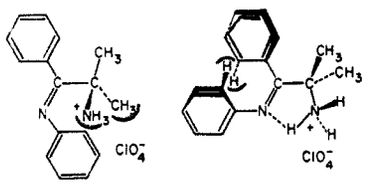
yielded α-ammoniumisobutyrophenone perchlorate (**4**) (or α-aminoisobutyrophenone perchlorate).

The ring opening reaction was extended to other examples by using the perchlorates of *p*-anisidine and *p*-toluidine with 3,3-dimethyl-2-phenyl-1-azirine (**1**) in anhydrous acetonitrile below 0°, which yielded α-ammoniumisobutyrophenone *p*-methoxyanil perchlorate (**3b**) and α-ammoniumisobutyrophenone *p*-methylanil perchlorate (**3c**), respectively. The structures were assigned by analogy, elemental analysis, and ir and nmr spectra. The assignment of the stereochemistry of the anils requires a decision between the *trans* (with respect to the two phenyl groups) form of **3**, in which there is unfavorable interaction between the ammoniumisopropyl group and the N-phenyl ring, and the *cis* form, in which the unfavorable steric interaction between the two phenyl rings may be relieved to some extent by twisting of a phenyl ring slightly out of coplanarity with the C=N bond[6]



3 (*trans*) **3** (*cis*)

and may be balanced by the intramolecular hydrogen bonding[7] which is possible in this geometric isomer. However, the relative stability of the two forms can be a function of the state and, in solution, of the solvent. A clear decision has not been reached on the basis of the evidence available at this time, but the ultraviolet spectra of these and related compounds in absolute ethanol suggest that the *cis* form of **3** is favored in this solvent.

Experimental Section

Aniline Salts.—A chilled solution of 1.0 g of aniline, *p*-anisidine, or *p*-toluidine in 10 ml of water was treated with 1.4 g of commercial 70% perchloric acid at −20°. After 15 min the reaction mixture was treated with 50 ml of ether. The white solid was collected and recrystallized from ethylene chloride or ethylene chloride–*n*-pentane. The yields varied from 81 to 94%.

Anilinium perchlorate had mp 259–260° dec (*caution:* explodes just above the melting point!).

Anal. Calcd for $C_6H_8ClNO_4$: C, 37.23; H, 4.17. Found: C, 37.62; H, 4.17.

***p*-Methoxyanilinium perchlorate** had mp 189–190° dec.

Anal. Calcd for $C_7H_{10}ClNO_5$: C, 37.60; H, 4.51. Found: C, 37.90; H, 4.65.

***p*-Methylanilinium perchlorate** had mp 254–255° dec.

Anal. Calcd for $C_7H_{10}ClNO_4$: C, 40.50; H, 4.86; N, 6.75. Found: C, 40.75; H, 4.86; N, 6.64.

Reaction of 3,3-Dimethyl-2-phenyl-1-azirine (1) with Anilinium Perchlorates. Formation of α-Ammoniumisobutyrophenone Anil Perchlorates (3).—A solution of 0.75 g (0.005 mole) of 3,3-dimethyl-2-phenyl-1-azirine,[4,8] $n^{22.5}D$ 1.5237, in 5 ml of acetonitrile was stirred at −10° while a solution of 1 g (0.005 mole) of anilinium perchlorate in 25 ml of acetonitrile was added dropwise over a period of 30 min. The pale yellow reaction mixture was allowed to stand at −10° for 64 hr, and the precipitated crystalline material (0.99 g), mp 161°, was collected by filtration. The filtrate was concentrated *in vacuo* to about half of its volume, cooled to −10°, and diluted by dropwise addition of ether, which caused the precipitation of shiny white crystals (0.65 g). The *final* total yield of product was 1.68 g (96%). Crystallization from ethylene chloride gave **α-ammoniumisobutyrophenone anil perchlorate (3a)** as shiny white prisms (1.05 g): mp 161.5–162.5°; ν_{max}^{Nujol} 3180, 1660 cm^{-1}; ν_{max}^{KBr} 3125, 3050, 1650 cm^{-1}; $\nu_{max}^{ClCH_2CH_2Cl}$ (0.01 *M*) 3050–3250 (w, br), 1650 cm^{-1} (w); (0.1 *M*) 3050–3250 (s, br), 1650 cm^{-1} (s); nmr τ (acetone-d_6), 8.20 (s, 6 H), 2.71 (s), and 2.34 to 3.37 (m, 13 H); λ_{max}^{EtOH} 293 mμ (ε 1630).

