[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF THE UNIVERSITY OF BUFFALO]

# THE ACTION OF ETHYL ORTHOFORMATE ON ANILINE AND CERTAIN OF ITS DERIVATIVES

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## Received September 30, 1946

# INTRODUCTION

The purpose of this investigation was first to determine the nature and course of the reaction between ethyl orthoformate and aniline. Because the former contains three functional groups and the latter two labile hydrogens, it might be expected that different products would result from the use of these two compounds against each other in different molar ratios. An attempt has been made to clarify this problem. Secondly, it was desired to obtain similar information with regard to the action of ethyl orthoformate on certain substituted anilines, namely the three isomeric nitroanilines and the three chloroanilines.

A summary of the literature covering the subject of this paper has already been presented (1) and for this reason only a short survey will be given here. Suffice it to say here however that reactions of this type have been found to yield both amidines (2, 3, 4, 5, 7) and derivatives of triphenylmethane (6). To make matters worse, physical properties are often very confusing. Thus 139° is listed by Giacolone (6) as the melting point of triphenyltriaminomethane and 138° by others for diphenylamidine (3).

The situation is therefore one of confusion, as pointed out by Dr. Edwin R. Erickson, in a private communication to the last author, some time ago. Most investigators seem to feel that an amidine is produced on the interaction of ethyl orthoformate and aniline in the molar ratio of 1:2, but Giacolone (6) believed the reaction to proceed with three moles of aniline to form an entirely different compound. Data on the nitro substitution products are very confusing, as will be seen from a review of the information presented above. Some analytical figures favor one formula, some the other.

Similar situations exist with respect to the products formed from the isomeric toluidines (3, 6, 7) and from the monobromoanilines (3, 7, 8, 9, 10).

# ETHYL ORTHOFORMATE AND ANILINE

It was at first desired to repeat the work of R. Walther (7) and of Giacolone (6). Thus, heating aniline and ethyl orthoformate on the steam-bath (Walther) for 2.5 hours and recrystallizing the product twice from benzene, gave a compound with the melting point  $139.0^{\circ}$  (cor.). When heated at reflux temperatures in 3:1 molar ratio (Giacolone) there was produced a white crystalline product. This product, recrystallized in the same manner, showed the melting point  $139.0^{\circ}$  (cor.). A second run was made using an air condenser for reflux instead of water. The results of determinations of mixed melting points are shown in Table I.

REACTING COMPOUND	MELTING POINT, °C.
$C_6H_5NH_2$ (b)	139.0
$C_6H_5NH_2$ (c)	139.0
$C_6H_5NH_2$ (d)	138.8
$C_6H_5NH_2$ (b + c)	138.7
$C_6H_5NH_2$ (c + d)	139.0
$C_6H_5NH_2$ (2c + b)	138.5
$C_6H_5NH_2$ (c + 3d)	138.8
$o-\mathrm{ClC}_6\mathrm{H}_4\mathrm{NH}_2$ (a)	141.1
$o-\mathrm{ClC}_{6}\mathrm{H}_{4}\mathrm{NH}_{2}$ (b)	141.1
$o-ClC_6H_4NH_2$ (a + b)	140.9
o-ClC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub> (a + 2b)	141.2
o-ClC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub> (2a + b)	141.1
m-ClC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub> (a)	111.4
m-ClC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub> (b)	111.4
m-ClC <sub>6</sub> N <sub>4</sub> NH <sub>2</sub> (a + b)	111.1
m-ClC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub> (a + 2b)	111.5
m-ClC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub> (2a + b)	111.4
$p-\mathrm{ClC}_{6}\mathrm{H}_{4}\mathrm{NH}_{2}$ (a)	183.9
$p-\text{ClC}_6\text{H}_4\text{NH}_2$ (b)	183.9
$p-\text{ClC}_6\text{H}_4\text{NH}_2$ (a + b)	184.0
$p-\text{ClC}_{6}\text{H}_{4}\text{NH}_{2}$ (a + 2b)	183.9
$p-\text{ClC}_6\text{H}_4\text{NH}_2$ (2a + b)	183.7

TABLE I Melting Points

a = reflux temperatures, molar ratio 1.76:1.

b = water-bath temperature, molar ratio 1.76:1.

c = reflux temperatures, molar ratio 3.20:1.

d = water-bath temperature, molar ratio 3.20:1.

