The Reaction of Sulfamide with α- and β-Diketones. The Preparation of 1,2,5-Thiadiazole 1,1-Dioxides and 1,2,6-Thiadiazine 1,1-Dioxides

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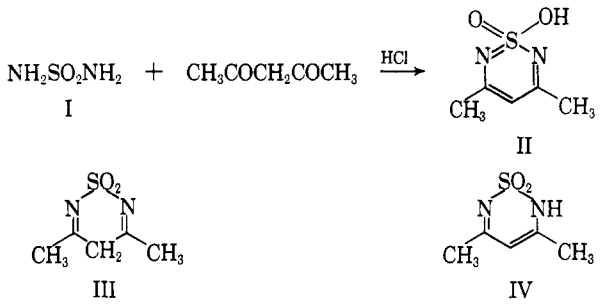
Reaction of sulfamide with a variety of β-diketones gave (2H)-1,2,6-thiadiazine 1,1-dioxides (V). The use of N-monosubstituted sulfamides gave 2-substituted 1,2,6-thiadiazine 1,1-dioxides (VI). The use of ethyl acylpyruvates as the β-diketones led to the 3-carbethoxy derivatives (VII), which reacted readily with amines to give amides and with hydrazine to give a hydrazide. The use of 2-acylcyclohexanones in the reaction with sulfamide gave 5,6,7,8-tetrahydro-(1H)-2,1,3-benzothiadiazine 2,2-dioxides (VIII). Catalytic hydrogenation of 3,5-dimethyl-(2H)-1,2,6-thiadiazine 1,1-dioxide gave the completely saturated tetrahydro-3,5-dimethyl-(2H)-1,2,6-thiadiazine 1,1-dioxide. Reaction of sulfamide with α-diketones led to 3,4-disubstituted 1,2,5-thiadiazole 1,1-dioxides (IX). Reaction of sulfamide with α-hydroxy ketones gave 3,4-disubstituted 1,2,5-Δ²-thiadiazoline 1,1-dioxides (X). Catalytic reduction of either IX or X (where $R_1 = R_2 = C_6H_5$) led to the corresponding 3,4-disubstituted 1,2,5-thiadiazolidine 1,1-dioxide (XIII).

As part of a study underway in these laboratories aimed at the synthesis of new and unique heterocyclic systems we were interested in investigating the chemistry of sulfamide (I), a substance which has recently become commercially available.[1]

The use of sulfamide and N-substituted sulfamides in the preparation of heterocyclic compounds has been studied to a certain extent by Paquin,[2] and by others.[3] We were interested especially in investigating the reactions of sulfamide and substituted sulfamides with α- and β-diketones of various kinds.

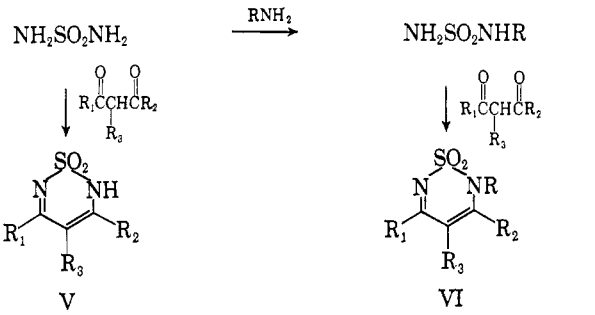
One report appears in the literature by Degering and Wilson[4] on the reaction between sulfamide and 2,4-pentanedione in the presence of gaseous hydrogen chloride. Structures II, III, and IV were considered by these authors for the reaction product. Some preference was indicated for II because of the pronounced acidity shown by the compound.



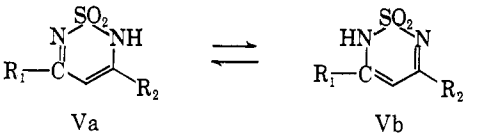
We have repeated this reaction according to the directions of Degering and Wilson[4] and have investigated the product formed. The n.m.r. spectrum (A-60, deuterated acetone) shows a singlet at 350 c.p.s. (reference line is tetramethylsilane) possessing an area of one proton attributable to vinyl hydrogen. The infrared spectrum shows a band at 3140 cm.$^{-1}$ attributable to O–H or N–H. These facts would argue against structure III. Furthermore, the compound possesses pronounced acidity (pK_a determined, 3.27), as reported by Degering and Wilson.[4]

Structure II requires the sulfonyl group to be present in an enolic form, considered by some authors to be a less preferred configuration.[5] On the basis of the above facts structure IV would appear to be preferred. The acidity shown should not be incompatible with this structure.

