Acknowledgment.—The author wishes to thank the University of Kansas for the award of an Elizabeth M. Watkins Faculty Fellowship during the summer of 1964.

Unsaturated Heterocyclic Systems. XVII.[1] The Reaction of 2(1H)-Pyridone with Hexafluoro-2-butyne

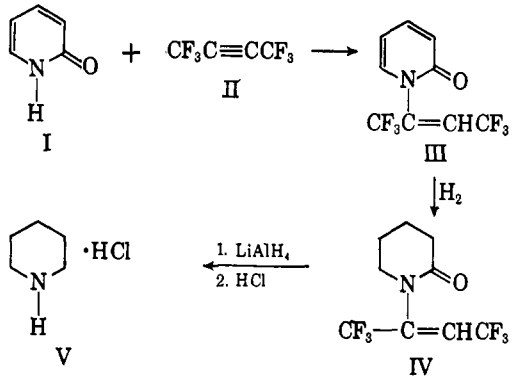
LEO A. PAQUETTE[2]

Department of Chemistry, The Upjohn Company, Kalamazoo, Michigan

Received February 17, 1965

The 2(1H)-pyridone molecule (I) represents a *cis*-dienoid ring system which has yet to enter into a Diels–Alder reaction.[3] Because of the remarkable capability of hexafluoro-2-butyne (II) to react with dienes such as benzene, durene, and naphthalene,[4] we have attempted a diene synthesis utilizing I as the diene and II as the dienophile.

When 2(1H)-pyridone (I) was heated with a slight excess of hexafluoro-2-butyne (II) in an autoclave at 175° for 12 hr., there resulted a mobile black liquid. Chromatography of this material on Florisil afforded a 61% yield of a solid 1:1 adduct, m.p. 55–56°. On the basis of the following data, we have shown that this adduct (III) did not result from a diene synthesis, but rather was formed by a 1,2 addition of the amide proton to the triple bond.



The infrared spectrum of III exhibited the usual pyridone carbonyl band at 1675 cm.$^{-1}$, but lacked the characteristic band of the amide proton below 3000 cm.$^{-1}$. The presence of the intact pyridone ring was inferred from the ultraviolet absorption pattern [λ_{max}^{EtOH} 274 mμ (ε 4400) and 302 mμ (ε 5000)]. A large measure of further support came from the n.m.r. spectrum which, although quite complex in the aromatic region, was in full agreement with structure III.

Catalytic reduction of III over platinum in ethyl acetate proceeded readily with the uptake of 2 moles of hydrogen. The interesting aspect of this reaction was the rapidity of the reductive process[5] which we have attributed to the electronic influence of the two trifluoromethyl groups. Lithium aluminum hydride reduction of IV produced the corresponding enamine in 53% yield. Direct hydrochloric acid hydrolysis of this enamine gave rise in good yield to piperidine hydrochloride (V), which was identical by the usual criteria with an authentic sample. The isolation of V established beyond doubt the integrity of the heterocyclic ring in the above reactions.

The possibility was considered that reaction of II with N-methyl-2(1H)-pyridone, a system in which a 1,2 addition of the above type is structurally forbidden, might lead to a Diels–Alder adduct. Attempts to condense these components under a wide range of temperatures afforded only uncharacterizable black tars.

Experimental[6]

1-[3,3,3-Trifluoro-1-(trifluoromethyl)propenyl]-2(1H)-pyridone (III).—A mixture of 48 g. (0.5 mole) of 2(1H)-pyridone and 97 g. (0.6 mole) of hexafluoro-2-butyne was placed in an autoclave blanketed with nitrogen, and heated at 175° for 12 hr. There resulted a mobile black liquid which was chromatographed on Florisil.[7] Elution with hexane–ether (9:1) afforded 78.0 g. (60.5%) of a pale yellow oil which crystallized on cooling and scratching. Three recrystallizations of this material from hexane–ether gave pure III as long white blades, m.p. 55–56°, ν^{Nujol} 1675 cm.$^{-1}$ (pyridone carbonyl), λ_{max}^{EtOH} 224 mμ (ε 4400) and 302 mμ (ε 5000).

Anal. Calcd. for $C_9H_5F_6NO$: C, 42.03; H, 1.96; F, 44.33; N, 5.45; mol. wt., 257. Found: C, 42.18; H, 2.28; F, 44.26; N, 5.66; mol. wt., 297 (osmometric in DMF).

1-[3,3,3-Trifluoro-1-(trifluoromethyl)propenyl]-2-piperidone (IV).—A solution of 20.8 g. (0.08 mole) of III in 130 ml. of ethyl acetate containing 1 g. of platinum oxide was hydrogenated in a Parr apparatus at an initial pressure of 50 p.s.i. The uptake of hydrogen proceeded rapidly and was complete in 1 hr. The catalyst was removed by filtration and the filtrate was evaporated. The colorless residue was distilled to give 19.0 g. (91.4%) of IV as a colorless liquid, b.p. 90–94° (13 mm.), $n^{26}D$ 1.3970. Redistillation afforded the analytical sample, b.p. 90° (14 mm.), $n^{26}D$ 1.3970, ν^{Nujol} 1680 cm.$^{-1}$ (amide carbonyl), ultraviolet end absorption only.

