[CONTRIBUTION FROM THE JOHN HARRISON LABORATORY OF CHEMISTRY OF THE UNIVERSITY OF PENNSYLVANIA]

Reduction Studies of Schiff Bases. III. The Condensations of Certain Secondary Aromatic Amines with Formaldehyde in Acid Solution; Nuclear or N-Methylations by Means of Formaldehyde

BY E. C. WAGNER

Condensations of formaldehyde and other aldehydes with aromatic amines in neutral or alkaline media yield compounds of either the azomethine or the di-imine type. A similarly simple statement cannot be made regarding condensations in acid media. There is scattered evidence, mostly for negatively substituted aldehydes or amines,[1] that in any case the initial step is the additive union of aldehyde and amine, but the actual existence of intermediate addition compounds has been demonstrated in only a few instances, owing to the ease with which the condensation is usually completed by loss of a molecule of water. From acid media the azomethine or di-imine is obtained in some cases,[2] but in general, though a trace of acid may catalyze condensation,[3] presence of mineral acid may promote the reverse hydrolysis, or, especially in the case of formaldehyde, may lead to further changes, with the result that the first isolable product is of secondary origin. Such secondary products may be designated as of (1) the anhydro-aminobenzyl alcohol type, (2) the less important intermediate aminobenzylaniline type[4] and (3) the diaminodiphenylmethane type, the last representing the final stage, since compounds of this type are obtainable not only from the first two,[4,5] but from the azomethines, the di-imines,[6] or without the appearance of intermediate stages, from the amines.[7] Of the three types whose formation is peculiar to condensations in acid media it seems probable that the anhydro-aminobenzyl alcohol type forms first.[6e,4c] The mechanism of its formation is therefore important in a study of condensations of formaldehyde and aromatic amines in acid media, and several investigations have been made of this matter.

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(1) Wheeler and Jordan, THIS JOURNAL, **31**, 937 (1909); Dimroth and Zoeppritz, *Ber.*, **35**, 984 (1902); Rügheimer, *ibid.*, **39**, 1653 (1906); Lowy and Balz, THIS JOURNAL, **43**, 341 (1921); Kondo and Ishida, *J. Pharm. Soc. Japan*, **489**, 979 (1922); *Chem. Abstracts*, **17**, 1456 (1923).

(2) Tröger, *J. prakt. Chem.*, [2] **36**, 225 (1887); Haegele, *Ber.*, **25**, 2753 (1892); Walther and Kausch, *J. prakt. Chem.*, [2] **56**, 111 (1897); Möhlau, *Ber.*, **31**, 2250 (1898); Dimroth and Zoeppritz, Ref. 1; Lowy and Westcott, THIS JOURNAL, **42**, 849 (1920); Lowy and Downey, *ibid.*, **43**, 346 (1921); Lowy and Balz, Ref. 1; Lowy and King, *ibid.*, **43**, 625 (1921); **46**, 757 (1924); Shimo, *Bull. Chem. Soc. Japan*, **1**, 202 (1925); *Chem. Zentr.*, I, 597 (1927); Levi, *Gazz. chim. ital.*, **59**, 544 (1929).

(3) Reddelien, *Ber.*, **46**, 2718 (1913).

(4) (a) German Patent 87,934; *Friedl.*, **4**, 66; (b) Maffei, *Gazz. chim. ital.*, **58**, 261 (1928); (c) Meyer and Stillich, *Ber.*, **35**, 739 (1902).

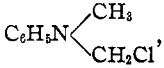
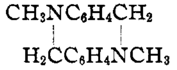
(5) German Patent 83,544; *Friedl.*, **4**, 50; German Patent 97,710; *Friedl.*, **5**, 94.

(6) (a) German Patent 53,937; *Friedl.*, **2**, 53; (b) Patent 58,072 *Friedl.*, **3**, 79; (c) Patent 70,402; *Friedl.*, **3**, 80; (d) v. Braun, *Ber.*, **41**, 2145 (1908); (e) Meyer and Rohmer, *ibid.*, **33**, 250 (1900); (f) Eberhardt and Welter, *ibid.*, **27**, 1804 (1894).

