IX.—*The Action of Sodium Alcoholate on Amides.*

By JULIUS B. COHEN, Ph.D., and WILLIAM H. ARCHDEACON, B.Sc., The Yorkshire College.

At the meeting of the British Association in 1894 (*Brit. Assoc. Reports*, p. 625) a communication was read by one of us on the constitution of the amides, containing a brief reference to the action of sodium methoxide on acetanilide. As this action appeared to us to have an important bearing on the constitution of the amides, we have studied it more fully, and now bring before the Society the results which we have obtained.

If, to a solution of acetanilide in dry ether, powdered sodium methoxide is added in molecular proportion, it dissolves; but after the lapse of a few minutes, a voluminous crystalline compound is deposited, filling the liquid. This substance has the formula

Similar compounds have been prepared with ortho- and para-acetotoluidide and α - and β -acetonaphthalide on the one hand and with sodium methoxide and ethoxide on the other. Benzanilide and form-anilide form similar compounds. With formylphenylhydrazide, however, no additive compounds are formed; but the sodium appears to displace the hydrogen in the amido-groups. In the case of benzamide, a fine granular compound is obtained, which appears to be a mixture of the alcoholate additive compound with sodium benzamide. With propionanilide, butyranilide, diphenylacetamide, and ethylacetanilide no definite compounds have so far been obtained by this method. In the case of propionanilide and butyranilide such compounds appear to exist in solution; for if a little ether be added to either of these substances, sufficient to dissolve a fraction of the whole, the addition of the sodium alcoholate will at once produce a clear solution; on evaporating the ether under diminished pressure, nothing separates out until the greater portion of the ether has gone, when crystals of the unchanged anilide are deposited.

Acetanilide Sodium Methylozide, $\text{C}_6\text{H}_5\cdot\text{NH}\cdot\text{CO}\cdot\text{CH}_3, \text{CH}_3\cdot\text{ONa}$.—1.35 grams of acetanilide is dissolved in dry ether (complete solution is not necessary) and 0.54 gram of finely powdered sodium methoxide is added; on shaking, a clear solution is obtained, but very soon a pasty magma of needle-shaped crystals forms. The crystals are collected, washed with ether, and dried over sulphuric acid in a vacuum. The substance forms a white, apparently amorphous mass. It gave the following results on analysis.

- I. 0.2455 gave 0.0942 Na_2SO_4 . $\text{Na} = 12.47$.
 II. 0.4359 „ 0.1695 „ $\text{Na} = 12.59$.
 III. 0.2620 „ 16.1 c.c. dry nitrogen at 13° and 770 mm. $\text{N} = 7.45$.
 IV. 0.1890 „ 0.372 CO_2 and 0.1115 H_2O . $\text{C} = 56.98$; $\text{H} = 6.55$.
 $\text{C}_9\text{H}_{12}\text{NaNO}_2$ requires $\text{Na} = 12.17$; $\text{N} = 7.40$; $\text{C} = 57.14$; $\text{H} = 6.35$.

In some of the subsequent determinations, the sodium has been estimated by decomposing the compound with water and titrating with decinormal oxalic acid, using phenolphthalein as indicator. The above compound is quickly decomposed by water and alcohol and also by boiling ether and acetone, which dissolve out the acetanilide. It is also decomposed by acid chlorides, forming the methylic salt of the acid, sodium chloride, and acetanilide according to the equation

If acetyl chloride is added to the calculated quantity of the substance suspended in ether, methylic acetate, sodium chloride, and acetanilide are formed; the latter was identified by decomposing it, with potash, into acetic acid and aniline, and by a nitrogen estimation.

0.1905 gave 17.5 c.e. moist nitrogen at 752 mm. and 16° . $\text{N} = 10.48$.
 $\text{C}_8\text{H}_5\text{NO}$ requires $\text{N} = 10.37$ per cent.

Benzoyl chloride acts similarly. From 2 grams of the sodium methoxide compound and 1.79 gram of benzoyl chloride, 1 gram of methylic benzoate, and 1.29 gram of acetanilide were obtained. On heating the compound in a stream of dry hydrogen for four hours to 100° , methylic alcohol distils together with a little aniline; the aniline was identified by converting it into the platinochloride and analysing it.

0.294 gave 0.0955 Pt. $\text{Pt} = 32.48$.

$(\text{C}_6\text{H}_5\cdot\text{NH}_2)_2\cdot\text{H}_2\text{PtCl}_6$ requires $\text{Pt} = 32.66$ per cent.

The residue consisted for the most part of sodium acetanilide.

0.231 gave 15 c.c. moist nitrogen at 759 mm. and 13° . $\text{N} = 7.65$.

$\text{C}_9\text{H}_{12}\text{NNaO}$ requires $\text{N} = 7.40$ per cent.

