N-(Carboxymethyl)-α-(p-methoxyphenyl)nitrone.—In a similar fashion, *anti*-anisaldoxime (54.8 g, 0.362 mol) was converted into 53.2 g (70.4%) of the nitrone, mp 165–165.5° dec. A sample which recrystallized from aqueous ethanol had mp 165.5–166° dec.

Anal. Calcd for $C_{10}H_{11}NO_4$: C, 57.41; H, 5.30; N, 6.70. Found: C, 57.51; H, 5.13; N, 6.98.

Sodium N-Formylhydroxyaminoacetate Dihydrate.[13]—To 65.6 ml (1.7 mol) of 98% formic acid in a three-necked flask maintained at 25–30° was added 87.5 ml (0.925 mol) of acetic anhydride over 30 min with stirring. The solution was aged 15 min at 25° and then treated with 35.0 g (0.195 mol) of N-carboxymethyl-α-phenylnitrone portionwise over 15 min. The resultant slurry was stirred over 25° until the solid dissolved (1.5 hr) and then for an additional hour. Versene (0.2 g) was added;[14] the solution cooled to 5° and partially neutralized, at a temperature kept below 30°, by dropwise addition of 122 ml of 8 *N* aqueous NaOH. The final pH was 3.7. The solution was washed with 50 ml of ethyl ether to remove benzaldehyde. The product was crystallized by slow addition of 720 ml of ethanol, with stirring and seeding. The resulting slurry was cooled to 0–5°, aged at that temperature for 30 min, and filtered. The cake was washed with three 35-ml portions of 95% ethanol, sucked damp dry, and dried under forced air at 35°. There was obtained 24.2 g of sodium N-formylhydroxyaminoacetate dihydrate (70% of theory) mp 191–193° dec.

Anal. Calcd for $C_3H_4NO_4Na \cdot 2H_2O$: C, 20.34; H, 4.55. Found: C, 20.56; H, 4.57.

Very similar results were obtained when N-carboxymethyl-α-(p-methoxyphenyl)-nitrone was employed in this reaction.

Registry No.—**1a,** 13830-84-7; **2a,** 3884-90-0; **2b,** 17556-16-0; **4,** 2618-22-6.

Acknowledgments.—We wish to thank Dr. Byron H. Arison and Dr. Nelson R. Trenner for the nmr spectra, Mr. Robert Walker for the infrared spectra, and Mr. Richard N. Boos and his staff for the elemental analyses.

(13) The procedure as originally developed used a larger volume of formic acid and acetic anhydride, and the reaction mixture was evaporated to a syrup at reduced pressure below 40°. Under these conditions a possibly hazardous exotherm was sometimes observed. We are indebted for this modification, in which smaller initial volumes obviate the vacuum concentration, to Mr. William F. Elmendorf and Dr. David F. Hinkley of these laboratories.

(14) Hadacidin forms an intensely colored chelate with iron, and an off-color product may be obtained unless a sequestering agent is used.

Diazomethane and Deuteriodiazomethane by the Base-Catalyzed Reaction of Hydrazine with Chloroform

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The record number of preparations for diazomethane which appear in "Organic Syntheses"(1) accentuates not only its importance to the synthetic organic chemist, but also its lability. Despite its many years in the chemists repertory of reagents, the explosive nature(2) of diazomethane is not understood. In the course of another study,(3) pure deuterated diazomethane was required. Although the best preparative methods(4) avoid concentrated solutions of diazomethane,(2) the solvent-free gas and a procedure easily adaptable for preparation of deuteriodiazomethane was desired for the above mentioned study.

Demore, Pritchard, and Davidson,(5) and others(6,7) report the preparation of deuterated diazomethane by direct exchange with D_2O. An ir spectrum shown by Demore, *et al.*, indicates the presence of approximately 40% CD_2N_2, 40% $CHDN_2$, and 20% CH_2N_2. In the present work, this technique was extended to two 30-min exchanges and resulted in the loss of 95% of the original diazomethane sample due to the reaction of diazomethane with water to produce methyl ether.

Leitch, Gagnon, and Cambron(8) have prepared a relatively pure sample of deuterated diazomethane by decomposing methyl-d_3-nitrosourea in NaOD–D_2O. Although the presence of CH_2N_2 was negligible, the end product contained a large quantity of $CHDN_2$. The rather lengthy procedure required to produce all the deuterated intermediate reactants and solvents illustrated the necessity of having such species deuterated in all positions.

