benzylsulfonated with benzylsulfonyl chloride and pyridine as described for 7 (R_1 = $CHPh_2$; R_3 = $PhOCH_2CO$). The product was chromatographed on silica gel with Et_2O–CH_2Cl_2 (1:20) to give 74% of an oil: IR (film) 1780, 1725, 1625, 1495, 1450, 1370, 1220 cm^{-1}; NMR ($CDCl_3$) δ 2.05 (s, 3 H), 3.45 (s, 2 H), 4.58 (s, 2 H), 4.55–5.20 (d on q, J = 13, 21 Hz, 3 H), 5.70 (d, J = 4.5 Hz, 1 H), 6.95 (s, 1 H), 7.45 (m, 15 H).

7β-Benzylsulfonylcephalosporanic Acid 7 (R_1 = H; R_3 = $PhCH_2SO_2$). Compound 7 (R_1 = $CHPh_2$; R_3 = $PhCH_2SO_2$) was deblocked as described for 7 (R_1 = $CHPh_2$; R_3 = $PhOCH_2CO$) to give a yellow oil. Treatment with potassium 2-ethyl hexanoate gave 60 mg of the potassium salt: IR (KBr) 2910, 1755, 1725, 1600, 1360, 1225 cm^{-1}.

Benzhydryl 7β-(2-*tert*-Butoxycarbonylamino-D-phenylacetoxy)cephalosporanate 7 [R_1 = $CHPh_2$; R_3 = $PhCH(NHCO_2$-*t*-Bu)CO]. Compound 7 (R_1 = $CHPh_2$; R_3 = H) (2.8 g, 6.4 mmol) was esterified with 2-*tert*-butoxycarbonylamino-D-phenylacetic acid as described for 7 (R_1 = $CHPh_2$; R_3 = $C_4H_3SCH_2CO$). Chromatography on silicic acid with Et_2O–CH_2Cl_2 (1:20) gave 0.5 g (11%) of oil: IR (film) 3300, 2960, 1790, 1720, 1500 cm^{-1}; NMR ($CDCl_3$) δ 1.90 (s, 3 H), 4.06 (q, J_{gem} = 15 Hz, 2 H), 4.82 (d, J = 4 Hz, 2 H), 5.35 (d, J = 13 Hz, 1 H), 5.60 (m, 2 H), 6.03 (d, J = 4.8 Hz, 1 H), 6.86 (s, 1 H), 7.24 (m, 15 H).

7β-(2-Amino-D-phenylacetoxy)cephalosporanic Acid 7 [R_1 = H; R_3 = $PhCH(NH_2)CO$]. Compound 7 [R_1 = $CHPh_2$; R_3 = $PhCH(NHCO_2$-*t*-Bu)CO] (0.13 g, 0.149 mmole) was deblocked as described for 7 (R_1 = $CHPh_2$; R_3 = $PhOCH_2CO$). After evaporation of the solvents the residue was dissolved in 10 ml of cold dioxane and 20 ml of cold methylene chloride. Toluenesulfonic acid (29 mg) was added and the solution freeze-dried. The residue was crystallized from dioxane–ether to give a white solid 7 [R_1 = H; R_3 = D-$PhCH(NH_3^+CH_3PhSO_3^-)CO$]: mp 138–140 °C; IR (KBr) 3400, 2900, 1760, 1730, 1610, 1500, 1375 cm^{-1}; NMR (acetone-d_6) δ 1.80 (s), 2.13 (s, 3 H), 3.12 (m, 2 H), 4.70 (d, J = 4 Hz, 2 H), 4.90 (d, J = 5 Hz, 1 H), 5.33 (s, 1 H), 6.15 (d, J = 4 Hz, 1 H), 6.90–7.50 (m, 9 H).

Acknowledgment. This work was supported by a grant from the Sloan Basic Research Fund. We thank Smith Kline and French Laboratories, Philadelphia, Pa., for providing us cephalosporin C sodium salt dihydrate.

