## Summary

The high-boiling residue from cane molasses fusel oil has been found to consist mainly of the ethyl esters of capric, lauric, myristic and palmitic acids together with a little non-saponifiable material.

URBANA, ILLINOIS

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# DEAMINIZATION.[1] III. EVIDENCE OF THE EXISTENCE OF ALIPHATIC DIAZONIUM SALTS FROM THE FORMATION OF CHLORO-OXIMINO COMPOUNDS

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The nitrites of aromatic primary amines lose one molecule of water to give diazohydrates which according to Hantzsch[2] give diazonium salts with acids through tautomeric change. The nitrites of aliphatic primary amines give by the loss of two molecules of water the diazo compound as the first isolable decomposition product which still contains the nitrogen of the amine. These nitrites of aliphatic bases are regarded as very unstable compounds, but it has been shown by Wallach[3] that some are so stable as to be crystallizable from water in the absence of the last trace of acid. With respect to the diazo compounds themselves it has been shown by Staudinger and others[4] that the substitution of so-called negative groups on the carbon atom bearing the amino group greatly increases the stability. Aliphatic diazonium salts have not been isolated.

It seemed reasonable that typical aliphatic diazonium salts must exist from a review of their well-known reactions although they do not undergo certain reactions of aromatic diazonium compounds. For example, the coupling reaction does not take place, but with water, alcohol and acids they react to give products which are exactly analogous. However, it may be argued that the true diazo compound, $RCHN_2$, is first formed and that this reacts to give compounds which are similar to those in the aromatic series. In the production of the aliphatic diazo compound from the amine the reaction may well pass through either the diazohydrate or the diazonium salt, but as long as they have not been isolated it is still open to question. The isolation of certain heterocyclic diazonium salts and derivatives which are obtained by the coupling reaction from antipyrine, triazole and pyrazole shows that the existence of such compounds is not

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[1] Previous papers: Skinner, THIS JOURNAL, **45**, 1498 (1923). Barker and Skinner, *ibid.*, **46**, 403 (1924).

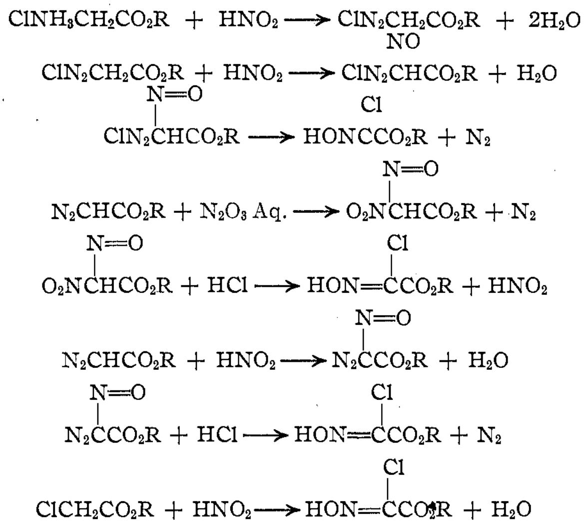
[2] Engler and Hantzsch, *Ber.*, **33**, 2150 (1900).

[3] Wallach, *Ann.*, **353**, 318 (1907).

[4] Staudinger and Gaule, *Ber.*, **49**, 1897 (1916).

peculiar to benzene and its homologs.[5] These compounds have systems of crossed double bonds also possessed by the similar compounds in the aromatic series.

The study of reactions which cannot be explained as taking place through either the true diazo compound or the diazonium salt to give the same products, therefore, seems to be the most promising mode of procedure. In attempting to obtain evidence by working at low temperature in the treatment of glycine ester hydrochloride with sodium nitrite and an extra molecule of hydrochloric acid it is believed that such a reaction has been found. By using fairly concentrated solutions nearly all of the reaction product separates as the ester of chloro-oximino-acetic acid. The formation of this type of compound may be explained as follows.



