L.III.—*Studies in the Acridine Series. Part III. The Methylation of Chrysaniline (2-Amino-5-p-aminophenylacridine).*

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IN two previous papers, Hewitt and Fox (Trans., 1904, **85**, 529, and 1905, **87**, 1058) have described the formation of paraquinonoid anhydrobases resulting from the hydrolysis of the methiodides of 8-acetylamino-3:7-dimethylacridine and 2:8-diacetylamino-5-phenyl-3:7-dimethylacridine (diacetylbenzoflavine) respectively, and subsequent precipitation by an alkali. In the former case, a carbinol base was isolated, which lost the elements of water at 200°; in the latter case, no such intermediate compound was observed; the changes occurring may be represented by the following schemes :

The fact that the carbinol base cannot be isolated in the second instance is indicated by the inclusion of the hypothetical formula of such a substance in brackets.

As a further instance of the elimination of water which occurs between the carbinol group and a *p*-amino-group, the behaviour of chrysaniline in similar circumstances may be cited; it will be seen in the sequel that no carbinol base has been isolated in this case, but simply the product of its dehydration.

Chrysaniline (2-amino-5-*p*-aminophenylacridine) was the subject of an extended investigation by Hofmann (*Ber.*, 1869, **2**, 379), O. Fischer and G. Körner (*Ber.*, 1884, **17**, 203; *Annalen*, 1886, **226**, 175), and Anschütz (*Ber.*, 1884, **17**, 434). This colouring matter occurs commercially as an impure nitrate or hydrochloride under the name of phosphine, and is used to a limited extent as a basic dye for leather and silk. The chrysaniline used in this investigation was obtained in the following manner. The commercial phosphine was added to hot water in small portions at a time to avoid clotting, constant stirring being employed. After cooling, precipitation of the fine yellow colour base was effected by addition of caustic soda, the precipitate being collected at the pump and well washed, then dried and dissolved in boiling benzene. After boiling some hours in a reflux apparatus, the solution was decanted, the solid matter in the flask being worked up with a fresh batch of material. Crystalline crusts separate from the cooling solution, and these, as observed by Fischer and Körner, contain benzene of crystallisation. By boiling with dilute sulphuric acid, the benzene is driven off, the solution of the sulphate of the base yielding purified chrysaniline on decomposition with caustic soda. Recrystallisation from 50 per cent. alcohol furnishes a product containing two molecules of water; after drying, the base was found to melt at 265° (uncorr.). Fischer and Körner give the melting point as 267—270°.

A solution of the base in hydrochloric acid furnishes a chromate by

0.0821 gave 0.0123 Cr_2O_3 . $\text{Cr} = 12.5$.

$\text{C}_{19}\text{H}_{15}\text{N}_3, \text{H}_2\text{CrO}_4$ requires $\text{Cr} = 12.8$ per cent.

Acetylation of Chrysaniline.

Anschütz (*loc. cit.*) acetylated chrysaniline by heating it with excess of acetic anhydride in sealed tubes at 140° ; Fischer and Körner found that acetylation might be effected under the ordinary pressure. The diacetylchrysaniline required in this investigation was obtained by boiling equal weights of the base and fused sodium acetate with five parts by weight of acetic anhydride for four hours in a reflux apparatus. The chrysaniline at first dissolves with a deep red colour, but this gradually changes to an orange shade as acetylation proceeds (compare Hewitt and Fox, *Trans.*, 1905, **87**, 1058). The fused mass was poured into dilute alcohol to destroy excess of the anhydride; after standing overnight, a brown residue was left which separated on recrystallisation from acetic anhydride in yellowish-brown needles. This substance proved to be the tetra-acetyl derivative.

0.1853 gave 0.4840 CO_2 and 0.0824 H_2O . $\text{C} = 71.25$; $\text{H} = 4.88$.

0.1491 „ 0.3875 CO_2 „ 0.0757 H_2O . $\text{C} = 70.9$; $\text{H} = 5.63$.

$\text{C}_{27}\text{H}_{23}\text{O}_4\text{N}_3$ requires $\text{C} = 71.5$; $\text{H} = 5.07$ per cent.

On pouring the filtrate from the tetra-acetyl derivative into dilute ammonia solution, the diacetylchrysaniline, described by Anschütz, was obtained as a pale yellow precipitate; it was recrystallised by solution in boiling absolute alcohol, water was then added until a faint turbidity was noticed, this was removed by addition of a few drops of alcohol, and the solution allowed to cool slowly. Minute crystals separated which melted at 200° with decomposition.