Registry No.—**2** (R_1 = p-NO_2PhCH_2; R_2 = H), 51056-21-4; **3** (R_1 = p-NO_2PhCH_2; R_2 = H), 61394-33-0; **3** (R_1 = Ph_2CH; R_2 = OAc), 61394-34-1; **4** (R_1 = p-NO_2PhCH_2; R_2 = H), 61394-35-2; **5** (R_1 = p-NO_2PhCH_2), 61394-36-3; **5** (R_1 = H), 61394-37-4; **6** (R_1 = p-NO_2PhCH_2; R_2 = H), 61394-38-5; **6** (R_1 = Ph_2CH; R_2 = OAc), 59128-53-9; **7** (R_1 = Ph_2CH; R_3 = H), 59128-54-0; **7** (R_1 = R_3 = H), 59128-55-1; **7** (R_1 = $CHPh_2$; R_3 = $PhOCH_2CO$), 59128-56-2; **7** (R_1 = H; R_3 = $PhOCH_2CO$), 57792-80-0; **7** (R_1 = $CHPh_2$; R_3 = $C_4H_3SCH_2CO$), 59128-57-3; **7** (R_1 = H; R_3 = $C_4H_3SCH_2CO$), 59128-58-4; **7** (R_1 = $CHPh_2$; R_3 = $PhCH_2SO_2$), 61394-39-6; **7** (R_1 = H; R_3 = $PhCH_2SO_2$), 61394-40-9; **7** (R_1 = $CHPh_2$; R_3 = $PhCHNHCO_2$-*t*-Bu)CO, 61436-64-4; **7** (R_1 = H; R_3 = $PhCHNH_2COMeC_6H_4SO_3H$), 61394-42-1; dinitrogen tetroxide, 10544-72-6; p-nitrobenzyl 7β-phenoxyacetamidodeacetoxycephalosporanate, 28974-31-4; benzhydryl 7β-(benzhydryl-5-*N*,*N*-phthaloyl-5-aminoadipamido)cephalosporanate, 16361-81-2; benzhydryl 7β-*N*-nitrosobenzhydryl-5-*N*,*N*-phthaloyl-5-aminoadipamidocephalosporanate, 61394-43-2; 2-thienylacetyl chloride, 50529-60-7; phenoxyacetyl chloride, 701-99-5; 2-thienylacetic acid, 1918-77-0; benzylsulfonyl chloride, 1939-99-7; 2-*tert*-butoxycarbonylamino-D-phenylacetic acid, 33125-05-2.

References and Notes

(1) For review see P. G. Sammes, *Chem. Rev.*, **76**, 113 (1976).
(2) L. D. Cama, R. J. Leanza, T. R. Beattie, and B. G. Christensen, *J. Am. Chem. Soc.*, **94**, 1408 (1972).
(3) J. S. Wiering and H. Wynberg, *J. Org. Chem.*, **41**, 1574 (1976).
(4) J. C. Sheehan, Y. S. Lo, J. Löliger, and C. C. Podewell, *J. Org. Chem.*, **39**, 1444 (1974); D. Hauser and H. P. Sigg, *Helv. Chim. Acta*, **50**, 1327 (1967).
(5) G. Lowe, German Patent 2 305 972 (1973); *Chem. Abstr.*, **79**, 115602 (1973).
(6) D. M. Brunwin and G. Lowe, *J. Chem. Soc., Chem. Commun.*, 192 (1972).
(7) F. Scheinmann, Ed., "An Introduction to Spectroscopic Methods for the Identification of Organic Compounds", Vol. I, Pergamon Press, Elmsford, N.Y. 1970, p 129.