Anal. Calcd for $C_{16}H_{19}ClN_2O_4$: C, 56.72; H, 5.63; N, 8.27; Cl, 10.47. Found: C, 56.81; H, 5.80; N, 8.54; Cl, 10.65.

α-Ammoniumisobutyrophenone *p*-methoxyanil perchlorate (3b) was prepared from **1** and *p*-anisidine: mp 168–169°; ν_{max}^{Nujol} 3200, 1640 cm^{-1}; $\nu_{max}^{ClCH_2CH_2Cl}$ 3050–3250 (s, br), 1650 cm^{-1} (s); nmr τ ($CDCl_3$), 8.42 (s, 6 H, *gem* CH_3's), 6.42 (s, 3 H, OCH_3), 2.78 (s, br) and 2.5-3.8 (m, 12 H); λ_{max}^{EtOH} 292 mμ (ε 4220).

Anal. Calcd for $C_{17}H_{21}ClN_2O_5$: C, 55.36; H, 5.74; N, 7.60. Found: C, 55.29; H, 5.90; N, 7.49.

α-Ammoniumisobutyrophenone *p*-methylanil perchlorate (3c) was prepared from **1** and *p*-toluidine: mp 167–168°; ν_{max}^{Nujol} 3250, 1640 cm^{-1}; $\nu_{max}^{ClCH_2CH_2Cl}$ 3050–3250 (s, br), 1650 cm^{-1} (s); nmr τ (acetone-d_6), 8.21 (s, 6 H, *gem* CH_3's), 7.87 (s, 3 H, $ArCH_3$), 2.71 (s) and 2.6–3.7 (m, 12 H); λ_{max}^{EtOH} 293 mμ (ε 2290).

Anal. Calcd for $C_{17}H_{21}ClN_2O_4$: C, 57.87; H, 6.00; N, 7.94. Found: C, 58.05; H, 5.93; N, 7.87.

α-Ammoniumisobutyrophenone Perchlorate (4).—A solution of 0.20 g of the anil **3a** in 10 ml of water was heated at 80° for 2 hr. Removal of the water *in vacuo* gave 0.15 g of white prisms. Recrystallization from acetone–ether gave the ketone **4**[4] as colorless prisms: mp 253.5–254.5° dec; 0.12 g (73% yield of purified product); ν_{max}^{Nujol} 3150, 1680 cm^{-1}; nmr τ (acetone-d_6), 7.96 (s, 6 H), 1.82–2.50 (m, 5 H), identical with those of an authentic specimen.[4]

Anal. Calcd for $C_{10}H_{14}ClNO_5$: C, 45.54; H, 5.36; N, 5.30. Found: C, 45.26; H, 5.30; N, 5.02.

Composite Spectra.—When *p*-anisidine was added to an equimolar (actually 0.049 m*M*) solution of α-ammoniumisobutyrophenone perchlorate (λ_{max}^{EtOH} 277 mμ (ε 750)) in absolute ethanol, the solution containing both showed a composite λ_{max}^{EtOH} 297 mμ (ε 3220). Accordingly, it was ascertained that **3b** (above) was not hydrolyzed immediately in absolute ethanol to its component parts. The ultraviolet absorption maxima of additional anils in absolute ethanol anils were determined for direct comparison purposes: benzalaniline, 262 mμ (ε 17,000), 308 (8620); benzal-*p*-anisidine, 264 (12,900), 331 (12,650); benzal-*p*-toluidine, 262 (13,900), 318 (8990). All three anils showed ν_{max}^{Nujol} 1620 cm^{-1}.

Registry No.—**1**, 14491-02-2; **3a**, 14796-07-7; **3b**, 14796-08-8; **3c**, 14796-09-9; **4**, 14901-51-0; anilinium perchlorate, 14796-11-3; *p*-methoxyanilinium perchlorate, 14796-12-4; *p*-methylanilinium perchlorate, 14796-13-5.