Anal. Calcd. for $C_9H_9F_6NO$: C, 41.39; H, 3.47; F, 43.65; N, 5.36. Found: C, 41.90; H, 3.79; F, 45.46; N, 5.34.

Reduction and Acid Hydrolysis of IV.—To a stirred slurry of 2.66 g. (0.07 mole) of lithium aluminum hydride in 150 ml. of anhydrous ether was added dropwise a solution of 18.5 g. (0.071 mole) of IV in 50 ml. of ether at such a rate to maintain gentle reflux. When the addition was completed, the mixture was refluxed with stirring for 2 hr. With external ice cooling, there was added 3 ml. of water, 3 ml. of 25% sodium hydroxide solution, and 8 ml. of water, in that order. The precipitated salts were filtered and washed thoroughly with ether. The filtrate was evaporated and the residue was distilled to give 9.3 g. (53.1%) of colorless enamine, b.p. 44–46° (14 mm.), $n^{26}D$ 1.3910.[8]

The enamine was dissolved in 50 ml. of ethanol and the solution was treated with 10 ml. of concentrated hydrochloric acid. The mixture was refluxed for 1 hr., cooled, and evaporated to dryness. The residue was recrystallized from ethanol–ether to give 3.8 g. (83.4%)[9] of piperidine hydrochloride. Recrystalli-

(1) Part XVI: L. A. Paquette, *Tetrahedron*, in press.

(2) Department of Chemistry, The Ohio State University, Columbus, Ohio.

(3) For a recent attempt to effect such a reaction between N-methyl-2(1H)-pyridone and maleic anhydride, see B. S. Thyagarajan and K. Rajagopalan, *Tetrahedron*, **19**, 1483 (1963).

(4) C. G. Krespan, B. C. McKusick, and T. L. Cairns, *J. Am. Chem. Soc.*, **82**, 1515 (1960); **83**, 3428 (1961).

(5) Whereas III underwent complete reduction within 1 hr. at room temperature and an initial hydrogen pressure of 50 p.s.i., N-methyl-2(1H)-pyridone has been reported to require 17 hr. for the theoretical uptake of hydrogen in acetic acid solution: N. J. Leonard and E. Barthel, Jr., *ibid.*, **71**, 3098 (1949).

(6) Melting points are corrected and boiling points are uncorrected.

(7) Florisil is a magnesia–silica gel adsorbent manufactured by the Floridin Co., Tallahassee, Fla.

(8) Infrared and gas chromatographic analyses of this sample indicated the presence of approximately 8% unreacted IV.

(9) This yield is based on the assumption that the enamine was of 100% purity.

zation of this sample from ethanol gave pure V, m.p. 246.5–247, identical with an authentic sample by infrared analysis and mixture melting point.

Acknowledgment.—The author is indebted to M. A. Rebenstorf for performing the autoclave reactions and to the Physical and Analytical Chemistry Department of The Upjohn Company under the direction of Dr. D. R. Myers for the microanalyses and spectral data.

Reactions of Dichloramine. I. A Convenient Method of Preparation of Diazirine

W. H. GRAHAM

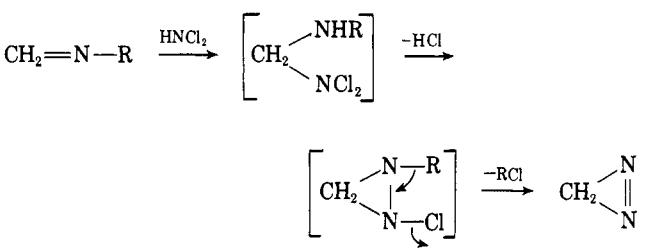
Rohm and Haas Company, Redstone Arsenal Research Division, Huntsville, Alabama

Received February 12, 1965

The preparation of diazirine by the reaction of difluoramine and *t*-octylazomethine,[1] although an efficient method[2] of preparing diazirine, suffers the disadvantage of the lack of general availability of difluoramine and the hazards associated with its use.[3]

Dichloramine,[4] although highly reactive,[5] is easily prepared in solution from ordinary laboratory reagents. Like difluoramine, dichloramine reacted readily with *t*-octylazomethine[6,7] to produce diazirine in moderate yield. The best yield of diazirine was obtained when 5% NaOCl solution[8] was dropped slowly into a mixture containing an aqueous sodium formate–formic acid buffer, ammonium chloride, and *t*-octylazomethine maintained at 5–12°. Dibutyl ether was sometimes used as solvent with somewhat better results. The volatile contents were removed under vacuum through a train of four traps at −35, −80, −142, and −196°. The diazirine was retained principally in the −142° trap and was generally contaminated by CO_2 to the extent of 15% or less. Yields of 25–33% were typical. Other procedures, involving preparation of dichloramine prior to addition of the imines, gave poorer yields, probably because of the instability of the dichloramine solutions.

