[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF NORTHWESTERN UNIVERSITY]

THE 1-AMINO-2-NITROETHENES

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Received January 19, 1948

1-Amino-2-nitroethenes have not been previously reported. A few such compounds are described in this paper. These compounds are formed by interaction of ethyl ethoxymethylenemalonate (I) with nitromethane in the presence of certain amines. Two amines which are effective in this reaction are piperidine and morpholine, giving rise to 1-piperidino-2-nitroethene (II) and 1-morpholino-2-nitroethene (III), respectively.

Apparently the first step in the reaction is the rapid replacement of the ethoxy group of ethyl ethoxymethylenemalonate (1) to form, for example, ethyl piperidinomethylenemalonate (IV).

$$C_5H_{10}NH + \underset{\text{I}}{C_2H_5OCH{=}C(COOC_2H_5)_2} \rightarrow \underset{\text{IV}}{C_5H_{10}N{-}CH{=}C(COOC_2H_5)_2} + C_2H_5OH$$

A similar reaction with arylamines gives rise to arylaminomethylenemalonic esters which have been used widely in recent years for the synthesis of quinoline derivatives (2).

The base-catalyzed addition of nitromethane to IV causes the formation of an unstable intermediate, ethyl (1-piperidino-2-nitroethyl)malonate (V), which decomposes immediately in the manner of a retrograde Michael reaction (3) to give II and ethyl malonate.

$$\text{(IV)} \quad + CH_3NO_2 \xrightarrow{C_5H_{10}NH} \left[\begin{array}{c} C_5H_{10}NCHCH(COOC_2H_5)_2 \\ | \\ CH_2NO_2 \end{array}\right]$$

$$\text{V}$$

$$\text{(V)} \quad \longrightarrow \underset{\text{II}}{C_5H_{10}NCH{=}CHNO_2} + CH_2(COOC_2H_5)_2$$

Strong evidence for the above formulation is the fact that if nitromethane is added in the presence of a catalytic amount of morpholine to ethyl morpholinomethylenemalonate (VI), the morpholino analog of IV, there results a good yield of III. Without catalyst, no reaction occurs.

It is not clear why piperidine and morpholine should be the only two amines out of several tested which yielded these aminonitroethenes. Dimethylamine, diethylamine, dipropylamine, pyrrolidine, and piperazine all failed to function when treated with nitromethane and ethyl ethoxymethylenemalonate.

Aminonitropropenes were prepared by methods resembling those used for the aminonitroethenes. Thus, by substitution of ethyl α-ethoxyethylidenemalonate (VII) (4) for I in the above reaction, one obtains 2-piperidino-1-nitro-1-propene (VIII) and 2-morpholino-1-nitro-1-propene (IX) as reaction products.

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$$\underset{\text{VII}}{C_2H_5O\overset{\displaystyle CH_3}{\overset{|}{C}}{=}C(COOC_2H_5)_2} + CH_3NO_2 + C_5H_{10}NH \rightarrow$$

$$\underset{\text{VIII}}{C_5H_{10}N\overset{\displaystyle CH_3}{\overset{|}{C}}{=}CH{-}NO_2} + C_2H_5OH + CH_2(COOC_2H_5)_2$$

These two compounds were found to decompose on standing at room temperature for two months.

Evidence supporting the structure of II and its analogs were the reactions of hydrolysis, hydrogenation, and ozonolysis. Analysis and molecular weight determinations of II revealed the empirical formula $C_7H_{12}N_2O_2$, while the quantitative regeneration of piperidine by the action of aqueous alkali indicated a partial formula as follows: $C_5H_{10}N$-$C_2H_2NO_2$. This conclusion was proved by

TABLE I

THE AMINONITROETHENES AND AMINONITROPROPENES

COMPOUND	FORMULA	M.P. °C	YIELD, %	N	
				Calc'd	Found
1-Piperidino-2-nitroethene........	$C_7H_{12}N_2O_2$	95	40	17.94	17.57
1-Morpholino-2-nitroethene.......	$C_6H_{10}N_2O_3$	140–141	34.5	17.71	17.20
2-Piperidino-1-nitro-1-propene....	$C_8H_{14}N_2O_2$	84	21.5	16.48	16.13
2-Morpholino-1-nitro-1-propene...	$C_7H_{12}N_2O_3$	126–127	40	16.27	15.72