(6) D. Y. Curtin and J. W. Hausser, *J. Am. Chem. Soc.*, **83**, 3474 (1961).
(7) C. L. Stevens, A. Thuillier, and F. A. Daniher, *J. Org. Chem.*, **30**, 2962 (1965).
(8) R. F. Parcell, *Chem. Ind.* (London), 1396 (1963).

The Rearrangement of a 2-Aminobenzylidenaminoacetic Acid N-Oxide with Ethyl Chloroformate[1]

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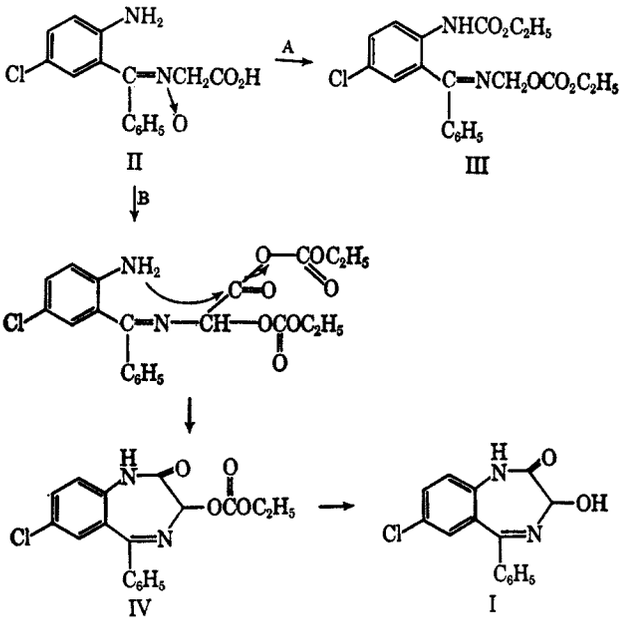
In an attempt to find fresh approaches to the preparation of 7-chloro-1,3-dihydro-3-hydroxy-5-phenyl-2H-1,4-benzodiazepin-2-one (I),[2] we have studied the

(1) Reported at the Medicinal Chemistry Symposium, Bloomington, Ind., June 1966.
(2) S. C. Bell and S. J. Childress, *J. Org. Chem.*, **27**, 1691 (1962).

reaction of 2-amino-5-chloro-α-phenylbenzylidenaminoacetic acid N-oxide (II)[3] with several reagents that might have been expected to cause the rearrangement of the N-oxide II. We have already reported[4] the unexpected rearrangement that took place upon treatment of II with acetic anhydride to afford 2′-(α-acetoxymethyliminobenzyl)-4′-chloroacetanilide[5] as well as the production of 6-chloro-4-phenyl-2(1H)quinazolinone from the reaction between II and phenyl chloroformate. The reaction between II and ethyl chloroformate[6] followed an entirely different course which is described below.

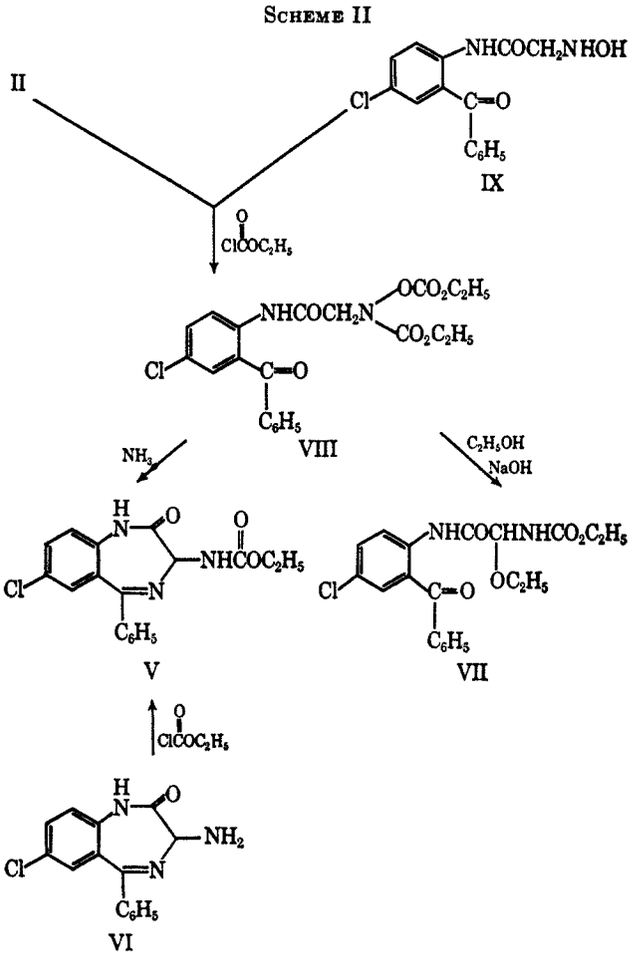
Although it was desired that the reaction between II and ethyl chloroformate[7] follow path B and ultimately yield I, consideration of the result[4] obtained with acetic anhydride suggested III as the more likely product (Scheme I). The product obtained, however, was neither III nor IV but was ethyl 7-chloro-1,3-dihydro-2-oxo-5-phenyl-2H-1,4-benzodiazepine-3-carbamate (V). Since V had previously been prepared unambiguously from 3-amino-7-chloro-1,3-dihydro-5-phenyl-2H-1,4-benzodiazepin-2-one (VI)[8] and ethyl chloroformate, its identification caused no difficulty.

