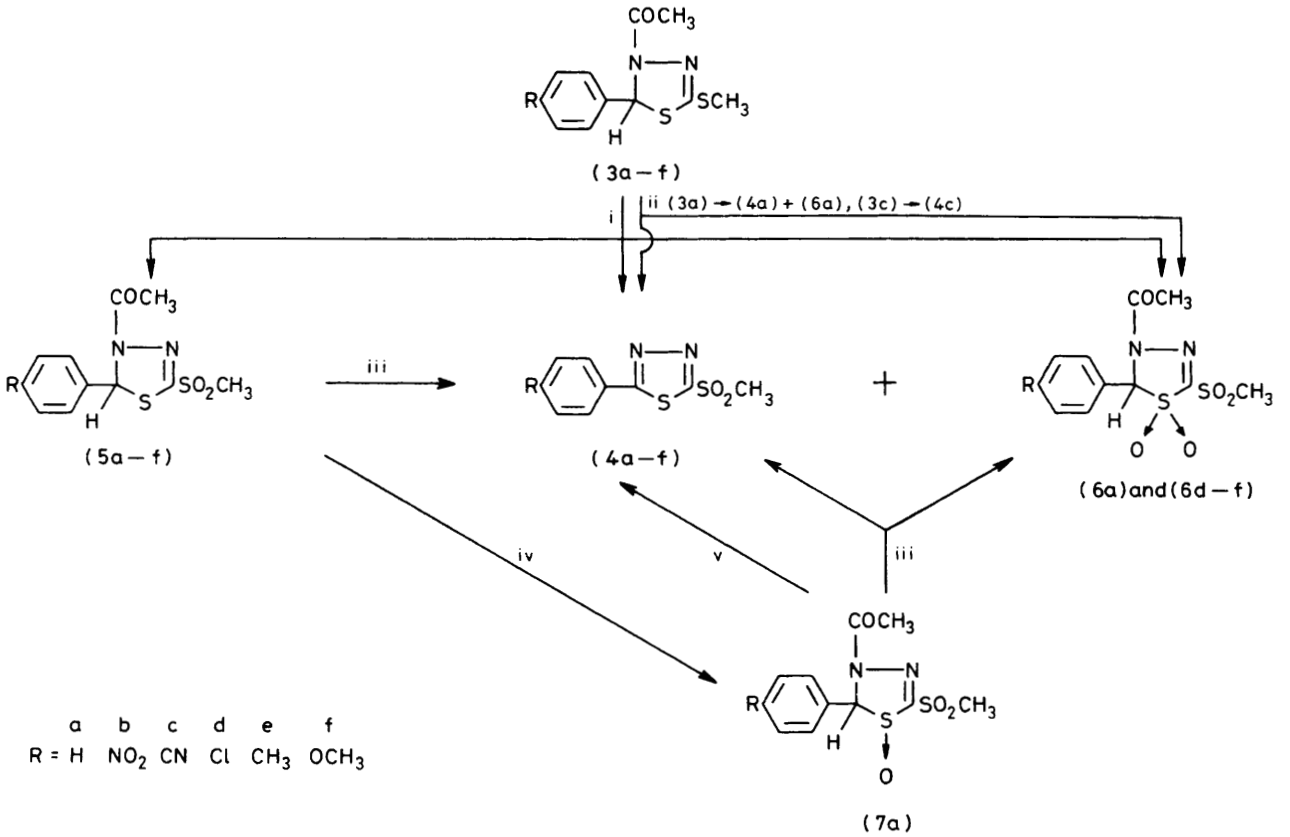
Oxidation of compound (3a) with 2 mol equiv. of potassium permanganate in acetic acid at room temperature for 1 h gave a solid which was separated by column chromatography into three fractions. A major product from the first fraction was identified as 2-methylsulphonyl-5-phenyl-1,3,4-thiadiazole (4a) (50%) by direct comparison with an authentic sample [2] obtained by the oxidation of 2-methylthio-5-phenyl-1,3,4-thiadiazole with potassium permanganate. Needles, m.p. 116—118 °C, were obtained from the second fraction, and the compound was identified as 4-acetyl-2-methylsulphonyl-5-phenyl-Δ²-1,3,4-thiadiazoline (5a) (12%) from the following spectral data. The mass spectrum, *m/z* 284 (M^+), and the elemental analysis agreed with the molecular formula $C_{11}H_{12}N_2O_3S_2$ for compound (5a). An i.r. band at 1 680 cm^{-1}, peaks at δ_H 7.31 (5-H) and 2.29 ($COCH_3$) in the ^{1}H n.m.r. spectrum, and ^{13}C n.m.r. signals at δ_C 21.93, 169.18 ($COCH_3$), 151.22 (C-2), and 72.56 p.p.m. (C-5) suggested the presence of a 4-acetyl-Δ²-1,3,4-thiadiazoline ring system. I.r. bands at 1 320 and 1 145 cm^{-1}, a peak at δ_H 3.47 in the ^{1}H n.m.r. spectrum, and a peak at δ_C 41.75 p.p.m. in the ^{13}C n.m.r. spectrum indicated the presence of a methylsulphonyl group in the molecule. From the third fraction, needles, m.p. 190—191 °C, were obtained which were identified as 4-acetyl-2-methylsulphonyl-Δ²-1,3,4-thiadiazoline 1,1-dioxide (6a) (6%) from the following spectral data. The mass spectrum, *m/z* 334 $(M + NH_4)^+$, and the elemental analysis agreed with the molecular formula $C_{11}H_{12}N_2O_5S_2$ for compound (6a). An i.r. band at 1 720 cm^{-1}, peaks at δ_H 6.56 (5-H) and 2.40 ($COCH_3$) in the ^{1}H n.m.r. spectrum, and ^{13}C n.m.r. signals at δ_C 20.47, 169.21 ($COCH_3$), 143.84 (C-2), and 75.22 p.p.m. (C-5) indicated the presence of a 4-acetyl-Δ²-1,3,4-thiadiazoline ring system. I.r. bands at 1 140, 1 150, 1 330, and 1 350 cm^{-1}, a peak at δ_H 3.55 in the ^{1}H n.m.r. spectrum, and a ^{13}C n.m.r. signal at δ_C 44.56 p.p.m. indicated the presence of both a sulphonyl group and a methylsulphonyl group in the molecule.