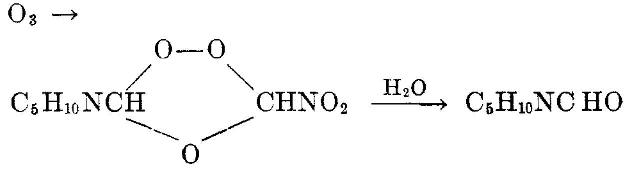
hydrogenation. Four moles of hydrogen were absorbed by II over a platinum oxide catalyst to give the expected N-(2-aminoethyl)piperidine (X):

$$C_5H_{10}NCH{=}CHNO_2 + 4H_2 \xrightarrow{Pt} \underset{\text{X}}{C_5H_{10}NCH_2CH_2NH_2} + 2H_2O$$

The diamine (X) was isolated as N-(2-benzamidoethyl)piperidine, which proved identical with the benzoyl derivative of the authentic diamine as independently prepared by the method of Gabriel (5). This proved that the nitrogens of II were separated by two carbon atoms and provided strong support for the proposed formula.

Finally, ozonolysis of II pointed to the presence of a carbon-to-carbon double bond. The isolation of formopiperidide as a reaction product established both the position of the double bond and the fact that a hydrogen was attached to the carbon adjacent to the piperidine nitrogen.

$C_5H_{10}NCH{=}CHNO_2 + O_3 \rightarrow$



A study of other reactions of II disclosed its cleavage by potassium ethoxide into piperidine and a substance believed to be potassium *aci*-nitroacetaldehyde (XII). This contention was supported by conductivity data and by the fact that XII could be oxidized to potassium nitroacetate (XIII). These steps are summarized by these equations:

$$\underset{\text{II}}{C_5H_{10}NCH{=}CHNO_2} + KOEt \xrightarrow{H_2O} C_5H_{10}NH + \underset{\text{XII}}{K^+(OCH{=}CHNO_2)^-}$$

$$\text{XII} \xrightarrow[KOH]{Ag_2O} \underset{\text{XII}}{KOOCCH{=}NOOK}$$

Nitroacetaldehyde (6) is itself unstable, and the enhanced stability of the potassium salt of nitroacetaldehyde may be attributed to resonance of the anion. Three important structures contributiug to the resonance hydrid are XIIa, XIIb, and XIIc.

$$\underset{\text{XIIa}}{{}^-O{-}CH{=}CH{-}\underset{O}{N{=}O}} \qquad \underset{\text{XIIb}}{O{=}CH{-}\overset{\cdot\cdot\ \ -}{C}H{-}\underset{O}{N{=}O}} \qquad \underset{\text{XIIc}}{O{=}CH{-}CH{=}\underset{O}{N{-}O^-}}$$

For conductivity measurements on this salt, standard conductivity equipment (7) was used. The resistance of an 0.0156 *M* aqueous solution of XII was 1270 ohms at 25.75° as measured with a Jones conductance bridge, a vacuum tube oscillator, an oscillograph and a cell of constant 2.23. The equivalent conductance, Λ, was then calculated.

$$\Lambda = \frac{1000 \times 2.23}{0.0156 \times 1270} = 111.5$$

This value of 111.5 is consistent with the formula assigned. A slow decrease in the resistance to 1214 ohms during a two-day period indicated decomposition.

Oxidation of II with silver oxide proceeded smoothly in the presence of a little potassium hydroxide to give a silver mirror, but to isolate the product, it was more convenient to oxidize XII. The potassium nitroacetate thus obtained was compared crystallographically with an authentic sample (6a) prepared by the action of concentrated potassium hydroxide on nitromethane. As nearly as could be readily determined, the two samples were identical.

This comparison was substantiated by the fact that both gave similar brown color reactions when treated with a ferric chloride solution. Both also gave a red colored reaction product with nitrous acid, in conformity with Victor Meyer's nitrolic acid test for the $-CH_2NO_2$ group (8).

Halogens and the hydrogen halides reacted instantly with II to give unstable solids which quickly turned into gummy substances. Bromine, for example, deposited a bulky precipitate when added to a cold solution of 1-piperidino-2-nitroethene in benzene. When this solid was collected on a filter and placed in a desiccator, it changed rapidly to a dark brown tar. Likewise, hydrogen bromide

caused precipitation (CCl_4 solution of II) but this product also was very unstable, tending to become tarry on standing either in the air or in a desiccator. When a solution of dry hydrogen chloride in ethyl ether was added to solid II the crystalline nature of the latter changed to a fluffy crystalline mass which was stable for a few hours. Analysis for chlorine (8.47%) suggested that one mole of hydrogen chloride and three moles of ether were added to one of the piperidinonitroethene [calc'd for $C_7H_{13}ClN_2O_3 \cdot 3(C_2H_5)_2O$: Cl, 8.55].

