of an aqueous solution of the corresponding dihydriodide, evaporation, dissolution of the residue in ethanol, and treatment with picric acid and showed an ir spectrum identical with that of an authentic sample.[13]

Alcoholysis of 1-(2-Imidazolin-2-yl)-2-(methylthio)-2-imidazoline Hydriodide (9) and Triethyl[1-(2-imidazolin-2-yl)-2-imidazolin-2-yl]ammonium Iodide Hydriodide Methanethiol (12). A. With Methanol and 2-Propanol.—A solution of 9 or 12 (0.020 mol) and the alcohol (distilled from calcium hydride, 25 ml) was heated under reflux for 5 days while a stream of nitrogen was bubbled through the reaction mixture and then allowed to cool to room temperature. The precipitate was collected; yield 0.005–0.0067 mol (25–30%) of imidazolidinone hydriodide **14a**, mp 255–257° dec alone or admixed with an authentic sample.

The ir spectra of the samples were identical.

B. With *tert*-Butyl Alcohol.—A solution of 9 or 12 (0.020 mol) and *tert*-butyl alcohol (distilled from calcium hydride, 175 ml) was treated as above to give 0.0180–0.0185 mol (90–93%) of unchanged 9 or 12 by mixture melting point determination and ir spectroscopy.

Registry No.—**5a**, 38631-03-7; **6**, 20112-79-2; **7**, 5464-11-9; **8**, 38621-46-4; **9**, 36858-50-1; **10**, 38631-06-0; **11**, 38631-07-1; **11** HI, 38631-08-2; **12**, 36813-47-5; **13**, 38621-48-6; **14a**, 38631-09-3; **14a** HI, 38677-78-0; **17**, 868-84-8; **18**, 38631-10-6; **19**, 38744-27-3; **20**, 38621-49-7.

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5-Imino-2-oxo-1,2,3-oxathiazolidines[1]

J. A. DEYRUP,* J. C. GILL, T. LEBLANC,[2] AND H. L. GINGRICH

Department of Chemistry, University of Florida, Gainesville, Florida 32601

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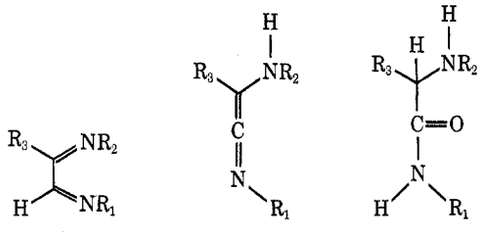
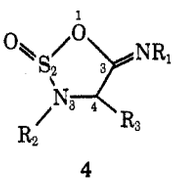
A series of aryl and aliphatic substituted 2-aminoamides have been prepared and treated with thionyl chloride and base to give 5-imino-2-oxo-1,2,3-oxathiazolidines in good yield. This structure was assigned on the basis of analytical, chemical, and spectral data as well as by comparisons with other 2-oxo-1,2,3-oxathiazolidines obtained previously. Asymmetry at sulfur is noted.

As part of our continuing study on the reactions of isonitriles with imines,[3] it became necessary to develop a general synthesis for unsymmetrically N-substituted 1,4-diaza-1,3-butadienes (**1**). Since a direct synthesis of **1** from 1,2-dicarbonyl compounds was precluded by imine interchange reactions,[4] we sought alternative approaches to **1**. Dehydration of readily available 2-aminoamides (**3**) to 2-aminoketenes (**2**) which might



1 **2** **3**

in turn be isomerizable to **1** constituted one attractive path.[5] Initial attempts at dehydration with PCl_5 and subsequent base treatment[7] or with P_2O_5[8] failed to give recognizable products. Reaction of **3** with thionyl chloride and subsequent treatment of the product with pyridine yielded compounds to which we have assigned the 5-imino-2-oxo-1,2,3-oxathiazolidine structure (**4**). In this paper, we wish to discuss the synthesis and structural assignment of this novel *functionally substituted* example of a relatively unexplored heterocyclic system.[9-13]



4

4	R_1	R_2	R_3
a	*o*-$C_6H_4CH_3$	*t*-Bu	H
b	*o*-$C_6H_4CH_3$	C_6H_5	H
c	*t*-Bu	C_6H_5	H
d	*i*-Pr	*t*-Bu	H
e	$CH_2C_6H_4$	*t*-Bu	H
f-1	C_6H_5	*t*-Bu	C_6H_5
f-2	C_6H_5	*t*-Bu	C_6H_5

Results and Discussion

A series of 2-aminoacetamides was prepared from the reactions of the appropriate 2-chloroacetamides and excess primary amines in benzene. These 2-aminoacetamides were in turn treated with excess thionyl chloride and subsequently (after removal of unreacted thionyl chloride) with excess pyridine. Equivalent results were obtained when base (triethylamine) was present during the thionyl chloride reaction.