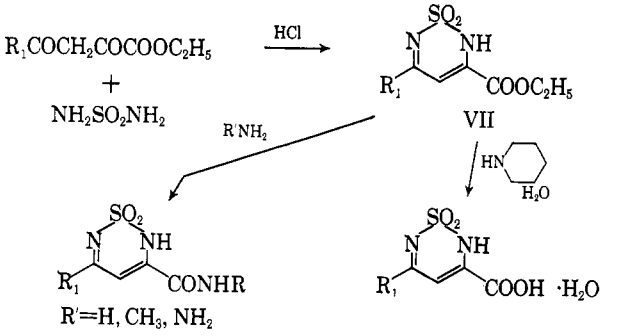
We have investigated also a rather large number of β-diketones in the reaction with sulfamide and N-substituted sulfamides. The reactions were carried out as indicated.



The compounds prepared are listed in Table I. The structures V and VI are assigned on the basis of an analogy to structure IV. In those cases in compounds of the type V where R_1 and R_2 are different only one compound was isolated. This would indicate the presence of a tautomeric system.



Those compounds in Table I in which R_2 was various amide or hydrazide groupings were prepared by



(1) Allied Chemical Corp., General Chemical Division, New York, N. Y.

(2) A. M. Paquin, *Angew. Chem.*, A**60**, 316 (1948).

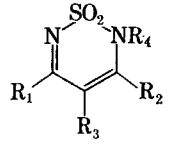
(3) (a) J. R. Geigy, A.-G, British Patent 859,316 (1961); (b) H. A Walter, U. S. Patent 2,454,261 (1948); (c) 2,454,262 (1948); (d) A. M. Paquin, *Kunstoffe*, **37**, 165 (1947); *Chem. Abstr.*, **43**, 5995[5] (1949); (e) R. Zimmermann and H. Hotze, *Angew. Chem.*, **75**, 1025 (1963).

(4) E. F. Degering and J. E. Wilson, *J. Org. Chem.*, **17**, 339 (1952).

(5) F. Arndt and B. Eistert, *Chem. Ber.*, **74**, 423 (1941).

TABLE I

1,2,6-THIADIAZINE 1,1-DIOXIDES

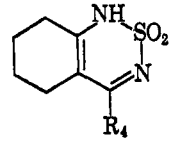


					Yield,			Analyses, %							
								Calcd.				Found			
R_1	R_2	R_3	R_4	Procedure	%	M.p., °C.	Molecular formula	C	H	N	S	C	H	N	S
C_6H_5	C_6H_5	H	H	A	95[a]	278–279[b]	$C_{15}H_{12}N_2O_2S$	63.36	4.26	9.85	11.28	63.09	4.00	9.36	11.30
p-$CH_3C_6H_4$	*p*-$CH_3C_6H_4$	H	H	A	88	288–290[c]	$C_{17}H_{16}N_2O_2S$	65.36	5.16	8.97	10.26	65.43	5.01	8.59	10.08
$C_6H_5CH_2$–	CH_3	H	H	A	68	67–69[d]	$C_{11}H_{12}N_2O_2S$	55.91	5.12	11.86	13.57	56.01	4.94	11.54	13.47
CH_3	–$COOC_2H_5$	H	H	B	69	101.5–103.0[e]	$C_7H_{10}N_2O_4S$	38.53	4.62	12.84	14.69	38.75	4.76	12.42	14.77
CH_3	–$CONH_2$	H	H	C	61	243 dec.	$C_5H_7N_3O_3S$	31.74	3.73	...	16.95	31.68	3.64	...	17.00
CH_3	–$CONHCH_3$	H	H	C[f]	70	245 dec.[b]	$C_6H_9N_3O_3S$	35.46	4.46	20.68	15.78	36.05	4.41	20.82	15.84
C_6H_5	–$COOC_2H_5$	H	H	B	92	188–190[b]	$C_{12}H_{12}N_2O_4S$	51.42	4.32	10.00	11.44	51.22	4.00	9.61	11.52
C_6H_5	–$CONH_2$	H	H	C[g]	27	265 dec.[b]	$C_{10}H_9N_3O_3S$	47.80	3.61	16.72	12.76	47.99	3.31	16.30	12.89
C_6H_5	–$CONHCH_3$	H	H	C[f]	93.5	265 dec.[b]	$C_{11}H_{11}N_3O_3S$	49.80	4.18	15.84	12.09	49.91	3.81	15.41	12.15
C_6H_5	–COOH	H	H	...	67	203 dec.	$C_{10}H_8N_2O_4S \cdot H_2O$[h]	44.44	3.73	10.37	11.86	44.62	3.67	10.33	12.06
p-$CH_3C_6H_4$	–$COOC_2H_5$	H	H	B[i]	85	176–177[b]	$C_{13}H_{14}N_2O_4S$	53.05	4.79	9.52	10.86	53.16	4.64	9.12	10.89
p-$CH_3C_6H_4$	–$CONHNH_2$	H	H	...	43	223 dec.	$C_{11}H_{12}N_4O_3S$	47.14	4.32	19.99	11.44	47.20	4.52	19.61	11.21
p-ClC_6H_4	–$COOC_2H_5$	H	H	B[j]	81	170.5–172.5[b]	$C_{12}H_{11}ClN_2O_4S$[k]	45.79	3.52	8.90	10.19	46.30	3.62	8.71	10.15
p-ClC_6H_4	–$CONH_2$	H	H	C	26	225 dec.[l]	$C_{10}H_8ClN_3O_3S$[m]	42.04	2.82	...	11.22	42.72	2.64	...	11.05
p-ClC_6H_4	–$CONHCH_3$	H	H	C[f]	55	268 dec.[b]	$C_{11}H_{10}ClN_3O_3S$[n]	44.08	3.36	...	10.70	44.39	3.49	...	10.58
	CH_3	H	H	B[o]	55	291 dec.	$C_9H_9N_3O_2S$	48.40	4.06	18.85	14.40	48.08	3.75	18.48	14.37
	CH_3	H	H	B	77	276 dec.[p]	$C_9H_9N_3O_2S \cdot HCl$[q]	41.62	3.88	16.18	12.35	42.24	3.77	15.87	11.91
CH_3	CH_3	C_6H_5	H	B[r]	73	195–195.5	$C_{11}H_{12}N_2O_2S$	55.93	4.58	11.86	13.55	55.56	4.80	11.45	13.53
C_6H_5	C_6H_5	H	C_4H_9	...	39	99–100	$C_{19}H_{20}N_2O_2S$	67.03	5.92	8.23	9.42	66.59	5.89	8.19	9.51