Several new aminomethylenemalonic esters were prepared in the course of this investigation, namely, the derivatives related to piperidine, morpholine, diethylamine, and piperazine.

EXPERIMENTAL

The 1-amino-2-nitroethenes. Starting materials: Ethyl ethoxymethylenemalonate (I) was obtained from National Aniline Division of Allied Chemical and Dye Corporation and was redistilled at 130–133° at 3 mm. Ethyl α-ethoxyethylidenemalonate was prepared essentially by the procedure of McElvain and Burkett (4).

The four compounds were prepared by the same general procedure, which is illustrated for 1-piperidino-2-nitroethene (II).

A mixture of 28 g. of ethyl ethoxymethylenemalonate, 17 g. of piperidine, and 17 g. of nitromethane was refluxed gently for two hours with an electric heater and transferred to a Claisen flask. Everything volatile at 100° and 12 mm. was removed by distillation and an equal volume of ether was added to the residue. After thorough mixing, the solution was chilled in a bath of dry-ice and acetone. Scratching the flask induced crystallization, and after about ten minutes, the crude product was removed and washed with cold ether until most of the tar had been removed and then was dissolved in about 100 g. of hot carbon tetrachloride. The solution was filtered and on cooling, 8.0 g. (40% yield) of II crystallized in the form of pale yellow, micaceous plates. Pertinent data are summarized in Table I. Other analytical data for 1-piperidino-2-nitroethene are as follows:

Anal. Calc'd for $C_7H_{12}N_2O_2$: C, 53.83; H, 7.74, mol. wt., 156.
Found: C, 53.80; H, 7.48; mol. wt., 157, 160.

Carbon tetrachloride was used to crystallize the piperidino compounds, while acetone-ether mixtures were best for the more insoluble morpholino analogs.

Alternate procedure: The preparation of 1-morpholino-2-nitroethene (III) from ethyl morpholinomethylenemalonate (VI). Ethyl morpholinomethylenemalonate was prepared by heating equimolar quantities of morpholine and I on a steam-bath for one hour. Dilution with ethanol and crystallization at −70° gave nearly quantitative yields of VI. An analytical sample melted at 64–66°.

Anal. Calc'd for $C_{12}H_{19}NO_5$: C, 56.02; H, 7.44.
Found: C, 56.34; H, 7.68.

A mixture of 5.94 g. of VI, 1.5 g. of nitromethane, and 0.3 g. of morpholine was heated for two hours in an oil-bath maintained at 140–150°. The volatile portion was distilled off as above and the product precipitated by the addition of ether followed by chilling to −70°. The yield was 1.61 g. (44%), m.p. 139–140°.

Ethyl piperidinomethylenemalonate and ethyl diethylaminomethylenemalonate. These two analogs of VI were prepared by the above procedure including the crystallization from ethanol at −70°. Both compounds melted at about room temperature.

Anal. (Piperidine derivative) Calc'd for $C_{13}H_{21}NO_4$: N, 5.49. Found: N, 5.60.

Anal. (Diethylamine derivative) Calc'd for $C_{12}H_{21}NO_4$: N, 5.76. Found: N, 5.53.

Alkaline hydrolysis of 1-piperidino-2-nitroethene (II). To 15 ml. of 10% potassium hydroxide solution was added 0.528 g. of II. The flask was swirled for thirty seconds to dissolve the solid. The liberated piperidine was converted to benzenesulfonpiperidide in the usual manner. A yield of 0.742 g. (97%) melting at 89–90° was obtained.

Ozonization of 1-piperidino-2-nitroethene (II). A mixture of oxygen and ozone was

passed through a solution of 5.00 g. of II in 300 g. of chloroform. When the reaction was complete, as determined by the fact that no more ozone was absorbed, 100 g. of water was added to the solution. Air was bubbled through the mixture and it was gently warmed on a steam-bath. After the chloroform had been removed, the heating was continued until the temperature was 100° and maintained there for two hours. After cooling, the solution was extracted with five 25-ml. portions of ether. The extract was dried with magnesium sulfate. The solvent was removed and distillation of the residue produced 0.98 g. of formopiperidide. The index of refraction ($n^{15}D$) of this fraction without further purification was 1.487 as compared to 1.485 for a synthetic specimen made from ethyl formate and piperidine.