(7) German Patent 68,011; *Friedl.*, **3**, 91; Rivier and Farine, *Helv. Chim. Acta*, **12**, 865 (1929).

A mechanism proposed in a Kalle and Co. patent[8] is represented thus:

$$C_6H_5NH_2HCl + CH_2O \longrightarrow \boxed{H\,|\,C_6H_4NHCH_2\,|\,Cl} \xrightarrow{\text{alkali}} \underbracket{CH_2C_6H_4NH}\ \text{(polymerized)}$$

Green and Saunders[9] suggested a similar course, the chloromethyl compound yielding momentarily the corresponding hydroxymethyl compound. The actuality of the chloromethyl compounds does not seem to be established, though analogous compounds such as $C_6H_5NHCH_2CN$, etc., are known. The crystalline and definite compounds obtained from methylaniline and ethylaniline, and represented[10] to be chloromethyl compounds, *e. g.*,  $C_6H_5N\begin{matrix}\diagup CH_3\\ \diagdown CH_2Cl\end{matrix}$, were shown by Friedländer[11] to be hydrochlorides of the dimeric anhydro-alkylaminobenzyl alcohols, the structure being proved, in the case of the methyl compound, by reduction to *p*-toluidine. Friedländer concluded that formaldehyde first unites at the para-position to yield the carbinol $CH_3NHC_6H_4CH_2OH$, of which two molecules condense with loss of water to yield the dimeric base  $\begin{matrix}CH_3NC_6H_4CH_2\\ |\qquad\quad |\\ H_2CC_6H_4NCH_3\end{matrix}$ whose dihydrochloride appears as product.

This view seems to be inconsistent with the ready formation of the anhydro-aminobenzyl alcohols from azomethines or di-imines, and with the claims of several patents[12] on N-alkylation of aromatic amines by condensation with homologs of formaldehyde, with concurrent reduction, in acid solution, indicating that the primary point of attack is the nitrogen atom. This is also the basis for the mechanism recently proposed for similar condensations by v. Braun and co-workers,[13] involving the assumed primary formation of a N-hydroxyalkyl compound, *e. g.*, $C_6H_5NR_2Cl\ CH(OH)R$, which rearranges to the form $R\underbracket{CHC_6H_4N}R_2Cl$.

The present study deals with the condensations of five alkylanilines (methyl, ethyl, *n*-propyl, *n*-butyl and isoamyl) with formaldehyde in dilute hydrochloric or sulfuric acid solution. Two series of experiments were made. In one series the initial product of the condensation was reduced promptly, before secondary changes could much interfere; this procedure led in every case to *N-methylation*, yielding tertiary bases. In the other series the amines were condensed with formaldehyde in dilute hydrochloric acid solution, and the solid hydrochlorides of the resulting bases allowed to precipitate. They were isolated, analyzed and submitted to vigorous reduction; in every case the corresponding alkyl-*p*-toluidine was obtained in quantity, the net result being *nuclear methylation*

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(8) German Patent 96,851; *Friedl.*, **5**, 91.

(9) Green and Saunders, *J. Soc. Dyers and Colourists*, **29**, 10 (1923).

(10) Goldschmidt, *Chem.-Ztg.*, **24**, 284 (1900); **26**, 606, 967 (1902); German Patent 97,710.

(11) Friedländer, *Monatsh.*, **23**, 973 (1902).

(12) German Patent 376,013 (1920); 491,856 (1923); 503,113 (1924)

(13) V. Braun and co-workers, *Ann.*, **472**, 1 (1929).

of the original amine. These results confirm the opinion that condensation in acid solution involves initially the nitrogen atom, yielding a compound which contains the unit  $C_6H_5N{<}^{R}_{CH_2-}$, and they show the separated hydrochlorides to have the same essential structure as Friedländer's dimeric anhydro-*p*-methylaminobenzyl alcohol, *i. e.*, to contain the unit  $R\underset{|}{N}C_6H_4\underset{|}{C}H_2$, which clearly is obtained from the first by a secondary rearrangement or condensation.

