trated to remove most of the ether and then was heated at 50° for 6 hr. After removal of the chloroform, the residual oil was triturated with ether to induce crystallization. The resulting solid, after recrystallization from an ethanol–ethyl acetate mixture, gave 28 g. of white needles, m.p. 168–169.5°.

Anal. Calcd. for $C_{16}H_{16}NOBr$: C, 60.39; H, 5.07; N, 4.40. Found: C, 60.44; H, 5.20; N, 4.18.

1,2-Dicarbomethoxy-3-benzoyl-5,6-trimethylenepyrrocoline (XIX).—To a solution of 2.0 g. of N-phenacylpyrindanium bromide in 50 ml. of water there was added an excess of solid sodium carbonate and the solution was extracted carefully with chloroform. The combined chloroform extracts were passed over a short column of Woelm neutral alumina and the chloroform eluate was concentrated under reduced pressure. The resulting unstable orange solid was taken up in toluene and 0.90 g. of dimethyl acetylenedicarboxylate and 2.0 g. of a 5% palladium-on-charcoal catalyst were added. The mixture was boiled under reflux for 6 hr. under a nitrogen atmosphere. After removal of the catalyst and solvent, the residual dark gum was taken up in benzene and chromatographed over Woelm neutral alumina. Concentration of the benzene eluate afforded yellow crystals which, after recrystallization from ethanol, gave 165 mg. (7%) of yellow prisms, m.p. 160.5–161.5°, λ_{max} 246 (log ϵ 4.49), 282–290 (4.03), 334 (4.12) and 371 mμ (3.89).

Anal. Calcd. for $C_{22}H_{19}NO_5$: C, 70.02; H, 5.07; N, 3.71. Found: C, 70.02; H, 5.12; N, 4.21.

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A Correlation of Some Electrophilic Substitution Reactions of Cycl[3.2.2]azine[1]

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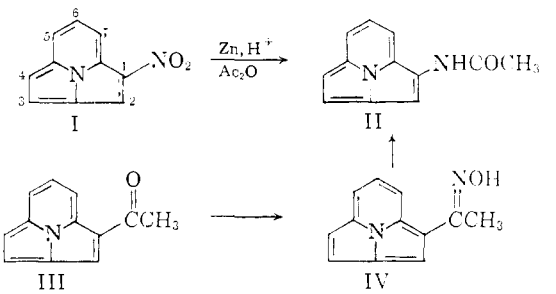
RECEIVED JULY 13, 1960

The monosubstitution products from the Friedel–Crafts reaction and from nitration of cycl[3.2.2]azine have been interrelated to show that the substituent group is introduced at the same position in each case. A further correlation with the adduct from pyrrocoline and methyl propiolate provides evidence that this is the 1-position as predicted from M.O. calculations.

Recently, a synthesis of cycl[3.2.2]azine was described and, as qualitative evidence for its aromatic character, it was found that the molecule readily underwent electrophilic substitution—nitration, bromination and the Friedel–Crafts reaction.[4] From simple molecular orbital calculations it was predicted that electrophilic substitution should occur most readily at the 1-position, radical attack at the 2- or 5-positions, and nucleophilic attack at the 5-position.[4] The present study was undertaken to try to test these predictions and to correlate the positions of substitution in various electrophilic reactions.

Nitration of cycl[3.2.2]azine proceeded in high yield to give a mononitro derivative I, as previously described.[4] However attempts to effect the reduction of the nitrocycl[3.2.2]azine to the corresponding amino derivative, either by catalytic hydrogenation or chemical means, were unsuccessful. The products from these experiments were too unstable to permit characterization. This behavior is reminiscent of that observed in attempts to prepare aminopyrroles and aminoazulenes[5,6] and so was not entirely unexpected. Schulze and Heilbronner were successful in preparing 1-aminoazulene by hydrosulfite reduction of the azo coupling product of azulene.[7] Unfortunately, attempts to obtain similar azo coupling products with cycl[3.2.2]azine have not proved fruitful. However, the procedure used by Anderson, Nelson and Tazuma[6] for the reductive acetylation of 1-nitroazulene was applicable and gave the corresponding acetamidocycl[3.2.2]azine (II) in good yield.