1-Oxo-1,2,5-thiadiazolidin-3-ones. A Structural Reassignment

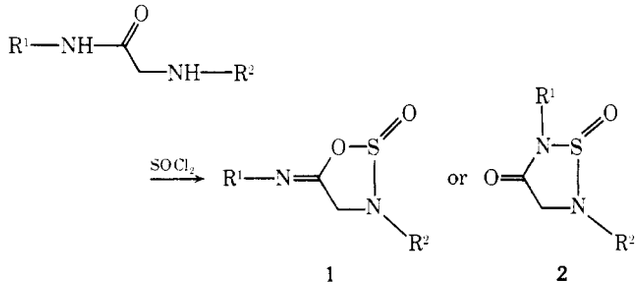
J. A. Deyrup* and H. L. Gingrich

Department of Chemistry, University of Florida, Gainesville, Florida 32611

Received June 29, 1976

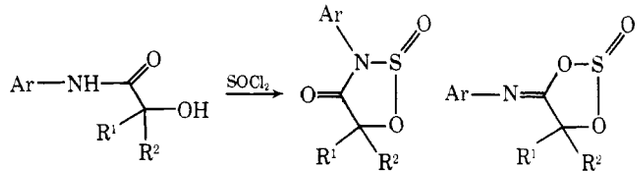
The structure of the products obtained from the reactions of 2-aminoamides with thionyl chloride has been reinvestigated by means of ^{13}C NMR spectroscopy. As a result of these investigations and comparisons with appropriate model compounds, the revised 1-oxo-1,2,5-thiadiazolidin-3-one structure has been assigned.

We reported previously the reaction of 2-aminoamides with thionyl chloride to produce 2-oxo-5-imino-1,2,3-oxathiazolidines (**1**).[1] This structure was based on IR and NMR spectral data as well as the mild acid hydrolysis of **1a** to its precursor 2-aminoamide. Subsequently, Chupp reported on a similar reaction between 2-hydroxyarylamides and thionyl chloride.[2] Consideration of the IR and NMR spectral data led this author to prefer the 2-oxo-1,2,3-oxathiazolidin-4-one structure (**3**) over the isomeric 2-oxo-4-imino-1,3,2-dioxathiolane structure (**4**). Chupp and Dahm later employed ^{18}O labeling and x-ray crystallography to confirm structure **3a** (Ar = 3,4-$Cl_2C_6H_3$; R^1 = CH_3; R^2 = H; 5-methyl group trans to the sulfinyl oxygen).[3] At the same time Chupp



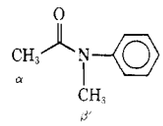
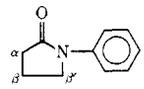
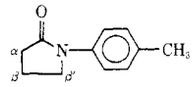
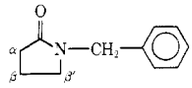
1 **2**

a, R^1 = *o*-$C_6H_4CH_3$; R^2 = *t*-Bu
b, R^1 = *o*-$C_6H_4CH_3$; R^2 = C_6H_5
c, R^1 = *t*-Bu; R^2 = C_6H_5
d, R^1 = $CH_2C_6H_5$; R^2 = *t*-Bu



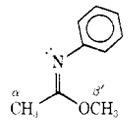
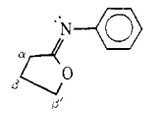
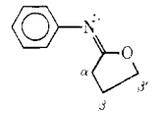
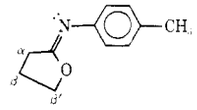
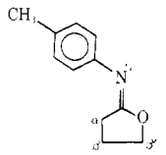
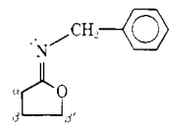
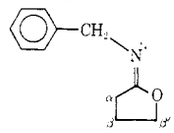
3 **4**

Table I. Amide and Lactam ^{13}C Chemical Shifts[a, b]

Structure	No.	C=O	C-α	C-β	C-β′
	7	170.0	22.3		37.0
	9	174.0	32.7	17.8	48.5
	10	173.8	32.6	17.8	48.6
	11	174.4	30.7	17.6	46.4[c]

[a] Chemical shifts are in parts per million downfield from Me_4Si. [b] Aromatic resonances between 119.6 and 144.7. [c] Assignment may be interchanged with a peak ($ArCH_2$) at 46.3.