Similarly, oxidation of compounds (3d—f) with 2 mol equiv. of potassium permanganate gave compounds (4d—f), (5d—f), and (6d—f). However, similar treatment of compounds (3b and c) with 2 mol equiv. of potassium permanganate only gave compounds (4b and c) and (5b and c) (Table 1).

Oxidation of compound (3a) with 3 mol equiv. of potassium permanganate gave the 1,3,4-thiadiazole derivative



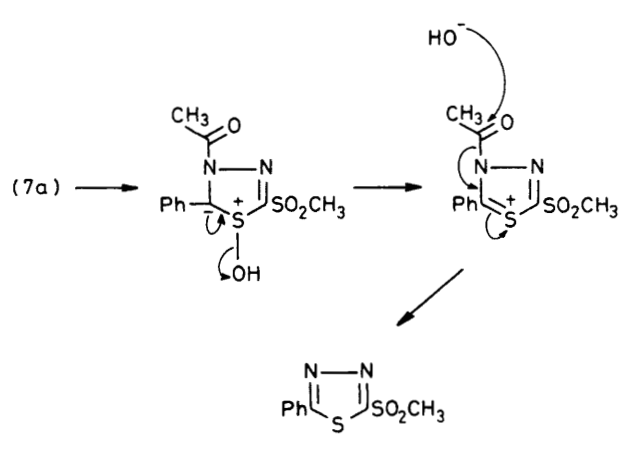
Reagents: i, AcCl or Ac_2O



Scheme 1. *Reagents:* i, $KMnO_4$ (2 mol equiv.); ii, $KMnO_4$ (3 mol equiv.); iii, $KMnO_4$; iv, *m*-CPBA; v, $(C_2H_5)_3N$–ethanol or CH_3CO_2K–CH_3CO_2H or DMSO, heat

Table 1. Oxidation of 5-(substituted phenyl) 4-acetyl-2-methylthio-Δ^2-1,3,4-thiadiazolines (3) with 2 mol equiv. of potassium permanganate

Starting compound (3)	R	Products: Compound (4) Yield (%)	Compound (4) M.p. (°C)	Compound (5) Yield (%)	Compound (5) M.p. (°C)	Compound (6) Yield (%)	Compound (6) M.p. (°C)
a	H	50	161—162	12	116—118	6	190—191
b	NO_2	41	210—211	24	154—156		
c	CN	24	197—199	38	165—166		
d	Cl	29	189—190	24	87—90	6	188—190
e	CH_3	47	171—172	16	104—107	12	165—166
f	OCH_3	52	151—152	12	92—94	8	155—156



Scheme 2.