The hydrogenation of 1-piperidino-2-nitroethene (II). Quantitative hydrogenation. A solution of 0.192 g. of II in 10 ml. of absolute ethanol was reduced in a semi-micro hydrogenation apparatus in the presence of 20 mg. of platinum oxide. At 751 mm. and 24°, 126 cc. (5.11×10^{-3} mole) was absorbed as compared with 4.94×10^{-3} mole calculated for the interaction of four moles of hydrogen with one mole of II.

Preparative hydrogenation. A solution of 0.547 g. of II in 20 ml. of absolute ethanol was hydrogenated in a Burgess-Parr apparatus in the presence of 30 mg. of platinum oxide and under 30 lb. of hydrogen pressure. The solution was acidified with 1 ml. of concentrated hydrochloric acid and evaporated to dryness. It was then dried under diminished pressure over phosphoric anhydride to remove all ethanol. The product was made alkaline with 10% potassium hydroxide solution and benzoylated with benzoyl chloride. Crystallization from an alcohol-water mixture gave 0.433 g. (54%) of N-(2-benzoylaminoethyl)piperidine, which after two recrystallizations, melted at 66.5–67.5°. This material showed no melting point depression with the benzoyl derivative of the amine as prepared by the method of Gabriel (5).

Anal. Calc'd for $C_{14}H_{20}N_2O$: N, 12.06. Found: 11.70.

Cleavage with potassium ethoxide. The preparation and properties of the potassium salt of nitroacetaldehyde. To a solution containing 1.00 g. of 1-piperidino-2-nitroethene in 30 ml. of absolute ethyl alcohol was added a potassium ethoxide solution consisting of clean potassium in about 20 ml. of absolute alcohol. A precipitate formed quickly, and the mixture was allowed to stand at −10° for thirty minutes. The salt was removed, washed twice with absolute ethanol, thrice with absolute ether, and allowed to dry in the air. The yield was 0.81 g. (100%).

On acidification of the filtrate of the above preparation with hydrochloric acid and taking it to complete dryness, a mixture of salts was obtained. This was dissolved in water, made basic, and treated with benzenesulfonyl chloride to give 1.44 g. (100%) of benzenesulfonpiperidide, m.p. 89–91°.

The salt of nitroacetaldehyde as prepared above is an almost white, fluffy crystalline solid. It is exceedingly soluble in water but is insoluble in organic solvents. It explodes on heating in a flame and melts with decomposition at 150–160°. It gave a fleeting brown color with ferric chloride solution and decomposed to a dark brown, water-soluble tar after standing for about six weeks. The analytical sample was dried in a desiccator but was not recrystallized.

Anal. Calc'd for $C_2H_3KNO_3$: K, 30.70. Found: K, 31.59, 31.63.

Oxidation of the potassium salt of nitroacetaldehyde. A mixture of 1.7 g. of the potassium salt, the moist silver oxide obtained from 10 g. of silver nitrate, 1.5 g. of potassium hydroxide, and 30 ml. of water was shaken overnight in a rotary shaker. The silver and the excess oxide were removed and the filtrate was evaporated under vacuum. The first crystals, about 0.5 g., were not of the desired compound. Addition of 10 ml. of ethanol threw out 1.4 g. of salt, which on recrystallization from 50% aqueous potassium hydroxide, gave the potassium nitroacetate for the crystallographic study previously discussed.

ACKNOWLEDGMENTS

Professor A. L. Howland of the Department of Geology, Northwestern University, performed the crystallographic comparisons. Microanalyses for nitro-

gen, carbon, and hydrogen were performed by Margaret Ledyard and Patricia Craig. Dr. Ralph Pearson of this department assisted in the electrical conductivity measurements.

SUMMARY

1-Piperidino-2-nitroethene, 1-morpholino-2-nitroethene, 2-piperidino-1-nitro-1-propene, and 2-morpholino-1-nitro-1-propene were prepared by interaction of piperidine or morpholine with ethyl ethoxymethylenemalonate or ethyl ethoxyethylidenemalonate and nitromethane. The steps in these processes and the limitations of the reaction have been expounded. Various reactions of 1-piperidino-2-nitroethene have been presented including alkaline hydrolysis to piperidine and nitroacetaldehyde, hydrogenation to N-(2-aminoethyl)piperidine, ozonolysis to formopiperidide, and reaction with bromine, hydrogen bromide, or hydrogen chloride.

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