[a] The yield is based upon the amount of diketone recovered. [b] Recrystallized from ethanol. [c] Recrystallized from dioxane and washed with acetone. [d] Recrystallized from benzene–cyclohexane (4:1). [e] Recrystallized from benzene. [f] Two molar equivalents of methylamine, as a 25% aqueous solution were used in place of an ammonia solution. [g] The solution was allowed to stand for several days instead of overnight. [h] *Anal.* Calcd. for H_2O: 6.67. Found: 7.02. [i] The reflux time was increased to 4 hr. [j] The reflux time was increased to 5 hr. [k] *Anal.* Calcd. for Cl: 11.26. Found: 11.28. [l] Recrystallized from water. [m] *Anal.* Calcd. for Cl: 12.41. Found: 12.45. [n] *Anal.* Calcd. for Cl: 11.83. Found: 11.86. [o] No precipitate formed following the reflux period. The solution was concentrated to dryness *in vacuo* and the residue recrystallized from water. [p] Recrystallized from methanol containing 1% water. [q] *Anal.* Calcd. for Cl: 13.65. Found: 13.48. [r] After filtration of the crude reaction product the filtrate was evaporated to dryness and the combined precipitate and residue recrystallized from benzene–cyclohexane (9:1).

TABLE II

5,6,7,8-TETRAHYDRO-(1H)-2,1,3-BENZOTHIADIAZINE 2,2-DIOXIDES

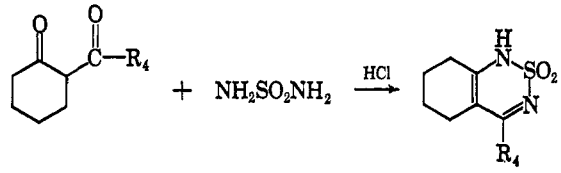


R_4	Yield, %	M.p., °C.	Procedure	Molecular formula	Analyses, % Calcd. C	H	N	S	Found C	H	N	S
CH_3	86	180–181	D[a]	$C_8H_{12}N_2O_2S$	47.98	6.04	13.99	16.01	48.25	6.28	13.60	16.18
C_6H_5	84.5	141–142	D[b]	$C_{13}H_{14}N_2O_2S$	59.52	5.38	10.68	12.22	59.35	5.21	10.77	12.26
p-$CH_3OC_6H_4$	83	149–151	D[b,c]	$C_{14}H_{16}N_2O_3S$	57.52	5.52	9.58	10.97	57.54	5.42	9.53	11.02
3,4,5-$(CH_3O)_3C_6H_2$	100	214–216	D[a,c]	$C_{16}H_{20}N_2O_5S$	54.53	5.72	7.59	9.10	54.70	6.06	7.84	9.03

[a] Recrystallized from ethanol. [b] Recrystallized from isopropyl alcohol. [c] The residue obtained upon concentration of the reaction mixture was triturated with an ether–water mixture to induce crystallization.