I.

$$ClNH_3CH_2CO_2R + HNO_2 \longrightarrow ClN_2CH_2CO_2R + 2H_2O$$

$$ClN_2CH_2CO_2R + HNO_2 \longrightarrow ClN_2\overset{NO}{C}HCO_2R + H_2O$$

$$ClN_2\overset{N=O}{\overset{|}{C}}HCO_2R \longrightarrow HON\overset{Cl}{C}CO_2R + N_2$$

II.

$$N_2CHCO_2R + N_2O_3\,Aq. \longrightarrow O_2N\overset{N=O}{\overset{|}{C}}HCO_2R + N_2$$

$$O_2N\overset{N=O}{\overset{|}{C}}HCO_2R + HCl \longrightarrow HON{=}\overset{Cl}{\overset{|}{C}}CO_2R + HNO_2$$

III.

$$N_2CHCO_2R + HNO_2 \longrightarrow N_2\overset{N=O}{\overset{|}{C}}CO_2R + H_2O$$

$$N_2\overset{N=O}{\overset{|}{C}}CO_2R + HCl \longrightarrow HON{=}\overset{Cl}{\overset{|}{C}}CO_2R + N_2$$

IV.

$$ClCH_2CO_2R + HNO_2 \longrightarrow HON{=}\overset{Cl}{\overset{|}{C}}CO_2R + H_2O$$

That the reaction does not take place according to IV has been shown by treating chloro-acetic ester with nitrous acid under the same conditions, in which case the unchanged ester was recovered. The nitrolic acid derivative might be formed according to II and might be expected to give the chloro-oximino compound with hydrochloric acid. Ethyl nitrolic acid when decomposed with dry hydrogen chloride in ether gives the hydrochloride of chloro-oximino-ethane.[6] Likewise, nitro-acetophenone with hydrogen chloride in dry ether gives chloro-oximido-acetophenone after ten days' standing.[7] If the reaction takes place in this way one should expect chloro-nitroso compounds to be formed from primary amines

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[5] Thiele and Manchot, *Ann.*, **303**, 41 (1898). Mohr, *J. prakt. Chem.*, **90**, 522 (1914). Morgan and Reilly, *J. Chem. Soc.*, **103**, 808 (1913); **109**, 155 (1916). Comm. Report, *Chem. News*, **123**, 186 (1921).

[6] Werner and Buss, *Ber.*, **28**, 1282 (1895).

[7] Steinkopf and Jürgens, *J. prakt. Chem.*, [2] **84**, 712 (1911).

in which the amine group is linked to a secondary carbon atom as in alanine esters or *iso*propyl amine. However, preliminary experiments under the same conditions indicate the formation of nitro-nitroso compounds in good yields. The results of these experiments and the action of aqueous hydrogen chloride on such compounds will be reported later. Furthermore, nitrosyl chloride should be expected to react with the diazo ester to give the chloro-oximino compound, but it was found to give almost entirely chloro-acetic ester and the nitrile oxide. The mechanism of the reaction is, therefore, at present believed to be represented by I.

The identity of the ethyl ester of chloro-oximino-acetic acid was established by its physical properties, analysis and conversion to the corresponding nitrile oxide. These types of compounds have been prepared in other ways by other investigators and considerable difference of opinion has been manifested as to their structure. Ethyl chloro-oximino-acetate has been made by the oxidation of ethyl chloro-acetate with fuming nitric acid,[8] by the action of hydrochloric acid on ethyl nitro-oximino-acetate,[9] and by the action of chlorine on isonitroso-aceto-acetic ester.[10] The corresponding nitrile oxide has been prepared by the action of alkalies on the chloro-oximino esters,[11] by the action of fuming nitric acid on aceto-acetic ester,[12] by the action of nitrous anhydride on oximino-acetic ester,[13] and by the action of nitrogen tetroxide on diazo-acetic ester.[14]

Evidence of the structure of the polymeric form of the nitrile oxide has been given by a study of the degradation products resulting from the action of ammonia and baryta.[15] Very definite evidence that the substance acts as a dimer has been supplied by its conversion to the acid ester.[16] It does not give hydroxylamine hydrochloride by hydrolysis but the chloro-oximino compound from which it is derived readily does so. The analytical data on the chloro-oximino compound given by Pröpper show high results for nitrogen. This analysis has been carefully repeated and high results were likewise obtained. The molecular weight is given for only one solvent, benzene, in which it was shown to be dimolecular. This determination has been carefully repeated with the result that it is monomolecular in this solvent. In nitrobenzene it is intermediate, while in acetic acid and ethylene bromide it is dimolecular. This result indicates that it is

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[8] Pröpper, *Ann.*, **222**, 46 (1884).

[9] Jowitschitsch, *Ber.*, **39**, 785 (1906).

[10] (a) Piloty and Steinbock, *Ber.*, **35**, 3113 (1902). (b) Wieland, Semper and Gmelin, *Ann.*, **367**, 61 (1909).