(4a) and the 1,3,4-thiadiazoline 1,1-dioxide (6a). Oxidation of compound (3c) with 3 mol equiv. of potassium permanganate gave only the 1,3,4-thiadiazole derivative (4c).

From these results, we have presumed that compounds (4) and (6) were produced *via* 5-(substituted phenyl) 4-acetyl-2-methylsulphonyl-Δ^2-1,3,4-thiadiazoline 1-oxides as intermediates from compounds (5).

In order to study the reaction process, we performed the following reactions as shown in Scheme 1. Oxidation of compound (5a) with 1.5 mol equiv. of potassium permanganate in acetic acid at room temperature for 2 h gave compounds (4a) (36%) and (6a) (27%). Oxidation of compound (5a) with 1.1 mol equiv. of *m*-chloroperbenzoic acid (*m*-CPBA) in chloroform gave a single isomer of compound (7a). In accord with our previous results,[9] the oxygen atom of the sulphinyl group of compound (7a) was assumed to be *trans* to the phenyl group. Oxidation of compound (7a) with 1.4 mol equiv. of potassium permanganate in acetic acid gave compounds (6a) and (4a).

Previously, we have reported that the treatment of 2-acetamido-4-acetyl-5-phenyl-Δ^2-1,3,4-thiadiazoline 1-oxide with triethylamine at room temperature gave 2-acetamido-5-phenyl-1,3,4-thiadiazole.[9] Similarly, compound (7a) with triethylamine or potassium acetate at room temperature gave compound (4a), which was also obtained by heating compound (7a) with dimethyl sulphoxide at 100 °C, or by refluxing compound (7a) in ethanol or toluene for several hours.

A possible mechanism for the formation of the 1,3,4-thiadiazole (4a) from the 1,3,4-thiadiazoline 1-oxide (7a), involving *S*-ylide and sulphonium intermediates, is shown in Scheme 2.

From these results we consider that compound (3a) was first oxidized to compound (5a) and that compounds (4a) and (6a) were produced from compound (5a) *via* the intermediate (7a).

Oxidation of compounds (3b) and (3c), which both possess an electron-withdrawing group in the *para*-position of the phenyl group, did not give the corresponding bis-sulphones (6b) and (6c), probably because deacetylation of the intermediate 1,3,4-thiadiazoline 1-oxides occurred much faster than *S*-oxidation.

Experimental

All m.p.s were determined by the capillary method and are uncorrected. I.r. spectra were recorded on a Hitachi 215 spectrometer. ^{1}H N.m.r. spectra were measured with a JEOL PS-100 spectrometer using $SiMe_4$ as an internal standard, and ^{13}C n.m.r. spectra with a JEOL FX-200 spectrometer. Mass spectra were recorded on a JEOL D-300 instrument.

Aldehyde Methylthio(thiocarbonyl)hydrazones (2).—Compounds (2a),[10] (2b),[11] (2d),[12] (2e),[12] and (2f) [13] were prepared by literature methods.

4-*Cyanobenzaldehyde methylthio(thiocarbonyl)hydrazone* (2c). 4-Cyanobenzaldehyde (2 g, 15.3 mmol) was added to a stirred solution of methyldithiocarbazate (1.86 g, 15.3 mmol) in methanol (25 ml). The resulting solid was recrystallised from ethanol to give the *methylthio(thiocarbonyl)hydrazone* (2c) (3.06 g, 85%), m.p. 199—201 °C (Found: C, 50.8; H, 3.7; N, 18.0. $C_{10}H_9N_3S_2$ requires C, 51.0; H, 3.9; N, 17.9%).