Utilization of the technique of Staudinger and Kupfer(9) to prepare deuterated diazomethane is more straightforward since deuterated hydrazine and chloroform are commercially available, and the preparation of deuterated solvent and potassium hydroxide are moderately simple. The relatively low yields of diazomethane (≈20%) and the impurities produced must be considered before utilizing this technique.

With reaction conditions as formulated by Staudinger and Kupfer(9) (eq 1), ammonia and ethylene are

$$NH_2NH_2 \cdot H_2O + CHCl_3 + 3KOH \xrightarrow{CH_3CH_2OH} CH_2N_2 + 3KCl + 4H_2O \quad (1)$$

gaseous contaminants in diazomethane by ir analysis. If methyl alcohol is substituted for ethyl alcohol as the solvent, methyl ether is an additional gaseous product. With no solvent, chloroacetylene has been identified as a minor product.(10) Variation of the reactants as shown in Table I causes a considerable variation in the products observed.

Although all of the gaseous products probably arise by interesting mechanisms, we were particularly fascinated with the formation of chloroacetylene. It was identified in the following way. Diazomethane

(1) (a) F. Arndt, "Organic Syntheses," Coll. Vol. II, John Wiley & Sons, Inc., New York, N. Y., 1943, p 165; (b) C. E. Redemann, F. O. Rice, R. Roberts, and H. P. Ward, ref 1a, Coll. Vol. III, John Wiley & Sons, Inc., New York, N. Y. 1955, p 244; (c) Th. J. deBoer and H. J. Backer, ref 1a, Coll. Vol. IV, John Wiley & Sons, Inc., New York, N. Y., 1963, p 250; (d) J. A. Moore and D. E. Reed, *Org. Syn.*, **41**, 16 (1961).

(2) Diazomethane is unpredictably dangerous. For leading references and representative warnings concerning its use, see ref 1d and the following: (a) I. T. Millar and H. D. Springall, "Sidgewick's Organic Chemistry of Nitrogen," 3rd ed, Clarendon Press, London, 1966, pp 478–479; (b) P. A. S. Smith, "The Chemistry of Open-Chain Nitrogen Compounds," Vol. II, W. A. Benjamin, Inc., New York, N. Y., 1966, pp 212–215.

(3) C. L. Dodson, Ph.D. Thesis, University of Tennessee, 1963.

(4) L. Fieser and M. Fieser, "Reagents for Organic Synthesis," John Wiley & Sons, Inc., New York, N. Y., 1967, pp 191–195.

(5) W. B. Demore, H. O. Pritchard, and N. Davidson, *J. Amer. Chem. Soc.*, **81**, 5874 (1959).

(6) G. W. Robinson and M. McCarty, Jr., *ibid.*, **82**, 1859 (1960).

(7) T. D. Goldfarb and G. C. Pimentel, *ibid.*, **82**, 1865 (1960).

(8) L. C. Leitch, P. E. Gagnon, and A. Cambron, *Can. J. Res.*, **28B** 256 (1950).

(9) H. Staudinger and O. Kupfer, *Ber.*, **45**, 505 (1912).

(10) We suspect chloroacetylene as a product with solvent also; its solubility may keep it from codistilling with diazomethane. In one experiment a mixture of CH_2N_2 and chloroacetylene was bubbled through ethyl alcohol which removed chloroacetylene, but CH_2N_2 reacted with the solvent to produce methyl ethyl ether.

TABLE I

REPRESENTATIVE EXAMPLES OF THE GASEOUS PRODUCTS FROM REACTION OF $CHCl_3$ AND $NH_2NH_2 \cdot H_2O$

Base	Solvent	% yield of CH_2N_2[a]	Calcd % partial pressure[b]				
			CH_2N_2	$CH_2{=}CH_2$	NH_3	CH_3OCH_3	$HC{\equiv}CCl$
KOH	CH_3CH_2OH	9.18	61	35	4		
KOH	CH_3OH	5.5[c]	79	6	6	9	
KOH	$PhCH_2OH$	4.3	70	Trace	29		
Na	CH_3OH	17	16		20		
KOH	$(n\text{-}C_4H_9)_2O$	6.4	70		25		4
KOH		Not calcd	30	44	22		4

[a] Does not include that amount which is measured as ethylene. [b] Estimated from comparison of ir spectra with spectra of known concentration. [c] Average of duplicate runs.

mixed with ammonia and chloroacetylene was removed by reaction with silicone grease. An ir spectrum of chloroacetylene was obtained with the ammonia in the mixture balanced out by a sample of pure ammonia with appropriate pressure in the reference beam of the spectrometer. All absorption bands present correlate with literature data for chloroacetylene as shown in Table II.