Experimental

General.—The alkylanilines used were Kahlbaum or Eastman products. In the analyses reported below, nitrogen was determined by the Kjeldahl method, using the boric acid modification, with methyl red as indicator, and halogen was determined by the sodium peroxide bomb method, the silver halide being weighed. Melting points were determined in an apparatus of the Anthes type,[14] provided with a mechanical stirrer in the bulb, and with the elongated neck vacuum-jacketed to permit more accurate stem corrections. Boiling points were determined in a small side-arm flask, using short-scale thermometers, the apparatus being that recommended by Mulliken.[15] Boiling points stated are substantially "corrected," though with several of the higher-boiling bases the entire mercury column, while within the flask, was not completely immersed in the vapors. All thermometers used had been calibrated.

N-Methylations of Alkylanilines by Reduction of the Initial Condensation Products with Formaldehyde in Acid Solution.—The procedure for methyl-, ethyl-, propyl- and butylanilines was as follows. The base was dissolved in dilute hydrochloric acid, the solution cooled to 20° or below in an ice-bath, and slightly more than one equivalent of formaldehyde added as a 35% solution. Within five minutes an excess of zinc dust was introduced as rapidly as possible without causing the temperature to exceed 25°, the mixture being vigorously stirred mechanically; more hydrochloric acid was added at intervals to maintain a brisk action. In a typical experiment there were used 15 g. of methylaniline dissolved in 75 cc. of water and 20 cc. of concd. hydrochloric acid; the chilled solution was treated with 12 cc. of 35% formaldehyde, 25 g. of zinc dust added and 80 cc. of concd. hydrochloric acid introduced gradually, the temperature being kept around 25°. The liquid was finally colorless and clear except for some undissolved metal.

With isoamylaniline the above procedure yielded an intermediate semi-solid material which trapped the zinc dust. To effect reduction it was necessary to raise the temperature to 70° or above, and to make further additions of zinc and acid. The liquid was finally clear, and the yield of methylisoamylaniline fairly good.

The reduction liquid was made alkaline with sodium hydroxide and the dialkylaniline distilled out with steam, extracted in ether, dried with sodium sulfate, the extract filtered and the product obtained by evaporation of the ether; it was purified by careful redistillation and then identified. The tertiary bases made in this way were all of good quality, boiling when crude within ranges of 4–5°, readily narrowed to 1–2° upon redistillation. The best yields varied, for the several amines, from 55 to 88%. There seemed to be no secondary amine finally present, indicating that the condensa-

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[14] Houben, "Die Methoden der organischen Chemie," Geo. Thieme, Leipzig, Vol. I, 3d ed., 1925, p. 798.

[15] Mulliken, "The Identification of Pure Organic Compounds," John Wiley and Sons, New York, Vol. I, 1904, p. 221.

tions with formaldehyde were rapid and complete. In experiments conducted at higher temperatures there was increased formation of material not volatile with steam, shown in one case to be the *p,p'*-bis-(dialkylamino)-diphenylmethane.

Data for individual experiments are given in Table I.

TABLE I

REDUCTION OF THE INITIAL CONDENSATION PRODUCTS OF SOME ALKYLANILINES WITH FORMALDEHYDE IN ACID SOLUTION

Product, dialkyl-aniline	Best yield crude, %	B. p. redist., °C.	Identification		
			Nitrogen, % Found	Calcd.	Derivative
Dimethyl	79.6	194–195	...	...	*p*-Nitroso compound, m. p. 87°
Methylethyl	87.8	207–209[a]	10.17	10.37	Picrate,[b] m. p. 129–129.5°
Methyl-*n*-propyl	75.5	222–224	9.42	9.39	Picrate,[c] m. p. 110.5°. Hydrochloride, see below
Methyl-*n*-butyl	54.9	241–242.4	...	...	Note[d]
Methylisoamyl	60.5	253–255[e]	7.75	7.91	Picrate,[f] m. p. 89.5°

[a] This value probably better than the b. p. 201° reported by Claus and Howitz [*Ber.*, **17**, 1325 (1884)] for methylethylaniline not specially purified.