[11] Wieland and others, *Ann.*, **367**, 61 (1909); *Ber.*, **40**, 1675 (1907).

[12] Ref. 8, p. 48.

[13] Bouveault and Wahl, *Bull. soc. chim.*, [3] **31**, 680 (1904).

[14] Wieland and Reisenegger, *Ann.*, **401**, 245 (1913).

[15] Ref. 10b, p. 100.

[16] Bouveault and Bongert, *Bull. soc. chim.*, [3] **27**, **1168** (1902).

an equilibrium mixture of the nitrile oxide and its polymer, furoxandicarboxylic ester.

TABLE I

MOLECULAR WEIGHT OF THE NITRILE OXIDE

| | Solvent G. | Substance G. | $-\Delta t_F$ | Mol. wt. |
|---|---|---|---|---|
| Benzene | 15.60 | 0.2420 | 0.346 | 224[17] |
| | 15.60 | .4611 | .640 | 223[17] |
| | 30.2 | .2851 | .235 | 113[18] |
| | 40.7 | .2851 | .165 | 119[18] |
| | 42.51 | .3972 | .206 | 127[18] |
| Acetic acid | 20.87 | .3972 | .434 | 123[18] |
| | 30.33 | .4439 | .232 | 228[18] |
| | 41.44 | .4439 | .175 | 221[18] |
| Ethylene bromide | 42.97 | .2672 | .304 | 239[18] |
| | 80.37 | .2672 | .180 | 216[18] |
| Nitrobenzene | 27.18 | .1952 | .251 | 195[18] |
| | 44.38 | .1952 | .168 | 167[18] |

Calcd. for $O{=}N{\equiv}C{-}CO_2C_2H_5$: 115.

## Action of Nitrous Anhydride and Nitrosyl Chloride

The nitrous anhydride was prepared by reducing nitric acid with arsenious oxide and purified by fractional condensation. The gas was then either used directly or liquefied and kept in sealed tubes. When used from sealed tubes it was distilled into the reaction mixture from a water-bath heated not more than 5° above its boiling point. A rapid reaction takes place at the temperature of a freezing mixture of salt and ice. Nitric oxide (NO) is evolved with the nitrogen, and slightly less than one molecular equivalent of nitrogen trioxide is necessary to complete the reaction. Approximately one-half of the liquid reaction product consists of the nitrile oxide, and the non-distillable residue is very small in amount. The probable reactions are the following: $N_2CHCO_2R + N_2O_3 \longrightarrow O{=}N{\equiv}CCO_2R + HNO_2 + N_2$; $N_2CHCO_2R + HNO_2 \longrightarrow ONOCH_2CO_2R + N_2$.

Nitrosyl chloride in solution such as is used in terpene chemistry could not be used here on account of the complicating factors of the solvent, and hence a satisfactory laboratory method was devised for the preparation of liquid nitrosyl chloride. The nitrosyl chloride was then distilled into the diazo ester after the manner used for nitrous anhydride. The products were the nitrile oxide and chloro-acetic ester and the probable reactions are as follows: $N_2CHCO_2R + ONCl \longrightarrow HCl + N_2 + O{=}N{\equiv}CCO_2R$; $N_2CHCO_2R + HCl \longrightarrow ClCH_2CO_2R + N_2$.

## Other Decomposition Products

Diazo-acetic ester gives glycolic ester when decomposed with dil. hydrochloric acid in a homogeneous system. The fact that the increase

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[17] Cramer, *Ber.*, **25**, 718 (1892).

[18] For observer, see experimental part.

in concentration of salts such as sodium chloride is accompanied by an increase in the yield of chloro-acetic ester is regarded as evidence of the intermediate formation of the diazonium salt.[19] The reaction when water alone was used as the solvent consisted first in the separation of diazo-acetic ester with simultaneous evolution of nitrogen. The subsequent addition of small quantities of hydrochloric acid to the aqueous layer produced a rapid reaction which proceeded for a short time and then practically ceased. Continuing in this way at intervals of several hours until the evolution of nitrogen was reduced to a minimum the product after extraction with ether was found to give no evidence of glycolic ester. The absence of more than a trace of the ether acid was shown by extraction with sodium bicarbonate solution. The yield of the non-distillable residue consisting of condensation products was small when the reaction was carried out by the addition of very small increments of acid over a long period of time. The decomposition of diazo-acetic ester in a similar fashion with and without mechanical stirring gave a product which distilled over a range of 5° at the boiling point of chloro-acetic ester.