The product in each reaction (Table I) was neutral and gave a mass spectral parent ion which corresponded to the original molecule plus SO minus 2 H. This empirical formula was confirmed by elemental analysis. The ir spectra indicated that the amide C=O band had

(1) Support of this work by the National Science Foundation (Grant GP-17642) is gratefully acknowledged.

(2) National Science Foundation Undergraduate Research Fellow, summer 1971.

(3) J. A. Deyrup, M. M. Vestling, W. V. Hagan, and H. J. Yun, *Tetrahedron*, **25**, 1467 (1969).

(4) *Cf.* S. Dayagi and Y. Degani in "The Chemistry of the Carbon–Nitrogen Double Bond," S. Patai, Ed., Interscience, New York, N. Y., 1970, p 81.

(5) One previous publication reported the synthesis of an α-acyl-α-aminoketene. No mention was made of its tautomerization.[6]

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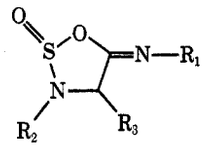
(12) J. A. Deyrup and C. L. Moyer, *J. Org. Chem.*, **34**, 175 (1969).

(13) F. Wudl and T. B. K. Lee, Abstracts, 162nd National Meeting of the American Chemical Society, Washington, D. C., Sept 1971, No. ORGN 177.

TABLE I

5-IMINO-2-OXO-1,2,3-OXATHIAZOLIDINES[a]

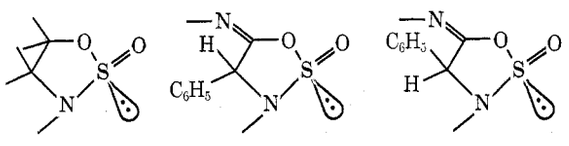


Compd	R_3	R_1	R_2	Yield, %	Mp, °C	Ir C=N, μ	Nmr data δ ppm[b] R_3[c]	H (J_{AB} in Hz, Δ_{AB} in Hz)	R_1 (J_{AB} in Hz, Δ_{AB} in Hz)	R_2
4a	H	*o*-$C_6H_4CH_3$	*t*-Bu	76	123–125[d]	5.81	4.09	(15.9, 19.2)	7.23 (s), 2.27 (s)	1.40 (s)
4b	H	*o*-$C_6H_4CH_3$	C_6H_5	56	129–131[e]	5.83	4.49	(15.7, 12.8)	6.90–7.60 (m), 2.30 (s)	6.90–7.60 (m)
4c	H	*t*-Bu	C_6H_5	41	84–86[d]	5.81	4.30	(15.5, 15.2)	1.65 (s)	6.90–7.54 (m)
4d	H	*i*-Pr	*t*-Bu	48	73–75[d]	5.83	3.93	(16.0, 22.0)	1.11–1.50 (m)	1.37 (s)
4e	H	CH_2–C_6H_5	*t*-Bu	64	88–89[d]	5.85	3.98	(16.0, 15.2)	4.70 (15.3, 36.7), 7.29 (s)	1.35 (s)
4f-1	C_6H_5	C_6H_5	*t*-Bu	80[f]	152–153.5[e]	5.87	7.20–7.90 (m), 5.11 (s)		7.20–7.90 (m)	1.36 (s)
4f-2	C_6H_5	C_6H_5	*t*-Bu		145–147[e]	5.81	7.25–7.55 (m), 5.25 (s)		7.25–7.55 (m)	1.30 (s)

[a] Satisfactory analytical values (±0.4% for C, H, N) for all compounds were reported: Ed. [b] Relative to tetramethylsilane (TMS) in deuteriochloroform. [c] When R_3 = H the values are for the center of the AB quartet. [d] From petroleum ether (bp 65–110°). [e] From absolute EtOH. [f] **4f-1** and **4f-2** were obtained in a 1:2 ratio.

