Both dextrose and levulose, 90 to 95% of the quantities used, were oxidized to carbonates with the liberation of methane and hydrogen. Ninety per cent. or more of the quantities reacting is oxidized in conformity with the equation,

$$C_6H_{12}O_6 + 8NaOH \longrightarrow 4Na_2CO_3 + 2H_2O + 2CH_4 + 4H_2$$

while the balance reacts according to the equation

$$C_6H_{12}O_6 + 12NaOH \longrightarrow 6Na_2CO_3 + 12H_2$$

Under identical conditions sucrose underwent carbonization to such an extent that the possibility of verifying any proposed equations for reactions occurring was precluded.

Cellulose was completely oxidized, about 95% of the quantity reacting, in conformity with the equation

$$C_6H_{10}O_5 + 14NaOH \longrightarrow 5Na_2CO_3 + Na_4CO_4 + 12H_2$$

while the remaining 5% reacted according to the equation

$$C_6H_{10}O_5 + 8NaOH \longrightarrow 4Na_2CO_3 + H_2O + 2CH_4 + 4H_2$$

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF LOUISVILLE]

RESEARCHES ON ACRIDINES. IV. THE PREPARATION OF HYDROXY-ACRIDINES AND DIFFERENT 5-POSITION ACRIDINE DERIVATIVES

BY H. JENSEN AND F. RETHWISCH[1]

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Introduction

In a previous paper a new method for the preparation of acridine derivatives has been outlined.[2] It has been shown that the treatment of *o*-aminobenzaldehyde with the halogen derivatives of nitrobenzene and with the corresponding derivatives of toluene would yield the corresponding diphenylamine derivatives. These diphenylamine derivatives split off water very easily to form acridine compounds. The authors have examined the general application of this reaction and have found that it can be extended in two ways. Halogen compounds of benzene, other than those mentioned, can be used, or the aminobenzaldehyde can be replaced by *o*-aminophenylketones.

The halogen derivatives of phenols were chosen first for the following reason. K. Matsumura[3] has described the preparation of 1(9)-hydroxyacridine by reduction of the corresponding acridone compound in boiling

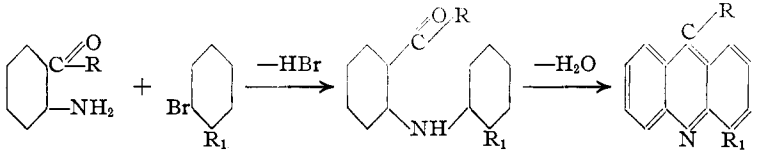
[1] A part of this paper is an abstract of a thesis presented by F. Rethwisch in partial fulfilment of the requirements for the degree of Master of Science in Chemistry at the University of Louisville.

[2] Jensen and Friedrich, THIS JOURNAL, 49, 1049 (1927).

[3] Matsumura, *ibid.*, 49, 816 (1927).

amyl alcohol with sodium. These results seemed open to question because it was believed that the dihydro-acridine derivative should be obtained, since acridine itself will give dihydro-acridine under the stated conditions. As our products are identical with those of the Japanese chemist, no hydrogenation of the acridine ring occurred during the reduction. In this work the free phenols could not be used as the hydroxy group itself reacted. For this reason the methyl and ethyl ethers were used.

Next the *o*-aminobenzaldehyde was replaced by *o*-aminophenylketones. This reaction should lead to 5-position acridine derivatives according to the following scheme



For R the investigations included the methyl and phenyl groups, and for R_1 the methyl, nitro and alkoxy groups, which were in either ortho or para position to the halogen. In all cases it was possible to secure the corresponding acridine compounds without great difficulty.