Table II. Imidate and Iminolactone ^{13}C Chemical Shifts[a, b]

Structure	No.	C=N-	C-α	C-β	C-β′	CH_3 or CH_2Ar
	8-*Z*	161.5	15.7		53.0	
	12-*Z*	163.5	29.8	22.9	71.2	
	12-*E*	168.9	25.0[c]	23.4[c]	69.1	
	13-*Z*	163.1	29.8	22.9	71.1	20.8
	13-*E*	168.8	24.8[c]	23.4[c]	68.9	20.7
	14-*Z*	163.6	28.8	23.4	70.1	51.2
	14-*E*	169.2	23.6[c]	23.3[c]	67.9	54.5

[a] Chemical shifts are in parts per million downfield from Me_4Si. [b] Aromatic resonances between 121.0 and 149.5. [c] Assignment may be interchanged.

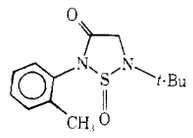
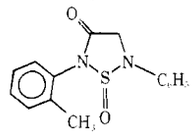
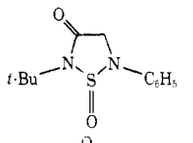
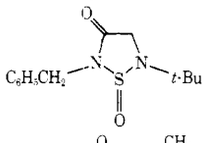
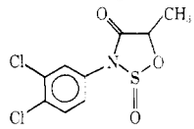
and Dahm also pointed out that our evidence for structure **1** was equally compatible with the isomeric 1-oxo-1,2-5-thiadiazolidin-3-one structure (**2**).

These observations led us to reexamine the structure of the 2-aminoamide–thionyl chloride products. Since the product structure could depend upon the precise nature of the amide nitrogen substituent, a more general technique than either ^{18}O labeling or x-ray crystallography was sought for differentiating between structures **1** and **2**.

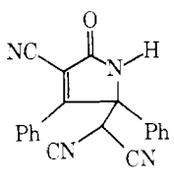
Observation that the 2-aminoamide–thionyl chloride product **1b** showed a peak at *m/e* 222 (8% of base peak) appeared to support the original assignment. This peak, which corresponds to the facile loss of SO_2 from the parent ion, would not be expected from structure **2b**. However, since the possibility of mass spectral rearrangement could not be excluded, we sought other evidence.

Ducker and Gunter recently reported the natural abundance ^{13}C chemical shifts for the C-2 carbons of lactam **5**

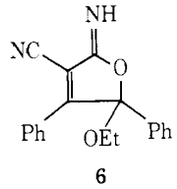
Table III. ^{13}C Chemical Shifts of 2-Aminoamide–Thionyl Chloride Products and 3a[a,b]

Structure	No.	C=O	C-α	CH_3	$C(CH_3)_3$	$C(CH_3)_3$	CH_2
	2a	170.9	46.1	18.0	55.8	27.9	
	2b	169.2	48.4	18.0			
	2c	171.0	49.8		58.4	28.7	
	2d	171.9	46.1[c]		55.4	27.9	43.5[c]
	3a	170.5	76.4	17.0			

[a] Chemical shifts are in parts per million downfield from Me_4Si. [b] Aromatic resonances between 116.9 and 139.6 ppm. [c] Assignments may be interchanged.



5



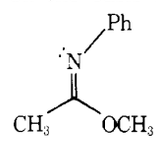
6

(170.4 ppm) and the iminolactone **6** (155.7 ppm).[4] Thus, it appeared that ^{13}C NMR spectroscopy might provide a simple, unambiguous method for differentiating between the amide and imidate moieties, and ultimately between structures **1** and **2**.

To test the validity of this approach, the ^{13}C NMR spectra were obtained for the following model compounds: *N*-methylacetanilide (**7**),[5] *O*-methyl *N*-phenylacetimidate (**8**),[6-8] the 1-substituted 2-pyrrolidinones (**9–11**),[9,10] and the N-substituted 2-iminotetrahydrofurans (**12–14**).[11,12] The assignments of the pertinent ^{13}C resonances of these model compounds are shown in Tables I and II.