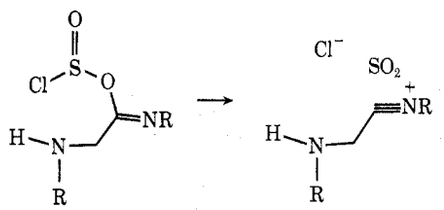
been replaced by an absorption at approximately 5.83 μ (Table I). This is consistent with the exocyclic imino ether substructure in **4**.[14] Other tautomeric structures were excluded by the absence of N–H or OH peaks. Additional support for structure **4** was provided by the mild, high yield (91%) acid hydrolysis of 3-*tert*-butyl-2-oxo-5-(*o*-toluidino)-1,2,3-oxathiazolidine (**4a**) to its precursor, 2-aminoacetamide (**3a**).

Further structural information was revealed by the nmr spectra of these compounds (Table I). The geminal methylene protons of compounds **4a–e** are in a nonequivalent environment as evidenced by their appearance as a doublet of doublets. The benzylic methylene group of compound **4e** also experiences an asymmetric situation. In the case of **4f**, a pair of isomers (**4f-1** and **4f-2**) could be separated by fractional recrystallization. These results require that **4** has a noncarbon dissymmetric center. Asymmetry at sulfur and long-range anisotropic effects by the S–O bond have been discussed previously for the parent 2-oxo-1,2,3-oxathiazolidines (**5**).[12] Thus **4f-1** and **4f-2** must differ with respect to the cis–trans relationship between the sulfur–oxygen bond and the phenyl group (**6**).[15]



5 **6**

Reasons for the formation of the 5-imino-2-oxo-1,2,3-oxathiazolidines and failure to observe the desired imidoyl chlorides are not totally clear. If initial reaction occurs at oxygen to give **7**, then neighboring-group participation by nitrogen must be faster than ionization to nitrilium salt **8**. Protonation on the amino nitrogen (when base is not present during the thionyl chloride reaction) apparently inhibits ionization with loss of SO_2. Alternatively, thionyl chloride might initially react at the α nitrogen. Subsequent neighboring-group participation by the amide oxygen could then yield the product **4**. At the present time, we have no basis for choosing between these alternatives.



7 **8**

A wide variety of similarly functionalized heterocyclic systems should be available by application of the principle embodied in the formation of **4**. It is also worthy of note that formation of these 5-imino-2-oxo-1,2,3-oxathiazolidines results in the simultaneous protection of the nitrogen and activation of the amide. Synthetic utilization of this situation as well as further chemical study of this and related heterocycles is in progress.

Experimental Section

Melting points and boiling points are uncorrected. Ir spectra were recorded on a Perkin-Elmer 137 spectrophotometer. All nmr spectra were recorded on a Varian A-60A spectrometer. Mass spectra were obtained on a RMU 6E mass spectrometer. Microanalyses were obtained from Atlantic Microlab, Atlanta, Ga. 30308.

Chloroacetamides.—*N*-Benzyl-2-chloroacetamide,[16] 2-chloro-*o*-acetotoluidide,[17] *N*-*tert*-butyl-2-chloroacetamide,[18] *N*-isopropyl-2-chloroacetamide,[18] and 2-chlorophenylacetanilide[19] were prepared according to published procedures.[20]

General Procedure for Preparation of 2-Aminoacetamides.—Into a 250-ml round-bottomed flask equipped with a magnetic stirrer, heating mantle, and a reflux condenser was placed the 2-chloroacetamide (0.05 mol) in 100 ml of benzene along with the primary amine (0.5 mol). The reaction was refluxed for 14–60 hr under a nitrogen atmosphere. After this time the 2-amino-

(14) *Cf.* J. A. Deyrup and K. K. Killion, *J. Heterocycl. Chem.*, **9**, 1045 (1972).

(15) Uncertainties in ring and substituent conformation as well as in a precise knowledge of the S–O anisotropic effect precluded assignment of the cis–trans stereochemistry.

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(18) A. J. Speziale and P. C. Hamm, *J. Amer. Chem. Soc.*, **78**, 2556 (1956).

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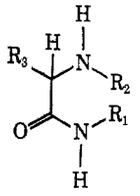
(20) *Cf.* reference 16.