TABLE II

COMPARISON OF IR DATA FOR CHLOROACETYLENE

Assignment	$HC{\equiv}C{-}Cl$		$DC{\equiv}C{-}Cl$	
	Obsd, cm^{-1}	Lit., cm^{-1}	Obsd, cm^{-1}	Lit., cm^{-1}[b]
C—H stretch (ν_1)	3341	3319,[a] 3340[b]	2611	2612
C≡C stretch (ν_2)	2114	2109,[a] 2110[b]	1977	1980
($2\nu_5$)	1199	1202[a]		941
C—Cl stretch (ν_3)	756	756[a,b]	744	742
C≡C—Cl bend (ν_4)	607	606,[a] 604[b]	491	472
C≡C—Cl bend (ν_5)	323	326[b]		312

[a] W. S. Richardson and J. H. Goldstein, *J. Chem. Phys.*, **18**, 1314 (1950). [b] G. R. Hunt and M. K. Wilson, *ibid.*, **34**, 1301 (1961).

When deuterated diazomethane was prepared, deuterated chloroacetylene was obtained, and again the measured frequencies (Table II) of this species were in agreement with literature values. (Deuterated ammonia[3] was required in this instance in the reference beam of the spectrometer.)

The obvious mechanism for the formation of chloroacetylene involves the stepwise formation of dichlorocarbene[11] by basic hydrolysis of chloroform followed by the reaction of dichlorocarbene with diazomethane (eq 2) to produce 1,1-dichloroethylene. A base-catalyzed dehydrohalogenation of 1,1-dichloroethylene (eq 3) would then complete the sequence for formation of chloroacetylene.

$$:CCl_2 + CH_2N_2 \longrightarrow [\overset{-}{C}Cl_2{-}CH_2{-}\overset{+}{N}{\equiv}N] \xrightarrow{-N_2} CCl_2{=}CH_2 \tag{2}$$

$$CCl_2{=}CH_2 + {}^{-}OH \longrightarrow Cl{-}C{\equiv}C{-}H + H_2O + Cl^- \tag{3}$$

The suspected path was tested to determine if dichlorocarbene was formed as expected[11] under the reaction conditions employed.[12] When cyclohexene was used as an additive, 7,7-dichlorobicyclo[4.1.0]heptane was identified as a product by comparison of its glpc retention time and ir spectrum with those of a known sample.[13] Reimlinger[14] has recently demonstrated that dihalocarbenes react with diazoalkanes to form dihaloethylene derivatives. His examples, however, were all disubstituted, and no further reaction of the type as shown here was possible. By treating a commercial sample of 1,1-dichloroethylene under conditions present for the reaction depicted by eq 3, chloroacetylene was isolated and identified. This then establishes eq 2 and 3 as the most likely mechanism of formation of chloroacetylene. Despite the low yields obtained,[15] the formation of chloroacetylene here suggests the general use of this one-step process to form certain difficultly prepared acetylenic products.

Of all by-products, ethylene is the most expected. It is assumed to occur by reaction of methylene with diazomethane.[16] If ethyl alcohol is used as a solvent in the reaction between hydrazine and chloroform, ethylene also originates from the alcohol as has been previously demonstrated.[17,18] This was verified in the present work by an experiment which utilized all deuterated materials, except the alkyl portion of the alcohol, and it was observed that 95% of the ethylene obtained was the completely protonated species. The relatively high yield of ethylene obtained when ethyl alcohol is used as a solvent (see Table I) is consequently explained. Methyl ether is a known insertion product[19] between methylene and methyl alcohol.

Ammonia could be derived by more than one feasible process. Hydrazine is known to undergo base-catalyzed air oxidation to form ammonia.[20] We have found that heating hydrazine and chloroform together at 50° for 40 min in a helium atmosphere produces small, but measurable, quantities of ammonia. We were not able to identify any ammonia, however, if sodium methoxide and hydrazine reacted under the above conditions. One explanation for the forma-

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(11) J. Hine, *J. Amer. Chem. Soc.*, **72**, 2438 (1950).