[b] Komatsu [*Mem. Coll. Sci. Eng. Kyoto Imp. Univ.*, **3**, 371 (1912); *Chem. Abstracts*, **7**, 1021 (1913)] reported the value 121–122°. A number of Komatsu's constants are incorrect; see Reilly and Hickinbottom, note *d*, and also notes *c* and *f*.

[c] Meisenheimer [*Ann.*, **449**, 196 (1926)] reported 109°; Komatsu's value was 103–104°.

[d] Boiling point in good agreement with value 242.5° reported for the pure base by Reilly and Hickinbottom [*J. Chem. Soc.*, **117**, 109 (1920)].

[e] Previous values, for specimens made by two distinct methods and not specially purified: 257° (Claus and Rautenberg) and 246–248° (Thomas and Jones).

[f] This picrate separated as oil from ordinary or aqueous alcohol, but crystallized from hot absolute alcohol. Komatsu reported m. p. 93–94°.

In the first preparation of dimethylaniline (Table I), using higher temperature (70–75°) for condensation and reduction, the main product was a solid not volatile with steam. It was crystallized several times from alcohol, and the melting point thus raised from 72 to 82°, with indications that the substance was still impure. It was eventually identified as *p,p'*-bis-(dimethylamino)-diphenylmethane by means of the picrate, which melted at 178°, and by its nitrogen content of 11.05% (calcd., 10.90%). A mixed melting point test of the picrate with a specimen (m. p. 179° corr.), made from the base prepared in the usual way, gave the result 178.5° corr., and confirmed the identification.

As an additional identifying derivative for methyl-*n*-propylaniline the hydrochloride was prepared (in dry ether). It melted 120–122° uncorr., and analyzed satisfactorily: nitrogen, 7.47% (calcd., 7.55%), chlorine, 18.84% (calcd. 19.11%). The melting point 106°, reported by Claus and Hirzel[16] for an impure specimen prepared from an impure base (b. p. 212°) is therefore incorrect.

In the preparation of methylisoamylaniline there was formed an oily product not volatile with steam. This was distilled *in vacuo*, and after three distillations yielded a main fraction boiling at 275–280° at 10 mm. (282–287° corr.). Analysis for nitrogen gave 7.50, 7.51%, indicating the compound to be probably *p,p'*-bis-(methylisoamylamino)-diphenylmethane (nitrogen, calcd., 7.65%), formed by side reaction during the hot reduction.

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(16) Claus and Hirzel, *Ber.*, **19**, 2785 (1886).

Nuclear Methylations of Alkylanilines by Reduction of the Anhydro-*p*-alkylaminobenzyl Alcohol Salts

(a) **Preparation of the Anhydro-*p*-alkylaminobenzyl Alcohol Salts.**—The conditions approximated those given in references previously cited.[10,11] The amine was dissolved in four to five parts of water by addition of slightly more than one equivalent of hydrochloric acid. The solution was chilled in ice, and treated with a small excess of formaldehyde, added as a 35% solution. After about an hour the mixture was allowed to come to room temperature, when there separated after a time the solid amine salt, the liquid generally "setting." The product was filtered off the following day, and the filtrate allowed to stand a further time, from one to several smaller crops of product being thus frequently obtained. The salt was washed with cold water containing hydrochloric acid. The methyl, ethyl and propyl compounds were highly crystalline and white. They were washed finally with alcohol, then with ether and were dried *in vacuo*. The butyl and amyl compounds were yellowish and granular. Attempted washing with alcohol rendered them slimy and unfilterable, so these compounds were dried thoroughly *in vacuo* after washing with water containing hydrochloric acid.