SCHEME I



The production of V was dependent upon the method used for working up the reaction mixture. Compound V was formed only when the intermediate product from the treatment of II with ethyl chloroformate was further treated with ammonia for the purpose of neutralization. The use of alcoholic sodium hydroxide instead of ammonia afforded another compound whose structure was determined by interpretation of its nmr and infrared spectra to be 2′-benzoyl-4′-chloro-2-ethoxy-2-ethoxycarbonylaminoacetanilide (VII). The formation of VII revealed the probable route by which V had likely arisen. We have described elsewhere[8b,9] the base-catalyzed elimination of acetate from a molecule containing the grouping $-NHCOCH_2N(OAc)Ac$ followed by addition of an available nucleophile to give the grouping $-NHCOC(Nu)HNHAc$. The logical precursor of VII is therefore 2′-benzoyl-2-(N-ethoxycarbonyl-N-ethoxycarbonyloxyamino)-4′-chloroacetanilide (VIII), from which VII is formed by elimination of ethyl carbonate, followed by addition of the ethoxide nucleophile. In an analogous way, the formation of V can be explained by the elimination–addition reaction of VIII with ammonia followed by ring closure of the intermediate amine. A careful exclusion of base in a repetition of the original reaction between II and ethyl chloroformate yielded VIII, the structure of which was confirmed by direct synthesis from 2′-benzoyl-4′-chloro-2-hydroxyaminoacetanilide[1,9] (IX) and ethyl chloroformate. Compound VIII, when treated with ethanol and ammonia, afforded VII and V, respectively (see Scheme II).

SCHEME II



A plausible mechanism for the formation of the benzophenone VIII from the reaction of the N-oxide II with ethyl chloroformate is outlined in eq 1. For-

(3) S. C. Bell, T. S. Sulkowski, C. Gochman, and S. J. Childress, *J. Org. Chem.*, **27**, 562 (1962); L. H. Sternbach and E. Reeder, *ibid.*, **26**, 4936 (1961).

(4) S. C. Bell and P. H. L. Wei, *ibid.*, **30**, 3576 (1965).

(5) The formation of 3-acetoxy-7-chloro-1,3-dihydro-5-phenyl-2H-1,4-benzodiazepin-2-one from the reaction of compound II with acetic anhydride has been reported by E. Reeder and L. H. Sternbach, U. S. Patent 3,291,791 (1966).

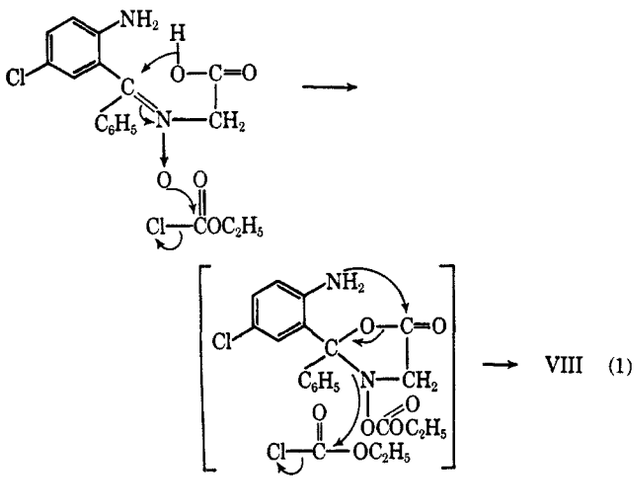
(6) N-Oxides have been reported to undergo Polonovski-like rearrangements with ethyl chloroformate: S. C. Bell, U. S. Patent 3,296,249 (1967).