4-*Acetyl*-2-*methylthio*-5-*phenyl*-Δ^2-1,3,4-*thiadiazoline* (3a).—*Method A*. A mixture of compound (2a) (9.465 g, 45.0 mmol) and acetic anhydride (60 ml) was heated at 100 °C for 1 h and the solution was then evaporated to dryness under reduced pressure. The resulting solid was crystallised from methanol to give the 1,3,4-*thiadiazoline* (3a) (10.93 g, 96%), m.p. 75—76 °C; δ_C [$(CD_3)_2SO$] 14.92 (SCH_3), 21.61 ($COCH_3$), 69.14 (C-5), 124.88—128.33 (Ar C-2′, -3′, -4′, -5′, and -6′), 140.30 (Ar C-1′), 150.35 (C-2), and 167.02 p.p.m. (C=O).

Method B. Acetyl chloride (0.16 g, 2 mmol) was added dropwise to a stirred solution of compound (2a) (0.2 g, 1 mmol) in pyridine (5 ml) and the mixture was stirred for 24 h at room temperature. Addition of water gave a precipitate which was filtered off and crystallised from ethanol to afford compound (3a) (0.21 g, 87%).

5-(*Substituted Phenyl*) 4-*Acetyl*-2-*methylthio*-Δ^2-1,3,4-*thiadiazolines* (3b—f).—*Compounds* (3b—f) were prepared by a method similar to Method A described above for compound (3a). M.p.s, yields, microanalytical data, and n.m.r. spectral data are shown in Table 2.

Oxidation of 4-*Acetyl*-2-*methylthio*-5-*phenyl*-Δ^2-1,3,4-*thiadiazoline* (3a) *with* 2 *Mol Equiv. of Potassium Permanganate*.—Powdered potassium permanganate (6.28 g, 39.7 mmol) was added portionwise to a stirred, water-cooled solution of compound (3a) (5 g, 19.8 mmol) in acetic acid (35 ml) and the mixture was then stirred for a further 1 h. Water (35 ml) was then added and the mixture was treated with 30% hydrogen peroxide in an ice–water bath and kept overnight. The resulting precipitate was filtered off and chromatographed on silica gel. Elution with chloroform–acetone (25 : 1) gave three fractions. Evaporation of the first fraction gave a solid which was crystallised from ethanol as crystals of 2-methylsulphonyl-5-phenyl-1,3,4-thiadiazole [2] (4a) (2.36 g, 50%), m.p. 161—162 °C. Evaporation of the second fraction gave a solid which was crystallised from ethanol to give 4-*acetyl*-2-*methylsulphonyl*-5-*phenyl*-Δ^2-1,3,4-*thiadiazoline* (5a) (0.67 g, 12%) as needles, m.p. 116—118 °C; *m/z* 284 (M^+); δ_C [$(CD)_3SO$] 21.93 ($COCH_3$), 41.75 (SO_2CH_3), 72.56 (C-5), 125.50—128.94 (Ar) (C-2′, -3′, -4′, -5′, and -6′), 140.07 (Ar C-1′), 151.22 (C-2), and 169.18 p.p.m. (C=O). Evaporation of the third fraction gave a solid which was crystallised from ethanol–ethyl acetate to give 4-*acetyl*-2-*methylsulphonyl*-5-*phenyl*-Δ^2-1,3,4-*thiadiazoline* 1,1-*dioxide* (6a) (0.36 g, 6%) as needles, m.p. 190—191 °C; *m/z* (NH_3; c.i.m.s.) * 334 ($M + NH_4$)$^+$; δ_C [$(CD_3)_2SO$] 20.47 ($COCH_3$), 44.56 (SO_2CH_3), 75.22 (C-5), 127.45—129.99 (Ar), 143.84 (C-2), and 169.21 p.p.m. (C=O).

Oxidation of 5-(*Substituted Phenyl*) 4-*Acetyl*-2-*methylthio*-Δ^2-1,3,4-*thiadiazolines* (3b—f) *with* 2 *Mol Equiv. of Potassium Permanganate*.—Compounds (3b—f) were oxidized with 2 mol equiv. of potassium permanganate by a method similar to that described for compound (3a) and the 1,3,4-*thiadiazoles* (4b—f), 2-*methylsulphonyl*-1,3,4-*thiadiazolines* (5b—f), and 2-*methylsulphonyl*-1,3,4-*thiadiazoline* 1,1-*dioxides* (6d—f) were obtained, respectively, from the separated column fractions. The elemental analyses and spectral data are shown in Tables 3, 4, and 5, respectively.