The methyl, ethyl and propyl compounds are soluble in water, and are reprecipitated by addition of hydrochloric acid; the corresponding bases are precipitated by alkali or sodium acetate. The butyl and amyl compounds are not appreciably soluble in water. All five compounds dissolve in dilute sulfuric acid. The *n*-propyl, *n*-butyl, and isoamyl compounds appear to be new. Yields and analytical data are given in Table II.

TABLE II

PREPARATION OF SOME ANHYDRO-*p*-ALKYLAMINOBENZYL ALCOHOL SALTS

Product $RNC_6H_4CH_2(HCl)$ R =	Best yield, %	Nitrogen, % Found	Calcd.[a]	Chlorine, % Found	Calcd.[a]	No. of specimens anal.
Methyl	83.4	8.54	9.01	21.96	22.80	4
Methyl (hydrobromide[b])	86	6.85	7.01	38.70	39.96	1
Ethyl	76.5	8.15	8.26	20.71	20.91	2
n-Propyl	57	7.52	7.63	19.18	19.32	2
n-Butyl	90.6	6.53	7.09	18.30	17.95	2
Isoamyl	96.4	6.26	6.62	15.87	16.76	3

[a] Yields and elementary percentages are calculated from the formula at the head of the first column.

[b] Prepared from methylaniline, formaldehyde and hydrobromic acid; *cf.* Goldschmidt, *Chem.-Ztg.*, **26**, 967 (1902).

For the ethyl and *n*-propyl compounds (Table II) the analytical results support the formula  $CH_2C_6H_4NR(HCl)$. For the methyl compound Friedländer's results could not be duplicated.[17] The averaged values for four specimens indicate a molecular weight of 161.6 per atom of chlorine, or 164.2 per atom of nitrogen, *i. e.*, 6 and 8.6 units higher than required by formula, and suggest possible presence of a molecule of water for each dimeric molecule of the salt. The butyl and isoamyl compounds likewise yielded results for nitrogen and chlorine lower than those required by formula, but these compounds were probably less pure than the first three. All these compounds, however, were reproducible within rather narrow limits of composition and their identity in essential structure was shown by their reducibility to the corresponding alkyl-*p*-toluidines.

There was a noticeable delay in the precipitation of these salts. Their separation

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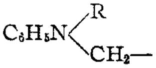
[17] Friedländer determined only chlorine (by direct precipitation with silver nitrate from aqueous solution acidified with nitric acid) and obtained 22.74%.

was much retarded if the reaction mixture was kept cold. At room temperature precipitation usually began only after an hour or more, and in some cases continued for days. As was shown by the experiments on N-methylation above, the condensation of amine and formaldehyde is rapid; further, the anhydro-*p*-alkylaminobenzyl alcohol hydrochlorides when dissolved in water are promptly precipitated by hydrochloric acid. It is therefore obvious that the delay noticed in every case was not due to a slow amine-aldehyde condensation, nor to a lag in precipitation of the amine-salt, but that it represented the interval during which there occurred the secondary change by which the first-formed unit  $C_6H_5N\begin{smallmatrix}\diagup R\\ \diagdown CH_2-\end{smallmatrix}$ assumed the structure $—CH_2C_6H_4NR—$. It seems that a kinetic study of one of these reactions should be feasible.

(b) **Reduction of Anhydro-*p*-alkylaminobenzyl Alcohol Salts to Alkyl-*p*-toluidines.**—Reduction was most successful using zinc dust and dilute sulfuric acid at 70–85°. Cold reduction was ineffective, and hydrochloric acid was unsatisfactory because of its salting-out action. For the reductions two procedures were used. (1) The methyl, ethyl and propyl compounds were dissolved or suspended in 10–20 parts of 3 *N* sulfuric acid, the mixture stirred mechanically, some zinc dust added, and the temperature raised quickly to 70–85°. As rapidly as possible the rest of the zinc dust (in all about twice the weight of the compound to be reduced) was added, and the reduction temperature was maintained, with vigorous stirring, until action ceased. (2) The butyl and isoamyl compounds were ground with twice their weight of zinc dust, and the mixture added in small portions, but rapidly, to the hot acid. In either case reduction was rapid, with usually not more than moderate frothing, and the liquid was finally colorless and clear except for some undissolved metal. It was found advisable to reduce not more than 5 or 10 g. of the anhydro-alkylaminobenzyl alcohol salts at a time, the operations outlined then requiring about thirty minutes.