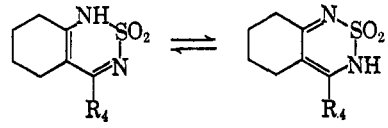
treatment of the carbethoxy derivative (VII) with ammonia, methylamine, or hydrazine. Treatment of the ester (VII) with piperidine in water followed by acidification with hydrochloric acid resulted in hydrolysis to the acid.

The use of 2-acylcyclohexanones in the reaction gave excellent yields of 5,6,7,8-tetrahydro-(1H)-2,1,3-benzothiadiazine 2,2-dioxides (VIII).



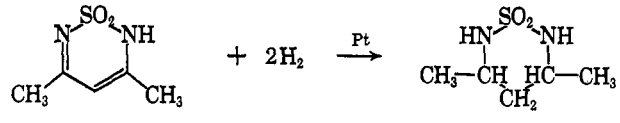
VIII

These compounds are listed in Table II. In each case only one product was formed. Although an isomeric structure may be written for VIII this probably tautomerizes readily.



VIII

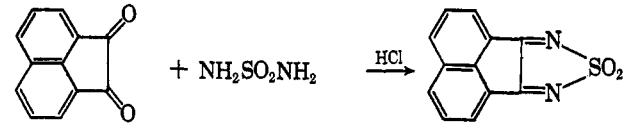
Catalytic hydrogenation of 3,5-dimethyl-1,2,6-thiadiazine 1,1-dioxide using Adams catalyst proceeded with the absorption of 2 moles of hydrogen.



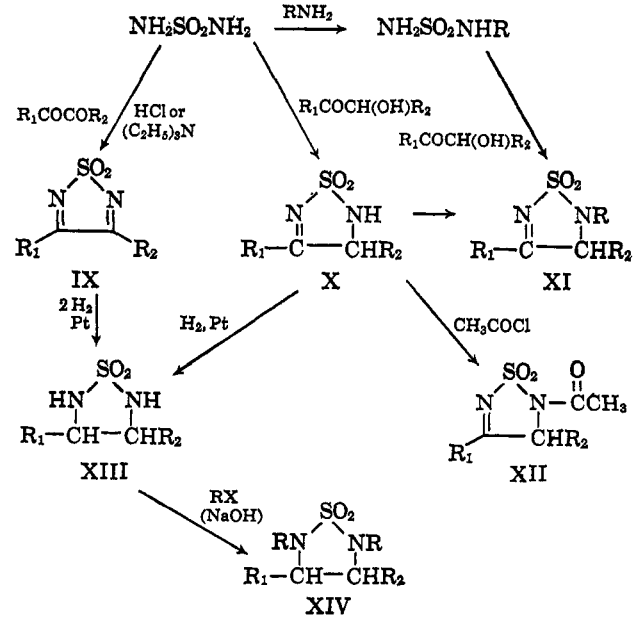
The infrared and nuclear magnetic resonance spectra were in agreement with the tetrahydro-3,5-dimethyl-(2H)-1,2,6-thiadiazine 1,1-dioxide structure. The infrared spectrum significantly showed no absorption in the C=C or C=N regions. Absorption bands were present at 3210 (attributable to NH), 1340 and 1175 (attributable to SO_2) and 1135 cm.$^{-1}$ (attributable to C–N). The n.m.r. spectrum showed a doublet centered at δ 1.2 (J = 7 c.p.s.), possessing an area of six protons, assignable to the two methyl groups. Absorption assignable to the tertiary hydrogens, possessing an area of two protons, was centered at δ 3.6. Also present were triplets showing an AB pattern, centered at δ 1.78 and 1.08, assignable to the hydrogens of the methylene group.[6]

Reaction of α-diketones with sulfamide proceeded readily under conditions of acidic (gaseous HCl) or basic [$(C_2H_5)_3N$] catalysis to give 3,4-disubstituted 1,2,5-thiadiazole 1,1-dioxides (IX). The compounds of this type that were prepared are listed in Table III.

Acenaphthenequinone with sulfamide gave acenaphtho[1,2-c](1,2,5)thiadiazole 8,8-dioxide. Reaction of



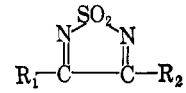
α-hydroxy ketones with sulfamide in the presence of gaseous hydrogen chloride gave the corresponding 3,4-disubstituted 1,2,5-thiadiazoline 1,1-dioxides (X). The use of an N-substituted sulfamide (N-butylsulfamide) in place of sulfamide in this reaction gave the corresponding 2-alkyl derivative XI. One 2-alkyl derivative (XI, R = CH_3; R_1 = R_2 = C_6H_5) was prepared by treatment of X (R_1 = R_2 = C_6H_5) with diazomethane. Acylation of X (R_1 = R_2 = C_6H_5) proceeded readily with boiling acetyl chloride to give the 2-acetyl deriva-



(6) This spectrum was taken on an A-60 n.m.r. spectrometer (Varian Associates, Inc.) using tetramethylsilane as the reference standard.