TA	BL	Έ	II

# MOLECULAR WEIGHTS

REACTING COMPOUND	FOUND	LITERATURE	Kf BENZENE
C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub> (b)	$293 \pm 6$	196	4.90
$C_6H_5NH_2$ (b)	$312 \pm 6$	196	5.23
$C_6H_5NH_2$ (a)	$267 \pm 3$	289	4.90
$o-\mathrm{ClC}_6\mathrm{H}_4\mathrm{NH}_2$ (b)	$392 \pm 4$	265	4.90
o-ClC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub> (a)	ſ	393	
m-ClC <sub>6</sub> H <sub>4</sub> NH <sub>2</sub> (b)	$393 \pm 4$	393	4,90
$p-\mathrm{ClC}_{6}\mathrm{H}_{4}\mathrm{NH}_{2}$ (b)	$393 \pm 4$	393	4.90

a = product prepared at reflux temperatures.

b = product prepared on the water-bath.

As a preliminary to the determination of molecular weights, the exact solubility of the reaction product, prepared by the method of Walther, in benzene was found to be 3.7 g. per 100 g. of solvent at 7° (cor.).

Determination of the molecular weights of products formed at reflux temperatures was not considered necessary in view of the results of the determinations of mixed melting points.

These data make the average freezing point lowering  $0.294^{\circ} \pm 0.006$ , the correction being estimated on the basis of  $0.001^{\circ}$  for each reading. Temperatures were read with the aid of a lens. The following formula was used:

Mol. Wt. = 
$$\frac{(1000) (K_f) (W)}{(dT_f) (W_0)}$$

In this equation,  $K_f$  is the cryoscopic constant of the solvent (two were used, *i.e.* 4.9° and 5.23° per mole of benzene), W the weight in grams of solute in  $W_0$  grams of solvent and  $dT_f$  the freezing point lowering in degrees C. Thus

Mol. Wt. = 
$$\frac{(1000) (K_f) (0.4225)}{(0.294) (24.06)}$$

If  $K_f$  be taken as 4.9, the Mol. Wt is calculated as  $293 \pm 6$ , and if the constant be taken as 5.23,  $312 \pm 6$ . Theory for Giacolone's compound is 289 and for Walther's 196.

TABLE III FREEZING POINTS

BENZENE	SOLUTION, WALTHER'S PRODUCT
4.900	4.607
4.898	4.606
4.900 (av)	4.606 (av)

Determination of the nitrogen content was not attempted. Triphenyltriaminomethane has a nitrogen content of 14.52% and diphenylamidine 14.27%. It was decided not to rely on any method where the choices were so close together. Titration as a base failed. The product is not even wetted by cold water and dissolves in hydrochloric acid very slowly.

Giacolone (6) was able to cause triphenyltriaminomethane to rearrange in aniline solution, with hydrochloric acid or aniline hydrochloride as a catalyst. The identical reaction was easily carried out. Color changes observed check with Giacolone's observations and are recorded in the Experimental Part. They may be due to oxidation of the rearranged product to  $(p-H_2NC_6H_4)_2C=C_6H_4=$ NH<sub>2</sub>Cl. The product of the rearrangement is p,p',p''-triaminotriphenylmethane. Triphenyltriaminomethane hydrochloride was prepared, by passing dry hydrogen chloride into a dilute benzene solution of the product from the steam-bath reaction, with precipitation of a white solid, m.p. 244° (cor.). This product had been washed but not recrystallized. Giacolone recorded the melting point 240° for assumedly the same product. Aniline hydrochloride, for use in rearrangement reaction, was prepared in the same manner using an ether solution of aniline. The salt melted at 197.8° (cor.), literature 198°.

# ETHYL ORTHOFORMATE AND THE ISOMERIC NITROANILINES

The isomeric nitroanilines proved poor reactants with ethyl orthoformate. The products were never obtained in a pure state and apparently the reactions were never complete. Melting points varied by entire degrees from one run to the next and determinations of molecular weights could never be made to check.