F. Mayer[4] has shown that the chlorine in *o*-chloro-acetophenone is not labile enough to react with aromatic amino compounds to give the corresponding diphenylamine derivatives, as is the case with *o*-chlorobenzophenone. It was thought that by introducing a nitro group in the para position to the halogen, the latter could be made more reactive. It was found that the chlorine in 5-nitro-2-chloro-acetophenone reacts very readily with aniline to give the corresponding diphenylamine derivative. The latter could be converted very easily into 3(7)-nitro-5-methylacridine, which has also been prepared in a different way. Experiments indicate that the chlorine in 5-nitro-2-chloro-acetophenone reacts also with *o*- and *p*-nitro-aniline. These products would give dinitro-methylacridines in the final step of the reactions. It would be interesting to see if the chlorine in 5-nitro-2-chlorobenzaldehyde would react similarly.

The preparation of the methyl and ethyl esters of the acridine-5-carboxylic acid may also be reported. It is intended to use these esters as the starting materials for the preparation of different acridine compounds. The acridine-5-carboxylic acid could not be esterified with alcohol and hydrochloric acid, either by letting the mixture stand in the cold for several days or by heating for two days. No reaction could be obtained with sulfuric acid and alcohol. Pfitzinger[5] observed the same phenomenon in the cases of β-methyl- and of β-phenyl-cinchonic acids, as did also

[4] F. Mayer and H. Freund, *Ber.*, **55**, 2054 (1922).

[5] Pfitzinger, *J. prakt. Chem.*, [2] **33**, 100 (1886); **38**, 582 (1888); **56**, 283 (1897).

Borsche[6] in the case of the tetrahydro-acridine-5-carboxylic acid. Steric hindrance will probably account for this behavior of the acridine-5-carboxylic acid. The esters can be obtained from the acid chloride, which can be prepared by heating the acid with thionyl chloride.

The melting points given in this work are all uncorrected. They were, however, made with the same thermometer under identical conditions.

Experimental

The following acridine derivatives were prepared (Table I).

The following general procedure was adopted for preparing these acridine derivatives. Six g. of *o*-aminobenzaldehyde—in the case of the 5-methylacridine *o*-amino-acetophenone was used—a slight excess of the theoretical amount of the corresponding halogen derivatives of benzene, 0.4 g. of copper powder, 10 g. of anhydrous sodium carbonate and 60 cc. of nitrobenzene were refluxed for three hours at 220°. The nitrobenzene and the excess of the halogen derivatives of benzene were removed by steam distillation. The residue was extracted with ether, the ether solution dried over sodium sulfate, filtered and then evaporated. The condensation product was dissolved in 15 cc. of glacial acetic acid, and 3 cc. of concd. sulfuric acid was added.[7] This mixture was then heated on a water-bath for five minutes, poured into ice water and filtered. The filtrate was made alkaline with ammonium hydroxide. The precipitate was crystallized from the solvent given in the table.

The hydrolysis of the alkoxy-acridine to the corresponding hydroxy-acridine was effected by boiling the substance for one hour with hydriodic acid (sp. gr. 1.7) and traces of red phosphorus. The solution was then diluted with water and made alkaline with sodium hydroxide. The filtrate was made neutral with acetic acid. The precipitate was crystallized from the given solvent.

The derivatives of 5-methyl- and 5-phenylacridine were prepared in a similar way, except that *o*-amino-acetophenone or *o*-aminobenzophenone[8] was used instead of the *o*-aminobenzaldehyde.

As the melting point of our 5,3(7)-dimethylacridine was not in agreement with that given by Bonna,[13] we repeated his experiment.

Pure acetyl-*p*-tolylamine was used in this synthesis. The melting point of the product obtained from this was also 90°. The mixed melting point showed no depression. The same was true with the picrate. The product of Bonna might be the 5,2(8)-dimethyl compound.[9] This has the m. p. 122–123° which is given by Bonna for his product.

Anal. Calcd. for $C_{15}H_{13}N$: C, 86.91; H, 6.32. Found: C, 87.12; H, 6.60.

Picrate: *Anal.* Calcd. for $C_{15}H_{13}N.C_6H_3O_7N_3$: C, 57.79; H, 3.70. Found: C, 57.89; H, 4.07.

Condensation Product of *o*-Aminobenzaldehyde and *o*-Bromo-anisole.[10]—The gen-

[6] Borsche, *Ann.*, **377**, 70–123 (1910).