(12) In each case either hydrazine or chloroform was intentionally left out to prevent formation of diazomethane[2] while still maintaining a meaningful experiment.

(13) W. von E. Doering and A. K. Hoffmann, *ibid.*, **76**, 6162 (1954).

(14) H. Reimlinger, *Ber.*, **97**, 339, 3503 (1964).

(15) No attempts were made to optimize the yields of chloroacetylene in our experiments.

(16) (a) J. Hine, "Divalent Carbon," Ronald Press Co., New York, N. Y. 1964, p 31; (b) W. Kirmse, "Carbene Chemistry," Academic Press Inc., New York, N. Y., 1964, p 11.

(17) J. Hine, E. L. Pollitzer, and Hans Wagner, *J. Amer. Chem. Soc.*, **75**, 5607 (1953).

(18) M. Hermann, *Ann.*, **95**, 211 (1855).

(19) H. Ogoshi and Y. Takezaki, *Bull. Inst. Chem. Res., Kyoto Univ.*, **38**, 299 (1960); *Chem. Abstr.*, **55**, 20913 (1961).

(20) For leading references, see L. F. Audrieth and B. A. Ogg, "The Chemistry of Hydrazine," John Wiley & Sons, Inc., New York, N. Y., 1951, pp 139–145.

tion of ammonia could be the acid–base reaction shown in eq 4 followed by a nucleophilic cleavage (eq 5).

$$\mathrm{CHCl_3 + NH_2NH_2 \longrightarrow \overset{-}{C}Cl_3 + \overset{+}{N}H_3NH_2} \qquad (4)$$

$$\mathrm{\overset{+}{N}H_3NH_2 + \overset{-}{C}Cl_3 \longrightarrow NH_3 + CCl_3NH_2} \qquad (5)$$

Because of its probable mode of formation and of the contaminating by-products which we have described here and because of other adaptable methods,[1] this method is not a recommended procedure for the preparation of pure protonated diazomethane.[21-24] It is competitive with others[5-7] for the preparation of deuteriodiazomethane since a sample approximately 92% deuterated was obtained when no solvent was used and all starting materials contained 99% of the maximum possible deuterium.

Although there is convincing evidence that diazomethane will explode alone,[2] the presence of previously unknown contaminants may make these mixtures more explosive[25,26] than pure diazomethane from other sources.[4] While we recognize and respect the explosive unpredicability of diazomethane, our experience[27] supports recent evidence[1d] that contrary to previous practice ground-glass apparatus can be used in its preparation without incident. As a result of this study, however, we do not claim to understand the reasons for the unpredictability of the decomposition of diazomethane.

Experimental Section

Infrared measurements were recorded as liquids or gases using a Beckman IR-10, Perkin-Elmer 421, or Perkin-Elmer 237 instrument. The gas chromatographic analysis were performed with a F & M Model 700 gas chromatograph using a flame ionization detector and a 10% diisodecylphthalate on a Chromosorb W column.

Caution: Proper precautions must be taken when working with diazomethane.[2]

Preparation of Diazomethane.—Variations of the procedure of Staudinger and Kupfer[9] were used throughout (see Table I). Ground-glass joints were used throughout.[14] All gaseous products were collected in a liquid nitrogen trap.

Preparation of Deuteriodiazomethane.—Deuterated chloroform and hydrazine hydrate were purchased from Merck Sharp and Dohme of Canada, Ltd. Potassium hydroxide-*d* was prepared by adding clean potassium directly to D_2O in a dry box using a nitrogen atmosphere. It was then dried over P_2O_5 in a vacuum desiccator. The KOD and $D_2NND_2 \cdot D_2O$ were placed in the reaction flask, while in the dry box. Connection of the reaction flask to the generating assembly and the addition of $CDCl_3$ to a dropping funnel were accomplished while helium flushed out the entire apparatus to prevent exchange with atmospheric moisture. Procedure then followed that of Staudinger and Kupfer.[9] Deuterated diazomethane was collected in a liquid nitrogen cooled trap and was twice distilled under vacuum from −80 to −196°. Ethylene was removed by exposing the sample, maintained at −150° by an isopentane bath, to vacuum pumping for 30 min.

Proof of the Presence of Dichlorocarbene.—From a reaction of 28.0 g (0.50 mol) of potassium hydroxide and 16.9 ml (0.167 mol) of dried ($CaCl_2$) and freshly distilled cyclohexene in 122 ml of methanol with 13.4 ml (0.167 mol) of chloroform, 3 ml of a yellow oil identified by glpc analysis as 7,7-dichlorobicyclo-[4.1.0]heptane[13] was obtained. Infrared comparison with a known sample[13] confirmed the glpc analysis.