The ethyl ester of diazo-acetic acid has heretofore been prepared from glycine ester hydrochloride in the presence of sodium acetate. It is also directed to dry the ethereal solution of the diazo ester with calcium chloride. From the experience gained one hesitates to recommend either of these procedures. The addition of sodium acetate will not prevent the presence of chloride ion. In the formation of the diazo ester according to the standard procedure the reaction tends to start with a rush owing to the certain degree of stability of the salt with nitrous acid, and with chloride ion present it would seem to be impossible to prevent the formation of at least a trace of the chloro ester. Since the chloro and diazo esters boil at practically the same temperature the impurity would not be removed by distillation. The safer procedure for obtaining a very pure product is the conversion to the free base in spite of the accompanying loss of material and the use of either acetic or sulfuric acid to liberate the nitrous acid. In one preparation according to the standard procedure in which the reaction "got away" more than usual, 80 g. of material was distilled under diminished pressure and all boiled over a range of 5° at the boiling point of the diazo ester. However, upon standing several months in a closed cupboard the material had largely crystallized without the evolution of nitrogen. The crystalline material was identified as pyrazoline tricarboxylic ester by its melting point and by analysis. The formation of this compound from diazo-acetic ester alone could only have taken place with the evolution of nitrogen. When calcium chloride is used as a drying agent an orange-yellow color develops, and if a portion of the

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[19] Bredig and Ripley, *Ber.*, **40**, 4015 (1907). Mumm, *Z. physik. Chem.*, **62**, 589 (1908).

ether solution is allowed to evaporate with this reagent a gummy residue is formed. Also, diazo-acetic ester dried in this way gives a large residue of high-boiling, orange-colored material upon distillation under diminished pressure. When the material is worked rapidly and dried with a capillary under diminished pressure this residue is very small in amount.

The mechanism of the formation of the high-boiling condensation products is not understood. It is probably due to the reaction of the diazo ester with the hydroxy, chloro and unsaturated esters. This view is supported by the fact that the most stable intermediate diazo esters give the largest yields of these complex products. On the other hand, the polymerization of diazo-acetic ester appears to be hastened by the presence of acids and certain salts, so that the reaction may take place in this way with the slow elimination of nitrogen.

## Experimental Part

**Hydrochloride of Glycine Ethyl Ester.**—The material used in the subsequent experiments was obtained as a by-product in the preparation of alanine by the hydrolysis of silk. When recrystallized from absolute alcohol and after treatment with a good grade of boneblack, it melted at 144°.

**Glycine *n*-Butyl Ester.**—The hydrochloride of this ester was not isolated, since it crystallized only with difficulty.

Twenty-one g. of methylene aminonitrile is treated with a mixture of 400 cc. of dry butyl alcohol and 6 cc. of water. Dry hydrogen chloride is then passed in rapidly while the cold mixture is either shaken or mechanically stirred until the weight has increased by 35–40 g. The mixture is then refluxed in an oil-bath for 5 hours. After the mixture has cooled, the ammonium chloride is filtered off with suction and the filtrate is concentrated under diminished pressure on the water-bath until it has a sirupy consistency. The alcohol should not be completely removed, as the residue will not then mix well with ether, and if too much alcohol remains the yield of the liberated ester will be decreased in the subsequent fractional distillation. The residue is dissolved in 100 cc. of dry ether and kept cold in a freezing mixture of salt and ice. To it is added a cold solution of 50 g. of potassium carbonate in 75 cc. of water and the mixture constantly shaken. The ether layer is separated and the water layer is extracted once more with 50 cc. of ether. The ether solution is dried first with potassium carbonate for a few minutes and then with powdered lime for one to two hours, being kept cold in an ice-salt mixture. Most of the ether is removed on the water-bath at atmospheric pressure and the residue is fractionated under diminished pressure using an efficient column. The yield of the fraction boiling constantly at 65° (5 mm.) is 20–25 g.; $d_4^{20}$, 0.967; $d_4^{25}$, 0.960; $n_{706}$, 1.4209; $n_{587}$, 1.4254; $n_{501}$, 1.4294; $n_{447}$, 1.4333.