The ^{13}C spectra for the acyclic amide **7** and the lactams **9–11** were all easily assigned with the lactam carbonyl carbons appearing ca. 4 ppm further downfield than the amido carbon of **7**.

The spectra of imidate **8** and the iminolactones **12–14** proved to be more complex because of syn–anti isomerism. Moriarty et al. reported that **8** exists as the configurationally stable *Z* isomer (**8**-*Z*) on the basis of 100-MHz ^1H NMR

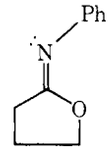


8-*Z*

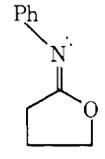
studies.[8] Our ^{13}C spectrum of **8** confirms the presence of only one isomer. In contrast, Saito and Nukada reported that **12** exists as a mixture of syn–anti isomers **12**-*Z* and **12**-*E*.[13] On the basis of their spectral studies, Saito and Nukada assigned the major isomer the *Z* configuration. Apparently, the effective size of the **12**-*E* methylene group is larger than the oxygen.

The ^{13}C and ^1H spectra of iminolactones **12–14** confirm the existence of syn–anti isomerism. For example, from the ^1H spectra the major isomer was shown to represent ca. 65 and 89% of **13** and **14**, respectively. The major isomer in each case is assigned the *Z* configuration based on the work of Saito and Nukada.[13,14] It is not clear why the chemical shifts for the imino carbon of the *E* isomers is deshielded relative to the same carbon in the *Z* isomer. It is possible that repulsive interaction between the α-methylene protons and the phenyl ring causes the angle between the C=N and the *N*-phenyl bond to become slightly larger than 120°. The concomitant rehybridization of the nitrogen atom from sp^2 toward sp would increase s character in the nitrogen orbital participating in the C–N σ bond and thereby cause a deshielding of the imino carbon.[21]

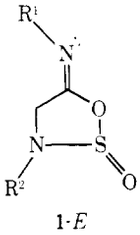
The ^{13}C spectra were obtained for a variety of our 2-aminoamide–thionyl chloride products **1a–d** or **2a–d** and for compound **3a**. These spectral results are summarized in Table III. An examination of these spectra reveals that the low-field resonance corresponding to the imino carbon in structure **1** or the amido carbon in structure **2** appears in the range of 169–172 ppm. This chemical shift range is in good agreement with the chemical shift of ca. 174 ppm observed for the amido carbon in lactams **9–11**. The slight shielding effect could be due to the adjacent sulfinyl group in structure **2**. The observed ^{13}C chemical shift of 170.5 ppm for the amido carbon of **3a** supports this assignment.[17] Of equal or greater significance is the failure to observe any sign of syn–anti isomerism in the



12-*Z*



12-*E*



1-*E*

^{13}C spectra of these 2-aminoamide–thionyl chloride products.[22] The 169–172 ppm chemical shift range could be consistent with structure **1**, if the products existed solely as the configurationally stable *E* isomer **1**-*E*. It appears unlikely, however, that the configurational preference of these compounds should be completely opposite that of the iminolactones **12–14**. On the basis of these ^{13}C spectra, the 2-aminoamide–thionyl chloride products should be reassigned the 1-oxo-1,2,5-thiadiazolidin-3-one structure (**2**) rather than the initially assigned 2-oxo-5-imino-1,2,3-oxathiazolidine structure (**1**).

Experimental Section

Spectra. Carbon-13 spectra were recorded on a Varian XL-100-15 NMR spectrometer, equipped with a Transform Technology FT attachment, operating at 25.16 MHz under conditions of full proton decoupling at a probe temperature of about 38 °C. Samples were observed in 12-mm o.d. tubes as saturated solutions (for solid compounds) or approximately 50% solutions (for liquid compounds) in $CDCl_3$ containing Me_4Si as internal standard. ^1H NMR spectra were also recorded on $CDCl_3$ solutions using a Varian XL-100-15 NMR spectrometer. Chemical shifts are relative to internal Me_4Si.