Isolation of Chloroacetylene from the Dehydrohalogenation of 1,1-Dichloroethylene.—In a three-necked 100-ml flask fitted with a condenser, an additional funnel, and a nitrogen inlet, 4.0 g of potassium hydroxide in 5.6 ml of hydrazine were stirred by a magnetic stirrer and treated dropwise with 1.58 g of 1,1-dichloroethylene. During the addition, the temperature was kept at 5°; the system was swept with dry nitrogen; and all volatile products were collected in a Dry Ice–acetone trap. A noticeable reaction occurred as the solution became yellow and a precipitate formed. After the mixture had been stirred for 1.5 hr, the trap was closed to the system and opened to an evacuated ir cell which was connected through a ballast flask and a drying tube ($CaCl_2$). After the product was allowed to warm to room temperature, the pressure in the cell was 200 mm. The ir spectra clearly revealed the presence of chloroacetylene.

Experiments to Elucidate Ammonia Formation Mechanism. A.—To 15 ml of methyl alcohol was added 1.5 g of sodium and 2.5 ml of anhydrous hydrazine. The resulting solution was heated to 50° for 0.5 hr, and all gaseous products were collected in a liquid nitrogen trap. No ammonia was present by ir analysis.

B.—Approximately 2 g of anhydrous hydrazine and 5.5 g of chloroform were heated together at 50° for 40 min with all gases being trapped in a liquid nitrogen trap. All ir peaks were assigned to chloroform and ammonia with the latter being the minor component.

Registry No.—Diazomethane, 334-88-3; deuteriodiazomethane, 17510-78-0; hydrazine, 302-01-2; chloroform, 67-66-3.

Acknowledgment.—This work was partially supported by a NASA grant, NsG-381, for which we are grateful.

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[21] It has been proposed[22,23] that diazomethane is formed with amino isocyanide as intermediate. For rearrangement to diazomethane, another probable intermediate would be isodiazomethane,[22] which explodes at temperatures lower than those of the reaction conditions used here.[24]

[22] I. T. Millar and H. D. Springall, ref 22, p 476.

[23] E. Muller, "Neuere Anschauungen Der Organischen Chemie," 2nd ed, Julius Springer, Berlin, Germany, 1957, pp 452–454.

[24] J. P. Anselme, *J. Chem. Ed.*, **43**, 596 (1966).

[25] (a) Impure CH_2N_2 is said[2a] to be especially dangerous and explodes even at low temperatures. (b) Chloroacetylene is reported to be sensitive to oxygen and is a treacherous explosive.[26]

[26] E. H. Huntress, "Organic Chlorine Compounds," John Wiley & Sons, Inc., New York, N. Y., 1948, p 930.

[27] In the course of this and other work, stopcocks and ground-glass joints were freely used in the apparatus for generating and storing diazomethane. Relatively pure samples of the compound have been passed through medium-porosity, fritted-glass bubblers and chromatographic columns using ground fire-brick as a supporting material and over irregularly shaped KOH and silica gel. No explosions were observed in any of these experiments.

During preparation and manipulation of diazomethane, no explosions have occurred using this or other more conventional procedures.[4] In contrast, an explosion occurred with a spectroscopically pure sample of solid diazomethane following 3 days' storage in liquid nitrogen.

The Preparation of 2-(Substituted amino)-3-phenyl-3H-indol-3-ols

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The synthesis of amidines from amides, without formation of intermediates such as imino chlorides or imidate salts, is known, but its preparative usefulness is limited to formamidines[1] or to special cases, such as the preparation of 2,3,4,6,7,8-hexahydropyrrolo[1,2-*a*]pyrimidine from 1-(3-aminopropyl)-2-pyrrolidinone, where the amine function is held in proximity of the amide carbonyl.[2]

In the preparation of 1-methyl-2-(phenylimino)pyrrolidine from 1-methyl-2-pyrrolidinone and aniline,

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[1] J. B. Shoesmith and J. Haldane, *J. Chem. Soc.*, **123**, 2704 (1923).

[2] H. Oediger, H. J. Kabbe, F. Möller, and K. Eiter, *Chem. Ber.*, **99**, 2012 (1966).