Further, the sodium acetanilide obtained in this way was treated with benzoyl chloride, when benzanilide, melting at 160° , is formed. The substance was analysed with the following result.

0.1745 gave 11.3 c.c. moist nitrogen at 21° and 760 mm. $\text{N} = 7.38$.

$\text{C}_{13}\text{H}_{11}\text{NO}$ requires $\text{N} = 7.11$ per cent.

The action of iodine on the sodium methoxide compound suspended in ether gives rise to a number of products, among which phenyl-carbamine, acetanilide, and iodoform were identified. Ethylic iodide yields ethyl methyl ether and acetanilide.

The following compounds have been prepared in a manner similar to acetanilide sodium methoxide. Where the amide is but slightly soluble in ether, the sodium alcoholate has been added to the substance suspended in the ether, well shaken, and then filtered or decanted. The clear filtrate, on standing, deposits crystals of the new compound.

Acetanilide sodium ethoxide, $C_6H_5 \cdot NH \cdot CO \cdot CH_3 \cdot C_2H_5 \cdot ONa$.—The preparation of this compound is identical with that of the sodium methoxide compound, and the substance is not distinguishable from the latter.

The following results were obtained on analysis.

0.283 required 13.9 c.c. decinormal oxalic acid. Na = 11.3 per cent.

0.2345 " 11.7 " " Na = 11.4 "

$C_{10}H_{14}NO_2Na$ requires Na = 11.6 per cent.

Paracetotoluidide sodium methoxide, $CH_3 \cdot C_6H_4 \cdot NH \cdot CO \cdot CH_3 \cdot CH_3 \cdot ONa$.

Prepared as above from paracetoluidide, gave on analysis.

0.113 required 5.65 c.c. oxalic acid. Na = 11.74 per cent.

$C_{10}H_{14}NO_2Na$ requires Na = 11.33 per cent.

Orthoacetotoluidide sodium methoxide, $CH_3 \cdot C_6H_4 \cdot NH \cdot CO \cdot CH_3 \cdot CH_3 \cdot ONa$.

0.1705 required 7.8 c.c. oxalic acid. Na = 10.52 per cent.

$C_{10}H_{14}NO_2Na$ requires Na = 11.33 per cent.

α -Acetonaphthalide sodium methoxide, $C_{10}H_7 \cdot NH \cdot CO \cdot CH_3 \cdot CH_3 \cdot ONa$.

This substance crystallises in brilliant, needle-shaped crystals.

0.2875 required 11.6 c.c. oxalic acid. Na 9.3 per cent.

$C_{13}H_{14}NO_2Na$ requires Na = 9.6 per cent.

Paracetotoluidide sodium ethoxide, $CH_3 \cdot C_6H_4 \cdot NH \cdot CO \cdot CH_3 \cdot C_2H_5 \cdot ONa$

0.176 gave 0.0566 Na_2SO_4 . Na = 10.4 per cent.

0.1413 required 6.5 c.c. oxalic acid. Na = 10.6 per cent.

$C_{11}H_{16}NO_2Na$ requires Na = 10.6 per cent.

Orthoacetotoluidide sodium ethoxide, $CH_3 \cdot C_6H_4 \cdot NH \cdot CO \cdot CH_3 \cdot C_2H_5 \cdot ONa$.

0.1335 gave 0.0440 Na_2SO_4 . Na = 10.6 per cent.

$C_{11}H_{16}NO_2Na$ requires Na = 10.6 per cent.

α -Acetonaphthalide sodium ethoxide, $C_{10}H_7 \cdot NH \cdot CO \cdot CH_3 \cdot C_2H_5 \cdot ONa$.

0.4035 required 15.8 c.c. of oxalic acid. Na = 9.0 per cent.

$C_{14}H_{16}NO_2Na$ requires Na = 9.1 per cent.

β -Acetonaphthalide sodium ethoxide, $C_{10}H_7 \cdot NH \cdot CO \cdot CH_3 \cdot C_2H_5 \cdot ONa$.

0.346 gave 0.1 Na_2SO_4 . Na = 9.3 per cent.

$C_{14}H_{16}NO_2Na$ requires Na = 9.1 per cent.

Benzanilide sodium ethoxide, $C_6H_5 \cdot NH \cdot CO \cdot C_6H_5, C_2H_5 \cdot ONa$.

0.3040 required 12.1 c.c. oxalic acid. Na = 9.1 per cent.

$C_{15}H_{16}NO_2Na$ requires Na = 8.7 per cent.

Formanilide sodium ethoxide, $(C_6H_5 \cdot NH \cdot COH)_2, C_2H_5 \cdot ONa$.—If sodium methoxide in molecular proportion is added to formanilide dissolved in ether, crystalline nodules of the new compound are deposited on the sides of the flask and the contents eventually become nearly solid. The same thing occurs with sodium ethoxide.

The following are the results of two analyses of the sodium ethoxide compound.