**Ethyl Diazo-acetate.**—This substance was prepared according to the usual procedure and also by the action of nitrous acid upon the freshly prepared free base using sulfuric acid and sodium acetate. The ester used in the experiments with nitrosyl chloride was prepared by the second method.

Glycine ethyl ester (22.5 g.) is gradually added to a solution of 6.1 cc. of sulfuric acid (d., 1.84) and 0.5 g. of sodium acetate in 20 cc. of water which is kept cold in a freezing mixture. Crushed ice (25 g.) is added meanwhile. A solution of the equivalent amount of sodium nitrite in 25 cc. of water is now run in. The reaction may be started by allowing the temperature of the solution to rise somewhat or by adding a drop or two of dil. sulfuric acid, and can be kept from becoming violent by agitating the flask in the ice-salt bath. The reaction is complete in a few minutes. The ester is separated, washed once with sodium sulfate solution and filtered at once through a small fluted filter into a small flask for fractional distillation under diminished pressure. The ester is dried with a capillary at 70°, under such pressure that very little is volatilized. The weight of the fraction boiling constantly at 42° (5 mm.) is 16.5 g. The receiver should be surrounded by a freezing mixture of salt and ice during this operation.

***n*-Butyl Diazo-acetate.**—This substance was made exclusively by the second method employed for the ethyl ester. The yield from 14.5 g. of *n*-butyl amino-acetate is 10 g. It is a lemon-yellow oil, of very pleasant odor; b. p., 59° (4 mm.).

**Preparation of Nitrosyl Chloride.**—A 1-liter distilling flask is fitted with a rubber stopper bearing a dropping funnel, the stem of which is drawn out to a tube of small diameter. The delivery tube is connected to a U-tube of small bore with a bulb in each arm. This is connected to two condensers (Fig. 1) in series, which are suitable for sealing and which are very easily made from test-tubes. The final exit is protected by a drying tube. The neck of the condensing tube should have thick walls and be about 5 mm. in diameter. Powdered sodium nitrite (120 g.) is placed in the flask and, with the temperature kept at approximately —20°, 160 g. of phosphorus oxychloride may be added slowly from the dropping funnel. The U-tube should contain about 1 cc. of phosphorus oxychloride. The first condensing tube is surrounded by a bath of ice water and the second by a freezing mixture of salt and ice. The flask is gently rotated and when the reaction mixture has become homogeneous the temperature is gradually raised and the nitrosyl chloride is allowed to distil. The contents of the first tube is fractionated before sealing. The yield is 32 g. and can be improved. Using 80 g. of phosphorus oxychloride and 120 g. of sodium nitrite the yield was only 15 g. Nitric oxide (NO) was evolved continuously during the reaction. That the product does not contain chlorine or nitrous anhydride is evidenced by the observation that it gives no nitric oxide or dichloro-acetic ester by reacting with diazo-acetic ester.

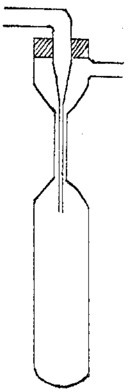

Fig. 1.

**Action of Nitrous Anhydride on Ethyl Diazo-acetate.**—The ester (5 g.) is placed in a U-tube of convenient size which is immersed in a bath of ice water. An equivalent amount of nitrous anhydride is then passed in. An excess can easily be noted by the persistence of a faint blue color and by the diminished rate of gas evolution. After a half hour the product is distilled under diminished pressure using a micro Claisen flask and a thermometer with a small mercury well. Small side-neck test-tubes immersed in a freezing mixture of salt and ice are used as condensers. The pale, straw-colored oil is thus separated into two fractions, (1) b. p. 53–52° (3–2 mm.) and (2) b. p. 130–134° (3 mm.). The weights of the different fractions although varying somewhat in the different experiments were 2.7 and 2.3 g., respectively, while the residue amounted to 0.4 g. A fairly sharp separation is possible with this quantity by proper control of the temperature of the Wood's metal bath. It is advisable to maintain the temperature for a short time just below the point at which (2) distils. The amount of gas evolved is approximately 150 cc. more than that calculated, due to the formation of nitric oxide. The gas in the second arm of the tube is colorless, and when two tubes are used in series the material in the second tube is not attacked until the reaction is complete in the first. Fraction 2 is the polymeric nitrile oxide. The proportion of the nitrile oxide formed appears to be increased by keeping the temperature at —20° instead of 0°. The examination of Fraction 1 is not complete. When distilled at atmospheric pressure it starts to boil at about 150° with evolution of oxides of nitrogen, and then explodes.