TABLE III

1,2,5-THIADIAZOLE 1,1-DIOXIDES

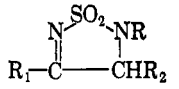


R_1	R_2	Yield, %	M.p., °C.	Procedure	Molecular formula	Analyses, % Calcd. C	H	N	S	Found C	H	N	S
C_6H_5	C_6H_5	58	248–250	E	$C_{14}H_{10}N_2O_2S$	62.21	3.73	10.37	11.86	61.90	3.38	10.11	11.64
p-$CH_3C_6H_4$	p-$CH_3C_6H_4$	82	206–207	F[a]	$C_{16}H_{14}N_2O_2S$	64.41	4.73	9.39	10.75	64.45	4.83	9.08	10.46
C_6H_5	CH_3	29	135 dec.	F[b,c]	$C_9H_8N_2O_2S$	51.91	3.87	...	15.40	52.05	3.64	...	15.50
p-$CH_3OC_6H_4$	p-$CH_3OC_6H_4$	45	185–186	F[d]	$C_{16}H_{14}N_2O_4S$	58.17	4.27	8.48	9.71	58.31	4.11	8.41	9.70

[a] Recrystallized from butanone-2. [b] The reflux period was increased to 3 hr. The mother liquors from the filtration were concentrated *in vacuo* and the residue washed with water and then ether before recrystallization. [c] Recrystallized from benzene. [d] Recrystallized from ethyl acetate.

TABLE IV

1,2,5-THIADIAZOLINE 1,1-DIOXIDES



R_1	R_2	R	Yield, %	M.p., °C.	Molecular formula	Analyses, % Calcd. C	H	N	S	Found C	H	N	S
C_6H_5	C_6H_5	H	63	135.5–136.0	$C_{14}H_{12}N_2O_2S$	61.75	4.44	10.29	11.77	62.32	4.23	10.05	11.44
C_6H_5	C_6H_5	CH_3	42	158–160	$C_{15}H_{14}N_2O_2S$	62.92	4.93	9.79	11.20	62.87	4.87	9.54	11.06
C_6H_5	C_6H_5	C_4H_9	37	132.5–134	$C_{18}H_{20}N_2O_2S$	65.84	6.14	8.53	9.75	65.78	6.15	8.22	9.77
C_6H_5	C_6H_5	CH_3CO	92	170–171	$C_{16}H_{14}N_2O_3S$	61.13	4.49	8.91	10.20	61.35	4.62	8.78	10.03
p-$CH_3C_6H_4$	p-$CH_3C_6H_4$	H	45	72–75 dec.	$C_{16}H_{16}N_2OS$	63.98	5.37	9.33	10.67	64.54	5.21	9.40	10.84

tive (XII, $R_1 = R_2 = C_6H_5$). The 1,2,5-thiadiazoline 1,1-dioxides that were prepared are listed in Table IV.

Catalytic hydrogenation of both 3,4-diphenyl-1,2,5-thiadiazole 1,1-dioxide (IX, $R_1 = R_2 = C_6H_5$) and 3,4-diphenyl-1,2,5-thiadiazoline 1,1-dioxide (X, $R_1 = R_2 = C_6H_5$) proceeded readily with Adams catalyst with the absorption of 2 moles and 1 mole of hydrogen, respectively, to give the corresponding 3,4-diphenyl-1,2,5-thiadiazolidine 1,1-dioxide (XIII, $R_1 = R_2 = C_6H_5$). The latter compound underwent alkylation readily with 2 moles of methyl iodide in the presence of sodium hydroxide to give 2,5-dimethyl-3,4-diphenyl-1,2,5-thiadiazolidine 1,1-dioxide (XIV, R = CH_3; $R_1 = R_2 = C_6H_5$). It was also acylated readily, with dimethylcarbamyl chloride in the presence of sodium hydroxide, to give 2,5-bis(dimethylcarbamyl)-3,4-diphenyl-1,2,5-thiadiazoline 1,1-dioxide (XIV, R = $(CH_3)_2N—C(O)—$; $R_1 = R_2 = C_6H_5$). (See p. 1907.)