The mechanism of the reaction is believed to involve the *in situ* formation of dichloramine in the buffered aqueous phase, extraction of dichloramine into the organic phase,[4] addition to the imine, internal ring closure by displacement of chloride from nitrogen, and loss of the elements of *t*-octyl chloride from the unstable N-chlorodiaziridine. The addition–ring closure mechanism is preferred to one involving formation of chloronitrene because of the evidence for a similar mechanism in the addition of hydroxylamine-O-sulfonic acid to the imine double bond.[9]



R = *t*-octyl

This method of preparation of diazirine has advantages over the recently discovered method using methylenediammonium salts[2b] because of the ease of preparation and handling of *t*-octylazomethine and the adaptability of the method to the preparation of substituted diazirines for which the diammonium salt precursors cannot be prepared.[10]

Experimental

Diazirine.—A 1-l. three-neck flask, fitted with a 500-ml. pressure-equalizing dropping funnel, magnetic stirring bar, and thermometer was connected to a train of four U-tube traps which were cooled to temperatures of −35, −80, −142 (methylcyclopentane slush bath), and −196°. To the flask was added 150 ml. of a formate buffer solution[11] (1 *N* in formic acid and 1 *N* in sodium formate), 150 ml. of a 4 *N* NH_4Cl solution (0.6 mole NH_3), and 150 ml. of dibutyl ether, and the contents were cooled to 5°. Immediately prior to beginning the addition of NaOCl, 7.05 g. (0.05 mole) of *t*-octylazomethine was added[12] to the reaction flask. The flask was opened to a vacuum pump through the four cold traps and 300 ml. of 0.4 *N* NaOCl was added over a period of 6 min. Vigorous gas evolution was observed during the addition and for several minutes afterwards. The traps were isolated from the reactor after 5 min. and a vacuum was applied to the traps for another 10 min. The bulk of the diazirine (308 cc., STP, 27.5%) was retained in the −142° trap with a smaller amount (12 cc., STP, 1%) being trapped in the −196° trap. The purity of the diazirine in the −142° trap was 85–90%; CO_2 was the chief contaminant along with traces of methyl formate and cyanogen chloride. The −196° trap contained chiefly CO_2 along with lesser amounts of diazirine and traces of ethane. Analyses of the gas mixtures were by mass and infrared spectra. The yield data for several runs at various ratios of *t*-octylazomethine–sodium hypochlorite is summarized in Table I. The theoretical yield of dichloramine is based upon the assumption that 2 moles of sodium hypochlorite produce 1 mole of dichloramine. *Caution: Diazirine is explosive and should be prepared only with proper safety precautions.*

TABLE I
DIAZIRINE YIELDS

Moles			
NaOCl	*t*-Octylazomethine	Diazirine	Yield, %
0.12	0.025	0.0078	31.2
0.12	0.05	0.0143	28.5
0.12	0.075	0.0157	26.2
0.12	0.10	0.0154	25.7
0.12	0.20	0.0082	13.6
0.075	0.060	0.011	29.6

Acknowledgment.—This investigation was supported by Army Ordnance Contract DA-01-021 ORD-11878 Modification No. 15.

(1) W. H. Graham, *J. Am. Chem. Soc.*, **84**, 1063 (1962).

(2) For other methods of preparation of diazirine, see (a) E. Schmitz and R. Ohme, *Tetrahedron Letters*, 612 (1961); (b) R. Ohme and E. Schmitz, *Chem. Ber.*, **97**, 297 (1964).

(3) W. H. Graham and C. O. Parker, *J. Org. Chem.*, **28**, 850 (1963), and references cited therein.

(4) R. M. Chapin, *J. Am. Chem. Soc.*, **51**, 2112 (1929).

(5) R. E. Corbett, W. S. Metcalf, and F. G. Soper, *J. Chem. Soc.*, 1927 (1953).

(6) M. D. Hurwitz, U. S. Patent 2,582,128 (1952).

(7) W. D. Emmons, *J. Am. Chem. Soc.*, **79**, 5739 (1957).

(8) Commercial "Clorox."

(9) For evidence, see the excellent review article by E. Schmitz, *Angew. Chem., Intern. Ed. Engl.*, **3**, 333 (1964).

(10) Methyldiazirine has been prepared by a modification of this procedure using acetaldehyde-*t*-octylimine. The yield and purity of product were less favorable, however.

(11) Both 90% and 98–100% grades of formic acid contain appreciable amounts of methyl formate which will contaminate the product if not removed prior to reaction by a suitable degassing procedure.

(12) The *t*-octylazomethine was not added earlier in order to minimize any side reaction such as hydrolysis.