**Action of Nitrosyl Chloride on Ethyl Diazo-acetate.**—An equivalent amount of nitrosyl chloride is distilled from a bath of ice water into 5.65 g. of the ester contained in a U-tube cooled by a freezing mixture of salt and ice. The reaction takes place rapidly and the presence of an excess is easily noted by the appearance of the reddish color. There is no evidence of the formation of nitric oxide and the nitrogen evolved is practically the calculated amount. The following fractions were obtained by the method described above: (1) b. p., 40–45° (9–10 mm.), 2.7 g.; (2) b. p., 120–124° (2 mm.), 1.6 g.; (3) residue with the bath at 175°, 0.8 g. of an orange-colored, viscous oil. This oil did not crystallize on long standing and gave only a faint test for chlorides with alcoholic silver nitrate, showing the absence of more than a trace of the chloro-oximino compound. Fraction 1 distils at 140–142° under atmospheric pressure and is chloro-acetic ester, while (2) is the polymeric nitrile oxide. In another run using 8.0 g. of the ester the weights of the fractions were as follows: (1) 3.6 g.; (2) 3.5 g.; (3) residue with the bath at 235°, 0.4 g.

**Nitrite Decomposition of Glycine Ethyl Ester Hydrochloride.**—The hydrochloride (69.7 g.) is dissolved in 250 cc. of water and to this is added a solution of the equivalent quantity of sodium nitrite in 100 cc. of water. The mixture is allowed to stand in a loosely stoppered flask kept at room temperature and one equivalent of hydrochloric acid is added in quantities of a few tenths of a cubic centimeter during a period of one week. The absence of more than a trace of the ether acid is shown by the extraction of the ether solution with sodium bicarbonate solution. The volatile portion of the indifferent substances amounts to 35 g. and consists entirely of chloro-acetic ester. The viscous residue weighs 5 g. and when seeded with the ester of chloro-oximino-acetic acid it does not crystallize. When the reaction is carried out over a short period of time the volatile product likewise consists entirely of chloro-acetic ester when sufficient acid has been added to complete the decomposition of the intermediate diazo ester.

**Decomposition of Glycine *n*-Butyl Ester Hydrochloride.**—The ester (31.5 g.) is carefully dissolved in a mixture of 19.4 cc. hydrochloric acid (d., 1.19) and 100 cc. of water and the mixture kept cold. To this is added a cold solution of the equivalent amount of sodium nitrite in 50 cc. of water. More acid (30 cc.) is added in small portions in the course of 48 hours. Absence of more than a trace of the ether acid was shown by extraction with sodium carbonate solution. After fractionating from the small amount of butyl alcohol present the volatile portion boiled at 177–182° and weighed 22 g. A sample of Eastman's *n*-butyl chloro-acetate boiled at the same temperature. The weight of the non-volatile residue is 3 g.

**Decomposition of Ethyl Diazo-acetate with Dilute Acid.**—The ester is gradually added to ten times its volume of water containing the calculated amount of hydrochloric acid. The nitrogen evolved is very near that calculated. The product obtained is the chloro ester but the yield is diminished by stirring.

**Formation of Ethyl Chloro-oximino-acetate.**—Glycine ester hydrochloride (69.7 g.) is dissolved in 95 cc. of water and to the cooled solution is added 41.5 cc. (1 equivalent) of hydrochloric acid (d. 1.19). While the mixture is constantly agitated in a freezing mixture of salt and ice a solution of one equivalent of sodium nitrite in 50 cc. of water is added dropwise. Another equivalent of hydrochloric acid is then added followed by the addition of an equivalent of sodium nitrite in the same manner. The evolution of nitrogen is slow at first but the total amount exceeds that calculated due to the formation of nitric oxide. The product separates as a white crystalline substance and after a few minutes in the freezing mixture it is filtered with suction, dissolved in a small quantity of hot benzene, the solution filtered, concentrated to a small volume and crystallized by stirring in an excess of hot ligroin; m. p., 80°. The chloro-acetic ester in the oil from the aqueous filtrate described above is distilled from the oxime under diminished pressure at a temperature of 75°. The total yield of the chloro-oximino ester is 40 g. and that of the chloro-acetic ester is 6.5 g. The melting point of the chloro-oximino compound is identical with that given in the literature, its aqueous or alcoholic solution precipitates silver with the same ease as sodium chloride, and it gives by treatment with sodium carbonate solution a substance that is identical with furoxancarboxylic ester. Its identity is further confirmed by analysis.[20]

*Analyses.* Calc. for $C_4H_6O_3NCl$: C, 31.68; H. 3.96; N, 9.24; Cl, 23.43. Found: C, 31.48, 31.54, 31.59; H, 4.12, 3.77, 3.99; N, 10.12, 10.23, 10.18; Cl, 23.33, 23.24, 23.46.