Diacetylchrysaniline dissolves in dilute hydrochloric acid and behaves as a monacid base, whereas the parent substance forms salts with 2 molecules of a monobasic acid. The chromate, which was prepared by precipitation from the solution in hydrochloric acid, gave the following result on analysis:

0.1893 gave 0.0168 Cr_2O_3 . $\text{Cr} = 5.96$.

$2\text{C}_{23}\text{H}_{21}\text{O}_2\text{N}_3, \text{H}_2\text{CrO}_4$ requires $\text{Cr} = 6.07$ per cent.

This result is in agreement with the observations of Anschütz, who found that diacetylchrysaniline furnishes a mononitrate and monohydrochloride. It is not merely acridine which may be characterised and purified by means of its chromate, but very many of its derivatives also give characteristic chromates.

Action of Methyl Iodide on Diacetylchrysaniline.

Diacetylchrysaniline, one equivalent of methyl iodide, and an excess of methyl alcohol were heated for four hours at 120° under pressure. The magnificent crimson liquid thus obtained deposited small, dark needles, very readily soluble in alcohol and dyeing cotton directly to a deep brown shade. If the alcoholic solution is poured into ammonia, a red precipitate is obtained which darkens considerably on drying. When the base thus produced is boiled with hydrochloric acid, it dissolves with a deep red colour, the solution on cooling depositing a hydrochloride in the form of dark-coloured needles having a green reflex. The percentage of chlorine showed that the base was monacid and that the acetyl groups had been completely hydrolysed.

0.0915 gave 0.0396 AgCl. Cl = 10.7.

$C_{20}H_{18}N_3Cl$ requires Cl = 10.6 per cent.

By precipitation of a solution of the hydrochloride with ammonia and recrystallisation from absolute alcohol, the anhydro-base was obtained.

0.1193 gave 0.34625 CO_2 and 0.0647 H_2O . C = 79.9 ; H = 6.03.

0.1515 „ 0.4421 CO_2 „ 0.0903 H_2O . C = 79.6 ; H = 6.62.

0.2586 „ 0.7580 CO_2 „ 0.1604 H_2O . C = 79.9 ; H = 6.88.

0.0773 „ 8.5 c.c. N at 15° and 770 mm. N = 13.3.

$C_{20}H_{17}N_3$ requires C = 80.25 ; H = 5.69 ; N = 14.04 per cent.

The low numbers for carbon and nitrogen and the high results for hydrogen are to be ascribed to the fact that the substance being very difficult to burn completely, the combustions were necessarily protracted ; we may point out, however, that the percentages obtained for carbon quite exclude the carbinol formula, $C_{20}H_{19}ON_3$, which requires C = 75.7 per cent.

The two following formulæ are possible for the anhydro-base :

Of these we prefer the first from analogy with benzoflavine, although no definite proof can be assigned.

The methylation of diacetylchrysaniline may also be effected by means of methyl sulphate. Equal weights of the two substances were made into a paste and heated for half an hour at 120°. The clear red product of fusion was readily soluble in water, giving a solution having a colour comparable with that of the methiodide previously described; to obtain the anhydro-base, boiling for one hour with dilute sulphuric acid and precipitation with ammonia were adopted. The base obtained resembled in all respects that produced by means of methyl iodide; a portion was converted into a platinichloride by solution in hydrochloric acid and precipitation with hydrogen platinichloride. The brown, amorphous salt obtained was washed with water and alcohol, dried, and analysed.

0.0712 gave 0.0138 Pt. $Pt = 19.63$.

$(C_{20}H_{18}N_3)_2PtCl_6$ requires $Pt = 19.34$ per cent.

The solution of the methylsulphate readily furnishes other salts (for example, chromate, nitrate, &c.), which will be described in another communication, together with further derivatives of chrysaniline.

In his classical research on the acridines, Bernthsen (*Annalen*, 1885, 224, 13) described a dinitro-derivative of phenylacridine which he considered might yield chrysaniline or an isomeride on reduction. This base has been examined during the past year, and corresponding derivatives (chromate, platinichloride, acetyl derivative, and quaternary methiodide) certainly exhibit a striking resemblance to compounds derived from chrysaniline. Since, however, it is unlikely that the two nitro-groups enter into the molecule unsystematically we consider it not improbable that the positions 2 and 8 are those which are substituted.