Oxidation of 4-*Acetyl*-2-*methylthio*-Δ^2-1,3,4-*thiadiazolines* (3a *and* c) *with* 3 *Mol Equiv. of Potassium Permanganate*.—In a similar way to the oxidation of compound (3a) with 2 mol equiv. of potassium permanganate, the 1,3,4-thiadiazole (4a) (1.51 g, 53%) and the 1,3,4-thiadiazoline 1,1-dioxide (6a) (0.226 g, 6%) were obtained by oxidation of compound (3a) (3.0 g, 11.9 mmol) with potassium permanganate (5.65 g, 35.7 mmol). The 1,3,4-thiadiazole (4c) (0.33 g, 50%) was obtained by oxidation of compound (3c) (0.69 g, 2.49 mmol) with potassium permanganate (1.18 g, 7.47 mmol).

Oxidation of Compound (5a) *with Potassium Permanganate*.—Powdered potassium permanganate (84 mg, 0.53 mmol) was added portionwise to a stirred, water-cooled solution of compound (5a) (100 mg, 0.35 mmol) in acetic acid (5 ml) and the mixture was stirred for a further 1 h. Water was added and the mixture was treated with 30% hydrogen peroxide in an ice–water bath and kept overnight. The resulting precipitate was collected by filtration and chromatographed on silica gel. Elution with chloroform–acetone (25 : 1) gave two fractions. From the first fraction, the 1,3,4-thiadiazole (4a) (30 mg, 36%) was obtained. From the second fraction, the 1,3,4-thiadiazoline 1,1-dioxide (6a) (30 mg, 27%) was obtained as needles by recrystallisation from ethanol–ethyl acetate.

4-*Acetyl*-2-*methylsulphonyl*-5-*phenyl*-Δ^2-1,3,4-*thiadiazoline* 1-*Oxide* (7a).—A solution of 85% *m*-chloroperbenzoic acid

* Chemical ionization mass spectrum with ammonia.

Table 2. 5-(Substituted phenyl) 4-acetyl-2-methylthio-Δ^2-1,3,4-thiadiazolines (3)

Compound	m.p. (°C)	Yield (%)	Formula	Found (%) (Required) C	H	N	ArH	δ_H [$(CD_3)_2SO$] 5-H (1 H, s)	SCH_3 (3 H, s)	$COCH_3$ (3 H, s)	
(3a)	75—76	96	$C_{11}H_{12}N_2OS_2$	52.5 (52.4	4.8 4.8	11.0 11.1)	7.24—7.36 (5 H, m)	7.22	2.59	2.25	
(3b)	94—95	87	$C_{11}H_{11}N_3O_3S_2$	44.5 (44.4	3.7 3.7	14.2 14.1)	7.56 (2 H, dd) 8.24 (2 H, dd)	7.37	2.60	2.27	
(3c)	114—115	84	$C_{12}H_{11}N_3OS_2$	51.8 (52.0	3.8 4.0	14.9 15.2)	7.44 (2 H, dd) 7.84 (2 H, dd)	7.29	2.60	2.26	
(3d)	84—85	93	$C_{11}H_{11}ClN_2OS_2$	46.2 (46.1	3.8 3.9	9.8 9.8)	7.31 (2 H, dd) 7.37 (2 H dd)	7.21	2.59	2.25	
(3e)	85—87	98	$C_{12}H_{14}N_2OS_2$	54.0 (54.1	5.3 5.3	10.5 10.5)	7.13 (4 H, s)	7.18	2.57	2.22	2.26 (s, CH_3)
(3f)	127—129	86	$C_{12}H_{14}N_2O_2S_2$	50.7 (51.0	5.2 5.0	9.8 9.9)	6.89 (2 H, dd) 7.21 (2 H, dd)	7.17	2.58	2.21	3.71 (s, OCH_3)

Table 3. 5-(Substituted phenyl) 2-methylsulphonyl-1,3,4-thiadiazoles (4)