(7) The formation of peptide bonds using a mixed carbonic carboxylic acid anhydride prepared from alkyl chloroformates is discussed by N. F. Albertson, *Org. Reactions*, **12**, 172 (1962).

(8) (a) S. C. Bell, U. S. Patent 3,198,789 (1965). (b) S. C. Bell, R. J. McCaully, and S. J. Childress, *Tetrahedron Letters*, 2889 (1965).

(9) S. C. Bell, R. J. McCaully, and S. J. Childress, *J. Org. Chem.*, **32**, 216 (1967).

mation of a reactive cyclic intermediate is facilitated by the ethoxycarbonyloxy group on the nitrogen. Intramolecular nucleophilic attack on the lactone carbonyl group results in ring opening to form product VIII.



VIII (1)

Experimental Section[10]

2'-Benzoyl-4'-chloro-2-ethoxy-2-ethoxycarbonylaminoacetanilide (VII). Method A.—A mixture of 4.0 g of 2-amino-5-chloro-α-phenylbenzylidenaminoacetic acid N-oxide (II) in 30 ml of ethyl chloroformate and 30 ml of chloroform was refluxed for 1.5 hr. The solvent was removed *in vacuo* and the residue was dissolved in ethanol and made basic with 10 ml of sodium hydroxide. Dilution with water and acidification with acetic acid gave 1.4 g of VII. After recrystallization from ethanol the compound had a mp of 171–172°.

The infrared spectrum (KBr) of VII showed carbonyl peaks at 5.85 (NHC(=O)OC_2H_5), 5.90 (—NHC(=O)—), and 6.10 μ (diaryl ketone) and NH peaks at 3.09 and 6.55 μ (shoulder) (amide II). The nmr spectrum ($CDCl_3$) had peaks at δ 1.27 (CH_3, t, J = 7 cps), 1.38 (CH_3, t, J = 7 cps), 3.83 (CH_2, q, ether), 4.20 (CH_2, q), and 5.5 (-CH–, d, J = 9 cps), which on warming in D_2O was converted to a singlet.

Anal. Calcd for $C_{20}H_{21}ClN_2O_5$: C, 59.34; H, 5.23; N, 6.92; Cl, 8.76. Found: C, 59.58; H, 5.33; N, 6.96; Cl, 8.80.

Method B.—To a suspension of 200 mg of VIII in ethanol was added an excess of alkali. The resultant alkaline solution was diluted with water and the product was recrystallized from ethanol. The compound (mp 171–172°) was the same as that prepared by method A.

Ethyl 7-Chloro-1,3-dihydro-2-oxo-5-phenyl-2H-1,4-benzodiazepine-3-carbamate (V). Method A.—To a solution of 10 ml of concentrated ammonium hydroxide and 20 ml of ethanol was added 300 mg of VIII. The mixture was heated to boiling, concentrated to one-half of the original volume and diluted with water. The hot solution was acidified with acetic acid and filtered from impurities. Upon cooling, 150 mg of product (mp 253–255°) was collected.

Anal. Calcd for $C_{18}H_{16}ClN_3O_3$: C, 60.42; H, 4.51; N, 11.74; Cl, 9.91. Found: C, 60.58; H, 4.21; N, 12.00; Cl, 9.90.

Method B.—To a chilled solution of 2.0 g of 3-amino-7-chloro-1,3-dihydro-5-phenyl-2H-1,4-benzodiazepin-2-one hydrochloride (VI) in pyridine was added, dropwise, 0.75 g of ethyl chloroformate. The solution was diluted with water to give 1.8 g of product. After recrystallization from acetonitrile the compound had a melting point of 251–253° and was the same as that prepared by method A.