Colour and Fluorescence of Acridine Derivatives.

The colours exhibited by acridine, *mesophenylacridine*, chrysaniline, benzoflavine, and various derivatives of the two latter substances call for some comment. Acridine and its phenyl derivative both exhibit a somewhat pale yellow colour, whilst the introduction of the two amino-groups in para-positions to the *meso*-carbon atom, whether as in benzoflavine the 2- and 8-positions be occupied or the 2- and 5-*p*-positions be replaced as in chrysaniline, results in the production of deep yellow colouring matters, the substances in the solid condition exhibiting a deep orange shade. If, now, the amino-group is acetylated, light yellow compounds are formed, the colour of which is strictly comparable with that of the parent phenylacridine.

This behaviour has suggested the possibility that the colour bases may possess a paraquinonoid structure, and it is certainly worth mentioning that the undoubted paraquinonoid methyl derivatives in

which the chance of tautomerism is excluded are intensely-coloured compounds. The intermediate shade exhibited by the non-methylated bases (chrysaniline and benzoflavine) suggests the possibility that both the quinonoid and non-quinonoid forms may be represented, but speculation on this point would be vain without a careful spectrographic investigation.

The fluorescent phenomena of these substances call for some remark : the fluorescence exhibited by acridine, phenylacridine, and the diacetyl derivatives of benzoflavine and chrysaniline is blue in shade and somewhat resembles that exhibited by anthracene. The diamino-compounds, however, exhibit a strong green fluorescence if the free bases are dissolved in alcohol, this fluorescence being very nearly destroyed by the addition of acids : the fluorescence is probably a property of the free bases. As one of the present authors has already pointed out, the more symmetrical benzoflavine shows a much more marked fluorescence than the less symmetrical chrysaniline (*Zeit. physikal. Chem.*, 1900, **34**, 14). In the case of the non-tautomeric paraquinonoid methyl derivatives the observed fluorescence of the free bases is so faint as to be perhaps attributable to a small amount of admixed non-methylated base.

The connection between fluorescence and constitution of organic compounds has engaged the attention of several chemists. R. Meyer (*Zeit. physikal. Chem.*, 1897, **24**, 468) attributes fluorescence to the occurrence of certain "fluorophore" groups in the molecules of substances exhibiting the property. These groups are mostly six-membered rings, for example, the pyrone ring and its congeners, the middle 6-carbon ring in anthracene, the pyridine ring in acridine compounds, and the paradiazine ring in safranines.

J. T. Hewitt (*Zeit. physikal. Chem.*, 1900, **34**, 1) attributes fluorescence to internal vibrations in the molecule conditioned by symmetrical double tautomerism ; the molecules of acridine and benzoflavine, for example, swinging between the extreme positions indicated schematically as follows :

Finally, H. Kauffmann (*Ber.*, 1900, **33**, 1731 ; 1904, **37**, 294 ; 1905, **38**, 789 ; *Annalen*, 1906, **344**, 30), as a result of his extensive investigations, has propounded the theory that the molecules of a fluorescent substance contain at least two groups. The first of these groups is the one from which the radiant energy is emitted when the molecules are excited either by light of suitable wave-length, Tesla currents, or exposure to the action of radium. This group Kauffmann terms the luminophore.

The second group, the "fluorogen," has a specific action. Thus, in the case of anthranilic acid, the aniline grouping is considered as the luminophore. Aniline is not a fluorescent substance, but the introduction of a fluorogen (in this case, carboxyl) results in the production of fluorescent anthranilic acid. The precise action of the fluorogen is at present left unsolved, but it is apparently an unsaturated group in all cases.

Whilst the theories of Meyer and Hewitt have not been applied hitherto to an explanation of the fluorescence of such compounds as anthranilic acid, it may be mentioned that the theory connecting double tautomerism with fluorescence agrees very well with the observed facts in the case of acridine, phenylacridine, and its diamino-derivatives. Where only shifting of linkings is possible, as with acridine and the diacetyl derivatives of benzoflavine and chrysanthine, the character of the fluorescence is very similar. But with the introduction of the two amino-groups the fluorescence partakes more of the character of that exhibited by fluorescein, and the possible mechanism of the tautomerism is not unlike that with alkaline solutions of fluorescein.

Finally, if the tautomerism is inhibited to a greater or less extent, either by salt formation or by methylation of the *meso*-nitrogen atom, the fluorescence is strikingly diminished.

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