# ETHYL ORTHOFORMATE AND THE ISOMERIC CHLOROANILINES

Again, as in the aniline reaction, it was found that the product prepared by the interaction of ethyl orthoformate and a chloroaniline was the same whether prepared at reflux temperatures or on the water-bath. A determination of molecular weights indicated that the formulas advanced by Giacolone could be considered correct, namely  $CH(NHC_6H_4Cl)_3$ .

A summary of data relative to mixed melting points will be found on reference to Table I and with regard to molecular weights, to Table II.

p, p', p''-Trichlorotriphenyltriaminomethane underwent rearrangement as did the corresponding compound without chlorine, but satisfactory identification of the product was not attempted because of the difficulty in purification. Probably the reaction did not go to completion.

# EXPERIMENTAL PART

Thermometers used solely for melting point determinations, were standardized by the National Bureau of Standards. Numerical corrections to observed values were applied as directed.

Ethyl orthoformate was purchased from the Eastman Kodak Co., suitably purified and checked with respect to its physical properties, with the same compound prepared in our laboratories.

Aniline, Merck, was subjected to purification, b.p. 180°.

Nitroanilines were taken from stock and recrystallized from ethyl alcohol. Satisfactory, corrected melting points were obtained.

o-Chloroaniline and *m*-chloroaniline were purified by distillation, *p*-chloroaniline by recrystallization from ethyl alcohol. Physical properties were satisfactory.

Reactions with aniline. Walther's procedure was repeated using a molar aniline :ester ratio of 1.76:1 and Giacolone's with a ratio of 3.20:1. Aniline : ester ratios were used corresponding to both Walther's and Giacolone's procedures, each ratio being tried out (a) at reflux temperatures and (b) on the water-bath. After extensive purification, molecular weights were determined by the cryoscopic method in benzene according to Reilly and Rae (11) and Findlay (12). The hydrochlorides were prepared by passing dry hydrogen chloride into a benzene solution of the reaction product. Rearrangements were brought about by following the method of Giacolone (6).

Reactions with nitroanilines. p-Nitroaniline and ethyl orthoformate were refluxed in molar ratio of 1.76:1, using twenty grams of each, over an open flame for 2.3 hours. Even after this length of time, both solid and liquid phases were still present and there seemed to be no evidence that a reaction had taken place. A second run was also carried out under like circumstances but no definite melting points were obtained. Products were brown in color and obviously impure, in spite of attempts at purification, carried out along the lines which had proved successful in the case of the product resulting from the use of aniline. Reactions with chloroanilines. o-Chloroaniline, 3 grams, was refluxed with 3 grams of ethyl orthoformate for 1.3 hours over an open flame. A fine white crystalline precipitate settled out of the red-brown solution on cooling to room temperature. This was washed with cold ethyl orthoformate and recrystallized twice from benzene, m.p. 141.1° (corrected). The filtrate was fractionated and enough ethyl alcohol was distilled off at 78° to verify the assumption of a 65% yield of product, based on the o-chloroaniline used, probably—

#### I. $HC(OC_2H_5)_3 + 3 \ o - ClC_6H_4NH_2 \rightarrow 3C_2H_5OH + HC(NHC_6H_4Cl-o)_3$ .

A second run was carried out as above except that the reaction was heated on the steambath for four hours. Also, this time, the reaction mixture was cooled more slowly with the result that the crystals were larger and better formed. The yield amounted to about 70%, based on the *ortho*-chloroaniline used. Mixed melting point with the product from the first reaction gave 141.0° and a molecular weight determination of this second product showed 392 (see Table II). *m*-Chloroaniline and *p*-chloroaniline were treated in the same manner. Data from all of these runs will be found summarized in Tables I and II.

# SUMMARY

1. It has been shown, within the limits of experimental error, that aniline reacts with ethyl orthoformate to form  $CH(NHC_6H_5)_3$ , irrespective of the molar proportions in contact. Changing the temperature of reaction from reflux to water-bath also has no effect on the chemical nature of the product.

2. Attempts to extend this reaction to isomeric nitroanilines were unsatisfactory.

3. The isomeric chloroanilines react as does aniline itself.

4. Rearrangement of compounds thus prepared can be effected by the catalytic action of aniline hydrochloride.

BUFFALO, NEW YORK

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