Method C.—A mixture of 4.0 g of II in 30 ml of ethyl chloroformate and 30 ml of chloroform was refluxed for 1.5 hr. The solvent was removed *in vacuo* and the residue was treated with ethanol and ammonium hydroxide as in method A. The product had a melting point of 251–253° after recrystallization from acetonitrile and was the same as that prepared by methods A or B.

(10) The nmr spectra were obtained on a Varian A-60 spectrometer using tetramethylsilane as the internal reference.

2'-Benzoyl-2-(N-ethoxycarbonyl-N-ethoxycarbonyloxyamino)-4'-chloroacetanilide (VIII).[11] **Method A.**—A mixture of 4.0 g of 2-amino-5-chloro-α-phenylbenzylideneaminoacetic acid N-oxide (II), 25 ml of chloroform, and 25 ml of ethyl chloroformate was refluxed for 2 hr. The solvent was removed *in vacuo* and the residue was dissolved in 30 ml of ethyl acetate and 20 ml of hexane. The solution was filtered from impurities and diluted with 130 ml of hexane and cooled. After 24 hr, 1.9 g of product, mp 100–102°, was collected. The infrared absorption spectrum (KBr) of VIII showed carbonyl peaks at 5.61 (N—OC(=O)OC_2H_5), 5.79 (N—C(=O)OC_2H_5), 5.87 (NH—C(=O)—), and 6.09 μ (diaryl ketone) and NH peaks at 3.11 and 6.62 μ (amide II). The nmr spectrum ($CDCl_3$) had peaks for the two ethoxy groups at δ 1.25 (CH_3, t, J = 7 cps), 1.30 (CH_3, t, J = 7 cps), 4.29 (CH_2, q), and 4.32 (CH_2, q) and a $-CH_2-$ singlet at 4.46.

Anal. Calcd for $C_{21}H_{21}ClN_2O_7$: C, 56.20; H, 4.72; N, 6.23; Cl, 7.90. Found: C, 55.98; H, 4.75; N, 5.81; Cl, 7.90.

Method B.—A mixture of 0.5 g of 2'-benzoyl-4'-chloro-2-hydroxyaminoacetanilide (IX) and 15 ml of ethyl chloroformate was refluxed for 3 hr. The solvent was removed *in vacuo* and the residue was treated with a small amount of cold ethanol. From the ethanol was filtered off 0.15 g of solid, (mp 101–102°) which was the same as the material produced by method A.

Registry No.—Ethyl chloroformate, 541-41-3; II, 793-99-7; V, 14789-64-1; VII, 14789-65-2; VIII, 14789-66-3.

(11) The author is indebted to Mr. Bruce Hofmann for the infrared spectra and his proposal for the structure of compound VIII.

Further Studies on Reactions of Perfluorophenolates with Substituted Pentafluorobenzenes and Perfluorocyclohexene

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Previous reports have indicated that pentafluorophenoxide is a poor nucleophile.[1,2] We have recently shown that sodium pentafluorophenolate reacts with a series of substituted pentafluorobenzenes in dipolar aprotic solvents giving rise to substituted perfluorinated diphenyl ethers.[3] Our studies have now been extended to the preparation of the disodium salt of tetrafluorohydroquinone (I) and the dilithium salt of tetrafluororesorcinol (VI) and their subsequent reactions with activated fluorinated substrates.[4]

Compound I was prepared by proton exchange with sodium methoxide in methanol. This salt turned black on exposure to air which necessitated its storage under nitrogen. It reacted with pentafluorobenzonitrile in acetone and octafluorotoluene in N,N-

(1) W. J. Pummer and L. A. Wall, *J. Res. Nat. Bur. Std.*, **68A**, 277 (1964).
(2) E. S. Blake, G. A. Richardson, and J. A. Webster, Air Force Materials Laboratory Technical Report, RTD-TDR-63-4186.
(3) R. J. De Pasquale and C. Tamborski, *J. Org. Chem.*, **32**, 3163 (1967).
(4) The fluorine atom of hexafluorobenzene is readily replaced by numerous nucleophiles, *e.g.*, OH^-, SH^-, NH_2^-, R^-, etc. In certain monosubstituted compounds as, for example, C_6F_5X where X = CF_3, $CO_2C_2H_5$, substitution of a fluorine atom *para* to X is enhanced by the group X (see ref 3). Such C_6F_5X compounds are referred to in this paper as activated fluorinated substrates.