Materials. The 2-aminoamide–thionyl chloride products (**2a–d**) were prepared as previously described.[1] Compound **3a** was prepared according to the procedure of Chupp.[2] Compound **7** was prepared by the acetylation of *N*-methylaniline with acetyl chloride.[5] Compound **8**[6-8] was prepared from acetanilide by methylation using methyl fluorosulfonate. Compounds **9**,[9] **10**,[9] and **11**[10] were prepared by potassium hydroxide fusion of *N*-phenyl- (**15**),[9] *N*-*p*-tolyl- (**16**),[9] and *N*-benzyl-4-chlorobutanamide (**17**),[10] respectively. Compounds **12**,[11,12] **13**,[11] and **14**[11] were prepared from **15**, **16**, and **17**, respectively, upon treatment with silver tetrafluoroborate, according to the general procedure of Eschenmoser et al.[20] as applied by Schmir and Cunningham[12] for the preparation of **12**. All of the compounds had IR and ^1H NMR spectra in agreement with the assigned structures.

Acknowledgments. The authors thank the National Science Foundation for partial support of this work and Dr. W. S. Brey, Jr., Dr. L. W. Jaques, and Mr. P. I. Yang for recording the ^{13}C spectra reported in this paper. H. L. G. thanks the Proctor & Gamble Co. for a graduate fellowship (1974–1975).

Registry No.—**2a**, 61218-56-2; **2b**, 61218-57-3; **2c**, 61218-58-4; **2d**, 61218-59-5; **3a**, 52559-50-9; **7**, 579-10-2; **9**, 4641-57-0; **10**, 3063-79-4; **11**, 5291-77-0; **8**-*Z*, 31001-89-5; **12**-*Z*, 51229-48-2; **12**-*E*, 51229-49-3; **13**-*Z*, 61218-60-8; **13**-*E*, 61218-61-9; **14**-*Z*, 61218-62-0; **14**-*E*, 61218-63-1.