The reduction liquid was made alkaline with sodium hydroxide and was steam-distilled until no more oil passed over. The oil was extracted in ether, the solution dried with sodium sulfate and filtered, and the product obtained as a residue or by distillation after removal of the ether. The best yields of the alkyl-*p*-toluidines ranged from 54 to 80%. The products, as obtained by steam distillation, seemed to be substantially pure, boiling within narrow ranges; on redistillation the widest boiling range observed for any main fraction was 1.5°. The alkyl-*p*-toluidines were fully identified; isoamyl-*p*-toluidine has apparently not been prepared hitherto

In all these experiments there remained in the steam distilling flask an oil not volatile with steam. This was examined in several cases and found to consist largely of the corresponding *p,p'*-bis-(alkylamino)-diphenylmethane.

In preliminary experiments it was found that anhydro-*p*-methylaminobenzyl alcohol was not hydrolyzed under the conditions of reduction, no steam volatile product resulting. The anhydromethylaminobenzyl alcohol itself was found to be non-volatile with steam. The steam volatile oils obtained by reduction of the methyl and ethyl compounds were examined for primary or tertiary amines, but no such products could be isolated, nor was there any indication that some of the original alkylaniline contaminated the alkyl-*p*-toluidine.

Data as to yields and identification of products obtained in these reductions are given in Table III.

In the first preparation of methyl-*p*-toluidine (Table III) the oil not volatile with steam was distilled *in vacuo*, and identified as *p,p'*-bis-(methylamino)-diphenylmethane. It yielded a nitrosamine of m. p. 97–97.5° uncorr., identical with a specimen (m. p. 97–98° corr.)[18] made from the base prepared as described by v. Braun,[19] as shown by

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(18) V. Braun and Kayser, *Ber.*, **37**, 2675 (1904).

(19) V. Braun, *ibid.*, **41**, 2148 (1908).

TABLE III

REDUCTION OF ANHYDRO-*p*-ALKYLAMINOBENZYL ALCOHOL SALTS TO ALKYL-*p*-TOLUIDINES

Product,[a] alkyl-*p*-toluidine	Best yield[b] crude, %	B. p. redist., °C.	Identification				
				Nitrogen, %		Chlorine, %	
			Compound	Found	Calcd.	Found	Calcd
Methyl	53.6	212–212.9	Benzenesulfonyl deriv., m. p. 65°[c]	..	..	...	...
Ethyl	70.6	222	Benzenesulfonyl deriv., m. p. 57°[c]	..	..	...	...
			Picrate[d] m. p. 139.6°	..	..	...	...
n-Propyl	79.6	237.3–238.8	Base	9.38	9.39	...	...
			Hydrochloride, m. p. 155°	7.45	7.55	18.90	19.11
n-Butyl	55.7	255–256[e]	Base	8.47	8.59	...	...
			Hydrochloride, m. p. 148–149°	6.90	7.02	17.63	17.76
Isoamyl	56.9	267–268	Base	7.77	7.91	...	...
			Hydrochloride, m. p. 146°; from dil. HCl	6.52	6.56	16.69	16.60

[a] In every case the material reduced was the corresponding anhydro-*p*-alkylaminobenzyl alcohol salt.

[b] Yields are calculated from the ideal formulas for the salts, and for the methyl, butyl and amyl compounds are therefore slightly lower than if based upon analysis (Table II).

[c] Identification verified by mixed melting point test with the same derivative prepared from Eastman Co. alkyl-*p*-toluidine.

[d] The picrate obtained from Eastman Co. ethyl-*p*-toluidine melted at 140°.