0.398 required 13.1 c.c. oxalic acid. Na = 7.8 per cent.

0.296 " 9.6 " " N = 7.5 "

$C_6H_5 \cdot NH \cdot COH, C_2H_5 \cdot ONa$ requires Na = 12.2 per cent.

$(C_6H_5 \cdot NH \cdot COH)_2, C_2H_5ONa$ " Na = 7.4 "

From this it would appear that in the case of formanilide, 2 mols. combine with 1 mol. of the alcoholate. This might take place in the

following way,
$$\begin{array}{c} C_6H_5 \cdot NNa \cdot \overset{\text{CH} \cdot OH}{\underset{\text{CH} \cdot OH}{\text{N}}} \\ C_6H_5 \cdot N \cdot \text{CH} \cdot OH \cdot OC_2H_5 \end{array}$$

Action of Sodium Ethoxide on Benzamide.

In this case, a fine granular precipitate is obtained, which apparently has a constant composition, but this does not correspond with that of any definite compound. It might be a mixture of equal quantities of the additive compound and sodium benzamide. The action is evidently of a different order from that previously described.

Three different preparations gave the following results.

I. 0.196 required 12 c.c. oxalic acid; Na = 14.1 per cent.

II. 0.1785 " 11.1 c.c. " Na = 14.3 "

III. 0.1945 " 12 " " Na = 14.2 "

$C_6H_5 \cdot CO \cdot NH_2, C_2H_5 \cdot ONa$ requires Na = 12.1 per cent.

$C_6H_5 \cdot CO \cdot NHNa$ requires Na = 16.1 per cent.

Action of Sodium Ethoxide and Sodium Methoxide on Diphenylacetamide.

Diphenylacetamide dissolves readily in ether, but on the addition of the alcoholate very little of the latter appears to pass into solution; the clear filtrate gives only a slight, flocculent deposit on standing, and on evaporation in a vacuum, unchanged diphenylacetamide separates.

Action of Sodium Ethoxide and Methoxide on Ethylacetanilide.

The same result was obtained as in the case of diphenylacetamide. On the addition of sodium methoxide to the ethereal solution of the amide, none of the alcoholate appeared to dissolve. Sodium ethoxide was rather more soluble; but in neither case did the ethereal solution, on standing or on evaporation, give any indication of a crystalline additive compound.

Action of Sodium Ethoxide on Formylphenylhydrazide.

On adding sodium ethoxide to formylphenylhydrazide a yellow solution is obtained, from which an orange-yellow compound is deposited; in the dry state this is of a light ochre colour.

0.0788 gave 0.0623 of Na_2SO_4 ; $\text{Na} = 25.6$ per cent.

$\text{C}_7\text{H}_6\text{N}_2\text{ONa}_2 = 25.5$ per cent.

Apparently, this substance has the formula $\text{C}_6\text{H}_5\text{NNa}\cdot\text{NNa}\cdot\text{COH}$.

The formation of additive compounds of the acetyl derivatives of aniline, the toluidines, and naphthylamines with sodium methoxide and ethoxide would indicate the presence of an unsaturated group in these amides.

Claisen has shown that such additive compounds are formed in the case of the ethereal salts, and that numerous condensations of these salts with compounds containing the group $\text{CH}_2\cdot\text{CO}$ occur in this manner according to the following equations.

Applying this idea to the acetyl derivatives we may have the addition of the sodium alcoholate taking place in one of the following ways.

Formula I.

Formula II.

The second formula is the one which appears to us to agree best with the properties of the substance. We have shown that alcohol is given off from the additive compound of acetanilide with sodium methoxide on heating, and that sodium acetanilide is formed.

This reaction is confirmed by the experiments of Seifert (*Ber.*, 1885, 18, 1358), who prepared sodium acetanilide by evaporating to dryness an alcoholic solution of sodium ethoxide and acetanilide. Moreover, there is no doubt, considering the formation of alkyl-anilides by the action of alkyl iodides on sodium acetanilide, that the sodium atom is attached to the nitrogen atom. The formation of this sodium compound from acetanilide, sodium methoxide, by heating it, would be difficult to explain by the first formula. This being the case, it would appear probable that acetanilide itself has the formula $C_6H_5 \cdot N : C(OH) \cdot CH_3$.

The fact that diphenylacetamide and ethylacetanilide do not appear to form analogous compounds is then easily explained, for these two compounds contain no replaceable hydrogen, and cannot therefore form a hydroxyl group.

We do not, of course, lose sight of the possibility of a tautomeric change taking place at the moment of formation of these addition compounds, for, as Claisen has pointed out, questions of tautomerism cannot be satisfactorily decided where chemical changes are involved. An attempt to solve the problem by the electrical conductivity of the acid amides, kindly undertaken for us by Dr. Ewan, is described by him in another communication.