Experimental[7-9]

Procedure A. Preparation of 3,5-Diphenyl-(2H)-1,2,6-thiadiazine 1,1-Dioxide.—A mixture of 4.8 g. (0.05 mole) of sulfamide and 11.21 g. (0.05 mole) of 1,3-diphenylpropanedione-1,3 in 40 ml. of anhydrous ethanol was treated with hydrogen chloride gas for a short period of time. The mixture was heated at 60° for 3 hr. and then heated under reflux 5 min. The mixture was heated at 60° for 3 hr. and then heated under reflux 5 min. The mixture was evaporated to dryness *in vacuo* and the residue was triturated with several portions of ether and filtered after each treatment. From the ethereal filtrate there was obtained 5.91 g. of recovered 1,3-diphenylpropanedione-1,3. The ether-insoluble residue was stirred with several portions of water, filtered after each washing, and the residue recrystallized from ethanol.

Procedure B. Preparation of Ethyl 5-Methyl-(2H)-1,2,6-thiadiazine-3-carboxylate 1,1-Dioxide.—To a stirred mixture of 15.82 g. (0.1 mole) of ethyl acetopyruvate, 9.6 g. (0.1 mole) of sulfamide, and 100 ml. of anhydrous ethanol was added gaseous anhydrous hydrogen chloride until the temperature reached 50°. The mixture was then heated under reflux for 3 hr. and the product removed by filtration and purified by recrystallization from benzene.

Procedure C. Preparation of 5-Methyl-(2H)-1,2,6-thiadiazine-3-carboxamide 1,1-Dioxide.—A solution of 15.0 g. (0.069 mole) of ethyl 5-methyl-(2H)-1,2,6-thiadiazine-3-carboxylate 1,1-dioxide and 10 ml. of concentrated ammonium hydroxide in 50 ml. of water was allowed to stand at room temperature for 18 hr. and was then acidified with 1 *N* hydrochloric acid. The precipitate was removed by filtration, washed with water, and purified by recrystallization from water.

5-Phenyl-1,2,6-(2H)-thiadiazine-3-carboxylic Acid 1,1-Dioxide Hydrate.—To 2.80 g. (0.01 mole) of ethyl 5-phenyl-(2H)-1,2,6-thiadiazine-3-carboxylate 1,1-dioxide was added 1.70 g. (0.02 mole) of piperidine and 15 ml. of water. After standing overnight the yellow solution was acidified by the addition of 1 *N* hydrochloric acid; the precipitate was removed by filtration and recrystallized from water.

5-*p*-Tolyl-(2H)-1,2,6-thiadiazine 1,1-Dioxide 3-Carboxyhydrazide.—A solution of 8.0 g. (0.027 mole) of ethyl 5-*p*-tolyl-(2H)-1,2,6-thiadiazine-3-carboxylate 1,1-dioxide and 27 g. (0.54 mole) of hydrazine hydrate was allowed to stand overnight and was then acidified by the addition of 1 *N* hydrochloric acid. The precipitate was removed by filtration, washed with water, and recrystallized from ethanol–dimethylformamide (2:1).

2-Butyl-3,5-diphenyl-1,2,6-thiadiazine 1,1-Dioxide.—Into a stirred mixture of 6.88 g. (0.03 mole) of 1,3-diphenylpropanedione-1,3, 4.66 g. (0.03 mole) of butylsulfamide,[2] and 30 ml. of anhydrous ethanol was passed anhydrous hydrogen chloride gas until the temperature reached 50°. The solution was then heated under reflux for 5 hr., and concentrated *in vacuo*, the residue taken up in ether and water. The ether layer was separated, dried over anhydrous magnesium sulfate, and the ether removed. The residue was recrystallized from ethanol.

Procedure D. Preparation of 5,6,7,8-Tetrahydro-4-methyl-(1H)-2,1,3-benzothiadiazine 2,2-Dioxide.—Into a stirred mixture of 86.0 g. (0.61 mole) of 2-acetylcyclohexanone, 58.8 g. (0.61 mole) of sulfamide, and 480 ml. of anhydrous ethanol was

(7) All melting points are corrected.

(8) The author is indebted to Mr. Albert Lallinger for much technical assistance. He is indebted also to Dr. George Slomp and his associates for the nuclear magnetic resonance spectra, to Dr. Gerald Umbreit and his associates for the microanalytic data, and to Miss Lorraine Pschigoda for the infrared spectral data.

(9) Unless otherwise noted, the physical properties and analytical data are given in the tables.

bubbled hydrogen chloride gas until the temperature reached 60°. The solution was then heated under reflux for 30 min. and the solution concentrated to dryness *in vacuo*. The residue was purified by recrystallization.