[7] It was found in many cases that glacial acetic acid with a few cc. of concd. sulfuric acid was more satisfactory in closing the ring than was concd. sulfuric acid alone. If only sulfuric acid was used, sulfonation sometimes took place, and in the case of the ethoxy compound partial hydrolysis of the ether group was effected.

[8] Ullmann and Bleier, *Ber.*, **35**, 4273 (1902).

[9] Borsche, *Ann.*, **377**, 97 (1902).

[10] The intermediate diphenylamine derivatives in these reactions are hard to isolate because at the high temperature used some ring closure takes place. For this reason we did not spend much time in trying to isolate them.

TABLE I

MONO SUBSTITUTION PRODUCTS OF ACRIDINE

Substance	Formula	M. p., °C.	Solvent	Crystal form	Color	% Carbon Calcd.	% Carbon Found	% Hydrogen Calcd.	% Hydrogen Found
3(7)-Ethoxy-acridine	$C_{15}H_{13}ON$	99	Dil. alc.	Plates	Yellow	80.68	80.51	5.87	6.12
Picrate of 3(7)-ethoxy-acridine	$C_{15}H_{13}ON.C_6H_3O_7N_3$	Did not melt at 250	Acetone	Needles	Yellow	55.74	55.97	3.57	3.81
Hydrochloride of 3(7)-ethoxy-acridine	$C_{15}H_{13}ON.HCl$	Decomposed at 200	Alcohol	Needles	Bright yellow	Calcd. Cl,	Found Cl,	13.65	13.71
3(7)-Hydroxy-acridine	$C_{13}H_9ON$	Did not melt at 250	Alcohol	Needles	Yellow	79.97	79.85	4.65	5.02
1(9)-Methoxy-acridine	$C_{14}H_{11}ON$	130–131	75% alc.	Needles	Light yellow	80.35	80.28	5.30	5.44
Picrate of 1(9)-methoxy-acridine	$C_{14}H_{11}ON.C_6H_3O_7N_3$	Decomposed at 250	Alcohol	Needles	Orange-red	54.79	54.63	3.22	3.18
1(9)-Hydroxy-acridine[3]	$C_{13}H_9ON$	116.5	75% alc.	Needles	Yellow	79.97	80.00	4.65	4.77
Picrate of 1(9)-hydroxy-acridine[3]	$C_{13}H_9ON.C_6H_3O_7N_3$	216	Alcohol	Needles	Red	53.77	53.62	2.85	3.14
5-Methylacridine	$C_{14}H_{11}N$	114	Petroleum ether	Needles	Slightly yellow	87.01	87.13	5.74	5.92
Picrate of 5-methyl-acridine	$C_{14}H_{11}N.C_6H_3O_7N_3$	213–214	Alcohol	Needles	Yellow	56.86	57.21	3.34	3.61

TABLE II

DI-SUBSTITUTION PRODUCTS OF ACRIDINE

Substance	Formula	M. p., °C.	Solvent	Crystal form	Color	% Carbon Calcd.	% Carbon Found	% Hydrogen Calcd.	% Hydrogen Found
5,3(7)-Dimethylacridine	$C_{15}H_{13}N$	90	Petroleum ether	Plates	Cream	86.91	86.84	6.32	6.52
Picrate of 5,3(7)-dimethylacridine	$C_{15}H_{13}N \cdot C_6H_3O_7N_3$	Darkened at 215 Melted at 225	Alcohol	Needles	Yellow	57.79	57.96	3.70	3.92
3(7)-Nitro-5-methylacridine	$C_{14}H_{10}O_2N_2$	Did not melt at 300	Alcohol	Needles	Brown-yellow	70.57	70.63	4.23	4.42
1(9)-Nitro-5-phenylacridine[11]	$C_{19}H_{12}O_2N_2$	189-190	Alcohol	Needles	Yellow	75.98	75.92	4.03	4.21
3(7)-Nitro-5-phenylacridine[12]	$C_{19}H_{12}O_2N_2$	209-210	Alcohol	Needles	Yellow	75.98	76.07	4.03	4.18
3(7)-Methyl-5-phenylacridine[13]	$C_{20}H_{15}N$	135	Alcohol	Needles	Brown	89.18	89.27	5.62	5.87
Picrate of 3(7)-methylacridine	$C_{20}H_{15}N \cdot C_6H_3O_7N_3$	226	Alcohol	Needles	Yellow	...	...	..	..
3(7)-Ethoxy-5-phenylacridine	$C_{21}H_{17}ON$	105–107	Alcohol	Plates	Yellow	84.25	84.18	5.73	5.96
3(7)-Hydroxy-5-phenylacridine[14]	$C_{19}H_{13}ON$	Darkened at 260 Sintered without melting at 275	Dil. alc.	Leaves	Yellow	84.10	84.23	4.83	5.03