The acylation of cycl[3.2.2]azine under Friedel–Crafts conditions gives both mono- and diacyl derivatives. The monoacyl derivative III was readily converted to the corresponding oxime IV and this, in turn, underwent a Beckmann rearrangement to give an acetamido derivative. The fact that the acetamidocycl[3.2.2]azine from the Beckmann rearrangement was identical with that obtained from reductive acylation of the nitrocycl[3.2.2]azine establishes that both the Friedel–Crafts reaction and nitration lead to substitution at the same position.

Alternatively, the monacetyl derivative of cycl[3.2.2]azine (III) was degraded to the corresponding acid V using sodium hypoiodite. Treatment of V with methanolic hydrogen chloride readily gave a well-defined, crystalline ester VI. The same ester was obtained from the direct condensation of pyrrocoline and methyl propiolate. From our present knowledge of the addition of dieneophiles to pyrrocoline,[8] it would be anticipated that the addition of methyl propiolate would lead to 1-carbomethoxycycl[3.2.2]azine (VI). For example, the reaction of pyrrocoline with methyl phenylpro-

(1) Supported in part by the Office of Ordnance Research, Army Ordnance Contract No. DA-30-069-O.R.D.-2528.

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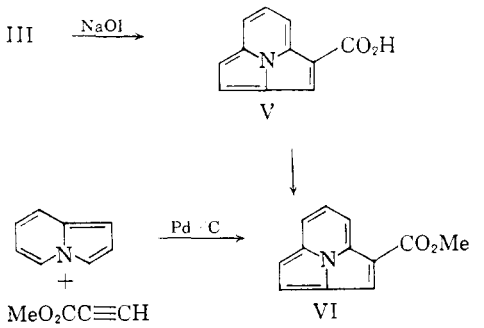
piolate has been shown to give 1-carbomethoxy-2-phenylcycl[3.2.2]azine.[8] Thus the identity of the esters prepared by these two routes provides good evidence that acetylation of cycl[3.2.2]azine under the conditions of the Friedel–Crafts reaction gives 1-acetylcycl[3.2.2]azine (III) as predicted from the molecular orbitals calculations. Also, since the nitro- and acetyl-derivatives have been interrelated, nitration must give 1-nitrocycl[3.2.2]azine (I).



In the case of azulene the pattern of nucleophilic substitution has been studied with several reagents, methyllithium being one of the best.[9,10] An attempt to make a similar study of the nucleophilic substitution of cycl[3.2.2]azine using methyllithium simply led to recovery of unchanged cycl[3.2.2]-azine.

Experimental[11]

1-Acetamidocycl(3.2.2)azine (II). (A) By Reduction of 1-Nitrocycl(3.2.2)azine.—To a solution of 57.5 mg. of 1-nitrocycl(3.2.2)azine (I)[4] and 200 mg. of sodium acetate dissolved in a mixture of 5 ml. of glacial acetic acid and 10 ml. of acetic anhydride there was added 500 mg. of zinc dust with swirling over a 5-minute period. After the mixture had been stirred at room temperature for 1 hr., water was added and the resulting mixture was extracted with methylene chloride. The methylene chloride extracts were washed successively with aqueous ammonia and water and then dried. Concentration gave a brown solid which was taken up in benzene and chromatographed over Woelm neutral alumina. From the ether eluate there was obtained 35 mg. (57%) of yellow crystals, m.p. 143–145°; λ_{max} 425 (log ϵ 3.68), 307 (3.32), 290 (3.77), 256 (4.44) and 234 mμ (4.39).

Anal. Calcd. for $C_{12}H_{10}N_2O$: C, 72.71; H, 5.09. Found: C, 72.88; H, 5.43.

(B) From 1-Acetylcycl(3.2.2)azine.—To a solution of 486 mg. of 1-acetylcycl(3.2.2) azine[4] in 19 ml. of ethanol there was added a solution of 916 mg. of hydroxylamine hydrochloride and 2.81 g. of sodium acetate in 28 ml. of water and the resulting mixture was warmed on a steam-bath for 1 hr. After the solution had been allowed to stand at room temperature overnight, it was diluted with water and the solid, which separated, was collected by filtration. This, when recrystallized from ethanol, gave 490 mg. (95%) of yellow crystals of the **oxime of 1-acetylcycl(3.2.2)azine**, m.p. 139–140°.