[e] Reilly and Hickinbottom [*J. Chem. Soc.*, **113**, 977 (1918)] found the boiling point of carefully purified *n*-butyl-*p*-toluidine to be 264–265° (766 mm.).

mixed melting point test. The preparation of ethyl-*p*-toluidine yielded a similar by-product, whose nitrosamine (from alcohol and ether) melted at 81° uncorr., close to the value (83°) found by v. Braun[20] for the nitrosamine of *p,p'*-bis-(ethylamino)-diphenylmethane.

Summary

1. The secondary aromatic amines methyl-, ethyl-, *n*-propyl-, *n*-butyl- and isoamylanilines, when condensed with formaldehyde in aqueous solution in presence of hydrochloric acid, yield solid products which have, or approximate, the composition $[\mathrm{R\underset{|}{N}C_6H_4\underset{|}{C}H_2(HCl)}]_n$, and are to be considered the hydrochlorides of the anhydro-*p*-alkylaminobenzyl alcohols. This essential structure was shown by reduction of these compounds to the corresponding alkyl-*p*-toluidines.

2. When the same secondary amines are condensed with formaldehyde in acid solution, with prompt reduction of the initial condensation product, they are methylated to yield the corresponding tertiary amines.

3. It is concluded that condensation of these monoalkylanilines with formaldehyde in acid solution involves primarily the nitrogen atom, and

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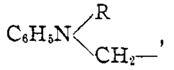
(20) V. Braun, Ref. 19, p. 2151.

yields first a compound which contains the unit  $C_6H_5N(R)(CH_2-)$, reducible to methylalkylaniline. The formation of the anhydro-*p*-alkylaminobenzyl alcohol salts, which eventually occurs under the same conditions but in absence of reducing agent, is therefore not the result of a special primary condensation, but of a secondary intra- or intermolecular action, probably a coupling of the units shown in (1).

4. By the procedures described either nuclear or N-methylation of alkylanilines can be effected by means of formaldehyde.

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Alkyl-Nitroguanidines. Dearrangement and Preparation by Nitration[1]

BY TENNEY L. DAVIS AND ROBERT C. ELDERFIELD

Nitroguanidine dearranges in two modes and may be used for synthesis in two ways by taking advantage of the products which result from its dearrangement in one manner or the other. Thus, with ammonium carbonate it yields guanidine carbonate, and with primary aliphatic amines it gives N-alkyl-N'-nitroguanidines.[2] These alkyl-nitroguanidines, having a hydrogen atom attached to each of the guanidine nitrogens, are capable of dearrangement in two modes, as follows.

$$RNH-C(NH)-NH-NO_2 \rightleftharpoons \begin{cases} RNH_2 + HNCN-NO_2 & \text{(I)} \\ RNCNH \text{ (or } RNHCN) + NH_2-NO_2 & \text{(II)} \end{cases}$$

The first of these modes corresponds to the method by which the substances have been synthesized from nitroguanidine; the second opens new possibilities of synthesis. We have therefore wished to determine whether the alkyl-nitroguanidines dearrange in the predicted manner and to investigate their usefulness for the easy preparation of monoalkyl- and N,N'-dialkyl-guanidines by reaction with ammonia and with primary amines, respectively.[3]

As no alkyl-nitroguanidines have heretofore been prepared by the nitration of alkyl-guanidines, we have studied that reaction in an effort to gain a further insight into the mechanism of the nitration of amines, and have found that the only alkyl-nitroguanidines which we have been able to

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[1] A summary of part of the Doctor's Dissertation of Robert C. Elderfield, Massachusetts Institute of Technology, June, 1930.

[2] Davis and Abrams, *Proc. Am. Acad. Arts Sci.*, **61**, 437 (1926); Davis and Luce, THIS JOURNAL, **49**, 2303 (1927).

[3] Other papers on the urea dearrangement: Davis and Underwood, *ibid.*, **44**, 2595 (1922); Davis and Blanchard, *ibid.*, **45**, 1816 (1923); Davis, *Proc. Nat. Acad. Sci.*, **11**, 68 (1925); Davis and Blanchard, THIS JOURNAL, **51**, 1790, 1801, 1806 (1929).