[11] F. Mayer, ref. 4, gives the melting point of this product as 218°. Time was not available for repeating his experiment.

[12] Ullmann, *Ber.*, **39**, 301 (1906).

[13] Bonna, *Ann.*, **239**, 63 (1887).

[14] Hess and Bernthsen, *Ber.*, **18**, 695 (1885); Kehrmann and Stépanoff, *Ber.*, **41**, 4138 (1908).

eral procedure was followed. The residue left after steam distillation was purified, giving light yellow needles from petroleum ether, m. p. 99°.

Anal. Calcd. for $C_{14}H_{13}O_2N$: C, 73.96; H, 5.77. Found: C, 73.91; H, 6.04.

Preparation of 2-Acetyl-4'-nitrodiphenylamine.—It was prepared from *o*-aminoacetophenone and *p*-nitrobromobenzene. The residue left after steam distillation was crystallized several times from alcohol; yellow needles, m. p. 152°.

Anal. Calcd. for $C_{14}H_{12}O_3N_2$: C, 65.60; H, 4.72. Found: C, 65.51; H, 5.03.

Condensation of 5-Nitro-2-chloro-acetophenone with Aniline.—Four g. of nitrochloro-acetophenone,[15] 4 g. of potassium carbonate and 5 cc. of freshly distilled aniline were heated for three hours at 170–180° and the mixture extracted with hot alcohol. The crystals from this were crystallized from alcohol as light yellow needles, m. p. 125°.

Anal. Calcd. for $C_{14}H_{12}O_3N_2$: C, 65.60; H, 4.72. Found: C, 65.68; H, 5.07.

The condensations of 5-nitro-2-chloro-acetophenone with *o*- and *p*-nitro-aniline were carried out in a similar way.

3(7)-Nitro-5-methylacridine.—Ring closure of the preceding 2-acetyl-4-nitrodiphenylamine was again obtained with acetic acid and sulfuric acid. The properties were the same as for the product prepared from 2-acetyl-4'-nitrodiphenylamine.

Anal. Calcd. for $C_{14}H_{10}O_2N_2$: C, 70.57; H, 4.23. Found: C, 70.48; H, 4.53.

Ethyl Ester of Acridine-5-carboxylic Acid.—Six and five-tenths g. of acridine-5-carboxylic acid[16] and 20 g. of thionyl chloride were refluxed for two hours in a flask which was connected to a reflux condenser by a ground glass joint. The excess of thionyl chloride was removed by extracting three times with absolute benzene. Then the residue was filtered and washed several times with benzene. The acid chloride was immediately refluxed with 50 cc. of absolute ethyl alcohol. After all the chloride had gone into solution, water was added and the solution was made alkaline with sodium carbonate. The precipitate was purified from ligroin. The ethyl ester precipitates out in yellow, rhombohedral plates, m. p. 78°.

Anal. Calcd. for $C_{16}H_{13}O_2N$: C, 76.47; H, 5.22. Found: C, 76.53; H, 5.18.

Picrate.—Flaky yellow needles from alcohol, m. p. 226°.

Anal. Calcd. for $C_{16}H_{13}O_2N.C_6H_3O_7N_3$: C, 54.99; H, 3.36. Found: C, 55.23; H, 3.62.

Hydrochloride.—Yellow needles which did not melt at 250°.