**The Nitrile Oxide from Ethyl Chloro-oximino-acetate.**—The nitrile oxide is obtained by agitation in a long-neck flask with a mixture of ether and a slight excess of a concd. solution of sodium carbonate. By distillation it is obtained as a water-clear liquid; b. p., 132–133° (3 mm.). The molecular weight was determined in benzene (m. p., 5.48°), acetic acid (m. p., 15.72°), nitrobenzene (m. p., 5.68°), and ethylene bromide (m. p., 9.34°). The melting points of the solvents were determined with a Bureau of Standards thermometer. The other data are given in the discussion; $d_4^{20}$, 1.2780; $d_4^{25}$, 1.2726.

*Analyses.* Calc. for $C_4H_5O_3N$: C, 41.72; H, 4.38; N, 12.17. Found: C, 41.36, 41.51; H, 4.60, 4.49; N, 11.95, 12.30.

***n*-Butyl Chloro-oximino-acetate.**—Freshly distilled ice-cold *n*-butyl aminoacetate (41.5 g.) is carefully added to a mixture of 52.4 cc. of hydrochloric acid (2 equivalents) and 70 cc. of water kept cold in a freezing mixture. Two equivalents of sodium nitrite and one of hydrochloric acid are then added in the manner described above. The heavy oil is separated and the water layer is extracted once with a little ether. The ether and moisture are removed under strongly reduced pressure with a protected capillary at 60°. When the bath is heated to 70° or higher a peculiar wave-like decomposition takes place which subsides and begins at regular intervals. The pale straw-colored liquid is allowed to stand in an ice box overnight in a stoppered wide-mouth bottle and then filtered as quickly as possible on a cold Hirsch funnel. The weight of the crystalline residue is 17.5 g. It is melted and the process is repeated. By crystallization from less than its weight of hot ligroin the butyl chloro-oximino-acetate was obtained in the form of colorless transparent needles; m. p., 56°. The first filtrate is shaken with ether and a solution of 25 g. of sodium carbonate in 100 cc. of water to convert the remaining chloro-oximino-acetate to the nitrile oxide. The last of the ether is removed at a pressure of 5 mm. with the bath at 60°. The nitrile oxide and the chloro ester are separated by fractionation under diminished pressure. The weight of the chloro ester is 11 g.; b. p., 56° (5 mm.). The weight of the nitrile oxide is 15 g. and the residue in the flask amounts to 0.5 g. A chlorine determination was made by direct precipitation from a water-alcohol solution.

*Analysis.* Subs., 0.2064: AgCl, 0.1626. Calc. for $HON{=}CClCO_2C_4H_9$: Cl, 19.7. Found: 19.5.

**Preparation of Chloro-oximino-ethane.**—A cold 30% solution of ethyl amine (37.5 cc.) is treated with 43.5 cc. of hydrochloric acid (2 equivalents) and then with two

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[20] Many analyses were made for nitrogen with high results of which observation has been previously made and for which the writer has no explanation. Compare Cramer, *Ber.*, **25**, 721 (1892).

equivalents of sodium nitrite and one of hydrochloric acid as described above. The material cannot be extracted with ether. The solution is evaporated almost to dryness and filtered with suction. The water is removed by means of a capillary at 100° under diminished pressure and filtered on a small Hirsch funnel to remove the small amount of salt which separates. The light straw-colored oil is then allowed to stand overnight in an ice box protected from moisture. The crystals are filtered off with suction and allowed to stand on a porous plate in a desiccator, as the material is hygroscopic; yield, 4 g.; m. p., 84–85° (closed tube).

*Analysis.* Subs. 0.2698: AgCl, 0.4104. Calc. for $CH_3O(Cl)=NOH$: Cl, 37.92%. Found: 37.63%.