Anal. Calcd. for $C_{12}H_{10}N_2O$: C, 72.71; H, 5.09. Found: C, 73.02; H, 5.39.

To a solution of 250 mg. of the oxime of 1-acetylcycl(3.2.2) azine in 20 ml. of ethylene dichloride there was added 348 mg. of phosphorus pentachloride in 100 ml. of ethylene chloride. After the mixture had been stirred at room temperature for 10 min., water was added, the organic layer was separated and washed successively with a 5% sodium bicarbonate solution and water. Concentration of the ethylene dichloride solution gave a dark gum which was taken up in benzene and chromatographed over Woelm neutral alumina. The benzene–1% methanol eluate gave a brown solid which, on crystallization from an ether–hexane–acetone mixture led in poor yield to yellow crystals, m.p. 138–143°. Comparison of these crystals with those obtained in (A) both in the infrared and by a mixture melting point determination showed the two to be identical.

1-Carbomethoxycycl(3.2.2)azine (VI). (A) From 1-Acetylcycl(3.2.2)azine.—To a solution of 115 mg. of 1-acetylcycl(3.2.2)azine (III)[4] in 5 ml. of dioxane there was added successively 1.0 ml. of a 10% aqueous sodium hydroxide solution and a solution of 1.0 g. of iodine and 2.0 g. of potassium iodide in 8.0 ml. of water. After the mixture had been shaken for a few minutes, a mixture of aqueous 5% sodium hydroxide solution and ether was added. The aqueous layer was separated and the ether layer again extracted with 5% aqueous sodium hydroxide solution. The basic aqueous layer was then acidified with 2 *N* hydrochloric acid and the iodine color, which appeared, was destroyed by addition of sodium thiosulfate. The solution was then extracted with ether and the ether extracts were washed with water and dried. Concentration of the ether solution gave a high-melting green solid which could not readily be purified by recrystallization. Instead the acid V was converted directly to the ester VI by taking it up in 60 ml. of methanol, adding a small drop of concd. sulfuric acid, and boiling the solution under reflux for 7 hours. Water was then added and the solution was extracted with ether. After the ether extract had been washed successively with a 5% sodium bicarbonate solution and water, it was dried and concentrated to give a yellow solid. This, after sublimation, yielded 23 mg. (18%) of yellow crystals, m.p. 61–62°; λ_{max} 411 (log ϵ 4.04), 400 (4.01), 392 (3.93), 302 (3.97), 296 (3.93), 260 (4.17) and 243 mμ (4.50). The same product was also obtained by treating 1,4-diacetylcycl(3.2.2)azine[4] in the same manner. Presumably under these conditions the 1 acetyl-4-carboxycycl(3.2.2)azine undergoes ready decarboxylation.

Anal. Calcd. for $C_{12}H_9NO_2$: C, 72.35; H, 4.55; N, 7.03. Found: C, 72.50; H, 4.68; N, 6.94.

(B) From the Addition of Methyl Propiolate to Pyrrocoline.—To a solution of 200 mg. of freshly-sublimed pyrrocoline and 192 mg. of methyl propiolate in 30 ml. of toluene there was added 1.0 g. of a palladium-on-charcoal catalyst and the resulting mixture was boiled under reflux under a nitrogen atmosphere for 24 hr. After removal of the catalyst and solvent, the dark residual solid was taken up in benzene and passed over Woelm neutral alumina. A yellow band separated on the column and was removed by elution with benzene. Concentration of the benzene eluate gave again a dark solid which, on sublimation, gave 39 mg. (11%) of yellow crystals, m.p. 59–60°. A comparison of these crystals with those obtained in (A) both in the infrared and by a mixture point determination showed them to be identical.

(9) K. Hafner and H. Weldes, *Ann.*, **606**, 90 (1957).

(10) D. H. Reid, W. H. Stafford and J. P. Ward, *J. Chem. Soc.*, 1100 (1958).

(11) All melting points are corrected. Analyses by Micro-Tech Laboratories and T. Montzka.