Anal. Calcd. for $C_{16}H_{14}O_2NCl$: Cl, 12.33. Found: Cl, 12.25.

Methyl Ester of Acridine-5-carboxylic Acid.—Crystallized from methyl alcohol in slightly yellow needles, m. p. 126.5–127.5°.

Anal. Calcd. for $C_{15}H_{11}O_2N$: C, 75.93; H, 4.68. Found: C, 76.12; H, 4.55.

Picrate.—Yellow needles, m. p. 229–230°.

Anal. Calcd. for $C_{15}H_{11}O_2N.C_6H_3O_7N_3$: C, 54.07; H, 3.03. Found: C, 54.35; H, 3.41.

Hydrochloride.—The yellow needles did not melt at 250°.

Anal. Calcd. for $C_{15}H_{12}O_2NCl$: Cl, 12.96. Found: Cl, 12.88.

Summary

The method described in an earlier paper for the preparation of acridine derivatives has been extended and the following compounds have been

[15] Meisenheimer, *Ann.*, **464**, 220 (1926).

[16] Jensen and Homberger, THIS JOURNAL, **48**, 800 (1926).

prepared: 1(9)-methoxy-acridine, 1(9)-hydroxy-acridine, 3(7)-ethoxy-acridine, 3(7)-hydroxy-acridine, 5-methyl-acridine, 5,3(7)-dimethyl-acridine, 5-methyl-3(7)-nitro-acridine, 5-phenyl-1(7)-nitro-acridine, 5-phenyl-3(7)-nitro-acridine, 5-phenyl-3(7)-methyl-acridine, 5-phenyl-3(7)-ethoxy-acridine and 5-phenyl-3(7)-hydroxy-acridine.

It has been shown that the chlorine in 5-nitro-2-chloro-acetophenone is labile enough to react with aniline and with *o*- and *p*-nitro-aniline.

The preparation of the methyl and ethyl esters of acridine-5-carboxylic acid has been described.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF PRINCETON UNIVERSITY]

THE ACTION OF SODIUM TRIPHENYLMETHYL UPON TRIMETHYLMETHOXYAMMONIUM IODIDE AND OF TRIPHENYLMETHYL HALIDES UPON TRIMETHYLAMINE[1]

BY LAUDER W. JONES AND MERRILL W. SEYMOUR

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The researches of Schlenk and Holz, which led to the preparation of tetramethylammonium triphenylmethyl, $(CH_3)_4N{\cdot}C(C_6H_5)_3$, and tetramethylammonium benzyl, suggested the possibility of synthesizing compounds of a new class similar in type to the isomeric alkylated amine oxides, $R_3N(OR)(OR')$, investigated by Meisenheimer,[2] but differing from them by a substitution of the triphenylmethyl radical for an alkoxy group, for example, $R_3NOR{\cdot}C(C_6H_5)_3$. Isomeric with compounds of this class would be alcoholates of the form $R_3N[C(C_6H_5)_3]{\cdot}OR$. The experiments described below were undertaken with the hope of obtaining derivatives of these types.

I. The Action of Sodium Triphenylmethyl upon Trimethylmethoxyammonium Iodide.—When these two substances were shaken together in very carefully purified ether, the deep red color of the solution changed in time to a pale yellow shade, but no intensely colored compound such as that described by Schlenk as characteristic of tetramethylammonium aryls was noticed; sodium iodide, trimethylamine, triphenylmethane and triphenylethanol were the chief products isolated.

These results suggest that trimethylmethoxyammonium triphenylmethyl was undoubtedly formed in the first stages of the reaction.

$$(CH_3)_3{\equiv}\underset{\displaystyle I}{\underset{|}{N}}.OCH_3 + NaC(C_6H_5)_3 \longrightarrow (CH_3)_3{\equiv}\underset{\displaystyle C(C_6H_5)_3}{\underset{|}{N}}{-}OCH_3 + NaI$$

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[1] This article is based upon a thesis presented by Merrill W. Seymour to the Faculty of the Graduate School of Princeton University in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

[2] Meisenheimer, *Ann.*, **397**, 273 (1913).