Tetrahydro-3,5-dimethyl-(2H)-1,2,6-thiadiazine 1,1-Dioxide.—A solution of 8.0 g. (0.05 mole) of 3,5-dimethyl-(2H)-1,2,6-thiadiazine 1,1-dioxide in 100 ml. of ethanol was hydrogenated at 3 atm. of hydrogen using 200 mg. of platinum oxide as catalyst. Two moles of hydrogen were absorbed after 3 hr. The catalyst was removed by filtration, the solvent removed under vacuum, and the residue recrystallized from ethyl acetate. There was obtained 4.0 g. (49%) of colorless prisms melting at 140–144°. Additional recrystallization raised the melting point to 144–145°.

Anal. Calcd. for $C_5H_{12}N_2O_2S$: C, 36.57; H, 7.37; N, 17.06; S, 19.52. Found: C, 37.13; H, 7.39; H, 16.75; S, 19.50.

Procedure E. Preparation of 3,4-Diphenyl-1,2,5-thiadiazole 1,1-Dioxide.—A mixture of 10.5 g. (0.05 mole) of benzil, 4.8 g. (0.05 mole) of sulfamide, and 2 ml. of triethylamine in 100 ml. of ethanol was heated under reflux for 24 hr. The solution was concentrated to dryness *in vacuo;* the residue was triturated with water, then with ether, and purified by recrystallization from acetone.

Procedure F. Preparation of 3,4-Diphenyl-1,2,5-thiadiazole 1,1-Dioxide.—Into a mixture of 10.51 g. (0.05 mole) of benzyl and 4.8 g. (0.05 mole) of sulfamide in 50 ml. of anhydrous ethanol was bubbled hydrogen chloride gas until the temperature reached 55°. The mixture was heated under reflux for 2 hr., and the precipitate that formed on cooling was removed by filtration (6.33 g., m.p. 248–250°). An additional 0.53 g. was obtained by concentration of the mother liquors. The total yield was thus 6.86 g. (51%). This material gave no depression in melting point when mixed with the material made according to procedure E. The infrared spectra were also identical.

Acenaphtho[1,2-*c*](1,2,5)thiadiazole 8,8-Dioxide.—Into a stirred mixture of 9.1 g. (0.05 mole) of acenaphthenequinone, 4.8 g. (0.05 mole) of sulfamide, and 50 ml. of anhydrous ethanol was bubbled dry hydrogen chloride gas until the temperature reached 60°. The mixture was heated under reflux for 3 hr. with stirring, cooled, and the precipitate removed by filtration. Recrystallization from pyridine gave 8.62 g. (71%) of material melting at 227–232°. Additional recrystallization raised the melting point to 233–234°.

Anal. Calcd. for $C_{12}H_6N_2O_2S$: C, 59.50; H, 2.49; N, 11.57; S, 13.23. Found: C, 59.70; H, 2.09; N, 11.80; S, 13.32.

3,4-Diphenyl-1,2,5-Δ²-thiadiazoline 1,1-Dioxide.—Into a stirred mixture of 127.2 g. (0.6 mole) of benzoin, 57.6 g. (0.6 mole) of (0.6 mole) of sulfamide, and 600 ml. of anhydrous ethanol was bubbled dry hydrogen chloride gas until the temperature rose to 50°. The mixture was then heated under reflux for 4 hr. and the resulting solution concentrated *in vacuo*. The residue was taken up in water and extracted with ether and once with chloroform. The extracts were concentrated by distillation and the residue was recrystallized from anhydrous ethanol–cyclohexane (1:1).

5-Methyl-3,4-diphenyl-1,2,5-Δ²-thiadiazoline 1,1-Dioxide.—To a solution of 3.20 g. (0.01172 mole) of 3,4-diphenyl-1,2,5-Δ²-thiadiazoline 1,1-dioxide in 50 ml. of methylene chloride was added an ethereal solution of diazomethane. After standing at room temperature for 1 hr. the excess diazomethane was destroyed by the addition of acetic acid and the solution evaporated to dryness. The residue was recrystallized from ethanol.

5-Butyl-3,4-diphenyl-1,2,5-Δ²-thiadiazoline 1,1-Dioxide.—The procedure described above for 3,4-diphenyl-1,2,5-Δ²-thiadiazoline 1,1-dioxide was employed using an equivalent amount of butylsulfamide.[2] The product was purified by recrystallization from ethanol.

5-Acetyl-3,4-diphenyl-1,2,5-Δ²-thiadiazoline 1,1-Dioxide.—A mixture of 5.45 g. (0.02 mole) of 3,4-diphenyl-1,2,5-Δ²-thiadiazoline 1,1-dioxide and 15 ml. of acetyl chloride was heated under reflux for 1 hr. and the excess acetyl chloride then removed by distillation under reduced pressure. The residue was triturated with ethanol and then recrystallized from ethyl acetate.