The non-crystalline portion weighs 14 g. and contains about 25% of the chloro-oximino compound, judging from the chlorine content. The corresponding compounds from allyl and *n*-amyl amines have thus far been obtained only as liquids. Crystalline compounds have been prepared in good yield from *iso*propyl amine and the ethyl ester of alanine which do not contain chlorine and which thus far appear to be nitro-nitroso derivatives.

**Formation of Pyrazoline Tricarboxylic Ester.**—Glycine ester hydrochloride (139.5 g.) in two equal portions is dissolved in a total of 200 cc. of water and treated with a total of 75 g. of sodium nitrite in 125 cc. of water, while the reaction mixture is kept in a large bath of water at room temperature. A few drops of hydrochloric acid are added to the aqueous layer after the first reaction. The mixture is allowed to stand for about two hours and then extracted with ether. By distillation under diminished pressure 80 g. of a lemon-yellow liquid is obtained, boiling over a range of 5° at 40° (4–5 mm.). White, transparent crystals separate after the oil has stood for 7 months in a tightly stoppered bottle. The material was frequently observed during this time and there was no evidence of evolution of gas. After two recrystallizations from a mixture of benzene and ligroin the product weighed 12 g.; m. p., 98°. Silberrad and Roy[21] give 97.5° for pyrazoline tricarboxylic ester.

*Analyses.* Calc. for $C_{12}H_{18}O_6N_2$: C, 50.32; H, 6.33; N, 9.78. Found: C, 49.90, 50.26; H, 6.63, 6.24; N, 10.11, 10.14.

## Summary

1. A method is described for preparing chloro-oximino compounds from primary amines in which the amino group is linked to a primary carbon atom.

2. Evidence is submitted that the reaction passes through the diazonium salt rather than the diazo compound.

3. A convenient laboratory method is described for the preparation of nitrosyl chloride.

4. The reactions of nitrous anhydride and nitrosyl chloride on diazo-acetic ester are described.

5. A modified method for preparing pure diazo esters is given.

6. The formation of pyrazoline tricarboxylic ester under unusual conditions has been noted.

7. The heterogeneous decomposition of esters of glycine leads exclusively to the formation of chloro-acetic esters with a comparatively

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[21] Silberrad and Roy, *J. Chem. Soc.*, **89**, 179 (1906).

small amount of high-boiling condensation products. The ether acid is not formed.

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[Contribution from the Laboratory of Organic Chemistry of the University of Wisconsin]

# THE ALKYLATION OF PRIMARY AMINES WITH ALUMINUM ALKOXIDES TO GIVE SECONDARY AMINES FREE FROM TERTIARY AMINES

By Wilbur A. Lazier and Homer Adkins

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The direct alkylation of a primary amine with any of the usual alkylating agents results in the formation of tertiary as well as secondary amines. However, John Ulric Nef[1] alkylated aniline and acetanilide with sodium ethoxide in a sealed tube at 250–305°, and obtained ethyl aniline entirely free from diethyl aniline. The yield with aniline was 20% of that calculated and 40% with the acetanilide. We have duplicated Nef's results and extended the method to the use of aluminum alkoxides with a great increase in yield, smoothness of reaction and quality of product. It has been possible to obtain a mixture of bases consisting of 94% of ethyl aniline and 6% of aniline by the direct alkylation of aniline with aluminum ethoxide.

Aluminum alkoxides possess at least three advantages in alkylation over the sodium compounds: (1) They may be used as alkylating agents at least 100° above the temperature at which sodium alkoxides decompose. (2) The by-product of the reaction, alumina, is without effect upon the other products of the reaction as contrasted with the tar and acid-forming propensities of sodium hydroxide; hence the yields are higher and the products water-white. (3) They give better results with the free amine than with the acetyl derivative; hence the preparation of the latter is avoided. Nef explained the better results with the anilide than with the free amine by assuming that the reaction came to a definite equilibrium and that the sodium hydroxide produced worked against the further production of ethyl aniline. He said that when acetanilide was used the acetic acid produced by the reaction removed the sodium hydroxide and displaced the equilibrium in favor of the formation of ethyl aniline. With aluminum ethoxide a much better yield was obtained with aniline than with acetanilide. If the assumption of Nef is true, it should apply here equally well. It seems more plausible to regard the low yield with the sodium compounds as due to the strong alkali which causes decomposition of the remainder of the alkoxide with the formation of fatty acids. The

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[1] Nef, *Ann.*, **318**, 138 (1901).