Compound	Formula	Found (%) (Required) C	H	N	$\nu_{max.}$ (KBr) (cm^{-1}) SO_2	ArH	δ_H [$(CD_3)_2SO$] SO_2CH_3 (3 H, s)	
(4a)	$C_9H_8N_2O_2S_2$		*a*		1 325, 1 155	7.54—7.74 (3 H, m) 8.00—8.20 (2 H, m)	3.65	
(4b)	$C_9H_7N_3O_4S_2$	37.6 (37.9	2.3 2.5	14.8 14.7)	1 330, 1 160	8.39 (4 H, s)	3.66	
(4c)	$C_{10}H_7N_3O_2S_2$	45.5 (45.3	2.5 2.7	16.1 15.8)	1 320, 1 150	8.06 (2 H, dd) 8.28 (2 H, dd)	3.67	
(4d)	$C_9H_7ClN_2O_2S_2$	39.4 (39.4	2.5 2.6	10.1 10.2)	1 325, 1 150	7.66 (2 H, dd) 8.10 (2 H, dd)	3.64	
(4e)	$C_{10}H_{10}N_2O_2S_2$	47.5 (47.2	3.9 4.0	11.3 11.0)	1 325, 1 155	7.41 (2 H, dd) 7.97 (2 H, dd)	3.65	2.39 (s, CH_3)
(4f)	$C_{10}H_{10}N_2O_3S_2$	44.4 (44.4	3.7 3.7	10.4 10.4)	1 325, 1 155	7.11 (2 H, dd) 8.03 (2 H, dd)	3.62	3.83 (s, OCH_3)

[a] Lit.,[2] m.p. 161 °C; lit.,[4] m.p. 159—160 °C.

Table 4. 5-(Substituted phenyl) 4-acetyl-2-methylsulphonyl-Δ^2-1,3,4-thiadiazolines (5)

Compound	Formula	Found (%) (Required) C	H	N	$\nu_{max.}$ (KBr) (cm^{-1}) SO_2	ArH	δ_H [$(CD_3)_2SO$] SO_2CH_3 (3 H, s)	$COCH_3$ (3 H, s)	5-H (1 H, s)	Others
(5a)	$C_{11}H_{12}N_2O_3S_2$	46.4 (46.5	4.1 4.3	10.0 9.9)	1 320, 1 145	7.20—7.48 (5 H, m)	3.47	2.29	7.31	
(5b)	$C_{11}H_{11}N_3O_5S_2$	39.8 (40.1	3.3 3.4	12.6 12.8)	1 330, 1 160	7.66 (2 H, dd) 8.26 (2 H, dd)	3.52	2.33	7.55	
(5c)	$C_{12}H_{11}N_3O_3S_2$	46.5 (46.6	3.7 3.6	13.5 13.6)	1 325, 1 155	7.55 (2 H, dd) 7.89 (2 H, dd)	3.52	2.32	7.48	
(5d)	$C_{11}H_{11}ClN_2O_3S_2$	41.2 (41.4	3.3 3.5	8.5 8.8)	1 325, 1 155	7.24—7.50 (4 H, m)	3.47	2.28	7.34	
(5e)	$C_{12}H_{14}N_2O_3S_2$	48.0 (48.3	4.9 4.7	9.4 9.4)	1 320, 1 150	7.16 (4 H, s)	3.48	2.28	7.34	2.28 (s, CH_3)
(5f)	$C_{12}H_{14}N_2O_4S_2$	45.9 (45.9	4.6 4.5	8.7 8.9)	1 320, 1 150	6.88 (2 H, dd) 7.22 (2 H, dd)	3.47	2.27	7.33	3.70 (s, OCH_3)

(393 mg, 1.94 mmol) in chloroform (12 ml) was added to a cooled solution of the 2-methylsulphonyl-1,3,4-thiadiazoline (5a) (500 mg, 1.76 mmol). After being stirred for 5 h, the mixture was neutralised with 5% aqueous sodium hydrogen carbonate and then extracted with chloroform (3 × 100 ml). The combined extracts were dried over anhydrous Na_2SO_4. Evaporation of the solvent under reduced pressure gave a solid which was recrystallised from ethanol to give needles of the 1,3,4-*thiadiazoline* 1-*oxide* (7a) (355 mg, 67%), m.p. 136—138 °C (Found: C, 43.7; H, 3.8; N, 9.0. $C_{11}H_{12}N_2O_4S_2$ requires C, 44.0; H, 4.0; N, 9.3%); $\nu_{max.}$ (KBr) 1 720 (C=O), 1 325, 1 310, and 1 145 cm^{-1} (SO_2CH_3); δ_H ($CDCl_3$) 2.61 (3 H, s, $COCH_3$), 3.36 (3 H, s, SO_2CH_3), 6.73 (1 H, s, 5-H), 7.00—7.50 (5 H, m, ArH); δ_C [$(CD_3)_2SO$] 21.75 ($COCH_3$), 44.67 (SO_2CH_3), 87.86 (C-5), 125.82—129.76 (Ar), 152.86 (C-2), and 169.30 (C=O).