References and Notes

(1) J. A. Deyrup, J. C. Gill, T. LeBlanc, and H. L. Gingrich, *J. Org. Chem.*, **38**, 1645 (1973).
(2) J. P. Chupp, *J. Heterocycl. Chem.*, **11**, 1 (1974).
(3) J. P. Chupp and D. J. Dahm, *J. Heterocycl. Chem.*, **12**, 393 (1975).
(4) J. W. Ducker and M. J. Gunter, *Aust. J. Chem.*, **27**, 2229 (1974).
(5) A. W. Hoffman, *Ber.*, **7**, 525 (1874).
(6) A. Buhner, *Justus Liebigs Ann. Chem.*, **333**, 289 (1904).
(7) A. Pilotti, A. Reuterhall, and K. Torssell, *Acta Chem. Scand.*, **23**, 818 (1969).
(8) R. M. Moriarty, C. L. Yeh, K. C. Ramey, and P. W. Whitehurst, *J. Am. Chem. Soc.*, **92**, 6360 (1970).
(9) P. Lipp and F. Caspers, *Chem. Ber.*, **58**, 1011 (1925).
(10) W. E. Hanford and R. Adams, *J. Am. Chem. Soc.*, **57**, 921 (1935).
(11) T. Mukaiyama and K. Sato, *Bull. Chem. Soc. Jpn.*, **36**, 99 (1963).
(12) G. L. Schmir and B. A. Cunningham, *J. Am. Chem. Soc.*, **87**, 5692 (1965).
(13) H. Saito and K. Nukada, *Tetrahedron*, **22**, 3313 (1966).
(14) Possible support for this assignment comes from the observation that the α-methylene carbon of the minor isomer is ca. 5 ppm upfield from the α-methylene carbon of the major isomer in each case. This upfield shift is probably a steric compression shift similar to those observed for α-syn carbons of oximes.[15,16]
(15) G. C. Levy and G. L. Nelson, *J. Am. Chem. Soc.*, **94**, 4897 (1972).
(16) G. E. Hawkes, K. Herwig, and J. D. Roberts, *J. Org. Chem.*, **39**, 1017 (1974).
(17) Inspection of the ^{13}C chemical shifts of the aromatic ring carbons of the imidate **8** and the iminolactones **12** and **13**[18] reveals a pattern qualitatively consistent with nitrogen lone pair conjugation with the phenyl π system. In these spectra the ortho and para carbons are shielded by at least 5 ppm relative to the meta carbons.[19] Lactams **9** and **10** also show a similar shielding pattern due to amide–phenyl conjugation, while the ortho and para ring carbons of amide **7** are not shielded presumably due to steric inhibition of amide–phenyl conjugation. Inspection of the *o*-tolyl ring carbons of the 2-aminoamide–thionyl chloride products (**1a** or **2a** and **1b** or **2b**) reveals the absence of any appreciably shielded carbons. Molecular models of these compounds suggest that the *o*-tolyl methyl group should sterically inhibit the amide–phenyl conjugation in **2a** and **2b**, while not interfering with the nitrogen lone pair–phenyl conjugation in **1a** and **1b**. Thus, the absence of a shielded ortho or para carbon in the *o*-tolyl ring of these two compounds also favors assignment of structure **2** over structure **1**.
(18) H. L. Gingrich, Ph.D. Thesis, University of Florida, 1977.
(19) G. L. Nelson, G. C. Levy, and J. D. Cargioli, *J. Am. Chem. Soc.*, **94**, 3089 (1972).
(20) H. Peter, M. Brugger, J. Schreiber, and A. Eschenmoser, *Helv. Chim. Acta*, **46**, 577 (1963).
(21) **Note Added in Proof.** Sauers and Relles have reported the ^{13}C chemical shifts of two *N*-aryl-2,2-dimethylsuccinisoimides, which exhibit syn–anti isomerism. As in the case of the iminolactones reported in this paper, the methylene carbon α to the imino group in the *E* isomer of these *N*-aryl-2,2-dimethylsuccinisoimides exhibits a steric compression shift: C. K. Sauers and H. M. Relles, *J. Am. Chem. Soc.*, **95**, 7731 (1973).
(22) **Note Added in Proof.** A referee suggested that the failure to observe any sign of syn–anti isomerism in the ^{13}C NMR spectra of our 2-aminoamide–thionyl chloride products could be consistent with structure **1** if syn–anti isomerization is fast at room temperature and/or the concentration of the minor isomer is too low to be detected by ^{13}C NMR, which is less sensitive than ^1H NMR. However, the proton spectrum of the 2-aminoamide–thionyl chloride product (**1d** or **2d**) failed to show any additional signals even upon cooling to −50 °C.

Heteroaromatic 10-π-Electron Systems. New *s*-Triazolo-*as*-triazines with a Bridgehead Nitrogen Atom

J. Daunis and H. Lopez*

Laboratoire de Synthèse et d'Étude Physicochimique d'Hétérocycles Azotés, Université des Sciences et Techniques du Languedoc, 34060 Montpellier Cedex, France.

G. Maury

Département de Chimie, Faculté des Sciences, Rabat, Maroc

Received September 28, 1976

Four different polyazaindolizine systems of the *s*-triazolo-*as*-triazine type have been prepared either from 3-amino- or 3-hydrazino-*as*-triazines, or from 5-chloro-, 3,4-diamino-, or 3-hydrazino-*s*-triazoles.

s-Triazolo-*as*-triazine heterocycles are among the least known in the polyazaindolizine series. In particular *s*-triazolo[2,3-*b*]-*as*-triazines **2** have never been described and only *s*-triazolo[4,3-*b*]-*as*-triazines **1**, *s*-triazolo[3,4-*c*]-as-triazines **3**, and *s*-triazolo[3,2-*c*]-*as*-triazines **4** substituted with phenyl, amino, hydroxy, or mercapto groups are known.[1-8] The synthesis and properties of unsubstituted and methyl-substituted *s*-triazolo-*as*-triazines **1–4** (Chart I) were of interest in con-