3,4-Di-*p*-tolyl-1,2,5-Δ²-thiadiazoline 1,1-Dioxide.—The procedure described above for 3,4-diphenyl-1,2,5-Δ²-thiadiazoline 1,1-dioxide was employed using an equivalent amount of 4,4'-toluoin in place of benzoin. The product was recrystallized from benzene–cyclohexane (3:1).

3,4-Diphenyl-1,2,5-thiadiazolidine 1,1-Dioxide.—A mixture of 43.2 g. (0.16 mole) of 3,4-diphenyl-1,2,5-thiadiazole 1,1-dioxide in 500 ml. of ethanol was hydrogenated at 3 atm. of hydrogen using 1.2 g. of platinum oxide as catalyst. When the theoretical amount of hydrogen was absorbed (2 hr.) the mixture was heated to reflux on a steam bath and the catalyst removed by filtration of the hot solution. The precipitate that formed on cooling was removed by filtration. Additional material was obtained by concentration of the mother liquors, total yield, 32.60 g. (75%); m.p. 202–203.5°. Recrystallization from ethanol gave colorless needles melting at 202.5–203.5°.

Anal. Calcd. for $C_{14}H_{14}N_2O_2S$: C, 61.29; H, 5.14; N, 10.21; S, 11.69. Found: C, 61.08; H, 4.96; N, 10.03; S, 11.67.

Hydrogenation of 3,4-diphenyl-1,2,5-Δ²-thiadiazoline 1,1-dioxide (8.17 g., 0.03 mole) in 150 ml. of ethanol using 150 mg. of PtO_2 proceeded with the uptake of 1 mole of hydrogen in 30 min. The reaction mixture was worked up as described above, giving 4.16 g. (51%) of colorless needles melting at 202–203°. A mixture melting point with the material obtained above by reduction of 3,4-diphenyl-1,2,5-thiadiazole 1,1-dioxide showed no depression. The infrared spectra of the two samples were also identical.

2,5-Dimethyl-3,4-diphenyl-1,2,5-thiadiazolidine 1,1-Dioxide.—To a stirred mixture of 5.49 g. (0.02 mole) of 3,4-diphenyl-1,2,5-thiadiazolidine 1,1-dioxide, 1.76 g. (0.044 mole) of sodium hydroxide, 10 ml. of water, and 20 ml. of ethanol was added 4 ml. of methyl iodide. The mixture was stirred at room temperature overnight. The mixture was diluted with 25 ml. of water and the solid removed by filtration and recrystallized from ethanol. There was obtained 5.35 g. (88%) of colorless prisms melting at 164–165°.

Anal. Calcd. for $C_{16}H_{18}N_2O_2S$: C, 63.55; H, 6.00; N, 9.27; S, 10.60. Found: C, 63.74; H, 6.02; N, 9.25; S, 10.55.

2,5-Di(dimethylcarbamyl)-3,4-diphenyl-1,2,5-thiadiazolidine 1,1-Dioxide.—A mixture of 5.49 g. (0.02 mole) of 3,4-diphenyl-1,2,5-thiadiazolidine 1,1-dioxide, 5.6 g. (0.052 mole) of dimethylcarbamyl chloride, 16 g. of anhydrous potassium carbonate, and 90 ml. of dry benzene was heated under reflux using a water trap. The theoretical amount of water was collected after 20 hr. of refluxing. The mixture was filtered and the filtrate was concentrated *in vacuo*. Recrystallization of the residue from ethanol gave 4.43 g. (53%) of colorless prisms melting at 210–211°.

Anal. Calcd. for $C_{20}H_{24}N_4O_4S$: C, 57.68; H, 5.81; N, 13.45; S, 7.70. Found: C, 57.48; H, 5.88; N, 13.25; S, 7.82.

3,4-Di-*p*-Tolyl-1,2,5-thiadiazolidine 1,1-Dioxide.—A mixture of 7.45 g. of 3,4-di-*p*-tolyl-1,2,5-thiadiazole 1,1-dioxide and 200 ml. of ethanol was hydrogenated at 3-atm. pressure using 400 mg. of platinum oxide as catalyst. Two moles of hydrogen were absorbed in 7 hr. The catalyst was removed by filtration, the filtrate concentrated to dryness *in vacuo*, and the residue recrystallized repeatedly from a benzene–cyclohexane mixture (2:1). There was obtained 1.61 g. (21%) of colorless platelets melting at 165–167°. Further recrystallization raised the melting point to 167–168°.

Anal. Calcd. for $C_{16}H_{18}N_2O_2S$: C, 63.55; H, 6.00; N, 9.27; S, 10.60. Found: C, 63.24; H, 6.03; N, 9.11; S, 10.55.