TABLE II

2-AMINOACETAMIDES



Compd	R_3	R_2	R_1	Time, hr	Yield, %	Mp, °C, or bp (mm)	Calcd, % C	Calcd, % H	Calcd, % N	Found, % C	Found, % H	Found, % N
3a	H	*t*-Bu	*o*-$C_6H_4CH_3$	22	95	77–79[a]	70.87	9.15	12.72	70.76	9.26	12.71
3b	H	C_6H_5	*o*-$C_6H_4CH_3$	22	89	159.5–161[b]	74.97	6.71	11.66	74.82	6.77	11.55
3c	H	C_6H_5	*t*-Bu	14	51	72–74[c]	69.87	8.80	13.58	69.77	8.89	13.62
3d	H	*t*-Bu	*i*-Pr	21	86	72 (0.23)	62.75	11.70	16.26	62.65	11.66	16.15
3e	H	*t*-Bu	$CH_2C_6H_5$	21	96	36.5–37.5[a]	70.87	9.15	12.72	70.79	9.20	12.76
3f	C_6H_5	*t*-Bu	C_6H_5	60	58	123.5–125.5[d]	76.56	7.85	9.92	76.61	7.87	9.85

[a] From petroleum ether (bp 65–110°). [b] From absolute EtOH. [c] From C_6H_6 and petroleum ether (bp 65–110°). [d] From MeOH.

acetamide was extracted into 10% hydrochloric acid to separate it from neutral or acidic by-products and then the acid layer was made basic with 10% sodium hydroxide solution and extracted with methylene chloride. The organic layer was dried with anhydrous magnesium sulfate, filtered, and evaporated. The reactions and reaction products are summarized in Table II.

General Procedure for Preparation of 5-Imino-2-oxo-1,2,3-oxathiazolidines.—Into a 200-ml round-bottomed flask equipped with a heating mantle, a magnetic stirrer, a reflux condenser, and a drying tube was placed the 2-aminoacetamide (0.01 mol) in 100 ml of benzene with thionyl chloride (33.1 g, 20 ml, 0.278 mol). The solution was refluxed for 2 hr, cooled, and evaporated to ~10–15 ml to remove excess thionyl chloride. To the residue was added 100 ml of benzene and to this with stirring 25 ml of dry pyridine was slowly added. The resulting mixture was then extracted with 50 ml of water, 100 ml of 10% hydrochloric acid, 50 ml of 10% sodium hydroxide, and then 50 ml of water. The organic layer was dried with anhydrous magnesium sulfate, filtered, and evaporated to an oil. The resulting oil was crystallized from an appropriate solvent (see Table I).

The isomers of compound **4f** were separated by fractional crystallization since column chromatography over 5% deactivated alumina failed to produce separation. It was found that some isomer **4f-1** could be removed very efficiently from isomer **4f-2** by recrystallization from methanol.

As an example of an alternative procedure, a solution of thionyl chloride (0.72 ml, 0.01 mol) in 25 ml of benzene was added to a solution of 2-*tert*-butylamino-*o*-acetotoluidide (2.20 g, 0.01 mol) and triethylamine (2.79 ml, 0.02 mol) in 100 ml of benzene over 1 hr at room temperature. The solution was then refluxed for 2 hr. After the solution had cooled, the triethylamine hydrochloride precipitate was collected by filtration and washed with 50 ml of benzene. The combined filtrates were then washed with 100 ml of 10% HCl, 50 ml of 10% NaOH, and 50 ml of water. The organic layer was dried over anhydrous magnesium sulfate, filtered, and evaporated to a solid. The resulting solid was recrystallized once from absolute EtOH to give 1.93 g (73%) of a colorless crystalline solid, mp 123–125° (**4a**).

Acid Hydrolysis of 4a.—A solution of 666 mg (2.5 mmol) of **4a**, 20 ml of tetrahydrofuran, 10 ml of water, and 6 ml of concentrated hydrochloric acid was allowed to stand at room temperature for 24 hr. The tetrahydrofuran was then evaporated, and, after basification with 10% NaOH, the basic aqueous phase was extracted with chloroform. The dried chloroform extracts ($MgSO_4$) were evaporated to give a yellow solid. This solid was recrystallized from petroleum ether (bp 65–110°) to give 502 mg (91%) of a colorless crystalline solid which was identified as 2-*tert*-butylamino-*o*-acetotoluidide (**3a**) by comparing melting point and ir and nmr spectra with those of an authentic sample.

Registry No.—**3a**, 38630-92-1; **3b**, 38630-93-2; **3c**, 38630-94-3; **3d**, 38630-95-4; **3e**, 38630-96-5; **3f**, 38630-97-6; **4a**, 38630-98-7; **4b**, 38630-99-8; **4c**, 38631-00-4; **4d**, 38631-01-5; **4e**, 38631-02-6; **4f-1**, 38630-66-9; **4f-2**, 38630-67-0.