Oxidation of the 1,3,4-*Thiadiazoline* 1-*Oxide* (7a) *with Potassium Permanganate*.—Powdered potassium permanganate (370 mg, 2.34 mmol) was added portionwise to a stirred, cooled solution of compound (7a) (500 mg, 1.67 mmol) in acetic acid (16 ml) and the mixture was stirred for a

Table 5. 5-(Substituted phenyl) 4-acetyl-2-methylsulphonyl-Δ^2-1,3,4-thiadiazoline 1,1-dioxides (6)

Compound	Formula	Found (%) (Required) C	H	N	ν_{max} (KBr) (cm^{-1}) SO_2	ArH	δ_H [$(CD_3)_2SO$] SO_2CH_3 (3 H, s)	$COCH_3$ (3 H, s)	5-H (1 H, s)	Others
(6a)	$C_{11}H_{12}N_2O_5S_2$	41.6 (41.8	3.7 3.8	8.9 8.9)	1 350, 1 330 1 150, 1 140	7.24—7.52 (5 H, m)	3.55	2.40	6.56	
(6d)	$C_{11}H_{11}ClN_2O_5S_2$	37.8 (37.7	3.5 3.2	8.0 8.0)	1 350, 1 330, 1 155, 1 145	7.49 (4 H, s)	3.55	2.40	6.61	
(6e)	$C_{12}H_{14}N_2O_5S_2$	43.6 (43.6	4.2 4.3	8.3 8.5)	1 340, 1 330, 1 155, 1 130	7.26 (4 H, s)	3.55	2.40	6.54	2.32 (s, CH_3)
(6f)	$C_{12}H_{14}N_2O_6S_2$	41.6 (41.6	4.1 4.1	8.0 8.1)	1 335, 1 325 1 155, 1 130	6.98 (2 H, dd) 7.32 (2 H, dd)	3.55	2.40	6.52	3.76 (s, OCH_3)

further 1 h. Water (8 ml) was added and the mixture was treated with 30% hydrogen peroxide in an ice–water bath and kept overnight. The resulting precipitate was chromatographed on silica gel. Elution with chloroform–acetone (25 : 1) gave the 1,3,4-thiadiazole (4a) (67 mg, 17%) and the 1,3,4-thiadiazoline 1,1-dioxide (6a) (200 mg, 38%).

2-Methylsulphonyl-5-phenyl-1,3,4-thiadiazole (4a) *from the 1,3,4-Thiadiazoline 1-Oxide* (7a).—*Method A.* A solution of triethylamine (74 mg, 0.73 mmol) in ethanol (2.5 ml) was added dropwise to a stirred solution of compound (7a) (200 mg, 0.67 mmol) in ethanol (3 ml), and the mixture was stirred at room temperature for a further 30 min. The solvent was removed under reduced pressure and the residue was recrystallised from ethanol as crystals of compound (4a) (112 mg, 70%).

Method B. A solution of potassium acetate (164 mg, 1.67 mmol) in acetic acid (2 ml) was added to a stirred solution of compound (7a) (50 mg, 0.17 mmol) in acetic acid (2 ml), and the mixture was stirred at room temperature for a further 24 h. Work-up as in method A gave crystals of compound (4a) (39.5 mg, 99%).

Method C. A stirred solution of compound (7a) (50 mg, 0.17 mmol) in dimethyl sulphoxide (3 ml) was heated at 100 °C under argon for 4 h. The solvent was removed under reduced pressure. A solid which appeared after the addition of water to the residue was crystallised from ethanol as crystals of compound (4a) (28 mg, 70%).

Method D. A solution of compound (7a) (50 mg, 0.17 mmol) in ethanol (6 ml) was refluxed under argon for 6.5 h. Work-up as in method A gave crystals of compound (4a) (28 mg, 70%).

Method E. A solution of compound (7a) (50 mg, 0.17 mmol) in toluene (5 ml) was refluxed under argon for 4 h. Work-up as in method A gave crystals of compound (4a) (25 mg, 63%).

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Received 27th August 1982; *Paper* 2/1488